

# Curriculum and Detailed Syllabi

For

## B.E. Mechatronics 2018 Regulations



**Thiagarajar College of Engineering**

(A Govt. Aided, Autonomous Institution, Affiliated to Anna University)

**Madurai – 625 015, Tamil Nadu**

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# Thiagarajar College of Engineering

*– Where quality and ethics matter*

## **Vision Statement:**

“World class quality technical education with strong ethical values”

## **Mission Statement:**

We at TCE shall strive continuously,

- Academic excellence in Science, Engineering and Technology through dedication to duty, commitment to research, innovation in learning and faith in human values
- Enable the students to develop into outstanding professionals with high ethical standards capable of creating, developing and managing global engineering enterprises
- Fulfil expectations of the society and industry by equipping students with state of art technology resources for developing sustainable solutions
- Achieve these through team efforts making Thiagarajar College of Engineering the socially diligent trend setter in technical education

## DEPARTMENT OF MECHATRONICS ENGINEERING

### **Vision:**

“Be a globally renowned school of engineering in Mechatronics”

### **Mission:**

As a department, we are committed to

- Develop ethical and competent engineers by synergizing world class teaching, learning and research
- Establish state-of-art laboratories and to provide consultancy services to fulfil the expectations of industry and needs of the society
- Inculcate entrepreneurial qualities for creating, developing and managing global engineering ventures
- Motivate the students to pursue higher studies and research

### **Programme Educational Objectives (PEOs) of B.E. (Mechatronics)**

**PEO 1:** The programme will prepare graduates to synergistically integrate mechanical engineering with electronic and intelligent computer control in the design and manufacture of industrial products and processes.

**PEO 2:** The programme will prepare graduates with strong team skills to solve multi-disciplinary problems using Mechatronics approach.

**PEO 3:** The programme will prepare graduates with an understanding of their ethical and social responsibility.

**Programme Outcomes (POs) of B.E. (Mechatronics)**

<b>PO1</b>	<b>Engineering knowledge</b>	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
<b>PO2</b>	<b>Problem analysis</b>	Identify, formulate, research literature, and analyses Complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
<b>PO3</b>	<b>Design/development of solutions</b>	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
<b>PO4</b>	<b>Conduct investigations of complex problems</b>	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
<b>PO5</b>	<b>Modern tool usage</b>	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
<b>PO6</b>	<b>The engineer and society</b>	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
<b>PO7</b>	<b>Environment and sustainability</b>	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
<b>PO8</b>	<b>Ethics</b>	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
<b>PO9</b>	<b>Individual and team work</b>	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
<b>PO10</b>	<b>Communication</b>	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
<b>PO11</b>	<b>Project management and finance</b>	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
<b>PO12</b>	<b>Life-long learning</b>	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

**PEO – PO Matrix**

POs PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1	S	S	S	S	S	M	S	M	L	M	M	M
PEO2	S	S	S	S	S	S	M	M	S	S	S	L
PEO3	L	M	M	L	L	S	S	S	S	M	S	M

*S – Strong**M-Medium**L-Low***Programme Specific Outcomes (PSO):**

After the successful completion of the B.E. Mechatronics Engineering degree programme, the students will be able to:

**PSO1:**

Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

**PSO2:**

Design, develop and analyse mechatronics system using hardware and software tools.



**SCHEDULING OF COURSES**

Sem	Theory / Theory cum Practical / Laboratory Courses									Mandatory Audit Courses	Total Credits
I	18MA110 Engineering Calculus 4	18PHA20 Physics 3	18CHA30 Chemistry 3	18EG140 English 2	18ES150 Engineering Exploration 3	18ME160 Engineering Graphics 4	18EG170 English Laboratory 1	18PH180 Physics Laboratory 1	18CH190 Chemistry Laboratory 1	---	22
II	18MA210 Matrices and Ordinary Differential Equations 3	18MT220 Electrical Machines 3	18MT230 Analog Electronics 3	18MT240 Free Body Mechanics 3	---	18MT260 Manufacturing Processes (TCP) 3	18MT271 Electrical Machines Laboratory 1	18MT280 Workshop 1	18ES290 Lateral Thinking 1	18CHAA0 Environmental Science	18
III	18MT310 Partial differential equations 3	18MT320 Kinematics and Dynamics of Machinery 3	18MT330 Digital Electronics 3	18MT340 Thermal Fluid Engineering 3	18MT350 Programming for problem solving 2	18MT360 Programming and Coding Laboratory 1	18MT370 Thermal Fluid Engineering Laboratory 1	18MT380 Digital Electronics Laboratory 1	18ES390 Design Thinking 2	---	19
IV	18MT410 Probability and Statistics 3	18MT420 Power Electronics and Drives 3	18MT430 Micro Controller 3	18MT440 Sensors and Measurements 3	18YYFX0 Foundation Elective 3	18EG460 Professional Communication (TCP) * 2	18MT470 Sensors and Measurements Laboratory 1	18MT480 Micro Controller Laboratory 1	18MT490 Project Management 3	18CHAB0 Constitution of India	22
V	18MT510 Control System 3	18MT520 Industrial Automation 3	18MT530 Design of Machine Elements 3	18MTPX0 Program Elective I 3	18YYGX0 General Elective 3	18MT560 Accounting and Finance 3	18MT570 Industrial Automation Laboratory 1	18MT580 Dynamics and Control Laboratory 1	18ES590 System Thinking 2	Essence of Indian Knowledge	22
VI	18MT610 Industrial Robotics 3	18MT620 CNC Technology 3	18MTEX0 Engineering Science Elective 3	18MTPX0 Program Elective II 3	Program / Foundation Elective 3	18MT660 Virtual Instrumentation (TCP) 3	18MT670 CAD / CAM Laboratory 1	18MT680 Robotics Laboratory 1	18ES690 Engineering Design Project 3	---	23
VII	18MT710 Mechatronics System Design 3	18MTPX0 Program Elective III 3	18MTPX0 Program Elective IV 3	18MTPX0 Program Elective V 3	Program / General Elective 3	18MT760 System Integration Laboratory 1	---	---	18ES790 Capstone Design Project 3	---	19
VIII	18MT810 Project 9	18MTPX0 Program Elective VI 3	18MTPX0 Program Elective VII 3	---	---	---	---	---	---	---	15
<b>Total Credits</b>											<b>160</b>

**CATEGORIZATION OF COURSES**

Degree: B.E.

Program: Mechatronics

Sl. No	Category		Credits	
			Regular Admission	Lateral Entry Admission
<b>A.</b>	<b>Foundation Courses</b>			
	a.	Humanities and Social Science (HSS)	9-11	6-8
	b.	Basic Science (BS)	21	6
	c.	Engineering Science (ES)	22-25	10-13
	d.	Foundation Elective (FE) from HSS, BS and ES	3-6	3-6
<b>B.</b>	<b>Core Courses</b>		<b>55</b>	<b>45</b>
<b>C.</b>	<b>Elective Courses</b>			
	a.	Programme Specific Electives	12-24	12-24
	b.	Prog. Specific Electives for Expanded Scope	6-12	6-12
	c.	Interdisciplinary Elective	3-6	3-6
<b>D.</b>	<b>Project</b>		<b>15</b>	<b>15</b>
<b>E</b>	Mandatory Audit Courses (Not to be included in CGPA)		2-4	2-4
	Minimum Credits to be earned for the award of the degree		<b>160</b> (from A to D) and <b>2</b> (from E)	<b>120</b> (from A to D) and <b>2</b> (from E)

**Humanities and Social Science (HSS)**

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18EG140	English	2	0	0	2	Nil
2	18EG170	English Laboratory	0	0	2	1	Nil
3	18EG460	Professional Communication	1	0	2	2	Nil
4	18MT490	Project Management	3	0	0	3	Nil
5	18MT560	Accounting and Finance	3	0	0	3	Nil

**Basic Sciences (BS)**

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MA110	Engineering Calculus	3	1	0	4	Nil
2	18PHA20	Physics	3	0	0	3	Nil
3	18CHA30	Chemistry	3	0	0	3	Nil
4	18PH180	Physics Laboratory	0	0	2	1	Nil
5	18CH190	Chemistry Laboratory	0	0	2	1	Nil
6	18MA210	Matrices and Ordinary Differential Equations	3	0	0	3	Nil
7	18MT310	Partial differential equations	3	0	0	3	18MA110, 18MA210
8	18MT410	Probability and Statistics	3	0	0	3	18MA110

Engineering Sciences (ES)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18ES150	Engineering Exploration	3	0	0	3	Nil
2	18ME160	Engineering Graphics	3	0	2	4	Nil
3	18MT240	Free Body Mechanics	3	0	0	3	18MA110
4	18MT280	Workshop	0	0	2	1	Nil
5	18ES290	Lateral Thinking	0	0	2	1	Nil
6	18MT350	Programming for problem solving	2	0	0	2	Nil
7	18MT360	Programming and Coding Laboratory	0	0	2	1	Nil
8	18ES390	Design Thinking	1	0	2	2	Nil
9	18MTEX0	Engineering Science Elective	3	0	0	3	Nil
10	18MT660	Virtual Instrumentation	2	0	2	3	Nil
11	18ES790	System Thinking	0	0	4	2	Nil

Engineering Science Electives							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MTEA0	Integrated Product development	3	0	0	3	18ES290, 18ES390
2	18MTEB0	Battery Management System	3	0	0	3	18MT230, 18MT330

Professional Core Courses (PCC)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MT220	Electrical Machines	3	0	0	3	18MA110, 18PHA20
2	18MT230	Analog Electronics	3	0	0	3	Nil
3	18MT260	Manufacturing Processes	2	0	2	3	Nil
4	18MT271	Electrical Machines Laboratory	0	0	2	1	18MA110, 18PHA20
5	18MT320	Kinematics and Dynamics of Machinery	3	0	0	3	18MA110, 18MT240
6	18MT330	Digital Electronics	3	0	0	3	Nil
7	18MT340	Thermal Fluid Engineering	3	0	0	3	Nil
8	18MT370	Thermal Fluid Engineering Laboratory	0	0	2	1	Nil
9	18MT380	Digital Electronics Laboratory	0	0	2	1	Nil

Professional Core Courses (PCC)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
10	18MT420	Power Electronics and Drives	3	0	0	3	18MT220, 18MT230
11	18MT430	Microcontroller	3	0	0	3	18MT330, 18MT380
12	18MT440	Sensors and Measurements	3	0	0	3	Nil
13	18MT470	Sensors and Measurements Laboratory	0	0	2	1	Nil
14	18MT480	Micro Controller Laboratory	0	0	2	1	18MT330, 18MT380
15	18MT510	Control System	3	0	0	3	Nil
16	18MT520	Industrial Automation	3	0	0	3	18MT220
17	18MT530	Design of Machine Elements	3	0	0	3	18MT240
18	18MT570	Industrial Automation Laboratory	0	0	2	1	Nil
19	18MT580	Dynamics and Control Laboratory	0	0	2	1	18MT320
20	18MT610	Industrial Robotics	3	0	0	3	18MT320
21	18MT620	CNC Technology	3	0	0	3	18MT420, 18MT440
22	18MT670	CAD / CAM Laboratory	0	0	2	1	18ME160
23	18MT680	Robotics Laboratory	0	0	2	1	Nil
24	18MT710	Mechatronics System Design	3	0	0	3	18MT230, 18MT330, 18MT430, 18ES390
25	18MT760	System Integration Laboratory	0	0	2	1	18MT520, 18MT570

Project (PJ)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18ES590	Capstone Design Project	0	0	6	3	Nil
2	18ES690	Engineering Design Project	0	0	6	3	Nil

Programme Specific Electives (PE)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MTPA0	Machine Vision System	3	0	0	3	Nil
2	18MTPB0	Micro Electro Mechanical Systems	3	0	0	3	18PHA20
3	18MTPC0	Additive Manufacturing	3	0	0	3	Nil
4	18MTPD0	Embedded system	3	0	0	3	18MT430

Prog. Specific Electives for Expanded Scope (PEES)							
Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MTPE0	Machine Learning and its Applications	3	0	0	3	18MT350, 18MT410
2	18MTPF0	Internet of Things	3	0	0	3	18MT430, 18MT440
3	18MTPG0	Industrial Communication Networks	3	0	0	3	Nil

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**  
**B.E. / B.Tech. Degree Programme**

**COURSES OF STUDY**  
 (For the candidates admitted from 2018-19 onwards)

**FIRST SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
<b>THEORY</b>						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHA20/ 18PHB20/ 18PHC20	Physics	BS	3	-	-	3
18CHA30/ 18CHB30/ 18CHC30	Chemistry	BS	3	-	-	3
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
<b>THEORY CUM PRACTICAL</b>						
18ME160	Engineering Graphics	ES	3	-	2	4
<b>PRACTICAL</b>						
18EG170	English Laboratory	HSS	-	-	2	1
18PH180	Physics Laboratory	BS	-	-	2	1
18CH190	Chemistry Laboratory	BS	-	-	2	1
<b>Total</b>			<b>17</b>	<b>1</b>	<b>8</b>	<b>22</b>

BS : Basic Science  
 HSS : Humanities and Social Science  
 ES : Engineering Science

L : Lecture  
 T : Tutorial  
 P : Practical

**Note:**

1 Hour Lecture is equivalent to 1 credit  
 1 Hour Tutorial is equivalent to 1 credit  
 2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**  
**B.E. / B.Tech. Degree Programme**

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-19 onwards)

**FIRST SEMESTER**

Sl. No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MA110	Engineering Calculus	3	50	50	100	25	50
2	18PHA20/ 18PHB20/ 18PHC20	Physics	3	50	50	100	25	50
3	18CHA30/ 18CHB30/ 18CHC30	Chemistry	3	50	50	100	25	50
4	18EG140	English	3	50	50	100	25	50
5	18ES150	Engineering Exploration	3	50	50	100	25	50
<b>THEORY CUM PRACTICAL</b>								
6	18ME160	Engineering Graphics	3	50	50	100	25	50
<b>PRACTICAL</b>								
7	18EG170	English Laboratory	3	50	50	100	25	50
8	18PH180	Physics Laboratory						
9	18CH190	Chemistry Laboratory	3	50	50	100	25	50

\* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SUBJECTS OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**SECOND SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MA210	Matrices and Ordinary Differential Equations	BS	3	0	0	3
18MT220	Electrical Machines	PC	3	0	0	3
18MT230	Analog Electronics	PC	3	0	0	3
18MT240	Free Body Mechanics	ES	3	0	0	3
<b>THEORY CUM PRACTICAL</b>						
18MT260	Manufacturing Processes	PC	2	0	2	3
<b>PRACTICAL</b>						
18MT270	Electrical Machines Laboratory	PC	0	0	2	1
18MT280	Workshop	ES	0	0	2	1
18ES290	Lateral Thinking	ES	0	0	2	1
<b>AUDIT COURSE</b>						
18CHAA0	Environmental Science	AC	1	0	1	-
<b>Total</b>			<b>14</b>	<b>0</b>	<b>8</b>	<b>18</b>

- BS : Basic Sciences  
PC : Professional Core Course  
ES : Engineering Sciences  
AC : Audit Course  
L : Lecture  
T : Tutorial  
P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit



**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**SECOND SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MA210	Matrices and Ordinary Differential Equations	3	50	50	100	25	50
2	18MT220	Electrical Machines	3	50	50	100	25	50
3	18MT230	Analog Electronics	3	50	50	100	25	50
4	18MT240	Free Body Mechanics	3	50	50	100	25	50
<b>THEORY CUM PRACTICAL</b>								
5	18MT260	Manufacturing Processes	3	50	50	100	25	50
<b>PRACTICAL</b>								
6	18MT270	Electrical Machines Laboratory	3	50	50	100	25	50
7	18MT280	Workshop	3	50	50	100	25	50
8	18ES290	Lateral Thinking	3	50	50	100	25	50
<b>AUDIT COURSE</b>								
9	18CHAA0	Environmental Science	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SUBJECTS OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**THIRD SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MT310	Partial differential equations	BS	3	0	0	3
18MT320	Kinematics and Dynamics of Machinery	PC	3	0	0	3
18MT330	Digital Electronics	PC	3	0	0	3
18MT340	Thermal Fluid Engineering	PC	3	0	0	3
18MT350	Programming for problem solving	ES	2	0	0	2
<b>PRACTICAL</b>						
18MT360	Programming and Coding Laboratory	ES	0	0	2	1
18MT370	Thermal Fluid Engineering Laboratory	PC	0	0	2	1
18MT380	Digital Electronics Laboratory	PC	0	0	2	1
18ES390	Design Thinking	ES	0	0	4	2
<b>Total</b>			<b>14</b>	<b>0</b>	<b>10</b>	<b>19</b>

BS : Basic Sciences

PC : Professional Core Course

ES : Engineering Sciences

L : Lecture

T : Tutorial

P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**THIRD SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MT310	Partial differential equations	3	50	50	100	25	50
2	18MT320	Kinematics and Dynamics of Machinery	3	50	50	100	25	50
3	18MT330	Digital Electronics	3	50	50	100	25	50
4	18MT340	Thermal Fluid Engineering	3	50	50	100	25	50
5	18MT350	Programming for problem solving	3	50	50	100	25	50
<b>PRACTICAL</b>								
6	18MT360	Programming and Coding Laboratory	3	50	50	100	25	50
7	18MT370	Thermal Fluid Engineering Laboratory	3	50	50	100	25	50
8	18MT380	Digital Electronics Laboratory	3	50	50	100	25	50
9	18ES390	Design Thinking	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SUBJECTS OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**FOURTH SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MT410	Probability and Statistics	BS	3	0	0	3
18MT420	Power Electronics and Drives	PC	3	0	0	3
18MT430	Microcontroller	PC	3	0	0	3
18MT440	Sensors and Measurements	PC	3	0	0	3
18MT490	Project Management	HSS	3	0	0	3
18YYFX0	Foundation Elective	FE	3	0	0	3
<b>THEORY CUM PRACTICAL</b>						
18EG460	Professional Communication	HSS	1	0	2	2
<b>PRACTICAL</b>						
18MT470	Sensors and Measurements Laboratory	PC	0	0	2	1
18MT480	Micro Controller Laboratory	PC	0	0	2	1
<b>Total</b>			<b>19</b>	<b>0</b>	<b>6</b>	<b>22</b>

BS : Basic Sciences

PC : Professional Core Course

ES : Engineering Sciences

HSS : Humanities &amp; Social Sciences

L : Lecture

T : Tutorial

P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**FOURTH SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MT410	Probability and Statistics	3	50	50	100	25	50
2	18MT420	Power Electronics and Drives	3	50	50	100	25	50
3	18MT430	Microcontroller	3	50	50	100	25	50
4	18MT440	Sensors and Measurements	3	50	50	100	25	50
5	18MT490	Project Management	3	50	50	100	25	50
6	18YYFX0	Foundation Elective	3	50	50	100	25	50
<b>THEORY CUM PRACTICAL</b>								
7	18EG460	Professional Communication	3	50	50	100	25	50
<b>PRACTICAL</b>								
8	18MT470	Sensors and Measurements Laboratory	3	50	50	100	25	50
9	18MT480	Micro Controller Laboratory	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****COURSES OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**FIFTH SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MT510	Control System	PC	3	0	0	3
18MT520	Industrial Automation	PC	3	0	0	3
18MT530	Design of Machine Elements	PC	3	0	0	3
18MTPX0	Program Elective I	PE	3	0	0	3
18YYGX0	General Elective	GE	3	0	0	3
18MT560	Accounting and Finance	HSS	3	0	0	3
<b>PRACTICAL</b>						
18MT570	Industrial Automation Laboratory	PC	0	0	2	1
18MT580	Dynamics and Control Laboratory	PC	0	0	2	1
18ES590	System Thinking	ES	0	0	4	2
<b>Total</b>			<b>18</b>	<b>0</b>	<b>8</b>	<b>22</b>

HSS : Humanities &amp; Social Sciences

PC : Professional Core Course

PE : Program Elective

GE : Program Elective

PJ : Project

L : Lecture

T : Tutorial

P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**FIFTH SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MT510	Control System	3	50	50	100	25	50
2	18MT520	Industrial Automation	3	50	50	100	25	50
3	18MT530	Design of Machine Elements	3	50	50	100	25	50
4	18MTPX0	Program Elective I	3	50	50	100	25	50
5	18YYGX0	General Elective	3	50	50	100	25	50
6	18MT560	Accounting and Finance	3	50	50	100	25	50
<b>PRACTICAL</b>								
7	18MT570	Industrial Automation Laboratory	3	50	50	100	25	50
8	18MT580	Dynamics and Control Laboratory	3	50	50	100	25	50
9	18ES590	System Thinking	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****COURSES OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**SIXTH SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MT610	Industrial Robotics	PC	3	0	0	3
18MT620	CNC Technology	PC	3	0	0	3
18MTEX0	Engineering Science Elective	ES	3	0	0	3
18MTPX0	Program Elective II	PE	3	0	0	3
18YYZX0	Program Elective / Foundation Elective	PE/FE	3	0	0	3
<b>THEORY CUM PRACTICAL</b>						
18MT660	Virtual Instrumentation	ES	2	0	2	3
<b>PRACTICAL</b>						
18MT670	CAD / CAM Laboratory	PC	0	0	2	1
18MT680	Robotics Laboratory	PC	0	0	2	1
18ES690	Engineering Design Project	PJ	0	0	6	3
<b>Total</b>			<b>17</b>	<b>0</b>	<b>12</b>	<b>23</b>

- ES : Engineering Sciences  
PC : Professional Core Course  
PE : Program Elective  
FE : Foundation Elective  
PJ : Project  
L : Lecture  
T : Tutorial  
P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit



**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**SIXTH SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MT610	Industrial Robotics	3	50	50	100	25	50
2	18MT620	CNC Technology	3	50	50	100	25	50
3	18MTEX0	Engineering Science Elective	3	50	50	100	25	50
4	18MTPX0	Program Elective II	3	50	50	100	25	50
5	18YYZX0	Program Elective / Foundation Elective	3	50	50	100	25	50
<b>THEORY CUM PRACTICAL</b>								
6	18MT660	Virtual Instrumentation	3	50	50	100	25	50
<b>PRACTICAL</b>								
7	18MT670	CAD / CAM Laboratory	3	50	50	100	25	50
8	18MT680	Robotics Laboratory	3	50	50	100	25	50
9	18ES690	Engineering Design Project	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****COURSES OF STUDY**

(For the candidates admitted from 2018-2019 onwards)

**SEVENTH SEMESTER**

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
<b>THEORY</b>						
18MT710	Mechatronics System Design	PC	3	0	0	3
18MTPX0	Program Elective III	PE	3	0	0	3
18MTPX0	Program Elective IV	PE	3	0	0	3
18MTPX0	Program Elective V	PE	3	0	0	3
18YYZX0	Program Elective / General Elective	PE/GE	3	0	0	3
<b>PRACTICAL</b>						
18MT760	System Integration Laboratory	PC	0	0	2	1
18ES790	Capstone Design Project	PJ	0	0	6	3
<b>Total</b>			<b>15</b>	<b>0</b>	<b>8</b>	<b>19</b>

PC : Professional Core Course

PE : Program Elective

GE : General Elective

ES : Engineering Sciences

L : Lecture

T : Tutorial

P : Practical

**Note:**

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.****B.E. DEGREE (Mechatronics) PROGRAMME****SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2018-2019 onwards)

**SEVENTH SEMESTER**

Sl. No	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
<b>THEORY</b>								
1	18MT710	Mechatronics System Design	3	50	50	100	25	50
2	18MTPX0	Program Elective III	3	50	50	100	25	50
3	18MTPX0	Program Elective IV	3	50	50	100	25	50
4	18MTPX0	Program Elective V	3	50	50	100	25	50
5	18YYZX0	Program Elective / General Elective	3	50	50	100	25	50
<b>PRACTICAL</b>								
6	18MT760	System Integration Laboratory	3	50	50	100	25	50
7	18ES790	Capstone Design Project	3	50	50	100	25	50

\* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. / B.Tech. DEGREE PROGRAMME**

**FIRST SEMESTER**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Government Aided ISO 9001:2008 certified Autonomous Institution affiliated to Anna University)

**MADURAI – 625 015, TAMILNADU**

Phone: 0452 – 2482240, 41

Fax: 0452 2483427

18MA110	ENGINEERING CALCULUS	Category	L	T	P	Credit
		BS	3	1	0	4

**Preamble**

This course aims to convey to the student a sense of the utility of calculus and develop technical competence. This course is designed to implement the calculus through geometrically, numerically, algebraically and verbally. Students will apply the main tools for analyzing and describing the behavior of functions of single and multi variables: limits, derivatives, integrals of single and multi variables to solve complex engineering problems using analytical methods and MATLAB.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Understand the concept of functions, limits and continuity	Understand
CO2	Compute derivatives and apply in solving engineering problems	Apply
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	Apply
CO4	Demonstrate and apply the techniques of integration	Apply
CO5	Apply integrals of multivariable to find areas enclosed between two curves and volume enclosed between surfaces	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M								
CO2	S	S	M	M								
CO3	S	S	S	M								
CO4	S	S	S	M								
CO5	S	S	S	M								

S- Strong; M-Medium; L-Low

**Assessment Pattern**

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	0
Understand	30	30	30	30
Apply	60	60	60	70
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

**Course Level Assessment Questions****Course Outcome 1(CO1)**

1. Define function and limit.
2. Estimate the value of  $\lim_{x \rightarrow 0} \frac{\sin x}{\sin \pi x}$ .
3. If  $f(x)$  is continuous on  $(-\infty, \infty)$ , what can you say about its graph?

**Course Outcome 2(CO2)**

1. What is wrong with this equation  $\frac{x^2+x-6}{x-2} = x+3$  and investigate why the equation  $\lim_{x \rightarrow 2} \frac{x^2+x-6}{x-2} = \lim_{x \rightarrow 2} (x+3)$  is correct.
2. Between  $0^\circ\text{C}$  and  $30^\circ\text{C}$ , the volume  $V$  (in cubic centimeters) of 1 kg of water at a temperature  $T$  is given approximately by the formula  $V = 999.87 - 0.06426T + 0.0085043T^2 - 0.0000679T^3$ , Compute the temperature at which water has its maximum density.
3. The voltage,  $v$ , across a capacitor of capacitance, in series with a resistor of resistance,  $R$ , is given by  $(t+1)e^{-1000t}$  where  $C=1\mu\text{F}$ ,  $E > 0$ , is a constant. Determine  $i$  where  $i = C \frac{dv}{dt}$ .

**Course Outcome 3(CO3)**

1. Define partial derivative of a function of two variables.
2. Suppose that the temperature at a point  $(x, y, z)$  in space is given by  $T(x, y, z) = \frac{80}{1+x^2+2y^2+3z^2}$ , where  $T$  is measured in degrees Celsius and  $(x, y, z)$  in meters. In which direction does the temperature increase fastest at the point  $(1, 1, -2)$ ? Identify the maximum rate of increase.
3. Compute the dimensions of the rectangular box with largest volume if the total surface area is given as  $64 \text{ cm}^2$ .
4. Show that the Cobb-Douglas production function  $P = bL^\alpha K^\beta$  satisfies the equation  $L \frac{\partial P}{\partial L} + K \frac{\partial P}{\partial K} = \alpha \frac{P}{L} + \beta \frac{P}{K}$ .

**Course Outcome 4(CO4)**

1. State fundamental theorem of calculus.
2. Find the volume of the solid obtained by rotating the region bounded by  $y = x^3$ ,  $y = 8$  and  $x = 0$  about the  $y$  axis.
3. A charged rod of length  $L$  produces an electric field at point  $P(a, b)$  given by  $E(P) = \int_{-a}^{L-a} \frac{\lambda b}{4\pi\epsilon_0(x^2+b^2)^{3/2}} dx$  where  $\lambda$  is the charge density per unit length on the rod and  $\epsilon_0$  is the free space permittivity (see the below figure). Evaluate the integral to determine an expression for the electric field  $E(P)$ .

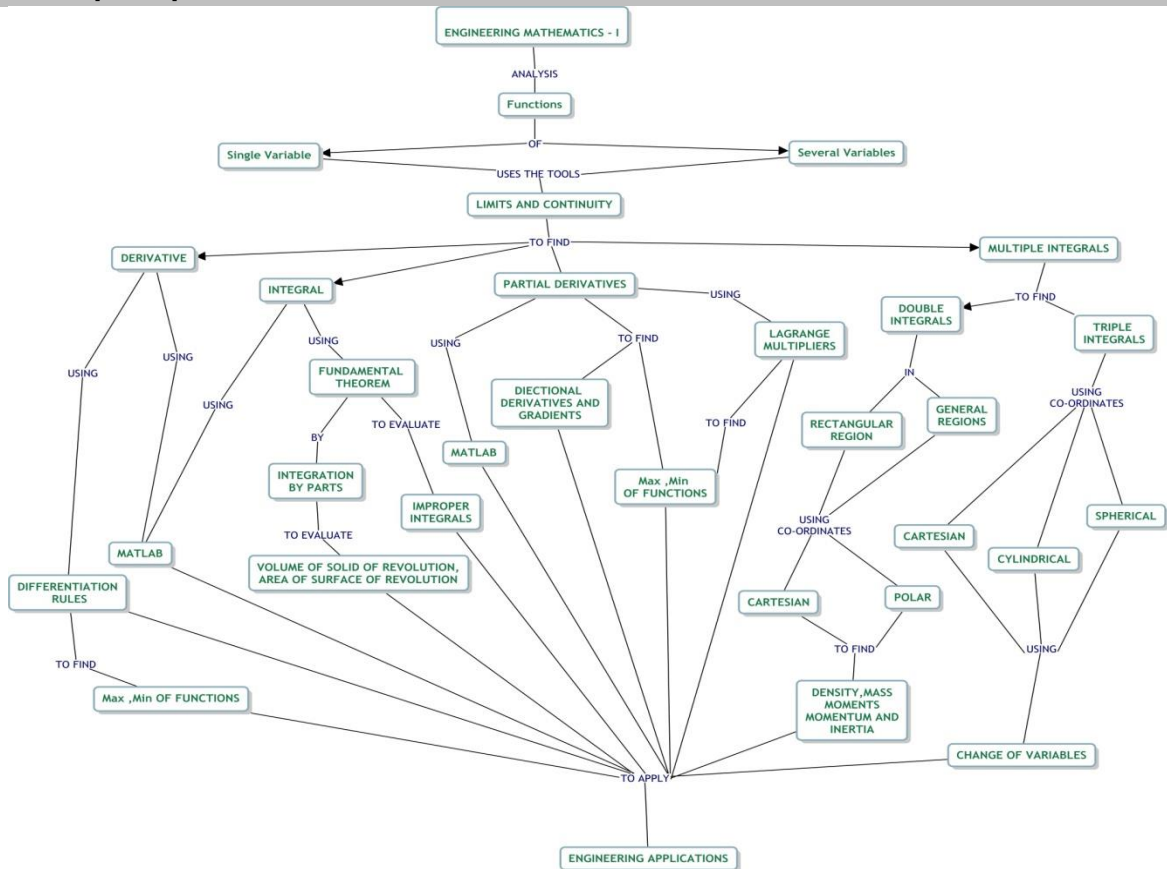


4. A cantilever beam of length  $L$ , fixed at one end and deflected by a distance  $D$  at the free end has strain energy  $V$  given by  $V = \frac{EI}{2} \int_0^L \left( \frac{d^2y}{dx^2} \right)^2 dx$  where  $EI$  is the flexural rigidity. The deflection  $y$  at a distance  $x$  from the fixed end is given by  $y = D \left[ 1 - \cos\left(\frac{\pi x}{2L}\right) \right]$   
Find  $V$ .

**Course Outcome 5(CO5)**

- Recall any three properties of double integrals
- Calculate the static moments of homogeneous lamina with respect to the coordinate axes. The lamina is bounded by lines  $\frac{x^2}{9} + \frac{y^2}{4} = 1$ ,  $2x + 3y - 6 = 0$ .
- Calculate the coordinates of the center of mass of homogeneous solid bounded by surfaces  $x=0$ ,  $y = 0$ ,  $z = 0$ ,  $x + y = 1$ ,  $x^2 + y^2 = 1$ .

**Concept Map**



**Syllabus****DIFFERENTIAL CALCULUS (12 hours)**

Representation of functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Differentiation rules(formula and problems only) –The mean value theorem - Maxima and Minima of functions of one variable - Application problems in engineering – Application problems using MATLAB.

**FUNCTIONS OF SEVERAL VARIABLES (12 hours)**

Partial derivatives – Chain rule - Vector functions and their Derivatives - Directional derivatives and gradient vector - Maxima and minima of functions of two variables - Lagrange Multipliers - Application problems in engineering - Application problems using MATLAB.

**INTEGRAL CALCULUS (12 hours)**

Area under curves - The definite integrals – Fundamental theorem of calculus - Integration by parts - Volume of solid of revolution - Area of surface of revolution - Improper integrals - Application problems in engineering - Application problems using MATLAB

**MULTIPLE INTEGRAL (12 hours)**

Iterated integrals - Double integrals over general regions - Double integrals in polar coordinates - Applications of double integrals (density, mass, moments & moments of inertia problems only) - Triple integrals - Triple integrals in cylindrical coordinates - Triple integrals in spherical coordinates - Change of variables in multiple integrals - Application problems in engineering

**Text Book**

- 1) James Stewart, "Calculus Early Transcendentals", 7e, Cengage Learning, New Delhi, 2017.

**DIFFERENTIAL CALCULUS:**[Sections: 1.1, 1.3, 2.2,2.5,2.6,2.8, 3.1-3.6,4.1,4.2]

**FUNCTIONS OF SEVERAL VARIABLES:** Sections: 14.3, 14.5,13.1,13.2,14.6-14.8]

**INTEGRAL CALCULUS:** [Sections: 5.1-5.4,7.1, 6.2, 8.2 and 7.8]

**MULTIPLE INTEGRAL:** [Sections: 15.2-15.5, 15.7-15.10]

- 2) Lecture Notes on Engineering Mathematics-I Application Problems and Solution Manual, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

**Reference Books**

- 1) Kuldeep Singh, "Engineering Mathematics Through Applications",2e, Palgrave Macmillan, 2011.
- 2) Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
- 3) George B. Thomas, " Thomas Calculus: early transcendentals ", Pearson, New Delhi, 2013.
- 4) R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics"5e, Narosa Publishing House, 2016.



**Course Contents and Lecture Schedule**

<b>S.No</b>	<b>Topic</b>	<b>No. of Hours</b>
<b>1</b>	<b>DIFFERENTIAL CALCULUS</b>	
1.1	Representation of functions, New functions from old functions	1
1.2	Limits of a function	1
1.3	Continuity, Limits at infinity	1
1.4	Tutorial	1
1.5	Derivatives as a function, Differentiation rules	2
1.6	The mean value theorem	1
1.7	Maxima and minima of function of one variable	1
1.8	Tutorial	1
1.9	Application problems in engineering	2
1.10	Application problems using MATLAB(Tutorial)	1
<b>2</b>	<b>FUNCTIONS OF SEVERAL VARIABLES</b>	
2.1	Partial derivatives, Chain rule	2
2.2	Vector functions and their derivatives	1
2.3	Tutorial	1
2.4	Directional derivatives, Gradient vector	1
2.5	Maxima and minima of functions of two variables	2
2.6	Lagrange Multipliers	1
2.7	Tutorial	1
2.8	Application problems in engineering	2
2.9	Application problems using MATLAB(Tutorial)	1
<b>3</b>	<b>INTEGRAL CALCULUS</b>	
3.1	Area under curves, The definite integrals, fundamental theorem of calculus	2
3.2	Integration by parts	1
3.3	Tutorial	1
3.4	volume of solid of revolution, area of surface of revolution	2
3.5	Improper integrals	2
3.6	Tutorial	1
3.7	Application problems in engineering	2
3.8	Application problems using MATLAB(Tutorial)	1
<b>4</b>	<b>MULTIPLE INTEGRAL</b>	
4.1	Iterated integrals	1
4.2	Double integrals over general regions	1
4.3	Double integrals in polar coordinates	1
4.4	Tutorial	1
4.5	Applications of double integrals	1
4.6	Triple integrals	2
4.7	Tutorial	1
4.8	Triple integrals in cylindrical coordinates	1
4.9	Triple integrals in spherical coordinates	1

S.No	Topic	No. of Hours
4.10	Change of variables in multiple integrals	1
4.11	Tutorial	1
	<b>Total</b>	<b>48</b>

### Course Designers

1. Dr.V.Gnanaraj - [vgmat@tce.edu](mailto:vgmat@tce.edu)
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18PHA20	PHYSICS (Common to Civil, Mechanical and Mechatronics)	Category	L	T	P	Credit
		BS	3	0	0	3

**Preamble**

The course work aims in imparting fundamental knowledge of oscillations, waves and optics, and mechanics which are essential in understanding and designing mechanical systems and measuring devices.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Solve for the solutions and describe the behavior of a damped harmonic oscillator and waves	Apply
CO2	Explain the fundamentals of optical phenomena and its application.	Understand
CO3	Use the vector analytical techniques for analysis of forces and moments in mechanical systems	Apply
CO4	Demonstrate ability to utilize principles of vector mechanics to analyze weather systems	Understand
CO5	Explain the fundamental concepts of kinetics and kinematic of rigid bodies for analysis of practical problems.	Understand
CO6	Use the principles of angular velocity to study three dimensional motion of rigid bodies	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	L					L	L		
CO2	M	L	L	-					L	L		
CO3	S	M	L	L					L	L		
CO4	M	L	L	-					L	L		
CO5	M	L	L	-					L	L		
CO6	S	M	L	L					L	L		

S- Strong; M-Medium; L-Low

**Assessment Pattern**

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	0
Understand	30	30	30	50
Apply	50	50	50	50
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

**Course Level Assessment Questions****Course Outcome 1 (CO1):**

1. A  $5.00 \times 10^5$  kg subway train is brought to a stop from a speed of 0.500 m/s in 0.400 m by a large spring bumper at the end of its track. What is the force constant  $k$  of the spring?
2. Show that the wave velocity of deep water waves is twice the group velocity.
3. Derive the law of reflection based on Fermat's principle.

**Course Outcome 2 (CO2):**

1. Consider a lower energy level situated  $200 \text{ cm}^{-1}$  from the ground state. There are no other energy levels nearby. Determine the fraction of the population found in this level compared to the ground state population at a temperature of 300 K. Boltzmann's constant is equal to  $1.38 \times 10^{-23} \text{ JK}^{-1}$ . The conversion from  $\text{cm}^{-1}$  to joules is given by:  $E(\text{J}) = 100hc E(\text{cm}^{-1})$ , where  $h$  is Planck's constant ( $6.62 \times 10^{-34} \text{ Js}$ ) and  $c$  is the speed of light in a vacuum ( $3 \times 10^8 \text{ ms}^{-1}$ )
2. Explain the principle, construction and working of Mach-Zehnder interferometer.
3. What is a four level solid state laser? Discuss the principle and operation of Nd:YAG Laser.

**Course Outcome 3 (CO3):**

1. A 10,000 lb aircraft is descending on a cylindrical helix. The rate of descent is  $z' = -10 \text{ ft/s}$ , the speed is  $v = 211 \text{ ft/s}$ , and  $\theta' = 3^\circ \approx 0.05 \text{ rad/s}$ . This is standard for gas turbine powered aircraft. Find out the force on the aircraft and the radius of curvature of the path
2. Derive Newton's second law of motion in spherical and cylindrical coordinate systems.
3. A particle attached to a string of length 2 m is given an initial velocity of 6 m/s. The string is attached to a peg and, as the particle rotates about the peg, the string winds around the peg. By conservation of angular momentum, find the length of string wound around the peg when the velocity of the particle is 20 m/s?

**Course Outcome 4 (CO4):**

1. Consider a situation where a cricket player (fielder) slides to a stop on level ground. Using energy considerations (in non conservative forces), calculate the distance the 60 kg cricket player slides, given that his initial speed is 7 m/s and the force of friction against him is a constant 430 N.
2. Compute the centripetal force per unit mass on a spacecraft in an 820 km circular Polar orbit as it flies over the equator and the South pole.
3. Solve Newton's equations of motion in polar coordinates

**Course Outcome 5 (CO5):**

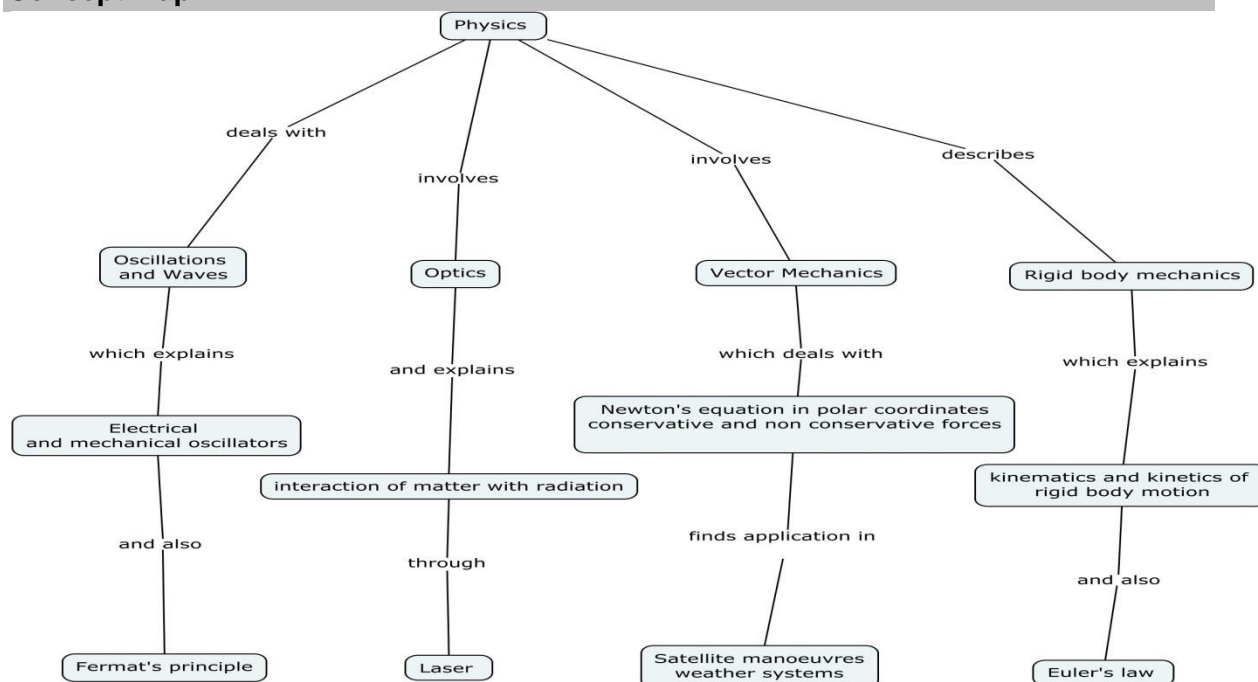
1. A motor shaft attains a velocity of 1500 rpm in 3 seconds starting from rest. Assuming constant angular acceleration, find out the number of full revolution of the shaft during this period.
2. Derive Euler's equations of motion of a rigid body.
3. A cylinder of diameter 500 mm rolls down an inclined plane with uniform acceleration (of the center-of-mass)  $a = 0.1 \text{ m/s}^2$ . At an instant  $t_0$ , the mass-center has speed  $v_0 = 0.5 \text{ m/s}$ . (i) Find the angular speed  $\omega$  and the angular acceleration  $\omega'$  at  $t_0$ . (ii) How many revolutions does the cylinder make in the next 2 seconds?

**Course Outcome 6 (CO6):**

1. A solid right circular cone of base radius  $r$  and height  $h$  rolls on a flat surface without

- slipping. The centre of the circular base moves in a circular path around the z- axis (vertical axis passing through the tip of the cone) with a constant speed  $v$ . Determine the angular velocity and angular acceleration of the solid cone.
- Derive an expression for angular velocity and its rate of change for three dimensional motion of a rigid body.
  - Discuss the conical motion of a rod with center of mass fixed.

### Concept Map



### Syllabus

#### Oscillations and Waves

Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves- Acoustic waves- superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging.

#### Optics

Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients –CO<sub>2</sub> – Nd-YAG lasers - applications of lasers.

#### Vector Mechanics of Particles

Transformation of scalars and vectors under Rotation transformation - Forces in Nature - Newton's laws and its completeness in describing particle motion - Solving Newton's equations of motion in polar coordinates -Conservative and non-conservative forces - curl of a force field -Conservation of Angular Momentum - Energy equation and energy diagrams – circular and elliptical orbits.- Applications to Satellite manoeuvres

#### Rigid Body Mechanics

Motion of a rigid body in the plane - Rotation in the plane - Kinematics in a coordinate system rotating and translating in the plane - Angular momentum about a point of a rigid body in planar motion - Euler's laws of motion - their independence from Newton's laws -

Two-dimensional motion in terms of angular velocity vector, and its rate of change – Difference between 2D & 3D motion.

### Text Book

1. Ian G.Main, Vibrations and waves in Physics -3<sup>rd</sup> edition, Cambridge University, Press, 1994.
2. M.K.Verma, Introduction to Mechanics, CRC Press, 2009.
3. JL Meriam and L.G. Kraige, Engineering Mechanics – Dynamics - 7<sup>th</sup> edition, Wiley,2015.
4. D. Kleppner and R. Kolenkow, An Introduction to Mechanics – 1<sup>st</sup> edition, McGraw Hill, 2009.

### Reference Books

1. M.K.Harbola, Engineering Mechanics-2<sup>nd</sup> edition, Cengage Learning, 2012.
2. JL Synge & BA Griffiths, Principles of Mechanics, McGraw-Hill Book company Inc, 1949.
3. WT Thomson, Theory of Vibrations with Applications,-3<sup>rd</sup> edition, CBS Publishers, 2002.

### Course Contents and Lecture Schedule

S No.	Topic	No. of Hours
<b>1.</b>	<b>Oscillations &amp; Waves</b>	
1.1	Simple harmonic motion – Mechanical and Electrical simple harmonic oscillators.	2
1.2	Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension.	2
1.3	Waves with dispersion – water waves- Acoustic waves – superposition of waves – wave groups and group velocity.	1
1.4	Rayleigh criteria for limit of resolution and its applications to imaging	1
<b>2</b>	<b>Optics</b>	
2.1	Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer.	2
2.2	Fraunhofer diffraction from a single slit and a circular aperture .	1
2.3	Einstein's theory of matter radiation interaction and A and B coefficients .	1
2.4	CO <sub>2</sub> Laser.	1
2.5	Nd-YAG lasers Applications of lasers.	1
<b>3.</b>	<b>Vector Mechanics of Particles</b>	
3.1	Transformation of scalars and vectors under rotation transformation	2
3.2	Forces in Nature, Newton's laws and its completeness in describing particle motion	2
3.3	Solving Newton's equations of motion in polar coordinates	2
3.4	Conservative and non-conservative forces, curl of a force field, Conservation of angular momentum	2
3.5	Energy equation and energy diagrams, circular and elliptical orbits	2
3.6	Applications to Satellite manoeuvres	2
<b>4.</b>	<b>Rigid Body Mechanics</b>	
4.1	Motion of a rigid body in the plane, Rotation in the plane	2
4.2	Kinematics in a coordinate system rotating and translating in the plane	2
4.3	Angular momentum about a point of a rigid body in planar motion	2
4.4	Euler's laws of motion, their independence from Newton's laws	2

S No.	Topic	No. of Hours
4.5	Two-dimensional motion in terms of angular velocity vector, and its rate of change.	2
4.6	Distinction between 2D & 3D motion	2
	<b>Total</b>	<b>36</b>

### Course Designers

1. Dr. M.Mahendran [mmphy@tce.edu](mailto:mmphy@tce.edu)
2. Dr. N. Sankara Subramanian [nssphy@tce.edu](mailto:nssphy@tce.edu)
3. Dr. R. Kodipandyan [rkp@tce.edu](mailto:rkp@tce.edu)
4. Dr. A. Karuppasamy [akphy@tce.edu](mailto:akphy@tce.edu)

18CHA30	CHEMISTRY (COMMON TO CIVIL, MECHANICAL AND MECHATRONICS)	Category	L	T	P	Credit
		BS	3	0	0	3

**Preamble**

The objective of this course is to bestow a better understanding of basic concepts of chemistry and its applications on Civil, Mechanical and Mechatronics domain. It also imparts knowledge on properties of water and its treatment methods, spectroscopic techniques for material characterization, corrosion and protection of metals. This course also highlights preparation, properties and applications of polymer and composite materials. It also gives basic idea about adhesives and lubricants and their mechanisms.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Identify the properties of water and its treatment methods	Understand
CO2	Summarize the Principles and Instrumentations of Spectroscopic techniques	Understand
CO3	Select the appropriate spectroscopic techniques for characterization of materials	Apply
CO4	Adapt the customized corrosion control methods	Apply
CO5	Dramatize the preparation, properties and applications of Engineering materials	Understand
CO6	Describe the mechanism of adhesion and lubrication	Understand

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	M	-	-	-	-	-	-	-	-	-	M	-
2.	M	L	L	-	-	-	-	-	-	-	-	-
CO3.	S	S	M	M	-	-	-	-	-	-	-	-
CO4.	S	S	M	M	-	-	L	-	-	-	L	-
CO5.	M	M	M	-	-	-	L	-	-	-	-	-
CO6.	M	-	L	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

**Assessment Pattern**

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

**Course Level Assessment Questions****Course Outcome 1 (CO1):**



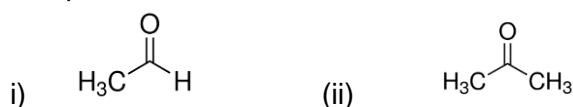
1. Distinguish between scale and sludge.
2. 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure  $\text{CaCO}_3$  per ml. Calculate the permanent, temporary and total hardness of given water sample in  $\text{CaCO}_3$  equivalents.
3. Outline the steps involved in the waste water treatment process.

**Course Outcome 2 (CO2):**

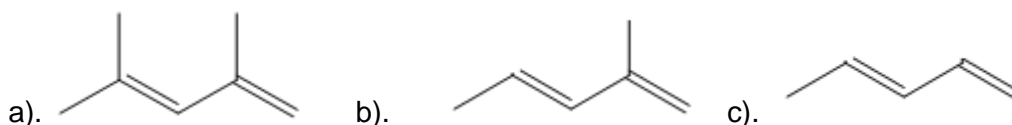
1. State Beer-Lambert law.
2. Write the selection rule in absorption spectroscopy.
3. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

**Course Outcome 3 (CO3):**

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds



2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.



3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

**Course Outcome 4 (CO4)**

4. Illustrate the different forms of corrosion with appropriate mechanism
5. Dramatize suitable methods to prevent corrosion of iron bar used in construction.
6. Discuss in detail about the constituents and functions of paint.

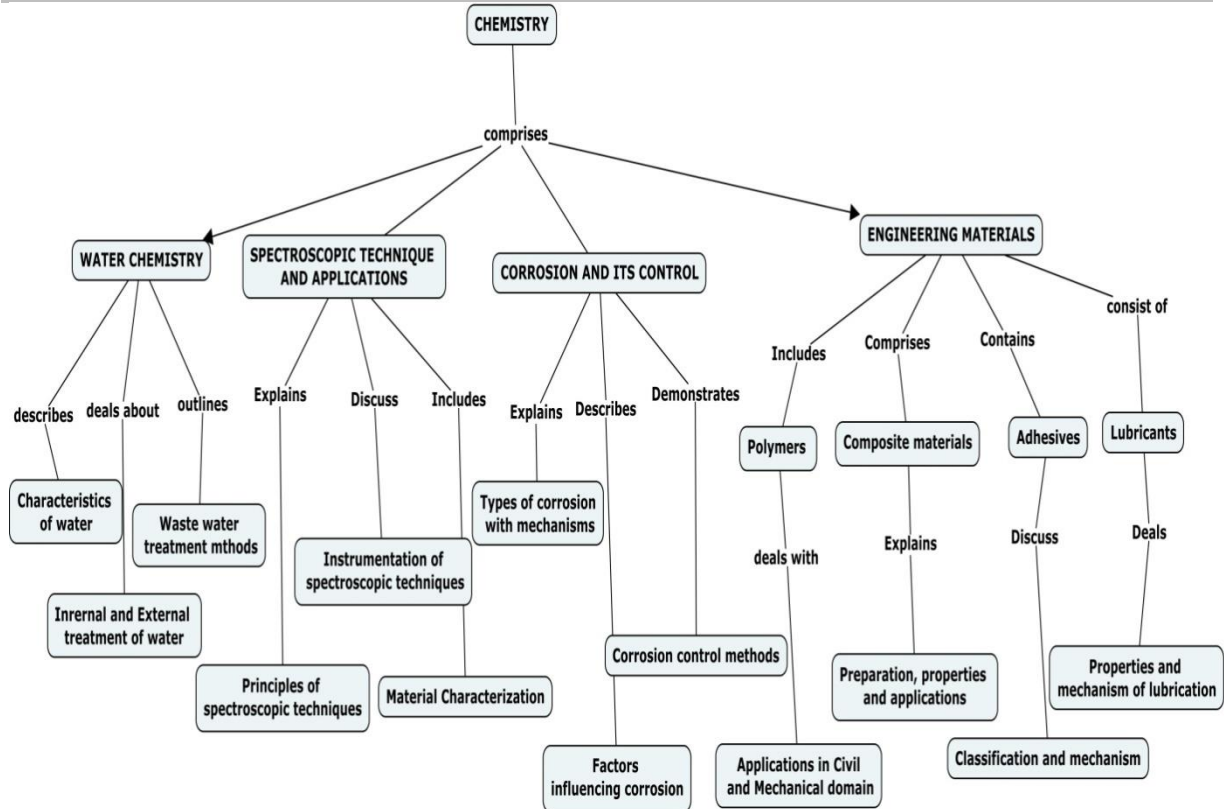
**Course Outcome 5 (CO5)**

1. Explain the application of composite materials in automobile engineering.
2. Demonstrate the applications of polymer in the enhancement of concrete properties.
3. Summarize the properties and application of reinforced composite materials.

**Course Outcome 6 (CO6)**

1. List the types of lubricant materials.
2. Identify the factors which influence the action of adhesive.
3. Discuss the mechanism of lubrication.

## Concept Map



## Syllabus

**Water Chemistry** : Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge. Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications**-Principles of spectroscopy and selection rules-Electronic spectroscopy, Fluorescence- applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules- Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.

**Corrosion and its prevention**-Corrosion- causes- factors- types- chemical, electrochemical corrosion (galvanic, differential aeration), Corrosion of steel in various environments. Rate of corrosion. Corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method. Coatings – Metallic – Chromate conversion coating, electroplating – precious metal coating. Paints-constituents and function.

**Engineering materials** – Polymers - Introduction-classification-properties –applications in construction and manufacturing processes. Composite Materials: Introduction-Classification – Preparation, properties and applications. Fiber-Reinforced Composites-preparation, properties and applications..Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive action. Lubricants-introduction-classification-properties-functions-mechanism of lubrication.

**Text Book**

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, Dhanpat Rai publications, New Delhi, 16<sup>th</sup> edition, 2015.
2. C. N. Banwell and E.M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5<sup>th</sup> Edition, 2013.

**Reference Books**

1. S.S. Dara and S.S. Umare, "A Textbook of Engineering Chemistry", S.Chand & Company, 12<sup>th</sup> Edition, Reprint, 2013.
2. Shashi Chawla, "A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) Ltd, 3<sup>rd</sup> edition, reprint 2011.

**Course Contents and Lecture Schedule**

S. No.	Topic	No. of hours
1.0	<b>Water Chemistry</b>	
1.1	Introduction -Water- sources-Hardness of water-types	1
1.2	Estimation of hardness of water by EDTA method	2
1.3	Disadvantages of hard water -Boiler troubles- scale & sludge.	1
1.4	Internal treatment methods	1
1.5	External treatment methods- zeolite, ion exchange	1
1.6	Desalination process- reverse osmosis, electro dialysis, multi stage flash distillation	1
1.7	Waste water treatment processes	2
2.0	<b>Spectroscopic technique and applications</b>	
2.1	Introduction	1
2.2	Principles of spectroscopy and selection rules	1
2.3	Electronic spectroscopy, Fluorescence- applications in medicine.	1
2.4	Vibrational and rotational spectroscopy of diatomic molecules- Applications	2
2.5	Nuclear magnetic resonance and magnetic resonance imaging	2
2.6	Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.	2
3.0	<b>Corrosion and its prevention</b>	
3.1	Corrosion- causes- factors-	1
3.2	types- chemical, electrochemical corrosion (galvanic, differential aeration), Corrosion of steel in various environments (Marine)	2
3.3	Rate of corrosion	1
3.4	Corrosion control - material selection and design aspects	1
3.5	electrochemical protection – sacrificial anode method and impressed current cathodic method	1
3.6	Coatings – Metallic - Chromate conversion coating, electroplating – precious metal coating.	2
3.7	Paints- constituents and function.	1
4.0	<b>Engineering materials</b>	
4.1	Polymers - Introduction-classification-properties	1

S. No.	Topic	No. of hours
4.2	Applications in construction and mechanical domains	1
4.3	Composite Materials: Introduction-Classification – Preparation, properties and applications of Polymer Matrix Composites,	1
4.4	Metal Matrix Composites, Ceramic Matrix Composites Carbon-Carbon Composites	2
4.5	Fiber-Reinforced Composites- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and boron carbide fibers and nature-made composites, and applications.	2
4.6	Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive action	1
4.7	Lubricants-introduction-classification-properties-functions-mechanism of lubrication.	1
<b>Total</b>		<b>36</b>

**Course Designers:**

- |    |                  |                             |
|----|------------------|-----------------------------|
| 1. | Dr. M.Kottaisamy | hodchem@tce.edu             |
| 2. | Dr.(Mrs).K.Radha | krchem@tce.edu              |
| 2. | Dr.S.Rajkumar    | rajkumarsubramanium@tce.edu |
| 3. | Dr.M.Velayudham  | mvchem@tce.edu              |

18EG140	ENGLISH	Category	L	T	P	Credit
		HSS	2	0	0	2

**Preamble**

The course aims at developing communication skills in English essential for understanding and expressing the ideas in different academic, social, and professional contexts. The students acquire the skills of listening, speaking, reading, and writing competencies in English language, making them employable in the globalised scenario.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Recall the basics of language in terms of vocabulary, grammar, pronunciation, syntax and semantics.	Remember
CO2	Understand the grammatical nuances and use them accordingly in respective contexts.	Understand
CO3	Read and comprehend the content in English in general and technical contexts.	Understand
CO4	Write with coherence and cohesion effectively.	Apply
CO5	Apply the language in established structure with precision in social and professional contexts.	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.										S		S
CO2.										S		M
CO3.										S		S
CO4.										S		S
CO5.										S		S

S- Strong; M-Medium; L-Low

**Assessment Pattern**

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	15	15	30	30
Apply	35	35	70	70
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

**Course Level Assessment Questions****Course Outcomes 1, 2 and 3**

1. Rewrite as directed.

a) Write a basic definition of a “mobile”.

b) Combine the following sentences to bring out the “Purpose and Function”.

The coal gas is compressed. Condensation in the gas mains can be avoided.

c) Expand the following nominal compounds: i) car race ii) race car

d) Combine the following sentences using a relative clause.

Smart meters are small computers. They provide real-time information on how much electricity is being used by each customer.

e) Combine the following sentences to bring out the “Cause and Effect”

Sand is mixed with the cement. It prevents the excessive shrinkage during drying.

f) Give the words for the following transcriptions

i) /tek'nɒl.ə.dʒi/      ii) /prə'nʌnt.si'eɪ.ʃən/

g) Write down the phonetic symbols of the letters underlined. i).Thick ii) Pleasure

h) Syllabify the word and underline the stressed syllable: Communication

i) Frame question tags for the following sentence: Don't open your books

j) Fill in the blank with the correct form of the verb given in brackets.

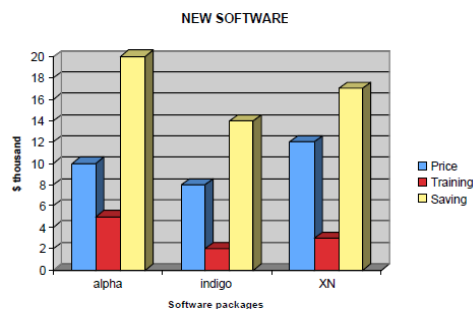
Tamil Nadu's share of students in the IITs and NITs \_\_\_\_\_ (register) a considerable drop in the recent years.

2. Read the following passage and answer the following (different types of) questions.

- Descriptive questions for eliciting short answers
- True or false
- Sentence Completion
- Synonyms/meaning of the words in the text

**Course Outcomes 4 & 5**

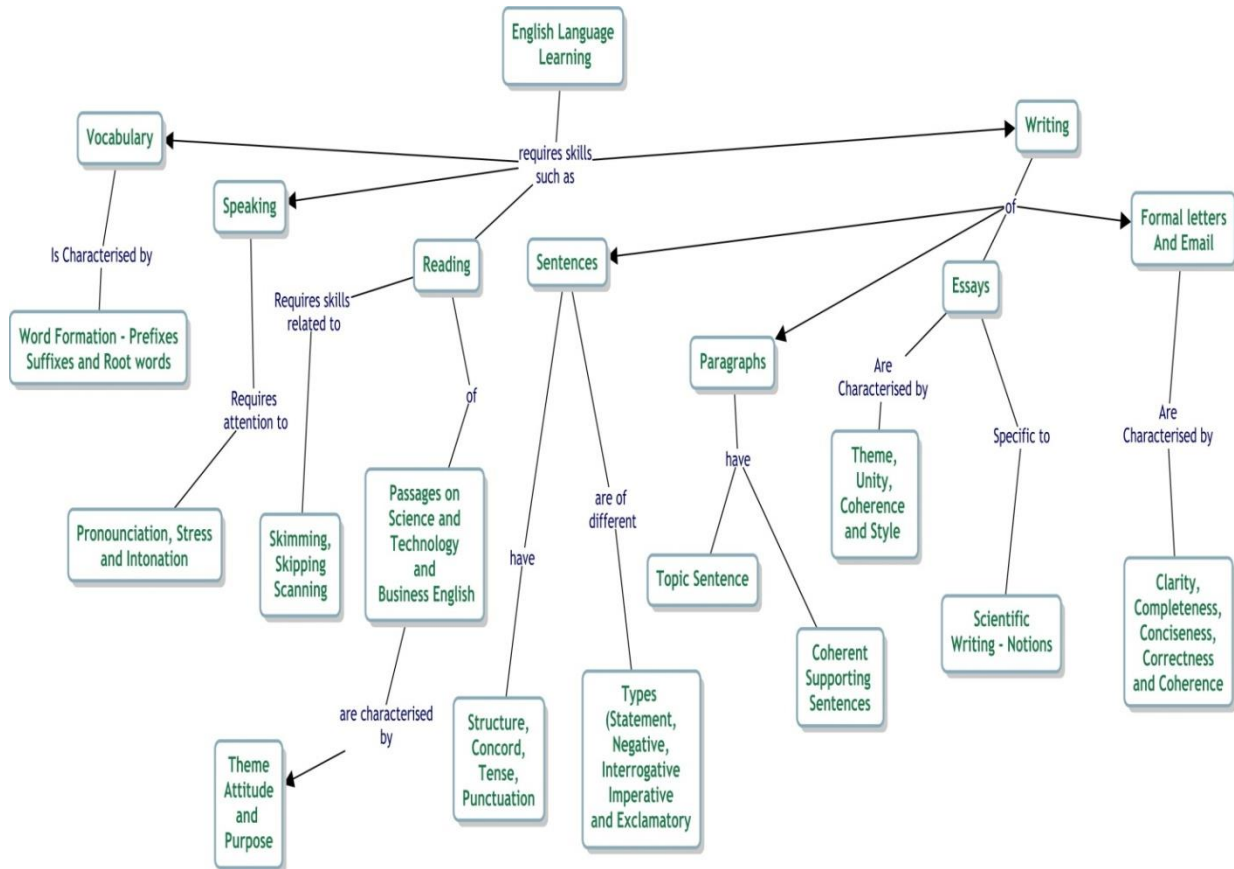
1. Write a paragraph in about 100-150 words on E-learning
2. Write a paragraph in about 100-150 words on Plastics
3. Write an e-mail to a company requesting permission to attend in-plant training for a fortnight.
4. Draft a letter to a company requesting you to undergo in-plant training there, inventing necessary details, in proper format.
5. Prepare a set of 10 instructions on how to draw money from an ATM.
6. Prepare a set of 12 recommendations to keep our environment clean.
7. Make notes of the passage given in appropriate format with a title and summarize in about 100 words.
8. Interpret the following graphic data in about 150 words



9. Write an essay in about 250 words on 'The Impact of Technology on Nature'

10. Write an essay in about 250 words on 'Green Engineering'

**Concept Map:**



## Syllabus:

### MODULE- I

Basics of language – Phonetics - Phonemes, Syllables and Stress, Vocabulary – Word Analysis, Prefix, Suffix, Roots, Parts of Speech, Sentence Patterns.

### MODULE- II

Basics of grammar – Tenses, Subject-Verb Agreement, Impersonal Passive Voice, Relative Clauses; Notions for Technical English – Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives, Reading Comprehension – Skimming, Scanning, Skipping ( as tested in BEC Vantage Level)

### MODULE-III

Writing with coherence and cohesion, Summarizing, Note-Making, Interpretation of Graphics, Writing Instructions and Recommendations, Paragraph and Essay Writing.

### MODULE-IV

Writing with correct spelling, punctuation and grammar, Blog writing, E-mail Writing (BEC Vantage Writing-Unit I) – Formal Letters by students for Bonafide Certificate/Permission.

## Suggested Reading:

### Books:

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
3. Brook-Hart, Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP, 2014.
4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.

5. Swan, Michael. Practical English Usage.4<sup>th</sup> Edn. OUP. 2016.

Websites:

1. <http://www.englishclub.com>
2. <http://owl.english.purdue.edu>
3. <https://www.oxfordonlineenglish.com>
4. [www.bbclearningenglish.com](http://www.bbclearningenglish.com)

### Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1.	Introduction	1
2.	Sentence Patterns	1
3.	Tenses	2
4.	Subject-Verb Agreement	1
5.	Phonetics – Consonants, Vowels, Diphthongs	1
6.	Phonetics – Syllable and Stress	1
7.	Word Formation – Prefixes, Suffixes and Root Words	1
8.	Reading Comprehension - I (Skipping, Skimming, and Scanning)	1
9.	Note-Making and Summarizing	1
10.	Writing Instructions and Recommendations	1
11.	Tutorials	1
12.	Defining and Non-Defining Relative Clauses	1
13.	Impersonal Passive Voice	2
14.	Notions of Technical English – Noun Compounds, Definitions, Cause & Effect, Purpose and Function, Numerical Adjectives	1
15.	Paragraph / Essay Writing- Topic and Supporting Sentences, Coherence	2
16.	E-Mail Writing – (BEC Vantage Writing Task I )	1
17.	Formal Letters by students for Bonafide Certificate/Permission	1
18.	Interpretation of Graphics	1
19.	Reading Comprehension – II (As tested in BEC Writing Task III)	2
20.	Tutorials	1
<b>Total</b>		<b>24</b>

### Course Designers:

- |   |                             |  |
|---|-----------------------------|--|
| 1 | Dr. S. Rajaram              | <a href="mailto:sreng@tce.edu">sreng@tce.edu</a>           |
| 2 | Dr.A.Tamilselvi             | <a href="mailto:tamilselvi@tce.edu">tamilselvi@tce.edu</a> |
| 3 | Mr. R. Vinoth               | <a href="mailto:vino@tce.edu">vino@tce.edu</a>             |
| 4 | Dr. R. K. Jaishree Karthiga | <a href="mailto:jai@tce.edu">jai@tce.edu</a>               |



18ES150	ENGINEERING EXPLORATION	Category	L	T	P	Credit
		ES	1	2	-	3

**Preamble**

The course Engineering Exploration provides an introduction to the engineering field. It is designed to help the student to learn about engineering and how it affects our everyday lives. On the successful completion of the course, students will be to explain how engineering is different from science and technology and how science, mathematics and technology are an integral part of engineering design.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1. Explain technological & engineering development, change and impacts of engineering	Understand
CO2. Draw a product in enough detail that others can accurately build it and write specification sheet for a given product	Apply
CO3. Complete initial steps (Define a problem, list criteria and constraints, brainstorm potential solutions and document the ideas) in engineering design process	Apply
CO4. Draw sketches to a design problem and provide a trade-off matrix	Apply
CO5. Communicate possible solutions through drawings and prepare project report	Apply
CO6. Use reverse engineering to suggest improvements in a tool design	Apply
CO7. Apply the concept of engineering fundamentals in Civil, Mechanical, Electrical and Computer Engineering	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	M	L	-	-	-	-	-	-	-	-	-	-
C02	S	M	L	-	-	-	-	-	-	-	-	-
C03	S	M	L	-	-	-	-	-	-	-	-	-
C04	S	M	L	-	-	-	-	-	-	-	-	-
C05	S	M	L	-	-	-	-	-	-	-	-	-
C06	S	M	L	-	-	-	-	-	-	-	-	-
C07	S	M	L	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

**Assessment Pattern**

S.No	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

## Course Level Assessment Questions

### Course Outcome 1 (CO1):

1. What is the role of Engineer?
2. How do you believe the growth of engineering has impacted the product that we have today?
3. Select an engineering product, list the specifications and constraints that must be considered when designing the product. Make a list of tradeoff.

### Course Outcome 2 (CO2):

1. List the steps of a design problem.
2. Identify the problem you see in the product you used in your daily life.
3. Determine the design constraint and criteria for a problem.
4. Create an isometric drawing of a design.

### Course Outcome 3 (CO3):

1. List the five factors when considering development problem.
2. Imagine you have noticed the car you are riding is making a squeaking noise from the engine compartment. Define the problem with your vehicle. Classify the potential problem.
3. Imagine you are hired by your local city to develop a new public transportation.
  - a. Define the problem.
  - b. List the criteria and constraint.
  - c. List the potential solution.

### Course Outcome 4 (CO4):

1. Imagine you are an engineer who is designing a portable sitting device; you need to design a chair that will be portable that will fit in the trunk of the car which hold 100 kg individual and will be easily produced. Create sketches using a four step process to this design problem.
2. Imagine you are an engineer who develops method to automatically sort books at college library. Develop possible sketches and list potential solution and give the tradeoff matrix.
3. How can your research improve the design?

### Course Outcome 5 (CO5):

1. What details are able to show with the perspective drawing?
2. What is the difference between mockup and prototype?
3. List five different question engineers must ask about function of the design.

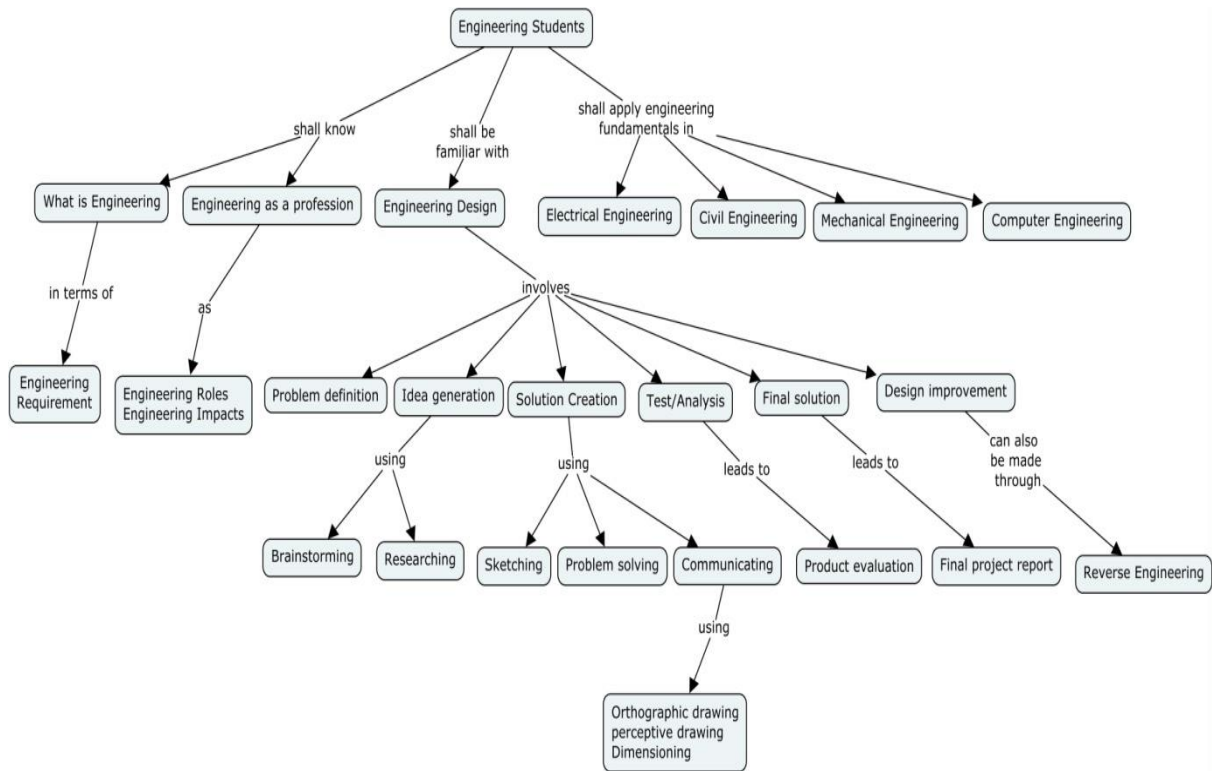
### Course Outcome 6 (CO6):

1. Select a product to analyze with respect to function, fit, aesthetics, safety and environment impact. Write a summary on evaluation of the product. If you would like make changes to the design list the changes.
2. What design components should be reconsidered in reverse engineering processes? Why?
3. What are the benefits of reverse engineering?

### Course Outcome 7 (CO7):

1. Explain ohms law and list the related formulas.
2. What role do you think the range selection plays in the accuracy of the measurements?
3. Why it is important for a civil engineer to study structural forces?
4. Describe the differences between fluids used in hydraulics and pneumatics.

**Concept Map**



**Syllabus**

**What is Engineering:** Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements **Engineering Design:** Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. **Defining problems and Brainstorming:** Researching design, sketching problem solving **Communicating solution:** Dimensioning orthographic drawing, perspective drawing **Modeling and Testing final output:** Product evaluation, reverse engineering, final project report. **Civil Engineering:** Structural forces structural analysis, bridge design components, structural design **Mechanical Engineering:** Types of motion, mechanical power system, mechanical power formula, mechanical design. **Electrical Engineering:** Reading analog multimeter, measuring current, voltage and resistance, electricity from chemicals, solar cells, magnets, Ohms law and watts law, circuit identification and circuit calculation, resistor color code, continuity **Computer Engineering:** Logic gates, algorithms, computer architecture, binary code

**Reference Books**

1. Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: “Engineering Fundamentals: Design, Principles, and Careers”, Goodheart-Willcox Publisher, Second Edition, 2014.
2. Saeed Moaveni ,“Engineering Fundamentals: An Introduction to Engineering”, Cengage learning, Fourth Edition, 2011.

**Course Contents and Lecture Schedule**

No.	Topic	No. of Lectures
1.	What is Engineering	

No.	Topic	No. of Lectures
1.1	Engineering Requirement	1
1.2	Knowledge within Engineering disciplines,	1
1.3	Engineering advancements	1
2	<b>Engineering Design</b>	
2.1	Problem definition,	1
2.2	idea generation through brainstorming and researching	1
2.3	solution creation through evaluating and communicating,	1
2.4	text/analysis	1
2.5	final solution and design improvement	1
3	<b>Defining problems and Brainstorming:</b>	
3.1	Researching design	1
3.2	sketching problem solving	2
4	<b>Communicating solution</b>	
4.1	Dimensioning orthographic drawing	1
4.2	perspective drawing	1
5	<b>Modeling and Testing final output</b>	
5.1	Product evaluation	1
5.2	reverse engineering	1
5.3	final project report	1
6	<b>Civil Engineering</b>	
6.1	Structural forces structural analysis	2
6.2	bridge design components	2
6.3	structural design	1
7	<b>Mechanical Engineering</b>	
7.1	Types of motion	2
7.2	mechanical power system	1
7.3	mechanical power formula	1
7.4	mechanical design	1
8	<b>Electrical Engineering:</b>	
8.1	Reading analog multimeter, measuring current, voltage and resistance	1
8.2	electricity from chemicals, solar cells, magnets,	1
8.3	Ohms law and watts law, circuit identification and circuit calculation	1
8.4	resistor color code, continuity	2
9	<b>Computer Engineering</b>	
9.1	Logic gates, algorithms,	1
9.2	computer architecture,	2
9.3	binary code	2
	Total	36

**Course Designers:**

1. Dr.S.J. Thiruvengadam [sjtece@tce.edu](mailto:sjtece@tce.edu)
2. Dr. S.Baskar [sbeee@tce.edu](mailto:sbeee@tce.edu)

18ME160	ENGINEERING GRAPHICS	Category	L	T	P	Credit
		ES	3	0	2	4

**Preamble**

Engineering Graphics is referred as language of engineers. An engineer needs to understand the physical geometry of any object through its orthographic or pictorial projections. The knowledge on engineering graphics is essential in proposing new product designs through drawings and in reading or understanding existing drawings. This course covers orthographic and pictorial projections, sectional views, development of surfaces and use of computer aided drafting tools.

**Prerequisite**

NIL

**Course Outcomes**

On successful completion of the course, students will be able to

CO1	Draw conic Sections such as ellipse, parabola, hyperbola and rectangular hyperbola.	Apply
CO2	Draw the orthographic projections (Elevation and Plan) of straight lines inclined to both reference planes.	Apply
CO3	Draw the orthographic projections (Elevation, Plan and End view) of plane surfaces inclined to both reference planes	Apply
CO4	Draw the orthographic projections (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one reference plane.	Apply
CO5	Draw the orthographic projections (Elevation and Plan) of sectioned solids (Prisms, Pyramids, Cylinder and Cone) with axis perpendicular to horizontal plane and true shape of the sections.	Apply
CO6	Draw the development of surfaces (base and lateral) of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone).	Apply
CO7	Draw the isometric projections of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) and of solid parts from the orthographic views.	Apply
CO8	Develop computer-aided 3D models for the given part drawing (2D/3D ) and draw orthographic views for the 3D model with appropriate dimensioning using CAD package. (Continuous Assessment only)	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	M	S	M	M	–	–	–	M	M	–	–
CO2.	S	M	S	M	M	–	–	–	M	M	–	–
CO3.	S	M	S	M	M	–	–	–	M	M	–	–
CO4.	S	M	S	M	M	–	–	–	M	M	–	–
CO5.	S	M	S	M	M	–	–	–	M	M	–	–
CO6.	S	M	S	M	M	–	–	–	M	M	–	–
CO7.	S	M	S	M	M	–	–	–	M	M	–	–
CO8.	S	M	S	M	S	–	–	–	M	M	–	–

**Assessment Pattern**

Bloom's Category	Continuous Assessment Test	Terminal Examination
Remember	0	0
Understand	0	0
Apply	100	100
Analyse	0	0
Evaluate	0	0
Create	0	0

**Course Level Assessment Questions****Course Outcome 1 (CO1)**

1. Draw an ellipse if the distance of focus from the directrix is 70 mm and the eccentricity is  $\frac{3}{4}$ .
2. Draw a parabola if the distance of focus from the directrix is 60 mm.

**Course Outcome 2 (CO2)**

2. One end "A" of a straight line AB 85 mm long is 10 mm above HP and 15 mm in front of VP. The line is inclined to HP at  $40^\circ$  and inclined to VP at  $30^\circ$ . Draw the projections.
3. A line CD has its end "C" 20 mm above HP and 25 mm in front of VP. The other end "D" is 45 mm above HP and 40 mm in front of VP. The distance between the end projectors is 60 mm. Draw its projections and find its true length.

**Course Outcome 3 (CO3)**

1. A semi circular plate of 80 mm diameter has its straight edge on V.P and inclined at  $30^\circ$  to H.P. The surface of the plate is inclined at  $45^\circ$  to V.P. Draw the projections of the plate.
2. A thin rectangular plate of 60 x 40 mm size has its shorter edge on H.P and inclined  $30^\circ$  to V.P. Draw the projections of the plate when its top view is a square of 40 mm side.

**Course Outcome 4 (CO4)**

1. A hexagonal prism of side of base 35 mm and axis length 80 mm rests on HP on one of its rectangular faces such that its axis is inclined to VP by  $45^\circ$ . Draw its elevation and plan.
2. A square pyramid of base side 40 mm and axis 75 mm long is resting on one of its base edges in such a way that one of its triangular faces is perpendicular to both HP and VP. Draw its front view and top view.

**Course Outcome 5 (CO5)**

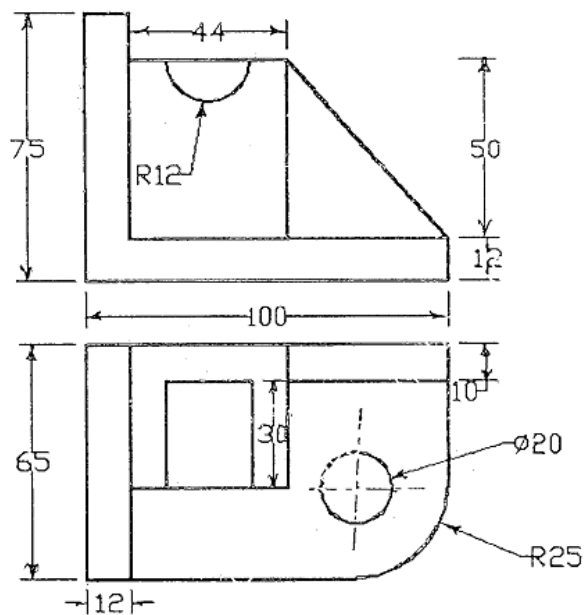
1. A cone of base 75 mm diameter and axis 80 mm long is resting on its base on H.P. It is cut by a section plane perpendicular to VP, inclined at  $45^\circ$  to H.P and cutting the axis at a point 35 mm from the apex. Draw the front view, sectional top view and true shape of the section.
2. A hexagonal pyramid, base 30 mm side and axis 65 mm long is resting on its base on HP with two edges of the base parallel to V.P. It is cut by a section plane perpendicular to V.P and inclined  $45^\circ$  to H.P, intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view and true shape of the section.

**Course Outcome 6 (CO6)**

1. A cone of base diameter 60 mm and axis 70 mm long is resting on its base on H.P. A section plane perpendicular to H.P and V.P cuts the cone at a distance of 10 mm from the axis. Draw the development of the cut solid.
2. A pentagonal prism of base side 30 mm and axis height 75 mm is resting on its base on HP such that rectangular face is parallel to V.P. It is cut by a cutting plane perpendicular to V.P and  $30^\circ$  inclined to H.P. It meets the axis 15 mm below the top base. Draw the development of the cut prism.

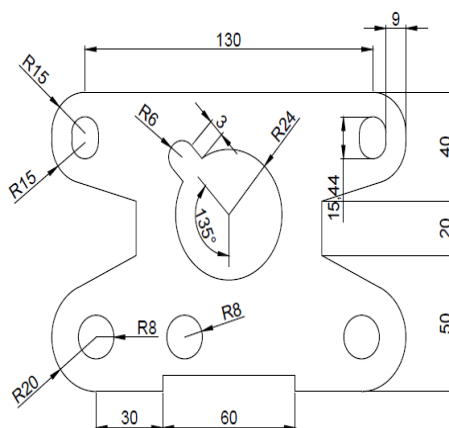
**Course Outcome 7 (CO7)**

1. Draw the isometric projection of hexagonal prism of base side 40 mm and height 60 mm with a right circular cone of base diameter 50 mm and altitude 50 mm resting on its top such that the axes of both solids are collinear and vertical.
2. Draw the isometric view of the part with the following orthographic views.

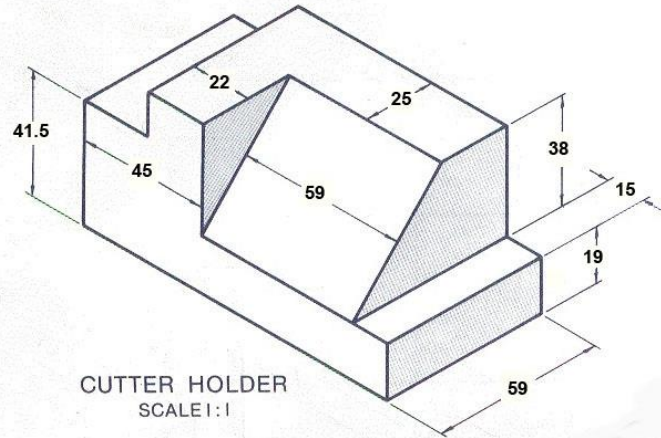


**Course Outcome 8 (CO8)**

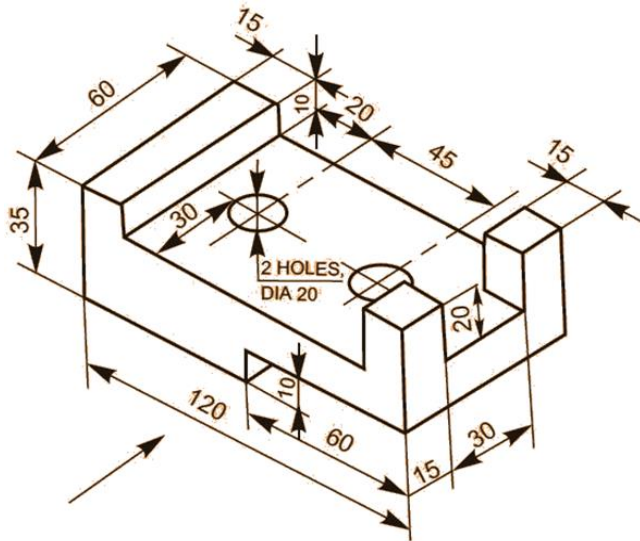
1. Develop a 2D model using CAD package for the given figure.



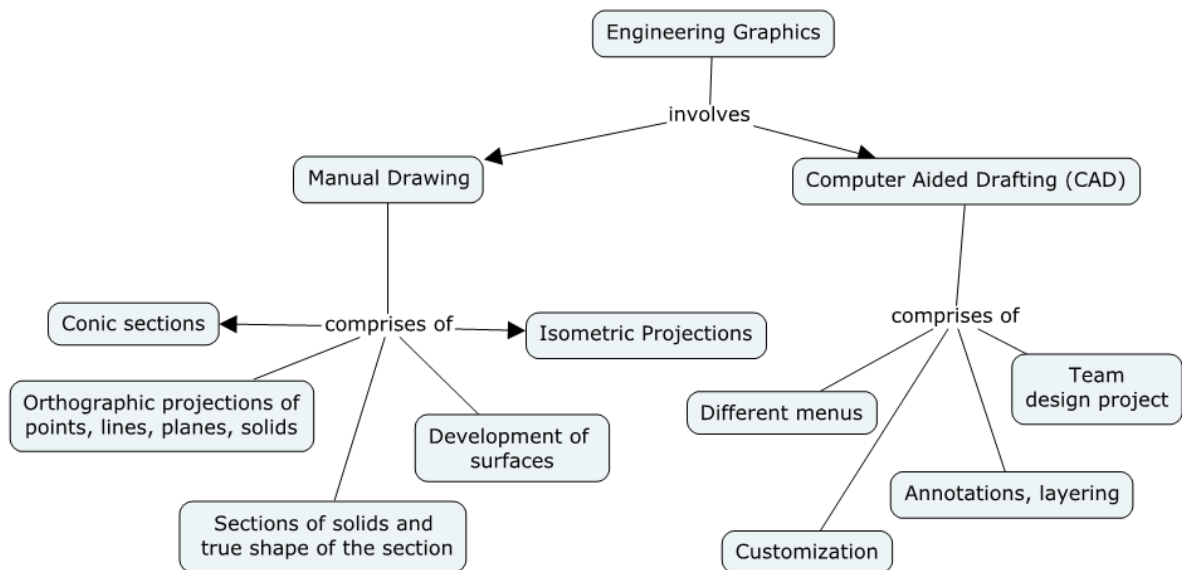
2. Develop a 3D model using CAD package for the given part drawing.



2. Draw the orthographic views for the given 3D model with appropriate dimensioning using CAD package.



**Concept Map**





## Syllabus

**Introduction-** Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales.

**Conic Sections** - Construction of ellipse, parabola, hyperbola (Eccentricity Method only) and rectangular hyperbola.

**Projection (Elevation and Plan) of points** located in all quadrants.

**Projection (Elevation and Plan) of straight lines** inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method.

**Projection (Elevation, Plan and End view) of planes** inclined to both reference planes by rotating object method.

**Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes.

**Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.

**Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone).

**Isometric projection** – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. **Conversion of orthographic projections** (Elevation, Plan and End view) of solid parts / engineering components into isometric view.

**Computer Aided Drafting** (For Continuous Assessment only):

Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits.

Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views.

## Text Book

1. Bhatt N.D., Panchal V.M. and Ingle P.R., (2014) "Engineering Drawing", Charotar Publishing House.

## Reference Books

1. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
2. Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008
3. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International (P) Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
5. Shah M.B, and Rana B.C (2008) "Engineering Drawing and Computer Graphics", Pearson Education.

6. (Corresponding set of) CAD Software Theory and User Manuals.

### Course Contents and Lecture Schedule

Sl.No	Topic	Lecture Hours	Practice Hours
1	<b>Introduction-</b> Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales.	2	1
2	<b>Conic Sections</b> - Construction of Ellipse, Parabola, hyperbola and rectangular hyperbola (Eccentricity Method only).	2	3
3	<b>Projection (Elevation and Plan) of points</b> located in all quadrants.	2	1
4	<b>Projection (Elevation and Plan) of straight lines</b> inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method.	4	2
5	<b>Projection (Elevation, Plan and End view) of planes</b> inclined to both reference planes by rotating object method.	5	2
6	<b>Projection (Elevation and Plan) of regular solids</b> (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes.	5	3
7	<b>Projection (Elevation and Plan) of sectioned solids</b> (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.	4	2
8	<b>Development of surfaces</b> (base and lateral) of <b>sectioned regular solids</b> (Prisms, Pyramids, Cylinder and Cone).	4	2
9	<b>Isometric projection</b> – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. <b>Conversion of orthographic projections</b> (Elevation, Plan and End view) of solid parts / engineering components into isometric view.	4	2
10	<b>Computer Aided Drafting</b> (For Continuous Assessment only): <b>10.1</b> Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits.	1	1
	<b>10.2</b> Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views.	3	5
<b>TOTAL</b>		<b>36</b>	<b>24</b>

### Question Pattern for Terminal Examination

Question	Description	Type	Marks
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Number			
1	Conic sections	Either or type	10
2	Projection of lines	Either or type	15
3	Projection of planes	Either or type	15
4	Projection of solids	Either or type	15
5	Section of solids	Either or type	15
6	Development of surfaces	Either or type	15
7	Isometric projections of combined solids Or Orthographic views to isometric view	Either or type	15
<b>Total</b>			<b>100</b>

**Marks Allocation for Continuous Assessment:**

Sl. No	Description	Marks
1	Plates (Drawing sheets) submission	20
2	Computer Aided Drafting (CAD) Exercises	15
3	Continuous Assessment Test (CAT)	15
<b>Total</b>		<b>50</b>

**Note:**

1. One test or two tests will be conducted locally by respective faculty-in-charge during regular class hours to account for continuous assessment test (CAT) marks.
2. Terminal examination (3 hrs) will be conducted centrally by the office of controller of examinations.

**Course Designers**

1. Dr. A.Samuel Raja      [samuel1973@tce.edu](mailto:samuel1973@tce.edu)
2. Prof. M.Kannan      [mknmech@tce.edu](mailto:mknmech@tce.edu)

18EG170	ENGLISH LABORATORY	Category	L	T	P	Credit
		HSS	0	0	2	1

**Preamble**

This practical course enables the students to develop and evaluate their basic English language skills in Language Lab, equipped with English Software, through individualized learning process and immediate feedback, and facilitates students with the need-based student-centric presentation sessions in a multi-media driven classroom environment.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Pronounce words intelligibly through listening and watching contents on social, technical and day-to-day conversations and respond to questions related to them	Apply
CO2	Apply appropriate lexicon in various contexts, by differentiating variations pertaining to spelling, pronunciation, meaning and grammar	Apply
CO3	Comprehend passages on various topics like general, business and science at various levels	apply
CO4	Read texts in newspapers, magazines, and articles on a variety of issues with clarity to understand and to be understood	Apply
CO5	Prepare and present on a topic to a group of audience with ICT and other educational aids	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										S		S
CO2										S		M
CO3										S		S
CO4										S		M
CO5										S		S

**Assessment Pattern**

**Internal:** No Continuous Assessment Test will be conducted

Students' performance will be assessed in the classroom as given below

- Spoken Task - General / Technical Presentation / BEC Speaking Tests II: 25 Marks
- Listening Task - Answering questions : 25 Marks

**External:** Tested on Phonetics, Grammar, and Vocabulary in the lab for 1 hour : 80 Marks

Submission of Students Record on Practical Tasks in the Class and Lab : 20 Marks

**List of Experiments**

S.No	Topic	Hours
	LAB ACTIVITIES	
1	Listening	2
2	Vocabulary	2
3	Grammar	2
4	Phonetics	2
5	Reading Comprehension – I (General)	2
6	Reading Comprehension – II (BEC Vantage Level)	2
	CLASSROOM ACTIVITIES	
7	Reading Practice (Extensive Reading)	2
8	English through Audios & Videos (Note-Taking & answering questions)	2
9	Presentation - I	2
10	Presentation - II	2
11	Revision	2
12	Model Test	2
	Total	24

**Software Used:**

1. Business English Certificate-Vantage- Practice Software
2. English Software

**Extensive Reading: ( Not for Terminal Exam, Prescribed only for Spoken Tasks)**

1. Khera, Shiv, You Can Win, Macmillan Books, New York, 2003.

**Teaching Resources and Websites:**

1. Oxford / Cambridge Online English Videos
2. Free Video Downloads from Youtube
3. <https://learningenglish.voanews.com/>
4. <https://www.ted.com/talks>
5. [www.esl-galaxy.com/video.htm](http://www.esl-galaxy.com/video.htm)

**Course Designers:**

- |   |                             |  |
|---|-----------------------------|--|
| 1 | Dr. S. Rajaram              | <a href="mailto:sreng@tce.edu">sreng@tce.edu</a>           |
| 2 | Dr.A.Tamilselvi             | <a href="mailto:tamilselvi@tce.edu">tamilselvi@tce.edu</a> |
| 3 | Mr. R. Vinoth               | <a href="mailto:vino@tce.edu">vino@tce.edu</a>             |
| 4 | Dr. R. K. Jaishree Karthiga | <a href="mailto:jai@tce.edu">jai@tce.edu</a>               |

18PH180	PHYSICS LABORATORY	Category	L	T	P	Credit
		BS	0	0	2	1

**Preamble**

This course ensures that students learn to apply the basic physics concepts and carry out the experiments to determine the various physical parameters related to the material

- Learn the necessary theory to understand the concept involved in the experiment.
- Acquire the skills to carry out the experiment.
- Tabulate the observed data and use the formula to evaluate the required quantities.
- Plot the data in a graph and use it for calculation.

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Analyze mechanical ,electrical oscillations and determine their resonance frequency	Apply
CO2	Analyze the diffraction and interference patterns for characterization	Apply
CO3	Determine the numerical aperture and bending loss in optical fiber	Apply
CO4	Determine the Planck's constant by using LEDs	Apply
CO5	Plot the VI characteristics of solar cell	Apply
CO6	Determine the time constant of an RC circuit	Apply
CO7	Determine the reversibility of classical and quantum logic gates	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	-	-	-	-	-	-	-	-
CO2	S	S	S	S	-	-	-	-	-	-	-	-
CO3	S	S	S	S	-	-	-	-	-	-	-	-
CO4	S	S	S	S	-	-	-	-	-	-	-	-
CO5	S	S	S	S	-	-	-	-	-	-	-	-
CO6	S	S	S	S	-	-	-	-	-	-	-	-
CO7	S	S	S	S	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

**List of Experiments****OSCILLATIONS AND WAVES**

1. Torsion pendulum- Determination of Moment of inertia of a disc
2. Compound pendulum –Determination of acceleration due to gravity

**OPTICS**

3. Spectrometer-Determination of Refractive index of the material of the prism.
4. Laser Diffraction – Determination of wavelength of Laser and particle size in a thin film.
5. Air wedge –Determination of diameter of wire by interference principle.
6. Fiber optics-Determination of numerical aperture and bending losses.

### QUANTUM MECHANICS

7. Photoelectric effect-Determination of Planck's constant
8. Solar cell-Plotting and studying of V-I characteristic
9. Study of Classical and quantum Logic gates.

### ELECTROMAGNETIC THEORY

10. RC circuit –Determination of time constant
11. LCR Circuit- Determination of resonant frequency

#### Course Designers:

- |                         |  |
|-------------------------|--|
| 1. Dr. R. Vasuki        | <a href="mailto:rvphy@tce.edu">rvphy@tce.edu</a>   |
| 2. Dr. M.Mahendran      | <a href="mailto:mmphy@tce.edu">mmphy@tce.edu</a>   |
| 3. Mr. V.Veeraganesh    | <a href="mailto:vvgphy@tce.edu">vvgphy@tce.edu</a> |
| 4. Dr. A.L.Subramaniyan | <a href="mailto:alsphy@tce.edu">alsphy@tce.edu</a> |
| 5. Dr.D.Ravindran       | <a href="mailto:drphy@tce.edu">drphy@tce.edu</a>   |

18CH190	CHEMISTRY LABORATORY	Category	L	T	P	Credit
		BS	0	0	2	1

**Preamble**

This course aims to provide the students, a basic practical knowledge in chemistry. The objective of this course is to develop intellectual and psychomotor skills of the students by providing hands on experience in quantitative, electrochemical and photo-chemical analysis.

**Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Estimate the chemical water quality parameters of sample water	Apply
CO2	Demonstrate the rate of corrosion of steel by weight loss method	Apply
CO3	Estimate the strength of acidic solution and pH of soil by conductometric and pH metric titrations	Apply
CO4	Illustrate the strength of oxidisable materials present in given sample by potentiometric method	Apply
CO5	Adapt colorimetric method for determination of iron in water	Apply

**Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	-	-	-	L	-	L	-	-	-
CO2	S	S	M	-	-	-	L	-	L	-	-	-
CO3	S	S	M	-	-	-	L	-	M	-	-	-
CO4	S	M	-	-	-	-	-	-	-	-	-	-
CO5	S	S	M	-	-	-	L	-	-	-	-	-

**List of Experiments****A. Quantitative analysis**

1. Estimation of Total hardness of water
2. Estimation of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  individual hardness of water samples
3. Estimation of alkalinity of water sample
4. Estimation of COD of industrial effluent
5. Estimation of Chloride in a water sample
6. Estimation of rate of corrosion of steel by weight loss method

**B. Electrochemical and photochemical analysis**

1. Conductometry Titration (Strong acid vs Strong base)
2. Potentiometric redox Titration ( $\text{K}_2\text{Cr}_2\text{O}_7$  vs FAS,  $\text{KMnO}_4$  vs FAS)
3. Determination of pH of soil by pH metric titration
4. Estimation of iron content of water sample using colorimeter

**Course Designers:**

Dr. M. Kottaisamy	<a href="mailto:hodchem@tce.edu">hodchem@tce.edu</a>
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**CURRICULUM AND SYLLABI**

For

**B.E. Mechatronics Program**

Second Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 57<sup>th</sup> Academic Council Meeting on 05.01.2019

<b>18MA210</b>	<b>MATRICES AND ORDINARY DIFFERENTIAL EQUATIONS</b>	Category	L	T	P	Credit(s)
		BS	3	0	0	3

**Preamble**

In engineering, particularly Solid Mechanics, Aerodynamics, Fluid Flow, Heat Flow and Robotics have application that requires an understanding of Vector Calculus and Differential Equations. Also, Mathematical tool Laplace Transforms is very much essential to solve ordinary differential equations that occur in the above areas. Eigen values and Eigenvectors are extremely important while creating engineering models in control systems, designing bridges, communication systems and searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to all Engineers and apply them in their areas of specialization.

**Prerequisite**

- 18MA110 - Engineering Calculus

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Compute the Laplace transform and inverse Laplace transform of different functions	10
CO2	Solve the given initial value problem using Laplace transform	15
CO3	Apply matrix algebra techniques for transformations of conic sections into principle axes	25
CO4	Solve the model developed for the given system using ordinary differential equation	25
CO5	Compute divergence and curl of vector functions	10
CO6	Apply the concepts of vector differentiation and vector integration to fluid flow and heat transfer problems	15

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components
		Cognitive	Affective	Psychomotor	
CO1	TPS2	K2	A2	-	1.1
CO2	TPS3	K3	A3	-	1.1
CO3	TPS3	K3	A3	-	1.1
CO4	TPS3	K3	A3	-	1.1
CO5	TPS2	K2	A2	-	1.1
CO6	TPS3	K3	A3	-	1.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	-	-	-	-	-	-	-	-	-	-
CO2	S	S	S	-	-	-	-	-	M	-	-	M
CO3	S	S	-	S	-	-	-	-	-	-	-	S
CO4	S	S	S	S	-	-	-	-	M	-	-	M
CO5	S	M	-	-	-	-	-	-	-	-	-	-
CO6	S	S	S	-	-	-	-	-	-	-	-	-

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	10
Understand	30	30	30	-	-	-	20
Apply	60	60	60	100	100	100	70
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1**

- Show that Laplace transform of  $\frac{1}{\sqrt{t}}$  is  $\frac{\sqrt{\pi}}{s}$ .
- Identify the inverse Laplace transform of  $\log\left(\frac{s^2+1}{(s-1)^2}\right)$ .
- Discuss any three properties of Laplace transforms.

**Course Outcome 2**

- Apply Laplace transform solve  $y''+9y = \delta\left(t - \frac{\pi}{2}\right)$ ,  $y(0) = 2$ ,  $y'(0) = 0$ .
- By using Laplace transform, solve  $x''(t) + 3x'(t) + 2x(t) = 2(t^2 + t + 1)$ ; with  $x(0) = 2, x'(0) = 0$ .
- Apply convolution theorem, Solve the Volterra integral equation of the second kind  $y(t) - \int_0^t y(\tau) \sin(t - \tau) d\tau = t$ .

**Course Outcome 3**

- An elastic membrane in the  $x_1 x_2$  plane with boundary circle  $x_1^2 + x_2^2 = 1$  is stretched so that a point  $P; (x_1, x_2)$  goes over into the point  $Q; (y_1, y_2)$  given by  $y_1 = 5x_1 + 3x_2$   
 $y_2 = 3x_1 + 5x_2$

Find the principal directions that is the directions of the position vector  $X$  of  $P$  for which the direction of the position vector  $Y$  of  $Q$  is the same or exactly opposite.

Predict the boundary circle take under this deformation?

- Discover the type of conic section the following quadratic form represents and transform it to principal axes:  $Q = 17x_1^2 - 30x_1x_2 + 17x_2^2 = 128$ .

- Diagonalize the matrix  $\begin{bmatrix} 6 & 0 & 0 \\ 12 & 2 & 0 \\ 21 & -6 & 9 \end{bmatrix}$

**Course Outcome 4**

- Reduce to first order and solve  $y'' - y' = 0$
- Compute the general solution for  $y'' + y' + (\pi^2 + 1/4)y = e^{-x/2} \sin \pi x$
- Solve  $(x^2 D^2 - 4xD - 6)y = c$

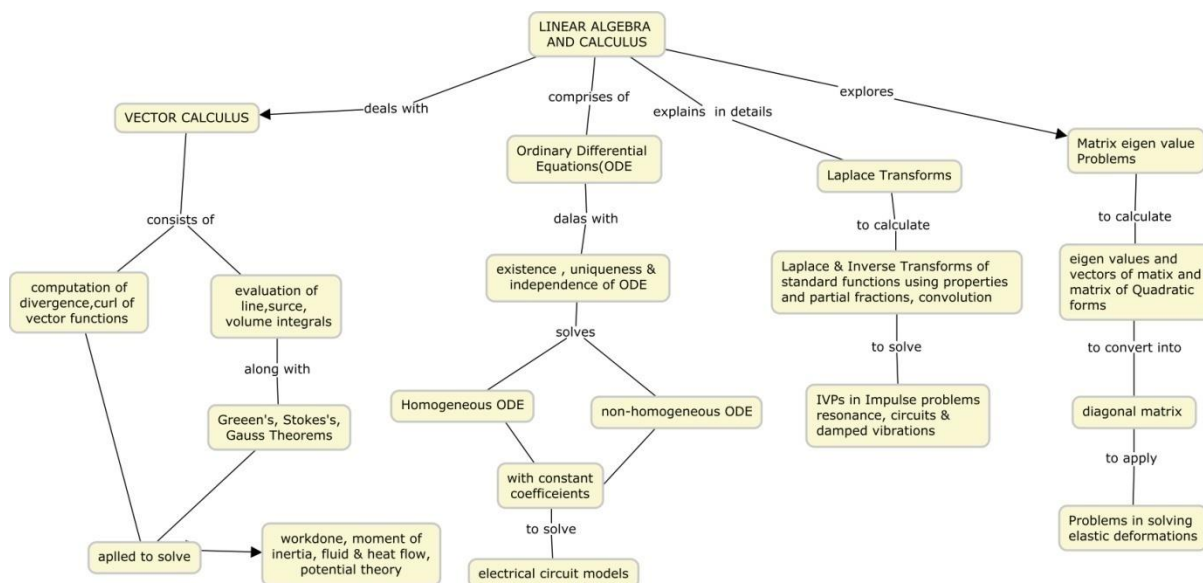
**Course Outcome 5**

1. Predict the value of  $div(curl \vec{F})$ .
2. If  $\phi_1$  and  $\phi_2$  are scalar point functions and  $\vec{F}$  is a vector point function such that  $\phi_1 \vec{F} = \nabla \phi_2$  then identify  $\vec{F} \cdot curl \vec{F}$ .
3. Estimate  $curl \vec{v}$ , where  $\vec{v} = [e^{-z^2}, e^{-x^2}, e^{-y^2}]$ .

**Course Outcome 6**

1. Predict the work done by the force  $\vec{F} = [y^2, -x^2]$  acting on a particle in  $y = 4x^2$  from (0,0) to (1,4).
2. Compute the amount of fluid that crosses the surface in a flow per unit time at any one instant, if the velocity field is  $\vec{v} = y\vec{i} + x\vec{j} + z\vec{k}$  over the boundary of the region enclosed by the paraboloid  $z = 1 - x^2 - y^2$  and the plane  $z = 0$ .
3. Apply Stokes theorem to compute  $\int_C \vec{F} \cdot r' ds$  where  $\vec{F} = [y, xz^3, -zy^3]$  and  $C$  is circle  $x^2 + y^2 = 4, z = -3$ .

**Concept Map**



**Syllabus**

**LAPLACE TRANSFORMS:** Laplace transform, Linearity, First Shifting theorem – Transforms of derivatives and integrals, ODEs – Unit step function, Second shifting theorem – Short Impulses, Dirac’s delta function, partial fractions – Convolution, Integral Equations – Differentiation and integration of transforms. **MATRIX EIGEN VALUE PROBLEM:** The Matrix Eigen value Problem, Determining Eigenvalues and Eigenvectors – Some Applications of Eigen value Problems – Symmetric, Skew symmetric and orthogonal matrices – Eigen bases, Diagonalization, Quadratic forms. **ORDINARY DIFFERENTIAL EQUATION:** Homogeneous

Linear ODEs of second order – Homogeneous Linear ODEs with constant coefficients – Euler Cauchy Equation – Existence and uniqueness of solutions, Wronskian - Nonhomogeneous ODE – Modelling: Electric Circuits- Solution by Variation of Parameters. **VECTOR CALCULUS:** Divergence of a Vector Field- Curl of a Vector Field- Line Integrals- Path independence of line integrals- Green’s Theorem in the plane- Surface Integrals- Triple Integrals, Divergence Theorem of Gauss- Applications of the Divergence Theorem- Stoke’s Theorem.

### Learning Resources

- Erwin Kreszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2017.
  - Laplace transforms : [sections 6.1,6.2,6.3,6.4,6.5,6.6]
  - Matrix eigen value problem : [sections 8.1,8.2,8.3,8.4]
  - Ordinary differential equations : [sections 2.1,2.2,2.5,2.6,2.7,2.9,2.10]
  - Vector calculus : [sections 9.8.9.9,10.1,10.2,10.4,10.6, 10.7,10.8,10.9]
- Peter V.O'Neil, "Advanced Engineering Mathematics", 7th edition, Cengage Learning, 2017.
- Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi, 2016.
- Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 3rd Edition, 2007.
- Made Easy Team, Engineering Mathematics, Made Easy Publications, 2018.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.</b>	<b>LAPLACE TRANSFORMS</b>		
1.1	Laplace Transform. Linearity. First Shifting Theorem ( $s$ -Shifting)	2	CO1
1.2	Transforms of Derivatives and Integrals. ODEs	2	CO2
1.3	Unit Step Function (Heaviside Function). Second Shifting Theorem ( $t$ -Shifting)	1	CO1
1.4	Short Impulses. Dirac’s Delta Function. Partial Fractions	1	CO1
1.5	Convolution. Integral Equations	2	CO2
1.6	Differentiation and integration of transforms	1	CO1
<b>2</b>	<b>MATRICES EIGEN VALUE PROBLEMS</b>		
2.1	Determining Eigenvalues and Eigenvectors	2	CO3
2.2	Some Applications of Eigenvalue Problems	1	CO3
2.3	Symmetric, Skew-Symmetric, and Orthogonal Matrices	2	CO3
2.4	Eigenbases. Diagonalization.	2	CO3
2.5	Quadratic Forms	2	CO3
<b>3</b>	<b>ORDINARY DIFFERENTIAL EQUATION</b>		
3.1	Homogeneous Linear ODEs of Second Order	2	CO4
3.2	Homogeneous Linear ODEs with Constant Coefficients	1	CO4
3.3	Euler–Cauchy Equations	1	CO4
3.4	Existence and Uniqueness of Solutions. Wronskian	1	CO4
3.5	Nonhomogeneous ODEs	2	CO4
3.6	Solution by Variation of Parameters	2	CO4
<b>4</b>	<b>VECTOR CALCULUS</b>		

4.1	Divergence and Curl of a Vector Field	2	CO5
4.2	Line Integrals	2	CO6
4.3	Green's Theorem in the Plane	1	CO6
4.4	Surface Integrals	1	CO6
4.5	Triple Integrals. Divergence Theorem of Gauss	1	CO6
4.6	Applications of the Divergence Theorem	1	CO6
4.7	Stoke's Theorem	1	CO6
	<b>TOTAL No. of Hours</b>	<b>36</b>	

### Course Designers:

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**18MT220****ELECTRICAL MACHINES**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

In future, the machines play a vital role in transforming the manufacturing system into automatic system. An electrical machine is the apparatus that converts energy in three categories: generators which convert mechanical energy to electrical energy, motors which convert electrical energy to mechanical energy, and transformers which changes the voltage level of an alternating current. The academic study of electric machines has become considerable importance in recent years for development of mechatronics in industries. This course aims to provide knowledge on construction and working principle, advantages, limitations and applications of various industrial machines

**Prerequisite**

- 18MA110 - Engineering Calculus
- 18PHA20 - Physics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Integrate knowledge about machines and its principles in real world application.	5
CO2	Explain the various types of Machines, principle and operation.	10
CO3	Explain the Construction principle and control of different types of Machines.	20
CO4	Explain the characteristics, Application of different types of Machines.	20
CO5	Determine performance parameters of different machines to solve the problems related to its application.	25
CO6	Select the suitable machine & working principle for a given situation and application.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception	1.1,1.2
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO4	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	L	L	-	-	-	M	L	-	-	-	L	M	L
CO2	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO3	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO4	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO5	S	S	S	S	S	L	L	-	M	M	-	S	L	S
CO6	S	S	S	S	S	L	L	-	M	M	-	S	L	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	60	40	40	-	-	-	40
Apply	20	40	40	100	100	-	40
Analyse	-	-	-	-	-	100	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Simulation of Machines Operation
Set	-
Guided Response	Assignments
Mechanism	Mini projects, Flipped classroom, Quiz, Active Learning Techniques.
Complex Overt Responses	-
Adaptation	-
Orignation	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. State Faradays Law.
2. Define Double field revolving theory.
3. Draw speed torque characteristics diagram with equation.

#### Course Outcome 2(CO2):

1. Explain briefly Variable Reluctance principle and how stepper motor works on that principle with neat sketch.
2. Discuss in detail the difference between VRSM &PMSM.
3. Explain the principle operation of Solenoid with neat circuit diagram.

#### Course Outcome 3(CO3):

1. Explain the construction of Transformer with neat sketches.
2. With neat sketch briefly explain the construction of Stepper motor.



**Course Outcome 4 (CO4):**

1. Explain the principle and operations of Alternator and give their advantages, limitations and specific applications.
2. With neat sketch, briefly explain the Principle operation of Permanent magnet stepper motor and its limitations.

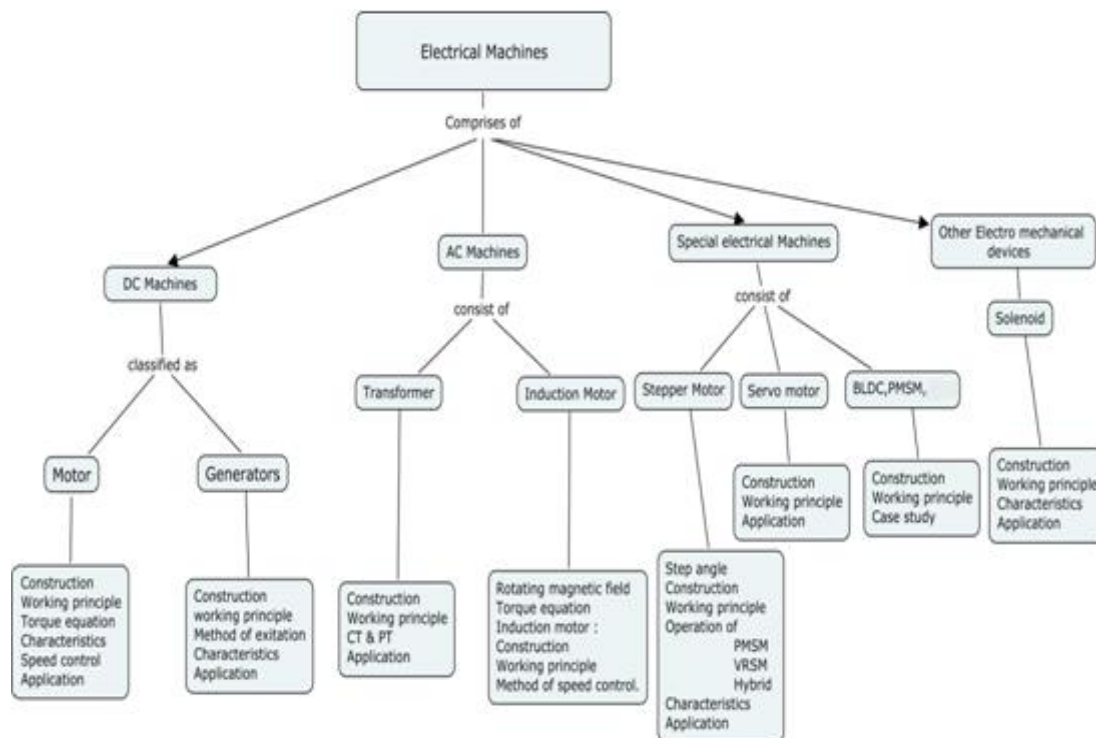
**Course Outcome 5 (CO5)**

1. A load has impedance  $10 + j 5$  and is fed by a voltage of 100V. Calculate the current and power at the load.
2. A 4 pole lap winding DC shunt generator has a useful flux per pole of 0.6Wb. The armature winding consist of 200turns, each turns having the resistance of 0.003ohm. Calculate the terminal voltage running at 1000rpm if armature current is 45Amp.

**Course Outcome 6(CO6):**

1. Suggest suitable design procedure along with justification for manufacture of the following Products:
  - (i). Position change application.
  - (ii). House pump
2. Select the appropriate special Machine and explain the construction and working principle for Robotic application

**Concept Map**



## Syllabus

**Introduction:** Overview and Introduction about Electrical systems and Electrical machines.

**Solenoids:** Types - Construction – Working principle – circuit diagram- characteristics - Applications

**DC Machines:** Types - Constructional details – Principle & operation - Emf equation -Methods of excitation of D.C.generators - Characteristics of series, shunt generator - Principle operation of D.C. motor - Back emf and torque equation - Characteristics of series and shunt motors - Starting of D.C. motors - Speed control of D.C. motors – Applications.

**Transformer:** Types - Construction - Working principle - Emf equation – Losses - Voltage regulation - CT & PT - Applications.

**AC Machines:** Production of rotating magnetic field - Torque equation - Torque – Slip characteristics - Power stages and efficiency - Principle and operation of single phase and three phase Induction motors - methods of speed control – applications.

**Special Machines:** Stepper Motor: Constructional features – Step angle - Principle of operation -Variable reluctance motor – Single and multi stack configurations – Characteristics of stepper motor.

Servo Motor: types - Construction and Working principle of Servomotor-Types-Position, speed control.

Permanent magnet DC motor, BLDC motor - Construction and working Principle.

Application: Application and case study of Special Machines in Mechatronics System.

## Learning Resources

1. Stephen J Chapman, "Electrical machines fundamentals" 4<sup>th</sup> edition. Tata McGraw hill, 2005.
2. A.E.Filtgerald & Charles Kingsley jr, "Electric Machinery "6th edition,McGrow science,2002.
3. J B Gupta, "Theory and Performances of Electrical Machines" 14th edition SK Kataria & Sons 2010.
4. D P Kothari and I J Nagrath ,"Electric Machines" 4th Edition , McGraw Hill Education,2010.
5. Takashi Kenjo, "Stepper motor & their microprocessor control" 2nd edition, Oxford science publication 1995.
6. Vedam Subramanian,"Electric Drives", 2<sup>nd</sup> edition, Tata McGraw Hill, 2011
7. <https://nptel.ac.in/courses/108106071/>
8. <https://nptel.ac.in/courses/108106072/>
9. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/>

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
1.	<b>Introduction:</b>		
1.1	Overview and Introduction about Electrical systems and Electrical machines	1	CO1
2.	<b>Solenoids:</b>		
2.1	Types - Construction – Working principle	1	CO1,CO2
2.2	Circuit diagram- characteristics - Applications	2	CO2,CO6
3.	<b>DC Machines:</b>		
3.1	Types - Constructional details – Principle & operation	2	CO1,CO2
3.2	Emf equation -Methods of excitation of D.C.generators	2	CO3,CO5
3.3	Characteristics of series, shunt generator, and series and shunt motors	2	CO4
3.4	Principle operation of D.C. motor - Back emf and torque equation	2	CO3,CO5
3.5	Starting of D.C. motors - Speed control of D.C. motors – Applications.	2	CO4,CO6
4.	<b>Transformer:</b>		
4.1	Types - Construction - Working principle	2	CO1,CO2
4.2	Emf equation - Voltage regulation- Losses	2	CO4,CO5
4.3	CT & PT - Applications.	2	CO5,CO6
5.	<b>AC Machines:</b>		
5.1	Types- Production of rotating magnetic field- Principle and operation of single phase and Three phase Induction motors	2	CO1,CO2
5.2	Torque equation - Torque – slip characteristics - Power stages and efficiency	2	CO3,CO5
5.3	Methods of speed control – applications.	1	CO5,CO6
6.	<b>Special Machines:</b>		
6.1	Constructional features – Step angle -Principle of operation -Variable reluctance motor	2	CO1,CO2
6.2	Single and multi stack configurations – Characteristics of stepper motor.	2	CO2,CO4
6.3	Types - Construction and Working principle of Servomotor-Types-Position, speed control.	2	CO3,CO4
6.4	Permanent magnet DC motor, Switched reluctance motor, BLDC motor - Construction and working Principle.	2	CO2,CO3
6.5	Application and case study of Special Machines in Mechatronics System	3	CO6

**Course Designers:**

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18MT230

ANALOG ELECTRONICS

Category L T P Credit(s)

PC 3 0 0 3

**Preamble**

This course provides engineering students with basic understanding of analog electronic components and designs of circuits using them. The syllabus includes some basic circuit theorems and circuit analysis; followed by different types of diodes, its characteristics and uses. Then we cover some basic transistor components and its construction and different circuit configurations. Then we have some of the Op-amp basics, its configurations and different configurations for different applications

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Study the electric circuit and its functions	20
CO2	Construct and solving circuit equations using network theorems	20
CO3	Implementation of PN Diode Circuits and its applications	15
CO4	Give understanding of various types of amplifier circuits	20
CO5	Design op-amp based circuit and its applications	25

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception	2.2.1,2.2.3
CO2	TPS3	Apply	Value	-	2.1.3,2.14,3.2.5,4.3.1,4.4.1,4.5.1
CO3	TPS2	Understand	Respond	-	2.1.2,2.2.1,2.2.3
CO4	TPS3	Apply	Value	Guided Response	2.3.1,3.2.5,4.3.1,4.4.1,4.5.1
CO5	TPS3	Apply	Value	Guided Response	2.3.1,3.2.5,4.3.1,4.4.1,4.5.1
CO6	TPS1	Remember	Receive	Perception	2.2.1,2.2.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	L	-	M	L	-	-	S	-	S	S	S	L
CO2	M	S	S	-	L		-	-	-	-	-	M	S	S
CO3	S	S	S	M	M	M	-	-	-	-	S	S	S	S
CO4	L	M	S	M	M	M	L	-	M	-	S	L	M	S
CO5	-	L	S	M	-	M	L	-	M	-	S	-	L	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	-	20	-	-	-	20
Understand	20	40	20	-	-	-	20
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

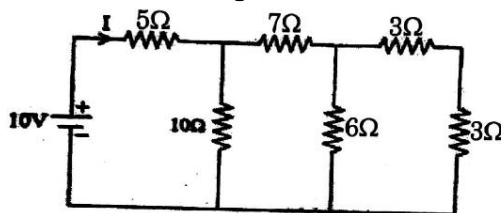
Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Assignment
Set	Assignment
Guided Response	Assignment
Mechanism	Mini Project
Complex Overt Responses	
Adaptation	
Orignation	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

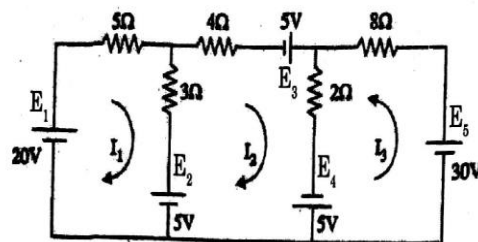
1. Define Kirchoffs current Law
2. Define ideal voltage and ideal current source
3. Explain how voltage source with source resistance can be converted into equivalent current source

**Course Outcome 2 (CO2):**

1. Find the current through each branch



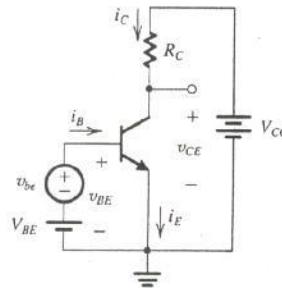
2. Using mesh analysis determine the current supplied by the battery in the circuit

**Course Outcome 3(CO3):**

1. Write the expression of current in a diode
2. Define cut-in voltage or barrier potential of a diode
3. Differentiate between static and dynamic resistance of a diode

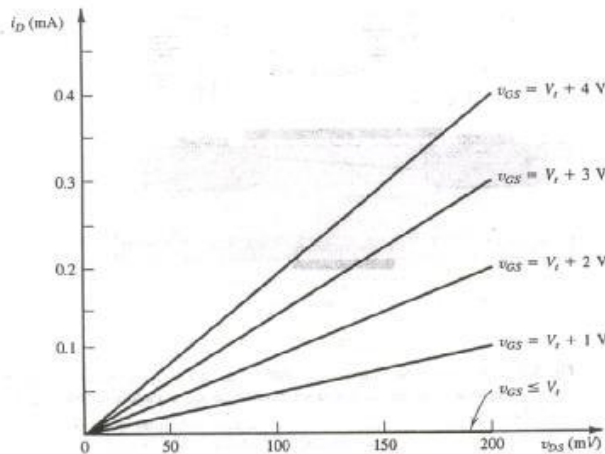
**Course Outcome 4 (CO4):**

1. Explain the functioning of MOSFET as a voltage controlled resistor.
2. Explain the need for biasing in a transistor.
3. Measurement of an *npn* BJT in a particular circuit shows the base current to be 14.46  $\mu\text{A}$ , the emitter current to be 1.460 mA, and the base-emitter voltage to be 0.7V. Calculate  $\alpha$ ,  $\beta$  and  $I_s$  for these conditions?
4. In the circuit shown in the figure  $V_{BE}$  is adjusted to yield a dc collector current of 1 mA. Let  $V_{CC} = 15\text{ V}$ ,  $R_C = 10\text{ k}\Omega$ , and  $\beta = 100$ . Find the voltage gain  $V_c/Bbe$ ? If  $V_{be} = 0.005 \sin \omega t$  volts, find  $v_C(t)$  and  $i_B(t)$ ?



a.

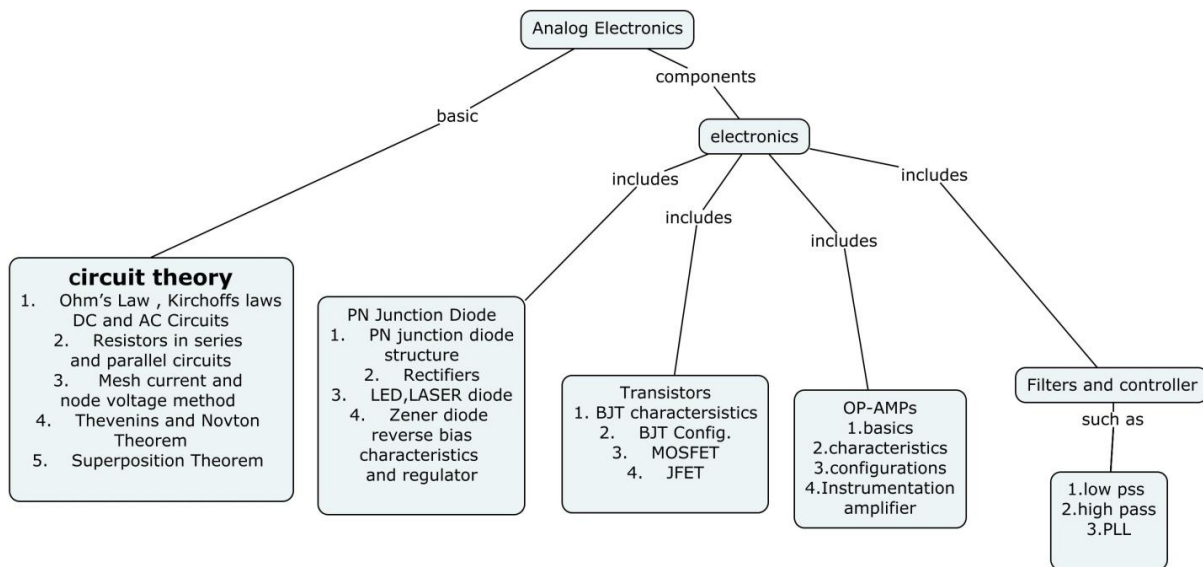
5. For the circuit shown in the figure select a value for  $R_B$  so that the transistor saturates with an overdrive factor of 10. The BJT is specified to have a minimum  $\beta$  of 30 and  $V_{CEsat} = 0.2\text{ V}$ . What is the value of forced  $\beta$  achieved?



**Course Outcome 5 (CO5):**

1. Explain the reason for high CMRR in op-amp used in noisy environment..
2. Explain the functioning of Non inverting amplifier.
3. Define CMRR and slew rate in an op-amp?
4. For the non-inverting operational amplifier with input resistance 100 k ohm and feedback resistance 900 k ohm. Find the effect on output voltage due to common mode voltage when input voltage changes by 1V? Assume CMRR as 70 dB?
5. A PLL has the free running frequency of 500 kHz and bandwidth of the low pass filter is 10 kHz. Will the loop acquire lock for an input signal of 600 kHz? Justify your answer. Assume that the phase detector produces sum and different frequency components.
6. Give the transfer function of a second-order band pass filter with centre frequency of  $10^5\text{ rad/s}$ , a centre-frequency gain of 10, and a 3-dB bandwidth of  $10^3\text{ rad/s}$ ?

## Concept Map



## Syllabus

### Basic Circuit analysis

Ohm's Law – Kirchoffs laws – DC and AC Circuits – Resistors in series and parallel circuits – Mesh current and node voltage method of analysis for D.C and A.C. circuits. Thevenins and Novton & Theorem – Superposition Theorem – Maximum power transfer theorem.

### PN-Junction Devices

PN junction diode-structure, operation and V-I characteristics, half wave and full wave rectifiers, ,LED, LASER diode characteristics zener diode reverse characteristics and regulator

### Transistors characteristics

BJT, JFET, MOSFET structure, biasing and operation. Thyristors and IGBT structure and characteristics JFET, MOSFET Characteristics.

### Operational amplifiers:

Basic information about op-amps – Ideal Operational Amplifier – General operational amplifier stages. DC and AC performance characteristics, slew rate, Open and closed loop, Sign Changer, Scale Changer, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Comparators, Schmitt trigger, Precision rectifier, peak detector, Low-pass, high-pass and band-pass Butterworth filters.

Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator

## Learning Resources

1. Electronic Devices and Circuits theory-Robert L.Boylestead, Louis Nashelsky ,11<sup>th</sup> Edition ,2009,Pearson
2. Sedra and smith, "Microelectronic circuits",7th Ed., Oxford University Press
3. Integrated Electronics, Jacob Milman,Christos C Halkias, Mcgraw Hill Education
4. Thomas L.Floyd, "Electronic devices" Conventional current version, Pearson prentice hall, 10th Edition, 2017
5. David A. Bell , "Electronic devices and circuits", Oxford University higher education, 5th edition 2008

6. Electronic Devices and Circuits ,S Salivahanan, N Suresh Kumar, A Vallvaraj, 5th Edition ,MCGRAW HILL EDUCATION
7. Electronics Circuits and Application, Md H Rashid, Cengage 2014

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome
1	<b>Basic Circuit analysis</b>		
1.1	Ohm's Law – Kirchoffs laws – DC and AC Circuits – Resistors in series and parallel circuits	2	CO1
1.2	Mesh current and node voltage method of analysis for D.C and A.C. circuits. Thevenins and Novton & Theorem	3	CO2
1.3	Thevenins and Novton & Theorem – Superposition Theorem – Maximum power transfer theorem	4	CO2
2	<b>PN-Junction Devices</b>		
2.1	pn junction diode-structure, operation and V-I characteristics	1	CO3
2.2	half wave and full wave rectifiers	1	CO3
2.3	LASER diode characteristics	1	CO3
2.4	zener diode reverse characteristics and regulator	2	CO3
3	<b>Transistors characteristics</b>		
3.1	BJT,JFET,MOSFET structure	2	CO4
3.2	biasing and operation	3	CO4
3.3	Thyristors and IGBT structure and characteristics	2	CO4
4	<b>Operational amplifiers</b>		
4.1	Basic information about op-amps – Ideal Operational Amplifier – General operational amplifier stages	2	CO5
4.2	DC and AC performance characteristics, slew rate	2	CO5
4.3	Open and closed loop configurations	1	CO5
4.4	Sign Changer, Scale Changer, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Comparators, Schmitt trigger	4	CO5
4.5	Low-pass, high-pass and band-pass Butterworth filters.	2	CO5
4.6	Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator	4	CO5

### Course Designers:

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**18MT240****FREE BODY MECHANICS**

Category	L	T	P	Credit(s)
ES	3	0	0	3

**Preamble**

Mechanics is the branch of physics concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effect of the bodies on their environment. The course addresses the modeling and analysis of static equilibrium problems with an emphasis on real world engineering applications and problem solving. For an engineer the knowledge of engineering mechanics is very essential. It helps an engineer in planning, designing, and construction of various types of structures and machines. If an engineer study engineering mechanics in systematic and scientific manner than he can take up his job more skillfully. The course covers a basic introduction to both statics and dynamics. Emphasis is placed upon the gaining of real understanding of the laws and principles of mechanics.

**Prerequisite**

- 18MA110 - Engineering Calculus

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Understand the laws and principles of mechanics	8
CO2	Analyse and solve simple problems using the concept of static equilibrium	12
CO3	Find the centroid and moment of inertia of a 2D and 3D components	20
CO4	Solve problems involving frictional phenomena in machines	20
CO5	Solve problems involving kinematics and kinetics of rigid bodies in plane motion	20
CO6	Solve problems using D'Alembertz principles	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception, Set	1.2,2.1.1
CO2	TPS2	Understand	Respond	Guided Response	1.2, 2.1.1,2.3.1, 2.4.3
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1,2.3.1, 2.4.3
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1,2.3.1, 2.4.3
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1,2.3.1, 2.4.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1,2.3.1, 2.4.3

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	-	-	-	-	-	M	-	L	L
CO2	S	M	M	-	-	-	-	-	-	-	M	-	L	L
CO3	S	M	M	-	-	-	-	-	-	-	M	-	L	L
CO4	S	M	M	-	-	-	-	-	-	-	M	-	L	M
CO5	S	M	M	-	-	-	-	-	-	-	M	-	L	M
CO6	S	M	M	-	-	-	-	-	-	-	M	-	L	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	20	20	20	50	50	50	20
Apply	60	60	60	50	50	50	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	Assignment
Mechanism	Assignment
Complex Overt Responses	
Adaptation	
Origination	

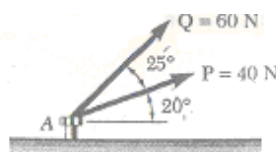
### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

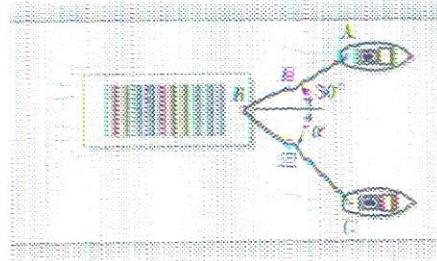
1. Define equilibrium of mechanical system.
2. State law of friction.
3. Describe the dynamic equilibrium of a rigid body in plane motion.

#### Course Outcome 2(CO2):

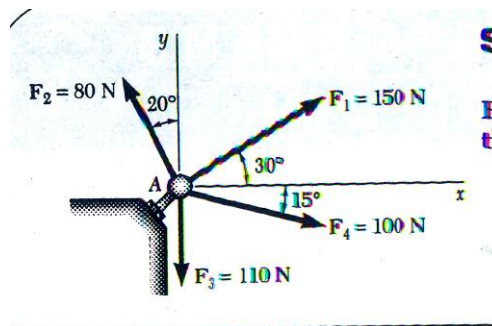
1. Determine the resultant of two force P and Q act on a bolt A



- A barge is pulled by two tugboats. If the resultant of the forces exerted by the tugboats is a 5000 N force directed along the axis of the barge, determine the a) the tension in each of the ropes knowing that  $\alpha = 45^\circ$  b) the value of  $\alpha$  for which the tension in rope 2 is minimum.

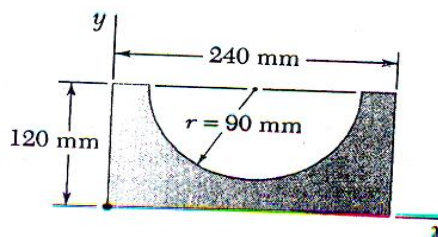


- Four forces act on bolt A shown, Determine the resultant of the forces on the bolt,



**Course Outcome 3(CO3):**

- Define centroid of an area
- State perpendicular axis theorem.
- Determine the moment of inertia of the shaded area with respect to the x axis



**Course Outcome 4 (CO4):**

- A body of mass 4 kg lying on a rough horizontal plane is attached to one end of a string. The string passes over a smooth pulley and carries at its other end, a body of mass 10 kg which hangs freely vertically down. If the system starts from rest and attains an acceleration of  $6 \text{ m/s}^2$ , find the coefficient of friction.
- Determine the horizontal force P required to raise the 200kg block. The coefficient of friction for all surfaces is 0.40.

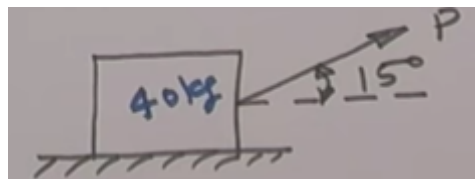
- If the coefficient of friction between the steel wedge and the moist fibers of the newly cut stump is 0.20, determine the maximum angle which the wedge may have and not pop out of the wood after being driven by the sledge.

**Course Outcome 5 (CO5):**

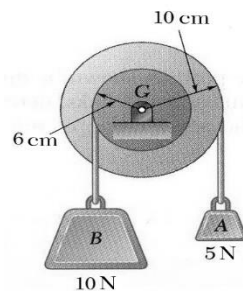
- A Stone is thrown vertically upwards with a velocity of 40 m/sec. Find its position after 5 seconds.
- A body of mass 4 kg lying on a rough horizontal plane is attached to one end of a string. The string passes over a smooth pulley and carries at its other end, a body of mass 10 kg which hangs freely vertically down. If the system starts from rest and attains an acceleration of  $6 \text{ m/s}^2$ , find the coefficient of friction.
- A pulley weighing 12 N and having a radius of gyration of 8 cm is connected to two blocks as shown. Assuming no axle friction, determine the angular acceleration of the pulley and the acceleration of each block.

**Course Outcome 6(CO6):**

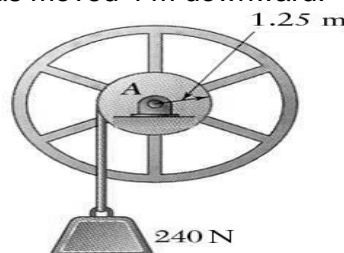
- Find P required to accelerate the block shown in fig below at  $2.5 \text{ m/s}^2$ . Take coefficient of friction  $= 0.3$



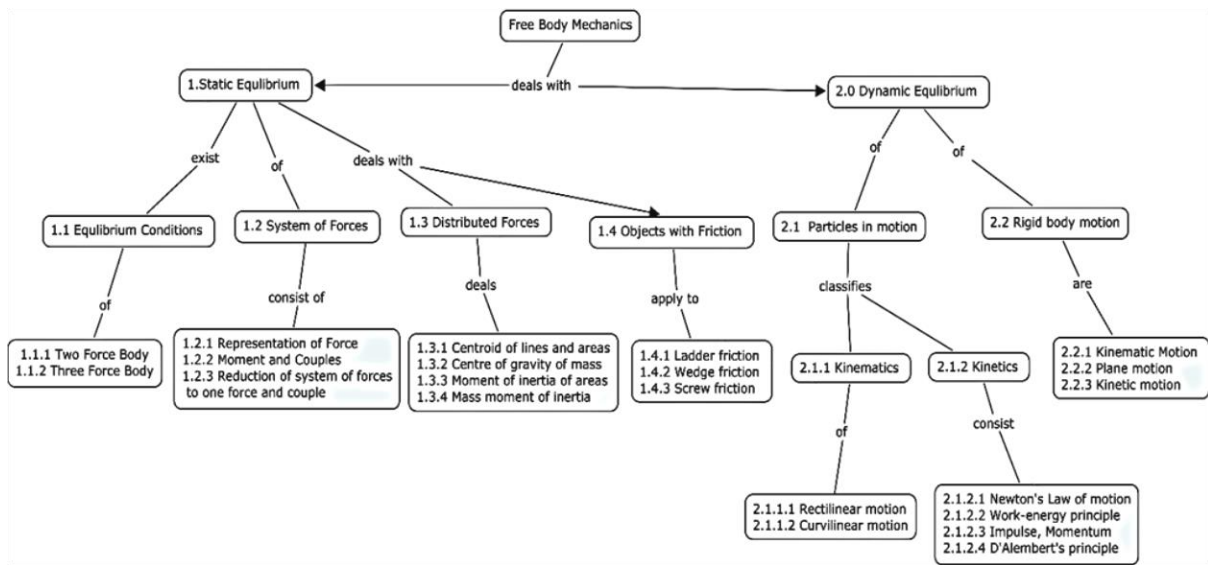
- A pulley weighing 12 N and having a radius of gyration of 8 cm is connected to two blocks as shown. Assuming no axle friction, determine the angular acceleration of the pulley and the acceleration of each block.



- For the drum and flywheel,  $I = 10.5 \text{ kg-m}^2$ . The bearing friction is equivalent to a couple of  $60 \text{ Nm}$ . At the instant shown, the block is moving downward at  $6 \text{ m/s}$ . Determine the velocity of the block after it has moved 4 m downward.



**Concept Map**



**Syllabus**

**Static Equilibrium of Mechanical Systems:** Equilibrium conditions-Two force body-Three force body.

**System of forces:** Representation of Force, Moment and Couples-Reduction of system of forces to one force and couple.

**Distributed forces:** Centroid of lines and areas-Centre of gravity of mass-Moment of inertia of areas-Mass moment of inertia.

**Objects with friction:** Ladder friction-Wedge friction-Screw friction-Applications

**Dynamic equilibrium:** Particles in motion-Kinematics of particles-Rectilinear motion-Curvilinear motion-Kinetics of particles-Newton's Law of motion-Work-energy principle-Impulse-Momentum principle, D'Alembert's principle.

**Rigid body motion:** Kinematic Motion -Rotary motion of rigid bodies-Plane motion-Kinetic motion.

**Learning Resources**

1. Beer F.P. and Johnston Jr. E.R., Vector Mechanics for Engineers: Statics and Dynamics, Twelfth student Edition, Tata McGraw Hill College, 2018
2. Hibbeler R.C., Engineering Mechanics – Statics & Dynamics, Fourteenth Edition, Pearson Publisher, 2015
3. R.C Hibbeler, Irving H Shames, D.P Sharma., Engineering Mechanics, Pearson Education 2011
4. Tayal A.K., Engineering Mechanics, Fourteenth Edition, Umesh Publications, 2010
5. <https://nptel.ac.in/courses/112103108/>

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
1.	Introduction Static Equilibrium of mechanical systems	2	CO1
1.1	Fundamental laws, Free body diagram	1	CO1
1.2	Two force body, three force body	1	CO2
2.	<b>System of forces</b>		CO2

2.1	Representation of Force,	1	CO2
2.2	Moment and Couples	1	CO2
2.3	Reduction of system of forces to one force and couple	1	CO2
3	<b>Distributed forces</b>		CO3
3.1	Centroid of lines and areas	1	CO3
3.2	Centre of gravity of mass	2	CO3
3.3	Moment of inertia of areas	1	CO3
3.4	Tutorial Problems in Moment of Inertia	2	CO3
4.	<b>Objects with friction</b>		CO4
4.1	Ladder friction	2	CO4
4.2	Wedge friction	1	CO4
4.3	Screw friction	2	CO4
5.	<b>Dynamic equilibrium</b>		CO5
5.1	Particles in motion	1	CO5
5.2	Kinematics of particles	1	CO5
5.3	Rectilinear motion	1	CO5
5.4	Curvilinear motion	1	CO5
5.5	Kinetics of particles	1	CO5
5.6	Newton's Law of motion	2	CO5
5.7	Work-energy principle	2	CO5
5.8	Impulse-Momentum principle ,	2	CO5
5.9	Tutorial Problems	1	CO5
6.	<b>Rigid body motion</b>		CO6
6.1	General plane motion	1	CO6
6.2	Kinematic Motion –Rotary motion of Rigid bodies	1	CO6
6.3	Plane motion -D Alembert's principle	1	CO6
6.4	Kinetic motion	1	CO6
6.5	Tutorial Problems	2	CO6

**Course Designers:**

Sl. No.	Name	E-mail Id
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**18MT260 MANUFACTURING PROCESSES**

Category	L	T	P	Credit(s)
PC	2	0	2	3

**Preamble**

The basic processes used for manufacturing desired shape of a product are casting, forming, machining, and joining processes. Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process.

Forming or metal forming, is the metalworking process of fashioning metal parts and objects through mechanical deformation; the work piece is reshaped without adding or removing material, and its mass remains unchanged.

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

Machining is a term used to describe a variety of material removal processes in which a cutting tool removes unwanted material from a work piece to produce the desired shape. The work piece is typically cut from a larger piece of stock, which is available in a variety of standard shapes, such as flat sheets, solid bars, hollow tubes, and shaped beams.

The first, second, third and fourth parts of this course aim to provide knowledge on the working principles, basic operations and applications of various metal casting, forming, joining and machining processes

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the principle, process capabilities, types and various operations of metal casting, metal forming, metal joining, and machining processes.	15
CO2	Select the suitable metal casting and forming processes for a given product or component.	15
CO3	Suggest the suitable joining methods for fabrication / assembly of product.	15
CO4	Select a suitable process for machining of a given part.	15
CO5	Construct the mould using single and split piece pattern and prepare for casting.	10
CO6	Perform Arc/MIG/Spot welding and Brazing /Soldering.	10
CO7	Perform various operations in lathe, milling, drilling and grinding machines.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2, 2.2.3, 2.4.5, 3.2.4, 4.1.1
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 2.4.5, 3.2.4,4.3.2
CO3	TPS2	Understand	Respond	Guided Response	1.2, 2.2.3, 2.4.5, 3.2.4, 4.3.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 2.4.5, 3.2.4, 4.3.2
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 2.4.1, 2.4.2, 2.4.7, 3.1.2, 3.2.5,4.2.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 2.4.1, 2.4.2, 2.4.7, 3.1.2, 3.2.5,4.2.3
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 2.4.1, 2.4.2, 2.4.7, 3.1.2, 3.2.5,4.2.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	-	-	-	-	-	L	-	L	L
CO2	L	-	-	-	-	-	-	-	-	-	M	-	M	L
CO3	S	M	L	-	-	-	-	-	-	-	M	-	M	M
CO4	S	M	L	-	-	-	M	-	-	-	M	-	M	M
CO5	S	L	L	L	L	L	L	L	L	L	L	L	L	M
CO6	S	L	S	L	L	L	L	L	L	L	L	L	L	M
CO7	S	S	S	L	L	L	L	L	L	L	L	L	L	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	Model Examination	1	2	3	
Remember	20	20		-	-	-	20
Understand	40	40		-	-	-	40
Apply	40	40	100				40
Analyse	-	-	-				-
Evaluate	-	-	-				-
Create	-	-	-				-

**Theory Cum Practical Courses:**

There shall be three tests: the first two tests (Maximum 50 marks for each test) will be from theory component and the third test (Maximum 50 Marks) will be for practical component. The sum of marks of first two tests shall be reduced to 20 Marks and the third test mark shall be reduced to 20 marks. Average mark awarded for viva – voce, conduct of experiments, observation & results, record work in regular class works shall be reduced to 10 marks. The sum of these 50 Marks would be rounded to the nearest integer.



**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	Practical Component
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Give the classification of welding processes.
2. Define impact extrusion.
3. Write down any four operations performed by a shaper.

**Course Outcome 2 (CO2):**

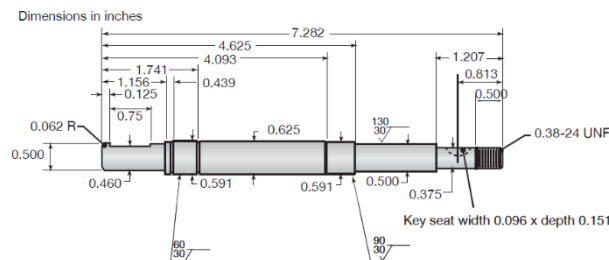
1. Select a suitable pressure die casting process for low melting point materials.
2. Suggest suitable metal forming process along with justification for manufacture of the following products:
  - i. (i). CAM shaft of IC Engine
  - ii. (ii). Threaded bolt
  - iii. (iii). Spur gears of Al
3. How is the following house hold articles produced? i) Can Tin and ii) Cups

**Course Outcome 3 (CO3):**

1. Suggest the suitable joining process for the manufacture of i) funnel made of MS sheet of 22 Gauge thickness and ii) PCB used in electronic products.
2. Suggest the suitable welding process for the following: i) Cast iron; ii) Aluminium alloy.
3. Select a suitable process to weld air craft body and explain with necessary sketches.

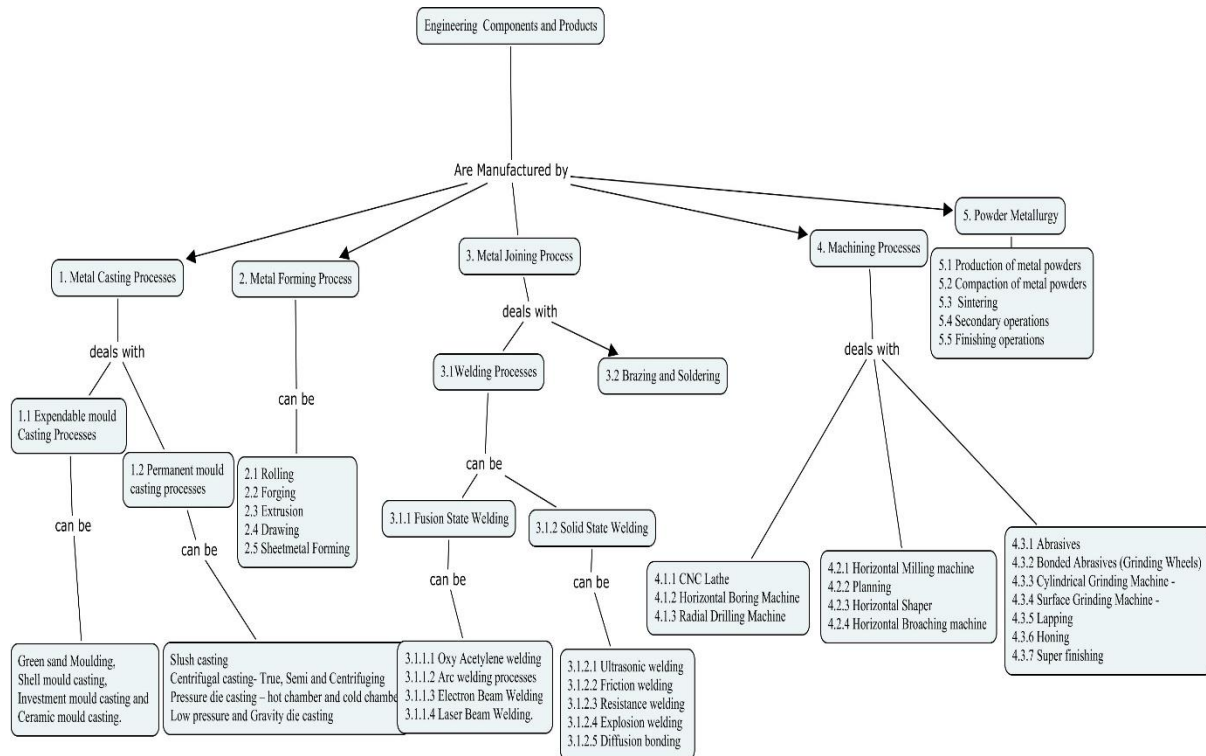
**Course Outcome 4 (CO4):**

1. How do you select a grinding wheel for the following materials?
  - a. (i).Aluminium
  - b. (ii). Copper
  - c. (iii) Steels
2. The part shown in the accompanying figure is a power-transmitting shaft; it is to be produced on a lathe. List the operations that are appropriate to make this part.



3. Sketch and describe the details of a broach used to machine an internal hole of  $\Phi$  10 mm diameter of specimen of size 250 x 150 x 25 mm.

### Concept Map



### Syllabus

#### (Working principles, Basic operations & Applications only)

**Manufacturing Processes-** Classification of Manufacturing Processes- Metal Casting- Metal Forming- Machining Processes- Metal Joining Processes- Metal Finishing Processes.

**Metal Casting Processes:** Expendable mould Casting Processes -Sand Casting - Shell moulding – Plaster Mould casting – Ceramic mould casting – Investment casting – Permanent Mold casting Processes – Slush casting – Pressure casting - Die casting - Centrifugal casting.

**Plastic forming Processes:** Plastics, general properties and applications of thermo plastics and thermosets, Extrusion, Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Transfer molding.

**Metal Forming Processes:** Flat Rolling – Flat Rolling Practice –Rolling Mills – Shape Rolling operations – Production of seamless tubing and pipe – Forging –Open die forging – Impression Die and Closed die forging – Related forging operations – Extrusion - Hot extrusion – Cold extrusion – Impact extrusion – Hydrostatic extrusion. **Sheet metal forming Processes:** Shearing – Sheet Metal characteristics – Bending sheet and plate.

**Metal Joining Processes:** Fusion Welding Processes-Oxy Acetylene welding - Arc welding processes: Consumable Electrode and Non-consumable Electrode – Electron Beam Welding – Laser Beam Welding. Solid State Welding Processes: - Ultrasonic welding – Friction welding – Resistance welding.

**Brazing, Soldering:** Introduction to Brazing and Soldering

**Machining processes for producing Round shapes**

Centre Lathe, Horizontal Boring Machine – Radial Drilling Machine.

**Machining processes for producing various shape**

Horizontal Milling machine – Shaper – Horizontal Broaching machine.

**Abrasive machining and finishing processes**

Abrasives – Bonded Abrasives (Grinding Wheels) – Cylindrical Grinding Machine - Surface Grinding Machine - Lapping – Honing - Super finishing.

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hours.	Cos
1	Preparation of Mould for sand casting using single piece pattern	2	CO5
2	Preparation of Mould for sand casting using split pattern	2	CO5
3	Preparation of Castings	2	CO5
4	Make a butt/lap/ corner/ Tee joint using the given metal strips in ARC welding	2	CO6
5	Make a butt/lap/ corner/ Tee joint using the given metal strips in MIG welding	2	CO6
6	Make a butt/lap/ corner/ Tee joint using the given metal strips in SPOT welding	2	CO6
7	Plain, Taper and Step turning in lathe	2	CO7
8	Grooving (UCD)and Thread (Left), and Thread (Right) in lathe	2	CO7
9	Spur / Helical Gear Cutting in Horizontal Milling Machine	2	CO7
10	Key Way Milling and Flat Milling in Vertical Milling Machine	2	CO7
11	Plain Grinding, Morse Taper Grinding in Grinding Machine	2	CO7
12	Drilling, Counter Boring and Tapping	2	CO7
13	Demonstration of 3D printing in RP Machine	2	CO5

**NOTE:**

- Minimum 12 Exercises are to be conducted.
- Students should be tested in any two exercises each 1½ hours duration in Continuous Assessment Test 3.
- Students should be tested in any one exercise either in casting /welding and one exercise in machining operation in lathe/milling/drilling/grinding.

**Learning Resources**

1. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Sixth Edition, PHI, 2010.
2. Mikell P.Groover "Fundamental of Modern Manufacturing", Wiley India Edition, Third Edition, Reprint, 2012.
3. E. Paul DeGarmo, J. T. Black and Ronald A. Kohser, "Degarmo's Materials and Processes in Manufacturing ", John Wiley & Sons, 11th Edition 2011.
4. Philip F. Oswald, and Jairo Munoz, "Manufacturing Process and systems", John Wiley India Edition, 9<sup>th</sup> Edition, Reprint 2008.
5. S. K. Hajra Choudhury, Nirjhar Roy, A. K. Hajra Choudhury, "Elements of Work shop Technology", Vol – II Manufacturing Processes, Media Promoters and Publishers Pvt. Ltd, 2009.
6. P.N.Rao, "Manufacturing Technology", Volume-2, Tata McGraw Hill, New Delhi, Third Edition, 2011.
7. P.C. Sharma, "A Text Book of Production Technology (Manufacturing Processes)", S. Chand & Company Ltd., New Delhi, Seventh Reprint, 2012.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	<b>Manufacturing Processes</b>		
1.1	Classification of Manufacturing Processes- Metal Casting- Metal Forming- Machining Processes- Metal Joining Processes- Metal Finishing Processes.	1	CO1
1.2	<b>Metal casting Processes</b> Expendable mould Casting Processes -Sand Casting Shell moulding – Plaster Mould casting	1	CO1
1.3	Ceramic mould casting – Investment casting Permanent Mould casting Processes – Slush casting	1	CO1
1.4	Pressure casting – Die casting – Centrifugal casting	1	CO1
1.5	Plastic forming Processes: Plastics, general properties and applications of thermo plastics and thermosets, Extrusion, Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Transfer molding.	1	CO1
2	<b>Metal Forming Processes</b>		
2.1	Production of seamless tubing and pipe	1	CO2
2.2	Forging –Open die forging, Impression Die and Closed die forging and related forging operations	1	CO2
2.3	Extrusion- Hot extrusion – Cold extrusion, Impact extrusion – Hydrostatic extrusion	1	CO2
2.4	Sheet metal forming Processes: Shearing, Sheet Metal characteristics – Bending sheet and plate	1	CO2
3	<b>Metal Joining Processes</b>		
3.1	Fusion Welding Processes-Oxy Acetylene welding	1	CO3
3.2	Arc welding processes: Consumable Electrode and Non consumable Electrode	1	CO3
3.3	Electron Beam Welding – Laser Beam Welding.	1	CO3
3.4	Solid State Welding Processes:- Ultrasonic welding, Friction welding – Resistance welding	1	CO3
3.5	Introduction to Brazing and Soldering	1	CO3
4	<b>Machining Processes</b>		
4.1	<b>Machining processes for producing Round shapes</b> Centre Lathe	1	CO4
4.1.1	Horizontal Boring Machine	1	CO4
4.1.2	Radial Drilling Machine	1	CO4
4.2	<b>Machining processes for producing various shape</b> Horizontal Milling machine	1	CO4
4.2.1	Shaper	1	CO4
4.2.2	Horizontal Broaching machine.	1	CO4
4.3	<b>Abrasive machining and Finishing processes</b> Abrasives – Bonded Abrasives (Grinding Wheels)	1	CO4
4.3.1	Cylindrical Grinding Machine - Surface Grinding Machine	1	CO4
4.3.2	Lapping – Honing - Super finishing	1	CO4

### Course Designers:

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<b>18MT270 ELECTRICAL MACHINES LABORATORY</b>	Category	L	T	P	Credit(s)
	PC	0	0	2	1

**Preamble**

The course is designed to provide students a widespread knowledge and understanding of the basic Electrical machines concepts and provide basic knowledge about its working and application. The indispensable and pervasive knowledge of electrical wiring and run the machine to understand the characteristics will give the students an insight to their practical approach in our daily life.

**Prerequisite**

- 18PHA20 - Physics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Analyse the characteristics of no load and load condition of various DC motors.	10
CO2	Analyse the characteristics of no load and load condition of various AC motors.	10
CO3	Analyse no load and load condition of DC Generators and practice the applications.	20
CO4	Formulate performance parameters of Electrical machines in different conditions.	20
CO5	Study and practice the function of different motor starters.	20
CO6	Select the suitable special machines for given real time application.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO4	TPS2	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS1	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO2	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO3	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO4	S	S	S	S	S	L	L	-	M	M	-	S	S	S
CO5	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO6	S	S	S	S	S	L	L	-	M	M	-	S	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	20	20
Apply	20	20
Analyse	40	40
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hours.	Cos
1	No load and Load Characteristics of DC Separately excited generator.	2	CO3
2	Load test on DC Series Motors	2	CO1
3	Speed control of DC Shunt motor	2	CO1
4	Study of AC and DC Starters.	2	CO5
5	Load test on Single phase Transformer	2	CO2
6	OC/SC test on single phase Transformer	2	CO2
7	Load test on Single phase Induction motor	2	CO2
8	Load test on Three phase DOL start Induction motor.	2	CO2,CO5
9	Load test on Three phase Star Delta start Induction motor.	2	CO2,CO5
10	Speed control of Induction motor using VFD.	2	CO2
11	Load test on Alternator.	2	CO2
12	Position and Speed control of Lead Screw using Stepper Motor.	2	CO6
13	Speed control of BLDC motor.	2	CO5,CO6
14	Study of Special machine characteristics.	2	CO6

### **Learning Resources**

1. Stephen J Chapman, "Electrical machines fundamentals" 4th edition. Tata McGraw hill,2005
2. Department Laboratory Manual

### **Course Designers:**

<b>Sl. No.</b>	<b>Name</b>	<b>E-mail Id</b>
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<b>18MT271 ELECTRICAL MACHINES LABORATORY</b>	Category	L	T	P	Credit(s)
	PC	0	0	2	1

### Preamble

Electric motors impact almost every aspect of modern living. Refrigerators, vacuum cleaners, air conditioners, fans, computer hard drives, automatic car windows, and multitudes of other appliances and devices all use electric motors to convert electrical energy into useful mechanical energy. In addition to running the common place appliances that we use every day, electric motors are also responsible for a very large portion of industrial processes. Electric motors are used at some point in the manufacturing process of nearly every conceivable product that is produced in modern factories. The systems that controlled electric motors in the past suffered from very poor performance and were very inefficient and expensive. In recent decades, the demand for greater performance and precision in electric motors, combined with the development of better solid-state electronics and cheap microprocessors has led to the creation of modern Adjustable speed drives.

The course is designed to provide the students a hands-on experience to understand the Characteristics of Electrical machines and its control which enables them to select the suitable motor for the given application.

### Prerequisite

- Nil

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Analyse the characteristics of no load and load condition of various DC motors.	10
CO2	Analyse the characteristics of no load and load condition of various AC motors.	10
CO3	Analyse no load and load characteristics of transformers and study applications of CT and PT.	20
CO4	Formulate performance parameters of Electrical machines in different conditions.	20
CO5	Study and practice the function of different motor starters.	20
CO6	Select the suitable special machines for given real time application.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4



CO4	TPS2	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS1	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO2	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO3	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO4	S	S	S	S	S	L	L	-	M	M	-	S	S	S
CO5	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO6	S	S	S	S	S	L	L	-	M	M	-	S	S	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Cut view of machines
Set	-
Guided Response	Characteristic study through experimentation.
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Orignation	-

### List of Experiments/Activities with CO Mapping

S.No	Exercises / Experiments	No of Hours.	Cos
1	Load test on DC Series Motors	2	CO1
2	Speed control of DC Shunt motor	2	CO1
3	Study of DOL and Star-Delta starting of Induction motor.	2	CO5
4	Load test on Single phase Transformer	2	CO3,CO5

5	OC/SC test on single phase Transformer	2	CO3,CO4
6	Characteristic study of CT and PT	2	CO3,CO4
7	Load test on Single phase Induction motor	2	CO2,CO5
8	Load test on Three phase Induction motor.	2	CO2,CO5
9	Speed control of Induction motor using VFD.	2	CO2
10	Position and Speed control of Stepper Motor.	2	CO6
11	Characteristics study of AC Servo motor	2	CO6
12	Speed control of BLDC motor.	2	CO5,CO6
13	Speed control of PMAC motor	2	CO6
14	Electrical control circuit Design using relay, timers, Solenoid, OLR and motor contactors.	2	CO5

### Learning Resources

1. Stephen J Chapman, "Electrical machines fundamentals" 4th edition. Tata McGraw hill,2005
2. Department Laboratory Manual

### Course Designers:

Sl. No.	Name	E-mail Id
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**18MT280****WORKSHOP**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

Workshop is a hands-on training practice to engineering students. The aim of this course is to impart fundamental hands-on skill in carrying out experiments at higher semester practical courses.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Select and use accurately various methods of wiring.	20
CO2	Accurately discriminate and use fuses and Circuit breakers	10
CO3	Make different types of wooden joints/sheet metal components	30
CO4	Select and make use of components in bread board and soldering in the PCBs	20
CO5	Accurately use the AFO and CRO in electronic circuits	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO2	TPS 3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO3	TPS 3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO2	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO3	S	M	M	M	L	L	L	-	-	-	-	L	L	M
CO4	S	S	S	S	S	L	L	-	M	M	-	S	S	S
CO5	S	M	M	M	L	L	L	-	-	-	-	L	L	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	Practical Component
Complex Overt Responses	
Adaptation	
Origination	

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hours.	Cos
1	Realization and selection of different fuses and Circuit breakers.	2	CO2
2	Wiring practices and testing. (Electrical and Electronics)	4	CO1
3	Structure cabling. (LAN)	2	CO1
4	Functionalities of RPS/AFO/CRO using Simple Analog Circuit.	2	CO5
5	Preparation of wooden parts like Door frame/Office tray Litre Cone/Dust pan (Straight, Taper)/Tray (Straight, Taper)	8	CO3
6	Identifying electronic components and understanding PCB glossary	2	CO4
7	Conversion of schematic into PCB layout and PCB fabrication	2	CO4
8	Practicing of soldering and desoldering	2	CO4
	Total	<b>24</b>	

**Learning Resources**

1. John K.C "Mechanical Workshop", Practice by Prentice Hall India Learning Private Limited, Second edition, 2010.

**Course Designers:**

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**18ES290****LATERAL THINKING**

Category	L	T	P	Credit(s)
ES	0	0	2	1

**Preamble**

The purpose of thinking is to collect information and to make the best possible use of it. Vertical thinking is concerned with proving or developing concept patterns. Lateral thinking is concerned with restructuring such patterns (insight) and provoking new ones (creativity). Lateral and vertical thinking are complementary. Skill in both is necessary. Although the emphasis in education has always been exclusively on vertical thinking, the need for lateral thinking arises from the limitations of the behaviour of mind as a self-maximizing memory system. Lateral thinking can be learned, practised and used. It is possible to acquire skill in it just as it is possible to acquire skill in mathematics. The course provides formal opportunities to practise lateral thinking and also an explanation of the processes involved.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the concept of lateral thinking, distinguish it from vertical thinking.	10
CO2	Use lateral thinking for problem solving	10
CO3	Generate Alternatives, challenge assumptions and suspend judgment and Practice lateral thinking in design process	20
CO4	Apply the concept of factorization and reversal method for restructuring	20
CO5	Organize brainstorming sessions	10
CO6	Use PO for innovation	10
CO7	Aware of limitation of established patterns and practice lateral thinking in small projects	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.3.1, 3.2.6
CO2	TPS3	Apply	Value	-	2.4.1, 2.4.2, 2.4.3
CO3	TPS3	Apply	Value	-	2.4.1, 2.4.2, 2.4.3, 2.4.5, 2.4.6
CO4	TPS3	Apply	Value	-	2.3.1, 2.4.2, 2.4.3
CO5	TPS4	Analyse	Organize	-	3.1.1, 3.1.2, 3.2.1, 3.2.2
CO6	TPS3	Apply	Value	-	2.1.4, 2.3.1, 2.4.1, 2.4.2, 2.4.3, 2.4.6
CO7	TPS5	Evaluate	Characterize	-	2.3.4, 4.5.1, 4.6.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	-	-	-	-	-	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	L
CO3	S	M	L	-	-	-	-	S	L	L	-	L
CO4	S	M	L	-	-	-	-	S	L	L	-	L
CO5	S	S	M	L	-	-	-	S	S	S	-	L
CO6	S	M	L	-	-	-	-					L
CO7	S	S	S	M	-	S	-	-	S	S	-	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain****Continuous Assessment**

Worksheets (5)	:	20 Marks
Case Studies (3)	:	30 Marks

**Terminal Examination**

Ability Test	:	50 Marks
Case Study (Best) Presentation and Viva Voce	:	50 Marks

**Syllabus**

The way the mind works, Difference between lateral and vertical thinking, Attitudes towards lateral thinking, Basic nature of lateral thinking, The use of lateral thinking Techniques, The generation of alternatives, Challenging assumptions, Innovation, Suspended judgment, Design, Dominant ideas and crucial factors, Fractionation, The reversal method, Brainstorming, Analogies, Choice of entry point and attention area, Random stimulation, Concepts/divisions/polarization, The new word PO, Blocked by openness, Description/problem solving/design

**Learning Resources**

1. Edward de Bono, "Lateral Thinking: Creativity Step by Step", Happer Collins Publisher, 1990.
2. Edward de Bono, "Six Thinking Hats", Little Brown and Company Publisher, 1985.
3. Edward de Bono's Thinking Course, Video Lecture, Weblink: [https://www.youtube.com/watch?v=AUq\\_AL2LNEw](https://www.youtube.com/watch?v=AUq_AL2LNEw)

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
1.	The way the mind works	1	CO1
1.1	Difference between lateral and vertical thinking	1	CO1
1.2	Attitudes towards lateral thinking	1	CO2
2.	Basic nature of lateral thinking	1	CO2
2.1	The use of lateral thinking techniques	1	CO2
2.2	The generation of alternatives	1	CO3
2.3	Challenging assumptions	1	CO3
2.4	Innovation	1	CO3
2.5	Suspended judgment	1	CO3
3.	Design	1	CO3
3.1	Dominant ideas and crucial factors	1	CO3
3.2	Fractionation	1	CO4
4.	The reversal method	1	CO4
4.1	Brainstorming	1	CO5
4.2	Analogies	1	CO5

4.3	Choice of entry point and attention area	1	CO5
4.4	Random stimulation	1	CO5
4.5	Concepts/divisions/polarization	1	CO5
4.6	The new word PO	2	CO6
5.	Blocked by openness	2	CO7
5.1	Description/problem solving/design	2	CO7

**Course Designers:**

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**18CHAA0****ENVIRONMENTAL SCIENCE**

Category L T P Credit(s)

AC 1 0 1 -

**Preamble**

The objective of this course is intended to make the students to understand the basic concepts of environment, ecology and pollution of the current environmental issues and to participate in various activities on conserving and protecting the environment.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the importance and progression of ecological system	15
CO2	Explain the significance of natural resources	10
CO3	Demonstrate the effects of pollution on environment and human beings	15
CO4	Practice the suitable management method during disaster episode	10
CO5	Explain the ethics and values related to Environment	15
CO6	Describe the Traditional values and Impact of modernization on Environment	10
CO7	Carry out group activities	25

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO Number	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,2.3.1,2.3.2,2.3.4
CO2	TPS2	Understand	Respond	Guided Response	1.1,2.3.1,2.3.2,2.3.4
CO3	TPS3	Apply	Value	Mechanism	1.1,2.1.1,2.1.5,2.4.1,4.1.2
CO4	TPS3	Apply	Value	Mechanism	1.1,2.4.1,2.4.7,4.1.1,4.1.2
CO5	TPS2	Understand	Respond	Guided Response	1.1,2.5.1,2.5.2,
CO6	TPS2	Understand	Respond	Guided Response	1.1,2.4.7,2.5.4,
CO7	TPS4	Analyse	Organise	Complex Overt Responses	3.1.1,3.1.2,3.1.3,3.1.4,4.1.1, 4.1.2



**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	-	-	-	-	L	S	-	-	-	-	-
CO2	M	-	-	-	-	L	-	L	-	-	-	-
CO3	M	M	-	-	L	M	S	-	-	-	-	-
CO4	M	-	L	L	L	M	M	-	-	-	-	-
CO5	L	-	-	-	-	-	-	M	-	-	-	-
CO6	L	L	-	-	-	-	M	-	-	-	-	-
CO7	S	M	M	M	M	M	-	-	S	M	M	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment #			Terminal Examination ***
	1	2	3	1	2	3	
Remember	-	20	-	NA	NA	NA	Presentation on Case study report
Understand	-	40	-				
Apply	-	40	-				
Analyse	-	-	-				
Evaluate	-	-	-				
Create	-	-	-				

# Assignment: Marks will be given for the review I, II & III of case study presentation.

\*\*\* Case study presentation and evaluation

- ❖ Each group comprise of maximum three students
- ❖ Students will submit the case study report similar to final year project report
- ❖ Evaluation of case study presentation is based on the approved rubrics

**Method of Evaluation****a) Internal assessment**

S.No	Description	Max.marks	Final conversion
1	CAT -II	50	40
2	Assignment marks ( from Review I,II & III)	3 X 10 =30	10
		Total	50

**b) End semester examination – Case study presentation**

Performance Index	Marks per Individual
Originality of the work	20
Data collected	20
Suggestion to overcome for the identified issues	20
Final Presentation	40
Total	100

**Model Titles for Case Study:**

1. Environmental impacts of quarry industries in Melur Taluk.
2. A study on impacts of tanneries on ground water and soil quality in Dindigul district.
3. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, Alagar Kovil.
4. Solid waste and waste water management in TCE hostel.

5. Environmental effect of Kudankulam atomic power plant.
6. Case study on effect of Sterlite industry.
7. Effect on ground water and soil quality by dyeing industries in Tiruppur.
8. Effect of textile wastes in Karur District.
9. Segregation of waste and its recycling by Madurai Municipality at Vellakkal
10. Effect of fire work waste on atmosphere in Sivakasi region

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Describe the Universal Energy flow model in an Ecosystem.
2. Discuss the conversion of one ecosystem into another ecosystem with example.
3. Explain the multidisciplinary nature of the environment.

**Course Outcome 2 (CO2):**

1. Summarize the importance of Natural resources to animals and human beings.
2. Describe the role of an individual in the conservation of Natural resources.

**Course Outcome 3(CO3):**

1. Demonstrate the effects and control measures of air pollution
2. Investigate the sources and management methods of e-waste.

**Course Outcome 4(CO4):**

1. Dramatize the mitigation methods adopted in severe cyclone affected areas.
2. Suggest the precautionary steps to prevent life from flood.

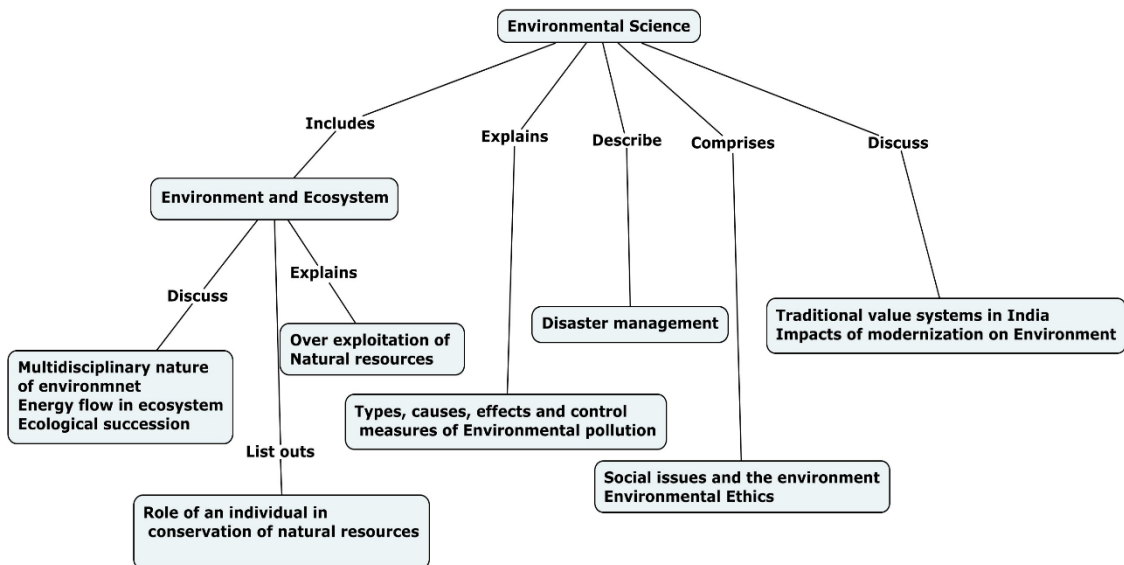
**Course Outcome 5 (CO5):**

1. Discuss the need for public awareness on environmental protection.
2. Identify the requirement for the equitable utilization of natural resources.

**Course Outcome 6(CO6):**

1. Describe the traditional value systems of India.
2. Recall the environmental related points discussed in our Indian Vedas.
3. List out the impacts of modernization on environment

**Concept Map**



## Syllabus

**Environment and Ecosystem** - Multidisciplinary nature of environment- Ecosystem- Energy flow in ecosystem-Ecological succession-Over exploitation of Natural resources-Role of an individual in conservation of natural resources. **Environmental pollution and control** - Environmental pollution – types, causes, effects and control measures - Disaster management strategies. **Environmental Ethics and Values** - Social issues and the environment -need for public awareness, Environmental Ethics- need for equitable utilization of natural resources-Traditional value systems in India, Impacts of modernization on Environment

### Awareness and actual activities:

- ✓ Group meeting on water management, promotion of recycle use, reduction of waste,
- ✓ Plantation
- ✓ Cleanliness drive
- ✓ Drive on segregation of waste
- ✓ Energy saving
- ✓ Lectures by Environmentalist
- ✓ Slogan and poster making event

## Learning Resources

1. Kaushik,A & Kaushik.C.P, Environmental Science and Engineering, 6<sup>th</sup> Edition, New Age International, 2018.
2. Erach Bharucha, Text book of Environmental studies for Undergraduate courses, 2<sup>nd</sup> Edition, UGC, 2013.
3. Gilbert M.Masters, Introduction to Environmental Engineering and Sciences, 2<sup>nd</sup> Edition, Pearson , 2004.
4. Garg S.K & Garg, Ecological and Environmental studies, Khanna Publishers, 2006.
5. Wright &Nebel, Environmental science towards a sustainable future, 8<sup>th</sup> Edition,Prentice Hall of India Ltd, 2002.
6. Documentary titled “HOME” by Yves Bertrand, Video Link: <https://www.youtube.com/watch?v=jqxENMKaeCU>

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	<b>Environment and Ecosystem</b>		
1.1	Multidisciplinary nature of environment-Ecosystem	1	CO1
1.2	Energy flow in ecosystem – Universal energy flow model	1	CO1
1.3	Ecological succession	1	CO1
1.4	Over exploitation of Natural resources	1	CO2
1.5	Role of individual in conservation of natural resources	1	CO2
2.0	<b>Environmental pollution and control</b>		
2.1	Environmental pollution – types( Air, Water,soil,Marine),	2	CO3
2.2	causes (gaseous, liquid, solid, plastic, e-waste, biomedical waste and radiations),	2	CO3
2.3	Effects and control measures of Pollution	2	CO3
2.4	Disaster managements during cyclone, Tsunami, flood, draught and earthquake	2	CO4
3.0	<b>Environmental Ethics and Values</b>		
3.1	Social issues and the environment -need for public awareness	1	CO5
3.2	Environmental Ethics- need for equitable utilization of natural resources	1	CO5

3.3	Traditional value systems in India,	1	CO6
3.4	Impacts of modernization on Environment	2	CO6
4.0	<b>Awareness and actual activities</b>		
4.1	Group meeting on water management, promotion of recycle use, reduction of waste	2	CO7
4.2	Plantation	1	CO7
4.3	Cleanliness drive	1	CO7
4.4	Drive on segregation of waste	1	CO7
4.5	Energy saving	1	CO7
4.6	Lectures by Environmentalist	1	CO7
4.7	Slogan and poster making event	Through online	CO7

**Course Designers:**

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18ES290	LATERAL THINKING	Category	L	T	P	Credit
		ES	0	0	2	1

### Preamble

The purpose of thinking is to collect information and to make the best possible use of it. Vertical thinking is concerned with proving or developing concept patterns. Lateral thinking is concerned with restructuring such patterns (insight) and provoking new ones (creativity). Lateral and vertical thinking are complementary. Skill in both is necessary. Although the emphasis in education has always been exclusively on vertical thinking, the need for lateral thinking arises from the limitations of the behaviour of mind as a self-maximizing memory system. Lateral thinking can be learned, practised and used. It is possible to acquire skill in it just as it is possible to acquire skill in mathematics. The course provides formal opportunities to practise lateral thinking and also an explanation of the processes involved.

### Prerequisite

NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO #	Course Outcome Statement	Weightage in %
CO1	Explain the concept of lateral thinking, distinguish it from vertical thinking.	10
CO2	Use lateral thinking for problem solving	10
CO3	Generate Alternatives, challenge assumptions and suspend judgment and Practice lateral thinking in design process	20
CO4	Apply the concept of factorization and reversal method for restructuring	20
CO5	Organize brainstorming sessions	10
CO6	Use PO for innovation	10
CO7	Aware of limitation of established patterns and practice lateral thinking in small projects	20

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.3.1, 3.2.6
CO2	TPS3	Apply	Value	-	2.4.1, 2.4.2, 2.4.3
CO3	TPS3	Apply	Value	-	2.4.1, 2.4.2, 2.4.3, 2.4.5, 2.4.6
CO4	TPS3	Apply	Value	-	2.3.1, 2.4.2, 2.4.3
CO5	TPS4	Analyse	Organize	-	3.1.1, 3.1.2, 3.2.1, 3.2.2
CO6	TPS3	Apply	Value	-	2.1.4, 2.3.1, 2.4.1, 2.4.2, 2.4.3, 2.4.6
CO7	TPS5	Evaluate	Characterize	-	2.3.4, 4.5.1, 4.6.1

### Mapping with Programme Outcomes and Programme Specific Outcomes

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	-	-	-	-	-	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	L
CO3	S	M	L	-	-	-	-	S	L	L	-	L
CO4	S	M	L	-	-	-	-	S	L	L	-	L
CO5	S	S	M	L	-	-	-	S	S	S	-	L
CO6	S	M	L	-	-	-	-					L
CO7	S	S	S	M	-	S	-	-	S	S	-	S

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain****Continuous Assessment**

Worksheets (5)	:	20 Marks
Case Studies (3)	:	30 Marks

**Terminal Examination**

Ability Test	:	50 Marks
Case Study (Best) Presentation and Viva Voce	:	50 Marks

**Syllabus**

The way the mind works, Difference between lateral and vertical thinking, Attitudes towards lateral thinking, Basic nature of lateral thinking, The use of lateral thinking Techniques, The generation of alternatives, Challenging assumptions, Innovation, Suspended judgment, Design, Dominant ideas and crucial factors, Fractionation, The reversal method, Brainstorming, Analogies, Choice of entry point and attention area, Random stimulation, Concepts/divisions/polarization, The new word PO, Blocked by openness, Description/problem solving/design

**Learning Resources**

1. Edward de Bono, "Lateral Thinking: Creativity Step by Step", Happer Collins Publisher, 1990.
2. Edward de Bono, "Six Thinking Hats", Little Brown and Company Publisher, 1985.
3. Edward de Bono's Thinking Course, Video Lecture, Weblink: [https://www.youtube.com/watch?v=AUq\\_AL2LNEw](https://www.youtube.com/watch?v=AUq_AL2LNEw)

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
1.	The way the mind works	1	CO1
1.1	Difference between lateral and vertical thinking	1	CO1
1.2	Attitudes towards lateral thinking	1	CO2
2.	Basic nature of lateral thinking	1	CO2
2.1	The use of lateral thinking techniques	1	CO2
2.2	The generation of alternatives	1	CO3
2.3	Challenging assumptions	1	CO3
2.4	Innovation	1	CO3
2.5	Suspended judgment	1	CO3
3.	Design	1	CO3
3.1	Dominant ideas and crucial factors	1	CO3
3.2	Fractionation	1	CO4
4.	The reversal method	1	CO4
4.1	Brainstorming	1	CO5
4.2	Analogies	1	CO5
4.3	Choice of entry point and attention area	1	CO5
4.4	Random stimulation	1	CO5
4.5	Concepts/divisions/polarization	1	CO5
4.6	The new word PO	2	CO6
5.	Blocked by openness	2	CO7
5.1	Description/problem solving/design	2	CO7

**Course Designers:**

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SYLLABI

For

**B.E. Mechatronics Program**

Third Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

**18MT310 PARTIAL DIFFERENTIAL EQUATIONS**

Category	L	T	P	Credit(s)
BS	3	0	0	3

**Preamble**

Many physical processes fundamental to science and engineering are governed by partial differential equations (PDE) that is equations involving partial derivatives. The most familiar of these processes are heat conduction and wave propagation. To describe such phenomena, we make assumptions about gradient and we write down balance equations; PDE are those produced in a natural way. The equations of fluid flow are PDE's, and are widely used in aeronautical engineering, acoustics, study of ground water flows in civil engineering, development of fluid handling devices in mechanical engineering and investigating flame and combustion processes in chemical engineering. Stress analysis is important in large area of civil and mechanical engineering which requires a complicate set of PDE's. The goal for this course is to gain the skill of using Fourier series and learning to apply Fourier series to solve PDE's. More over we aim to gain the ability to form PDE and solve them. The emphasis is to solve the heat equation and wave equation.

**Prerequisite**

- 18MA110 - Engineering Calculus
- 18MA210 - Matrices and ordinary differential equations

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Understand the concept of periodic functions, Fourier series and half range series.	10%
CO2	Obtain the periodic functions arising in the study of engineering problems in terms of Sines and Cosines or complex exponentials by using Fourier series.	15%
CO3	Formulate and Solve Partial Differential Equations (linear, nonlinear, homogeneous and non-homogeneous) by various methods.	25%
CO4	Understand the concept of hyperbolic, parabolic and elliptic type of partial differential equations.	10%
CO5	Solve the boundary value problems arising in engineering problems involving one dimensional vibration problems, one dimensional heat flow problems by Fourier series.	20%
CO6	Solve the boundary value problems arising in engineering problems represented by two dimensional heat flow problems by Fourier series.	20%

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	K2	A2		1.1
CO2	TPS3	K3	A3		1.1
CO3	TPS3	K3	A3		1.1
CO4	TPS2	K2	A2		1.1
CO5	TPS3	K3	A3		1.1, 2.1
CO6	TPS3	K3	A3		1.1, 2.1



### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	-	-	-	-	-	-	M	-	M	L	L
CO2	S	S	S	-	-	-	-	-	-	M	-	M	L	L
CO3	S	S	S	-	-	-	-	-	-	M	-	M	L	L
CO4	S	S	S	-	-	-	-	-	-	M	-	M	L	L
CO5	S	S	S	-	-	-	-	-	-	M	-	M	L	L
CO6	S	S	S	-	-	-	-	-	-	M	-	M	L	L

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	10
Understand	30	30	30	-	-	-	30
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. Define root mean square value.
2. Write Parseval's identity for half range sine and cosine series.
3. Find half range cosine and sine series for  $f(x) = e^{ax}$ ,  $0 < x < \pi$ .

#### Course Outcome 2(CO2):

1. Find the Complex form of the Fourier series for  $f(x) = e^{ax}$ ,  $-\pi < x < \pi$ .
2. Compute the first three harmonics of f(x) from the following data.

$x^0$	0	30	60	90	120	150	180	210	240	270	300	330
Y=f(x)	1.8	1.1	0.3	0.16	0.5	1.3	2.16	1.25	1.3	1.52	1.76	2

3. Express  $f(x) = x^2$  as a Fourier series of periodicity  $2\pi$  in  $-\pi < x < \pi$ . Hence deduce

$$\text{that (i) } \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \dots = \frac{\pi^2}{6}, \quad \text{(ii) } \frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \dots = \frac{\pi^2}{12} \quad \text{(iii)}$$

$$\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \dots = \frac{\pi^2}{8}$$

#### Course Outcome 3(CO3):

1. Predict the PDE by eliminating arbitrary function from  $z = f\left(\frac{xy}{z}\right)$ .
2. Identify the general solution for  $(D^2 + D'^2)z = 0$ .
3. Solve:  $[D^3 - 7DD'^2 - 6D'^3]z = \sinh(2x - 3y)$ .

**Course Outcome 4 (CO4):**

1. Classify the PDE  $\frac{\partial^2 y}{\partial x^2} = \frac{1}{\alpha^2} \frac{\partial^2 y}{\partial t^2}$
2. Classify the PDE  $\frac{\partial^2 y}{\partial x^2} = \frac{1}{\alpha^2} \frac{\partial y}{\partial t}$
3. Classify the PDE  $\frac{\partial^2 y}{\partial x^2} + \frac{\partial^2 y}{\partial t^2} = 0$

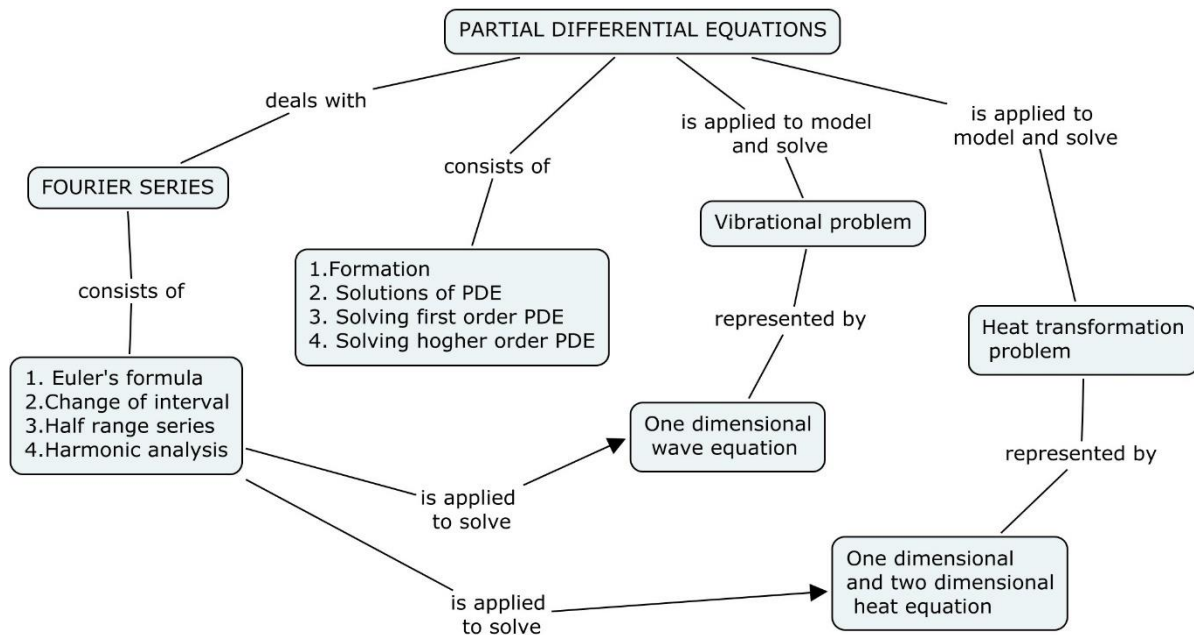
**Course Outcome 5 (CO5):**

1. A taut string of length  $2l$ , fastened at both ends, is disturbed from its position of equilibrium by imparting to each of its points an initial velocity of magnitude  $k(2lx - x^2)$ . Find the displacement  $y(x, t)$ .
2. A taut string of length  $2l$  is fastened at both ends. The midpoint of the string is taken to a height  $b$  and then released from the rest in that position. Find the displacement of the string.
3. A rod 30 cm long has its ends A and B kept at  $20^\circ\text{C}$  and  $80^\circ\text{C}$  respectively, until steady state conditions prevail. The temperature at each end is then suddenly reduced to  $0^\circ\text{C}$  and kept so. Find the resulting temperature function  $u(x, t)$ .

**Course Outcome 6 (CO6):**

1. A plate, in the form of a ring, is bounded by the lines  $r = 2$  and  $r = 4$ . Its surfaces are insulated and the temperature along the boundaries are given by  $u(2, \theta) = 10 \cos \theta + 6 \sin \theta$ ;  $u(4, \theta) = 17 \cos \theta + 15 \sin \theta$ . Find the most general form of the temperature distribution in the plate.
2. A rectangular plate of sides  $a$  and  $b$  has its faces and the edges  $y = 0$  and  $y = b$  insulated. If the edge  $x = 0$  is kept at temperature zero, while the edge  $x = a$  is kept at temperature  $k(2y - b)$ , find the steady state temperature distribution in the plate.
3. An infinite long plate is bounded by two parallel edges and an end at right angles to them. The breadth is  $\pi$ . This end is maintained at a constant temperature  $u_0$  at all points and the other edges are at zero temperature. Find the steady state temperature at any point of the plate

## Concept Map



## Syllabus

**Fourier Series:** Conditions for Fourier expansion - Euler's formula – Functions having points of discontinuity - Change of interval - Odd and even function – Expansions of odd or even periodic functions – Half range series – Fourier series of typical wave forms - Parseval's formula – Complex form of Fourier series – Harmonic analysis.

**Partial differential equations(PDE):** Formation of PDE – Solutions of PDE – Equations solvable by direct integration – Linear equations of the first order – Non linear equations of the first order – Homogeneous linear equations with constant coefficients – Rules for finding the complementary functions - Rules for finding the particular integral - working procedure to solve homogeneous and non homogeneous linear equations.

**Boundary value problems:** Method of separation of variables – Vibrations of a stretched string – Wave equations – One dimensional heat flow problems – two dimensional heat flow problems – Solution of Laplace equation in Cartesian coordinates – Laplace equations in polar coordinates.

## Learning Resources

1. Grewal. B.S, **Higher Engineering Mathematics**, 41<sup>st</sup> Edition, Khanna Publications, Delhi, 2011.
2. Erwin Kreyszig, **Advanced Engineering Mathematics**, 8<sup>th</sup> Edition, John Wiley & Sons, 2009.
3. Glyn James, **Advanced modern engineering mathematics**, fourth edition, Pearson education limited, 2011.
4. T.Veerarajan, **Engineering Mathematics**, 3<sup>rd</sup> Edition, Tata McGraw Hill, New Delhi, 2004.
5. B.V.Ramana, **Higher Engineering Mathematics**, Tata McGraw Hill, New Delhi.

### Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	Course Outcome
<b>1</b>	<b>Fourier Series</b>		
1.1	Conditions for Fourier expansion, Euler's formula, Functions having points of discontinuity	2	CO1
1.2	Change of interval, Odd and even function, Expansions of odd or even periodic functions	2	CO2
1.3	Half range series, Fourier series of typical wave forms, Parseval's formula	2	CO1
1.4	Complex form of Fourier series	1	CO2
1.5	Harmonic analysis	2	CO2
<b>2</b>	<b>Partial differential equations(PDE)</b>		
2.1	Formation of PDE, Solutions of PDE	2	CO3
2.2	Equations solvable by direct integration, Linear equations of the first order, Non linear equations of the first order	2	CO3
2.3	Homogeneous linear equations with constant coefficients, Rules for finding the complementary functions	2	CO3
2.4	Rules for finding the particular integral	2	CO3
2.5	working procedure to solve homogeneous and non homogeneous linear equations	1	CO3
<b>3</b>	<b>Boundary value problems</b>		
3.1	Method of separation of variables	2	CO4
3.2	Vibrations of a stretched string, Wave equations	4	CO5
3.3	One dimensional heat flow problems with zero boundary conditions	3	CO5
3.4	One dimensional heat flow problems with non zero boundary conditions	3	CO5
3.5	Solution of Laplace equation Cartesian coordinates	3	CO6
3.6	Laplace equations in polar coordinates	3	CO6
	<b>Total</b>	<b>36</b>	

### Course Designers:

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1	Dr.R.Suresh	suresh080183@tce.edu
2	Dr.C.S.Senthil kumar	kumarstays@tce.edu

18MT320

**KINEMATICS AND DYNAMICS OF  
MACHINERY**Category L T P Credit(s)  
PC 3 0 0 3**Preamble**

Kinematics is a subject which deals with relative motion between the various parts of the moving elements in a machinery. Machines are used to transform the available form of energy into other form, which transmits both force and motion to produce the specific operation. Kinematics of machines deals with the theoretical aspect such as the relative motion of the various parts of the machine. Dynamics of machinery deals with the analysis of forces and couples on the members of the machine due to external forces due to accelerations of machine elements.

**Prerequisite**

- 18MA110 - Engineering Calculus
- 18MT240 - Free Body Mechanics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop skills for design and analyze the linkages, mechanism and its inversions	10
CO2	Determine the velocity and acceleration for simple mechanism	20
CO3	Construct the turning moment diagram for flywheel	10
CO4	Develop the cam profile for three types of follower	25
CO5	Design gear and gear trains for a given input/output motion or force relationship	25
CO6	Determine the natural frequency of longitudinal, transverse and torsional vibrations	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception, Set	1.1,1.2,1.3,1.4,1.5,1.6,1.7
CO2	TPS3	Apply	Value	Mechanism	2.1.1, 2.2.1,3.1,3.2,3.3
CO3	TPS3	Apply	Value	Mechanism	4.1,4.2,4.3
CO4	TPS3	Apply	Value	Mechanism	5.1,5.2
CO5	TPS3	Apply	Value	Mechanism	6.1,6.2,6.3,6.4,6.5,6.6
CO6	TPS3	Apply	Value	Mechanism	7.1,7.2,7.3,7.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	L	L	-	-	-	-	-	-	-	-	S	M
CO2	S	M	L	L	-	-	-	-	-	-	-	-	S	M
CO3	M	S	L	L	-	-	-	-	-	-	-	-	S	M
CO4	S	M	L	L	-	-	-	-	-	-	-	-	S	M
CO5	S	M	L	L	-	-	-	-	-	-	-	-	S	M
CO6	M	M	L	L	-	-	-	-	-	-	-	-	S	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Mini Project	Terminal Examination
	1	2	3		
Remember	20	20	20	100	20
Understand	20	20	20		20
Apply	60	60	60		60
Analyse	-	-	-		-
Evaluate	-	-	-		-
Create	-	-	-		-

**Assessment Pattern: Psychomotor**

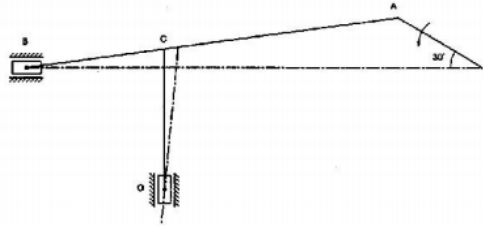
Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	MiniProject
Complex Overt Responses	
Adaptation	
Orignation	

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define Kinematic Link. Give examples for Kinematic links.
2. Define kinematic pair
3. Define Kinematic chain.

**Course Outcome 2(CO2):**

1. The crank of a slider crank mechanism rotates clockwise at a constant speed of 300rpm. The crank is 15 cm and the connecting rod is 600 mm long. Determine (a) linear velocity and acceleration of the midpoint of the connecting rod and (b) angular velocity and angular acceleration of the connecting rod at crank angle of  $45^\circ$  from the inner dead centre position.
2. In a four link mechanism, the dimensions of the links are AB=200 mm, BC=400mm, CD=450 mm and AD=600mm. At the instant when  $\angle DAB=90^\circ$ , the link AB has angular velocity of 36 rad/s in the clockwise direction. Determine (i) The velocity of point C, (ii) The velocity of point E on the link BC When BE =200 mm (iii) the angular velocities of links BC and CD, iv) acceleration of link BC.
3. The dimensions of the various links of a mechanism, as shown in fig. are as follows: OA=300 mm; AB=1200; BC=450 mm and CD=450 mm. if the crank OA rotates at 20 r.p.m. in the anticlockwise direction and gives motion to the sliding blocks B and D, find, for given configuration: (1) Velocity of sliding at B and D, (2) Angular velocity of CD (3) Linear acceleration of D and (4) angular acceleration of CD.

**Course Outcome 3(CO3):**

- The areas above and below the mean torque line for an I.C engine are -25,+200,-100,+150,-300,+150 and -75 mm<sup>2</sup> taken in order. The scale for the turning moment diagram is 1 mm vertical scale = 10Nm and 1 mm horizontal scale = 1.50. The mass of the rotating parts are 45 kg with a radius of gyration of 150 mm. if the engine speed is 1500 r.p.m, find the co-efficient of fluctuation of speed.
- The turning moment diagram of an engine rotating at 200rpm is given by the relation  $T(\text{kN-m}) = 15 + 8 \sin 2\theta - 2 \cos 2\theta$  where  $\theta$  is the crank angle. External resistance is constant. A flywheel weighing 20kN is fitted on the engine shaft so that the total fluctuation of speed does not exceed 1%. Determine the least value of moment of inertia of the fly wheel and the radius of gyration.
- The crank and connecting rod of a vertical single cylinder gas engine running at 1800rpm are 60mm and 240mm respectively. The diameter of the piston is 80mm and the mass of the reciprocating parts is 1.2kg. At a point during the power stroke when the piston has moved 20mm from the top dead centre position, the pressure on the piston is 800kN/m<sup>2</sup>. Determine the
  - Net force on the piston
  - Thrust in the connecting rod
  - Thrust on the sides of cylinder walls
  - Engine speed at which the above values are zero

**Course Outcome 4 (CO4):**

- A cam is used in a IC engine to operate the valves, is required to give a roller follower the motion defined below:
  - Follower to move outwards through 40 mm during 120° of cam rotation
  - Follower to move dwell for next 60° of cam rotation
  - Follower to return to its starting position during next 90° of cam rotation
  - Follower to dwell for the rest of the cam rotation.

The minimum radius of the cam is 50 mm and the diameter of the roller is 10mm. The line of the stroke of the follower is off-set by 20 mm from the axis of the cam shaft. The displacement of the follower takes place with uniform velocity. Create the cam profile for the given configurations. Also determine the maximum acceleration and velocity during ascent and decent when the cam rotates at 1000 r.p.m.
- A cam is rotating clockwise at a uniform speed is required to give a roller follower the motion defined below:
  - Follower to move outwards through 30 mm during 120° of cam rotation ,
  - Follower to move dwell for next 60° of cam rotation ,
  - Follower to return to its starting position during next 90° of cam rotation
  - Follower to dwell for the rest of the cam rotation.

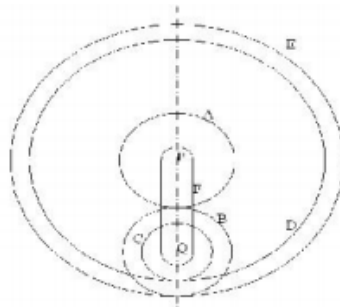
The minimum radius of the cam is 45 mm and the diameter of the roller is 20mm. The line of the stroke of the follower is off-set by 10 mm from the axis of the cam shaft. The displacement of the follower is to take place with simple harmonic motion on both the outward and return stroke. Create the cam profile for the given configurations. Also

determine the maximum acceleration and velocity during ascent and decent when the cam rotates at 1500 r.p.m.

3. Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam =25 mm; lift=30mm; Roller diameter= 15mm. The cam lifts the follower for 120° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 150° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 RPM. Calculate the maximum velocity and acceleration of follower during the descent period.

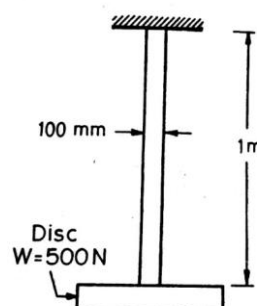
#### Course Outcome 5 (CO5):

1. A pair of spur gear with involute teeth is to give a gear ratio of 4:1. The arc of approach is not be less than the circular pitch and the smaller wheel is the driver. The angle of pressure is 14.5. Determine
  - i) least number of teeth can be used on each wheel
  - ii) addendum of the wheel in terms of circular pitch
2. An epicyclic gear train, an arm carries two gears A and B having no of teeth 36 and 45 respectively. If the arm rotates at 150 rpm in the clockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 300 rpm in the clockwise direction, what will be the speed of gear B
3. A compound epicyclic gear is shown in figure. The gears A, D and E are free to rotate on axis P. The compound gears B and C rotate together on the axis Q at the end of arm F. All the gears have equal pitch. The number of external teeth on gears, A B and C are 18, 45 and 21 respectively. The gears D and E are annulus gears. The gear A rotates at 100 rpm in anticlockwise direction and the gear D rotates at 450 rpm clockwise. Find the speed and direction of the arm and the gear E



#### Course Outcome 6(CO6):

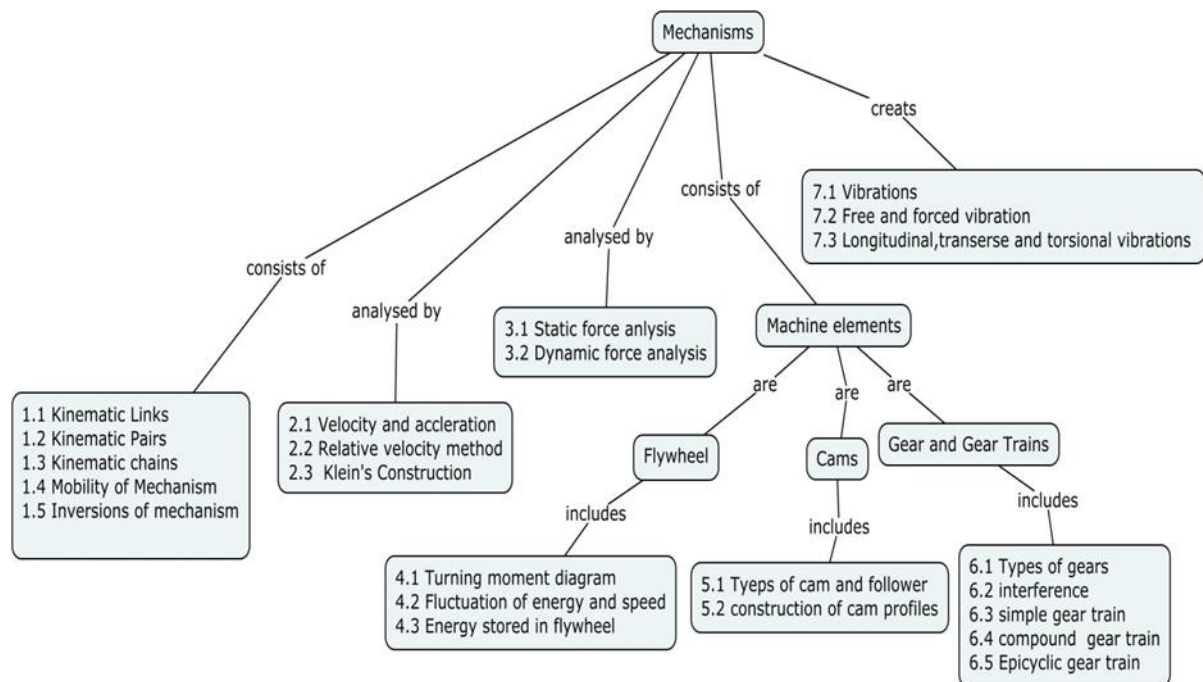
1. A vertical shaft 100mm in diameter and 1m in length has its upper end fixed at the top as shown in figure. At the other end it carries a disc of weight 500N. The Modulus of elasticity of the material of the shaft is  $2 \times 10^5 \text{ N/mm}^2$ . Neglecting the weight of the shaft, determine the frequency of longitudinal vibrations and transverse vibrations.





2. A Simply supported shaft of length 800mm carries a mass of 60kg placed 250mm from one end.  $E=200\text{GN/m}^2$  and diameter of shaft is 50mm, then find the natural frequency of transverse vibrations.
3. A cantilever shaft 50mm diameter and 300 mm long has a disc of mass 100kg at its free end. The young's modulus for the shaft material is  $200\text{GN/m}^2$ . Determine the frequency of longitudinal and transverse vibrations of the Shaft.

### Concept Map



### Syllabus

**Elements of machines and mechanism:** Introduction, Links-types, Kinematics pairs-classification, Constraints-types, Degree of Freedom, Grubler's equation, linkage mechanisms, inversions of four bar linkage, slider crank chain and double slider crank chain.

**Velocity in Mechanisms:** Velocity diagram - Slider Crank and Four Bar mechanism, relative velocity method

**Acceleration in Mechanisms:** Acceleration diagram, Slider Crank and Four Bar mechanism Klein's construction for Slider Crank mechanism

**Force Analysis:** Static force analysis of linkages, Equivalent offset inertia force, Dynamic analysis of slider crank mechanism.

**Turning moment diagrams:** Fluctuation of energy and speed, coefficient of fluctuation of energy and speed, Energy stored in a Flywheel, Dimensions of the flywheel rim.

**Cams and followers:** classification of cam & follower, pressure angle evaluation, cam profile for constant velocity, SHM and constant acceleration and retardation motion with knife edge and roller followers.

**Gears & Gear trains:** Classification, law of gearing, forms of tooth, interference, under cutting, minimum number of teeth on gear and pinion to avoid interference, contact ratio, simple, compound Epicyclic gear trains and Differential gears.

**Vibrations:** Introduction - Types of Vibration – Free and forced vibration, longitudinal, transverse and torsional vibrations

### Learning Resources

1. Gordon R. Pennock & Joseph E. Shigley John J. Uicker “**Theory of Machines and Mechanisms**”, Fourth Edition, Oxford University Press, 2014.
2. Cho W.S. To, “**Introduction to Kinematics and Dynamics of Machinery (Synthesis Lectures on Mechanical Engineering)**” Morgan & Claypool Publishers (30 December 2017) ISBN-10: 1681731754
3. Rattan.S.S, “Theory of Machines”, Tata McGraw–Hill Publishing Co., New Delhi, Fourth edition, 2017
4. Thomas Bevan, “**Theory of Machines**”, CBS – Third Edition, 2010.
5. Singh, V.P., “**Theory of Machines**”, Dhanpat Rai & Co., (P) Ltd., New Delhi, 2011.
6. Sadhu Singh, “**Theory of Machines**”. Pearson Education, New Delhi, 2009.
7. Ashok G.Ambekar, “**Mechanism and Machine theory**”, Prentice Hall of India , New Delhi, 2011.
8. Ballaney, P.L., “**Theory of Machines**”, Khanna Publishers, New Delhi, 2002.
9. Web resources :<http://nptel.ac.in/courses/112104121/>

### Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures	Course Outcome
1	<b>Elements of machines and mechanism</b>		
1.1	Kinematic link	1	CO1
1.2	Kinematic pairs		CO1
1.3	Kinematic chains – Mechanism	1	CO1
1.4	Mobility of mechanism	1	CO1
1.5	Inversions of Four bar chain	1	CO1
1.6	Inversions of Single slider crank chain mechanisms	2	CO1
1.7	Inversions of double slider crank chain mechanisms	2	CO1
2	<b>Velocity &amp; Acceleration in Mechanisms:</b>		
2.1	Relative velocity method	1	CO2
2.1.1	Velocity and acceleration of four bar mechanisms and Single slider crank chain Mechanisms	2	CO2
2.2	<b>Klein’s construction</b>		CO2
2.2.1	Velocity and acceleration of Single slider crank chain Mechanisms	1	CO2
3	<b>Force Analysis</b>		CO2
3.1	Static force analysis of linkages	2	CO2
3.2	Equivalent offset inertia force		CO2
3.3	Dynamic analysis of slider crank chain mechanism. Piston and Crank effort, Inertia, Torque,	2	CO2
4	<b>Turning moment diagrams</b>		CO3

S.No.	Topics	No. of Lectures	Course Outcome
4.1	Turning moment diagrams	2	CO3
4.2	Fluctuation of energy and speed, coefficient of fluctuation of energy and speed	1	CO3
4.3	Energy stored in a Flywheel, Dimensions of the flywheel rim	1	CO3
5	<b>Cams</b>		CO4
5.1	Types of cams and followers - Cam Nomenclature- Displacement, velocity and acceleration curves for various types of motions of follower- pressure angle evaluation in CAM profile	2	CO4
5.2	Construction of cam profiles- Knife edge followers - Roller follower - -Uniform Velocity Motion- Uniform Acceleration And Retardation Motion	2	CO4
6	<b>Gear and Gear trains</b>		CO5
6.1	General profiles of gears-Terminology of gears and types	1	CO5
6.2	law of gearing, forms of tooth	2	CO5
6.3	Interference, under cutting		CO5
6.4	Minimum number of teeth on gear and pinion to avoid interference, contact ratio	2	CO5
6.5	Simple, Compound Gear trains	1	CO5
6.6	Epicyclic gear trains- Differential gears	1	CO5
7	<b>Vibrations</b>		
7.1	Types of Vibration	1	CO6
7.2	Free Vibration	2	CO6
7.3	Forced Vibration	1	CO6
7.4	Longitudinal, transverse and torsional vibrations	1	CO6
	<b>Total</b>	36 Hours	

**Course Designers:**

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18MT330

DIGITAL ELECTRONICS

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Digital systems encompass the circuits, that process signals by discrete bands of analog levels, rather than by continuous ranges (as used in analog electronics). All levels within a band represent the same signal state. Because of this discretization, relatively small changes to the analog signal levels due to manufacturing tolerance, signal attenuation or parasitic noise do not leave the discrete envelope, and as a result are ignored by signal state sensing circuitry. In most cases the number of these states is two, and they are represented by two voltage bands: one near a reference value typically termed as "ground", and the other a value near the supply voltage. These correspond to the "false" ("0"), and "true" ("1"), values of the Boolean domain, respectively, yielding binary code. Digital electronic circuits are usually made from large assemblies of logic gates. Computer controlled digital systems can be controlled by software, allowing new functions to be added without changing hardware

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the different number systems and coding schemes and arithmetic operations on binary numbers	10
CO2	Explain the basic theorems and properties of Boolean algebra	10
CO3	Utilize K- Map for gate level minimization of the given Boolean function	10
CO4	Construct combinational logic circuits for the given requirement	30
CO5	Construct synchronous and asynchronous sequential logic circuits for the given requirement	40

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.1.5,2.4.3
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.1.5,2.4.3
CO3	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.1.5,2.4.3
CO4	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.1.5,2.4.3,4.4.4, 4.5.2,4.5.5
CO5	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.1.5,2.4.3,4.4.4, 4.5.2,4.5.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	-	-	-	-	-	-	-	-	-	M	M	L
CO2	M	M	-	-	-	-	-	-	-	-	-	M	M	L
CO3	M	M	L	-	-	-	-	-	-	-	-	M	S	L
CO4	S	M	S	M	M	L	-	-	-	-	-	S	S	S
CO5	S	M	S	M	M	L	-	-	-	-	-	S	S	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	40	40	40	50	-	-	40
Apply	20	40	40	50	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	Assignment / Quiz
Mechanism	Assignment
Complex Overt Responses	
Adaptation	
Origination	

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- Convert the given BCD number to Decimal number and hexadecimal number.  
1001 0011 1011
- Perform the following binary operations:  
10110110+10111000  
11111000-10101010
- Convert the given hexa-decimal numbers to binary numbers:  
9BC2, FDA5

#### Course Outcome 2(CO2):

- Simplify the given logic expression using Demorgan's theorem:  
 $Y=(A+B+(AB)'+CD)'$
- Prove the commutative and distributive laws in Boolean algebra.
- Simplify the given logic expression:  
 $Y=ABC+AB'C+A'B'C'+AB'C'$

#### Course Outcome 3(CO3):

- Simplify the logic function  $F(A,B,C,D)=\sum m(0,1,2,5,6,8,)+d(3,4,7,14)$  using K-map in

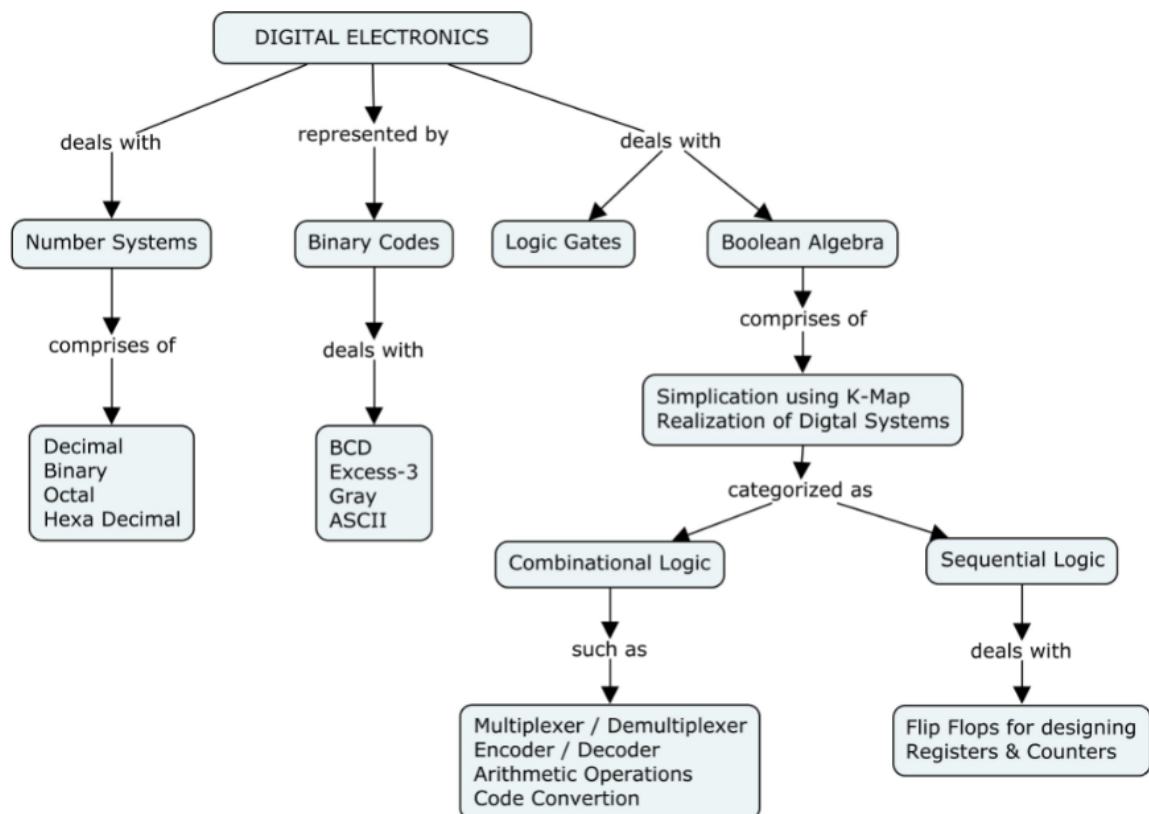
- SOP form and implement it using NAND gates.
- Construct a Karnaugh Map for the Boolean function  $Y = ABC + ABC' + A'B'C + A'BC$  and simplify the function.
  - Minimize the given expression using K-map and realize it using NOR gates.  
 $F(A,B,C,D) = \prod M(1,5,8,9,10,11) + d(0,4)$

**Course Outcome 4 (CO4):**

- Construct a 3x8 decoder by using 2x4 decoders and explain its operation.
- Realise the Boolean function  $F(A,B,C,D) = \sum m(1,2,5,7,8,11,13)$  using a 8x1 multiplexer.
- Construct a two-bit multiplier circuit and write its truth table.

**Course Outcome 5 (CO5)**

- Design Mod-5 synchronous up counter using J-K flipflops.
- Design Mod-10 ripple down counter using T flipflops.
- Explain the operation of 4-bit PISO shift register with necessary sketches.

**Concept Map****Syllabus****MINIMIZATION TECHNIQUES AND LOGIC GATES**

Number systems, Basic digital circuits: Characteristics of Digital IC's and Fan in -Fan out Logic circuits - universal building block construction using logic gates - Boolean Algebra- Simplification of Boolean functions - special forms of Boolean functions minterm (SOP) maxterm (POS) - K Map representation of logic functions - simplification of logic functions using K Map – Don't care conditions

**COMBINATIONAL CIRCUITS**

Half and Full Adders-Half and Full Subtractors - Code converters - Encoder-Decoder - Multiplexer- Demultiplexer - Binary/ BCD adders, subtractors - Carry look ahead adder- parity checker-parity generators- Magnitude comparator

### SEQUENTIAL CIRCUITS

General model of sequential circuits - flip-flops - latches - level triggering, edge triggering - master slave configuration - Mealy/Moore models - state diagram - state table - State minimization State assignment Excitation table and maps

### SEQUENTIAL MEMORIES

Shift registers, Recirculation shift registers Programmable Logic Devices (PLD) - Programmable Logic Array (PLA) - Programmable Array Logic (PAL) Field Programmable Gate Arrays (FPGA) - Implementation of combinational logic circuits using ROM, PLA, PAL

### SYNCHRONOUS AND ASYNCHRONOUS SEQUENTIAL CIRCUITS

Design of synchronous sequential circuits – Counter - parity checker - sequence detector - Asynchronous sequential logic: Race conditions and Cycles - Hazards in combinational circuits.

### Learning Resources

1. M. Morris Mano, Michel D. Ciletti, Digital Design, Pearson Education, New Delhi, 2012.
2. Ronald J. Tocci Neal S. Widmer and Gregory L. Moss, Digital Systems: Principles and Applications, Prentice Hall of India, New Delhi, 2010.
3. Anand Kumar, Fundamentals of Digital Circuits, PHI Learning Pvt. Ltd. 2014.
4. Thomas L. Floyd, Digital Fundamentals, Pearson Education Inc, New Delhi, 2003.
5. Donald P. Leach and Albert Paul Malvino, Digital Principles and Applications, Tata McGraw- Hill Charles H. Roth. Fundamentals of Logic Design, Thomson Learning, 2003
6. Charles H. Roth. Fundamentals of Logic Design, Thomson Learning, 2003
7. [https://onlinecourses.nptel.ac.in/noc19\\_ee09/preview](https://onlinecourses.nptel.ac.in/noc19_ee09/preview)
8. <https://nptel.ac.in/courses/117106086/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.1	Number systems	1	CO1
1.2	Characteristics of Digital IC's - Logic circuits - Universal building block construction using logic gates	1	CO1
1.3	Boolean Algebra- Simplification of Boolean functions - special forms of Boolean functions minterm (SOP) maxterm (POS)	2	CO2
1.4	K Map representation of logic functions - simplification of logic functions using K Map	2	CO3
1.5	Don't care conditions	1	CO3
2.1	Half and Full Adders-Half and Full Subtractors	2	CO4
2.2	Code converters	2	CO4
2.3	Encoder-Decoder	1	CO4
2.4	Multiplexer and Demultiplexer	1	CO4
2.5	Binary/ BCD adders, subtractors	2	CO4
2.6	Carry look ahead adder	1	CO4
2.7	Parity checker-parity generators	1	CO4
2.8	Magnitude comparator	1	CO4

3.1	General model of sequential circuits - flip-flops - -	1	CO5
3.2	Latches - level triggering, edge triggering	1	CO5
3.3	Master slave configuration	1	CO5
3.4	Mealy/Moore models	1	CO5
3.5	State diagram - state table - State minimization State assignment Excitation table and maps	2	CO5
4.1	Shift registers, Recirculation shift registers	1	CO5
4.2	Programmable Logic Devices (PLD) - Programmable Logic Array (PLA) - Programmable Array Logic (PAL)	2	CO5
4.3	Field Programmable Gate Arrays (FPGA)	1	CO5
4.4	Implementation of combinational logic circuits using ROM, PLA, PAL	2	CO5
5.1	Design of synchronous sequential circuits - parity checker - sequence detector	2	CO5
5.2	Asynchronous sequential logic:	2	CO5
5.3	Race conditions and Cycles	1	CO5
5.4	Hazards in combinational circuits.	1	CO5
	Total	36	

#### Course Designers:

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**18MT340 THERMAL FLUID ENGINEERING**

Category L T P Credit(s)  
PC 3 0 0 3

**Preamble**

This course aims at providing fundamental knowledge and applications in the field of thermal engineering and Fluid mechanics. The basic concepts, laws and theorem relevant to the working of thermal and fluid systems will be discussed.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Determine the properties and energy interaction in the closed and open system.	20
CO2	Determine the efficiency of heat engine and COP of heat pump and refrigerator and determine increase in entropy.	20
CO3	Calculate properties of fluids, pressure in fluids, velocity and acceleration of fluid particles ,	20
CO4	Determine flow rates and head losses using Bernoulli principle	20
CO5	Calculate heat transfer rates in conduction convection and radiation	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1.1, 1.1.2,2.1.1,2.1.2,2.3.1, 2.3.2,2.3.3, 4.3.2, 4.3.3
CO2	TPS3	Apply	Value	Mechanism	1.1.1, 1.1.2,2.1.1,2.1.2,2.3.1, 2.3.2,2.3.3, 4.3.2, 4.3.3
CO3	TPS3	Apply	Value	Mechanism	1.1.1, 1.1.2,2.1.1,2.1.2,2.3.1, 2.3.2,2.3.3, 4.3.2, 4.3.3
CO4	TPS3	Apply	Value	Mechanism	1.1.1, 1.1.2,2.1.1,2.1.2,2.3.1, 2.3.2,2.3.3, 4.3.2, 4.3.3
CO5	TPS3	Apply	Value	Mechanism	1.1.1, 1.1.2,2.1.1,2.1.2,2.3.1, 2.3.2,2.3.3, 4.3.2, 4.3.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO2	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO3	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO4	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO5	S	M	M	-	L	-	L	-	M	-	L	M	M	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20				20
Understand	30	30	30				30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini project
Complex Overt Responses	-
Adaptation	-
Orignation	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. State Zeroth law of thermodynamics.
2. Define the properties: Pressure and Temperature.
3. Distinguish between flow and non-flow system.
4. Derive the steady flow energy equation .
5. A stationary mass of gas is compressed without friction from an initial state of 0.3 m<sup>3</sup> and 0.105 MPa to a final state of 0.15m<sup>3</sup> and 0.105 MPa, the pressure remaining constant during the process. There is a heat transfer of 37.6 kJ of heat from the gas during the process. How does the internal energy of the gas change?
6. 4 kg/s of steam enters a turbine. The inlet of the turbine is 2.5 m higher than the outlet. The velocity is 132 m/s. Outlet velocity is 327 m/s and heat loss is 9.2 kJ/s. The enthalpy per kg at inlet and outlet of the turbine are 3127.4 kJ/kg and 2512 kJ/kg respectively. Determine the power output.

**Course Outcome 2(CO2):**

1. Write Kelvin Planck's statement of second law of thermodynamics.
2. Define heat engine
3. Define COP.
4. A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27°C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at - 5°C and transfers it to the same ambient air at 27°C. Determine (a) the maximum rate of heat removal from the refrigerated space and (b) the total rate of heat rejection to the ambient air.
5. 1200 kJ of heat is supplied to an engine from a source of 20 C, the sink temperature is 2 C. Which of the following cycle represents reversible, irreversible or impossible?

- (i) 275 kJ of heat is rejected to sink, (ii) 825 kJ of heat is rejected and (iii) 350 kJ heat is rejected.
- Water flows through a turbine in which friction causes the water temperature to rise from 35°C to 37°C. If there is no heat transfer, how much does the entropy of the water change in passing through the turbine? (Water is incompressible and the process can be taken to be at constant volume.) (Ans:  $\Delta S = 0.0243$  kJ/K)
  - (a) One kg of water at 273K is brought into contact with a heat reservoir at 373K. When the water has reached 373K, find the entropy change of the water, of the heat reservoir, and of the universe.  
(b) If the water is heated from 273K to 373K by first bringing it in contact with a reservoir at 323K and then with a reservoir at 373K, what will the entropy change of the universe be?  
(c) Explain how water might be heated from 273K to 373K with almost no change in entropy of the universe. (Ans: (a) 1.305 kJ/K, -1.122 kJ/K, 0.183 kJ/K (b) 0.098 kJ/K.
  - One kg of ice at -5°C is exposed to the atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium with the atmosphere. (a) Determine the entropy increase of the universe. (b) What is the minimum amount of work necessary to convert the water back into ice at -5°C?  $c_p$  of ice is 2.093 kJ/kgK and latent heat of fusion of ice is 333.3 kJ/kg. (Ans: 0.0949 kJ/K, 28.5 kJ)

**Course Outcome 3 (CO3):**

- Define the term fluid.
- Write Newton's law of viscosity. What is non-Newtonian fluid?
- Derive an expression for capillary rise or fall of a liquid.
- Determine the density, specific gravity and mass of the air in a room whose dimensions are 4 m x 5 m x 6 m at 100 kPa and 15°C
- A manometer is used to measure the pressure of a gas in a tank. The fluid used has a specific gravity of 0.85, and the manometer column height is 55 cm. If the atmospheric pressure is 96 kPa, determine the absolute pressure within the tank.
- State and prove the Pascal's law.

**Course Outcome 4(CO4):**

- Define steady flow.
- Derive an expression for 3D continuity equation.
- Derive Euler equation and obtain the Bernoulli's equation from it.
- The following represent the two velocity components. Determine the third component of velocity, such that they satisfy the continuity equation:  
$$u = x^2 + y^2 + z^2 : v = xy^2 - yz^2 + xy$$
- The water is flowing through a taper pipe of length 50 m having diameters 40 cm at the upper end and 20 cm at the lower end, at the rate of 60 lps. The pipe has a slop of 1 in 40. Find the pressure at the lower end if the pressure at the higher level is 24.525 N/cm<sup>2</sup>.
- Given the velocity field:  $V = (6+2xy+t^2) i - (xy^2+10t) j + 25k$ . What is the acceleration of a particle at (3,0,2) at time  $t = 1$ ?

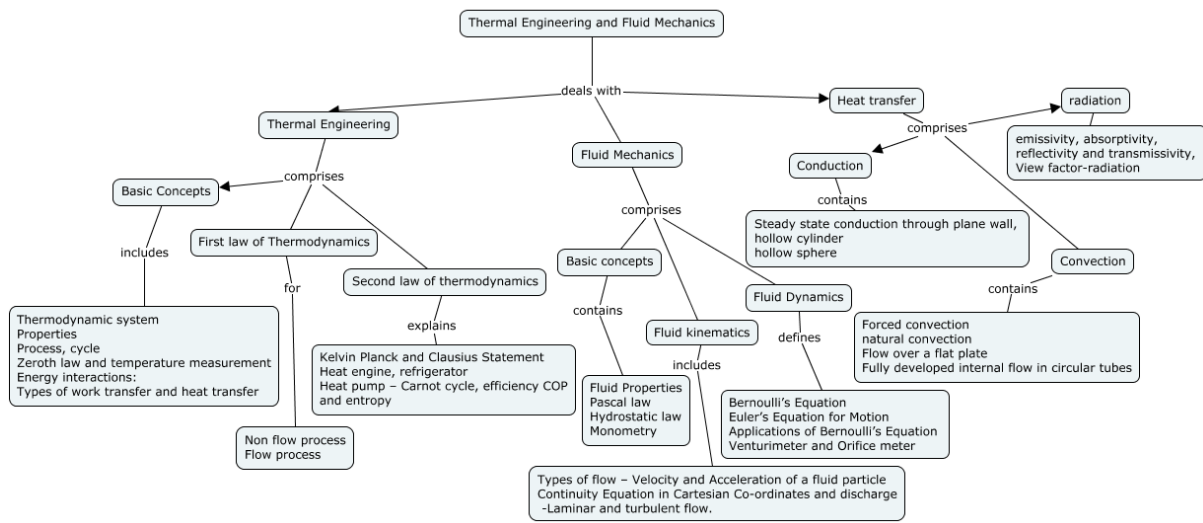
**Course Outcome5 (CO5) :**

- A plane wall of a refrigerated van is made of 1.5 mm steel sheet ( $k_s = 25$  W/(m K)) at the outer surface, 10 mm plywood ( $k_p = 0.05$  W/(m K)) at the inner surface and 20 mm glass wool ( $k_g = 0.01$  W/(m K)) in between the outer and inner surfaces. The temperature of the cold environment inside the van is -15°C, while the outside surface is exposed to a surrounding ambient at 24°C. The average values of convective heat

transfer coefficients at the inner and outer surfaces of the wall are 12 W/mK and 20 W/mK respectively. The surface area of the wall is 0.75 m<sup>2</sup>. Determine:

- (a) The individual components of the thermal resistance to heat flow.
  - (b) The rate of heat flow through the wall.
  - (c) The temperatures at (i) the outer surface of the wall, (ii) the interface between steel sheet and glass wool, (iii) the interface between glass wool and plywood, and (iv) the inner surface of the wall.
2. Consider a 20 mm thick plate with uniform heat generation of 80 MW/m<sup>3</sup>. The left and right faces are kept at constant temperatures of 160°C and 120°C respectively. The plate has a constant thermal conductivity of 200 W/m K. Determine (a) the expression for temperature distribution in the plate, (b) the location and the value of maximum temperature, and (c) the rate of heat transfer (i) at the left face (ii) at the right face and (iii) at the plate centre.
  3. A thin-walled copper tube of outside metal radius  $r = 0.01$  m carries steam at 400 K. It is inside a room where the surrounding air temperature is 300 K. The tube is insulated with magnesia insulation of an approximate thermal conductivity of 0.07 W/(m K).
    - (a) What is the critical thickness of insulation for an external convective coefficient  $h = 4.0$  W/(m<sup>2</sup> K)? (Assume negligible conduction resistance due to the wall of the copper tube.)
    - (b) Under these conditions, determine the rate of heat transfer per metre of tube length for
      - (i) a 0.002 m thick layer of insulation, (ii) the critical thickness of insulation, (iii) a 0.05 m thick layer of insulation.
  4. An electrical resistance wire 2.5 mm in diameter and 0.5 m long has a measured voltage drop of 25 V for a current flow of 40 A. The thermal conductivity of the wire material is 24 W/(m K). Determine (a) the rate of generation of thermal energy per unit volume within the wire and (b) the maximum temperature in the wire if the surface temperature is kept at 650 K.
  5. Air at a pressure of 6 kN/m<sup>2</sup> and a temperature of 300°C flows with a velocity of 10 m/s over a flat plate 0.5 m long. Estimate the cooling rate per unit width of the plate needed to maintain it at a surface temperature of 27°C.
  6. Air at one atmospheric pressure and 75°C enters a tube of 4.0 mm internal diameter with an average velocity of 2 m/s. The tube length is 1.0 m and a constant heat flux is imposed by the tube surface on the air over the entire length. An exit bulk mean temperature of air of 125°C is required. Determine (a) the heat transfer coefficient at exit  $h_L$ , (b) the constant surface heat flux  $q_w$ , and (c) the exit tube surface temperature. The properties of air at the average temperature of inlet and outlet bulk mean temperatures, i.e.  $(75 + 125)/2 = 100^\circ\text{C}$  are as follows:  $\rho = 0.95$  kg/m<sup>3</sup>;  $c_p = 1.01$  kJ/(kg K);  $\mu = 2.18 \times 10^{-5}$  kg/(m s);  $k = 0.03$  W/(m K);  $Pr = 0.70$
  7. A furnace cavity, which is in the form of a cylinder of 50-mm diameter and 150-mm length, is open at one end to large surroundings that are at 27°C. The bottom of the cavity is heated independently, as are three annular sections that comprise the sides of the cavity. All interior surfaces of the cavity may be approximated as blackbodies and are maintained at 1650°C. What is the required electrical power input to the bottom surface of the cavity? What is the electrical power to the top, middle, and bottom sections of the cavity sides? The backs of the electrically heated surfaces are well insulated.

## Concept Map



## Syllabus

**Basic Concepts:** Thermodynamic system, properties, process, cycle – Zeroth law and temperature measurement-Energy interactions: Types of work transfer and heat transfer

**First Law of thermodynamics:** Closed system undergoing a process and cycle- Internal energy and specific heats. Open system - steady flow energy equation for nozzle, turbine, compressor.

**Second Law of thermodynamics:** Kelvin Planck and Clausius Statement – Heat engine, refrigerator, Heat pump – Carnot and Reversed Carnot Engine – Efficiency and COP calculations.

**Entropy:** Concept of entropy, The increase of entropy principle, calculation of entropy generation in heating with finite temperature difference

**Basic Concepts of Fluid Mechanics:** Concept of fluid- Properties of Fluids: Pressure, Density, Specific Gravity, Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus.

**Fluid Statics:** Pressure at a Point: Pascal's Law – hydrostatic law –U- tube manometer

**Fluid Kinematics:** Types of flow – Velocity and Acceleration of a fluid particle - Continuity Equation in Cartesian Co-ordinates.

**Fluid Dynamics:** Bernoulli's Equation - Euler's Equation for Motion - Applications of Bernoulli's Equation, Venturimeter and Orifice meter.

**Basics of Heat transfer:** Modes of heat transfer and the governing formulas, steady state conduction through plane wall, hollow cylinder - Radiation Heat Transfer-emissivity, absorptivity, reflectivity and transmissivity,-radiation heat transfer between black surfaces-Convection – forced convection, natural convection, external flow, fully developed internal flow.

### Learning Resources

1. Yunus A. Cengel and Michael A. Boles, “**Thermodynamics: An Engineering Approach**”, 7<sup>th</sup> Edition, McGraw Hill Education (India) Private Ltd., 2011.
2. Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Rothmayer, “**Fluid Mechanics**”, Seventh Edition, Wiley India Pvt. Ltd, 2015.
3. Yunus A Cengel , John M Cimbala, Robert H Turner “**Fundamentals of thermal fluid sciences**”4<sup>th</sup> Edition, McGraw Hill Education (India) Private Ltd., 2017
4. Rayner Joel, ‘**Basic Engineering Thermodynamics in SI units**’, ELBS, 1998.
5. Nag, P.K., ‘**Engineering Thermodynamics**’, Tata McGraw Hill, 2013.
6. Venkatesh, A., ‘**Basic Engineering Thermodynamics**’, University Press, 2007.
7. Richard E. Sonntag, Claus Borgnakke, Gordon J. Vanwylen, ‘**Fundamental of Thermodynamics**’, Wiley, 2002.
8. S. K. Som, G. Biswas, SumanChakraborty, “**Introduction to Fluid Mechanics and Fluid Machines**”, Third Edition, Tata McGraw - Hill Publishing Company Limited - New Delhi, 2017.
9. Yunus A. Cengel, John M. Cimbala, “**Fluid Mechanics: Fundamental and Applications**”, Third Edition, McGraw-Hill Education (India) Pvt. Ltd, 2014.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.1	<b>Basic Concepts:</b> Thermodynamic system, properties, process, cycle – Zeroth law of thermodynamics	2
1.2	Energy interactions: Types of work transfer and heat transfer	2
2.1	<b>First Law of thermodynamics:</b> Closed system undergoing a process and cycle- Internal energy and specific heats.	2
2.2	Open system: steady flow energy equation for nozzle, turbine, compressor, turbine and	2
3.1	<b>Second Law of thermodynamics:</b> Kelvin Planck and Clausius Statement – Heat engine, refrigerator, Heat pump.	2
3.2	Carnot and Reversed Carnot Engine – Efficiency and COP calculations-concept of irreversible process	2
4.1	Concept of entropy, The increase of entropy principle,	1
4.2	calculation of entropy generation in heating with finite temperature	1
5.1	<b>Basic Concepts of Fluid Mechanics:</b> Concept of fluid - Dimensions and Units- Properties of Fluids: Pressure, Density, Specific Gravity, Viscosity	2
5.2	Surface Tension, Capillarity, Compressibility and Bulk Modulus.	2
6.1	<b>Fluid Statics:</b> Pressure at a Point: Pascal’s Law – hydrostatic law –U- tube manometer	2
8.1	<b>Fluid Kinematics:</b> Types of flow – Velocity and Acceleration of a fluid particle	2
8.2	Continuity Equation in Cartesian Co-ordinates	1
9.1	<b>Fluid Dynamics:</b> Bernoulli’s Equation - Euler’s Equation for Motion - Applications of Bernoulli’s Equation,	1
9.2	Venturimeter and Orifice meter	2
10.1	<b>Basics of Heat transfer:</b> Modes of heat transfer and the governing formulas	1

<b>Module No.</b>	<b>Topic</b>	<b>No. of Lectures</b>
10.2	Steady state conduction through plane wall, hollow cylinder	2
10.3	Radiation Heat Transfer-emissivity, absorptivity, reflectivity and transmissivity,	2
10.4	Heat transfer between black surfaces	1
10.5	Convection – forced convection, natural convection – Flow over a flat plate	2
10.6	Fully developed internal flow in circular tubes	2
<b>Total</b>		<b>36</b>

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**18MT350 PROGRAMMING FOR PROBLEM SOLVING** Category L T P Credit(s)  
ES 2 0 0 2

**Preamble**

This course is intended for the candidate who desires to learn problem-solving techniques and the design of computer solutions in a precise manner. This course emphasizes problem-solving methodologies, algorithm designs and developments and computer programming skills. The intention is to provide sufficient depth in these topics to enable candidates to achieve better understanding of problem-solving using computers.

The modules in the course reflect solving general problems via programming solution. Thus, modules collectively focus on programming concepts, strategies and techniques; and the application of these toward the development of programming solutions.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop algorithms for solving simple mathematical and engineering problems	15
CO2	Examine the suitability of appropriate repetition / selection / iteration / modularization structures for given problems and develop solution for the same	30
CO3	Solve problems related to Arrays & Matrix calculations	25
CO4	Solve problems related to searching, sorting	15
CO5	Organize files to perform text operations like editing, pattern searching and string manipulation problems	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO2	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO3	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO2	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO3	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO4	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO5	S	S	S	M	M	-	-	-	-	-	-	M	L	M

S – Strong

M – Medium

L – Low



**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	40	30	30	-	-	-	30
Apply	40	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Quiz
Mechanism	Online Programming
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Recall the list of symbols used in flowcharts for various purposes
2. Develop an algorithm to convert decimal to binary of a given number

**Course Outcome 2(CO2):**

1. Choose proper selection control structures to solve area of rectangle, triangle and circle
2. Compare function call and recursive call

**Course Outcome 3(CO3):**

1. Make use of arrays and functions to transpose an MxN matrix
2. Find the biggest number in the given array

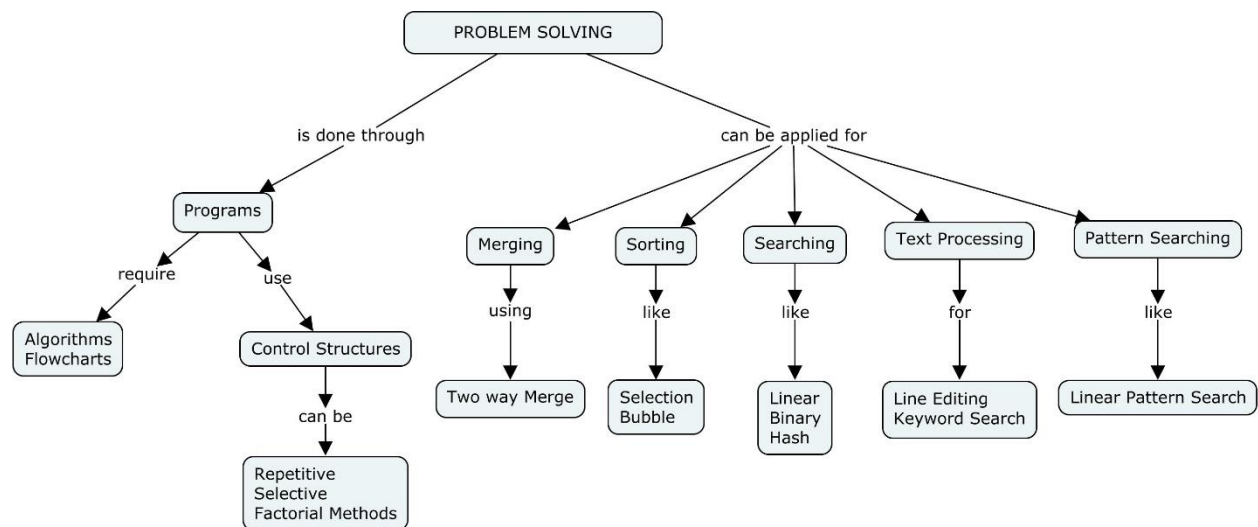
**Course Outcome 4 (CO4):**

1. Explain the algorithm for linear pattern searching
2. Explain bubble sorting technique with an example

**Course Outcome 5 (CO5):**

1. Develop an algorithm for comparing two strings
2. Create a text file to store records of N employees and retrieve and display the records with age > 40

## Concept Map



## Syllabus

**Introduction to Computer Problem Solving:** Introduction to Computer, Program Design, Flowcharts, Developing an Algorithm, Fundamental Algorithms, Exchanging values of variables, Counting

**Factoring methods and Control structures:** Selection Control Structures, Repetition Control Structures, Algorithms Using Selection and Repetition. Factoring Methods – Functions – Call by Value, reference

**Array Processing and Techniques:** Array Processing, Pointers, Modularization and recursion, Merging, Sorting and Searching, Sorting by selection, Linear search, Binary search, Simple Hash searching.

**Text Processing and pattern searching:** Text line editing, Keyword searching, Linear pattern searching.

## Learning Resources

1. How to solve it by Computer, R.G Dromey, Pearson education, Delhi, 2008
2. Simple Program Design, A Step-by-Step Approach, Lesley Anne Robertson, 5<sup>th</sup> Edition, Thomson, 2007
3. E. Balagurusamy, "Programming in ANSI C", IV Edition, Tata McGraw Hill Publication Company, 2008
4. Let us C, Yashavant P. Kanetkar, 12th edition, BPB Publications, 2012
5. NPTEL Course: [https://onlinecourses.nptel.ac.in/noc17\\_cs43/preview](https://onlinecourses.nptel.ac.in/noc17_cs43/preview)

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction to Computer Problem Solving</b>		
1.1	Introduction to Computer, Program Design, Developing an Algorithm	1	CO1
1.2	Flowcharts	1	CO1
1.3	Fundamentals Algorithms, counting	1	CO1
<b>2</b>	<b>Factoring methods and Control structures</b>		
<b>2.1</b>	<b>Selection Control Structures, Repetition Control Structures</b>	1	CO2
2.1.1	Summation of set of numbers, Factorial computation	1	CO2
2.1.2	Fibonacci sequence generation, Reversing the digits of an Integer	1	CO2
2.2.3	Base conversion, Character to number conversion	1	CO2
<b>2.2</b>	<b>Factoring Methods</b>		
2.2.1	Finding square root of a number, The smallest divisor of an integer	1	CO2
2.2.2	Generating Prime numbers	1	CO2
2.2.3	Generating Pseudo-random numbers, Computing n <sup>th</sup> Fibonacci number	1	CO2
<b>3</b>	<b>Array Processing and Techniques</b>		
<b>3.1</b>	<b>Array Processing &amp; Pointers</b>	1	CO3
3.1.1	Finding the maximum number in a set, Finding k <sup>th</sup> smallest number	1	CO3
3.1.2	Removal of duplicates from an ordered array, Partitioning array	1	CO3
3.1.3	Longest Monotone subsequence	1	CO3
<b>3.2</b>	<b>Matrix manipulations (arithmetic, transpose, pattern generation)</b>	2	CO3
<b>3.3</b>	<b>Modularization and recursion, Sorting</b>	2	CO4
<b>3.4</b>	<b>Linear search, Binary search, Simple Hash searching</b>	2	CO4
<b>4</b>	<b>Text Processing and pattern searching</b>		
<b>4.1</b>	<b>String Manipulations</b>	1	CO5
<b>4.2</b>	<b>Text line editing</b>	1	CO5
4.2.1	keyword searching	1	CO5
4.2.2	Linear pattern searching	1	CO5
<b>TOTAL</b>		<b>24</b>	

**Course Designers:**

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18MT360

**PROGRAMMING AND CODING  
LABORATORY**Category L T P Credit(s)  
ES 0 0 2 1**Preamble**

This course is intended for the candidate who desires to learn problem-solving techniques and the design of computer solutions in a precise manner. This course emphasizes problem-solving methodologies, algorithm designs and developments and computer programming skills. The intention is to provide sufficient depth in these topics to enable candidates to achieve better understanding of problem-solving using computers. The examinations will test the candidate's ability to develop computer-programming solutions for a series of programming tasks of varying complexity.

The modules in the course reflect solving general problems via programming solution. Thus, modules collectively focus on programming concepts, strategies and techniques; and the application of these toward the development of programming solutions.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop programs for solving simple mathematical and engineering problems using appropriate repetition / selection / iteration / modularization structures	25
CO2	Develop programs for problems related to Arrays & Matrix calculations using pointers	30
CO3	Develop programs for problems related to merging, searching, sorting	25
CO4	Develop program to perform text operations like editing, pattern searching and string manipulation problems	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO2	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO3	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO2	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO3	S	S	S	M	M	-	-	-	-	-	-	M	L	M
CO4	S	S	S	M	M	-	-	-	-	-	-	M	L	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Online / Offline Programming Test
Complex Overt Responses	-
Adaptation	-
Origination	-

**List of Experiments / Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	Introduction to C components	2	CO1
2	Fundamentals Algorithms using Control Structures (Factorial computation, Fibonacci sequence generation, Reversing the digits of an Integer, Base conversion, etc.)	4	CO1
3	Array techniques (Finding the maximum number in a set, Finding kth smallest number, Removal of duplicates from an ordered array, Partitioning array, Longest Monotone subsequence)	4	CO2
4	Matrix Manipulation (Arithmetic, Inverse, Transpose, Pattern generation)	4	CO2
5	Sorting & Searching Algorithms (Quick Sort, Bubble Sort, Linear search, Binary search, etc.)	6	CO3
6	Problems on Strings	2	CO4
7	Problems related to File operations	2	CO4
<b>TOTAL</b>		<b>24</b>	

**Note:** Students must be given data related to Mechatronics application such as automation, measurements, data logging, etc. for solving the problems.

**Learning Resources**

1. E. Balagurusamy, "Programming in ANSI C", IV Edition, Tata McGraw Hill Publication Company, 2008
2. Let us C, Yashavant P. Kanetkar, 12th edition, BPB Publications, 2012
3. NPTEL Course: [https://onlinecourses.nptel.ac.in/noc17\\_cs43/preview](https://onlinecourses.nptel.ac.in/noc17_cs43/preview)

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18MT370

**THERMAL FLUID ENGINEERING  
LABORATORY**Category L T P Credit(s)  
PC 0 0 2 1**Preamble**

The laboratory exercises aim at providing practical knowledge in thermal systems such as IC engines, compressor, and refrigerator.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Determine the performance of internal combustion engine.	20
CO2	Prepare heat balance sheet for internal combustion engine	20
CO3	Determine the performance of refrigerator,	20
CO4	Determine heat transfer parameters namely thermal conductivity, heat transfer coefficient and radiation properties	20
CO5	Determine the performance of the reciprocating compressor	10
CO6	Determine fluid properties namely viscosity, density, flow rate and pressure of incompressible fluids	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Apply	Value	Mechanism	1.1.1,1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO2	TPS2	Apply	Value	Mechanism	1.1.1,1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO3	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO4	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO5	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO6	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,2.1.1,2.1.2, 2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO2	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO3	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO4	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO5	S	M	M	-	L	-	L	-	M	-	L	M	M	M
CO6	S	M	M	-	L	-	L	-	M	-	L	M	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand		
Apply	100	100
Analyse		
Evaluate		-
Create	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	Lab Experiments
Mechanism	
Complex Overt Responses	
Adaptation	
Orignation	

### List of Experiments/Activities with CO Mapping

Minimum of 12 experiments are to be given

Ex.No	Experiments/Exercise	Hours	COs
1	Performance test on single cylinder 4-stroke Diesel engine at constant speed.	2	1
2	Determination of friction power of Diesel engine using retardation test	2	2
3	Determination of friction power of 4-stroke constant speed Diesel engine using Willan's line method.	2	3
4	Determination of volumetric efficiency test on a 4-stroke Diesel engine.	2	4
5	Energy balance test on Diesel engine using airflow measurement method	2	5
6	Energy balance test on Diesel engine using exhaust gas calorimeter measurement method	2	5
7	Performance test on vapour compression refrigeration test rig.	2	5

8	Determination of viscosity and density and pressure of incompressible fluid	2	5
9	Determination of mass flow rate of air through an orifice meter	2	5
10	Determination of power consumption by a reciprocating compressor.	2	5
11	Determination of thermal conductivity of metal rod.	2	6
12	Determination of heat transfer coefficient in natural convection	2	6
13	Determination of emissivity of given specimen	2	6
14	Performance analysis of electronics cooling fans	2	6
	<b>Total</b>	24 ( For 12 experiments)	

### Learning Resources

1. Yunus A. Cengel and Michael A. Boles, "**Thermodynamics: An Engineering Approach**", 7<sup>th</sup> Edition, McGraw Hill Education (India) Private Ltd., 2011.
2. Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Rothmayer, "**Fluid Mechanics**", Seventh Edition, Wiley India Pvt. Ltd, 2015.
3. Yunus A Cengel , John M Cimbala, Robert H Turner "**Fundamentals of thermal fluid sciences**"4<sup>th</sup> Edition, McGraw Hill Education (India) Private Ltd., 2017

### Course Designers:

Sl. No.	Name	E-mail Id
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<b>18MT380</b>	<b>DIGITAL ELECTRONICS LABORATORY</b>	Category	L	T	P	Credit(s)
		PC	0	0	2	1

### Preamble

To impart the knowledge about code conversion, Boolean algebra, logic gates, combinational and sequential logic, and converters.

### Prerequisite

- Nil

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Design and implementation of combinational logic circuits for the given requirement	80
CO2	Design and implementation of synchronous and asynchronous sequential logic circuits for the given requirement	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.1.5,2.4.3,4.4.4,4.5.2,4.5.5
CO2	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.1.5,2.4.3,4.4.4,4.5.2,4.5.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	L	-	-	-	-	L	-	-	L	M	M
CO2	S	S	M	L	-	-	-	-	L	-	-	L	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	Mini Project
Complex Overt Responses	
Adaptation	
Origination	

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hours.	Cos															
1	Study of Logic gates	2	CO1															
2	Design and Implementation of Half adder and Full adder	2	CO1															
3	Design and Implementation of Half Subtractor and Full subtractor	2	CO1															
4	Design and implementation of code converters using logic gates BCD to excess-3 code and vice versa	2	CO1															
5	Design and implementation of code converters using logic gates Binary to gray and vice-versa	2	CO1															
6	Design and implementation of 4-bit binary adder/subtractor	2	CO1															
7	Design and implementation of BCD adder.	2	CO1															
8	Design and implementation of Magnitude comparator.	2	CO1															
9	Design and implement a multiplexer and de-multiplexer	2	CO1															
10	Design and implement an encoder and decoder	2	CO1															
11	Construction and verification of 4-bit ripple counter	2	CO2															
12	Implementation of SISO, SIPO, PISO and PIPO shift registers using Flip- flops	2	CO2															
13	An automobile alarm circuit is used to detect certain undesirable conditions. Three switches are used to indicate the status of the door by the driver's seat, the ignition, and the headlights respectively. Design the logic circuit with these three switches as inputs so that the alarm will be activated whenever either of the following conditions exists: <ul style="list-style-type: none"> <li>•The headlights are on while the ignition is off</li> <li>•The door is open while ignition is on.</li> </ul>	2	CO2															
14	A simple security system for two doors consists of a card reader and a keypad. A person may open a particular door if he or she has a card containing the corresponding code and enters an authorized code for that card. The output from the card reader are as follows. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Action</th> <th>A</th> <th>B</th> </tr> </thead> <tbody> <tr> <td>No card inserted</td> <td>0</td> <td>0</td> </tr> <tr> <td>Valid Code for Door 1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Valid Code for Door2</td> <td>1</td> <td>1</td> </tr> <tr> <td>Invalid card code</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	Action	A	B	No card inserted	0	0	Valid Code for Door 1	0	1	Valid Code for Door2	1	1	Invalid card code	1	0	2	CO2
Action	A	B																
No card inserted	0	0																
Valid Code for Door 1	0	1																
Valid Code for Door2	1	1																
Invalid card code	1	0																

	To unlock a door, a person must hold down the proper keys on the keypad and then insert the card in the reader. The authorized keypad codes for door 1 are 101 and 110, and the authorized keypad codes for door 2 are 101 and 011. If the card has an invalid code or if the wrong keypad code is entered, the alarm will ring when card is inserted. If the correct keypad code is entered, the corresponding door will be unlocked when the card is inserted.																	
15	<p>A shifter is a combinational network capable of shifting of 0's and 1's to the left or right, leaving vacancies, by a fixed number of places as a result of control signal. For example, assuming vacated positions are replaced by 0's, the string 0011 when shifted right by 1 bit position becomes 0001 and when shifted left by 1 bit position becomes 0110. A shifter to handle an n – bit string can be readily designed with n multiplexers. Bits from the string are applied to the data input lines. The control signals for the various actions are applied to the select input lines. The shifted string appears on the output lines. Design a shifter for handling a 4 bit string where table indicates the control signals and desired actions. Vacated positions should be filled with 0's</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>S1</th> <th>S0</th> <th>Action</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>No change</td> </tr> <tr> <td>0</td> <td>1</td> <td>Shift right 1 bit position</td> </tr> <tr> <td>1</td> <td>0</td> <td>Shift left 1 bit position</td> </tr> <tr> <td>1</td> <td>1</td> <td>Clear data</td> </tr> </tbody> </table>	S1	S0	Action	0	0	No change	0	1	Shift right 1 bit position	1	0	Shift left 1 bit position	1	1	Clear data	2	CO2
S1	S0	Action																
0	0	No change																
0	1	Shift right 1 bit position																
1	0	Shift left 1 bit position																
1	1	Clear data																

Note : Minimum of 12 experiments are to be given for 24 Hours

### Learning Resources

1. M. Morris Mano, Michel D. Ciletti, Digital Design, Pearson Education, New Delhi, 2012.
2. Anand Kumar, Fundamentals of Digital Circuits, PHI Learning Pvt. Ltd. 2014.
3. Thomas L. Floyd, Digital Fundamentals, Pearson Education Inc, New Delhi, 2003.

### Course Designers:

Sl. No.	Name	E-mail Id
1	Mr.A.Prakash	apmech@tce.edu
2	Mr. S.Manikandan	smmect@tce.edu

18ES390	DESIGN THINKING	Category	L	T	P	Credit
		ES	1	-	2	2

### Preamble

Design has been defined as a “systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints”. Human-centered design is defined as a process and a set of techniques used to create new solutions for the world. Solutions include products, services, environments, organizations, and modes of interaction. The reason this process is called “human-centered” is because it starts with the people we are designing for. This course facilitates the development of students’ professional skills through their team engagement in developing conceptual design for a local community problem.

### Prerequisite

Nil

### Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Identify a specific social need to be addressed	20
CO2	Identify stakeholder’s requirements for the societal project	20
CO3	Develop measurable criteria in which design concepts can be evaluated	10
CO4	Develop prototypes of multiple concepts using user’s feedback	30
CO5	Select the best design solution among the potential solutions with its functional decomposition	20

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO5	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	M	L	M	M	S
CO2	S	M	L	-	-	M	M	M	L	M	M	S
CO3	S	M	L	-	-	M	M	M	L	M	M	S
CO4	S	M	L	-	M	M	M	M	L	M	M	S
CO5	S	S	M	L	M	M	M	M	L	M	M	S

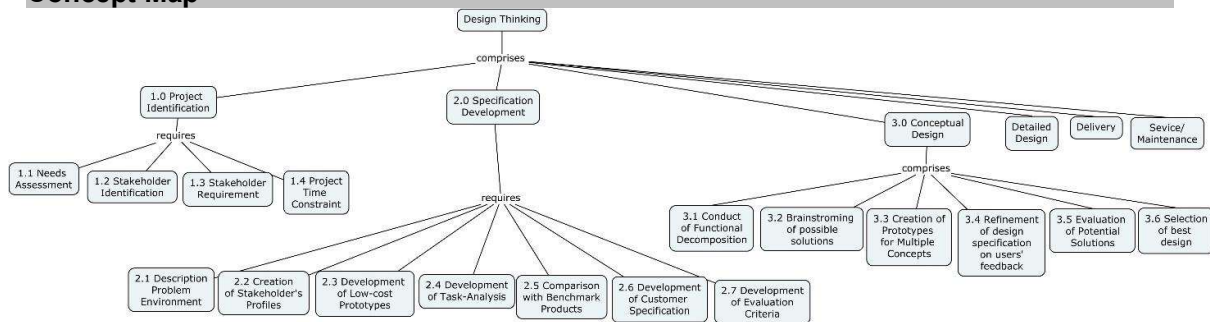
S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

Phases	Deliverables	Marks	Course Outcomes
<b>Continuous Assessment</b>			
Review 1 – Problem Identification	Technical Report	10	CO1 and CO2
Review 2 – Specification Development	Technical Report	20	CO3
Review 3 -Conceptual Design	Technical Report	20	CO4 and CO5
<b>End-Semester Examination</b>			
Demonstration	Prototype	60	CO1, CO2, CO3, CO4 and CO5
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

## Concept Map



## Syllabus

**1.0 Project Identification:** Needs Assessment, Stakeholder Identification, Stakeholder Requirement Project Time Constraint.

**2.0 Specification Development:** Description Problem Environment, Creation of Stakeholder's Profiles Development of Low-cost Prototypes, Development of Task-Analysis, Comparison with Benchmark Products, Development of Customer Specification, Development of Evaluation Criteria,

**3.0 Conceptual Design:** Conduct of Functional Decomposition, Brainstroming of possible solutions, Creation of Prototypes for Multiple Concepts, Refinement of Design Specification on users' feedback, Evaluation of Potential Solutions, Selection of best design

## Learning Resources

1. Learning Material prepared by TCE faculty members
2. <https://www.ideo.com/>
3. <https://engineering.purdue.edu/EPICS>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours		Course Outcome
		In-Class	Hands-on	
1.	<b>Project Identification:</b> Introduction to Human-Centered Design	1	-	CO1
1.1	Needs Assessment	1	2	CO1
1.2	Identification of Stakeholders	1	2	CO2
1.3	Identification of Stakeholder Requirements		2	CO2
1.4	Project Time Constraint	1	2	CO2
2.	<b>Specification Development</b>			
2.1	Description Problem Environment	1	2	CO3
2.2	Creation of Stakeholder's Profiles		2	CO3
2.3	Development of Low-cost Prototypes	1	2	CO3
2.4	Development of Task-Analysis	1	2	CO3
2.5	Comparison with Benchmark Products	1	2	CO3
2.6	Development of Customer Specification		2	CO3
2.7	Development of Evaluation Criteria	1	2	CO3
3.	<b>Conceptual Design</b>			
3.1	Conduct of Functional Decomposition	1	2	CO4
3.2	Brainstroming of possible solutions	1	2	CO5
3.3	Creation of Prototypes for Multiple Concepts	1	2	CO5
3.4	Refinement of design Specification on users' feedback		2	CO6
3.5	Evaluation of Potential Solutions	1	2	CO6
3.6	Selection of best design		2	CO6
	<b>Total</b>	<b>12</b>	<b>34</b>	

### Course Designers:

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SYLLABI

For

**B.E. Mechatronics Program**

Fourth Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

**18MT410 PROBABILITY AND STATISTICS**

Category	L	T	P	Credit(s)
BS	3	0	0	3

**Preamble**

Statistics, as a subject, is a science of learning from data and provides tools for making decisions when conditions of uncertainty prevail. The mechatronics engineers play a significant role in designing and developing new products and manufacturing systems and processes, and they also improve existing systems. Statistical techniques are an important tool in these activities because they provide the engineer with both descriptive and analytical methods for dealing with the variability in observed data. The course is designed to impart the knowledge and understanding of the statistical techniques to Mechatronics Engineers and apply them in their areas of specialization.

**Prerequisite**

- 18MA110 - Engineering Calculus

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Apply conditional probability, Baye's theorem to solve engineering problems.	20
CO2	Compute probability, probability mass and density function, cumulative distribution function for random variables	10
CO3	Apply probability distribution for solving engineering problems.	15
CO4	Test the hypothesis on mean, proportion, variance of small and large samples	30
CO5	Fit a curve for given data and draw a regression line for it	25

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	K3	A3		1.1.1,2.1.4
CO2	TPS2	K2	A2		1.1.1,2.1.4
CO3	TPS3	K3	A3		1.1.1,2.1.4
CO4	TPS3	K3	A3		1.1.1,2.1.5,2.2.1,2.2.4
CO5	TPS3	K3	A3		1.1.1,,2.1.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	S							S		L	L
CO2	S	S	S	S							S		L	L
CO3	S	S	S	S							S		L	L
CO4	S	S	S	S							S		L	L
CO5	S	S	S	S							S		L	L

S – Strong

M – Medium

L – Low



**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10				10
Understand	30	30	30				30
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

- In a certain assembly plant, three machines,  $B_1$ ,  $B_2$ , and  $B_3$ , make 30%, 45%, and 25%, respectively, of the products. It is known from past experience that 2%, 3%, and 2% of the products made by each machine, respectively, are defective. Now, suppose that a finished product is randomly selected. What is the probability that it is defective? And if a product was chosen randomly and found to be defective, what is the probability that it was made by machine  $B_1$ ,  $B_2$ , and  $B_3$  respectively?
- The probability that a regularly scheduled flight departs on time is  $P(D) = 0.83$ ; the probability that it arrives on time is  $P(A) = 0.82$ ; and the probability that it departs and arrives on time is  $P(D \cap A) = 0.78$ . Find the probability that a plane (a) arrives on time, given that it departed on time, and (b) departed on time, given that it has arrived on time.
- Define conditional probability

**Course Outcome 2(CO2):**

- Identify the following as discrete or continuous random variables:
  - Total number gold medals won by India in Asian games 2018.
  - Height of the ocean's tide at a kanyakumari.
  - Number of deer born per year in a state wildlife preserve
  - The amount water released from mettur dam this month
- The weekly demand for propane gas (in 1000s of gallons) from a particular facility is an rv  $X$  with pdf  $f(x) = \begin{cases} 2\left(1 - \frac{1}{x^2}\right), & 1 \leq x \leq 2 \\ 0, & \text{otherwise} \end{cases}$ 
  - Compute the cdf of  $X$ .
  - Compute  $E(X)$  and  $V(X)$ .
- An electronics store sells a particular model of a laptop computer. There are only four laptops in stock, and the manager wonders what today's demand for this particular model will be. She learns from the marketing department that the probability distribution for  $x$ , the daily demand for the laptop, is as shown in the table.
 

$x$	0	1	2	3	4	5
$p(x)$	.10	.40	.20	.15	.10	.05

 Find the mean, variance, and standard deviation of  $x$ . Is it likely that five or more customers will want to buy the laptop today?

**Course Outcome 3(CO3):**

- For a car travelling 30 miles per hour (mph), the distance required to brake to a stop is normally distributed with a mean of 50 feet and a standard deviation of 8 feet. Suppose you

are travelling 30 mph in a residential area and a car moves abruptly into your path at a distance of 60 feet.

a. If you apply your brakes, what is the probability that you will brake to a stop within 40 feet or less? Within 50 feet or less?

b. If the only way to avoid a collision is to brake to a stop, what is the probability that you will avoid the collision?

2. A company that produces fine crystal knows from experience that 10% of its goblets have cosmetic flaws and must be classified as "seconds."

a. Among six randomly selected goblets, how likely is it that only one is a second?

b. Among six randomly selected goblets, what is the probability that at least two are seconds?

c. If goblets are examined one by one, what is the probability that at most five must be selected to find four that are not seconds?

3. An electronics store sells a particular model of a laptop computer. There are only four laptops in stock, and the manager wonders what today's demand for this particular model will be. She learns from the marketing department that the probability distribution for  $x$ , the daily demand for the laptop, is as shown in the table.

$x$	0	1	2	3	4	5
$p(x)$	.10	.40	.20	.15	.10	.05

Find the mean, variance, and standard deviation of  $x$ . Is it likely that five or more customers will want to buy the laptop today?

#### Course Outcome 4 (CO4):

1. Define type 1 error.

2. The daily yield for a local chemical plant has averaged 880 tons for the last several years. The quality control manager would like to know whether this average has changed in recent months. She randomly selects 50 days from the computer database and computes the average and standard deviation of the  $n=50$  yields as  $\bar{x} = 871$  tons and  $s = 21$  tons, respectively. Test the appropriate hypothesis using  $\alpha = .05$ .

3..An experiment was performed to compare the abrasive wear of two different laminated materials. Twelve pieces of material 1 were tested by exposing each piece to a machine measuring wear. Ten pieces of material 2 were similarly tested. In each case, the depth of wear was observed. The samples of material 1 gave an average (coded) wear of 85 units with a sample standard deviation of 4, while the samples of material 2 gave an average of 81 with a sample standard deviation of 5. Can we conclude at the 0.05 level of significance that the abrasive wear of material 1 exceeds that of material 2 by more than 2 units? Assume the populations to be approximately normal with equal variances

#### Course Outcome 5 (CO5):

1. Define correlation coefficient.

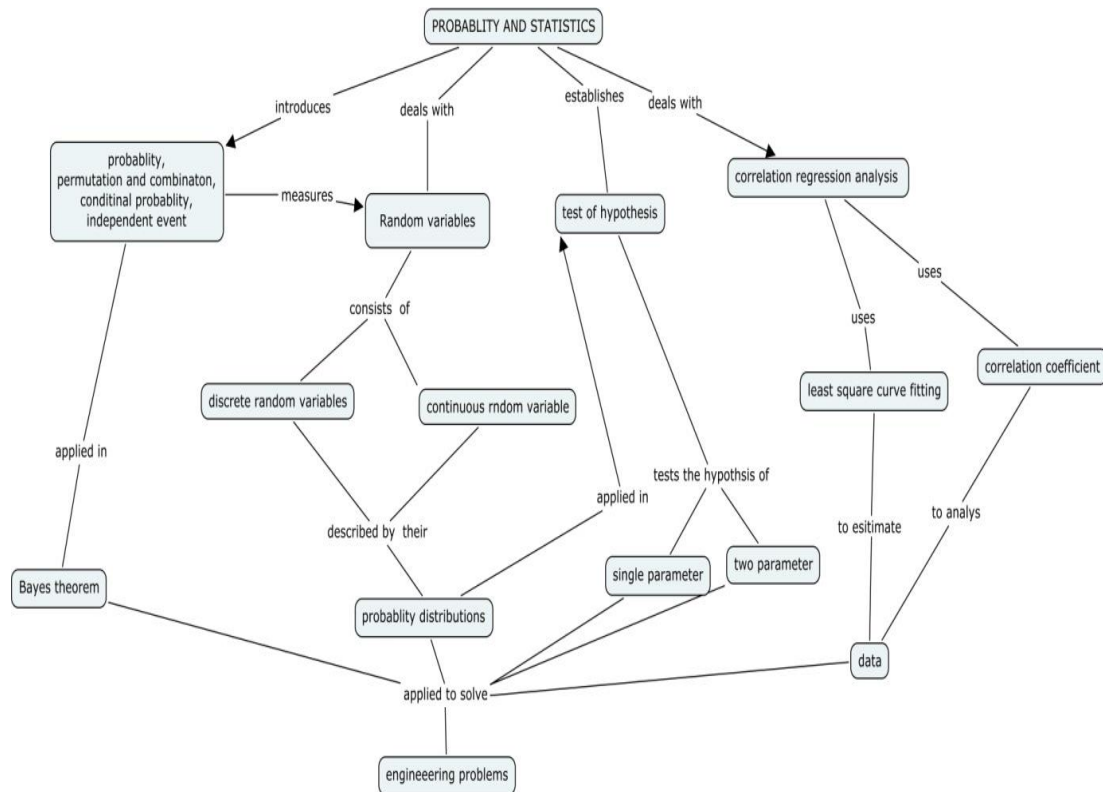
2. Fit a least-squares line to the data of

$x$	1	3	4	6	8	9	11	14
$y$	1	2	4	4	5	7	8	9

using (a)  $x$  as independent variable, (b)  $x$  as dependent variable.

3. Find the coefficient of correlation for the data given in the above problem.

## Concept Map



## Syllabus

**Probability** Introduction to probability - Permutation and combination - conditional probability, Independent events - Baye's theorem - **Random Variables and Probability Distributions** Discrete random variables - probability mass function - continuous random variables - probability density functions - cumulative distribution function - expected values for discrete and continuous random variables - - The Binomial probability distribution - the normal distribution **Tests of Hypotheses** - hypotheses and test procedures - tests concerning a population mean - tests concerning a population proportion - z tests and confidence intervals for a difference between two Population means - the two-sample *t* Test and confidence interval - inferences concerning a difference between population proportion - inferences concerning two population variances **Curve fitting and regression analysis**- Method of least squares: fitting a straight line, parabola- Coefficient of correlation, Coefficient of correlation for bivariate frequency distributions- rank correlation- Line of Regression.

## Learning Resources

1. Jay L. Devore, Probability and Statistics for Engineering and the Sciences (English) 8<sup>th</sup> Edition, Cengage Learning India Pvt Ltd, New Delhi, 2012.  
Module 1: chapter 2.1 to 2.5  
Module 2: chapter 3.1 to 3.4, 4.1 to 4.3  
Module 3: chapter 8.1 to 8.3, 9.1 to 9.5
2. Grewal. B.S, Higher Engineering Mathematics, 42<sup>st</sup> Edition, Khanna Publications, Delhi, 2012.  
Module 4: 24.4, 24.5, 25.12, 25.13, 25.14, 25.16
3. Ronald E. Walpole, Sharon L. Myers, Keying Ye, Probability & Statistics for Engineers & Scientists, 9<sup>th</sup> Edition, Pearson Education, New Delhi, 2012.
4. Mendenhall William, Introduction to Probability and Statistics, 14<sup>th</sup> Edition, Duxbury Press, New Delhi, 2012.

**Course Contents and Lecture Schedule**

Module No.	Topic	No. Of Hours	Course Outcome
<b>1</b>	<b>Probability</b>		
1.1	Introduction to probability	2	CO1
1.2	Permutation and combination	1	CO1
1.3	Conditional probability, Independent events	1	CO1
1.4	Baye's theorem	2	CO1
<b>2</b>	<b>Random Variables and Probability distributions</b>		
2.1	Discrete Random variables, probability mass function	2	CO2
2.2	Continuous random variables probability density functions,	2	CO2
2.2	cumulative distribution for discrete and continuous random variables	1	CO2
2.3	Expected values for discrete and continuous random variables	2	CO2
2.4	The Binomial probability distribution	2	CO3
2.5	The Normal distribution	2	CO3
<b>3</b>	<b>Tests of Hypotheses</b>		
3.1	Hypotheses and test procedures	2	CO4
3.2	Tests concerning a population mean	3	CO4
3.3	Tests Concerning a population proportion	1	CO4
3.4	z Tests and confidence intervals for a difference between two population means	2	CO4
3.5	The two-Sample <i>t</i> Test and confidence interval	1	CO4
3.6	inferences concerning a difference between population proportion	1	CO4
3.6	Inferences concerning two population variances	1	CO4
<b>4</b>	<b>Curve fitting and regression analysis</b>		
4.1	Method of least squares: fitting a straight line, parabola	2	CO5
4.2	Coefficient of correlation, Coefficient of correlation for bivariate frequency distributions	3	CO5
4.3	Rank correlation	1	
4.3	Line of Regression	2	CO5
	<b>TOTAL</b>	36	

**Course Designers:**

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**18MT420 POWER ELECTRONICS AND DRIVES**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Power Electronics is a technology that deals with the conversion and control of electrical power with high efficiency switching mode electronic devices. Around 40 percent of the world's power needs are currently met by electrical energy and that proportion is expected to rise as countries cut carbon emissions and shift to renewable energy sources. As the trend towards electrification and renewable energies increases, enabling technologies such as power electronics are becoming ever more important. Electrification is opening up more applications for power electronics such as drive trains for electric vehicles (EVs) and hybrids, as well as DC fast-charging stations, which can charge EV batteries in a matter of 15-30 minutes, compared with the many hours it takes using standard residential charging ports. The traditional application area of power electronics is variable speed drives for electrical motors. Power-electronics technologies are able to vary the speed of motor drives, making processes more efficient and reducing the amount of energy consumed. Electrical drives are required in large numbers in many industrial and domestic applications like transportation systems, rolling mills, paper machines, machine tools, fans, pumps, robots etc. This course covers in detail the basic and advanced control of power electronic converters that are used in electric drives.

**Prerequisite**

- 18MT220 - Electrical Machines
- 18MT230 - Analog Electronics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the operations of controlled converters for different types of Loads.	10
CO2	Differentiate the characteristics and performance Parameters of different power electronic converters.	10
CO3	Explain different power semiconductor switching circuits used in Electrical drives.	20
CO4	Describe basic structure of position, speed, and torque control in Electrical drives.	20
CO5	Choose appropriate converter technique to control different drives in industrial applications.	20
CO6	Select and integrate suitable electrical drives for motion control applications such as Machine tools and Industrial robotics.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception	1.1,1.2
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4

CO4	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	-	-	-	M	L	-	-	-	L	L	M
CO2	L	M	M	M	L	L	L	-	-	-	-	L	L	L
CO3	M	M	M	M	L	L	L	-	-	-	-	L	L	L
CO4	S	M	M	M	L	L	L	-	-	-	-	L	M	M
CO5	M	S	S	S	S	L	L	-	M	M	-	S	S	S
CO6	S	S	S	S	S	L	L	-	M	M	-	S	S	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	60	40	40	-	-	-	50
Apply	20	40	40	100	100	100	30
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Animation of Machines Operation
Set	Working Demonstration
Guided Response	Active Learning Techniques
Mechanism	Mini projects
Complex Overt Responses	
Adaptation	
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- List out the difference between Converter and Inverter with suitable examples.
- Define chopper.
- Explain the operation of three phase half wave-controlled converter with inductive load. Sketch the associated waveforms.
- With necessary circuit and waveforms, explain the principle of operation of three phase-controlled bridge rectifier feeding R-L load and derive the expression for the average output dc voltage

**Course Outcome 2(CO2):**

1. Explain the effect of source inductance in the operation of three phase fully controlled converter, indicating clearly the conduction of various thyristors during one cycle with relevant waveforms.
2. Explain the effect of source inductance in the operation of single phase fully controlled converter, indicating clearly the conduction of various thyristors during one cycle.
3. Explain the working of Buck-Boost chopper with circuit diagram and characteristic waveforms.
4. Classify the various techniques adopted to vary the inverter gain and brief on sinusoidal PWM.

**Course Outcome 3(CO3):**

1. Describe the working principle of boost converter with necessary circuit and waveforms.
2. Explain the operation of single-phase capacitor commutated CSI with R load.
3. Draw the circuit diagram of current source inverter and explain its operation with relevant waveforms.
4. Describe the VSI fed induction motor and drives with relevant diagram

**Course Outcome 4 (CO4):**

1. Explain the structure of closed loop position control of DC drive.
2. Describe the speed control scheme of Induction motor Drive.
3. Explain the torque control of AC Drive.

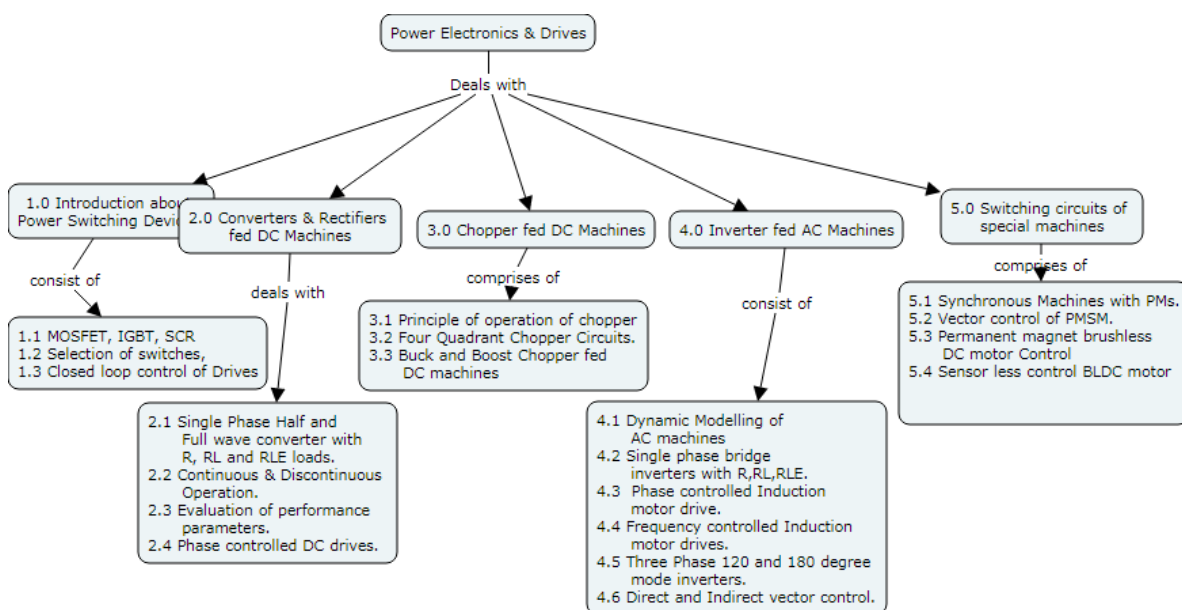
**Course Outcome 5 (CO5):**

1. Explain the function and applications of variable frequency drives.
2. Explain the direct vector-controlled Induction motor drive.
3. Explain the frequency-controlled Induction motor drive.

**Course Outcome 6(CO6):**

1. Select suitable drives used in CNC machines and explain in detail.
2. Select suitable Inverter driven AC Drive for machine tool applications.
3. Select and explain suitable drive for industrial robotics applications.

**Concept Map**



## Syllabus

### Introduction:

Power Devices-MOSFET, IGBT, SCR- Linear regulated vs Switched mode power supplies  
Electrical drive system-Advantages-Types of Electric drives-Dynamic of Drives- selection of electrical drives- Modes of operation of electrical drives- -closed loop control of Drives.

**Controlled Rectifiers (Converters) fed DC drives:** Single Phase Half wave / full wave half controlled /fully controlled converters with R, RL and RLE loads, Continuous and discontinuous current operations- Evaluation of performance parameters - Phase controlled DC drives.

**Chopper controlled DC Drives:** principle of operation of chopper-Four Quadrant Chopper Circuits- Buck and Boost Chopper fed DC machines.

**Induction Motor Drives:** Dynamic Modelling of Induction machines- Single phase bridge inverters with R, RL and RLE loads -Phase controlled Induction motor drive-Frequency controlled Induction motor drives-Variable frequency Drives Three phase 120 and 180 degree mode Inverter fed AC machine –Vector controlled Induction motor drives –Direct and Indirect vector control.

**Permanent Magnet Synchronous and Brushless DC Motor Drives:** Synchronous Machines with PMs-Vector control of PMSM-Permanent magnet brushless DC motor-Sensor less control BLDC motor.

## Learning Resources

1. R.Krishnan, "Electrical motor drives modelling, analysis and control" Pearson India, 2015.
2. Gopal K.Dubey, "Fundamentals of Electrical Drives" Narosa Publishing house, 2017.
3. P. S. Bimbhra, "Power Electronics" KHANNA PUBLISHERS-DELHI, 2012
4. Mohammed H Rashid, "Power electronics" Pearson Education India, 2009.
5. Bimal Bose, "Power electronics and driver circuits" Elsevier, 2006.
6. Bogdan M. Wilamowski, J. David Irwin,"Power Electronics and Motor Drives"CRC Press ,2011
7. Bimal K Bose, "Modern Power electronics and AC drives" Prentice hall, 2002.
8. [https://onlinecourses.nptel.ac.in/noc19\\_ee03](https://onlinecourses.nptel.ac.in/noc19_ee03)
9. <https://nptel.ac.in/downloads/108105066/>

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction</b>		
1.1	Power Devices-MOSFET, IGBT, SCR	1	CO3
1.1	Electrical drive system-Advantages-Types of Electric drives-Dynamic of Drives	1	CO4
1.2	Modes of operation of electrical drives- -closed loop control of Drives.	2	CO4
<b>2.0</b>	<b>Controlled Rectifiers (Converters) fed DC Motors:</b>		
2.1	Single Phase Half and Full wave converter with R, RL and RLE loads	2	CO1
2.2	Single phase Half controlled and Fully controlled converters with R, RL and RLE loads, Continuous and discontinuous operations	2	CO1
2.3	Evaluation of performance parameters	1	CO2
2.4	Phase controlled DC drives.	2	CO5



<b>3.0</b>	<b>Chopper controlled DC Drives</b>		
3.1	Principle of operation of chopper	1	CO2
3.2	Four Quadrant Chopper Circuits.	2	CO2
3.3	Buck and Boost Chopper fed DC machines	2	CO5
<b>4.0</b>	<b>Induction Motor Drives</b>		
4.1	Dynamic Modelling of Induction machines	2	CO4
4.2	Single phase bridge inverters with R, RL and RLE loads	2	CO1
4.3	Phase controlled Induction motor drive	2	CO4
4.4	Frequency controlled Induction motor drives	2	CO2
4.5	Three phase 120 and 180 degree mode Inverter fed AC machine		CO5
4.6	Vector controlled Induction motor drives –Direct and Indirect vector control.	3	CO6
<b>5.0</b>	<b>Permanent Magnet Synchronous and Brushless DC Motor Drives</b>		
5.1	Synchronous Machines with PMs.	1	CO5
5.2	Vector control of PMSM.	2	CO5
5.3	Permanent magnet brushless DC motor Control	2	CO6
5.4	Sensor less control BLDC motor	2	CO6
	<b>Total</b>	36	

**Course Designers:**

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**18MT430****MICROCONTROLLER**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Microcontrollers based embedded systems are involved in almost every facet of modern life. Consumer gadgets, entertainments gadgets, medical devices and automobiles all contain embedded Microcontroller. The tremendous number of applications for embedded computing has given rise to high demand for engineers with experience in designing and implementing embedded systems with microcontroller. This course is designed to provide an introduction to microcontroller architecture, internal and external peripherals, assembly language programming and embedded c programming. Students will be taught the basic use of a programming environment and how to develop the basic C programming for embedded application. This course highlights the general interfacing techniques and concepts through peripheral's data representation from input/output, and memory usage in the microcontroller in embedded C.

**Prerequisite**

- 18MT330 - Digital Electronics
- 18MT380 - Digital Electronics laboratory

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the underlying Architecture of 8051 microcontroller	20
CO2	Develop about the Assembly language programming for 8051	20
CO3	Design and Develop about the programming in C and Toolchains required for 8051 microcontroller Development.	20
CO4	Design an Embedded system using 8051 by interfacing Different Peripherals	20
CO5	Explain about the Advanced 8-bit AVR architecture and Programming	10
CO6	Develop knowledge on software framework and API for Embedded systems using IDE's	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2,1.3
CO2	TPS2	Understand	Respond	Guided Response	2.1,2.2,2.3,4.5.1
CO3	TPS3	Apply	Value	Mechanism	2.1,2.2,,2.3,4.4.1
CO4	TPS3	Apply	Value	Mechanism	2.3,4.4,4.5.4
CO5	TPS2	Understand	Respond	-	1.2,1.3
CO6	TPS3	Apply	Value	Mechanism	4.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L			L		M			L				L	M
CO2	M	S	M	M					M	M			L	M
CO3					S			S			S	S	L	M
CO4		S		S										
CO5		S			S				M	L			L	M
CO6	L		L			L	L		M			S		

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	-
Understand	50	50	50	100	-	-	50
Apply	50	50	50	-	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Practical Component
Set	Assignment
Guided Response	Assignment
Mechanism	Mini Project
Complex Overt Responses	
Adaptation	
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Distinguish between 8085 microprocessor and 8051 microcontrollers.
2. List the microcontrollers in intel.
3. Define the functionality of CPU in microprocessor and microcontroller.
4. Distinguish between 8 bit and 16-bit microcontroller.
5. Define the functionality of timer peripherals in a microcontroller.
6. List the internal peripherals present in 8051.
7. Define the functionality of a serial peripheral in 8051.
8. Show that how do you access the peripherals in 8051

**Course Outcome 2(CO2):**

1. Demonstrate the timer peripheral in mode 1 operation.
2. Give an example for accessing serial peripheral in polling driven.
3. Describe the use of serial peripheral in asm programming.
4. Develop a C program for a described value of time delay

**Course Outcome 3(CO3):**

1. Demonstrate the timer peripherals with mode 1 and mode 2
2. Give an example for accessing timer in asm and C program

3. Describe the functionality of the GPIO hardware for accessing IO device
4. Distinguish between timer and counter in its modes of operation

**Course Outcome 4 (CO4):**

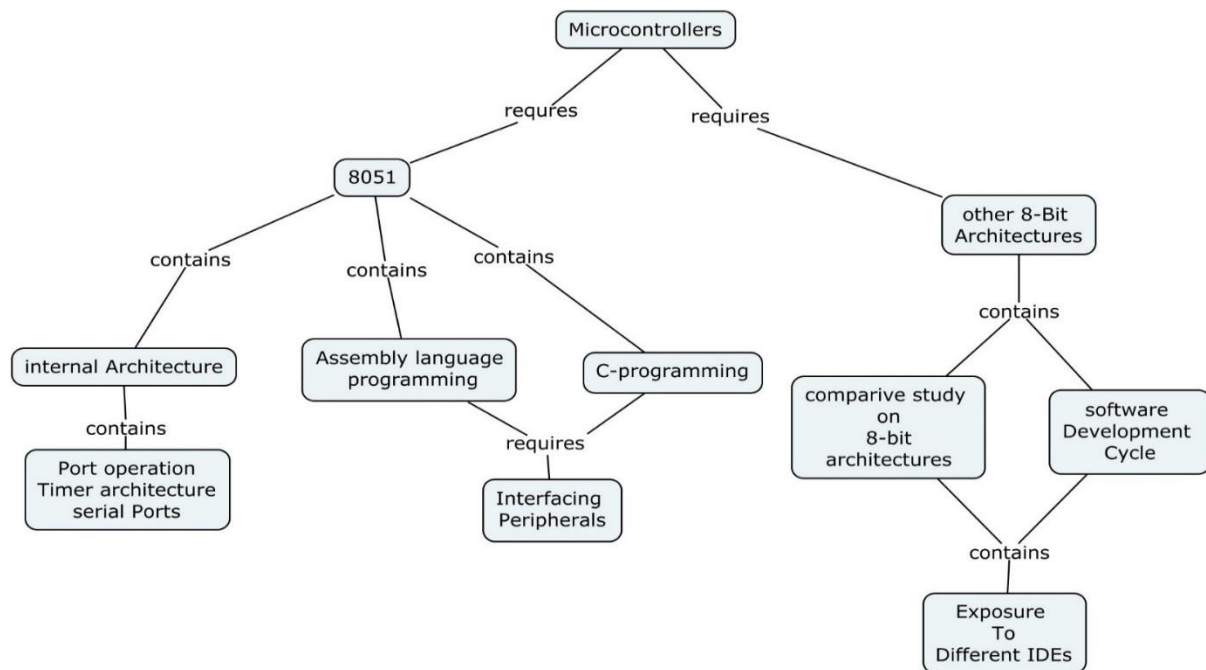
1. Illustrate the serials peripherals for transmitting the data in defined baud rate
2. Show the program for accessing a ADC and show it in LED display
3. Demonstrate the operation of keyboard interfacing with 8051 board
4. Construct the program for interfacing LCD module with 8051 board

**Course Outcome 5 (CO5):**

1. Compare AVR architecture with 8051 Architecture.
2. List out different 8-bit microcontrollers from Different manufacturers.
3. Define Toolchain.
4. What is make file and elaborate about the building a C-file.

**Course Outcome 6(CO6):**

1. Write in detail about the Arduino Framework.
2. Explain about Integrated Development Environment.
3. Explain about API and library management.

**Concept Map****Syllabus**

**8051 Microcontroller Basics:** Inside the Computer, Microcontrollers and Embedded Processors, Block Diagram of 8051, PSW and Flag Bits, 8051 Register Banks and Stack, Internal Memory Organization of 8051, IO Port Usage in 8051, Types of Special Function Registers and their uses in 8051, Pins Of 8051. Memory Address Decoding, 8031/51 Interfacing with External ROM And RAM. 8051 Addressing Modes.

**Assembly programming and instruction of 8051:** Introduction to 8051 assembly programming, Assembling and running an 8051 program, Data types and Assembler directives, Arithmetic, logic instructions and programs, Jump, loop and call instructions, IO port programming

**8051 programming in C:** Data types and time delay in 8051, IO programming in 8051, Logic operations in 8051 , Data conversion program in 8051 , accessing code ROM space in 8051, Data serialization using 8051, **8051 Timer programming , 8051 serial port programming ,8051 Interrupt programming , Interfacing with LCD, Keypad, ADC, DAC.**

**Microcontrollers:** Introduction to other 8-bit Architecture, Port Design, Toolchain and compilers, Arduino IDE Library Development, Arduino programming.

### Learning Resources

1. The 8051 Microcontroller and Embedded Systems Using Assembly and C 2nd Edition, Pearson, Muhammed Ali Mazidi. 2007
2. The 8051 Microcontroller 3rd Edition, Kenneth J. Ayala.2007, Cengage publications.
3. AVR Microcontroller and Embedded Systems: Using Assembly and C:using Arduino uno and atmel studio, Muhammed Ali Mazidi, sepehr naimi and armad naimi, 2017.
4. PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18, 1e, MuhammedAli Mazidi 2008.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
8051 architecture			
1.1	<b>Internal Architecture of 8051</b>	2	CO1
1.2	Memory organisation and addressing Modes	2	CO1
1.3	Assembler Directives and Data Types.	2	CO1
1.4	SFR and Memory Address Decoding	2	CO1
Assembly Language Programming			
2.1	Instruction set of 8051	2	CO2
2.2	Timer programming	2	CO2
2.3	Interrupt Programming	2	CO2
2.4	IO Port Programming	2	CO2
C Programming			
3.1	Cross Compilation and HEX file generation using Keil	2	CO3
3.2	Basics of Library Generation.	2	CO3
Interfacing With 8051			
3.3	Interfacing With ADC	2	CO4
3.4	Interfacing with DAC	2	CO4
3.5	Interfacing with Keypad	2	CO4
3.6	Interfacing With LCD	2	CO4
3.7	Interfacing with Sensors	1	CO4
3.8	Design of a System using 8051 (Data Logger)	1	CO4
Architecture			
4.1	Architecture of ATMEGA328P, PIC16F877A	2	CO5
4.2	Introduction to Toolchains and Compilers.	1	CO6
4.3	Using C++ for Library Development in Microcontrollers.	1	CO6
4.4	Introduction to Arduino Environment	2	CO6
Total		36	

### Course Designers:

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**18MT440      SENSORS AND MEASUREMENTS**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

In today's world, boundaries between different disciplines have become indistinct. In last two decades multidisciplinary approach has grown. Mechatronics is a field of engineering which deals with the integration of Mechanics and Electronics with intensive computer integration using a multidisciplinary approach to product and manufacturing system design. Hence every mechatronics engineer should understand the principle and functions of sensor and PIC based systems. The outcome of this course is to help students to acquire knowledge in understanding the sensor and PLC principles, functions and applications. Metrology is the science of measurement. The ability to measure and to compare measurements between laboratories is one of the cornerstones of the scientific method. Globalization of research, development and manufacture has produced greatly increased attention to international standards of measurement. It is no longer sufficient to achieve internal consistency in measurements within a local laboratory or manufacturing facility.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the basic principles and characteristics sensors	20
CO2	Classify and explain the measurement of displacement, pressure and temperature sensors	20
CO3	Classify and explain the measurement of velocity, acceleration and optical sensors	20
CO4	Explain the importance of signal conditioning circuits	20
CO5	Explain the various data acquisition system and its components.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TSP1	Remember	Receive	Perception Set	1.1, 1.2
CO2	TSP3	Apply	Value	Mechanism	2.1.1, 2.1.3, 2.1.4, 2.2.3
CO3	TSP3	Apply	Value	Mechanism	2.1.1, 2.1.3, 2.1.4, 2.2.3
CO4	TSP3	Apply	Value	Mechanism	2.1.1, 2.1.3, 2.1.4, 2.2.3
CO5	TSP3	Apply	Value	Mechanism	2.2.1, 2.4.6

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO2	M	L	S	-	-	-	M	-	-	-	-	-	M	L
CO3	M	L	S	-	-	-	M	-	-	-	-	-	M	L
CO4	M	L	S	-	-	-	M	-	-	-	-	-	M	L
CO5	S	L	-	-	S	M	S	-	-	-	-	S	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	50			20
Understand	40	40	40	50	50	50	40
Apply	40	40	40	-	50	50	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Quiz
Set	Objective type Question
Guided Response	Objective type Question
Mechanism	Mini project
Complex Overt Responses	-
Adaptation	-
Orignation	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Explain the following terms
  - a. Sensitivity
  - b. Hysteresis error
  - c. Stability
  - d. Resolution
2. Define calibration.
3. Explain different types of error in measuring instrument.

**Course Outcome 2(CO2):**

1. Explain the construction and principle of working of a LVDT.
2. Describe the different modes of operation of piezo electric transducers.
3. Describe the different principles of working of capacitive dectector.
4. What is Strain gauge.

**Course Outcome 3(CO3):**

1. Explain the function of a capacitive sensor in a robot end effector?
2. Explain the working principle of pirani gauge.
3. Select the suitable sensor used to measure the pressure.

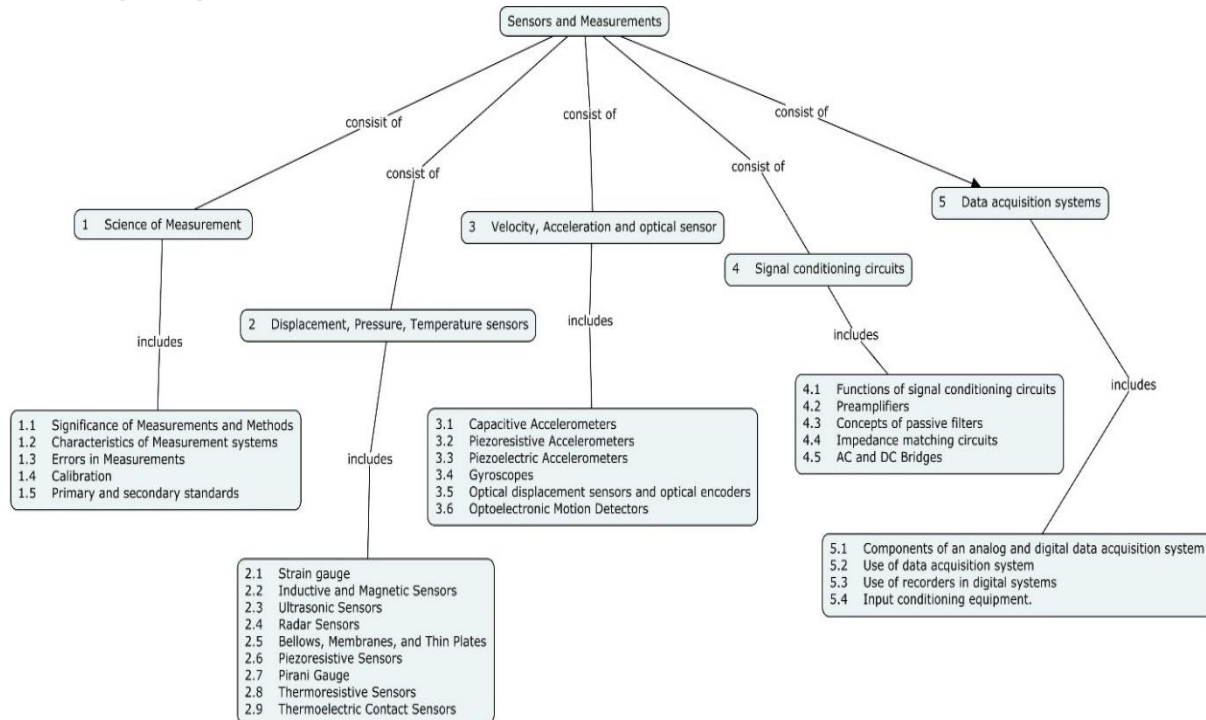
**Course Outcome 4 (CO4):**

1. Explain the role of amplifier in the measuring instrument.
2. Explain the working principle of Wheatstone bridge.
3. Select the suitable sensor to detect the human motion.

**Course Outcome 5 (CO5):**

1. Discuss in detail about optical encoder.
2. Explain the generalized diagram of a digital data acquisition system?
3. Explain the component in analog data acquisition system.

## Concept Map



## Syllabus

**Science of Measurement** - Significance of Measurements and Methods, Characteristics of Measurement systems, Errors in Measurements, Calibration, Primary and secondary standards, **Displacement, Pressure, Temperature sensors** - Strain gauge, Gauge factor, sensing elements, configuration, and unbounded strain gage, Inductive and Magnetic Sensors, LVDT and RVDT, Hall Effect Sensors, Ultrasonic Sensors, Radar Sensors, Bellows, Membranes, and Thin Plates, Piezoresistive Sensors, Pirani Gauge, Thermoresistive Sensors, Resistance Temperature Detectors, Thermistors, Thermoelectric Contact Sensors, **Velocity, Acceleration and optical sensor** - Capacitive Accelerometers, Piezoresistive Accelerometers, Piezoelectric Accelerometers, Gyroscopes, Optical displacement sensors and optical encoders, Optoelectronic Motion Detectors, Sensor Structures, Visible and Near-Infrared Light Motion Detectors, Far-Infrared Motion Detectors, **Signal conditioning circuits** - Functions of signal conditioning circuits, Preamplifiers, Concepts of passive filters, Impedance matching circuits, AC and DC Bridges, wheat stone bridge, Kelvin, Maxwell, Hay, Schering, **Data acquisition systems** - Components of an analog and digital data acquisition system, Use of data acquisition system, Use of recorders in digital systems, Input conditioning equipment.

## Learning Resources

1. A.K.Sawhney, —Electrical & Electronics Measurement and InstrumentationII, 10th edition, DhanpatRai& Co, New Delhi, 19th Revised edition 2011, Reprint 2014.
2. John G. Webster, —Medical Instrumentation Application and DesignII, 4th edition, Wiley India Pvt Ltd, New Delhi, 2015.
3. Ernest O Doebelin and Dhanesh N Manik, Measurement systems, Application and design, 6th edition, McGraw-Hill, 2012.
4. Khandpur R.S, —Handbook of Biomedical InstrumentationII, 3rd edition, Tata McGraw-Hill, New Delhi, 2014.



5. Leslie Cromwell, —Biomedical Instrumentation and measurementII, 2<sup>nd</sup> edition, Prentice hall of India, New Delhi, 2015.
6. Albert D.Helfrick and William D. Cooper. Modern Electronic Instrumentation and Measurement TechniquesII, Prentice Hall of India, 1<sup>st</sup> edition, 2016

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Science of Measurement</b>		
1.1	Significance of Measurements and Methods	1	CO1
1.2	Characteristics of Measurement systems	1	CO1
1.3	Errors in Measurements	1	CO1
1.4	Calibration	1	CO1
1.5	Primary and secondary standards	1	CO1
<b>2</b>	<b>Displacement, Pressure, Temperature sensors</b>		
2.1	Strain gauge		CO2
2.1.2	Gauge factor, sensing elements, configuration, and unbounded strain gage	1	CO2
2.2	Inductive and Magnetic Sensors		CO2
2.2.1	LVDT and RVDT	2	CO2
2.2.2	Hall Effect Sensors	1	CO2
2.3	Ultrasonic Sensors	1	CO2
2.4	Radar Sensors	1	CO2
2.5	Bellows, Membranes, and Thin Plates	1	CO2
2.6	Piezoresistive Sensors	1	CO2
2.7	Pirani Gauge	1	CO2
2.8	Thermoresistive Sensors		CO2
2.8.1	Resistance Temperature Detectors	1	CO2
2.8.2	Thermistors	1	CO2
2.9	Thermoelectric Contact Sensors	1	CO2
<b>3</b>	<b>Velocity, Acceleration and optical sensor</b>		
3.1	Capacitive Accelerometers	1	CO3
3.2	Piezoresistive Accelerometers	1	CO3
3.3	Piezoelectric Accelerometers	1	CO3
3.4	Gyroscopes	1	CO3
3.5	Optical displacement sensors and optical encoders	1	CO3
3.6	Optoelectronic Motion Detectors		CO3
3.6.1	Sensor Structures	1	CO3
3.6.2	Visible and Near-Infrared Light Motion Detectors	1	CO3
3.6.3	Far-Infrared Motion Detectors	1	CO3
<b>4</b>	<b>Signal conditioning circuits</b>		
4.1	Functions of signal conditioning circuits	1	CO4
4.2	Preamplifiers	1	CO4
4.3	Concepts of passive filters	1	CO4
4.4	Impedance matching circuits	1	CO4
4.5	AC and DC Bridges	1	CO4
4.5.1	wheat stone bridge	1	CO4
4.5.2	Kelvin, Maxwell	1	CO4
<b>5</b>	<b>Data acquisition systems</b>		
5.1	Components of an analog & digital data acquisition system	1	CO5

5.2	Use of data acquisition system	1	CO5
5.3	Use of recorders in digital systems	1	CO5
5.4	Input conditioning equipment.	1	CO5
Total		36	

**Course Designers:**

<b>Sl. No.</b>	<b>Name</b>	<b>E-mail Id</b>
1	Dr. L.R. Karlmarx	lrkarlmarx@tce.edu
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**18EG460 PROFESSIONAL COMMUNICATION**

Category	L	T	P	Credit(s)
HSS	1	0	2	2

**Preamble**

This course helps the students to achieve effective language proficiency for their professional, social and interpersonal communication skills, hence increasing their employability and career skills.

**Prerequisite**

- Basic English Knowledge

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Listen, watch, understand and respond to talks, conversations, etc by native and neutral speakers on science, general context, and from ETS test samples with confidence.	22%
CO2	Present ideas, express opinions/comments, practice presentation, and converse in discussions on a variety of technical and non-technical domains without fear	39%
CO3	Read and comprehend passages/texts from various topics – general and reasoning, to respond precisely through reading techniques, besides getting awareness on competitive exam lexicon/verbal exercises for career prospects	17%
CO4	Write journal abstracts/projects and business correspondences with clarity, accuracy, intelligibility, and precision.	22%

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	2.4.2, 2.4.6, 3.2.1, 3.2.2,
CO2	TPS3	Apply	Value	Mechanism	3.1.3, 3.1.2, 3.2.4, 3.2.5,3.2.6
CO3	TPS2	Understand	Respond	Guided Response	2.4.6, 2.4.5, 3.2.1,
CO4	TPS3	Apply	Value	Mechanism	2.4.3, 3.2.1, 3.2.3, 3.2.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									L	S		M		
CO2									S	S		M		
CO3									M	S		M		
CO4									M	S		M		
CO5									L	S		M		

S – Strong

M – Medium

L – Low

### Assessment Pattern

**Internal:** No Continuous Assessment Test(CAT) will be conducted. Students' performance will be continuously assessed in various classroom activities in Listening, Speaking, Reading and Writing for 50 marks as detailed below:

Listening Test	- 10
Speaking Test (Group Discussion and Technical Presentation)	- 20
Written Test(Objective/Descriptive to be tested for 40 marks and converted to 20 marks)-	20

**External (Practical):**

Group Discussion	- 20
Personal Interview / Situational Conversation (BEC speaking based)	- 20
Listening Test	- 20
Reading / Writing – Computerised or Paper-based Test / General Aptitude Test – Objective type	- 40

### List of Experiments/Activities with CO Mapping

S.No	Activities	Hours		CO Mapping			
		T	P				
1	Listening, Reading and Writing based on	2		CO1		CO3	CO4
2	Listening exercises at lab - online resources		2	CO1			
3	Developing Listening skills (BEC / IELTS / TOEIC		2	CO1			
4	GD/Mock interview/Presentation Intro at lab		2	CO1			
5	GD Practice at classroom in groups		4	CO1	CO2		
6	Presentation on Technical / general topics – from	1	4		CO2		
7	Mock interview practice at classroom	1	4	CO1	CO2		
8	Comprehension Descriptive and Reasoning	2	2			CO3	
9	General Aptitude Practice – Vocabulary Development / Sentence completion / Error	3	2			CO3	CO4
10	Business Correspondence - BEC Writing Task II	2					CO4
11	Basics of Technical Writing/ Project Reports		2		CO2		
12	Preparation of Resume	1					CO4

### Learning Resources

Reference Books:

1. Cappel, Annette and Sharp, Wendy, Cambridge English: Objective First, 4<sup>th</sup> Ed., CUP, New Delhi, 2013.
2. Cusack, Barry. Improve Your IELTS Listening and Speaking Skills (With CD) Paperback, Mcmillan, 2007.
3. Bates, Susan TOEFL iBT Exam Paperback – Oxford, 2012.
4. Hart, Guy Brook. Cambridge English Business Benchmark: 2 Ed., CUP 2014

### Websites:

1. <https://ielts-up.com> (IELTS – LSRW – Practice Tests)
2. [www.cambridgeenglish.org](http://www.cambridgeenglish.org) (BEC - LSRW)
3. [www.etsglobal.org](http://www.etsglobal.org) (TOEIC Preparation)
4. [www.examenglish.com](http://www.examenglish.com) (Online Exams for international ESL Exams)
5. [www.testpreppractice.net](http://www.testpreppractice.net) (GRE Tests -Vocabulary /Analogy / Sentence Completion / Reading)

6. <https://www.freshersworld.com> (Placement Papers)

**Extensive Reading:**

Coelho, Paulo. The Alchemist, Harper Publication, 2018.

**Course Designers:**

1. Dr.A.Tamilselvi , Convenor
2. Dr S.Rajaram
3. Mr.Vinoth.R
4. Dr.G.Jeya Jeevakani
5. Ms.R.Manibala

**18MT490****PROJECT MANAGEMENT**

Category	L	T	P	Credit(s)
HSS	3	0	0	3

**Preamble**

Management in business and human organization activity is simply the act of getting people together to accomplish desired goals. Qualified project managers are in high demand in this competitive world. This course focuses on project management methodology that will increase your ability to initiate and manage projects more efficiently and effectively. The Project Management course discusses activities of planning, organizing, motivating, controlling resources and leadership in theory and practice and the roles and responsibilities of the project manager. It deals with approaches to achieve the project goals and to optimize the allocation of necessary inputs and to integrate them.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the importance of project management and project initiation.	15
CO2	Determine the project duration and time estimates by Gantt Chart and Network techniques.	35
CO3	Optimize resources of projects using resource smoothing or resource levelling techniques.	15
CO4	Crash the project to its bare minimum value and obtain the optimum time – minimum cost relationships.	20
CO5	Describe about risk assessment process, project closure and agile techniques.	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	2.1.1,2.5.1,3.1.1,3.1.2,3.1.3,3.1.4
CO2	TPS3	Apply	Value	Mechanism	2.4.7,3.2.4,3.2.5,3.2.6,4.3.4
CO3	TPS3	Apply	Value	Mechanism	2.4.7,3.2.4,3.2.5,3.2.6,4.3.4
CO4	TPS3	Apply	Value	Mechanism	2.4.7,3.2.4,3.2.5,3.2.6,4.3.4
CO5	TPS2	Understand	Respond	Guided Response	2.1.1,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	L	L	-	-	M	S	S	S	-	M	M
CO2	L	L	M	L	M	-	-	L	L	M	S	-	L	L
CO3	L	L	M	L	M	-	-	L	L	M	S	-	L	L
CO4	L	L	M	L	M	-	-	L	L	M	S	-	L	L
CO5	L	L	L	L	L	-	-	M	S	S	S	-	M	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	20	20	20	-	-	-	20
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	Assignment
Mechanism	
Complex Overt Responses	
Adaptation	
Origation	

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define a project and draw its life cycle.
2. Suggest a suitable organisational structure for a Central Engineering Systems, Inc
3. Explain about Project charter

**Course Outcome 2(CO2):**

1. Draw the Gantt chart/ Bar chart over calendar dates and determine the duration & date of completion of the project using following logical relationships of activities.
  - i. M,N & Q start concurrently.
  - ii. O & P are concurrent & depend on completion of both M & N.
  - iii. R & S are concurrent and depend on completion of O.
  - iv. T depends on completion of P,Q,R
  - v. The project is complete when S & T are done.

Activity	M	N	O	P	Q	R	S	T
Duration (days)	6	8	7	5	7	6	5	4

Assume six working days per week taking date of commencement of the project as 26<sup>th</sup> April 2019(Friday). Find the status of the project by 8<sup>th</sup> May 2019

2. Develop network diagram of the following project on A-O-A and A-O-N basis using following logical relationships of activities. Also determine critical path using traditional method.
  - a. S,T and R are the initial activities of the Project.
  - b. K follows S; N follows T; V follows R.
  - c. K precede C & W
  - d. N & V precede D

e. D also depends on W for its start. C & D are terminal activities of the project

<b>Activity</b>	S	T	R	K	N	V	C	W	D
<b>Duration(days)</b>	5	4	5	3	6	2	4	3	2

3. Conduct activity oriented network analysis and determine following.

- i. Time estimates for activities
- ii. Floats
- iii. Critical path and its duration
- iv. Draw square network / time scaled version of the network.

<b>Activity i-j</b>	10-20	10-30	30-40	20-40	20-50	20-60	20-70	40-60	50-60	60-70
<b>Duration (days)</b>	5	4	5	3	6	2	4	3	2	1

4. Conduct PERT analysis for the following project & determine:

- a. Average time its degree of variability for activities.
- b. Earliest & Latest allowance occurrence times for events.
- c. Slack for events and total float for activities.
- d. Critical path, its duration & its degree of variability
- e. Probability of completing the project 3 days earlier
- f. Probability of completing the project 2 days later
- g. Probability of not completing the project 3 days later
- h. Date of completion which has 82% chance of being met.
- i. % utilization of resources for critical & non critical activities.

<b>Activity (i-j)</b>	<b>10-20</b>	<b>20-30</b>	<b>20-40</b>	<b>20-50</b>	<b>30-60</b>	<b>40-60</b>	<b>30-50</b>	<b>50-60</b>
<b>Optimistic time (<math>t_o</math>) days</b>	4	2	3	3	4	2	5	2
<b>Most Likely time (<math>t_m</math>) days</b>	8	4	3	7	6	7	8	2
<b>Pessimistic time (<math>t_p</math>) days</b>	12	6	3	11	13	9	12	2

### Course Outcome 3(CO3):

1. The resource requirement for a project is given in the table. Balance the resource so as to have a more uniform demand throughout the project.

<b>Activity</b>	<b>10-20</b>	<b>10-30</b>	<b>10-40</b>	<b>10-60</b>	<b>20-50</b>	<b>30-40</b>	<b>40-50</b>	<b>50-60</b>
<b>Duration (days)</b>	2	4	2	4	3	2	3	1
<b>Resource req Per day</b>	4	6	7	5	7	5	2	2

2. Balance the resource demand of the project so as to meet its availability of 6men/day.

<b>Activity</b>	10-20	20-30	20-40	30-40	30-50	40-50
<b>Duration (days)</b>	3	2	3	2	4	2
<b>Men Required/day</b>	6	5	4	3	3	4



**Course Outcome 4 (CO4):**

1. Explain the different types of cost.
2. Define cost slope.
3. Crash the project to its bare minimum value and obtain the optimum time – minimum cost relationships with the given data.

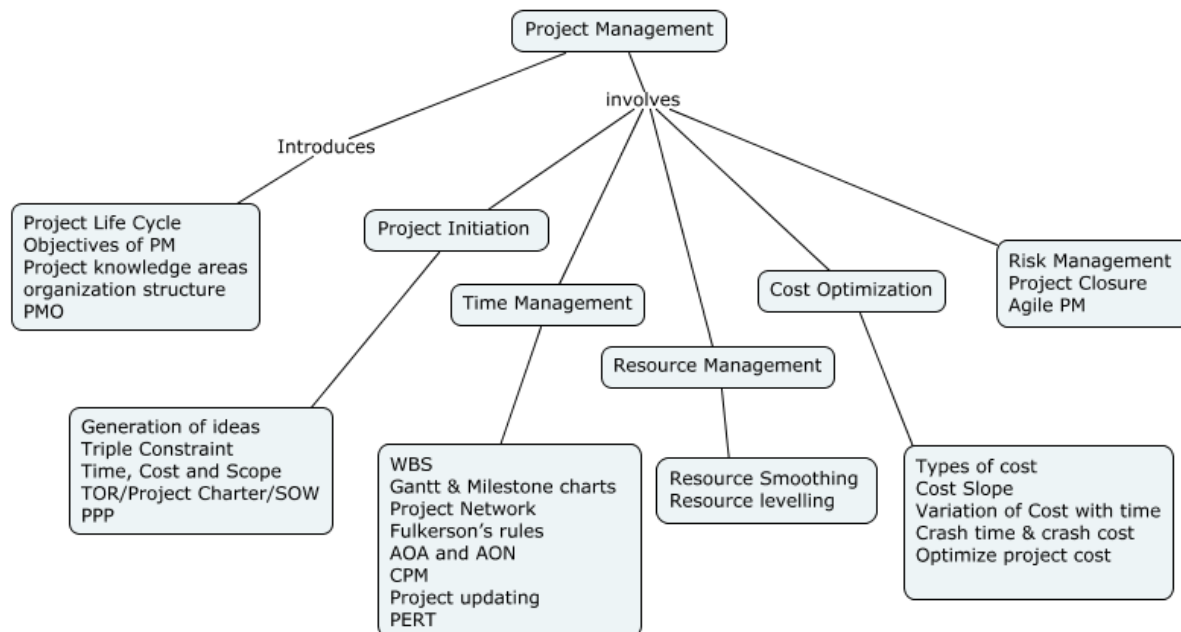
Activity (i-j)	Normal		Crash	
	Time(days)	Cost(Rs)	Time(days)	Cost(Rs)
1-2	5	5000	3	12000
1-3	4	2000	2	4500
1-4	3	3000	1	4800
2-3	4	1550	2	3030
3-5	6	4000	4	8000
4-5	7	2000	3	2850

Assume the indirect cost to vary at Rs.1000/day. Also draw the least cost network.

**Course Outcome 5 (CO5):**

1. Explain about risk management process.
2. State risk severity matrix.
3. Describe about agile project management technique.

**Concept Map**



**Syllabus**

**Overview of Project Management**

Definition - Project Life Cycle- Objectives of Project management-Project knowledge areas-organization structure-roles of project management group-project management office and its role- ISO 21500:2012 : Guidance on project management.

**Project Initiation:** Generation and Screening of PM ideas- Triple Constraint – Time, Cost and Scope - TOR/ Project Charter/ SOW (Statement of Work)-Project Presentation & Approval-Technology transfer: PPP – case study

**Time Management:** Work break down structure- Gantt Charts, Milestone chart - Project Network- Fulkerson's rules – Activity-On-Arrow and Activity- On -Node networks - Critical path method (CPM) - Project updating and monitoring- Program Evaluation & Review Technique (PERT)-case study

**Resource Management:** Types of resources- Balancing of resource- Resource Smoothing technique-Resource levelling technique-case study

**Cost Management:** Types of cost –Cost Slope- Variation of Cost with time- Crash time and crash cost- Optimize project cost for time and resource- case study

**Risk Management and Agile:** Risk Identification-Risk management process – Failure modes-FMEA - Project Closure- Project Report- Agile Project management- case study

### Learning Resources

1. A Guide to the Project Management Body of Knowledge ( PMBOK® Guide )—Fifth Edition, Project Management Institute.
2. Punmia B. C. and Khandelwal K.K., "Project Planning and Control with PERT/CPM", Laxmi publications, New Delhi, 2011.
3. Erik W. Larson, Clifford F. Gray, "Project Management The Managerial Process", McGraw-Hill/Irwin, Fifth Edition, 2011.
4. NPTEL – Online course on Project Management
5. <https://www.pmi.org>
6. <https://www.iso.org/standard>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	<b>Overview of Project Management</b>		
1.1	Definition - Project Life Cycle- Objectives of Project management	1	CO1
1.2	Project knowledge areas-	1	CO1
1.3	organization structure-roles of project management group-project management office and its role	1	CO1
1.4	ISO 21500:2012 : Guidance on project management	1	CO1
2.	<b>Project Initiation</b>		
2.1	Generation and Screening of PM ideas- Triple Constraint – Time, Cost and Scope -	1	CO1
2.2	TOR/ Project Charter/ SOW (Statement of Work)	1	CO1
2.3	Project Presentation & Approval –transfer: PPP , Case Study	1	CO1
3.	<b>Time Management</b>		
3.1	Work break down structure	2	CO2
3.2	Gantt Charts, Milestone chart	2	CO2
3.3	Project Network- Fulkerson's rules	1	CO2
3.4	Activity-On-Arrow and Activity- On -Node networks	2	CO2
3.5	Critical path method (CPM)	3	CO2
3.6	Project updating and monitoring	1	CO2
3.7	Program Evaluation & Review Technique (PERT)	2	CO2
4.	<b>Resource Management</b>		
4.1	Types of resource- Balancing of resource-	2	CO3
4.2	Resource Smoothing technique	2	CO3
4.3	Resource levelling technique	2	CO3

5.	<b>Cost Optimization</b>		
5.1	Types of cost – Cost slope	1	CO4
5.2	Variation of Cost with time- Crash time and crash cost	1	CO4
5.3	Optimize project cost for time and resource	4	CO4
6.	<b>Risk Management, Agile</b>		
6.1	Risk Identification, Risk management process	1	CO5
6.2	Failure modes, FMEA	1	CO5
6.3	Project Closure, Project Report	1	CO5
6.4	Agile Project management, Case study	1	CO5
	Total	36	

#### Course Designers:

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2	Mr.A.Prakash	apmech@tce.edu

18MT470

**SENSORS AND MEASUREMENTS  
LABORATORY**Category L T P Credit(s)  
PC 0 0 2 1**Preamble**

Metrology and Measurements lab helps to impart hands on practice on Metrology & measurement techniques. This course is also used to impart knowledge and skill in the field of metrology equipment's and instruments used in the industries and to increase the level of confidence of students by working individually in various machine like CMM, Profile projector, Auto collimator machine.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Check and measure the error produced in temperature measurement	20
CO2	Interface and measurement of distance using sensors	20
CO3	Measure Linear, angular, thread elements, 2D & 3D profiles, surface roughness, flatness and straightness	20
CO4	Check and calibrate different dimensions for given components	20
CO5	Measure and Verify displacement, force, level, torque, strain, speed temperature.	20

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4
CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	L	-	S	-	-	-	-	-	-	-	S	S
CO2	S	S	L	-	S	-	-	-	-	-	-	-	S	S
CO3	S	S	L	-	S	-	-	-	-	-	-	-	S	M
CO4	S	S	L	-	M	-	-	-	-	-	-	-	M	M
CO5	S	S	L	-	M	-	-	-	-	-	-	-	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	
Complex Overt Responses	
Adaptation	
Origination	

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hrs	Cos
<b>CYCLE I SENSORS</b>			
1.	Error measurement in temperature using thermocouple	2	CO1
2.	Error measurement in thermistor using thermistor	2	CO1
3.	Load effect in potentiometer	2	CO2
4.	Modifying and interfering inputs measurements	2	CO2
5.	Distance measurement using ultrasonic sensor	2	CO2
6.	Proximity and Magnetic sensing	2	CO2
<b>CYCLE II MEASUREMENTS</b>			
7.	Profile measurement of linear, angular and thread elements using Profile Projector.	2	CO3
8.	Measurement of Surface Roughness using portable surface roughness tester.	2	CO3
9.	Checking of OD and ID using comparators– Pneumatic, electronic and mechanical.	2	CO4
10.	Calibration of micrometre / Vernier calliper using Standard slip gauge	2	CO4
11.	Speed measurement of DC servo motor using Optical encoder	2	CO5
12.	LABVIEW based displacement measurement and data logging using LVDT.	2	CO5

**Course Designers:**

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**18MT480 MICRO CONTROLLER LABORATORY**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

Microcontrollers based embedded systems are involved in almost every facet of modern life. Consumer gadgets, entertainments gadgets, medical devices and automobiles all contain embedded Microcontroller. The tremendous number of applications for embedded computing has given rise to high demand for engineers with experience in designing and implementing embedded systems with microcontroller. This course is designed to provide an introduction to microcontroller architecture, internal and external peripherals, assembly language programming and embedded c programming. Students will be taught the basic use of a programming environment and how to develop the basic C programming for embedded application. This course highlights the general interfacing techniques and concepts through peripheral's data representation from input/output, and memory usage in the microcontroller in embedded C.

**Prerequisite**

- 18MT330- Digital Electronics
- 18MT380 – Digital Electronics laboratory

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain about the basics of Assembly language and Assembler for 8051	25
CO2	Develop knowledge about the C- Compiler and Building tools for 8051	25
CO3	Design an Embedded system using the different interfacing techniques with different peripherals.	20
CO4	Develop Knowledge about the integrated peripherals of other 8-bit Microcontroller architecture.	15
CO5	Design and Development software Framework using IDE	15

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	2.1,2.2,2.3,4.5.1,3.1,3.2,3.3
CO2	TPS2	Understand	Respond	Guided Response	2.1,2.2,2.3,4.4.1,3.1,3.2,3.3
CO3	TPS3	Apply	Value	Mechanism	2.3,4.4,4.5.4,3.1,3.2,3.3
CO4	TPS3	Apply	Value	Mechanism	1.2,1.3,3.1,3.2,3.3
CO5	TPS4	Analyse	Organise	Complex Overt Responses	4.3,3.1,3.2,3.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L			L		M			L				L	M
CO2	M	S	M	M					M	M			L	M
CO3					S			S			S	S	L	M
CO4		S		S										
CO5		S			S				M	L			L	M

S – Strong      M – Medium      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	50	50
Apply	50	50
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	Practical component
Set	Practical component
Guided Response	Mini Project
Mechanism	Assignment
Complex Overt Responses	
Adaptation	
Origation	

**List of Experiments/Activities with CO Mapping**

S.No	Exercises / Experiments	No of Hours.	Cos
Assembly Language Programming in 8051			
1	Single Precision operations using Assembly	2	CO1
2	Double Precision operations using Assembly	2	CO1
3	Searching, sorting and memory operations using Assembly	2	CO1
C-programming in 8051			
4	Introduction to Keil toolchain, compiling and building C Program with Timers	2	CO2
5	Port operations in 8051 using C. (input and output)	2	CO2
6	Serial Communication using 8051 with PC	2	CO2
Interfacing with 8051			
7	Interfacing ADC with 8051	2	CO3
8	Interfacing LCD with 8051	2	CO3
9	Design of Temperature Logging system using 8051	2	CO3
AVR programming			
10	Introduction to Arduino with ATMEGA328P	2	CO4
11	ADC programming using ATMEGA328P	2	CO4

12	PWM programming using ATMEGA328P	2	CO4
13	Serial communication between Two Microcontroller.	2	CO5
14	Study on I2C protocol and SPI.	2	CO5

### Learning Resources

1. The 8051 Microcontroller and Embedded Systems Using Assembly and C 2nd Edition, Pearson, Muhammed Ali Mazidi. 2007
2. The 8051 Microcontroller 3rd Edition, Kenneth J. Ayala.2007, Cengage publications.
3. AVR Microcontroller and Embedded Systems: Using Assembly and C:using Arduino uno and atmel studio, Muhammed Ali Mazidi, sepehr naimi and Armad naimi, 2017.
4. PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18, 1e, Muhammed Ali Mazidi 2008

### Course Designers:

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<b>18CHAB0</b>	<b>CONSTITUTION OF INDIA</b>	Category	L	T	P	Credit
		AC	2	0	0	0

### Preamble

On the successful completion of the course, the students will be able to explain the basic features and fundamental principles of Constitution of India. The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the “basic structure” of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of “Constitutionalism” – a modern and progressive concept historically developed by the thinkers of “liberalism” – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of “constitutionalism” in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India’s legacy of “diversity”. It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own AICTE Model Curriculum for Mandatory Courses & Activities (Non-Credit) for Undergraduate Degree in Engineering & Technology ancient legal heritage and cultural values. No law can be “static” and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it “as one of the strongest court in the world”

### Course Outcome:

On the successful completion of the course students will be able to

CO1	Explain the meaning of the constitution law and constitutionalism and Historical perspective of the Constitution of India	Understand
CO2	Explain the salient features and characteristics of the Constitution of India, scheme of the fundamental rights and the scheme of the Fundamental Duties and its legal status	Understand
CO3	Explain the Directive Principles of State Policy, Federal structure and distribution of legislative and financial powers between the Union and the States, and Parliamentary Form of Government in India	Understand
CO4	Explain the amendment of the Constitutional Powers and Procedure, the historical perspectives of the constitutional amendments in India, and Emergency Provisions.	Understand
CO5	Explain the Local Self Government – Constitutional Scheme in India, Scheme of the Fundamental Right to Equality,	Understand
CO6	Explain the scheme of the Fundamental Right to certain Freedom under Article 19, and Scope of the Right to Life and Personal Liberty under Article 21	Understand

**Mapping with Programme Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	M	-	M	-	L	-	-
CO2	M	L	-	-	-	M	-	M	-	L	-	-
CO3	M	L	-	-	-	M	-	M	-	L	-	-
CO4	M	L	-	-	-	M	-	M	-	L	-	-
CO5	M	L	-	-	-	M	-	M	-	L	-	-
CO6	M	L	-	-	-	M	-	M	-	L	-	-

S- Strong; M-Medium; L-Low

**Syllabus**

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

**Assessment Pattern**

Bloom's category	Continuous Assessment Tests		Seminar
	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

**References**

1. Durga Das Basu, 'Introduction to The Constitution of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
2. Constitution of India, National Portal of India, Web link: <https://www.india.gov.in/my-government/constitution-india>

**Course Designers:**

1. Adapted from AICTE Model Curriculum for Undergraduate Degree Courses in Engineering & Technology, Volume-II, January 2018.

SYLLABI

For

**B.E. Mechatronics Program**

Fifth Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 59<sup>th</sup> Academic Council Meeting on 07.12.2019

**18MT510****CONTROL SYSTEM**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

A Control system consists of interconnected components to achieve desired objective. It is an interconnection of components forming a system configuration that will provide a desired system response. The basis for analysis of a system is the foundation provided by linear system theory, which assumes a cause-effect relationship for the components of a system. The input-output relationship represents the cause-and-effect relationship of the process, which in turn represents a processing of the input signal to provide an output signal variable, often with a power amplification.

A closed-loop control system utilizes an additional measure of the actual output to compare the actual output with the desired output response. Time domain and frequency domain performance specifications are studied in this course. Compensator design using Lag, Lead, and Lead Lag is studied. Design of PID controller and its Digital implementation is also studied in this course. The aim of this course is to provide basic knowledge about the fundamentals of control system and digital control.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop a Mathematical model for physical Systems	20
CO2	Investigate the Performance Specification of Control system using Time domain techniques	30
CO3	Investigate the Performance Specification of Control system using Frequency domain techniques	30
CO4	Select the suitable compensator to improve the performance of control systems	10
CO5	Design a PID controller using Z-N Tuning technique.	5
CO6	Determine the system Observability and controllability using state space approach	5

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4

CO4	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4
CO6	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	-	-	-	-	-	-	-	-	-	S	S
CO2	S	M	M	-	M	-	-	-	M	M	-	-	S	S
CO3	S	M	M	-	M	-	-	-	M	M	-	-	S	S
CO4	S	M	M	-	-	-	-	-	-	-	-	-	S	S
CO5	S	M	M	-	M	-	-	-	M	M	-	-	S	S
CO6	M	L	L	-	-	-	-	-	-	-	-	-	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	20	20	20	-	-	-	20
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

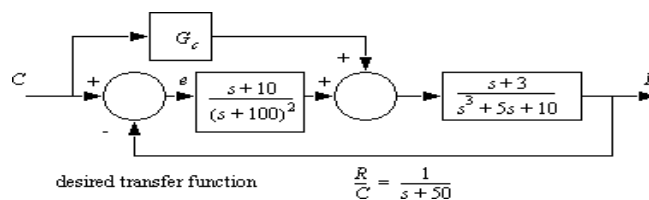
**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment I & II
Mechanism	Assignment III - PID controller tuning using MATLAB
Complex Overt Responses	-
Adaptation	-
Orignation	-

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Compare Open loop System and Closed Loop system
2. Derive the Transfer function for DC Motor
3. Determine the overall transfer function for the system shown below.



**Course Outcome 2(CO2):**

1. Draw root locus for the following system  $G(s)=k/s^2(.5s+1)$ .
2. Determine the time domain specifications for the damping ratio = 0.6 and natural frequency = 5 rad/sec.
3. Construct the Routh array and determine the stability of the system whose characteristic equation is  $s^6 + 2 s^5 + 8s^4 + 12 s^3 + 20 s^2 + 16 s + 16 = 0$ . Also determine the number of roots lying on right half of s-plane.

**Course Outcome 3(CO3):**

1. Increased track densities for computer disk drives necessitate careful design of the head positioning control. The transfer function is . Plot the polar plot for this system when  $k=4$ . Calculate the phase and magnitude at  $\omega=0.5, 1, 2$ .
2. Determine the phase margin and gain margin for the same. Sketch the bode plot of the transfer function and determine the system gain  $K$  for the gain cross over frequency to be 5 rad/sec  $G(s) = K/(1+0.2s) (1+0.02s)$ .
3. List the frequency domain specifications.

**Course Outcome 4 (CO4):**

1. State the need for Compensation.
2. Consider the unity feedback system whose open loop transfer function is

$$G(S) = \frac{K}{S(S + 3)(S + 6)}$$

Design a Lag-Lead Compensator to meet the following specifications

- i. Velocity error constant  $K_v = 80$
- ii. Phase Margin  $\geq 35$  Degree

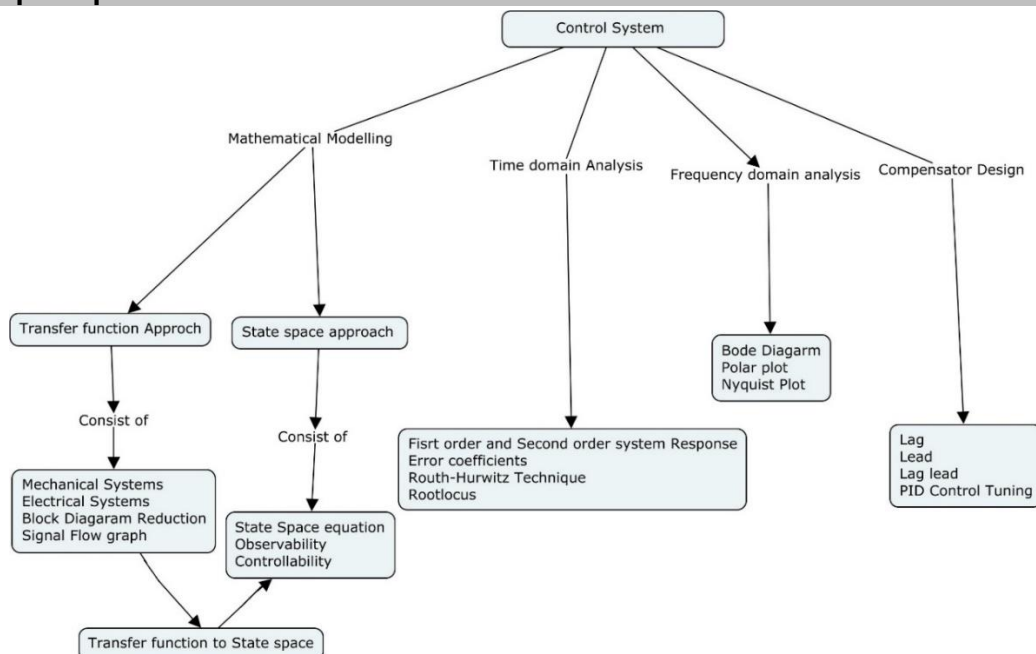
**Course Outcome 5 (CO5):**

1. Explain about Ziegler Nichols tuning of PID controller.
2. State the Ziegler Nichols rule.
3. Write the methodology to implement PID controller.

**Course Outcome 6 (CO6):**

1. Define Controllability and Observability
2. Compare the Transfer function methods and State space method
3. Explain the procedure for state space to transfer function

**Concept Map**



## Syllabus

**Systems representation:** Basic elements in control systems - open loop and closed loop – introduction to nonlinear system - introduction to Laplace transform - Transfer functions of mechanical, electrical and analogous systems - Block diagram reduction - signal flow graphs.

**Time response analysis:** Time response - Time domain specifications -Types of test inputs, First and Second order system response -Steady state error, error constants, generalized error coefficient - Stability concept and definition - Characteristic equation - Location of poles - Routh Hurwitz criterion - Root locus techniques: construction.

**Frequency domain analysis:** Frequency response methods -Bode plots - Polar plot - Nyquist stability criterion.

**Compensator and controller design:** Design of lag, lead, lag lead series compensator (using Bode plot), PID Controller design: Effect of  $K_p$ ,  $K_i$ ,  $K_d$ - Ziegler Nichols Tuning.

**State space analysis:** State equation – Solutions, Realization, Controllability, Observability - State space to transfer function conversion, transfer function to state space conversion, Pole placement.

## Learning Resources

1. Norman S. Nise, “**Control System Engineering**”, 6th Edition, John Wiley & Sons, 2018
2. J. Nagrath and M. Gopal, “**Control System Engineering**”, New Age International Publisher, New Delhi, 2018
3. Nagoor Kani A, “**Control systems**”, RBA Publications, 2017
4. M. Gopal, Digital “**Control and State Variable Methods**”, Tata McGraw Hill, 2017
5. K. Ogata, “**Modern Control Engineering**”, 4th Edition, Pearson Edition, 2010
6. Richard C. Dorf, Robert H. Bishop, “**Modern Control Systems**” 13<sup>th</sup> Edition, Pearson Education, 2017.
7. <https://nptel.ac.in/courses/108107115/>
8. <https://nptel.ac.in/courses/108102043/>

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	<b>Systems representation</b>		
1.1	Basic elements and open loop and closed loop systems - introduction to nonlinear system and Laplace transform	1	CO1
1.2	Transfer functions of mechanical systems	1	CO1
1.3	Transfer functions of electrical systems	1	CO1
1.4	Transfer functions of analogous systems	2	CO1
1.5	Block diagram reduction technique	2	CO1
1.6	signal flow graphs technique	2	CO1
2	<b>Time response analysis</b>		
2.1	Time domain specifications	1	CO2
2.2	Types of Test input, First order system response	1	CO2
2.3	Second order system response	1	CO2
2.4	Steady state error, error constants, generalized error coefficient	1	CO2

2.5	Stability, Characteristic equation	1	CO2
2.6	Routh Hurwitz criterion	2	CO2
2.7	Root locus techniques	2	CO2
<b>3</b>	<b>Frequency domain analysis:</b>		
3.1	Bode plots	2	CO3
3.2	Polar plot	2	CO3
3.3	Nyquist stability criterion.	2	CO3
<b>4</b>	<b>Compensator and controller design</b>		
4.1	Lag Compensator design	2	CO4
4.2	Lead Compensator design	2	CO4
4.3	Lag Lead Compensator Design	2	CO4
4.4	Effect of K <sub>p</sub> , K <sub>i</sub> , K <sub>d</sub> - Ziegler Nichols Tuning	2	CO5
<b>5</b>	<b>State space analysis</b>		
5.1	State equation – Solutions	1	CO6
5.2	Controllability, Observability	1	CO6
5.3	transfer function to State space conversion	1	CO6
5.4	State space to transfer function conversion Pole placement	1	CO6
<b>Total</b>		<b>36</b>	

**Course Designers:**

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3	Mr M.A Ganesh	ganeshma2015@tce.edu



**18MT520****INDUSTRIAL AUTOMATION**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Today's highly increasing competitiveness over the industry demands high quality and most consistent products with a competitive price. To address this challenge number of industries considering various new product designs and integrated manufacturing techniques in parallel with the use of automated devices. One of the remarkable and influential moves for getting the solutions of above mentioned challenge is the industrial automation. Industrial automation facilitates to increase the product quality, reliability and production rate while reducing production and design cost by adopting new, innovative and integrated technologies and services. Industrial Automation is the replacement with computers and machines to that of human thinking. Industrial automation deals with the set of technologies and automatic control devices that results the automatic operation and control of industrial processes and machines without significant human intervention and achieving superior performance than manual control. These automation devices include PLCs, HMI, SCADA etc. and technologies include various industrial communication systems.

**Prerequisite**

- 18MT220 - Electrical Machines

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Interpret the selection and programming methods of different automation components like PLC, SCADA, DCS and communication buses.	20
CO2	Illustrate the construction, working and control strategies of different industrial drives and valves.	20
CO3	Design pneumatic and Electro pneumatic circuits for given industrial applications.	20
CO4	Design Hydraulic and proportional hydraulic circuits for given industrial applications.	10
CO5	Construct a program using PLC and communication protocols to solve problems relate to industry 4.0.	20
CO6	Select suitable automation system for given Industrial application.	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4

CO4	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.3,2.1.5,2.2.3,2.3.1,2.4.1,2.4.3,2.4.4,2.4.6

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	L	L	-	-	-	-	-	-	-	-	L	L	-
CO2	-	L	L	-	-	-	-	-	-	-	-	L	L	-
CO3	S	S	S	M	S	-	-	-	-	-	-	M	M	M
CO4	S	S	M	S	S	-	-	-	-	-	-	M	S	M
CO5	M	M	M	M	S	-	-	-	-	-	-	M	S	S
CO6	L	S	S	M	S	-	-	-	-	-	-	S	S	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	60	40	20	-	-	-	40
Apply	20	40	60	100	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	Simulation of Machines Operation
Set	Working Demonstration
Guided Response	Flipped classroom, Active Learning Techniques.
Mechanism	Mini projects
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. Explain parts of PLC with neat diagram.
2. Define I/O Modules of PLC.
3. Explain the components of SCADA System.
4. Explain the I/O Interfacing Method of PLC.

#### Course Outcome 2(CO2):

1. Explain the use of pressure control valve in hydraulic circuits.
2. List the types of directional control valves available in fluidic systems.
3. Explain the V/F method of speed control in Induction motor drive.

4. Explain the elements of Servo control.

**Course Outcome 3(CO3):**

1. Design a sequential circuit using two cylinders with a sequence A+A-B+B-
2. Design a cascading circuit with a sequence A+B+B-A-
3. Design a proportional control system to control the cylinder position from 0 to 100mm with a gradient of 5 mm.
4. Design a electro hydraulic circuit using double acting cylinder for a large drilling machine.

**Course Outcome 4 (CO4):**

1. Design a ladder and hardware connection diagram for forward-reverse running of 3-phase Induction Motor with mutual interlock.
2. Write a PLC program to alternatively switch on and off a pump with a time delay of 5 sec. Also provide indication to show the on- off status of a pump.
3. Write a PLC program to start a second conveyor after a count of 10 pallets from first conveyor.
4. Write a PLC program to control the speed of the induction motor using PLC and VFD drive.

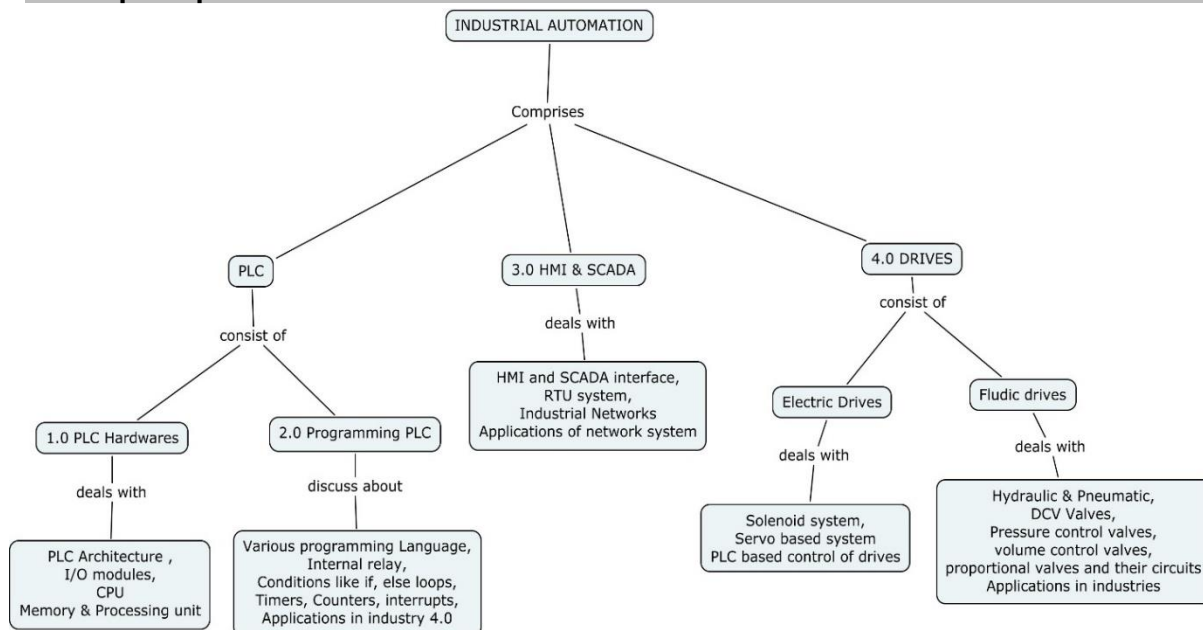
**Course Outcome 5 (CO5):**

1. Design a hydraulic sequence circuit for controlling two cylinders with a logic of A+B+A-B- using PLC.
2. Design a automated work cell to control two servo Motors in master/Slave mode using PLC and Servo drive.
3. Design pneumatic cascade circuit for controlling two cylinders with logic of A+B+B-A-

**Course Outcome 6 (CO6):**

1. Select and explain the communication protocol for interconnecting pick and place robot, CNC controller, ASRS system and conveyor in an automated work cell.
2. Select suitable sensors, controller and actuator for Automated Drain water purifying system.
3. Illustrate the role of mobile hydraulics and proportional valves in Industrial 4.0 application

**Concept Map**



## Syllabus

**PLC Basics:** Basics of Electrical control- Principles of Operation –Advantages and Disadvantages of PLC - PLC Size and Application- The I/O Section -Discrete I/O Modules- Analog I/O Modules-Special I/O Modules –I/O Specifications-Scanning cycle of PLC-The CPU-Memory Design-Memory Types-Processor Memory Organization-I/O Interfacing.

**Programming PLC:** PLC Programming Languages-PLC Modes of Operation- Relay-Type Instructions- Instruction Addressing-Branch Instructions Internal Relay Instructions Programming EXAMINE IF CLOSED and EXAMINE IF OPEN Instructions- Designing a Ladder Diagram for large process–Programming Timers-Programming counters-High Speed Counter-Subroutine and Interrupt - Developing a PLC program for Machine, Process and Motion control.

**HMI and SCADA:** HMI programming-Interfacing PLC with HMI. Basics of SCADA system-SCADA key features - Remote terminal units (RTUs)-Typical requirements for an RTU system - PLCs used as RTUs-Consideration and benefits of SCADA system-SCADA software package-Selection of Profibus, Profinet, Sercos and OPC-UA.

**Fluidic Power Automation:** Fundamentals of Relays and Solenoids, Basics of hydraulic, pneumatic drives and servo drives- benefits of fluidic drives-components of fluidic drive systems-Actuators-Control valves Classification- Directional, Pressure, Flow, Proportional and servo valves- Electro pneumatic circuit –Proportional Hydraulic circuits- Fluidic sequential circuit design using classical, cascade and step counter methods.

**Industrial Applications:** Role of PLC in Industry 4.0 application, Applications of AC, DC and servo drives in industrial automation, Application of Wireless Networks for Industrial automation, Application of Pneumatic, Hydraulic circuits in Industrial automation.

## Learning Resources

1. Frank D Petruzella, Programmable logic controllers, Fourth edition, McGraw Hill higher education ,2016
2. Steve Mackay ,Edwin Wright MIPENZ, Deon Reynders, John Park“Practical Industrial Data Networks -Design, Installation, trouble shooting”,IDC Technologies, Australia.
3. Frank D petruzella, Electrical Motor and control systems, McGraw Hill higher education ,2010
4. Antony Esposito ,Fluid power with applications, Pearson publications,2017.
5. Rajesh Mehra, Vikrant Vij, PLCs & SCADA: Theory and Practice, Laxmi Publications-2016.
6. Krishna Kant -Computer Based Industrial Control, EEE-PHI, 2nd edition, 2010.
7. Garry Dunning-Introduction to Programmable Logic Controllers, 2nd edition, Thomson, ISBN: 981-240-625-5.
8. W.Bolton- Programmable Logic Controllers, Sixth Edition (Paperback) ISBN-13: 978-0128029299, 2012.
9. <https://nptel.ac.in/courses/112102011/>

### Course Contents and Lecture Schedule

No	Topic	CO's	No. of Lectures
<b>1.0</b>	<b>PLC Basics</b>		
1.1	Basics of Electrical control-Parts of PLC, Principles of Operation, Advantages and Disadvantages of PLC.	CO1	1
1.2	PLC Size and Application- The I/O Section -Discrete I/O Modules	CO1	1
1.3	Analog I/O Modules-Special I/O Modules -I/O Specifications	CO1	1
1.4	Scanning cycle of PLC-The CPU-Memory Design-Memory Types- Processor Memory Organization, I/O interfacing.	CO2	1
<b>2.0</b>	<b>Programming PLC</b>		
2.1	Processor Memory Organization- PLC Programming Languages- PLC Modes of Operation	CO1	1
2.2	Relay-Type Instructions- Instruction Addressing-Branch Instructions Internal Relay Instructions	CO1	1
2.3	Programming EXAMINE IF CLOSED and EXAMINE IF OPEN Instructions	CO3	1
2.4	Designing a ladder diagram for Large Process	CO3	1
2.5	Programming Timers	CO3	1
2.6	Subroutine and Interrupt Concepts	CO3	1
2.6	Programming Counters-High speed counter.	CO3	1
2.7	Developing a PLC program for Machine, Process and Motion control.	CO3	1
<b>3.0</b>	<b>HMI and SCADA</b>		
3.1	HMI programming	CO5	1
3.2	Interfacing PLC with HMI	CO5	1
3.3	Basics of SCADA system-SCADA key features	CO5	1
3.4	Remote terminal units (RTUs)-Typical requirements for an RTU	CO5	1
3.5	PLCs used as RTUs-Consideration and benefits of SCADA system	CO5	1
3.6	SCADA software package	CO5	1
3.7	SCADA software package. Selection of Profibus, Profinet, Sercos and OPC-UA.	CO5	1
<b>4.0</b>	<b>Fluidic Power Automation</b>		
4.1	Fundamentals of hydraulic and pneumatic drives	CO2	1

No	Topic	CO's	No. of Lectures
4.2	Basic definitions and principles-benefits of fluidic drives	CO2	1
4.3	Components of fluidic drive systems	CO2	1
4.4	Control valves Classification-Pressure, Flow, Directional, Proportional and servo valves.	CO2	2
4.5	Fluidic actuators-Motors and Cylinders	CO2	2
4.6	Basic Fluidic Circuits	CO3,CO4	1
4.7	Electro pneumatic circuit	CO2	2
4.8	Fluidic speed control circuits – Proportional Hydraulic circuits	CO4	2
4.9	Sequential circuit-manual, electro and proportional, Cascading circuit-manual and electrical control	CO3,CO4	2
<b>5.0</b>	<b>Industrial Applications</b>		
5.1	Role of PLC in Industry 4.0 application	CO6	1
5.2	Application of Wireless Networks for Industrial automation	CO6	1
5.3	Application of Pneumatic, Hydraulic circuits in Industrial automation.	CO6	1
<b>TOTAL</b>			<b>36</b>

**Course Designers:**

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**18MT530 DESIGN OF MACHINE ELEMENTS**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Design of machine elements is the process of deriving a system, component or process to meet desired needs. It is a decision-making process, in which the basic sciences, mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criterion, synthesis, analysis, construction, testing and evaluation. Machine Elements Design deals with the creation of machine element that goes into the making of a machine as a product.

**Prerequisite**

- 18MT240 - Free Body Mechanics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Compute the static and fatigue strength of mechanical components.	20
CO2	Design the shafts for different loading conditions.	15
CO3	Design the Brake parametrically for different loading conditions.	5
CO4	Select a suitable flat belt, V-belt and chain drive for given loading condition	20
CO5	Select a suitable spur gear for given loading condition	10
CO6	Select a rolling contact bearing and sliding contact bearing for given power transmission application.	10
CO7	Design of Bolts and power screw.	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4
CO4	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4, 4.3.3, 4.4.4

CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	-	-	-	-	-	S	-	-	-	M	M
CO2	S	S	S	-	-	-	-	-	S	-	-	-	S	S
CO3	S	S	M	-	-	-	-	-	S	-	-	-	S	S
CO4	S	S	M	-	-	-	-	-	S	-	-	-	S	S
CO5	S	S	M	-	-	-	-	-	S	-	-	-	S	S
CO6	S	S	M	-	-	-	-	-	S	-	-	-	S	S
CO7	S	S	M	-	-	-	-	-	S	-	-	-	S	S

S – Strong

M – Medium

L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of bolt required according to
  - Maximum principal stress theory.
  - Maximum shear stress theory.
  - Maximum principal strain theory.
  - Maximum strain energy theory.
  - Maximum distortion energy theory.



- Determine the diameter of a circular rod made of ductile material with a fatigue strength (complete stress reversal),  $\sigma_{-1} = 265$  MPa and a tensile yield strength of 350 MPa. The member is subjected to a varying axial load from  $W_{\min} = 300 \times 10^3$  N to  $W_{\max} = 700 \times 10^3$  N and has a stress concentration factor = 1.8. Use factor of safety as 2.0.

#### Course Outcome 2(CO2):

- A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10000 N-m. The shaft is made of 45C8 steel having ultimate tensile stress of 700 MPa and a ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft.
- Design the rectangular key for a shaft of 50mm diameter. The shearing and crushing stresses for the key material are 42MPa and 70MPa.

#### Course Outcome 3(CO3):

- Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions: Power to be transmitted = 40 kW ; speed of the motor shaft = 1000 r.p.m.; diameter of the motor shaft = 50 mm ; diameter of the pump shaft = 45 mm. The bearing pressure in the rubber bush and allowable stress in the pins are to be limited to 0.45 N/mm<sup>2</sup> and 25 MPa respectively.

#### Course Outcome 4 (CO4):

- Design a fabric belt to transmit 15kW at 480rpm, from an engine to a line shaft at 1200rpm. The diameter of engine pulley is 600mm and centre distance between the pulley is 2m.
- Design a V-belt drive and calculate the actual belt tension and average stress for the following data. Driven pulley diameter,  $D = 500$  mm, driver pulley diameter,  $d = 150$  mm, center distance  $c = 925$  mm, speed  $n_1 = 1000$  rpm,  $n_2 = 300$  rpm and power,  $P = 7.5$  kW.
- Designs a chain drive to actuate a compressor from a 12 kW electric motor at 900 rpm, the compressor begin 250 rpm. Minimum centre distance should be 500 mm; the chain tension may be adjusted by shifting the motor on rails. The compressor is to work 8 hour/day to the need for Compensation.

#### Course Outcome 5 (CO5):

- A motor shaft rotating at 1500 rpm has to transmit 15kW to a low speed shaft with a speed reduction of 3:1. Assume starting torque to be 25% higher than the running torque. The teeth are 20° involutes with 25 teeth on the pinion. Both the pinion and gear are made of C45 steel. Design a spur gear drive to suit the above conditions and check for compressive and bending stresses and plastic deformations. Also sketch the spur gear drive.

#### Course Outcome 6 (CO6):

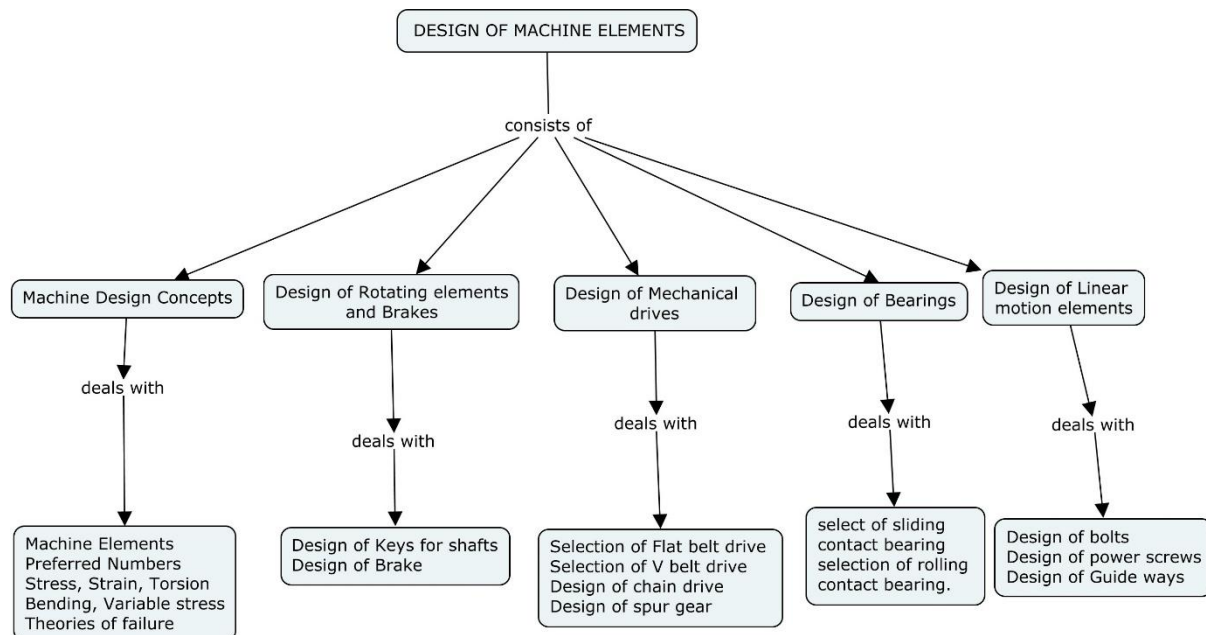
- Design a journal bearing for a centrifugal pump from the following data: Load on the journal = 20 000 N; Speed of the journal = 900 r.p.m. Type of oil is SAE 10, for which the absolute viscosity at 55°C = 0.017 kg / m-s; Ambient temperature of oil = 15.5°C; Maximum bearing pressure for the pump = 1.5 N / mm<sup>2</sup>. Calculate also mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited to 10°C. Heat dissipation coefficient = 1232 W/m<sup>2</sup>/°C.
- A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of 1.4 N/mm<sup>2</sup>. The speed of the journal is 900 r.p.m. and the ratio of journal diameter to

the diametral clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 35°C. Find 1. The amount of artificial cooling required, and 2. The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°C. Take specific heat of the oil as 1850 J / kg / °C.

### Course Outcome 7 (CO7):

1. A double threaded power screw, with ISO metric trapezoidal threads is used to raise a load of 300 kN. The nominal diameter is 100 mm and the pitch is 12mm. The coefficient of friction at the screw threads is 0.15. Neglecting collar friction, calculate
  - (i) torque required to raise the load
  - (ii) torque required to lower the load and
  - (iii) efficiency of the screw
2. Determine the diameter of ball in a linear motion guide way of length 60mm consisting of 12balls, when the maximum pressure acting on guide way is 5000N/mm<sup>2</sup>. Assume  $K=0.6\text{N/mm}^2$ .

### Concept Map



### Syllabus

**Machine Design Concepts:** Machine Elements, Procedure for design of machine elements, Basic requirements of machine elements, Preferred Numbers, Engineering materials-its properties and selection, Stress, Strain, Torsion, Bending, Variable stress, Factor of safety, Theories of failure.

**Design of Rotating elements and Brakes:** Shafts, Shafts subjected to twisting moment, combined Bending and twisting moment with axial loads. Design of Keys for shafts. Design of brake.

**Design of Mechanical drives:** Drives classification, selection of Flat belt drive, selection of V belt Drive, Design of chain drive, Design of Spur gear.

**Design of Bearings:** Introduction, Classification, select of sliding contact bearing and rolling contact bearing.

**Design of Linear motion elements:** Introduction, Design of bolts and power screws,

Design of guide ways.

### Learning Resources

1. V.B. Bhandari, "Design of machine elements", Fourth edition, Tata McGraw Hill, 2017.
2. Joseph Edward Shigley and Charles R. Misucke, " Mechanical Engineering Design", Tenth Edition, Tata McGraw Hill, 2015.
3. Robert L. Norton, "Machine Design: An integrated Approach", Third edition, Prentice Hall, 2005.
4. Sundarajamoorthy T.V. and Shanmugam. N, "Machine Design", Anuradha Publications, 2003.
5. K. Ganesh Babu, K.Srithar, "Design of machine Elements", MCGraw Hill Education, 2009.
6. Hall, Holowenko and Laughin, "Theory and Problems of Machine Design", Tata McGraw Hill Company, 2002.
7. Sharma P. C, and Agarwal D.K, "Machine design", S.K. Kataria and Sons, New Delhi, 2000.
8. M. F. Spotts, T. E. Shoup, "Design of Machine Elements", Eighth Edition, Pearson Education Asia, 2006.
9. Amit U Pawar, Apurav A Wagh and D U Patil, "Design of Linear Motion Guideways", International journal of Engineering Research and Science & Technology, Vol.2, No. 4, 2015.
10. PSG, "Design Data Book", 2015.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Machine design Concepts</b>		
1.1	Machine elements	1	CO1
1.2	Procedure for design of machine elements	1	CO1
1.3	Basic requirements of machine elements, Preferred numbers	1	CO1
1.4	Engineering materials- Its properties and selection	1	CO1
1.5	Stress, Strain, Torsion	1	CO1
1.6	Bending, variable stress, Factor of safety	1	CO1
1.7	Theories of failure	2	CO1
<b>2</b>	<b>Rotating Elements and Brakes</b>		
2.1	Shafts, Shafts subjected to Twisting moment and Combined Bending and Twisting moment	1	CO2
2.2	Shafts subjected to Combined Bending and Twisting moment with axial loads	2	CO2
2.3	Design of Keys for shafts	2	CO2
2.4	Design of Brake	2	CO3
<b>3</b>	<b>Design of Mechanical drives</b>		
3.1	Drives introduction and its classification	1	CO4
3.2	Selection of Flat belt drive	2	CO4
3.3	Selection of V belt drive	2	CO4
3.4	Design of chain drive	2	CO4
3.5	Design of spur gear	3	CO5
<b>4</b>	<b>Design of Bearings</b>		
4.1	Introduction and classification	2	CO6

4.2	select of sliding contact bearing and rolling contact bearing.	2	CO6
<b>5</b>	<b>Design of Linear motion elements</b>		
5.1	Introduction	1	CO7
5.2	Design of bolts	2	CO7
5.3	Design of power screws	2	CO7
5.4	Design of Guide ways	2	CO7
<b>Total</b>		<b>36</b>	

**Course Designers:**

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18MT560

**ACCOUNTING AND FINANCE**

Category	L	T	P	Credit(s)
HSS	3	0	0	3

**Preamble**

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds an engineer needs among other things data about the organization's routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting, and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Prepare financial statements and analyze them with common size statements, comparative statements and trend percentage methods.	15
CO2	Prepare apportionment of overheads and cost sheet for the given direct and indirect costs.	15
CO3	Calculate various functional budgets and cash budget for manufacturing applications.	20
CO4	Calculate material, labour and overhead cost variance by identify the reasons for the variances.	15
CO5	Calculate the break even points and margin of safety from the given statement.	15
CO6	Compute the capital budgeting decisions by using pay back, accounting rate of return, net present value and internal rate of return methods.	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.1.1, 2.1.1,2.1.2,2.4.4,4.2.2, 4.4.5,4.5.5
CO2	TPS3	Apply	Value	-	1.1.1,2.1.1,2.1.2,2.4.4,4.5.5, 4.5.6
CO3	TPS3	Apply	Value	Mechanism	1.1.1, 2.1.1,2.1.2,2.1.4, 2.1.5,2.4.4,4.2.2, 4.5.5 ,4.5.6
CO4	TPS3	Apply	Value	Mechanism	1.1.1,2.1.1,2.1.2,2.1.4,2.1.5,2.4.4, 4.2.2, 4.5.5 ,4.5.6

CO5	TPS3	Apply	Value	Mechanism	1.1.1,1.2.7,2.1.1,2.1.2,2.1.4,2.1.5 ,2.4.4,4.2.2, 4.5.5 ,4.5.6
CO6	TPS3	Apply	Value	-	1.1.1,1.2.7,2.1.1,2.1.2,2.1.4,2.1.5, 2.4.4,4.2.2, 4.5.5 ,4.5.6

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	S	L	-	-	-	-	-	-	-	S	-	-	-
CO2	M	S	L	-	-	-	-	-	-	-	S	-	-	-
CO3	M	S	L	-	-	-	-	-	-	-	S	M	-	-
CO4	M	S	L	-	-	-	-	-	-	-	S	-	-	-
CO5	M	S	L	-	-	-	-	-	-	-	S	M	-	-
CO6	M	S	L	-	-	-	-	-	-	-	S	M	-	-

S – Strong

M – Medium

L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100*	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

\* Software analysis based Assignment.

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment / Quiz / Software
Perception	-
Set	-
Guided Response	Assignment I & II
Mechanism	QUIZ/ Software Analysis/DPR presentation
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

1. Define Accounting?
2. Give the financing functions?
3. From the following Trial balance of Excellent & co on 31<sup>st</sup> March 2005 you are required to prepare the trading and profit and loss account and a balance sheet as on that date.

Ledger Balances	Amount in Rs.	Ledger balances	Amount in Rs.
Opening stock	500	Commission received	200
Bills receivable	2250	Purchases returns	250
Purchases	19500	Trade expenses	100
Wages	1400	Office fixtures	500
Insurance	550	Cash in hand	250
Sundry debtors	15000	Cash at bank	2375
Carriage inward	400	Rent and taxes	550
Commission paid	400	Carriage outward	725
Interest on capital	350	Sales	25000
Stationery	225	Bills payable	1500
Sales return	650	Sundry creditors	9825
Capital	8950		

The closing stock was valued at Rs.12,500.

### Course Outcome 2 (CO2):

1. Explain the various elements of cost.
2. From the following details prepare a cost sheet for the production of 5000 units for the month of Jan 2005.

Cost particulars	Amount in Rs
Stock of raw-materials on 1.01.2005	10,000
Stock of finished goods on 31.01.2005	12,000
Materials purchased	25,000
Carriage inwards	1500
Direct expenses	700
Factory Rent	1000
Office rent	2000
Depreciation : factory	900
Office	600
Repairs and maintenance: factory	900
Office	600
Lighting : Factory	450
Office	750
Manager's salary	3500
Printing and stationery	1000
Telephone charges	1250
General expenses	800
Salesmen commission	650
Advertising	1250
Opening stock of work-in-process (1.01.2005)	2000
Opening stock of finished goods (1.01.2005)	3000
Closing stock of work-in-process (31.01.2005)	4000
Closing stock of finished goods (31.01.2005)	5000

### Course Outcome 3 (CO3):

1. Explain the various types of budgets
2. Explain the procedure for preparing cash budget
3. Prepare cash budget for the months of March, April, May and June for the following information with the opening balance on March 1<sup>st</sup> being Rs.25, 000

Months	Sales	Purchases	Wages	Office Exp.	Selling Exp.	R & D exp.
Jan	120000	80000	1200	2500	1800	1600
Feb	125000	82000	1300	2600	2000	1720
March	120000	78000	1400	2750	2100	1640
April	130000	85000	1400	2750	1900	1680
May	140000	90000	1300	2600	2000	1760
June	135000	86000	1350	2700	2000	1800

Second Call money on shares to be received in May Rs.20000

Expected income from investments Rs.5000 in March

Dividends of Rs.3000 to be received in April

Machinery expected to sell for Rs. 10000 for cash in April

Dividend to be paid in May for Rs.6000

Delay in paying..... wages, office expenses one month

Selling expenses 1 / 4 month

R &d expenses 1/8 month

Credit allowed by suppliers one month

Credit allowed for customers 20% on sales immediately and remaining in two equal installments in subsequent months

Machinery purchased in May for Rs.2, 00,000.

#### Course Outcome 4(CO4):

1. Explain the standard costing.
2. From the following identify the Material cost, Price and Usage variances for an input of 100kgs of raw material, standard output expected was 75 units. Quantity of materials purchased during the period was 3003 Kgs for Rs.9000. Standard rate per unit is Rs.2.80. Opening stock of raw materials is 201Kgs and stock at the end was 400 Kgs. Actual output during the period was 2100 units (Stock of materials assumed at Rs.4).

#### Course Outcome 5(CO5):

1. Define marginal cost.
2. Explain the marginal cost statement.
3. For the given cost, identify the BEP in units, BEP in values, Margin of safety and profit of a given system.

Variable cost = Rs.100 per unit, Sales for the year 2018 = Rs.150 per unit and fixed cost = Rs.50000.

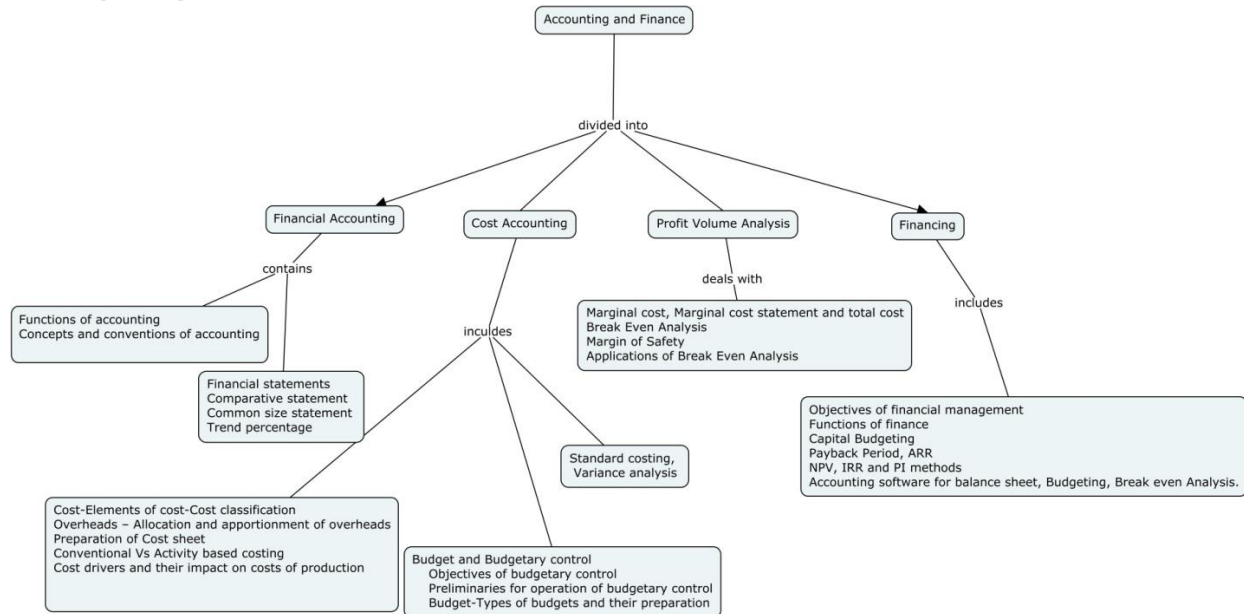
#### Course Outcome 6(CO6):

1. Explain capital budgeting.
2. Compare IRR and ARR.
3. PSG mills Ltd., is considering two mutually exclusive proposals A and B.

Particulars	Year	Proposal A (in Rs.)	Proposal B (in Rs.)
Expected cash outlay	0	2,25,000	3,75,000
Expected cash flows	1	1,50,000	2,50,000
	2	1,00,000	2,00,000
	3	75,000	1,25,000

Assuming a discount rate of 10% suggest which proposal can be accepted?



**Concept Map****Syllabus**

**Financial Accounting** - Introduction and Definition -Functions of accounting -Concepts and conventions of accounting -Financial statements and their analysis

**Cost Accounting** - Meaning and importance -Cost-Elements of cost-Cost classification - Overheads –Allocation and apportionment of overheads - Preparation of Cost sheet- Conventional Vs activity based costing -Cost drivers and their impact on costs of production Budget and Budgetary control- Introduction-Meaning -objectives of budgetary control - Preliminaries for operation of budgetary control-Budget-Types of budgets and their preparation -Standard costing-Meaning and definition-Importance -Variance analysis-calculation of material, labour and overhead variances.

**Profit Volume Analysis** – Cost – Volume ratio analysis - Marginal cost, Marginal cost statement and total cost -Break Even Analysis - Margin of Safety - Applications of Break Even Analysis.

**Finance** -Introduction and Definition-Objectives of financing-Profit maximization vs wealth maximization -Functions of finance-Capital Budgeting - Introduction-Meaning and Definition-Importance –process of capital budgeting - Appraisal of capital budgeting decisions Working capital - Meaning and definition-Importance-Factors influencing working capital-components of working capital -Estimation of working capital requirements Accounting software for balance sheet, Budgeting, Break even Analysis(only for hands on).

**Learning Resources**

1. M.C.Shukla, T.S.Grewal, S.C.Gupta: "Advanced Accounts-volume-I", Reprint, S.Chand& Company Ltd. 2017.
2. S.N.Maheswari, "Financial Management,principles and practices", Sultan Chand & Company Ltd. 2013.
3. P.S.BoopathiManickam, "Financial and Management Accounting" PSG Publications, 2009.
4. Prasanna Chandra, "Financial Management-Theory and Practice". Sixth Reprint, Tata McGraw-Hill publishing company Limited, 2015.
5. RamachandraAryasri, A, RamanaMoorthy, V.V, "Engineering Economics and financial Accounting", Tata McGraw hill, 2007.
6. S.N.Maheswari, "Advanced accountancy" Vikas publishing, 2007.
7. <https://nptel.ac.in/courses/110/101/110101132/>
8. <https://nptel.ac.in/courses/110/101/110101131/>
9. <https://nptel.ac.in/courses/110/107/110107127/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Financial Accounting</b>		
1.1	Introduction and Definition	1	CO1
1.2	Functions of accounting	1	CO1
1.3	Concepts and conventions of accounting	1	CO1
1.4	Financial statements		CO1
1.4.1	Comparative statement	2	CO1
1.4.2	Common size statement	1	CO1
1.4.3	Trend percentage	1	CO1
<b>2.0</b>	<b>Cost Accounting</b>		
2.1	Meaning and importance	1	CO2
2.2	Cost-Elements of cost-Cost classification	1	CO2
2.3	Overheads – Allocation and apportionment of overheads	1	CO2
2.4	Preparation of Cost sheet	2	CO2
2.5	Conventional Vs Activity based costing	1	CO2
2.6	Cost drivers and their impact on costs of production	1	CO2
2.7	Budget and Budgetary control		CO3
2.7.1	Introduction-Meaning -objectives of budgetary control	1	CO3
2.7.2	Preliminaries for operation of budgetary control	1	CO3
2.7.3	Budget-Types of budgets and their preparation	2	CO3
2.8	Standard costing		CO3
2.8.1	Meaning and definition-Importance	1	CO3
2.8.2	Variance analysis-calculation of material, labour and overhead variances.	1	CO4
2.8.3	Calculation of material, labour and overhead variances.	1	CO4
<b>3.0</b>	<b>Profit Volume Analysis</b>		
3.1	Marginal cost, Marginal cost statement and total cost	1	CO5
3.2	Break Even Analysis	1	CO5
3.3	Margin of Safety	1	CO5
3.4	Applications of Break Even Analysis	1	CO5
<b>4.0</b>	<b>Finance</b>		
4.1	Introduction and Definition	1	CO6
4.2	Objectives of financial management	1	CO6
4.3	Functions of finance	1	CO6
4.4	Capital Budgeting		CO6
4.4.1	Introduction-Meaning and Definition-Importance	1	CO6
4.4.2	Appraisal of capital budgeting decisions	1	CO6
4.4.3	Payback Period, ARR	2	CO6
4.4.4	NPV, IRR and PI methods	2	CO6
5	<b>Accounting software for balance sheet, Budgeting, Break even Analysis.</b>	2	CO6
5.1	<b>DPR Presentation (only for Assignment)</b>	1	CO6
	<b>Total</b>	<b>36</b>	

### Course Designers:

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<b>18MT570 INDUSTRIAL AUTOMATION LABORATORY</b>	Category	L	T	P	Credit(s)
	PC	0	0	2	1

### Preamble

Industrial automation is the use of computer and machinery aided systems to operate the various industrial operations in a well-controlled manner. Depends on the operations involved, the industrial automation systems are majorly classified into two types, namely process plant automation and manufacturing automation. Earlier the purpose of automation was to increase productivity and to reduce the cost associated with human operators. However, today, the focus of automation has shifted to increasing quality and flexibility in a manufacturing process.

In industrial automation control, a wide number of process variables such as temperature, flow, pressure, distance, and liquid levels can be sensed simultaneously. All these variables are acquired, processed and controlled by complex microprocessor systems or PC based data processing controllers. The automated system needs special dedicated hardware and software products for implementing control and monitoring systems. In recent years, the number of such products has been developed from various vendors which providing their specializing software and hardware products. This course provides the practical skills on automation technologies which enable the students to design and develop the automated systems to meet out the requirements of digital manufacturing.

### Prerequisite

Nil

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Design and Verify the function of hydraulic and pneumatic circuits.	25
CO2	Build programmable logic control for mechanical, hydraulic, pneumatic and electrical systems.	45
CO3	Develop algorithm for Motion control applications	10
CO4	Develop graphical user interface for industrial applications using HMI.	5
CO5	Develop graphical user interface for industrial applications using SCADA.	5
CO6	Program PLC for robot and Numerical Control.	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4
CO2	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4
CO3	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4
CO4	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4
CO6	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.1.1,2.4.5,2.5.3,3.1.1,3.1.5,3.2.3,4.3.1,4.3.2,4.4.1,4.4.2,4.5.1,4.5.3,4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	-	-	-	-	-	L	-	-	M	S	-
CO2	S	M	M	-	-	-	-	-	L	-	-	M	S	-
CO3	S	M	M	-	M	M	-	-	M	-	-	M	S	M
CO4	S	M	M	-	M	M	-	-	M	M	-	S	S	M
CO5	S	M	M	-	M	M	-	-	S	M	-	S	S	M
CO6	S	M	M	-	M	M	-	-	S	M	M	S	S	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	Simulator to physically understand functions of devices.

Set	--
Guided Response	Exercises for programming all automation devices
Mechanism	Mini project –Solving real time industrial issues using automation technologies.
Complex Overt Responses	-
Adaptation	-
Origination	-

### List of Experiments / Activities with CO Mapping

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	<b>Design, Simulation and Implementation of Hydraulic Circuits</b> a. Design and Simulation of Manual and Electro Hydraulics circuits. b. Design and Implementation of Manual and Electro Hydraulics circuits with Trainer kit. c. Design and Implementation of Proportional hydraulics circuits using trainer kit. d. Implementation of hydraulics circuits using PLC. (4 exercises)	4	CO1,CO2
2	<b>Design, Simulation and Implementation of Pneumatic Circuits</b> a. Design and Simulation of Manual and Electro pneumatic circuits. b. Design and Implementation of Manual and Electro pneumatic circuits with Trainer kit. (2 exercises)	2	CO1,CO2
3	Exercises using PLC Bit logic Functions (2 Exercises)	2	CO2
4	Exercises using PLC Timer functions (2 Exercises)	2	CO2
5	Exercises using PLC Counter Functions (2 Exercises)	2	CO2
6	Exercises using PLC Move Function and arithmetic function (2 Exercises)	2	CO2
7	PLC Functions and Function blocks (1 Exercise)	2	CO2
8	Programming PLC Analog module	1	CO2
9	Programming with HMI and SCADA	2	CO4,CO5
10	Programming PLC-IOT module	1	CO2
11	Motion control programming for Industrial Robot applications	2	CO3,CO6
12	PLC program for Numerical control applications.	2	CO2,CO3,CO6
13	Industrial automation Mini Project.	-	CO1 to CO6
<b>TOTAL</b>		<b>24</b>	

### Learning Resources

1. **“Indra Works 14VRS PLC Programming System Indra Logic 2G”** published by Bosch Rexroth Edition7- Application Description -R911343571,2019.
2. **“Learn-/Training Document –S71200”**, Siemens TIA Portal Module 011-001, Edition 09/2017 | Digital Factory, DF FA.
3. **S7-1500 Getting Started manual**, Siemens 05/2014, A5E03981761-AC.
4. KARL-HEINZ JOHN, **Programming Industrial automation systems**, Springer, 1995.

### Course Designers:

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**18MT580 DYNAMICS AND CONTROL LABORATORY** Category L T P Credit(s)  
PC 0 0 2 1

### Preamble

Dynamic response of a system is often a key factor in system's overall performance. The design of modern, quiet and efficient engineering systems requires a good understanding of dynamic response. Dynamics is the field of engineering concerned with predicting, measuring and analysing the behaviour responses such as force, torque, speed, mass, velocity and acceleration.

Control engineering concerns the design of automatic systems to control the behaviour of machines and processes. Effective control system design is critical in achieving optimal performance from machines and processes, and is dependent on a good understanding of the dynamics of the system that is to be controlled. Therefore, understanding the natural link between the fields of dynamics and control plays a vital role in modern engineering systems.

### Prerequisite

- 18MT320 - Kinematics and Dynamics of Machinery

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Infer the force, torque and gyroscope effect in rotating machinery	10
CO2	Test and observe the longitudinal, transverse and torsional vibrations so as to avoid resonance	20
CO3	Interpret the effect of unbalanced reciprocating and rotating masses	20
CO4	Compare the Responses of First order and second order systems	10
CO5	Compare the effect of Compensation, addition of poles, addition of zeros to the closed loop transfer function	10
CO6	Design a controller for the physical systems	30

\*\*\* Weightage depends on number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1, 1.2, 2.1.1, 2.1.2, 2.2.1, 2.4.7, 3.1.1, 3.1.2, 3.1.5, 3.2.3, 3.3.1, 4.3.2, 4.5.5
CO2	TPS2	Understand	Respond	Guided Response	1.1, 1.2, 2.2.1, 2.4.7, 3.1.1, 3.1.2, 3.1.5, 3.2.3, 3.3.1, 4.3.2, 4.5.5
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.2.1, 2.4.7, 3.1.1, 3.1.2, 3.1.5, 3.2.3, 3.3.1, 4.3.2, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.2, 2.2.1, 2.4.7, 3.2.3, 3.3.1, 4.5.5

CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.2, 2.2.1, 2.4.7, 3.2.3, 3.3.1
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.1, 1.2, 2.1.1, 2.1.2, 2.1.5, 2.2.1, 2.2.4, 2.4.5, 2.4.7, 3.1.1, 3.1.2, 3.1.5, 3.2.3, 3.2.6, 3.3.1, 4.3.2, 4.5.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	L	-	-	-	-	M	L	-	-	L	M
CO2	S	M	-	L	-	-	-	-	M	L	-	-	L	M
CO3	S	M	L	L	-	-	-	-	M	L	-	-	L	M
CO4	S	M	L	L	M	-	-	-	L	L	-	-	M	M
CO5	S	M	L	L	M	-	-	-	L	L	-	-	M	M
CO6	S	S	M	M	M	-	-	-	M	S	L	L	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Mini Project: 1. Mechanism for Simple application 2. Arduino based control system design
Complex Overt Responses	-
Adaptation	-
Orignation	-

### List of Experiments / Activities with CO Mapping

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	Governors - Determination of sensitivity, effort, etc. for watt, porter, proell, Hartnell governors	2	CO1
2	Cam - Study of jump phenomenon and drawing profile of the cam.	2	CO1
3	Motorized Gyroscope-Determination of Gyroscopic couple Verification of Laws.	2	CO2
4	Turn table-Determination of Moment of Inertia of Disc and Ring.	2	CO2



5	Balancing of rotating masses (Static and Dynamic Balancing)	2	CO3
6	Balancing of reciprocating masses.	2	CO3
7	Whirling of Shaft – Determination of Critical Speed	2	CO3
<b>CYCLE 2 - CONTROL LAB</b>			
8	Determination of a Step & Impulse response for a first order, second order, Type 0, Type 1 and Type 2 systems	2	CO4
9	Design a suitable compensator to obtain the open loop specifications using root locus and bode plot techniques.	2	CO5
10	Compare the effect of addition of poles, addition of zeros to the forward path transfer function of a closed loop system	2	CO5
11	Derive the simulation model for Open loop and closed loop systems, plot the step response, Study the effect of P, Pi, PD, PID control, and tune the controller using ZN Tuning rule.	2	CO6
12	Design a controller for DC Motor speed control and verify its performance	2	CO6
13	Design a controller for Inverted pendulum and verify its performance	2	CO6
14	Design a controller for process control application.	2	CO6
<b>TOTAL</b>		<b>24</b>	

### Learning Resources

1. John Joseph Uicker, Gordon Pennock, Joseph E. Shigley, "Theory of Machines and Mechanisms", Fourth Edition, Oxford University Press, 2014.
2. Rao and Dukkupati, R.V, "Mechanism and Machine Theory", Second edition New Age International (P) Ltd., 2010.
3. Rattan.S.S, "Theory of Machines", Fifth Edition, Tata McGraw–Hill Publishing Co., New Delhi, 2018
4. Norman S. Nise, "Control System Engineering", Eighth Edition, John Wiley & Sons, 2019
5. J. Nagrath and M. Gopal, "Control System Engineering", New Age International Publisher, Sixth Edition, New Delhi, 2018
6. K. Ogata, "Modern Control Engineering", Fifth Edition, Pearson Edition, 2009.

### Course Designers:

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18ES590

**SYSTEM THINKING**

Category	L	T	P	Credit(s)
ES	1	-	2	2

**Preamble**

Systems thinking is the integrated paradigm for systems science and system approaches to practice. It is concerned with understanding or intervening in problem situations, based on the principles and concepts of the system model. It can help to provide a common language and an intellectual foundation and make practical system concepts, principles, patterns and tools accessible to systems engineering. System thinking considers the similarities between systems from different domains in terms of a set of common systems concepts, principles, and patterns. The scope of systems thinking is a starting point for dealing with real-world situations using a set of related systems concept. The system thinking is viewed as both a set of founding ideas for the development of systems theories and practices and also as a pervasive way of thinking need by those developing and applying them. This systems approach is a way of tackling real-world problems and making use of the concepts, principle, patterns of systems thinking to enable the systems to be engineered and used.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Explain the concepts of systems thinking, System engineering and Systems Life Cycle	10
CO2	Identify system elements, interactions, boundary and environment for the given system descriptions	10
CO3	Develop a functional architecture with appropriate primary function(s) and sub-functions of the identified system	15
CO4	Develop a physical architecture with appropriate sub-systems and components of the identified system	15
CO5	Prepare a system requirement specification review documents for the various stages of acquisition phase of the identified system	20
CO6	Develop a system model with logical and physical architecture using system modelling tool like SysML	30

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1, 2.3.1, 2.3.2
CO2	TPS3	Apply	Value	-	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 4.3.1,
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4,

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
					3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	L	L	L	L	L	-	M
CO3	S	M	L	-	-	M	M	M	L	M	M	S
CO4	S	M	L	-	-	M	M	M	L	M	M	S
CO5	S	M	L	-	-	M	M	M	L	M	M	S
CO6	S	M	L	-	S	M	M	M	L	M	M	S

S- Strong; M-Medium; L-Low

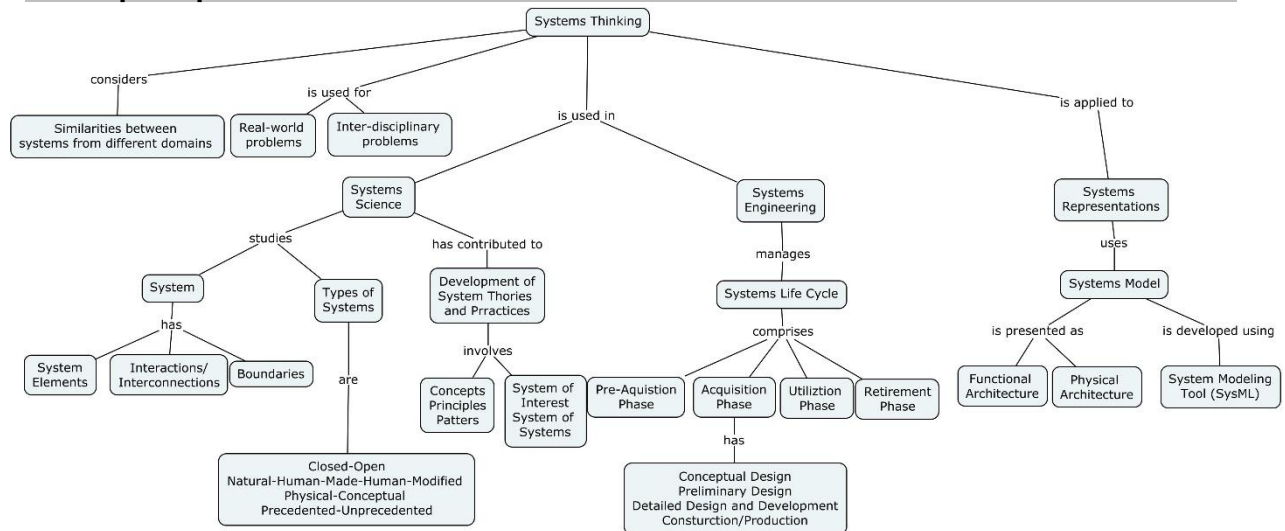
### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Test -2
Remember	20
Understand	40
Apply	40
Analyse	-
Evaluate	-
Create	-

Phases	Deliverables	Marks	Course Outcomes
<b>Continuous Assessment</b>			
Continuous Assessment Test-1		10	CO1 and CO2
Review 1 – Functional & Physical Architecture and System Requirement Specification	Technical Report	25	CO3, CO4 and CO5
Review 2 – Systems Modelling	Technical Report	15	CO6
<b>End-Semester Examination</b>			
Demonstration	Virtual Prototype with simulation	60	CO1, CO2, CO3, CO4 CO5 and CO6
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics.
- Demonstration of Virtual Prototype with simulation and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

## Concept Map



## Syllabus

**1.0 Systems Fundamentals:** System - Definition, System Elements, Interactions, System Boundary, - Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented. Systems science - Systems approaches. Systems Thinking: Concepts, principles and patterns. System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise. System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.

**2.0 Acquisition Phase:** Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture. Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture. Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review. Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.

**3.0 Systems Modeling:** System Model - Types of models – System Modeling Concepts – Modeling Standards. System Architecture: Logical Architecture Model – Physical Architecture Model. Systems Life Cycle Process Model: Vee model.

## Learning Resources

1. A Guide to Guide to the Systems Engineering Body of Knowledge (SEBoK), version 2.2, INCOSE Systems Engineering Research Center and IEEE Computer Society, Released 31 October 2019 – [https://www.sebokwiki.org/w/images/sebokwiki-farm!w/8/8b/SEBoK\\_v2.1.pdf](https://www.sebokwiki.org/w/images/sebokwiki-farm!w/8/8b/SEBoK_v2.1.pdf)
2. Systems Engineering Handbook, A Guide for Systems Life Cycle Processes and Activities, 4<sup>th</sup> Edition, INCOSE-TP-2003-002-04, 2015.
3. R. Ian Faulconbridge, Michael Ryan, “Systems Engineering Practice”, Argos Argos Press, 2014.
4. Jon Holt and Simon Perry, “SysML for Systems Engineering”, The Institution of Engineering and Technology, London, United Kingdom, 2008.
5. Sanford Friedenthal, Alan Moore and Rick Steiner, “A Practical Guide To SysML: The Systems Modeling Language, Third edition, Morgan Kaufmann, an imprint of Elsevier, 2015
6. Coursera course on Introduction to Systems Engineering - R. Ian Faulconbridge, Michael Ryan of The University of New South Wales, Sydney.
7. NPTEL Course: Systems Engineering Theory and Practice – IIT Kanpur – Prof. Deepu Philip (Last offered in 2019) - <https://nptel.ac.in/courses/110/104/110104074/>

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours		Course Outcome
		In-Class	Hands-on	
1.	<b>Systems Fundamentals:</b> System - Definition, System Elements, Interactions, System Boundary	1	-	CO1
1.1	Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented.	1	2	CO1
1.2	Systems science - Systems approaches.	1	-	CO1
1.3	Systems Thinking: Concepts, principles and patters.	1	-	CO1
1.4	System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.	2	2	CO2
2.	<b>Acquisition Phase</b>			
2.1	Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture.	1	4	CO3
2.2	Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture.	1	4	CO3
2.3	Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review.	1	4	CO4
2.4	Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.	1	4	CO5
3.	<b>Systems Modeling</b>			
3.1	System Model - Types of models – System Modeling Concepts – Modeling Standards.	1	2	CO6
3.2	System Architecture: Logical Architecture Model – Physical Architecture Model.	1	4	CO6
3.3	Systems Life Cycle Process Model: Vee model.	1	2	CO6
	Total	14	28	

**Course Designers:**

1. Dr.S.J.Thiruvengadam      sjtece@tce.edu
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18CHAC0	ESSENCE OF INDIAN KNOWLEDGE	Category	L	T	P	Credit
		AC	2	0	0	0

### Preamble

On the successful completion of the course, the students will be able to explain the concept of Indian Traditional Knowledge along with Indian Modern Knowledge. Traditional Knowledge Systems or Indigenous Knowledge Systems are a body of knowledge, which is very ancient and deep rooted. They have their origins in the remote past. Their systematisation and canonisation gave rise to the elite (the Greater Tradition) science. The nature of Traditional Knowledge System is diverse. It covers, among other things, literary, artistic and scientific works; songs, dances, medical treatments and practices; manufacturing and industry; and agricultural technologies and techniques. There is a dramatically growing national and international interest in incorporating Traditional Knowledge Systems, including Traditional Ecological Knowledge, into truly participatory approaches to development.

### Course Outcome:

On the successful completion of the course students will be able to

CO1	Explain the concept of Traditional Knowledge and Modern knowledge of India.	Understand
CO2	Explain the need and importance of protecting Traditional Knowledge, Knowledge sharing, and Intellectual property rights over Traditional Knowledge.	Understand
CO3	Explain about the use of Traditional Knowledge to meet the basic needs of human being.	Understand
CO4	Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle.	Understand
CO5	Explain the use of Traditional Knowledge in Manufacturing and Industry.	Understand
CO6	Explain about the cultural expression and modern applications of Traditional Knowledge	Understand

### Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO2	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO3	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO4	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO5	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO6	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

### Syllabus

**Traditional and Modern Knowledge:** Two Worlds of Knowledge - Phase of Explorers, Sir Arthur Cotton and Irrigation, Smallpox Vaccination, Late Nineteenth Century, Voelcker, Howard and Agriculture, Havell and Indian Art; Indians at the Encounter - Gaekwad of Baroda and Technical Education, Science Education and Modern Industries, Hakim Ajmal Khan and Ayurveda, R. N. Chopra and Indigenous Drugs, Gauhar Jaan and Indian Classical Music; Linking Science and the Rural - Tagore's Sriniketan Experiment, Marthandam, the YMCA Model, Gandhi's Thoughts on Development, Nehru's View of Growth; Post-Independence Era - Modernization and Traditional Knowledge, Social Roots of Traditional Knowledge Activism, Global Recognition for Traditional Knowledge. **Global Mechanisms of Protection and Sharing:** For Recognition and Protection - United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Labour Organization (ILO), UN Working Group on Indigenous Populations, Evolution of Other Organizations; Norms of Sharing - United Nations Environment Programme (UNEP), World Intellectual Property Organization (WIPO), World Trade

Organization (WTO); IPR and Traditional Knowledge - Theoretical Background, Positive Protections of TK, Defensive Strategies, IPR Facilitation for TK. **Traditional Knowledge for Basic Needs:** Indian Midwifery Tradition—The Dai System, Surface Flow Irrigation Tanks, Housing - A Human Right, Changing Priorities—Niyamgiri. **Biodiversity and Genetic Resources:** Jeevani - The Wonder Herb of Kanis, A Holistic Approach - FRLHT, Basmati - In the New Millennium, AYUSH-Based Cosmetics. **Traditional Knowledge in Manufacturing and Industry:** Drug Discovery, A Sweetener of Bengal, The Sacred Ring of Payyanur, Channapatna Toys. **Traditional Cultural Expressions:** Banarasi Saree, Music, Built and Tangible Heritage, Modern Yoga, Sanskrit and Artificial Intelligence, Climate Change and Traditional Knowledge.

#### Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar
	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

#### Learning Resources:

1. Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.
2. Amit Jha,"Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
3. Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
4. Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
5. NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: <https://nptel.ac.in/courses/121/106/121106003/#>.
6. Youtube video on "Introduction to Indian Knowledge Systems", Video link: <https://www.youtube.com/watch?v=LZP1StpYEPM>.
7. Youtube video on "12 Great achievements of Indian Civilization", Video link: <https://www.youtube.com/watch?v=xmogKGCmclE>.

#### Course Designers:

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SYLLABI

For

**B.E. Mechatronics Program**

Sixth Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 59<sup>th</sup> Academic Council Meeting on 07.12.2019



**18MT610****INDUSTRIAL ROBOTICS**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

Robotics is the interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. In the 20<sup>th</sup> century, engineers have mastered almost all forms of motion control and have proven that robots and machines can perform almost any job made by humans. Industrial Robotics deals with the types of robots used in industries both industrial and mobile robots.

**Prerequisite**

- 18MT320 - Kinematics and Dynamics of Machinery

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Review the Anatomy, types and applications of robots	10
CO2	Compute the forward kinematic model (position and orientation) of multi DOF manipulator	10
CO3	Compute the inverse kinematic model (joint angles) of 1 and 2 DOF manipulator	20
CO4	Compute the forward and inverse dynamic model of two DOF manipulator (torque)	20
CO5	Develop offline program an industrial robot for welding application	20
CO6	Develop online program an industrial robot for deburring, inspection and pick and place application	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3.2.4.4,4.3.1,4.3.2

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	-	L		-	-	-	-	-	M	M	M
CO2	S	S	S	-	S		-	-	-	-	-	M	M	M
CO3	S	S	S	-	S		-	-	-	-	-	M	M	M
CO4	S	S	S	-	S		-	-	-	-	-	M	M	M
CO5	S	S	S	-	S		-	-	-	-	-	M	M	M
CO6	S	S	S	-	S		-	-	S	S	S	S	M	M
CO7	S	S	S	-	L		-	-	-	-	-	M	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	30	20	20	-	-	-	20
Understand	40	40	40	100	-	-	40
Apply	30	40	40	-	100	-	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	100	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO<sub>1</sub>):

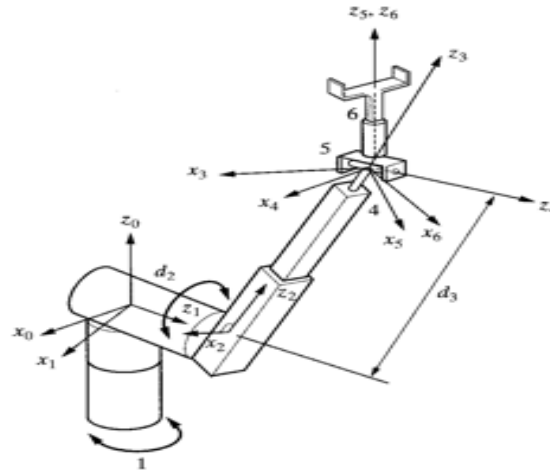
1. Define Robot
2. Explain the classification and the performance of Robots.
3. Describe the constructional features of a mobile robot.

#### Course Outcome 2(CO<sub>2</sub>):

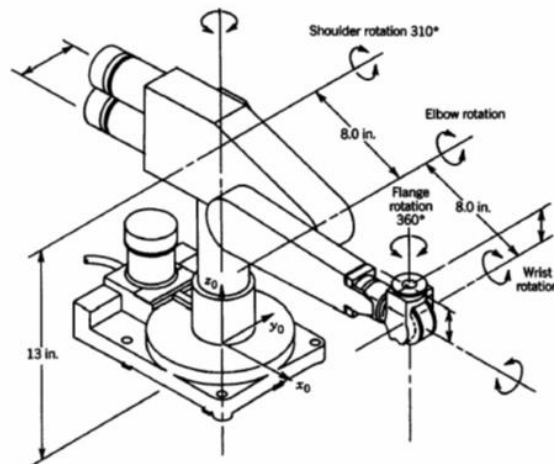
1. Write the coordinate transformation matrices for all PUMA joints as shown in the fig using DH parameters.



2. Find the DH parameters for the robot given in the following fig and derive the forward kinematics

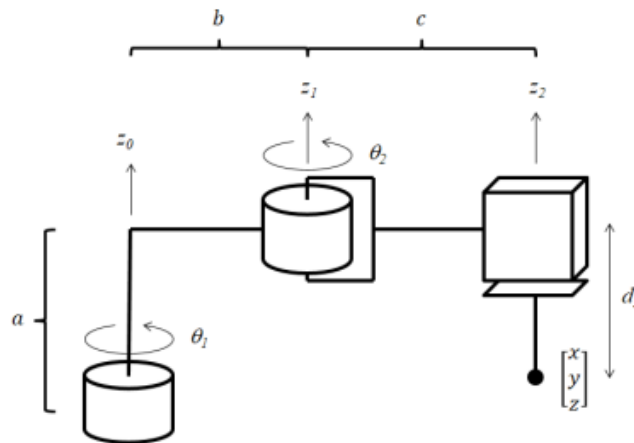


3. Determine the kinematic parameters for the PUMA 260 robot and derive the complete forward kinematics equations for the center of the wrist by establishing the DH frames, finding and taking the product of the corresponding homogenous transformations



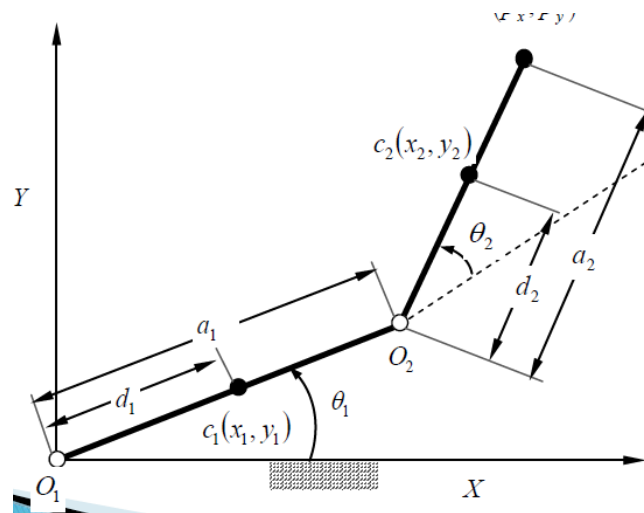
**Course Outcome 3(CO<sub>3</sub>):**

1. Calculate the joint angle of the single manipulator if the position of the end effector is (2, 2).
2. Derive the inverse kinematic equation using trigonometric approach
3. (a) Solve for the forward kinematics problem  
(b) Given the location of the end effector  $(x,y,z)^T$  solve for the inverse kinematics problem



**Course Outcome 4(CO<sub>4</sub>):**

1. Derive the dynamic model of two link manipulator



2. Explain the lagrangian dynamic model. Compute the kinetic energy and potential energy and hence derive the torque
3. Explain the differences between lagrangian and newton euler model.

**Course Outcome 5 (CO<sub>5</sub>):**

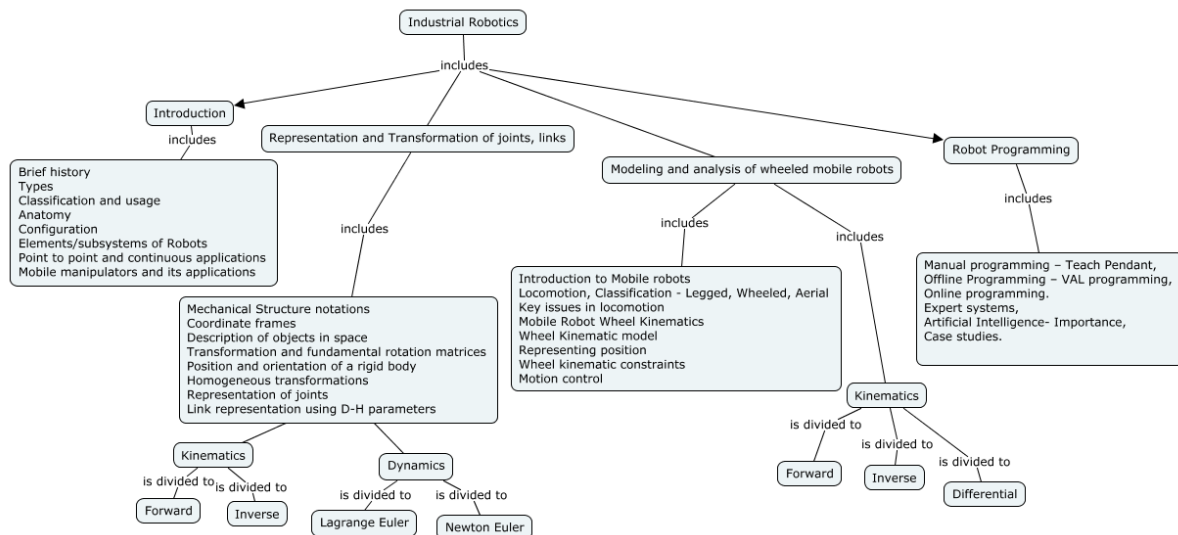
1. Two MS plates of size 50x100x10 mm which are vertically oriented need to be joined through robot welding. Draw suitable diagram of the situation and write the offline VAL program.

2. Program the motion of the welding electrode which removes filler at a speed of 3cm/sec. The total length of the welding material is 50 cm.
3. Choose a welding electrode, robot and a controller to weld the end points of a cubic car door of size 30cmX30cmX30cm. Write an algorithm for the same.

**Course Outcome 6 (CO<sub>6</sub>):**

1. Write a robot programming for a palletizing operation. The robot must pick up the parts from an incoming chute and deposit them onto a pellet. The pallet has four rows that are 50 mm apart and six columns that are 40 mm apart. The plane of the pallet is assumed to be parallel to the XY plane. The rows of the pallet are parallel to the x – axis and the columns of the pallet are parallel to the Y axis. The objects to be picked up are about 25mm tall.
2. Two MS plates of size 50x100x10 mm which are vertically oriented need to be joined through robot welding. Draw suitable diagram of the situation and write the offline VAL program.
3. Write a VAL statements for defining coordinate frame ‘Grasp – Point 1’ which can be obtained by rotating coordinate frame ‘Block – Point 2’ through an angle 65 about Y – axis and then translate it by 100 and 150 mm in X and Y axes respectively

**Concept Map**



**Syllabus**

**Introduction to Robotics**

Introduction – brief history, Robot – types – Industrial, Mobile; Classification and usage, configuration, Anatomy, Elements/subsystems of Robots, Point to point and continuous applications, Mobile manipulators, Grippers – Types; Application of robots in machining - Welding - Assembly - Material handling - Loading and unloading Inspection – Palletizing - Hostile and remote environments.

**Representation and Transformation of joints, links**

Mechanical Structure notations, Coordinate frames, Description of objects in space, Transformation and fundamental rotation matrices, Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, **Kinematics:** Forward kinematics of multi DOF manipulator - Inverse kinematics of 2DOF manipulator. **Dynamics:** Introduction – Manipulator dynamics – Lagrange - Euler formulation- Newton - Euler formulation. Examples of D-H parameters and link transforms. Introduction to Robo Analyser – Visualization of DH parameters

**Trajectory planning**

Definitions and planning tasks, Joint techniques – Motion profiles- cubic polynomial motion, Cartesian Space techniques. Robot Controller – open, closed

**Robot Programming**

Robot Programming: Manual programming – Teach Pendant, Offline Programming - Welding, Online programming – Deburring, Palletizing and Inspection.

**Artificial Intelligence in Robotics**

Expert systems, Artificial Intelligence- Knowledge Representation, AI in Robotics, Case studies.

**Learning Resources**

1. Shuai Li, Long Jin, Mohammed Aquil Mirza, "Kinematic Control of Redundant Robot Arms Using Neural Networks", IEEE press, April 29, 2019.
2. John J Craig, "Introduction to Robotics, Mechanics and Control, third edition, Pearson education, 2005
3. K.S.Fu, R.C Gonzalez and C.S Lee, Robotics – Control, sensing Vision and Intelligence, Tata McGraw – Hill Editions, 2008.
4. Roland Siegwart and Illah R Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2004.
5. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008.
6. Saeed B Niku, "Introduction to Robotics, Analysis, System, Applications," second edition, John Wiley, 2010.
7. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, "Industrial Robotics – Technology, Programming and Applications", Tata McGraw Hill Edition, 2008.
8. Robert J Schilling, Fundamentals of Robotics: Analysis and Control", Indian reprint, Prentice hall of India Private Limited, 1996

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction</b>		
1.1	Robot – types – Industrial, Mobile	1	CO <sub>1</sub>
1.2	Classification and usage, configuration	1	CO <sub>1</sub>
1.3	Anatomy, Elements/subsystems of Robots	1	CO <sub>1</sub>
1.4	Point to point and continuous applications	1	CO <sub>1</sub>
1.5	Mobile manipulators, Grippers – Types	1	CO <sub>1</sub>
1.6	Application of robots in machining - Welding – Assembly	1	CO <sub>1</sub>
1.7	Material handling - Loading and unloading Inspection	1	CO <sub>1</sub>
1.8	Palletizing - Hostile and remote environments	1	CO <sub>1</sub>

<b>2.0</b>	<b>Representation and Transformation of joints, links</b>		
2.1	Mechanical Structure notations, Coordinate frames	1	CO <sub>2</sub>
2.2	Description of objects in space, Transformation and fundamental rotation matrices	2	CO <sub>2</sub>
2.3	Position and orientation of a rigid body, Homogeneous transformations	2	CO <sub>2</sub>
2.4	Representation of joints, link representation using D-H parameters	1	CO <sub>2</sub>
2.5	<b>Kinematics:</b> Forward kinematics of multi DOF manipulator	2	CO <sub>2</sub>
2.6	Inverse kinematics of 2DOF manipulator	2	CO <sub>3</sub>
2.7	<b>Dynamics:</b> Introduction – Manipulator dynamics – Lagrange - Euler formulation	2	CO <sub>4</sub>
2.8	Newton - Euler formulation	1	CO <sub>4</sub>
2.9	Examples of D-H parameters and link transforms. Introduction to Robo Analyser – Visualization of DH parameters	1	CO <sub>4</sub>
3.0	<b>Trajectory planning</b>		
3.1	Definitions and planning tasks	1	CO <sub>4</sub>
3.2	Joint techniques – Motion profiles- cubic polynomial motion	2	CO <sub>4</sub>
3.3	Cartesian Space techniques	2	CO <sub>4</sub>
3.4	Robot Controller – open, closed	2	CO <sub>4</sub>
4.0	<b>Robot Programming</b>		
4.1	Manual programming – Teach Pendant	1	CO <sub>5</sub>
4.2	Offline Programming	1	CO <sub>5</sub>
4.3	Online programming	1	CO <sub>6</sub>
4.5	Expert systems	1	CO <sub>6</sub>
4.6	Artificial Intelligence	1	CO <sub>6</sub>
4.7	Knowledge Representation	1	CO <sub>6</sub>
4.8	AI in Robotics, Case studies	1	CO <sub>6</sub>
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

Sl. No.	Name	E-mail Id
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2	Mr M.A Ganesh	ganeshma2015@tce.edu

**18MT620****CNC TECHNOLOGY**

Category L T P Credit(s)

PC 3 0 0 3

**Preamble**

This course provides fundamental knowledge about the CNC system that are predominantly found in most manufacturing industries. CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. A CNC system is typically a traditional mechanical machine tool whose motion is controlled by electrical motors which depends on a computer program. CNC machines are capable of producing components with good accuracy and precision along with very high production rate. The dependency on the skill of the worker can be totally eliminated when CNC machines are employed.

In modern CNC systems, the design of a mechanical part and its manufacturing program is highly automated. The part's mechanical dimensions are defined using CAD software, and then translated into manufacturing directives by computer-aided manufacturing (CAM) software. The resulting directives are transformed into the specific commands necessary for a particular machine to produce the component, and then are loaded into the CNC machine

**Prerequisite**

- 18MT420 - Power Electronics and Drives
- 18MT440 - Sensors and Measurements

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Classify the CNC machine based on their specifications.	10
CO2	Illustrate the construction features of mechanical components used in a CNC system.	28
CO3	Design a 3 axis CNC System by selecting suitable controller, feed and spindle drives.	22
CO4	Develop CNC part program for turning as per product geometry.	11
CO5	Develop CNC part program for Milling Operations	11
CO6	Develop a CNC system by selecting suitable components and Suggest methodologies for CNC system maintenance and troubleshooting.	18

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.12,1.2
CO2	TPS2	Understand	Respond	Guided Response	1.12,1.2
CO3	TPS3	Apply	Value	Mechanism	1.12,1.2,2.11
CO4	TPS3	Apply	Value	-	1.12,1.2,2.11,2.12,2.13
CO5	TPS3	Apply	Value	-	1.12,1.2,2.11,2.12,2.13
CO6	TPS3	Apply	Value	Mechanism	1.12,1.2,2.11,2.12,2.13, 2.2.1,2.2.3,2.2.4,2.31,2.3.2,2.4.1, 2.4.5,3.11,3.1.2,3.1.5



### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	M
CO2	M	L	-	-	-	-	-	-	-	-	-	-	M	M
CO3	S	M	M	-	-	-	-	-	M	-	-	-	M	M
CO4	S	M	M	-	S	-	-	-	M	-	-	-	M	M
CO5	S	M	M	-	S	-	-	-	M	-	-	-	M	M
CO6	S	M	M	-	-	-	M	-	M	-	-	-	S	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	30	20	-	-	100 <sup>#</sup>		20
Understand	50	40	-	-			40
Apply	20	40	100*	100			40
Analyse	-	-	-	-			-
Evaluate	-	-	-	-			-
Create	-	-	-	-			-

\* Third assessment will be done in CNC Turning/Milling Software.

# 2nd assignment will be design part of Project and the third assignment will be working model.

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	3-D Models.
Set	---
Guided Response	Programming using software
Mechanism	Profile designing using Part Program, Mini project
Complex Overt Responses	--
Adaptation	---
Origination	---

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. List the vital specifications of a CNC Turning centre.
2. Explain the evolution of a CNC Machining centre.
3. Describe the safety aspects of CNC Turning and Machining centres.

#### Course Outcome 2(CO2):

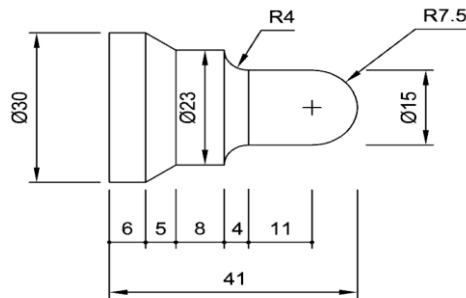
1. List the various types of loads acting in a CNC machine and elaborate how it influences the selection of various mechanical components.
2. Describe the ball screw and nut assembly with suitable sketches.
3. Explain the various tool monitoring system present in a CNC Turning centre.

**Course Outcome 3(CO3):**

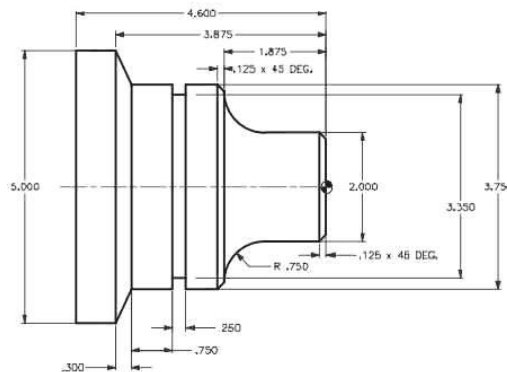
1. Design a spindle drive using VFD for varying the speed between a range of 500 to 1500 rpm for CNC Milling Machine.
2. Design a CNC control system using PLC and 3 Axis Servo Drive System.
3. Design a 3-axis Servo drive system for CNC Turning Machine.

**Course Outcome 4 (CO4):**

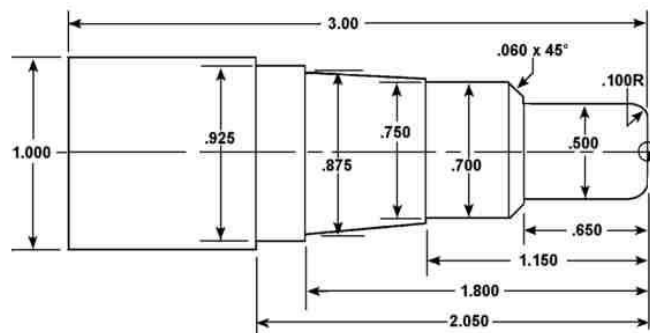
1. Develop part program for the given component shown in figure below that is to be manufactured in a CNC Turning centre.



2. Write a cnc code for the following profile with an aluminium work piece. Calculate the spindle speed. cutting velocity of aluminium is 80 MPM.

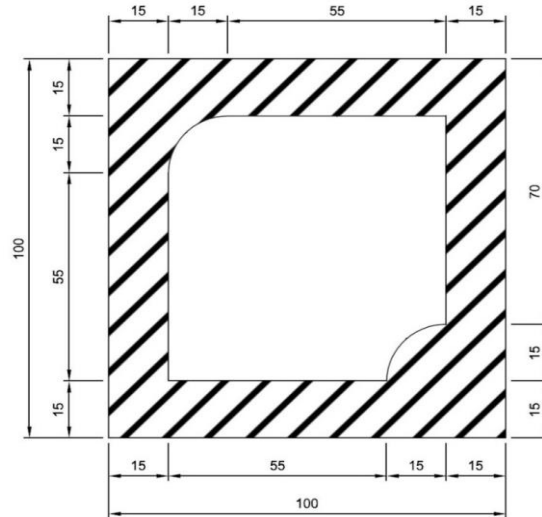


3. Write the part program for the following Profile.

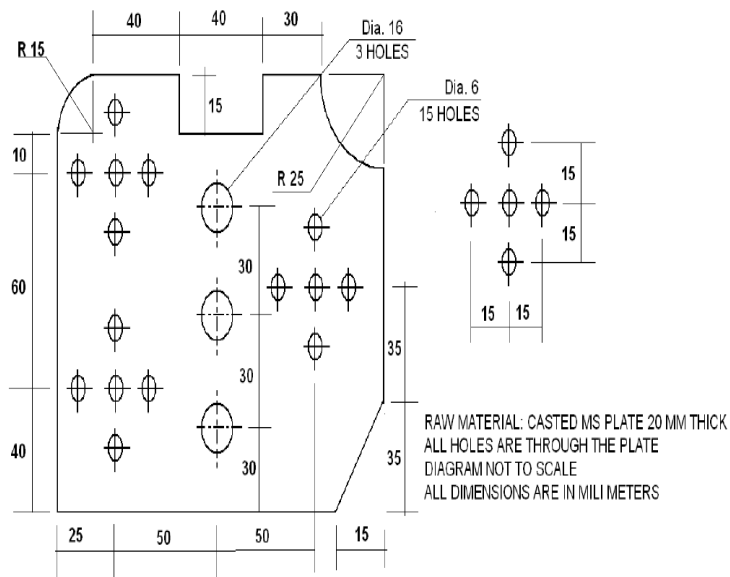


**Course Outcome 5 (CO5):**

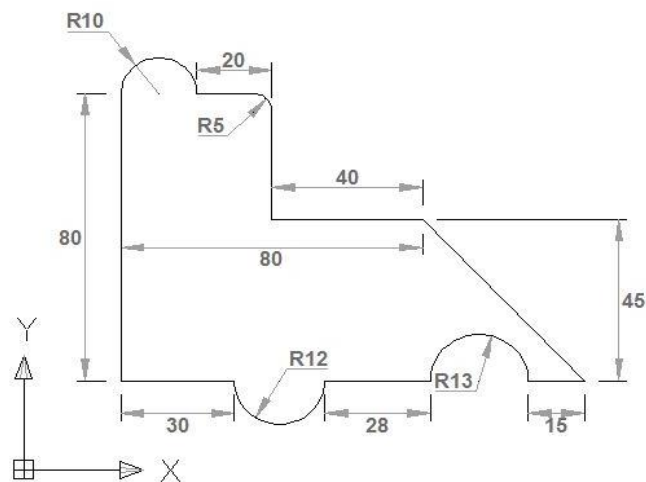
1. Develop part program for the given component shown in figure below that is to be manufactured in a CNC Machining centre.



2. Develop the part program for the given profile

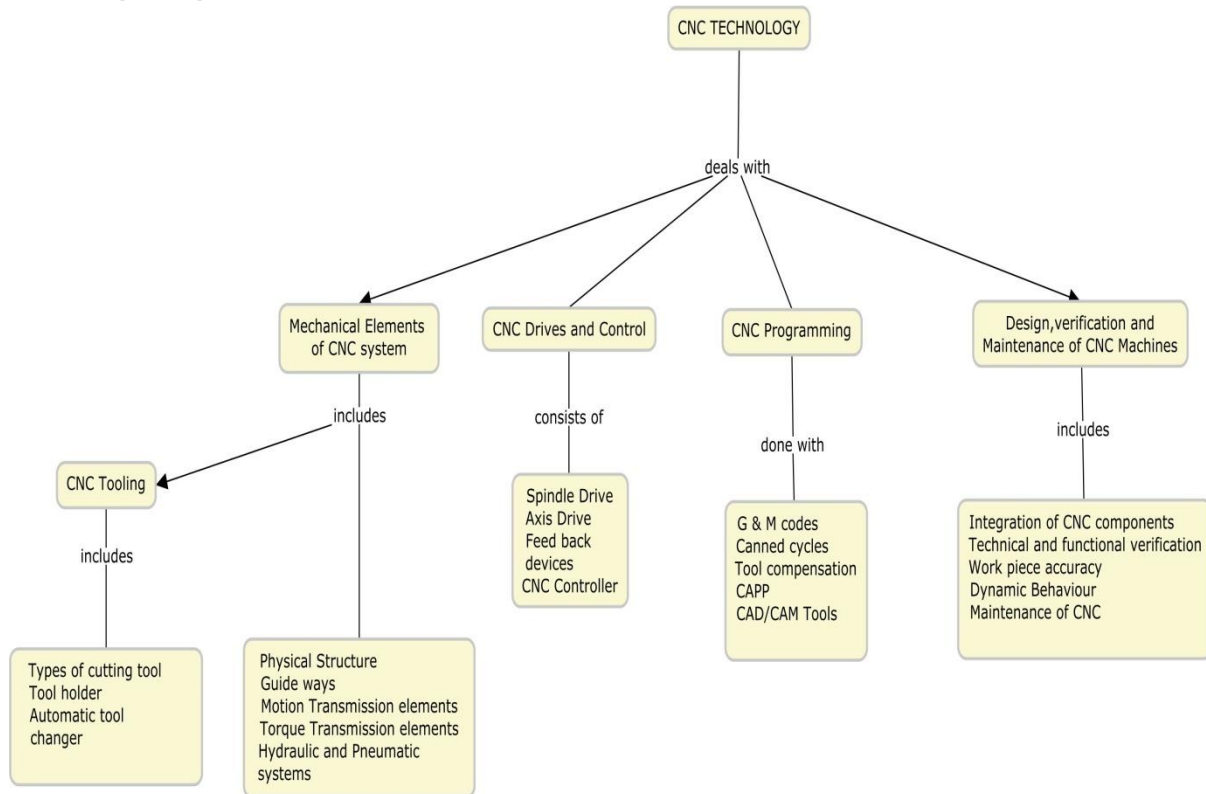


3. Develop the part program for the following profile.



**Course Outcome 6 (CO6):**

1. Explain the interface between controller and Axis drive with neat block diagram.
2. Design a 3 axis CNC lathe Machine by listing specification of components used and also make circuit and connection diagram.
3. Describe the procedure followed to verify the technical and functional specification of a CNC Machining centre.

**Concept Map****Syllabus**

**Introduction to CNC Systems:** Fundamentals of NC, CNC and DNC technologies, Evolution of CNC Turning centre, Evolution of CNC Milling centre, Principles, specification, features, advantages and applications of CNC machines, Factors influencing the selection of CNC machines, Practical aspects of introducing CNC machines in manufacturing industry, Safety aspects of CNC machines.

**Structure and Elements of CNC System:** Machine physical architecture – Structural details, Types of loads on CNC machine, Types of guide ways – Friction guide ways, Antifriction guide ways, Elements for rotary motion to linear motion – Screw & nut, recirculating ball screw, rack & pinion, Torque transmission elements – gears, timing belt, flexible coupling, bearing, Hydraulic and pneumatic systems in a CNC system – Industry 4.0 for Machine tools.

**CNC Tooling:** Cutting tool materials, types of cutting tool, tool selection, tool holder, tool probing and pre-setting, tool compensation, automatic turret changer, tool monitoring system

**CNC Drives and Control:** Spindle drive – Three phase induction motor – Construction, Characteristics, Speed control methods, VFD, Axis Drive – AC Servo motor, Construction,

Characteristics, Closed loop position control. Feedback devices – Rotary encoder, linear scale encoder, proximity sensor, synchronous resolver. Introduction to functioning and programming of CNC Controller, PLC, Man machine interface,

**CNC Programming:** Machine axes identification NC Programming, Part programming terminology – G and M codes, Types of interpolation, Types of Programming – manual part programming: fixed cycle and canned cycle for turning and milling operations, Computer Assisted Part Programming (CAPP), Introduction to CNC part programming using CAD/CAM tools.

**Design, Verification and Maintenance of CNC Machines:** Selection and Integration of CNC components-Case study 3 axis CNC turning and milling Machine, Verification of technical and functional aspects, Verification of CNC machine during idle running, Verification of CNC machine tool and work piece accuracy, Analysis of dynamic behaviour of CNC machines-Installation of CNC machines-Maintenance of CNC machines.

### Learning Resources

1. HMT, "Mechatronics", Tata McGraw-Hill Publishing Company Limited, New Delhi – 2018.
2. CNC Programming by Dr.S.K.Sinha, Galgotia publications pvt ltd-2016
3. Ken Evans, "Programming of Computer Numerically Controlled Machines", Industrial Press Inc. – 2007.
4. Peter Smid, "CNC Programming Handbook", Industrial Press Inc. 2007.
5. Yusuf Altintas, "Manufacturing Automation", Cambridge University Press, 2012.
6. G. E. Thyer, "Computer Numerical Control of Machine Tools", Second Edition, B/H Newnes, 1991.
7. Graham T. Smith, "CNC Machining Technology", Springer-Verlag London Limited, 1993.
8. FANUC Series 0, Maintenance Manual.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	<b>Introduction to CNC Systems</b>		
1.1	Evolution of CNC Turning centre, Evolution of CNC Milling centre	1	CO1
1.2	Principles, specification, features, advantages and applications of CNC machines	1	CO1
1.3	Factors influencing the selection of CNC machines, Practical aspects of introducing CNC machines in manufacturing industry	1	CO1
1.4	Safety aspects of CNC machines	1	CO1
2	<b>Structure of CNC System</b>		
2.1	Machine physical architecture – Structural details	1	CO2
2.2	Types of loads on CNC machine	1	CO2
2.3	Types of guide ways – Friction guide ways, Antifriction guide ways	1	CO2
2.4	Elements for rotary motion to linear motion – Screw & nut, recirculating ball screw, recirculating ball screw, rack & pinion	2	CO2
2.5	Torque transmission elements – gears, timing belt, flexible coupling, bearing	1	CO2

2.6	Hydraulic and pneumatic systems in a CNC system	1	CO2
<b>3</b>	<b>Tooling for CNC Machines</b>		
3.1	Types of cutting tool, Tool selection	1	CO2
3.2	Tool holder, tool probing and pre-setting	1	CO2
3.3	Automatic turret changer, Tool monitoring system	1	CO2
<b>4</b>	<b>CNC Drives and Control</b>		
4.1	Spindle drive – Three phase induction motor – Construction, Characteristics, Speed control methods	2	CO3
4.2	VFD Axis Drive – AC Servo motor, Construction, Characteristics, Closed loop position control	2	CO3
4.3	Feedback devices – Rotary encoder, linear scale encoder, proximity sensor, synchronous resolver.	2	CO3
4.4	Introduction to functioning and programming of CNC Controller, PLC, Man machine interface.	2	CO3
4.5	Industry 4.0 for Machine tools	1	CO3
<b>5</b>	<b>CNC Part Programming</b>		
5.1	Part programming terminology – G and M codes	2	CO4, CO5
5.2	Types of interpolation, manual part programming: fixed cycle and canned cycle for turning and milling operations	2	CO4, CO5
5.3	Tool compensation	1	CO4, CO5
5.4	Computer assisted part programming	1	CO4, CO5
5.5	Introduction to CNC part programming using CAD/CAM tools.	1	CO4, CO5
<b>6</b>	<b>Design, Verification and Maintenance of CNC Machines</b>		
6.1	Selection and Integration of CNC components-Case study 3 axis CNC turning and milling Machine	2	CO6
6.2	Verification of technical and functional aspects, Verification of CNC machine during idle running	1	CO6
6.3	Verification of CNC machine tool and work piece accuracy	1	CO6
6.4	Analysis of dynamic behaviour of CNC machine	1	CO6
6.5	Maintenance requirements of CNC machine – Preventive maintenance.	1	CO6
<b>TOTAL</b>		<b>36</b>	

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**18MT660****VIRTUAL INSTRUMENTATION**

Category	L	T	P	Credit(s)
ES	2	0	2	3

**Preamble**

A Virtual Instrumentation system consists of an industry-standard computer or workstation equipped with powerful application software, cost-effective hardware such as plug-in boards, and driver software, which together perform the functions of traditional instruments. Virtual instruments represent a fundamental shift from traditional hardware-centred instrumentation systems to software-cantered systems that exploit the computing power, productivity, display, and connectivity capabilities of popular desktop computers and workstations. In combination with powerful software, engineers can create custom-defined measurements and sophisticated analysis routines. Virtual instrumentation has been widely adopted in test and measurement areas and is rapidly making headway in control and design areas.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
<b>CO1</b>	Summarize the need and advantages of virtual instruments over traditional instruments	05
<b>CO2</b>	Illustrate the various software components needed to develop graphical programming using LabVIEW	20
<b>CO3</b>	Choose appropriate LabVIEW Architecture for realizing a given application	05
<b>CO4</b>	Develop Graphical Programming using LabVIEW	30
<b>CO5</b>	Acquire data from real world using various sensors and interpret the same	20
<b>CO6</b>	Develop LabVIEW based software application for realizing the given system	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 2	Understand	Respond	-	1.1, 1.2, 4.3.2
CO2	TPS 2	Understand	Respond	-	1.1, 1.2, 4.3.2
CO3	TPS 3	Apply	Value	-	1.2, 2.1.1, 2.4.3, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO6	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	-	-	-	-	-	-	-	-	-	M	M
CO2	M	M	L	-	-	-	-	-	-	-	-	-	M	M
CO3	M	M	L	-	-	-	-	-	-	-	-	-	M	M
CO4	S	S	M	-	S	-	-	-	-	-	-	-	S	S
CO5	S	S	M	-	S	-	-	-	-	-	-	-	S	S
CO6	S	S	M	-	S	-	-	-	-	-	-	-	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Model Examination (Practical)	Terminal Examination
	1	2	3		
Remember	20	20	20	-	20
Understand	60	40	40	-	40
Apply	20	40	40	100	40
Analyse	-	-	-	-	-
Evaluate	-	-	-	-	-
Create	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Practical Component
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. List the advantages of Virtual Instrument over Traditional Instrument.
2. Compare text-based programming with graphical programming
3. Explain data flow programming

**Course Outcome 2(CO2):**

1. Explain the difference between for loop and while loop
2. Illustrate the use of tunnel in a loop

**Course Outcome 3(CO3):**

1. Select a suitable LabVIEW architecture to implement an automatic soda vending machine. Explain the process involved.
2. Explain the use of producer/consumer architecture in LabVIEW with appropriate example

**Course Outcome 4 (CO4):**

1. Build a four-function calculator
2. Create a VI to find the factorial of the given number using For Loop and Shift Registers



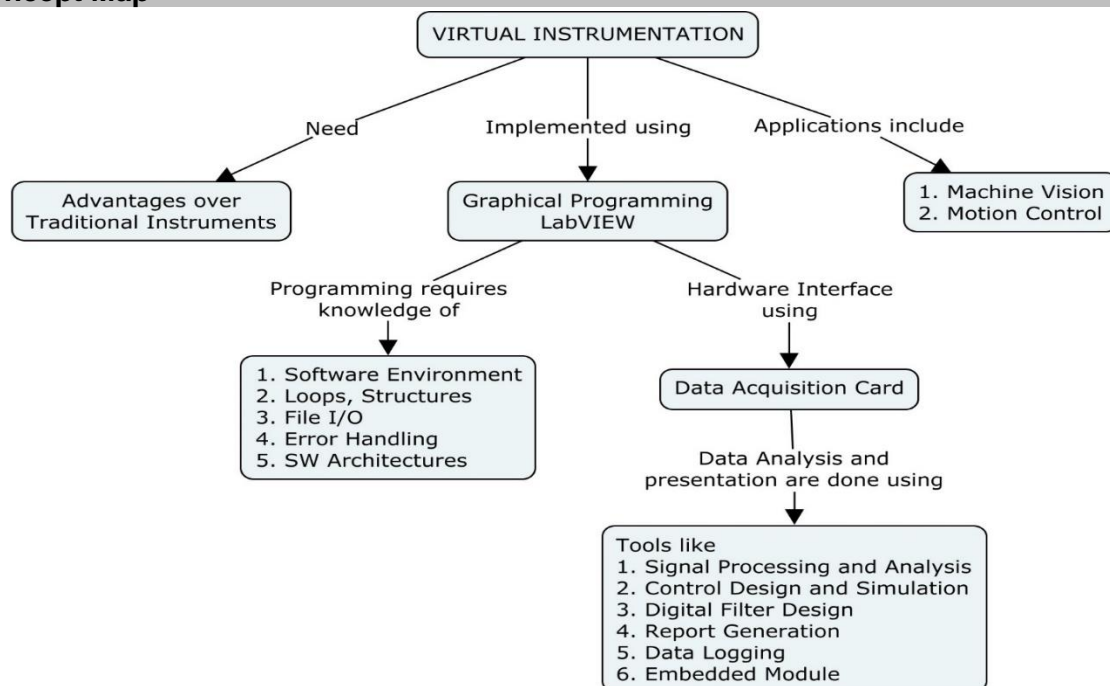
- Build a VI that generates 50 random numbers and plot it on a waveform chart using For and While Loops. Accumulate the random numbers into an array and display it on waveform graph.

**Course Outcome 5 (CO5):**

- Develop a Virtual Instrument to interface ultrasonic sonic sensor and interpret the values from the sensor.
- Develop a Virtual Instrument to interface a temperature sensor and convert the acquired values in to corresponding temperature in Fahrenheit.

**Course Outcome 6 (CO6):**

- Develop a Virtual Instrument to acquire data about the level of a water in a tank and display it continuously. Select appropriate sensor to achieve the same
- Develop a Virtual Instrument to acquire temperature for every one minute and store the data in Excel sheet.

**Concept Map****Syllabus**

**Virtual Instrumentation:** Introduction to Virtual Instrumentation: Virtual Instrument and traditional instrument - Hardware and software in Virtual Instrumentation - Virtual Instrumentation in the Engineering Process - Graphical Programming and Textual Programming

**Introduction to LabVIEW:** Software Environment - Creating and Saving A VI - Front Panel Toolbar - Block Diagram Toolbar - Palettes - Property Dialog Boxes - Front Panel Controls and Indicators - Block Diagram - Data Types - Data Flow Program, Modular Programming

**LabVIEW Programming:** Loops: FOR, WHILE Loops - Tunnels – Shift Registers – Feedback Nodes – Control Timing – Communicating among Multiple Loops - Local and Global Variables. Structures: Case, Sequential, Timed, Formula, Event. Arrays – Clusters. Plotting Data: Waveform Graphs, Charts - XY Graphs. Strings - File I/O – Error Handling. Architectures: Functional Global Variable - State Machine - Event-Driven User Interface - Producer / Consumer

**Data Acquisition:** Introduction – Transducers - Signals - Principles of Data Acquisition – Sampling – Modes of communication - DAQ Assistant

**Tools and Applications:** Tools: Signal Processing and Analysis - Control Design and Simulation - Digital Filter Design - Report Generation - Data Logging - Embedded Module - Math Interface Toolkit. Applications: Machine Vision and Motion Control

#### List of Experiments / Activities with CO Mapping

Sl. No.	Exercises / Experiments	No. of Hours	COs
1	Introduction to LabVIEW components	2	CO2
2	Programs using loops & structures	4	CO3
3	Programs involving graphs & charts	4	CO3
4	Programs using various architectures (Functional Global Variable - State Machine - Event-Driven User Interface - Producer / Consumer)	4	CO4
5	Programs using files & data logging	2	CO3
6	Interfacing and measurements from various sensors (Ultrasonic, IR, Gyro, Proximity, temperature, Accelerometer)	4	CO5
7	Interfacing and controlling using various devices (DC motor, Servo motor, LCD, Seven Segment display, Matrix Keyboard)	4	CO6
<b>TOTAL</b>		<b>24</b>	

#### Learning Resources

1. Jovitha Jerome, Virtual Instrumentation Using LabVIEW, PHI Learning, New Delhi, 2011
2. Sanjay Gupta, Joseph John, Virtual Instrumentation Using LabVIEW, Tata McGraw Hill Education Private Limited, 2010
3. Gary W. Johnson, Richard Jennings, LabVIEW Graphical Programming, Tata McGraw Hill Education Private Limited, 2017
4. Getting Started with LabVIEW: <http://www.ni.com/pdf/manuals/373427j.pdf>
5. LabVIEW Example Programs: <http://www.ni.com/examples/>

#### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Virtual Instrumentation</b>		
1.1	Introduction to Virtual Instrumentation: Virtual Instrument and traditional instrument - Hardware and software	1	CO1
1.2	Virtual Instrumentation in the Engineering Process - Graphical Programming and Textual Programming	1	CO1
<b>2</b>	<b>LabVIEW</b>		
2.1	Introduction to LabVIEW: Software Environment - Creating and Saving A VI - Front Panel - Block Diagram Toolbar	1	CO2, CO4
2.2	Palettes - Property Dialog Boxes - Front Panel Controls and Indicators - Block Diagram	1	CO2, CO4
2.3	Data Types - Data Flow Program - Modular Programming	1	CO2, CO4
<b>3</b>	<b>LabVIEW Programming</b>		
3.1	Loops: FOR, WHILE Loops - Tunnels – Shift Registers	1	CO2, CO4

Module No.	Topic	No. of Hours	Course Outcome
3.2	Feedback Nodes – Control Timing – Communicating among Multiple Loops - Local and Global Variables	1	CO2, CO4
3.3	Structures: Case, Sequential, Timed, Formula, Event	2	CO2, CO4
3.4	Arrays – Clusters	1	CO2, CO4
3.5	Plotting Data: Waveform Graphs, Charts - XY Graphs	1	CO2, CO4
3.6	Strings - File I/O - Error Handling	1	CO2, CO4
3.7	Architectures: Functional Global Variable	1	CO3, CO4
3.8	State Machine - Event-Driven User Interface	1	CO3, CO4
3.9	Producer / Consumer	1	CO3, CO4
<b>4</b>	<b>Data Acquisition</b>		
4.1	Introduction – Transducers - Signals - Principles of Data Acquisition – Sampling	2	CO5
4.2	Modes of communication - DAQ Assistant	2	CO5
<b>5</b>	<b>Tools and Applications</b>		
5.1	Tools: Signal Processing and Analysis - Digital Filter Design - Control Design and Simulation	1	CO6
5.2	Tools: Report Generation - Data Logging	1	CO6
5.3	Tools: Embedded Module - Math Interface Toolkit	1	CO6
5.4	Applications: Machine Vision & Motion Control	2	CO6
<b>Total</b>		<b>24</b>	

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**18MT670****CAD / CAM LABORATORY**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

Computer Aided Design (CAD) is the process of designing and developing computer assisted design tools in the design process. Computer Aided manufacturing (CAM) is concerned with use of computer to assist with manufacturing process through G codes and M codes.

**Prerequisite**

- 18ME160 - Engineering Graphics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop the basics of CAD drawing of 2D models.	20
CO2	Develop the basics of CAD drawing of 3D models.	20
CO3	Design part development drawing for given application.	10
CO4	Develop and simulate the CNC program for mechanical operations like taper, turning, threading and curvature.	20
CO5	Generate CNC code for milling and drilling operation.	20
CO6	Generate CNC program and interface with CNC machine/CNC simulator to draw the given pattern.	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3,2.3.1
CO2	TPS3	Apply	Value	Mechanism	2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3, 2.4.5,2.4.6
CO4	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3, 2.4.5,2.4.6,2.5.4
CO5	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3, 2.4.5,2.4.6,2.5.4
CO6	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3, 2.4.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	-	S	-	-	-	S	-	-	M	S	S
CO2	S	S	M	-	S	-	-	-	S	-	-	M	S	S
CO3	S	S	M	-	S	-	-	-	S	-	-	M	S	S
CO4	S	S	M	-	S	-	-	-	S	-	-	M	S	S
CO5	S	S	M	-	S	-	-	-	S	-	-	M	S	S
CO6	S	S	M	-	S	-	-	-	S	-	-	M	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Demonstration and simulation.
Complex Overt Responses	-
Adaptation	-
Origination	-

**List of Experiments / Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	2D-drawings using sketcher options - 2 Exercises	2	CO <sub>1</sub>
2	3D-modelling using form features - 2 Exercises	2	CO <sub>1</sub>
3	Develop 3D model of IC engine piston.	2	CO <sub>2</sub>
4	Develop 3D model of crankshaft.	2	CO <sub>2</sub>
5	Develop 3D model of Bearing Block Part Modelling.	2	CO <sub>2</sub>
6	Obtain the drafting of the part developed.	2	CO <sub>3</sub>
7	Write a manual CNC program for step and taper turning and simulate the operation.	2	CO <sub>4</sub>
8	Write a manual CNC program for curvature and threading and simulate the operation.	2	CO <sub>4</sub>
9	Complete the tool path simulation for drilling and pocket milling operations.	2	CO <sub>5</sub>
10	Generate CNC program for profile milling, drilling and pocket operations using CAD/CAM package.	2	CO <sub>5</sub>
11	Draw/Import the 2D diagram of the part using CAM package.	2	CO <sub>3</sub>
12	Create a given sheet metal model (both unfold and finished) using 2D CAD and CAM software	2	CO <sub>6</sub>
<b>TOTAL</b>		<b>24</b>	

**Software Required**

Pro/E, CATIA, Denford FANUC offline software for Turning, MasterCAM software, AutoCAD

**Course Designers:**

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**18MT680****ROBOTICS LABORATORY**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

The fundamental concepts in robotics are its design, and control. An engineer should be able to model and control the robots through software and hardware.

This course provides in-depth knowledge on programming of robots, simulating them in a particular environment and designing them to perform a particular task. This course is useful for those students interested in control engineering, robotics and systems engineering.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	To program and evaluate the point to point motion using an industrial robot	10
CO2	To program and evaluate the continuous point motion using an industrial robot	10
CO3	To simulate the function of a material handling robotic cell	20
CO4	To simulate the function of a welding robotic cell	20
CO5	To model, simulate and analyse the characteristics of a wheeled robot	20
CO6	To develop forward and inverse kinematic model of mobile robot	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO5	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	S	-	-	-	S	S	-	S	L	S
CO2	S	M	L	-	S	-	-	-	S	S	-	S	L	S
CO3	S	M	L	-	S	-	-	-	S	S	-	S	L	S
CO4	S	M	L	-	S	-	-	-	S	S	-	S	L	S
CO5	S	M	L	-	S	-	-	-	S	S	-	S	L	S
CO6	S	M	L	-	S	-	-	-	S	S	-	S	L	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Lab Experiments
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origation	-

**List of Experiments / Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	To simulate and analyse the forward and inverse kinematics of industrial robot using Robo Analyser	2	CO1
2	To program and evaluate the point to point motion (pick and place) of an industrial robot using MH5LS robot	2	CO1
3	To program and perform the continuous motion (Deburring operation) using GP12 robot	2	CO2
4	To program and evaluate the forward kinematics of a wheeled robot using QBOT2	2	CO6
5	To program and evaluate the inverse kinematics of a wheeled robot using QBOT2	2	CO6
6	To simulate the function of a material handling robotic cell in MOTOSIM	2	CO3
7	To simulate the function of a welding robotic cell using RoboDK software	2	CO4

8	To model, simulate and analyse the characteristics of a wheeled robot using 20 SIM software	2	CO5
9	To program and perform the inspection operation using MH5LS robot	2	CO2
10	To program and perform the Assembly operation using GP12 and MH5LF robot (Collaborative operation)	2	CO2
11	To program and evaluate the 2D mapping using QBOT2	2	CO6
12	To program and evaluate path planning using QBOT2	2	CO6
<b>TOTAL</b>		<b>24</b>	

### Learning Resources

1. Lab operation manual
2. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008
3. Roland Siegwart and Illah R Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2004.
4. Shuai Li, Long Jin, Mohammed Aquil Mirza, "Kinematic Control of Redundant Robot Arms Using Neural Networks", IEEE press, April 29, 2019.

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<b>18ES690</b>	<b>ENGINEERING DESIGN PROJECT</b>	Category	L	T	P	Credit
		Project	1	0	4	3

**Preamble**

An engineer must understand the economic, social, political, sustainability and environmental contexts in which the need arises. Engineering solutions are always created in response to some societal/industrial need. Understanding the societal/industrial need is central to success in engineering design. Therefore, the engineering students have been assigned on the problem identification phase of engineering design. Now, they have an opportunity to reflect and realise the knowledge that have been gained through the courses such as 18ES150 Engineering Exploration, 18ES290 Lateral Thinking, 18ES390 Design Thinking, 18XX490 Project Management and 18ES590 System Thinking. This course will enable the students to integrate CDIO Skill-based courses and their domain-specific courses. More specifically, by employing the broad knowledge they gain from experiences in foundation elective, general elective and audit courses, students are better equipped to provide engineering solution societal and/or industrial needs.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Execute different phases of engineering design project including functional composition and design specification in a team.	20
CO2	Evaluate the alternate engineering design approaches as per the performance criteria with design verification and validation.	20
CO3	Evaluate a design with the use of test verification matrix / Design Failure Mode Effect Analysis (DFMEA)/ Usability testing	15
CO4	Explain the significance of Intellectual Property rights and the procedure for searching and filing a patent.	15
CO5	Exhibit team work with appropriate conflict management strategies.	10
CO6	Prepare appropriate design documents and deliver effective technical presentations	10

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO2	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1
CO4	TPS2	Understand	Respond	Guided Response	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1

**Mapping with Programme Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	M	S	S	S	S
CO2	S	S	S	M	-	M	M	M	S	S	S	S
CO3	S	S	S	M	S	M	M	S	S	S	S	S
CO4	M	L	-	-	-	M	M	-	-	-	-	S
CO5	S	M	L	-	-	M	M	S	S	S	M	S
CO6	S	M	L	-	-	-	-	S	S	S	-	S

S- Strong; M-Medium; L-Low

**Assessment Pattern:**

Phases	Deliverables	Marks	Course Outcomes
<b>Continuous Assessment</b>			
Review 1 – Engineering Design Project Selection, functional decomposition and Specification	Technical Report	10	CO1, CO6
Review 2 – Evaluation of Design Approaches	Technical Report	20	CO2, CO5, CO6
Review 3 – Design Verification and validation	Technical Report	20	CO3, CO4, CO6
<b>End-Semester Examination</b>			
Demonstration	Prototype	60	CO1, CO2, CO3, CO4 CO5, CO6
Design Portfolio Presentation	Portfolio Document	40	
<ul style="list-style-type: none"> <li>• Reports are to be submitted at each review. The report and presentation will be evaluated based on customized Rubrics for periodic reviews.</li> <li>• Demonstration and Design Portfolio presentation will be evaluated by two faculty members nominated by their respective Head of the Department.</li> </ul>			

**Syllabus**

**Project Selection** – Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification, Proposal Report, Proposal Presentation

**Engineering Design Process** - The NASA Design Approach, Design Verification and Validation ,Design Verification Plan – DFMEA, test verification matrix, Usability testing, DRIDS-V Design Approach and Plan

**Intellectual Property Rights** – Trademarks, Copyrights and Patents, Types of patents, Searching patents, Filing Patents

**Team formation and Communication** – Types of teams, Team Conflict Management – common causes, cultural styles and conflict, Project Team Evaluation, Conducting Meetings and Making Presentations

**Learning Resources**

- Harvey F. Hoffman, “The Engineering Capstone Course: Fundamentals for Students and Engineers”, Springer, 2014
- [https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/EPICS\\_Design\\_Process.pdf?\\_ga=2.252800138.2089889711.1612784342-1089955741.1612784342](https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/EPICS_Design_Process.pdf?_ga=2.252800138.2089889711.1612784342-1089955741.1612784342)

**Course Contents and Lecture Schedule**

Module No	Topic	No. of Lectures	Course Outcome
1	<b>Project Selection</b>		
	Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification,	2	CO1, CO6

	Proposal Report, Proposal Presentation		
<b>2</b>	<b>Engineering Design Process</b>		
2.1	The NASA Design Approach	1	CO2
2.2	Design Verification and Validation	1	CO2
2.3	Design Verification Plan – DFMEA, test verification matrix, Usability testing,	2	CO3
2.4	DRIDS-V Design Approach and Plan	1	CO3
<b>3</b>	<b>Intellectual Property Rights</b>		
3.1	Trademarks, Copyrights and Patents,	1	CO4
3.2	Types of patents, Searching patents,.	1	CO4
3.3	Filing Patents	1	CO4
<b>4</b>	<b>Team formation and Communication</b>		
4.1	Types of teams, Team Conflict Management – common causes, cultural styles and conflict,	1	CO5
4.2	Project Team Evaluation, Conducting Meetings and Making Presentations	1	CO5, CO6
	<b>Total</b>	<b>12</b>	

**Course Designers:**

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SYLLABI

For

**B.E. Mechatronics Program**

VII Semester

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 59<sup>th</sup> Academic Council Meeting on 07.12.2019

**18MT710 MECHATRONICS SYSTEM DESIGN**

Category	L	T	P	Credit(s)
PC	3	0	0	3

**Preamble**

A Mechatronic system design is a design process that is characterized by synergistic integration of mechanisms, sensors, actuators and control to perform complex tasks in a metaphysical environment.

An important characteristic of mechatronic devices and systems is their built-in intelligence, which results through a combination of precision mechanical and electrical engineering and real-time programming integrated with the design process. Mechatronics system design makes possible to understand the basic design process involved in mechatronics, selection of sensors and actuators, the interface issues and communication problems. Design of a mechatronic systems is introduced in this subject to illustrate the concepts.

**Prerequisite**

- 18MT230 - Analog Electronics
- 18MT330 - Digital Electronics
- 18MT430 - Microcontroller
- 18ES390 - Design Thinking

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO <sub>1</sub>	Review the Mechatronic design process	10
CO <sub>2</sub>	Develop bond graph for the particular mechatronic system	10
CO <sub>3</sub>	Select the sensor and Actuator for a Mechatronic application	20
CO <sub>4</sub>	Interface the selected sensor, Actuator and Controller	20
CO <sub>5</sub>	Analyze and improve conventional designs by using the mechatronic design approach	20
CO <sub>6</sub>	Develop a Mechatronic product for the given problem	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS2	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2

CO5	TPS4	Analyze	Organise	-	1.1,1.2,1.3,2.1.1,2.1.2,2.1.3,2.1.4,2.1.5,2.3.1,2.3.2,2.3.3,2.3.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,4.3.1,4.3.2
CO6	TPS6	Create	Characterize	Mechanism	1.1,1.2,1.3,2.1.1,2.1.2,2.1.3,2.1.4,2.1.5,2.3.1,2.3.2,2.3.3,2.3.4,3.1.1,3.1.2,3.1.3,3.1.4,3.1.5,4.3.1,4.3.2,4.4.1,4.4.2,4.4.3,4.4.4,4.4.5,4.4.6,4.5.1,4.5.2,4.5.3,4.5.4,4.5.5,4.5.6,4.6.1,

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	-	L		-	-	-	-	-	M	M	M
CO2	S	S	S	-	S		-	-	-	-	-	M	M	M
CO3	S	S	S	-	L		-	-	-	-	-	M	M	M
CO4	S	S	S	-	S		-	-	-	-	-	M	M	M
CO5	S	S	S	-	S		-	-	S	S	S	S	M	M
CO6	S	S	S	-	S		-	-	S	S	S	S	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	-	-	-	-	20
Understand	20	40	-	100	-	-	40
Apply	60	40	-	-	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	100	-	-	-	-

#### \* Note:

- Assignment 2** should be Mechatronic system simulation in 20 SIM 4.6 professional.
- Continuous Assessment Test 3** is assessed by the prototype developed by the students. The prototype should be a mechatronic system submitted with a report.

The final report must include:

- An overall description of the system
- List of desired specifications
- System modelling and analysis in 20 SIM
- System block diagram with quantitative models
- Schematics of the mechanical and electronic subsystems
- Flowchart or pseudo code of the microcontroller software
- A comprehensive list of parts specifying the quantity, brand, model, description, and cost of each part
- Results and discussion

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Mini project, Prototype of a Mechatronic System
Complex Overt Responses	-
Adaptation	-
Origination	-

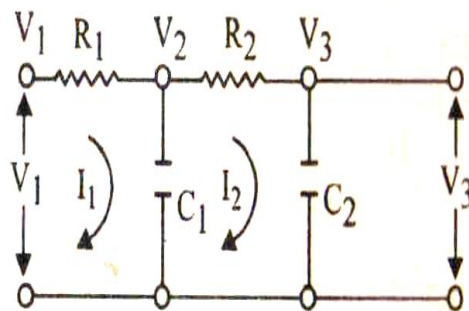
**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO<sub>1</sub>):**

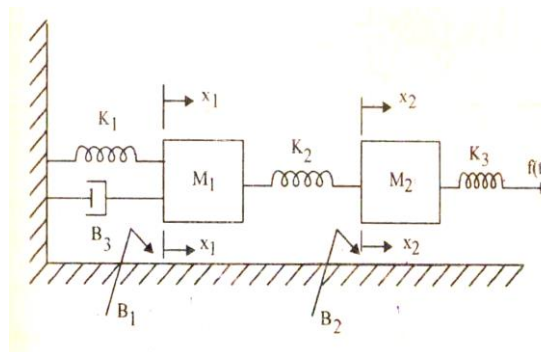
1. Describe modelling.
2. Explain various modelling methods of a Mechatronic system.
3. Describe the basic components of bond graphs

**Course Outcome 2(CO<sub>2</sub>):**

1. Develop a model for the physical system shown below using bond graph



2. Develop a model for the physical system shown below using bond graph



**Course Outcome 3(CO<sub>3</sub>):**

1. Choose a desired sensor and actuator to sense the nearby obstacles and plot a 3D graph. Obstacles from 0.5m to 5 m should be visible to the sensor and the graph plotted should be used to navigate from one point to another.

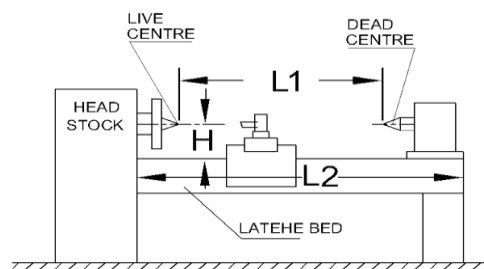
2. Select a sensor, actuator and controller to measure the smell of the food particles cooked inside a kitchen. According to the type of food the conveyor has to run to get the food to a particular direction.
3. Analyse the application of palletizing and select a suitable sensor and actuator to pack 20 bottles in a plastic box of size 3ft x 3ft.

**Course Outcome 4 (CO<sub>4</sub>):**

1. Interface the ultra-sonic sensor with Arduino micro controller and a DC motor. The DC motor has to rotate correspondingly to the signal from the ultra-sonic sensor. The program is written in 20 SIM software and it is verified.
2. What are the Interface issues while connecting an image grabber with a camera?
3. Draw the interfaced diagram of an industrial automation setup. The modified architecture of the system is drawn interface between the sensor, actuator and the micro controller.

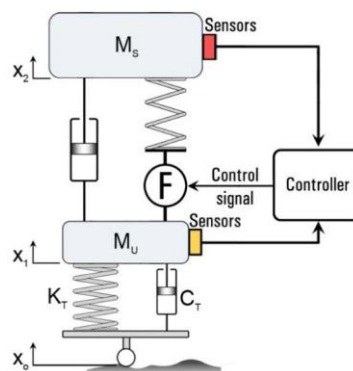
**Course Outcome 5 (CO<sub>5</sub>):**

1. Analyze and convert the conventional lathe machine as shown in the diagram to a numerically controlled machine. Choose appropriate sensors, actuators and controllers to design the machine. The length L<sub>1</sub>, L<sub>2</sub> and H are 2m, 1.5 m and 0.5 m respectively.



SPECIFICATION OF LATHE MACHINE

2. Analyze and convert a conventional suspension system to an active suspension system with the sensors and controllers included. Design the system as shown in the diagram.





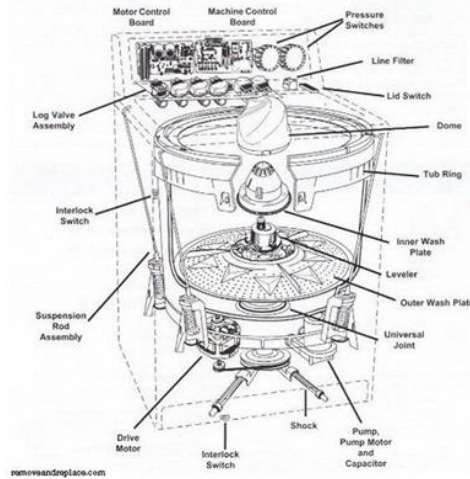
- Analyze and convert an automation system to industry 4.0 system with the required number of sensors, actuators and controllers. Design the system.

**Course Outcome 6 (CO<sub>6</sub>):**

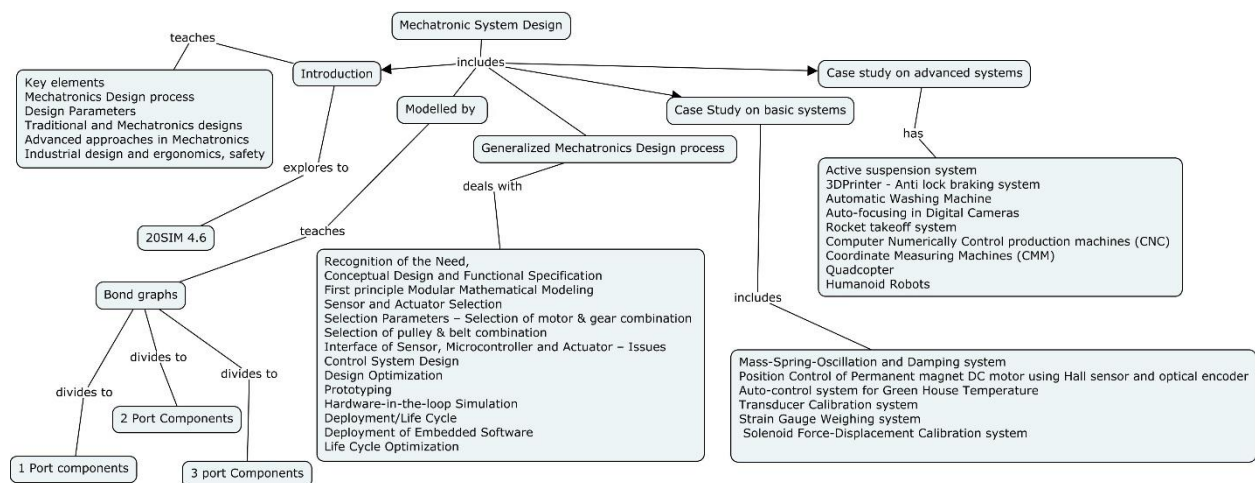
- Design a mobile robot which moves along a room and paints the wall at a height of 3m from the ground. Consider all the mechanical alternatives and draw all possible designs. Choose sensor, actuator, communication and interface method for all designs. The robot of mass 3 kg should reach the maximum velocity in 1 s, so an acceleration of  $0.15\text{m/s}^2$  is desired. The wheel radius is assumed to be 3 cm. Calculate the maximum torque and required power. According to the design considered, choose a differential (gear reduction mechanism) to raise the spray gun to a particular height. Design optimum motor driving circuitry, signal conditioning circuit and algorithm for smooth functioning of the robot.



- For a beam of length 0.285 m, width 0.0254 m, thickness 0.003 m, modulus 70.3 N/m<sup>2</sup>, density 2712 kg/m<sup>3</sup>, Obtain an optimum beam experimental setup. Assume that the beam is divided into 10 finite beams. To measure the vibration levels of the beam, consider a sensor – actuator is tightly bounded and placed below the beam. The moment generated is proportional to the voltage of the sensor. Model the sensor and PZT actuator. According to the voltage generated, develop the instrumentation setup (charge amplifier), signal conditioning circuit, Controller and software. Explain the algorithm of working.
- Model the automatic washing machine, analyze and interpret the simulation results if the maximum load is 6kg with the motor running torque at 20Nm.



**Concept Map**



**Syllabus**

**Introduction to Mechatronic System Design:**

Key elements – Mechatronics Design process –Design Parameters – Traditional and Mechatronics designs – Advanced approaches in Mechatronics - Industrial design and ergonomics, safety.

**Modelling of Mechatronic Systems by Bond Graphs:**

Introduction-model categories-fields of application, generalized variables in bond graph- Power variables – Energy variables, Basic components in Bond graph- 1 Port components- 1 Port Resistor- 1 Port Capacitor – 1 Port Inductor, 2 Port components- Transformer- Gyrator, 3 Port Components – 0 Junction, 1 Junction, Model development-Design examples.

**Generalized Mechatronics Design Process:**

Recognition of the Need, Conceptual Design and Functional Specification, First principle Modular Mathematical Modeling, Sensor and Actuator Selection – Selection Parameters – Selection of motor & gear combination, Selection of pulley & belt combination, Interface of Sensor, Microcontroller and Actuator – Issues. Communication protocols – Transmission Control **Protocol**/Internet **Protocol** (TCP/IP), ProfiBus, DeviceNet, FieldBus, Modbus.

Control System Design, Design Optimization, Prototyping, Hardware-in-the-loop Simulation, Deployment of Embedded Software, Deployment/Life Cycle, and Life Cycle Optimization.

**Case Study on basic systems**

Mass-Spring-Oscillation and Damping system – Position Control of Permanent magnet DC motor using Hall sensor and optical encoder – Auto-control system for Green House Temperature.

**Case study on advanced systems**

Active suspension system– 3DPrinter - Anti lock braking system – Automatic Washing Machine – Auto-focusing in Digital Cameras - Rocket takeoff system - Computer Numerically Control production machines (CNC) – Coordinate Measuring Machines (CMM) - Quadcopter – Humanoid Robots.

**Learning Resources**

1. Dobrivojje Popovich, "Mechatronics in Engineering Design and Product Development", CRC Press, First Edition, September 23, 2019.
2. Patrick O.J. Kaltjob "Mechatronic Systems and Process Automation: Model-Driven Approach and Practical Design Guidelines", CRC Press First Edition, March 22, 2018.
3. Shuvra Das., "Mechatronic Modeling and Simulation Using Bond Graphs", CRC Press, 2009.
4. W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd., Second edition, 2011.
5. Shetty and Kolk, "Mechatronics System Design", CENGAGE Learning, India, second edition, 2011.
6. Amalendu Mukherjee, Ranjit Karmakar, Arun kumar samantaray, "Bond Graph in Modeling, Simulation and Fault Identification" I.K International Pvt Ltd, Jan 2006.
7. Jacqueline Wilkie., Michael Johnson., Reza Katebi., "Control Engineering an Introductory course " Palgrave Publication, 2003.

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction to Mechatronic System Design</b>		
1.1	Key elements – Mechatronics Design process	1	CO <sub>1</sub>
1.2	Design Parameters, Traditional and Mechatronics designs	1	CO <sub>1</sub>
1.3	Advanced approaches in Mechatronics	1	CO <sub>1</sub>
1.4	Industrial design and ergonomics, safety	1	CO <sub>1</sub>
<b>2.0</b>	<b>Modelling of Mechatronic Systems by Bond Graphs</b>		
2.1	Introduction-model categories-fields of application	1	CO <sub>2</sub>
2.2	generalized variables in bond graph- Power variables – Energy variables	1	CO <sub>2</sub>
2.3	Basic components in Bond graph-1 Port components- 1 Port Resistor- 1 Port Capacitor – 1 Port Inductor	2	CO <sub>2</sub>
2.4	2 Port components- Transformer- Gyrator, 3 Port Components – 0 Junction, 1 Junction	2	CO <sub>2</sub>
2.5	Model development - Design examples	2	CO <sub>2</sub>
<b>3.0</b>	<b>Generalized Mechatronics Design Process</b>		
3.1	Recognition of the Need, Conceptual Design and Functional Specification	1	CO <sub>1</sub>
3.2	First principle Modular Mathematical Modeling	1	CO <sub>1</sub>
3.3	Sensor and Actuator Selection – Selection Parameters	2	CO <sub>3</sub>

34	Selection of motor & gear combination, Selection of pulley & belt combination	2	CO <sub>3</sub>
3.5	Interface of Sensor, Microcontroller and Actuator – Issues	2	CO <sub>4</sub>
3.6	Control System Design, Design Optimization	1	CO <sub>1</sub>
3.7	Prototyping, Hardware-in-the-loop Simulation	1	CO <sub>1</sub>
3.8	Deployment of Embedded Software, Deployment/Life Cycle,	1	CO <sub>1</sub>
3.9	Life Cycle Optimization	1	CO <sub>1</sub>
3.10	Communication Protocols	1	CO <sub>1</sub>
4.0	<b>Case Study on basic systems</b>		
4.1	Mass-Spring-Oscillation and Damping system, Position Control of Permanent magnet DC motor using Hall sensor and optical encoder	1	CO <sub>5</sub>
4.2	Auto-control system for Green House Temperature	1	CO <sub>5</sub>
5.0	<b>Case study on advanced systems</b>		
5.1	Active suspension system– 3DPrinter	1	CO <sub>6</sub>
5.2	Anti lock braking system – Automatic Washing Machine	2	CO <sub>6</sub>
5.3	Auto-focusing in Digital Cameras - Rocket takeoff system	2	CO <sub>6</sub>
5.4	Computer Numerically Control production machines (CNC) – Coordinate Measuring Machines (CMM)	2	CO <sub>6</sub>
5.5	Quadcopter – Humanoid Robots	2	CO <sub>6</sub>
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

Sl. No.	Name	E-mail Id
1	Prof H Ramesh	rameshh@tce.edu
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3	Prof S Manikandan	smmect@tce.edu

<b>18MT760</b>	<b>SYSTEM INTEGRATION LABORATORY</b>	Category	L	T	P	Credit(s)
		PC	0	0	2	1

### Preamble

System integration is the process of bringing together the component sub-systems into one system and ensuring that the subsystems function together as a system. System integration involves integrating existing, often disparate systems in such a way “that focuses on increasing value to the customer such as improved product quality and performance, while at the same time providing value to the company by reducing operational costs and improving response time. In the modern world connected by Internet, the role of system integration engineers is important as more and more systems are designed to connect, both within the system under construction and to systems that are already deployed.

Cross-disciplinary integration of mechanical engineering, electrical and electronic engineering as well as recent advances in information engineering are becoming more and more crucial for future collaborative design, manufacture, and maintenance of a wide range of engineering products and processes. This course gives insight in to the integration of sensors and actuators with controller through communication networks in order to realize the new product and total automated system.

### Prerequisite

- 18MT520 - Industrial Automation
- 18MT570 - Industrial Automation Laboratory

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify the sensors, actuators, controllers and communication protocols by their specifications.	5
CO2	Select a suitable sensor, actuator and controller for Mechatronics system integration	5
CO3	Develop a software program to integrate all Mechatronics components using suitable communication protocol.	25
CO4	Design a user interface to visualize and control the product and process.	20
CO5	Integrate sensor, actuator and controller with user interface through suitable drivers.	20
CO6	Integrate mechanisms with controller, sensor and actuator.	25

\*\*\* Weightage depends on number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Apply	Value	-	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5

CO2	TPS2	Apply	Value	-	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5
CO3	TPS3	Apply	Value	-	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5,4.5.3,4.4.5,
CO4	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5,4.5.4,4.5.5,4.5.6,4.61
CO5	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5,4.5.4,4.5.5,4.5.6,4.61
CO6	TPS3	Apply	Value	Mechanism	1.1.2,1.2,1.3,2.4.5,2.4.6,2.4.7,4.3.2,4.3.4,4.4.5,4.5.4,4.5.5,4.5.6,4.61

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	-	-	-	-	-	L	-	-	L	S	-
CO2	S	M	M	-	-	-	-	-	L	-	-	L	S	-
CO3	S	M	M	-	M	M	-	-	M	-	-	L	S	M
CO4	S	M	M	-	M	M	-	-	M	M	-	S	S	M
CO5	S	M	M	-	M	M	-	-	S	M	-	S	S	M
CO6	S	M	M	-	M	M	-	-	S	M	M	S	S	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Experimental exercises for integrating all system components.
Mechanism	Developing integrated system combining all components of Mechatronics.
Complex Overt Responses	-
Adaptation	-
Origination	-

### List of Experiments / Activities with CO Mapping

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	Develop a controller-based object sorting system by selecting and placing suitable sensor and actuator in a conveyor.	2	CO1,CO2,CO5
2	Develop a feed drive system using linear slide, servo drive and Encoder, and control the motion	2	CO2,CO3,CO5,CO6

	(Position, Velocity, and Acceleration) of feed drive using suitable controller.		
3	Design a Industrial level control system by fabricating suitable container, placing proper sensor and actuator, and controlling and Monitoring the same using PLC,HMI and SCADA.	2	CO1,CO2,CO4,CO6
4	Programming and Controlling Servo drive in Master –Slave mode using PLC for Industrial Robot Control.	2	CO3,CO5
5	Programming servo drive using virtual instrumentation and MATLAB	2	CO3,CO4
6	Design a User Interface for monitoring and controlling the plant parameters (Machine control, Process Parameters control, Energy control)	2	CO4,CO5
7	Design a cooling fan system in which the speed of the fan need to be controlled by VFD depending on the temperature of a system.	1	CO3,CO4,CO5,CO6
8	Controlling VFD through PLC and HMI	1	CO3,CO4
9	Motion control through sequential flow chart and Ladder Program.	2	CO3
10	Sequential operation of Hydraulic cylinders using the concept of IOT.	1	CO4,CO5
11	Integrating PLC with Machine vision system	1	CO3,CO4,CO5
12	Integrating Controller-Controller, Controller-Drive, Drive-Drive through Profinet communication.	2	CO3,CO4,CO5
13	Integrating Profibus and Sercos remote IO's with Controller.	2	CO3,CO4,CO5
14	Integrating Controller-Drive, Drive-Drive using Sercos communication.	2	CO3,CO4,CO5
15	System Integration Mini Project.	-	CO1-CO6
<b>TOTAL</b>		<b>24</b>	

### Learning Resources

1. Steve Mackay ,Edwin Wright MIPENZ, Deon Reynders, John Park “Practical Industrial Data Networks -Design, Installation, trouble shooting” ,IDC Technologies, Australia, 1st edition 2004.
2. “Rexroth IndraMotion MLC 13VRS functional description” published by Bosch Rexroth Edition 6,2015.
3. S7-1500 Getting Started manual, Siemens 05/2014, A5E03981761-AC
4. KARL-HEINZ JOHN, Programming Industrial automation systems, Springer,1995
5. Gary W.johnson, Richard Jennings, Labview Graphical Programming , McGraw Hill education, fourth edition 2017.

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SYLLABI

For

**B.E. Mechatronics Program**

Program Specific Electives

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015



**18MTPA0****MACHINE VISION SYSTEM**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Machine Vision (MV) is industry application-oriented subset of computer vision. It is the study of methods and techniques whereby artificial vision systems can be constructed and usefully employed in manufacturing applications. Machine vision integrates image capture systems with digital input/output devices and computer networks to provide real time quality control and for general control of manufacturing equipment such as automated assembly systems and robotic manipulator. Manufacturers accept machine vision systems due to its high-speed, high- magnification, 24-hour operation, and/or repeatability of measurements for visual inspection applications.

Machine Vision (MV) systems can be applied in almost any industry. Historically the first systems were deployed in the semi-conductor and automotive industries due to their highly intensive use of industrial automation within these industries. Modern vision systems can be applied across a hugely diverse range of industry sectors, these industries include: Automotive, Semi-conductor, Electronics, Medical Devices and Pharmaceutical, Printing and Packaging, Food Processing, Solar Production and Process Engineering.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Demonstrate the components of a machine vision system and their functions	05
CO2	Select the appropriate sensor and illumination techniques of machine vision system for the given application	30
CO3	Illustrate the various pre-processing technique used to design a machine vision system	15
CO4	Illustrate the various image processing technique used to design a machine vision system	25
CO5	Choose a suitable image processing technique for the specific requirement	15
CO6	Identify the suitable components of machine vision system for the given applications such as part identification, counting, measurement and gauging	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO2	TPS 3	Apply	Value	---	1.1, 1.2, 4.3.2
CO3	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO4	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO6	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	---	---	---	---	---	---	---	---	---	M	M
CO2	S	S	M	---	S	---	---	---	---	---	---	---	S	S
CO3	M	M	L	---	---	---	---	---	---	---	---	---	S	S
CO4	M	M	L	---	---	---	---	---	---	---	---	---	S	S
CO5	S	S	M	---	S	---	---	---	M	M	---	---	S	S
CO6	S	S	M	---	S	---	---	---	M	M	---	---	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	---	---	---	20
Understand	60	60	40	100	---	---	40
Apply	20	20	40	---	100		40
Analyse	---	---	---	---	---	---	---
Evaluate	---	---	---	---	---	---	---
Create	---	---	---	---	---	---	---

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	---
Set	---
Guided Response	Assignment - I
Mechanism	Assignment II, III – Simulation & Presentation
Complex Responses	Overt ---
Adaptation	---
Origination	---

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

1. With suitable block diagram, explain the components of a machine vision system.
2. How digital images are produced using CCD camera?
3. Explain the various illumination techniques used in a machine vision system

#### Course Outcome 2 (CO2):

1. Select a suitable optical system, image sensor and illumination technique to detect the presence of foreign bodies in the glass bottle used in a soft drink company. Justify your selection.
2. Select a suitable optical system, image sensor and illumination technique to find the manufacturing defect in a nut & bolt set. Justify your selection

#### Course Outcome 3 (CO3):

1. With suitable example, explain the use of binary morphology operations
2. Explain the various image arithmetic operations with suitable example

#### Course Outcome 4 (CO4):

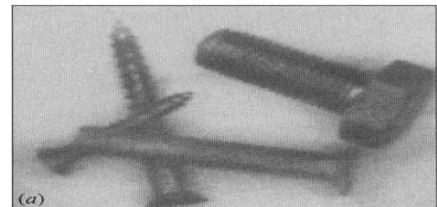
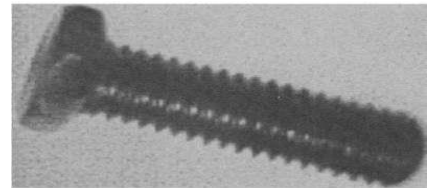
1. Illustrate how geometric features can be extracted from an image
2. Explain the steps involved in determining the shape of the object using contour tracing

#### Course Outcome 5 (CO5):

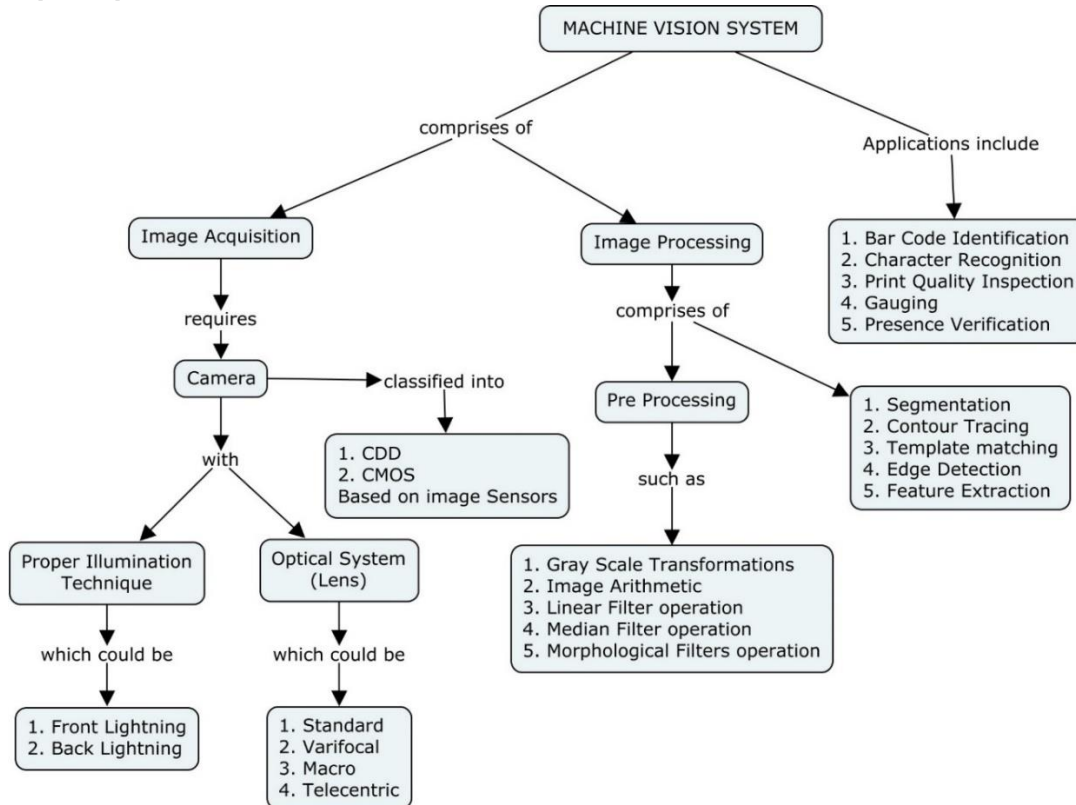
1. Select a suitable image processing technique to identify the missing component in a PCB board and explain the process involved
2. Select a suitable image processing technique to verify the hole shape and diameter of a punched panel

#### Course Outcome 6 (CO6):

1. Design a machine vision system to measure the dimensions of the threaded part moving in a slow speed conveyor as shown in figure
2. Suggest a suitable machine vision system to segregate the components shown in figure. Make judicious assumptions if required and justify them



## Concept Map



## Syllabus

**Introduction:** Introduction – Structure of Image Processing Systems - Possibilities and Limitations - Types of Inspection Tasks – Examples

**Image Acquisition:** Solid State Sensors: Operation of Charge Coupled Device (CCD) and Complementary Metal Oxide Semiconductor (CMOS) Sensors – Color Sensors – Properties of Sensors.

**Illumination Technology:** Optical foundations:  $f$  number – Laws of Imaging - Depth of field - Typical Capturing Situations - Aberrations - Lens Determination – Special Lens Types. Illumination: Light Sources - Front Lighting - Back Lighting

**Image Pre-processing:** Gray Scale Transformations - Image Arithmetic - Linear Filters - Median Filter - Morphological Filters

**Image Processing:** Segmentation: Regions of Interests (ROIs) - Binary Segmentation - Contour Tracing - Template matching – Edge Detection. Feature Extraction: Basic Geometric Features

**Applications:** Closed Loop Vision Systems - Bar Code Identification - Character Recognition – Print Quality Inspection – Gauging – Presence Verification – Surveillance

## Learning Resources

1. Christian Demant, Bernd Streicher-Abel, Carsten Garnica, **Industrial Image Processing**, Second Edition, Springer, 2013
2. R.C. Gonzalez, Richard E. Woods, **Digital Image Processing**, Fourth Edition, Prentice Hall India, 2018
3. Alexander Hornberg, **Handbook of Machine Vision**, Wiley VCH, 2006
4. [https://swayam.gov.in/nd1\\_noc19\\_ee55/preview](https://swayam.gov.in/nd1_noc19_ee55/preview)

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction</b>		
1.1	Introduction – Structure of Image Processing Systems - Possibilities and Limitations	1	CO1
1.2	Types of Inspection Tasks – Examples	1	CO1
<b>2</b>	<b>Image Acquisition</b>		
2.1	Solid State Sensors: Operation of Charge Coupled Device	2	CO2
2.2	Solid State Sensors: Operation of Complementary Metal Oxide Semiconductor (CMOS) Sensors	2	CO2
2.3	Color Sensors – Properties of Sensors	1	CO2
<b>3</b>	<b>Illumination Technology</b>		
3.1	Optical foundations: $f$ number	1	CO2
3.2	Laws of Imaging	2	CO2
3.3	Depth of field - Typical Capturing Situations	1	CO2
3.4	Aberrations - Lens Determination – Special Lens Types	2	CO2
3.5	Illumination: Light Sources - Front Lighting	2	CO2
3.6	Illumination: Light Sources - Back Lighting	1	CO2
<b>4</b>	<b>Image Pre-processing</b>		
4.1	Gray Scale Transformations	2	CO3, CO5
4.2	Image Arithmetic	1	CO3, CO5
4.3	Linear Filters - Median Filter	2	CO3, CO5
4.4	Morphological Filters	1	CO3, CO5
<b>5</b>	<b>Image Processing</b>		
5.1	Segmentation: Regions of Interests (ROIs), Segmentation	2	CO4, CO5
5.2	Contour Tracing	2	CO4, CO5
5.3	Template matching	2	CO4, CO5
5.4	Edge Detection	1	CO4, CO5
5.5	Feature Extraction: Basic Geometric Features	2	CO4, CO5
<b>6</b>	<b>Applications</b>		
6.1	Closed Loop Vision Systems - Bar Code Identification, Character Recognition	2	CO6
6.2	Print Quality Inspection, Gauging	2	CO6
6.3	Presence Verification, Surveillance	1	CO6
<b>Total</b>		<b>36</b>	

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<b>18MTPB0 MICRO ELECTRO MECHANICAL SYSTEMS</b>	Category	L	T	P	Credit(s)
	PE	3	0	0	3

**Preamble**

Micro Electro Mechanical System (MEMS) contains components of sizes less than 1 millimetre. MEMS achieve some engineering functions by electro mechanical or electro chemical means. In general a sensor, an actuator and a signal transduction unit forms the MEMS device. Automobile, Aerospace, Health care are some of the areas where MEMS found applications. Natural science, Mechanical, Electrical, Chemical, Materials and Industrial Engineering are the disciplines involved in design, Manufacture and Packaging of MEMS devices. This course provides a comprehensive treatment with synergetic integration of wide spectrum of discipline in science and engineering to cater the multidisciplinary nature of Mechatronics.

**Prerequisite**

- 18PHA20 - Physics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Solve problems in scaling laws applicable to miniaturization.	10
CO2	Identify the MEMS materials and their preparation	20
CO3	Identify suitable micro sensors and Micro actuators for MEMS application.	20
CO4	Select a suitable Micro-fabrication process for MEMS application.	15
CO5	Select a suitable Micro-manufacturing process for MEMS application.	15
CO6	Develop the flow process for fabrication of a silicon based micro pressure sensor, micro channel heat sink, micro accelerometer	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.1.2, 2.1.5
CO2	TPS2	Understand	Respond	Guided Response	1.1, 1.2, 2.3.1
CO3	TPS3	Apply	Value	Mechanism	1.2, 1.3, 2.1.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 1.3, 2.1.2, 2.2.3
CO5	TPS3	Apply	Value	Mechanism	1.2, 1.3, 2.1.2, 2.2.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 1.3, 2.1.2, 2.1.5, 2.2.3, 2.4.3, 3.1, 4.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	-	-	-	-	-	-	-	-	-	-	-
CO2	S	S	M	-	-	-	-	-	-	-	-	-	-	-
CO3	S	S	M	-	-	-	-	-	-	-	-	-	-	-
CO4	S	S	M	-	-	-	-	-	-	-	-	-	-	-
CO5	S	S	M	-	-	-	-	-	-	-	-	-	-	-
CO6	S	S	S	-	M	-	-	-	M	M	-	-	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment/ Model Presentation			Terminal Examination
	1	2	3	1	2	3*	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment 1 & 2
Mechanism	Ansys based model preparation
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Explain in detail, the Trimmer matrix to represent force scaling with related acceleration, time and power density required for scaling of systems in motion.
2. Estimate the associated changes in the acceleration, time and power supply to actuate a MEMS component if its weight is reduced by a factor 20.
3. Record two types of scaling laws used in micro-systems.
4. Write the scaling formula for a simple rectangular block.

**Course Outcome 2 (CO2)**

1. Define shape memory alloys.
2. Explain in detail the application of MEMS materials in automobile industry.
3. Write detail notes on polymer materials used MEMS and Microsystems.

**Course Outcome 3 (CO3)**

1. Distinguish microelectronics from MEMS.
2. With neat diagram explain the functioning of micro pressure sensor.
3. State the reason for which materials like silicon, Gallium Arsenide, germanium, quartz are preferred for sensors and actuators.

**Course Outcome 4 (CO4)**

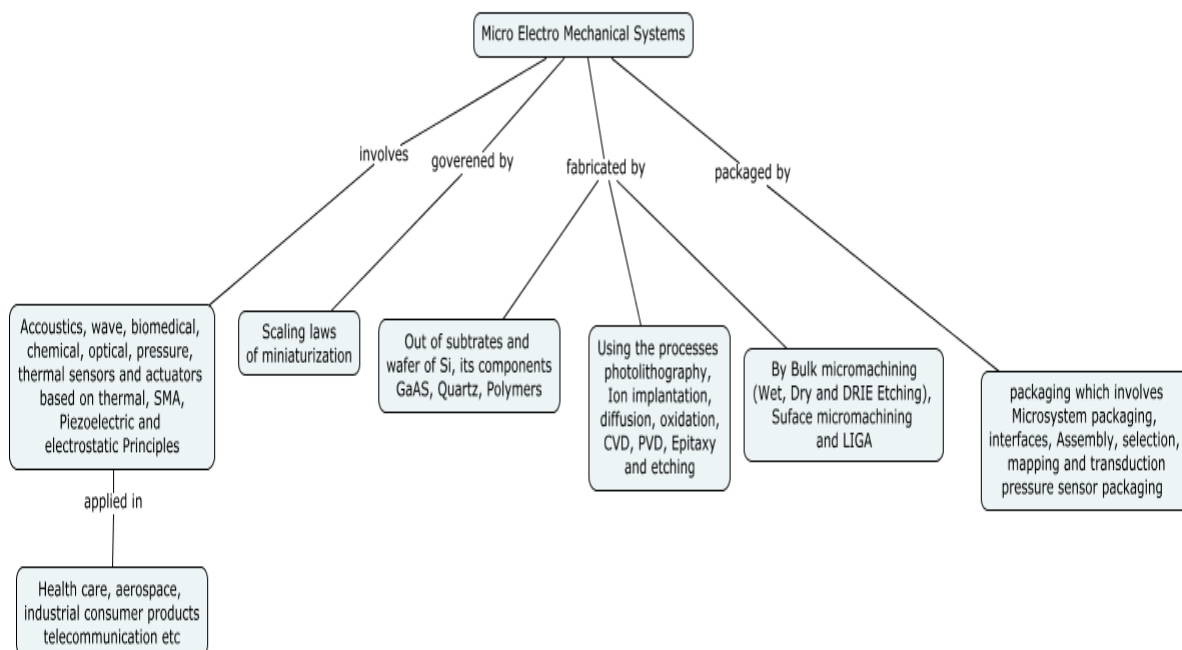
1. Distinguish between wet and dry etching.
2. Outline the general principle of diffusion process.
3. Name three mask materials used in etching.
4. Chose and explain a suitable micro fabrication process to fabricate

**Course Outcome 5 (CO5)**

1. State the purpose of packaging
2. Distinguish Microsystems from microelectronics packaging
3. Explain various levels of Microsystems packaging

**Course Outcome 6 (CO6):**

1. Elaborate various packaging technologies
2. Design a micro channel heat sink using the process of fabrication.

**Concept Map****Syllabus**

**Intorduction:** MEMS and Microsystems, products, Evolution of micro-fabrication, Micro system and Microelectronics, The multidisciplinary nature of MEMS, Miniaturization, applications of micro systems in automotive, health care, aerospace, and telecommunication fields.

**Scaling law inminiaturization:** Introduction to scaling, scaling in rigid body dynamics, electrostatic forces, electromagnetic forces, electricity, fluid mechanics and heat transfer.

**MEMS Materials and their preparation:** Metals, Semiconductors, Ceramics, Polymeric and Composite materials.

**Micro Sensors:**Acoustic wave sensors, Bio-medical sensors and Bio sensors, Chemical sensors, Pressure sensors, thermal sensors.



**Micro Actuators:** Actuation using Thermal forces, Shape memory alloys, Piezo-electric Crystals, Electrostatic Forces.

**MEMS with Micro-actuators:** Micro grippers, Micro motors, Micro valves, Micro Pumps, Micro accelerometers, Micro fluidics.

**Micro-system fabrication process:** Introduction, Photolithography, ion implantation, diffusion, oxidation, chemical vapour deposition, physical vapour deposition (sputtering), Deposition by epitaxy, wet and plasma etching.

**Overview of Micro-manufacturing:** Introduction, **Bulk micromachining:** Isotropic and Anisotropic Etching, Wet etchants, Etch Stop, Dry Etching, DRIE, Comparison of Wet versus Dry Etching, surface micromachining, the LIGA process.

**Design of micro pressure sensor:** Application of micro pressure sensor, process flow for silicon and packaging of micro pressure sensors.

**Design of micro-channel heat sink:** Application of micro-channel heat sink, silicon wafer preparation, SiO<sub>2</sub> Deposition over silicon wafer, photo-resist coating, Channel patterning, SiO<sub>2</sub> etching, Deep Reactive Ion Etching of silicon, photo resist removal, anodic bonding of glass and silicon micro-channel.

**Design of micro accelerometer:** Application of micro accelerometer, flow process and packaging of micro accelerometers.

Model preparation using Ansys Software.

### Learning Resources

1. Julian W.Gardner, Vijay.K.Varadhan, Osama.O.Awadelkarim, "Microsensors, MEMS and Smart Devices", John Wiley & Sons, LTD,2013.
2. Tai –Ran Hsu, "MEMS and Microsystem: Design and Manufacture ", Tata McGraw Hill, First Edition, 2002.
3. G.K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K.N. Bhat and V.K. Athrae, "Micro and Smart System", Wiley India Pvt Ltd, First edition, 2010.
4. Chang Liu , "Foundation of MEMS" 2<sup>nd</sup> Edition, Pearson education, 2012.
5. Marc J Madou: "Fundamentals of microfabrication and nanotechnology", Three volume set 3<sup>rd</sup> revised Edition, Taylor and Francis, 2011
6. Gad El Hak (Editor), "The MEMS Hand Book", Three volume set, 2<sup>nd</sup> revised Edition. CRC press, 2005.
7. <https://nptel.ac.in/courses/117/105/117105082/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	<b>Introduction:</b> MEMS and Microsystems, products,	1	CO1
1.1	Evolution of micro-fabrication	1	CO1

1.2	Micro system and Microelectronics	1	CO1
1.3	The multidisciplinary nature of MEMS	1	CO1
1.4	Miniaturization	1	CO1
1.5	Applications of micro systems in automotive, health care, aerospace, and telecommunication fields.	1	CO1
1.6	<b>Scaling law in miniaturization:</b> Introduction to scaling, scaling in rigid body dynamics	2	CO1
1.6.1	Electrostatic forces, electromagnetic forces, electricity, fluid mechanics and heat transfer.	1	CO1
2.2	<b>MEMS Materials and their preparation:</b> Metals, Semiconductors, Ceramics	2	CO2
2.2.1	Polymeric and Composite materials	1	CO2
3.0	<b>Micro Sensors:</b> Acoustic wave sensors, Bio-medical sensors and Bio sensors	2	CO3
3.1	Chemical sensors, Pressure sensors, thermal sensors	1	CO3
3.2	<b>Micro Actuators:</b> Actuation using Thermal forces, Shape memory alloys	2	CO3
3.2.1	Piezo-electric Crystals, Electrostatic Forces	2	CO3
3.3	<b>MEMS with Micro-actuators:</b> Micro grippers, Micro motors, Micro valves	2	CO3
3.3.1	Micro Pumps, Micro accelerometers, Micro fluidics	1	CO3
4.0	<b>Micro-system fabrication process:</b> Introduction, Photolithography, ion implantation	1	CO4
4.1	diffusion, oxidation, chemical vapour deposition	1	CO4
4.1.1	physical vapour deposition (sputtering)	1	CO4
4.1.2	Deposition by epitaxy, wet and plasma etching	1	CO4
5.0	<b>Overview of Micro-manufacturing:</b> Introduction	1	CO5
5.1	<b>Bulk micromachining:</b> Isotropic and Anisotropic Etching		
5.1.1	Wet etchants, Etch Stop, Dry Etching, DRIE	1	CO5
5.2	Comparison of Wet versus Dry Etching, surface micromachining, the LIGA process.	1	CO5
6.0	<b>Design of micro pressure sensor:</b> Application of micro pressure sensor, process flow for silicon and packaging of micro pressure sensors	2	CO6
6.1	<b>Design of micro-channel heat sink:</b> Application of micro-channel heat sink, silicon wafer preparation, SiO <sub>2</sub> Deposition over silicon wafer, photo-resist coating, Channel patterning, SiO <sub>2</sub> etching, Deep Reactive Ion Etching of silicon, photo resist removal, anodic bonding of glass and silicon micro-channel.	2	CO6
6.2	<b>Design of micro accelerometer:</b> Application of micro accelerometer, flow process and packaging of micro accelerometers.	2	CO6
	<b>Model Preparation using Ansys software</b>	1	CO6
<b>TOTAL</b>		<b>36</b>	

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**18MTPC0****ADDITIVE MANUFACTURING**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Additive Manufacturing is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology. Additive manufacturing improves product development by enabling better communication in a concurrent engineering environment and also reduces product development cycle time. This course aims to provide knowledge on the additive manufacturing and its application, advantages, limitations.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Illustrate the concepts of prototypes and AM process chain	20
CO2	Select the suitable Liquid based AM process for a given product/part drawing/Application	20
CO3	Select the suitable solid based AM/Powder based AM process for a given product/part drawing/Application	20
CO4	Choose the suitable AM process for rapid tooling application	20
CO5	Explain the need and steps involved in reverse engineering	10
CO6	Create 3D model using Additive manufacturing Method (Continuous Assessment only)	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1.2,1.2,2.3.1,3.2.5,4.3.2
CO2	TPS3	Apply	Value	Mechanism	1.1.2,1.2,2.2.2,2.2.3,3.2.5,4.3.2
CO3	TPS3	Apply	Value	Mechanism	1.1.2,1.2, 2.2.2,2.2.3,3.2.5,4.3.2
CO4	TPS3	Apply	Value	Mechanism	1.1.2,1.2, 2.2.2,2.2.3,3.2.5,4.3.2
CO5	TPS2	Understand	Respond	Guided Response	1.1.2,1.2,3.2.5,4.3.2
CO6	TPS3	Apply	Value	Mechanism	1.1.2,1.2,2.1.2,2.1.3,2.2.2,2.2.3, 2.4.6,2.4.7,3.1,3.2.5,4.1.2,4.2.3, 4.3.2,4.4,4.5.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	M	-	S	-	-	-	-	-	-	-	-	-
CO3	S	M	M	-	S	-	-	-	-	-	-	-	-	-
CO4	S	M	M	-	S	-	-	-	-	-	-	-	-	-
CO5	S	-	-	-	S	-	-	-	-	-	-	-	-	-
CO6	S	S	S	-	S	-	M	-	S	-	-	M	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment/ Model Part Fabrication	Terminal Examination
	1	2	3*#		
Remember	20	20	-	100	20
Understand	50	50	-		50
Apply	30	30	-		30
Analyse	-	-	-		-
Evaluate	-	-	-		-
Create	-	-	-		-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment
Perception	-
Set	-
Guided Response	Assignment I & II
Mechanism	Model part fabrication
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Define Prototyping
2. Explain the process chain of additive manufacturing process
3. Explain the classification of additive manufacturing process

**Course Outcome 2 (CO2):**

1. Define polymerization Process
2. Explain the process parameters of Solid Ground Curing (SGC).
3. Explain the principle of Stereo lithography (SLA) processes.
4. A prototype of a tube with a square cross-section is to be fabricated using stereo lithography. The outside dimension of the square = 100 mm and the inside dimension = 90 mm (wall thickness = 5 mm except at corners). The height of the tube is (z-direction) = 80 mm. Layer thickness = 0.10 mm. The diameter diameter of the laser beam ("spot size") = 0.25 mm, and the beam is moved across the surface of the photopolymer at a velocity of 500 mm/s. Compute an estimate for the time required to build the part, if 10 s

are lost each layer to lower the height of the platform that holds the part. Neglect the time for postcuring.

**Course Outcome 3 (CO3):**

1. Discuss the solid ground process steps in details with suitable diagrams.
2. Select the suitable AM process for the development of Pattern for jewellery application
3. Discuss the working principle of Fusion Deposition Modelling (FDM).
4. Select the suitable AM process for the development of Fixture for measurement purpose

**Course Outcome 4 (CO4):**

1. Discuss the process parameters to be considered in selective laser sintering
2. Explain the process parameters considered for laminated object manufacturing.

**Course Outcome 5 (CO5):**

1. Differentiate direct and indirect tooling process.
2. Differentiate soft tooling and hard tooling.
3. Select the suitable AM process for fabrication of injection moulding tool.

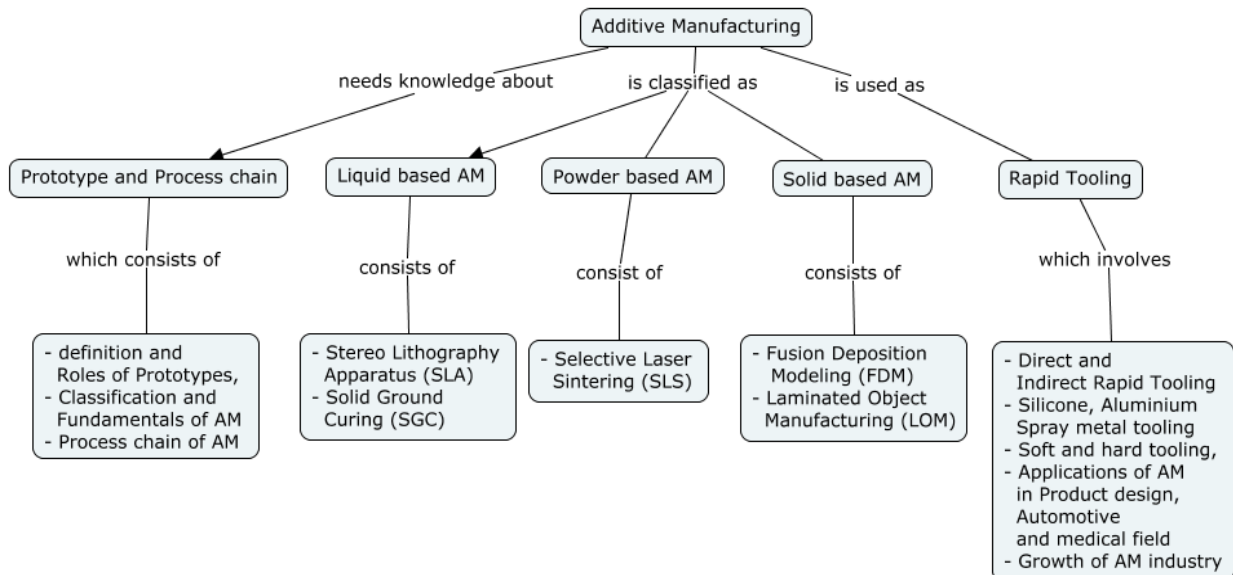
**Course Outcome 6: (CO6 - Continuous Assessment only)**

Fabrication of FDM product: Each Student will be given a week of time with 35cc material to fabricate the given component drawing.

**Evaluation pattern for CO6:**

S. No	Description	Marks
1	CAD Model Generation using solid modelling package	30
2	Process chain explanation and report preparation	50
3	Creation of 3D Product using additive manufacturing method	20
<b>Total Marks</b>		<b>100</b>

**Concept Map**



**Syllabus**

**Introduction:** Definition of Prototypes, Roles of Prototypes, Need for time compression in product development, History of AM Process, classification of AM Process - Fundamentals of AM Process – Process chain of AM Process – Data format – STL files. Benefits of AM.

**Liquid Based AM:** Stereo Lithography Apparatus (SLA) – Principle – Photo polymerization – Post processes – process parameters – Machine details – Advantages – Problems in

computing time to build parts, Solid Ground Curing (SGC) – Principle – processes parameters – Process details - Machine details – Limitations.

**Solid Based AM:** Fusion Deposition Modeling (FDM) – Principle – Raw materials – BASS – Water soluble support system – Process parameters – Machine details – Advantages and limitations, Laminated Object Manufacturing – Principle – Processes parameters – Process details – Advantages and limitations, Metal Additive Manufacturing processes – Direct Energy Deposition (DED).

**Powder based AM:** Selective Laser Sintering (SLS) – Principle – process parameters – Process details –Machine details. Electron beam Melting (EBM) - Principle – process parameters – Process details –Machine details.

**Rapid Tooling and Applications of AM:** Classification of Rapid Tooling - Indirect rapid tooling - Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Direct rapid tooling - Direct ACES Injection Moulding. Soft tooling vs hard tooling, Applications of AM in product design, automotive industry, medical field – Case studies, Role of AM Process parameter on Part Quality, Growth of AM industry

**Reverse Engineering:** Introduction - Definition - Generic Process - Scanning – Point Processing – Geometric model development - Applications of reverse engineering.

**Demonstration of 3D model generation using additive manufacturing method.**

### Learning Resources

1. Chua, C.K. Leong, K.F. and Lim, C.S. “**Rapid Prototyping: Principles and Applications**”, World Scientific, New Jersey, 2010
2. Pham, D.T. and Dimov, S.S., “**Rapid manufacturing**”, Springer-Verlag, Londo, 2011.
3. Jacobs, P.F., “**Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography**”, McGraw-Hill, New York, 2011.
4. Hilton. P.D., “**Rapid Tooling**”, Marcel Dekker, New York, 2000.
5. **Rapid Prototyping Journal**, Emerald Group Publishing Limited.
6. [www.utah.edu/~asn8200/rapid.html](http://www.utah.edu/~asn8200/rapid.html)
7. <http://www.cheshirehenbury.com/rapid/index.html>
8. <https://nptel.ac.in/courses/112104162/>
9. <https://nptel.ac.in/courses/112/104/112104265/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction:</b>		
1.1	Definition of Prototypes, Roles of Prototypes	1	CO1
1.2	History of AM Process, classification of AM Process, benefits of AM.	1	CO1
1.3	Need for time compression in product development	1	CO1
1.4	Fundamentals of AM Process – Process chain of AM Process – Data format – STL files	2	CO1
<b>2</b>	<b>Liquid Based AM:</b>		
2.1	Stereo Lithography Apparatus(SLA) – Principle	1	CO2
2.2	Photo polymerization – Post processes - process parameters	2	CO2
2.3	Machine details – Advantages, Problems in computing time to build parts	1	CO2
2.4	Solid Ground Curing (SGC) – Principle	2	CO2
2.5	Processes parameters	1	CO2

2.6	Process details - Machine details – Limitations	1	CO2
<b>3</b>	<b>Solid Based AM:</b>		
3.1	Fusion Deposition Modelling (FDM) – Principle – Raw materials – BASS	2	CO3
3.2	Water soluble support system – Process parameters	2	CO3
3.3	Machine details – Advantages and limitations	1	CO3
3.4	Laminated Object Manufacturing – Principle – Processes parameters - Process details – Advantages and limitations	2	CO3
3.5	Metal Additive Manufacturing processes.	1	CO3
3.6	Direct Energy Deposition (DED)	1	CO3
<b>4</b>	<b>Powder based AM:</b>		
4.1	Selective Laser Sintering (SLS) – Principle – process parameters - Process details –Machine details	2	CO3
4.2	Electron beam Melting (EBM) - Principle – process parameters – Process details - Machine details	2	CO3
<b>5</b>	<b>Rapid Tooling and Applications of AM:</b>		
5.1	Classification of Rapid Tooling - Indirect Rapid Tooling – Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling	1	CO4
5.2	Direct Rapid Tooling – Direct ACES Injection Moulding - soft tooling Vs hard tooling	1	CO4
5.3	Applications of AM in product design, automotive industry, medical field	1	CO4
5.4	Case studies	1	CO4
5.5	Role of AM Process parameter on Part Quality	1	CO4
5.6	Growth of AM industry	1	CO4
<b>6</b>	<b>Reverse engineering:</b>		
6.1	Introduction – Definition	1	CO5
6.2	Generic Process – Scanning – Point Processing – Geometric model development	1	CO5
6.3	Applications of reverse engineering.	1	CO5
<b>7</b>	<b>Demonstration of 3D model generation using additive manufacturing method</b>	1	CO6
	<b>Total</b>	<b>36</b>	

**Course Designers:**

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**18MTPD0****EMBEDDED SYSTEM**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Embedded systems are an omnipresent part of our daily lives. It is there in homes, offices, cars, factories, hospitals and consumer electronics. Normally, embedded systems are built around microcontrollers and SOCs based on ARM processors. This course aims at introducing embedded system design principles. Also the ARM architecture and programming is covered in this course. This course also focuses on real time concepts helping the student engineers to build real time embedded systems.

**Prerequisite**

- 18MT430 - Microcontroller

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Suggest the design approach for embedded system	15
CO2	Develop assembly code using ARM and Thumb instructions	25
CO3	Illustrate the concepts of memory management	10
CO4	Develop embedded C program using ARM controller	15
CO5	Demonstrate the task scheduling algorithm	25
CO6	Design real time systems using embedded system principles	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.3.1,2.3.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.3.1,2.3.2
CO3	TPS2	Understand	Respond	-	1.2, 2.3.1,2.3.2
CO4	TPS3	Apply	Value	Mechanism	1.2,2.1.2, 4.3.2
CO5	TPS3	Apply	Value	-	1.2, 2.1.2
CO6	TPS3	Apply	Value	-	1.2,2.1.2,2.3.1,2.3.2,2.3.3,2.3.4, 2.4.3,3.2.5,4.3.1,4.3.2,4.3.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	-	S	-	-	-	-	-	-	-	-	M	M	L
CO2	S	S	M	-	S	-	-	-	-	-	-	M	M	M
CO3	S	-	-	-	-	-	-	-	-	-	-	-	L	L
CO4	S	S	S	-	S	M	-	-	S	S	-	-	S	S
CO5	S	-	-	-	-	-	-	-	-	-	-	-	M	M
CO6	S	M	S	-	S	-	-	-	-	-	-	M	S	S

S – Strong

M – Medium

L – Low



**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	80	50	50	100	-	-	50
Apply	-	30	30		100	100	30
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Quiz
Mechanism	Simulation of embedded C programs using software tools
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define Embedded System.
2. Distinguish between RISC and CISC.
3. List the challenges in embedded system design.

**Course Outcome 2(CO2):**

1. Write an ARM instruction that does an operation on r1,r2 and obtain the result in r0. Given the PRE and POST conditions.

PRE	POST
r1 = 0b1111 r2 = 0b0101	r0 = 0b1010

2. Illustrate the various Barrel shifter operations in ARM with suitable examples.
3. Assume the values in registers r0 & r1 be : r0 = 0x00000000, r1 = 0x00009000. Let the data in the memory be: mem32[0x00009000] = 0x01010101, mem32[0x00009004] = 0x02020202

Find the data in r0 and r1 registers on execution of the following instructions separately.

```
LDR r0, [r1, #4]!
LDR r0, [r1, #4]
LDR r0, [r1], #4
```

**Course Outcome 3(CO3):**

1. Discuss about direct mapping and fully associative mapping techniques in a cache based system.
2. Give the differences between MPU and MMU.
3. Explain how ARM memory management unit supports the virtual memory.

**Course Outcome 4 (CO4):**

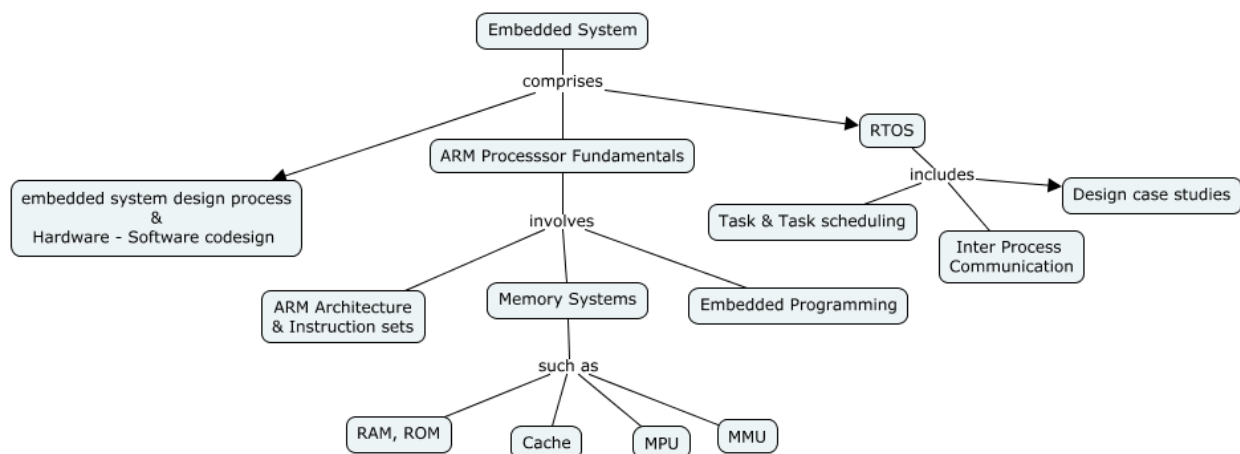
1. Develop an embedded C program for interfacing a stepper motor with an ARM controller.
2. Demonstrate how a sensor can be interfaced with an ARM controller and also write the C program for it.
3. Construct an embedded C program for displaying the string "EMBEDDED SYSTEM" in an LCD display with an ARM controller.

**Course Outcome 5 (CO5):**

1. Write about the various task states.
2. Illustrate the Rate Monotonic scheduling algorithm.
3. Distinguish between hard and soft real time system.

**Course Outcome 6 (CO6):**

1. Illustrate the concept of priority inversion.
2. List the features of Vx Works.
3. Demonstrate how an Automobile ABS system is developed using real time embedded system principles.

**Concept Map****Syllabus**

**Introduction to Embedded Systems:** Definition and Overview of embedded systems, embedded system design process, challenges - common design metrics and optimization, Hardware - Software co-design for embedded product development - reconfigurable FPGA-based systems design - Cyber physical systems

**Processor Fundamentals:** Architecture of ARM controllers-STM32407xx, TM4C123,LPC214x - ARM core dataflow model, Register sets, Pipeline, ARM instruction set, Thumb instruction set, Interrupt and Exception handling

**Memory Systems:** Memory hierarchy, Cache Architecture, Cache policies, Memory Protection Unit, Memory Management Unit

**Embedded Programming:** Features of an ARM Family, Peripherals, Timer Unit, Pulse Width Modulation Unit, UART, Programming Examples – Sensor, DC Motor, Stepper Motor, Keyboard, LCD Interfacing

**Real Time Operating Systems:** Real Time Systems Real time operating systems Architecture, Tasks and Task states, Scheduling Algorithms - First-Come First-Served - Shortest Job First - Round Robin - Rate-Monotonic - Earliest Deadline First - Least Laxity - Maximum Urgency First, Semaphore and shared data, Message queues, mail boxes and pipes, priority inversion, priority inheritance

**Case Study:** Automobile Antilock Braking System, Cruise Control System

### Learning Resources

1. Rajkamal, 'Embedded System – Architecture, Programming, Design', Tata Mc Graw Hill, 2017
2. Andrew N. Sloss Dominic Symes Chris Wright, "ARM System Developer's Guide Designing and Optimizing System Software", Elsevier Inc 2010
3. Peckol, "Embedded system Design", JohnWiley&Sons,2010
4. Jiacun Wang, "Real-Time Embedded Systems" John Wiley & Sons, 2017
5. David Simon, "An Embedded Software Primer", Addison Wesley, 2000
6. Steve Heath, 'Embedded System Design', II edition, Elsevier, 2003.
7. <https://nptel.ac.in/courses/117106111/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction to Embedded Systems</b>		
1.1	Definition and Overview of embedded systems,	1	CO1
1.2	embedded system design process, challenges	1	CO1
1.3	common design metrics and optimization,	1	CO1
1.4	Hardware - Software codesign for embedded product development.	1	CO1
1.5	reconfigurable FPGA based systems design, Cyber physical systems	2	CO1
<b>2</b>	<b>Processor Fundamentals:</b>		
2.1	Architecture of ARM controller	1	CO2
2.2	ARM core dataflow model	1	CO2
2.3	Register sets, Pipeline, ARM Processor Families	1	CO2
2.4	ARM instruction set	2	CO2
2.5	Thumb instruction set	2	CO2
2.6	Interrupt and Exception handling	2	CO2
<b>3</b>	<b>Memory Systems</b>		
3.1	Memory hierarchy	1	CO3
3.2	Cache Architecture, Cache policies	1	CO3
3.3	Memory Protection Unit	1	CO3
3.4	Memory Management Unit.	1	CO3
<b>4</b>	<b>Embedded Programming:</b>		
4.1	Features of an ARM Family	1	CO4
4.2	Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART	3	CO4
4.3	Programming Examples– Sensor , DC Motor, Stepper Motor, Keyboard, LCD Interfacing	2	CO4

<b>5</b>	<b>Real Time Operating Systems</b>		
5.1	Real Time Systems Real time operating systems Architecture	2	CO5
5.2	Tasks and Task states	2	CO5
5.3	Scheduling Algorithms- First-Come First-Served - Shortest Job First - Round Robin - Rate-Monotonic - Earliest Deadline First - Least Laxity - Maximum Urgency First	2	CO5
5.4	Semaphore and shared data	1	CO5
5.6	Message queues, mail boxes and pipes	1	CO5
5.7	priority inversion, priority inheritance	1	CO5
5.8	Case Study: Automobile Antilock Braking System, Cruise Control System	2	CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

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1	Dr. L.R. Karlmarx	lkarlmarx@tce.edu
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18MTPH0

**INDUSTRIAL CONTROL OF MOTION  
DRIVES**Category L T P Credit(s)  
PE 3 0 0 3**Preamble**

Today, Industries are increasingly demanding process automation in all sectors. Automation results into better quality, increased production and reduced costs. Machine tools and Robots are become fundamental components of any automated Manufacturing work cell. The controlling parameters like motion, Speed, Position and torque are paramount in raising productivity and quality and reducing energy and equipment costs in all industries. Electric drives share most of industrial machine control applications. The heart of the modern machine tool are the motion control elements, which includes a numerical controller and a number of servo drives. The servo drives which drives machine tools need to achieve a high precision and accuracy.

**Prerequisite**

- 18MT220 - Electrical Machines
- 18MT420 - Power Electronics and Drives
- 18MT510-Control Systems
- 18MT570 - Automation Lab

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the basic structure of the position, speed and torque control in drives.	15
CO2	Experiment position and speed control in Motion control drives.	25
CO3	Construct Field oriented control (FOC) for Induction, PMSM and BLDC drives.	15
CO4	Develop the Vector control algorithm for AC servo drives.	10
CO5	Program Motion controller for Motion applications.	20
CO6	Select motor, gear and transmission system for motion control system.	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO2	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO3	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO4	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	L	-	-	-	-
CO2	S	M	L	-	-	-	-	-	M	-	-	L	M	M
CO3	S	M	L	-	-	L	-	-	M	-	-	L	M	M
CO4	S	M	L	-	M	-	-	-	M	-	-	L	M	M
CO5	S	M	L	-	M	L	-	-	M	-	-	L	M	M
CO6	S	M	L	-	M	L	-	-	M	L	-	L	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	10
Understand	30	30	30	-	-	-	30
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	Simulation of Machines Operation
Set	
Guided Response	Flipped classroom, Active Learning Techniques.
Mechanism	Assignments, Mini Projects
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

4. Explain the basic elements of speed control system.
5. Describe the structure of Torque control in Servo Drive.
6. Write the important specifications of servo drive.

**Course Outcome 2 (CO2):**

3. Design the nonlinear position controller for CNC applications.
4. The mechanical sub system of a position-controlled system is described by  $J=0.01 \text{ kgm}^2$  and  $B=0.01 \text{ Nm}/(\text{rad/s})$ . The torque actuator gain is  $K_M=1$ . Assuming the sampling time of 10 ms, obtain the pulse transfer function  $W_P(z)$  of the control object.
5. Develop a Simulink model of nonlinear position controller

**Course Outcome 3 (CO3):**

3. Develop servo drive program for driving axis motor of CNC turning Machine.
4. Explain the step response of a integral speed controller.
5. Explain the Feed forward compensation of Integral speed controller.

**Course Outcome 4 (CO4):**

3. Explain the vector control methods in detail
4. Discuss the direct torque and flux control methods in drives.
5. Explain the structure of closed loop torque control in electric drives.

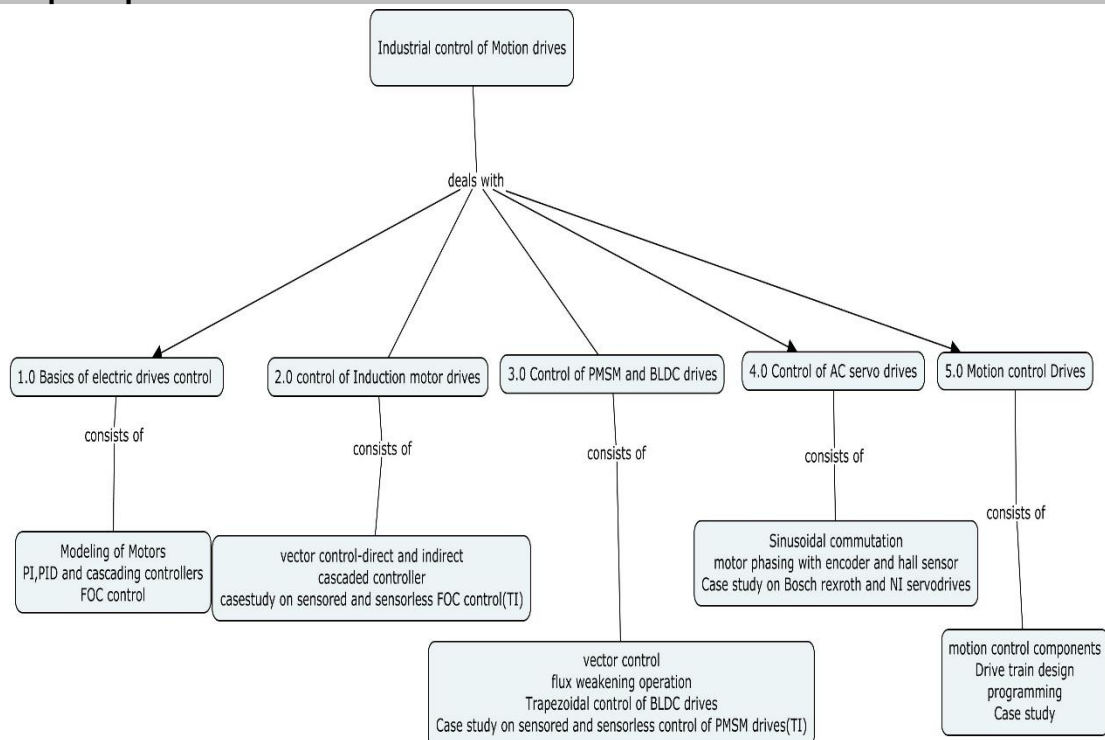
**Course Outcome 5 (CO5):**

3. Develop a experimental setup for the ramp tracking of PID controller.
4. Discuss the coordinated motion in multiaxis systems
5. Explain the spline interpolation of course reference profiles.

**Course Outcome 6 (CO6):**

1. A machine needs to be designed to apply glue to a product which is 60 in long. The glue head must travel over the product at constant speed while applying the glue. Due to the structural design of the machine, there are only additional 4 in of space at each end of the 60 in linear travel to be used to accelerate and decelerate the glue head. The glue must be applied in 0.8 s. The glue head is 7 in wide and weighs 28 lb. Select components from the following product families: MKR-Series linear belt drive by Bosch Rexroth AG [32], AKM™ servomotor by Kollmorgen [20] and EPL-H gearhead by GAM [17].
2. A small converting machine shown in Figure 3.34 is used to process sheet aluminium. The load inertia on the rewind axis is  $J_{load} = 2 \times 10^{-2} \text{ kg-m}^2$  and the axis has 7Nm load torque due to friction and tension. The motion uses trapezoidal velocity profile with  $\omega_{load} = 150 \text{ rpm}$ . Change in the size of the rewind roll can be ignored. Select a NEMA 23 size servomotor and a gearhead to drive the rewind axis if the cycle consists of (a)  $t_a = t_d = 30 \text{ ms}$ ,  $t_c = 3 \text{ s}$ ,  $t_{dw} = 4 \text{ s}$ , or (b)  $t_a = t_d = 30 \text{ ms}$ ,  $t_c = 5 \text{ s}$ ,  $t_{dw} = 1 \text{ s}$ .
3. Select a drive and program servo drive using PLC for a robotic application with a payload of 10 Kg.

**Concept Map**



## Syllabus

**Basics of Electrical Drives control** – Modelling of Induction motor, Permanent Magnet Synchronous motor(PMSM),Brushless DC motor(BLDC),AC servo motor Model-block diagram ,transfer function, state space modelling, Basic structure of position ,speed and torque controller-structure of cascaded control-PI and PID controllers-Introduction to Field oriented control.

**Control of Induction Motor Drives**-Principle of vector control, direct control, indirect control, Tuning of vector controller, Cascaded Position/velocity/Torque controller with feed forward gain- case study on Texas instruments sensed and sensorless FOC control of induction motor.

**Control of PMSM and BLDC Drives**-Vector control of PMSM drives-control strategies-flux weakening operation-speed controller design-Trapezoidal control of BLDC drives-Case study on Texas instruments Sensed and Sensorless control of PMSM and BLDC drives

**Control of AC Servo Drives**-Sinusoidal commutation –Torque generation with sinusoidal commutation-Motor phasing with encoders and hall sensors-Vector control of AC servo motor-Case study on Bosch Rexroth and National Instruments servo drive control.

**Motion control drives**-Components of motion control system-Drive train design-Motor, gearbox and transmission mechanism selection-common motion profiles-single axis and multi axis motion-Move modes-motion programming-Case study on Siemens and Bosch Rexroth Motion controllers

## Learning Resources

5. R.Krishnan, "Electric motor drives-Modelling, analysis and control", prentice hall publications,2001.
6. Hakan Gurocak, "Industrial Motion control" John Wiley publications,2016.
7. Ion Boldea, S.A Naser "Electric Drives" CRC Taylor & Francis group edition,2009
8. Texas instruments Motor Control Education <https://training.ti.com/node/1139615>
9. Frederick F. Ling, Servo motors and industrial control theory, springer,2009..
10. Indra Motion Logic Drives ,Indra works Software User Manual Bosch Rexroth.
11. National instruments CRIO motion control manual.

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Out comes
1	<b>Basics of Electrical Drives Control</b>		
1.1	Modelling of Induction, PMSM,BLDC and AC servo motors-block diagram, transfer function, state space modelling	2	CO1
1.2	Structure of position, speed and torque controller-PI,PID	1	CO1
1.3	Structure of cascaded control	1	CO1
1.4	Introduction to Field oriented control(FOC)	1	CO1
2	<b>Control of Induction Motor Drives</b>		
2.1	Principle of vector control, direct control, indirect control	2	CO2
2.2	Tuning of vector controller	1	CO2
2.3	Cascaded Position/velocity/Torque controller with feed forward gain	1	CO2



Module No.	Topic	No. of Lectures	Course Out comes
2.5	Case study on Texas instruments sensored and sensorless FOC control of induction motor	2	CO3
<b>3</b>	<b>Control of PMSM and BLDC Drives</b>		
3.1	Vector control of PMSM drives	1	CO2
3.2	Control strategies	2	CO2
3.3	Flux weakening operation	1	CO2
3.4	Speed controller design	1	CO2
3.5	Trapezoidal control of BLDC drives	2	CO3
3.6	Case study on Texas instruments Sensored and Sensorless control of PMSM and BLDC drives	2	CO3
<b>4</b>	<b>Control of AC Servo Drives</b>		
4.1	Sinusoidal commutation, Torque generation with sinusoidal commutation	2	CO4
4.2	Motor phasing with encoders and hall sensors	1	CO4
4.3	Vector control of AC servo motor	1	CO4
4.4	Case study on Bosch Rexroth and National Instruments servo drive control.	2	CO5
<b>5</b>	<b>Motion control drives</b>		
5.1	Components of motion control system	1	CO6
5.2	Drive train design-Motor, gearbox and transmission mechanism selection	2	CO6
5.3	common motion profiles, Move modes	1	CO6
5.4	Single axis and multi axis motion	1	CO6
5.5	Motion programming	2	CO5
5.6	Interfacing Motion controllers and Drives	1	CO5
5.7	Case study on Siemens and Bosch Rexroth Motion controllers	2	CO5
<b>Total</b>		<b>36 Hours</b>	

**Course Designers:**

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**18MTPJ0      ROBOTIC PROCESS AUTOMATION**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Robotic Process Automation is a software-based technology utilising software robot to emulate human execution of a business process. This means that it performs the task on a computer, uses the same interface a human worker would, clicks, types, opens applications and uses keyboard shortcuts. It can automate the data input, reconciliation error, and even it can process certain decision-making required for invoice processing, which minimizes the need for human intervention. RPA can automate end-to-end process from receipt to payment. In this subject the RPA bots are introduced and they are deployed to any process automation problems.

**Prerequisite**

- 18MT350 – Programming for Problem Solving

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Distinguish the traditional automation from robotic process automation	10
CO2	Identify the robotic process automation candidates in an automation environment	20
CO3	Develop a RPA template for an application	20
CO4	Deploy the RPA template for a particular application	20
CO5	Implement RPA for a particular automation process using RPA for python	20
CO6	Predict the RPAbot break conditions	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5,2.3.1
CO2	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2,4.3.4
CO3	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3,4.3.1,4.3.2,4.4.1,4.5.3
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.5.6
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1,4.5.3, 4.6.2
CO6	TPS3	Apply	Value	-	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3, 2.4.4,4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO2	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO3	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO4	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO5	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO6	S	M	L	-	S	-	-	-	S	-	-	S	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	40	20	20	-	-	-	20
Understand	40	40	40	100	-	-	20
Apply	20	40	40	-	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	
Set	
Guided Response	Process Automation Assignment
Mechanism	
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. What are digital workers?
2. List some of the processes which cannot be robot process automated
3. What Is the difference between traditional and robotic process automation
4. Describe the main benefits of robotic process automation

**Course Outcome 2 (CO2):**

1. List some of the factors based on which the general RPA candidates is chosen
2. Consider a car manufacturer using a six sigma technique to improve the business process in the company. Identify the RPA candidates to automate the process.
3. What are the RPA candidates of the data extraction process by Google forms? List according to the priority

**Course Outcome 3 (CO3):**

1. Automate the patient billing system for a hospital with 30 beds. The bill should consist of the receipt number, patient number, list of medicines, and bill of materials. This

should be generated and printed daily at 6.00 P.M. Select the RPA process to be implemented. Justify with reasons.

2. Chose the appropriate RPA template to automate the email reply system to a particular set of emails in the organization. Others should be analyzed and proper reply should be sent. The reply should be based on the emotion in the sentence.
3. Discuss the RPA template and the process to automate the repeated form filing systems of different organizations. The RPA bot should be able to analyze the question and provide short answers from a database of solutions.

**Course Outcome 4 (CO4):**

1. Select the RPA suitable template to automate Gmail trash clearing system. The trash should be cleared when the number of mails in trash reaches 25.
2. Deploy a RPA template to automate the Amazon online supply chain. The bot should be deployed 24/7 to accept orders, sort and send the orders to the corresponding warehouse. The allocation of trucks should be done according to the distance of the truck in real time.
3. Deploy a RPA system to allocate the daily work time of the employees based on the age, the department, the project currently allocated with the deadline of the project

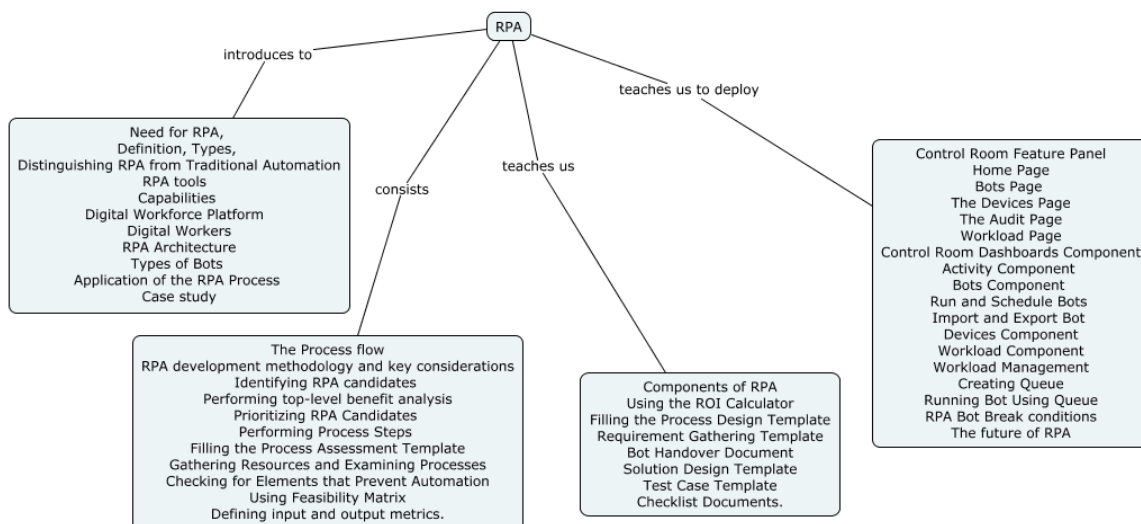
**Course Outcome 5 (CO5):**

1. Design an automated team member to collaboratively work with the humans to divide and complete a project within the stipulated time.
2. Design a robotic HR to recruit the employees based on the objectives of the company and the future projects. Select the suitable RPA tools, template and design the architecture.
3. Design a AI based loan approval system depending on the data gathered about the customers revenue and income tax details.

**Course Outcome 6 (CO6):**

1. Predict the reasons for RPA bot breaks for a supply chain mechanism?
2. Predict the RPA bot break condition in a multibot chain communication system for task allocation system
3. Suggest some measures to avoid botcrash in contract allocation system

**Concept Map**



**Syllabus**

**Overview**

Need for RPA, Definition, Types, Distinguishing RPA from Traditional Automation, RPA tools - UiPath, Blue Prism, TagUI, RPA for Python - Capabilities, Digital Workforce Platform – Digital Workers , RPA Architecture, Types of Bots, Application of the RPA Process - Case study.

### Identifying the Automation Process

The Process flow -RPA development methodology and key considerations - Identifying RPA candidates, Performing top-level benefit analysis, Prioritizing RPA Candidates, Performing Process Steps, Filling the Process Assessment Template, Gathering Resources and Examining Processes, Checking for Elements that Prevent Automation, Using Feasibility Matrix, Defining input and output metrics.

### Automation Process Design

Components of RPA – Recorder - Development studio - Extensions and plugins - Bot runner, Control center, Using the ROI Calculator, Filling the Process Design Template, Requirement Gathering Template, Bot Handover Document, Solution Design Template - Test Case Template - Checklist Documents.

### RPA Deployment and Maintenance

Control Room Feature Panel, Home Page, Bots Page, The Devices Page, The Audit Page - Workload Page - Control Room Dashboards Component - Activity Component - Bots Component - Run and Schedule Bots - Import and Export Bot - Devices Component - Workload Component - Workload Management, Creating Queue, Running Bot Using Queue, RPA Bot Break conditions, The future of RPA.

### Learning Resources

1. Alok Mani Tripathi, "Learning Robotic Process Automation", Packt Publishing Ltd, March, 2018.
2. Tom Taulli "The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems", Apress, 28 February 2020.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Overview</b>		
1.1	Need for RPA, Definition	1	CO <sub>1</sub>
1.2	Types, Distinguishing RPA from Traditional Automation	1	CO <sub>1</sub>
1.4	RPA tools - UiPath, Blue Prism	1	CO <sub>1</sub>
1.5	TagUI, RPA for Python	1	CO <sub>1</sub>
1.6	Capabilities	1	CO <sub>1</sub>
1.7	Digital Workforce Platform, Digital Workers	1	CO <sub>1</sub>
1.9	RPA Architecture, Types of Bots	2	CO <sub>1</sub>
1.11	Application of the RPA Process	1	CO <sub>1</sub>
1.12	Case study	2	CO <sub>5</sub>
<b>2.0</b>	<b>Identifying the Automation Process</b>		
2.1	The Process flow	1	CO <sub>2</sub>
2.2	RPA development methodology and key considerations	1	CO <sub>2</sub>
2.3	Identifying RPA candidates	1	CO <sub>2</sub>

2.4	Performing top-level benefit analysis	1	CO <sub>2</sub>
2.5	Prioritizing RPA Candidates, Performing Process Steps	1	CO <sub>2</sub>
2.6	Filling the Process Assessment Template, Gathering Resources and Examining Processes	1	CO <sub>2</sub>
2.7	Checking for Elements that Prevent Automation	1	CO <sub>2</sub>
2.8	Using Feasibility Matrix, Defining input and output metrics	1	CO <sub>2</sub>
3.0	<b>Automation Process Design</b>		
3.1	Components of RPA	1	CO <sub>3</sub>
3.2	Recorder - Development studio	1	CO <sub>3</sub>
3.3	Extensions and plugins - Bot runner	1	CO <sub>3</sub>
3.4	Control center, Using the ROI Calculator	1	CO <sub>3</sub>
3.5	Filling the Process Design Template	1	CO <sub>3</sub>
3.6	Requirement Gathering Template, Bot Handover Document	1	CO <sub>3</sub>
3.7	Solution Design Template - Test Case Template -	1	CO <sub>3</sub>
3.8	Checklist Documents	1	CO <sub>3</sub>
4.0	<b>RPA Deployment and Maintenance</b>		
4.1	Control Room Feature Panel, Home Page, Bots Page	1	CO <sub>4</sub>
4.2	The Devices Page, The Audit Page	1	CO <sub>4</sub>
4.3	Workload Page - Control Room Dashboards Component	1	CO <sub>4</sub>
4.5	Activity Component - Bots Component - Run and Schedule Bots	1	CO <sub>4</sub>
4.6	Import and Export Bot - Devices Component	1	CO <sub>4</sub>
4.7	Workload Component - Workload Management,	1	CO <sub>4</sub>
4.8	Creating Queue, Running Bot Using Queue	1	CO <sub>4</sub>
4.9	RPA Bot Break conditions	1	CO <sub>6</sub>
4.10	The future of RPA.	1	CO <sub>6</sub>
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**18MTPK0 OBJECT ORIENTED PROGRAMMING**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Object-Oriented Programming (OOPs) have proved to be effective solutions in handling the inherent complexity of software design, development, testing and maintenance. Instead of viewing a program as a series of steps to be carried out, it views it as a group of objects that have certain properties and can take certain actions. Many object-oriented languages have become available and have been widely adopted like Java, C++, Python, VB / VB.NET, C#, Perl, Ruby – to name a few. For an Engineer, solving any real time problem is not just about designing an algorithm and solving it, but also the ability to select appropriate data structures to solve the problem efficiently.

This course on introduce the concept of OOPs using C++ and Python along with ability to manipulate data using data structures.

**Prerequisite**

- 18MT350 - Programming for Problem Solving
- 18MT360 - Programming and Coding Laboratory

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the various concepts of Object-Oriented Programming (OOPs)	5
CO2	Develop C++ program for solving the given problem using OOPs	25
CO3	Explain the various concepts of programming in Python	10
CO4	Develop Python program for solving the given problem using OOPs	25
CO5	Analyse and debug the developed C++ and Python program	10
CO6	Implement linear and nonlinear data structures such as stack, queue, linked lists, trees for a given application	25

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.5, 3.2.3
CO2	TPS3	Apply	Value	-	1.3, 2.1.5, 3.2.3, 4.4.5
CO3	TPS2	Understand	Respond	-	1.3, 2.1.5, 3.2.3
CO4	TPS3	Apply	Value	-	1.3, 2.1.5, 3.2.3, 4.4.5
CO5	TPS3	Apply	Value	-	1.3, 2.1.5, 3.2.3, 4.4.5
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 3.2.3, 4.4.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	M
CO2	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	M
CO4	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO5	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO6	S	M	L	-	S	-	-	-	S	M	-	-	M	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3*	1	2	3	
Remember	20	20	-	-	-	-	20
Understand	40	40	-	-	-	-	40
Apply	40	40	100	100	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

\* CAT 3 assessment will be done through Programming.

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Illustrate the concept of class and objects in OOPs with necessary example
2. Explain inheritance, its types with simple diagram

**Course Outcome 2 & 4 (CO2 & CO4):**

1. Write a C++ program to add two complex numbers using operator overloading concept
2. Explain the use of object as function argument with a C++ program.
3. Write a python program to explain the concept of class and objects



**Course Outcome 3& 5(CO3& CO5):**

1. Predict the output of the following C++ programs

```
// Assume that integers take 4 bytes.
#include<iostream>

using namespace std;

class Test
{
    static int i;
    int j;
};

int Test::i;

int main()
{
    cout << sizeof(Test);
    return 0;
}
```

```
#include<iostream>
using namespace std;

class Test {
    int value;
public:
    Test(int v);
};

Test::Test(int v) {
    value = v;
}

int main() {
    Test t[100];
    return 0;
}
```

```
#include <iostream>
using namespace std;

int fun(int a, int b = 1, int c =2)
{
    return (a + b + c);
}

int main()
{
    cout << fun(12, ,2);
    return 0;
}
```

2. Predict the output of the following Python programs

```
class Acc:
    def __init__(self, id):
        self.id = id
        id = 555

acc = Acc(111)
print acc.id

data = [2, 3, 9]
temp = [[x for x in data] for x in range(3)]
print (temp)
```

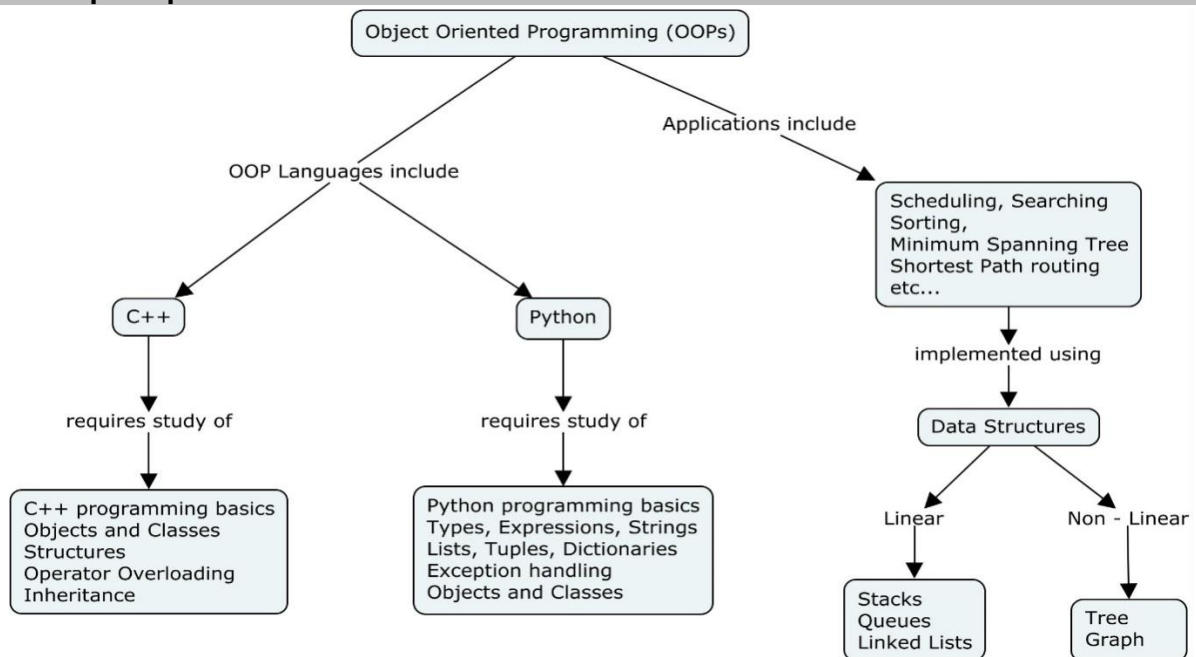
```
data = 50
try:
    data = data/0
except ZeroDivisionError:
    print('Cannot divide by 0 ', end = '')
else:
    print('Division successful ', end = '')

try:
    data = data/5
except:
    print('Inside except block ', end = '')
else:
    print('GFG', end = '')
```

**Course Outcome 6 (CO6):**

- Given an arithmetic expression, develop an algorithm to check for matching parenthesis and choose an appropriate data structure to implement the algorithm efficiently.
- Implement insertion, deletion and searching operations in Binary Search Tree

**Concept Map**



## Syllabus

**Introduction:** Introduction to Object Oriented Programming (OOPs) -Procedural Languages  
- The Object-Oriented approach - Objects and Classes

**OOPs in C++:** C++ programming basics – Objects and Classes - Defining the Class - Using the Class - Calling Member Functions - C++ Objects as Physical Objects - Objects as Data Types - Constructors - Destructors - Objects as Function Arguments - Overloaded Constructors - Member Functions Defined Outside the Class - Objects as Arguments - Returning Objects from Functions - Arguments and Objects - Structures and Classes - Operator Overloading and Inheritance - Overloading Unary & binary operators - Data Conversion - Derived Class and Base Class - Class Hierarchies - Public and Private Inheritance - Levels of Inheritance - Multiple Inheritance - Classes within Classes Inheritance

**OOPs in Python:** Pythonprogramming basics -Types - Expressions - Strings - Lists - list comprehension - Tuples - Dictionaries - Exception handling- Objects and Classes

**Applications:** Linear Data structures - Stacks - Queues - Linked Lists; Non-Linear Data structures - Trees - Graphs - Round Robin Scheduling - Searching - Sorting - Minimum Spanning Tree Algorithm - Shortest Path routing using Dijkstra’s Algorithm

## Learning Resources

1. Robert Lafore, **Object-Oriented Programming in C++**, Pearson Education, 2002
2. Mark Allen Weiss, **Data Structures and Algorithm Analysis in C++**, 4th edition, Pearson Education, 2014
3. Programming in C++ in Swayam: [https://swayam.gov.in/nd1\\_noc20\\_cs07/preview](https://swayam.gov.in/nd1_noc20_cs07/preview)
4. Programming, Data Structures and Algorithms using Python in NPTEL: <https://nptel.ac.in/courses/106/106/106106145/>
5. C++ Programming in Tutorials Point:<https://www.tutorialspoint.com/cplusplus/index.htm>
6. Python Programming in Tutorials Point: <https://www.tutorialspoint.com/python/index.htm>

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction</b>		
1.1	Introduction to Object Oriented Programming (OOPs) - Procedural Languages - The Object-Oriented approach - Objects and Classes	2	CO1
<b>2</b>	<b>OOPs in C++</b>		
2.1	C++ programming basics	2	CO2, CO5
2.2	Objects and Classes - Defining the Class - Using the Class - Calling Member Functions	2	CO2, CO5
2.3	Objects as Physical Objects &Data Types - Constructors - Destructors- Objects as Function Arguments	2	CO2, CO5
2.4	Overloaded Constructors - Member Functions Defined Outside the Class - Objects as Arguments - Returning Objects from Functions - Arguments and Objects - Structures and Classes	2	CO2, CO5

Module No.	Topic	No. of Hours	Course Outcome
2.5	Operator Overloading and Inheritance - Overloading Unary & binary operators - Data Conversion - Derived Class and Base Class - Class Hierarchies	2	CO2, CO5
2.6	Public and Private Inheritance - Levels of Inheritance - Multiple Inheritance – Classes within Classes Inheritance	2	CO2, CO5
<b>3</b>	<b>OOPs in Python</b>		
3.1	Python programming basics	3	CO3, CO4, CO5
3.2	Types - Expressions – Strings - Lists - list comprehension	2	CO3, CO4, CO5
3.3	Tuples – Dictionaries	2	CO3, CO4, CO5
3.4	Exception handling	2	CO3, CO4, CO5
3.5	Objects and Classes	3	CO3, CO4, CO5
<b>4</b>	<b>Applications</b>		
4.1	Linear Data structures - Stacks - Queues - Linked Lists	2	CO6
4.2	Non-Linear Data structures - Trees	2	CO6
4.3	Graphs - Round Robin Scheduling	2	CO6
4.4	Searching – Sorting	2	CO6
4.5	Minimum Spanning Tree Algorithm - Shortest Path routing using Dijkstra's Algorithm	2	CO6
<b>Total</b>		<b>36</b>	

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<b>18MTPN0 DIGITAL MANUFACTURING TECHNOLOGY</b>	Category	L	T	P	Credit(s)
	PE	3	0	0	3

**Preamble**

Modern market becomes more global and less national or local. Developed world market is reflected in the wide range of new products, the rapid obsolescence of products and the emergence of new products, high quality standards, short delivery and decreasing costs. Such conditions are very difficult for the classical industrial production we have today, and thanks to the progress of modern technological achievements, such as communication networks and the Internet, it is forcing us to develop and introduce a new modern era of industrial production based on communicational - informational linking of manufacturers and customers. This digital revolution is being driven by technology advancements in software, analytics, AI, machine learning, quantum mechanics, robotics, the IoT, material science, 3D printing, automated cars, and more. Advances in technology are having a profound impact on the manufacturing industry. The IoT, for example, will redefine human and machine interaction by adding connectivity to every kind of machine, from mobile devices to traditional appliances to wearable devices. Models like intelligent predictive maintenance, proactive replenishment, and inventory monitoring, along with pay-as-you-go, machine-to machine (M2M) communications and the IoT will make manufacturers more efficient and profitable.

**Prerequisite**

- 18MT260 - Manufacturing Processes
- 18MTEA0 – Integrated Product Development

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the basic components of Digital manufacturing	10
CO2	Implement digital thread components in Manufacturing enterprise	15
CO3	Perform virtual commissioning of Digital Twin in Smart Factory	15
CO4	Perform advanced manufacturing process analysis in digital manufacturing enterprise	20
CO5	Design intelligent manufacturing operations in manufacturing enterprise.	15
CO6	Formulate business models for advanced manufacturing process	25

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	2.3.1, 2.3.2, 4.3.1, 4.3.2
CO2	TPS3	Apply	Value	Mechanism	4.5.3,4.5.4
CO3	TPS3	Apply	Value	Mechanism	2.1.3, 2.1.4, 4.2.1
CO4	TPS3	Apply	Value	Mechanism	4.4.1,4.4.2,4.4.3,4.4.4
CO5	TPS3	Apply	Value	Mechanism	2.1.2, 4.2.3, 4.5.6
CO6	TPS3	Apply	Value	Mechanism	2.1.2, 4.3.3, 4.4.1,4.4.2, 4.4.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	M	-	-	-	-	-	-	-	S	S
CO3	S	M	L	-	S	-	-	-	-	-	-	-	M	M
CO4	S	M	L	-	-	-	M	-	-	M	-	-	S	S
CO5	S	M	L	-	-	-	-	-	-	-	S	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	M	-	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	20	20	20	-	-	-	20
Apply	60	60	60	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Online Quiz
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Write the components of PLM.
2. Define Digital thread and digital twin
3. Explain the components of digital manufacturing

**Course Outcome 2 (CO2):**

1. Explain the components of Digital thread.
2. Explain how digital thread can be implemented in a hospital industry.
3. Realize the computer integrated manufacturing using digital thread concept.

**Course Outcome 3 (CO3):**

1. Describe the types of Digital Twin.
2. Explain how digital thread and twin concepts can be implemented in automobile sector.
3. Describe the implementation of digital twin in Plant Maintenance.

**Course Outcome 4 (CO4):**

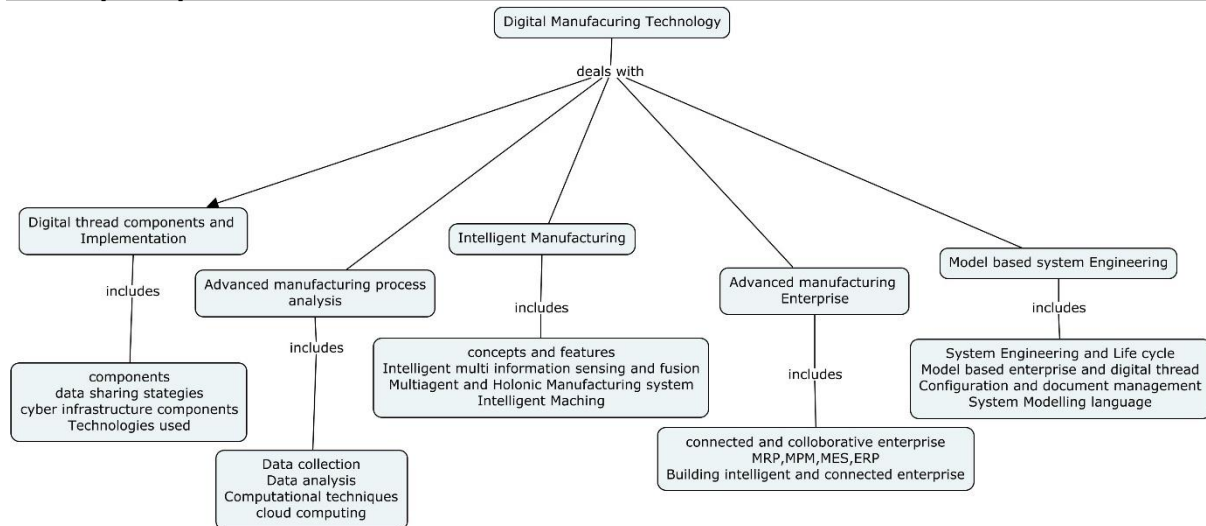
1. Distinguish traditional data set and big data
2. Demonstrate how big data concept can be applied to educational institutes.
3. Explain the different data computation techniques.

**Course Outcome 5 (CO5):**

1. Explain the supply chain management tools of DM.
2. Explain how intelligent manufacturing system can be implemented in shop floor.
3. Develop new business model to implement industry 4.0 in automobile industry.

**Course Outcome 6 (CO6):**

1. Define MRP and ERP.
2. Discuss the use of supply chain management tools for automobile industry.
3. Illustrate how the intelligent and connected enterprise can be built.

**Concept Map****Syllabus**

**Introduction to digital Manufacturing:** Definition-Components of DM- Introduction to 4<sup>th</sup> industrial revolution-cyber physical systems-Introduction to Digital thread and Digital twin-Introduction to product life cycle management (PLM)

**Digital thread and Digital twain:**Digital thread components-Data Sharing Strategies-Interoperability and Data Formats-semantic data-Technical data packages-Strategic issues in implementing the digitalthread-Cyber infrastructure Components of the Digital Thread -Digital Thread and the Manufacturing Enterprise-Types of Digital Twin -Product twin – Process Twin – Performance Twin-Virtual commissioning of Digital Twin– Data mapping – Simulation of Digital Twin – Data collection and visualisation-Case study on smart factory using Digital thread and Digital twain.

**Advanced manufacturing process analysis:**Data analysis-Manufacturing Settings and Data Collection-Traditional Data Sets vs Big Data-Data Storage and Organization-Data pre-processing-computational techniques and platform-Components, Categories and Capabilities-high performance and cloud computing

**Intelligent Manufacturing:** Concepts and features of intelligent Manufacturing -Intelligent Multi Information Sensing and Fusion in the Manufacturing Process -Intelligent machining-components-sensors and sensing techniques-machine learning and artificial intelligence in sensing techniques.

**Advanced manufacturing enterprise:** Connected and collaborative enterprise-digitally connected enterprise-PLM system-Introduction to a Set of Supply Chain Management Tools & Integrated Capabilities-Material Requirements Planning(MRP)-Manufacturing Process Management(MPM)-Manufacturing Execution Systems (MES)-Enterprise Resource Planning(ERP)- building the intelligent and connected enterprise

### Learning Resources

1. Zudezhou , "Fundamentals of Digital Manufacturing Science", Springer, 2012
2. Mark J. Barrenechea, Tom Jenkins. "Digital manufacturing", open text corp, 2018
3. KEN English, "Specialization course in Digital Manufacturing Design and Technology", Coursera.
4. Elvis Hozdić, "Smart factory for Industry 4.0" International Journal of Modern Manufacturing Technologies ISSN 2067–3604, Vol. VII, No. 1 / 2015

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome
<b>1</b>	<b>Introduction to digital Manufacturing</b>		
1.1	Definition-Components of DM	1	CO1
1.2	Introduction to 4 <sup>th</sup> industrial revolution-cyber physical systems	1	CO1
1.3	Introduction to Digital thread-Digital twain	1	CO1
1.4	Introduction to product life cycle management (PLM)	1	CO1
<b>2</b>	<b>Digital thread components and Implementation</b>		
2.1	Digital thread Components	1	CO2
2.2	Data Sharing Strategies	1	CO2
2.3	Interoperability and Data Formats-semantic data-Technical data packages	1	CO2
2.5	Strategic issues in implementing the digital thread-Cyber infrastructure Components of the Digital Thread	1	CO2
2.6	Digital Thread and the Manufacturing Enterprise	2	CO2
2.7	Types of Digital Twin, Product twin, Process Twin , Performance Twin	1	CO3
2.8	Virtual commissioning of Digital Twin	1	CO3
2.9	Data mapping – Simulation of Digital Twin	1	CO3
2.10	Data collection and visualisation	1	CO3
2.11	Case study on smart factory using Digital thread and Digital twin.	2	CO3
<b>3</b>	<b>Advanced manufacturing process analysis:</b>		
3.1	Data analysis	1	CO4
3.2	Manufacturing Settings and Data Collection	1	CO4
3.3	Traditional Data Sets vs Big Data	1	CO4
3.4	Data Storage and Organization-Data pre-processing	1	CO4
3.5	computational techniques and platform	1	CO4
3.6	Components, Categories and Capabilities	1	CO4
3.7	High performance and cloud computing	1	CO4
<b>4</b>	<b>Intelligent Manufacturing</b>		
4.1	Concepts and features of intelligent Manufacturing.	1	CO5
4.2	Intelligent Multi Information Sensing and Fusion in the Manufacturing Process	1	CO5

<b>Module No.</b>	<b>Topic</b>	<b>No. of Lectures</b>	<b>Course Outcome</b>
4.3	Intelligent machining-components.	1	CO5
4.4	Sensors and sensing techniques.	1	CO5
4.5	Machine learning and artificial intelligence in sensing techniques.	2	CO5
<b>5</b>	<b>Advanced manufacturing enterprise</b>		
5.1	Connected and collaborative enterprise	1	CO6
5.2	Digitally connected enterprise-PLM system	1	CO6
5.3	Introduction to a Set of Supply Chain Management Tools & Integrated Capabilities	1	CO6
5.4	Material Requirements Planning (MRP)-Manufacturing Process Management (MPM)	2	CO6
5.5	Manufacturing Execution Systems (MES)-Enterprise Resource Planning (ERP)	2	CO6
5.6	Building the intelligent and connected enterprise	2	CO6
<b>Total</b>		<b>36 Hours</b>	

**Course Designers:**

<b>Sl. No.</b>	<b>Name</b>	<b>E-mail Id</b>
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SYLLABI

For

**B.E. Mechatronics Program**

Program Specific Electives for Expanded Scope

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 59<sup>th</sup> Academic Council Meeting on 07.12.2019

18MTPE0

**MACHINE LEARNING AND ITS APPLICATIONS**Category L T P Credit(s)  
PEES 3 0 0 3**Preamble**

Machine learning uses interdisciplinary techniques such as statistics, linear algebra, optimization, and computer science to create automated systems that can sift through large volumes of data at high speed to make predictions or decisions without human intervention. Machine learning as a field is now incredibly pervasive, with applications spanning from business intelligence to homeland security, from analysing biochemical interactions to structural monitoring of aging bridges, and from emissions to astrophysics, etc. This class will familiarize students with a broad cross-section of models and algorithms for machine learning and prepare students for research or industry application of machine learning techniques.

The course will also discuss recent applications of machine learning, such as to robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing.

**Prerequisite**

- 18MT350 - Programming for Problem solving
- 18MT410 - Probability and Statistics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the mathematical concepts behind machine learning	10
CO2	Explain different terminologies and methods adapted for machine learning	10
CO3	Illustrate the basic architecture of perceptron and multilayer perceptron	25
CO4	Use supervised learning for developing machine learning models	25
CO5	Classify different learning techniques used in machine learning	15
CO6	Design a neural network model using TensorFlow 2.0.	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception	1.2,1.3
CO2	TPS2	Understand	Respond	Guided Response	2.1,2.2,2.3,4.5.1
CO3	TPS3	Apply	Value	Mechanism	2.1,2.2,.2.3,4.4.1
CO4	TPS3	Apply	Value	Mechanism	2.3,4.4,4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.2,1.3
CO6	TPS3	Apply	Value	Mechanism	4.3

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	L	-	-	-	-	-	-	-	-	L	S
CO2	M	M	M	S	-	-	-	-	-	-	-	-	-	S
CO3	M	M	M	M	-	-	-	-	M	M	-	-	M	M
CO4	S	S	M	M	-	S	M	-	M	L	-	S	L	M
CO5	L	M	M	L	-	S	S	-	M	S	-	S	-	M
CO6	-	-	-	-	S	S	L	-	L	L	-	S	L	S

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	50	-	-	50	-	-	20
Understand	50	20	20	-	-	-	20
Apply	-	80	80	50	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Mini project
Mechanism	Practical component / Assignment
Complex Overt Responses	-
Adaptation	-
Orignation	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. Define machine learning and its need?
2. Classify regression and its associative Techniques?
3. List out different learning techniques used in machine learning.

#### Course Outcome 2(CO2):

1. Explain about overfitting?
2. Illustrate ROC curve with neat diagram?
3. Brief about naive Bayes theorem?

#### Course Outcome 3(CO3):

1. Define Hebb's rule of Learning?
2. Solve the XOR problem with neural networks?
3. Compare LDA , PCA ,ICA.

#### Course Outcome 4 (CO4):

1. Draw the Architecture of Radial Basis Networks?

2. Explain in detail about dimensionality reduction.
3. List out the steps involved in gradient decent?

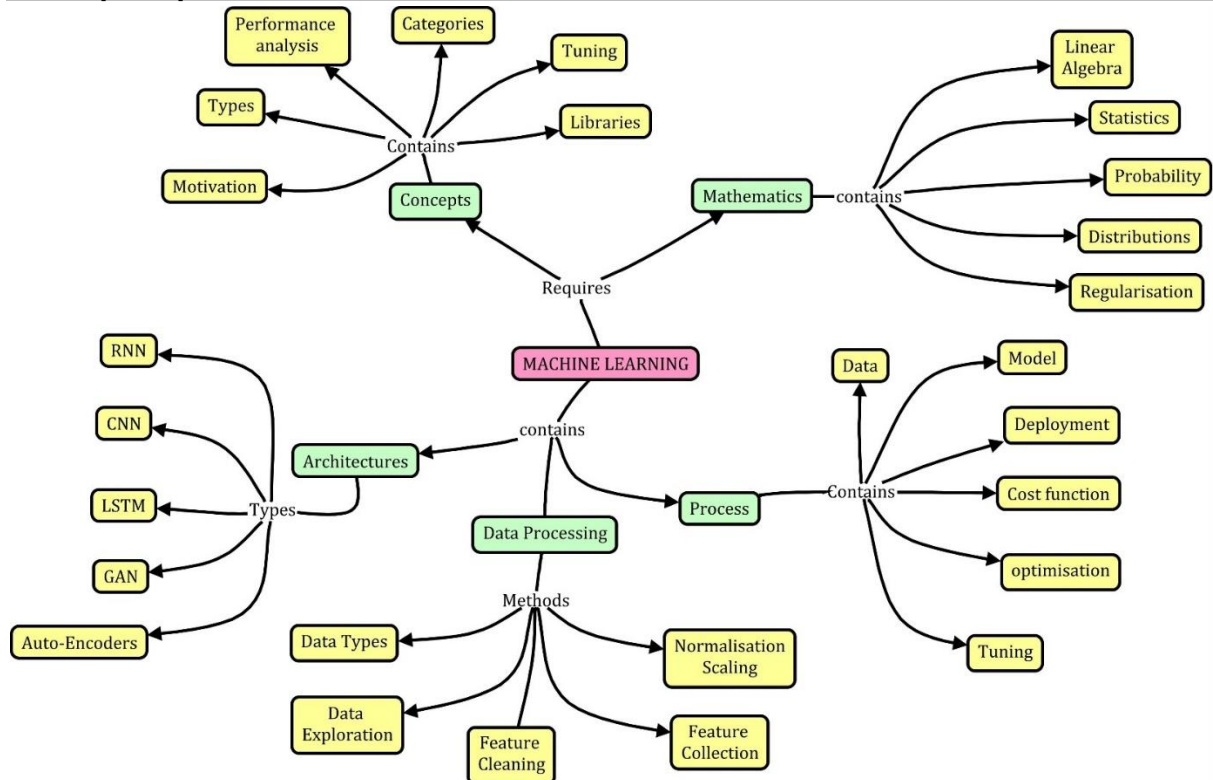
**Course Outcome 5 (CO5):**

1. Define reward function in reinforcement learning?
2. Discuss the use cases in which K-means clustering can be used?
3. Define Self Organising Map

**Course Outcome 6 (CO6):**

1. Explain about the NumPy library.
2. Write a python program to create a 3D tensor of 1000 entries?
3. Define RELU.

**Concept Map**



**Syllabus**

**Introduction to machine learning** – classification - applications – learning associations – regression- learning Techniques.

**Terminology** – overfitting – training, testing and validation sets – roc curve-unbalanced datasets – naïve Bayes classifier

**Neural networks** – hebb’s rule – the perceptron – linear separability – XOR problem – linear regression – multi layer perceptron (MLP) – back propagation of error – MLP applications- Radial basis function network – interpolation and basic functions – dimensionality reduction – Linear Discriminant Analysis (LDA) – (Principal component Anaysis (PCA) – Independent Component Analysis (ICA)

**Learning techniques** - Reinforcement learning – markov decision process – unsupervised learning – the k-means algorithm-vector quantization- the self-organizing map.

**TensorFlow 2.0** – importing code –tensor flow classes – tensors– linear algebra – dataset collection - training neural networks – model deployment

**Learning Resources**

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective. CRC Press, second edition 2015,

2. Ethem Alpaydin, Introduction to Machine Learning, Second Edition, the MIT press, 2014. <http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12012>
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, springer, 2011. <http://research.microsoft.com/en-us/um/people/cmbishop/prml/>.
4. Dr. Mark Fenner, Machine Learning with Python for Everyone (Addison-Wesley Data & Analytics Series) 1st Edition,2019.
5. NPTEL – Introduction to Machine Learning - <https://nptel.ac.in/courses/106106139/>
6. NPTEL – Practical Machine Learning with Tensor Flow - <https://nptel.ac.in/courses/106106213/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	Introduction to Machine Learning		
1.1	Machine learning applications	2	CO1
1.2	Learning associations	2	CO1
2.	Terminology		
2.1	Overfitting – training, testing and validation sets – ROC curve	2	CO2
2.2	Naive Bayes classifier	2	CO2
3.	Neural Networks		
3.1	Hebb's rule – perceptron	2	CO3
3.2	Linear separability	2	CO3
3.3	XOR Problem - Linear Regression	2	CO3
3.4	Multilayer perceptron – back propagation	2	CO3
3.5	Applications	2	CO3
3.6	Interpolation and Dimensionality Reduction	2	CO4
3.7	LDA – PCA – ICA	2	CO4
3.8	Reinforcement learning	2	CO4
3.9	Markov Decision process	2	CO4
4.	Learning Techniques		
4.1	Unsupervised learning - K -means clustering	2	CO5
4.2	Vector Quantization	2	CO5
4.3	Self-organising maps	1	CO5
5.	TensorFlow 2.0		
5.1	Tensors – Data collection and pre-processing	2	CO6
5.2	Training Neural networks	2	CO6
5.3	Model Deployment	1	CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

Sl. No.	Name	E-mail Id
1	Dr.G.Kanagaraj	gkgmech@tce.edu
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**18MTPF0****INTERNET OF THINGS**

Category L T P Credit(s)

PEES 3 0 0 3

**Preamble**

The explosive growth of the “Internet of Things” is changing our world and the rapid drop in price for typical IoT components is allowing people to innovate new designs and products at home. In this first class in the specialization you will learn the importance of IoT in society, the current components of typical IoT devices and trends for the future. IoT design considerations, constraints and interfacing between the physical world and your device will also be covered. You will also learn how to make design trade-offs between hardware and software. We'll also cover key components of networking to ensure that students understand how to connect their device to the Internet.

**Prerequisite**

- 18MT430 - Microcontroller
- 18MT440 - Sensors and Measurements

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe about integration of Multidisciplinary principles to develop IoT applications	10
CO2	Explain the Architecture of IoT and its Building Blocks	10
CO3	Demonstrate how to build embedded applications by interfacing Sensors and Actuators	25
CO4	Use the different wired and wireless protocols and standards for IoT Application Development.	25
CO5	Use Different cloud functionalities for Data storage and Analytics.	15
CO6	Illustrate the working of different applications for IoT.	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Remember	Receive	Perception	1.2,1.3
CO2	TPS2	Understand	Respond	Guided Response	2.1,2.2,2.3,4.5.1
CO3	TPS3	Apply	Value	Mechanism	2.1,2.2,.2.3,4.4.1
CO4	TPS3	Apply	Value	Mechanism	2.3,4.4,4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.2,1.3
CO6	TPS3	Apply	Value	Mechanism	4.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	L	-	-	-	-	-	-	-	-	L	S
CO2	M	M	M	L	-	-	-	-	-	-	-	-	-	S
CO3	M	M	M	M	M	-	-	-	L	M	M	-	M	M
CO4	S	S	M	L	-	S	S	-	M	M	-	S	L	M
CO5	L	M	M	L	M	S	-	-	S	L	-	S	-	M
CO6	L	M	S	L	M	S	M	-	L	S	M	S	L	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	50	-	-	50	-	-	20
Understand	50	20	20	-	-	-	20
Apply	-	80	80	50	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Mini project
Mechanism	Practical component / Assignment
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Differentiate IoT and IIoT?
2. Explain about API.
3. Illustrate the role of IIoT in Manufacturing Process?

**Course Outcome 2(CO2):**

1. Draw the reference Architecture of IIoT?
2. Illustrate the working of Gateways.
3. Explain in detail about the Working of WSN?

**Course Outcome 3(CO3):**

1. Differentiate MODBUS Serial and MODBUS Parallel?
2. Define M2M in IoT?
3. Classify the Different Types of Actuators used?

**Course Outcome 4 (CO4):**

1. Illustrate the use cases in which WIFI can be deployed?
2. Draw the architecture of I2C protocol?

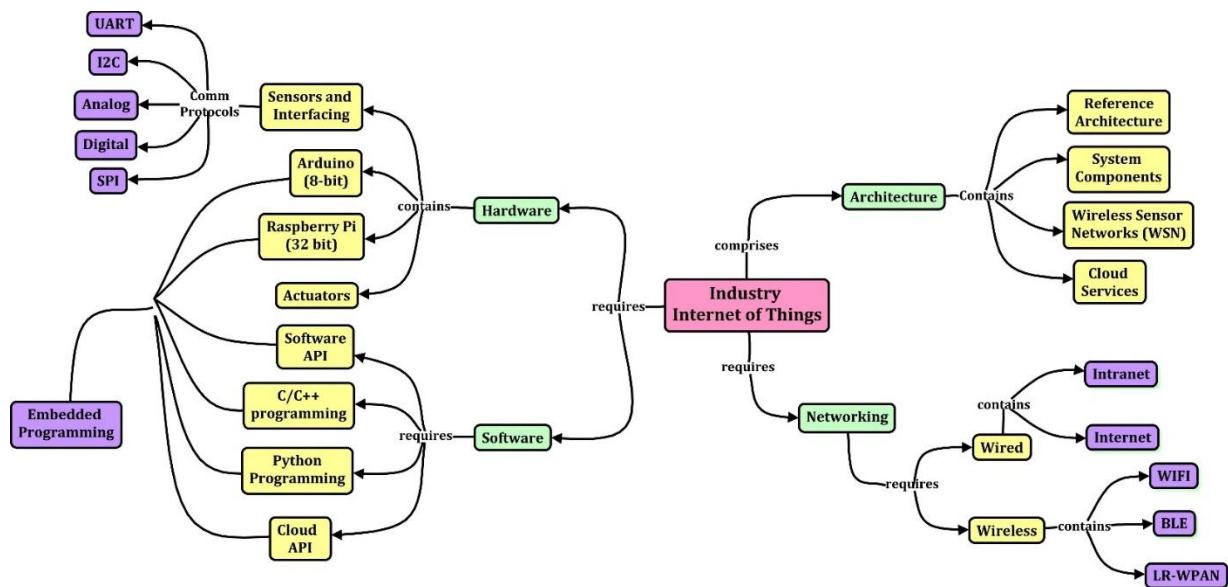
**Course Outcome 5 (CO5):**

1. List out the need for data analytics in IIoT?
2. Define cloud and fog computing?
3. Explain the MQTT protocol with neat Diagram?

**Course Outcome 5 (CO5):**

1. Design an IIoT based Smart metering System ?
2. Illustrate an Architecture for body area networks used in Patient Monitoring System ?
3. Develop an IIoT application for Automotive Applications?

## Concept Map



## Syllabus

**Introduction:** IOT Vs. IOT, History of IOT, Components of IOT - Sensors, Interface, Networks, People & Process, Hype cycle, IOT Market, Trends & future Real life examples, Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining & Manipulation; Role of IOT in Manufacturing Processes Use of IOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IOT

**Architectures:** Overview of IOT components ; Various Architectures of IOT and IOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT

**Sensor and Interfacing:** Introduction to sensors, Transducers, Classification, Roles of sensors in IOT , Various types of sensors , Design of sensors, sensor architecture, special requirements for IOT sensors ,interfacing with Arduino and Raspberry pi . Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACnet , Current, M2M etc.

**Protocols and Cloud:** Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, BACnet, BLE, Modbus, SPI , I2C, IOT protocols –COAP, MQTT,6lowpan, AMPQ , SDN IOT cloud platforms : Overview of cloud platforms. fog Computing, Cloud Data analytics, cloud services.

**Applications:** Smart Metering/Advanced Metering Infrastructure , e-Health/Body Area Networks ,City Automation , Automotive Applications ,Home Automation Smart Cards , Control Application

## Learning Resources

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Wiley Publications ,2013.
2. Bernd Scholz-Reiter, Florian 2. Michahelles, "Architecting the Internet of Things", ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer,2011.
3. Arshdeep Bahga, Vijay Madiseti, "Internet of Things – A hands-on approach", Universities Press,2015
4. Peter Waher "Learning Internet of Things",Packt Publishing,UK, 2015.
5. Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing, 2014
6. Adrian McEwen, Hakim Cassimally "Designing the Internet of Things",WileyPublishing, 2015



7. NPTEL – Introduction to Internet of Things, <https://nptel.ac.in/courses/106105166/#>.
8. NPTEL – Introduction to Industry 4.0 and IIoT, <https://nptel.ac.in/courses/106105195/>.
9. NPTEL – Design of Internet of Things, <https://nptel.ac.in/courses/108108098/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.</b>	<b>Introduction</b>		
1.1	Components of IoT	2	CO1
1.2	Key Terms	2	CO1
<b>2.</b>	<b>Architectures</b>		
2.1	Overview – Industrial internet – Reference Architecture	2	CO2
2.2	IoT System components	2	CO2
<b>3.</b>	<b>Sensor and Interfacing</b>		
3.1	Role of Sensors in IoT	2	CO3
3.2	Sensor architecture special requirements of IoT Sensors	2	CO3
3.3	Actuators and types	2	CO3
3.4	MODBUS and Ethernet	2	CO3
3.5	Interfacing with Arduino	2	CO3
3.6	Interfacing with Raspberry pi	2	CO4
<b>4.</b>	<b>Protocols and Cloud</b>		
4.1	Need and types of Protocols	2	CO4
4.2	Wi-Fi and BLE	2	CO4
4.3	SPI, I2C	2	CO4
4.4.	COAP , MQTT, 6lowpan,SDN	2	CO5
4.5	IoT Cloud Platforms , Fog Computing	2	CO5
4.6	Data analytics and Cloud Services	2	CO5
<b>5.</b>	<b>Applications</b>		
5.1	Smart metering – e-health	4	CO6
5.2	City automation automotive applications		CO6
5.3	Home automation, control applications		CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

Sl. No.	Name	E-mail Id
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2	Mr.S.Parthasarathi	Parthasarathi_s@tce.edu

**18MTPG0****INDUSTRIAL COMMUNICATION  
NETWORKS**Category L T P Credit(s)  
PEES 3 0 0 3**Preamble**

Data communication is the transfer of information from one point to another. Modern instrumentation and automation systems are almost wholly concerned with the transfer of digital data. In the past decade many standards and protocols have been established which allow data communications technology to be used more effectively in industry. Designers and users are beginning to realize the tremendous economic and productivity gains possible with the integration of discrete systems through networks. Protocols are the structures used within a communication system so that one device can talk to another device. Traditionally developers of software and hardware platforms have developed protocols, which only their products can use. In order to develop more integrated automation systems, standardisation of these communication protocols is required.

Standards may evolve from the wide use of one manufacturer's protocol or may be specifically developed by bodies that represent an industry. Standards allow manufacturers to develop products that will communicate with equipment already in use, which for the customer simplifies the integration of products from different sources.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify the components required to build different types of networks	10
CO2	Describe functionality of Physical and data link Layer	20
CO3	Illustrate the concept of networking	20
CO4	Demonstrate Field Bus and Profi Bus communication protocols in industrial network.	20
CO5	Demonstrate Modbus and Hart protocols in industrial network.	20
CO6	Choose the suitable protocol for interconnecting devices through an industrial network.	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.2.3, 2.4.3, 4.4.5
CO2	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.2.3, 2.4.3, 4.4.5
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.3, 4.3.3, 4.4.5, 4.5.4
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.3, 4.4.5
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.3, 4.3.3, 4.4.5, 4.5.4
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.3, 4.3.3, 4.4.5, 4.5.4

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	-	-	-	-	L	L
CO2	M	L	L	-	-	-	-	-	-	-	-	-	L	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	L	M
CO4	M	L	L	-	-	-	-	-	-	-	-	-	L	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	S
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	S

S – Strong9

M – Medium

L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	80	80	40	100	100	100	60
Apply	-	-	40	-	-	-	20
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment - Quiz
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

1. Define protocol.
2. List the advantages of Client Sever over Peer-to-Peer Model.
3. Explain each layer of Open System Interconnection model

#### Course Outcome 2(CO2):

1. Write the significance of the twisting in twisted pair cable.
2. Illustrate the three major classes of wired media.
3. Distinguish unicast and multicast routing.
4. Discuss about the RS- 232 and RS- 485 standards.

#### Course Outcome 3(CO3):

1. Describe the functions of network connecting devices.
2. Distinguish TCP and UDP.
3. Explain need of four segments for connection termination in TCP.
4. List the use of error control in TCP.

**Course Outcome 4 (CO4):**

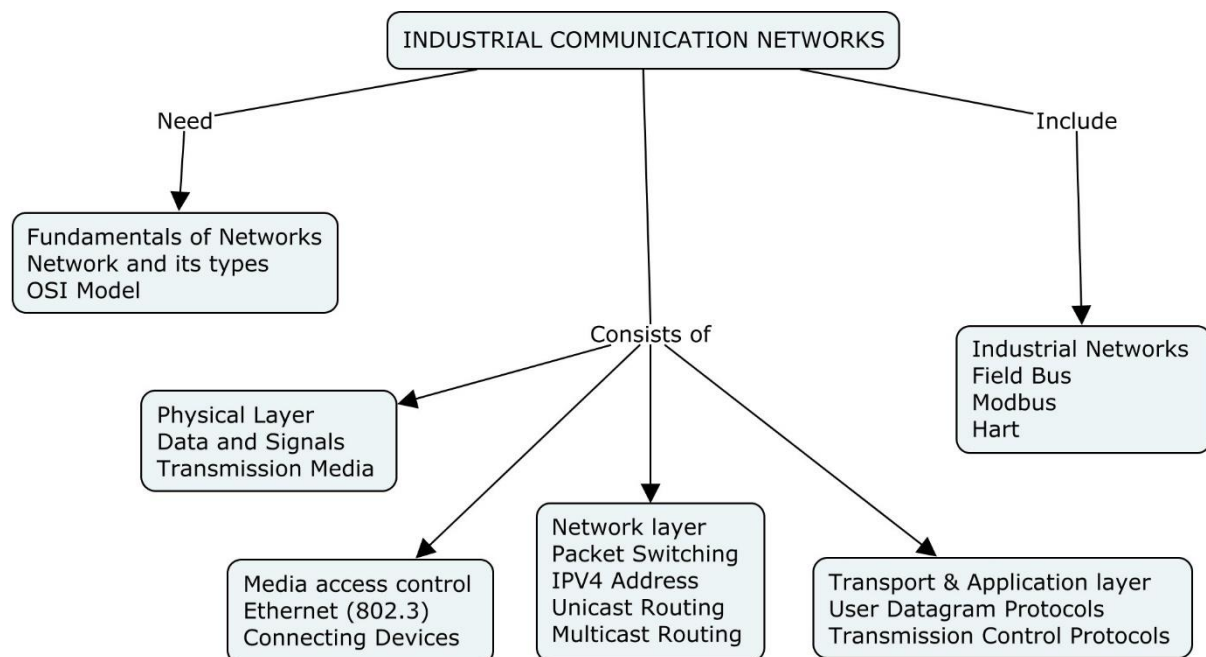
1. Explain the architecture of the Field bus protocol
2. State Cyclic & A Cyclic schedules
3. Name the several versions of the standard in Profi Bus.

**Course Outcome 5 (CO5):**

1. Define HART.
2. Define Encoding & Decoding
3. Distinguish token polling and token passing

**Course Outcome 6 (CO6):**

1. Select the suitable networking standard for process control and large assembly and material handling machines.
2. Choose the open standard protocol to all manufacturers for collected from instruments, sensors, and actuators.
3. Select the suitable protocol for connecting PLC with VFD in master/slave configuration.

**Concept Map****Syllabus****Fundamentals of Networks**

Overview of Data Communications - Data networks in Modern Instrumentation and automation systems- Networks – Building Network and its types – Protocol Layering - OSI Model – Physical Layer – Overview of Data and Signals - Transmission Media - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction - Ethernet (802.3) - Wireless LANs – Connecting Devices

**Networking**

Network layer services – Packet Switching – IPV4 Address - Routing - Unicast Routing - Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6 - Introduction to Transport layer

–Protocols- User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) – Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Application Layer

#### Field Bus and Profi Bus

Field Bus: Features, wiring rules, Data link layer, application layer, user layer – Profi Bus - Physical layer - Data link layer - Application layer - Fieldbus message specification - Lower layer interface - Fieldbus management layer

#### Modbus and Hart

Modbus: general overview, Modbus protocol structure, Function codes - Hart: Hart and smart instrumentation, Hart protocol, physical layer, data link layer, application layer – Device Net - Physical layer - Data link layer - application layer

Case studies aerospace application – transport industry – electric vehicles

### Learning Resources

1. Behrouz A. Forouzan, Data communication and Networkingll, Fifth Edition, Tata McGraw – Hill, 2013
2. Steve Mackay, Edwin Wright MIPENZ, Deon Reynders, John Park “Practical Industrial Data Networks -Design, Installation, troubleshooting”, IDC Technologies, Australia
3. James F. Kurose, Keith W. Ross, —Computer Networking - A Top-Down Approach Featuring the Internetll, Seventh Edition, Pearson Education, 2016.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	Fundamentals of Network		
1.1	Overview of Data Communications - Data networks in Modern Instrumentation and automation systems- Networks	1	CO1
1.2	Building Network and its types – Protocol Layering - OSI Model	2	CO1
1.3	Physical Layer – Overview of Data and Signals - Transmission Media	2	CO2
1.4	Introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction	2	CO2
1.5	Ethernet (802.3) - Wireless LANs – Connecting Devices	2	CO2
2	Networking		
2.1	Network layer services – Packet Switching – IPV4 Address	1	CO3
2.2	Routing - Unicast Routing	1	CO3
2.3	Multicast Routing and its basics – Overview of Intradomain and interdomain protocols	2	CO3
2.4	Overview of IPv6 Addressing – Transition from IPv4 to IPv6 -	2	CO3
2.4	Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) –Services	2	CO3
2.5	TCP Connection	1	CO3

2.6	State Transition Diagram – Flow, Error and Congestion Control - Application Layer	2	CO3
3	Field Bus and Profi Bus		
3.1	Field Bus: Features, wiring rules, Data link layer	1	CO4, CO6
3.2	application layer, user layer	1	CO4, CO6
3.3	Profi Bus - Physical layer - Data link layer	2	CO4, CO6
3.4	Application layer - Fieldbus message specification - Lower layer interface - Fieldbus management layer	2	CO4, CO6
4	Modbus and Hart		
4.1	Modbus: general overview, Modbus protocol structure, Function codes	3	CO5, CO6
4.2	Hart: Hart and smart instrumentation, Hart protocol, physical layer, data link layer, application layer	3	CO5, CO6
4.3	Device Net - Physical layer - Data link layer - application layer	2	CO5, CO6
5	Case studies		
5.1	aerospace application – transport industry	1	CO6
5.2	electric vehicles	1	CO6
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**18MTPL0 ELECTRONIC SYSTEM PACKAGING**

Category	L	T	P	Credit(s)
PEES	3	0	0	3

**Preamble**

Microelectronic packaging is an exciting and rapidly evolving technology of immense impact in the way we live in this modern world. Electronic products have become extremely pervasive and have become an integral part of our daily lives in terms of managing one's daily activities such as communication, travel, entertainment, personal, business transactions, etc. Electronics is an ever-expanding multibillion-dollar worldwide market. Products are being packaged into ever smaller form factors that are lighter, cheaper, faster, and better. Electronic packaging is a multidisciplinary technology comprising several traditional basic sciences and engineering disciplines such as physics, materials science, mechanical, electrical, semiconductor, and software engineering. There is hardly a scientific discipline that does not contribute to, participate in, and impact microelectronic packaging. The pervasive penetration and proliferation of electronic gadgets into the consumer market, the rapid technological innovations and implementations, and the high-volume manufacturing with high yields and throughputs created an increased need and demand for highly trained electronic packaging professionals.

**Prerequisite**

- 18MT340 - Thermal Fluid Engineering

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the first and second level of electronic system packaging	17
CO2	Describe the third level and advanced packing methods	16
CO3	Determine the conduction cooling requirement of electronics equipment	17
CO4	Estimate convection heat transfer requirement for electronic equipment	17
CO5	Select a suitable heat sink for prescribed application	16
CO6	Estimate heat transfer rate and pressure drop in fully developed laminar in microchannels with single phase liquid flow.	17

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2,4.1.4
CO2	TPS2	Understand	Respond	Guided Response	1.1,1.2,2.1,4.1.1,4.4.1
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.1.2,4.4.1
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,,3.1.1,4.1.1,4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	L	L	-	-	-	-
CO2	M	L	-	-	-	-	-	-	L	L	-	-	-	-
CO3	S	M	L	-	-	-	-	-	M	M	-	-	L	L
CO4	S	M	L	-	-	-	-	-	M	M	-	-	L	L
CO5	S	M	L	-	-	-	-	-	M	M	-	-	L	L
CO6	S	M	L	-	-	-	-	-	M	M	-	-	L	L

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini project/quiz
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. List the different types of circuit boards.
2. Explain the different levels of packaging.
3. Explain the design and manufacturing of printed wire boards.

**Course Outcome 2(CO2):**

1. Explain the third level of packaging of chassis and display.
2. List the different advanced packaging techniques.
3. Explain the specialized packaging of MEMS and Sensors.

**Course Outcome 3(CO3):**

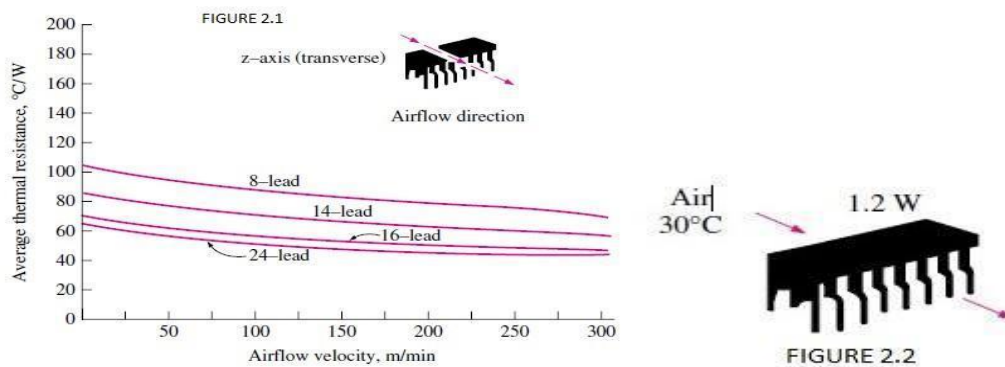
1. A chip is dissipating 0.6 W of power in a DIP with 12 pin leads. The materials and the dimensions of various sections of this electronic device are as given in the table below. If the temperature of the leads is 40°C, estimate the temperature at the junction of the chip.



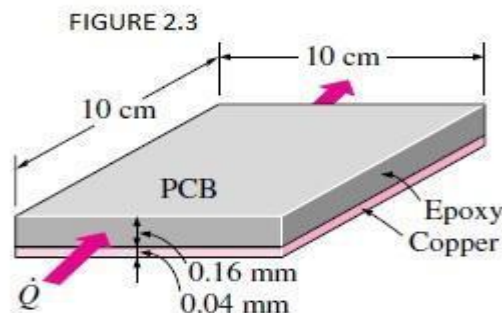
Section and Material	Thermal Conductivity, $W/m \cdot ^\circ C$	Thickness, mm	Heat Transfer Surface Area
Junction constriction	—	—	diameter 0.4 mm
Silicon chip	120†	0.4	3 mm × 3 mm
Eutectic bond	296	0.03	3 mm × 3 mm
Copper lead frame	386	0.25	3 mm × 3 mm
Plastic separator	1	0.2	12 × 1 mm × 0.25 mm
Copper leads	386	5	12 × 1 mm × 0.25 mm

The thermal conductivity of silicon varies greatly with temperature from  $153.5 W/m \cdot ^\circ C$  at  $27^\circ C$  to  $113.7 W/m \cdot ^\circ C$  at  $100^\circ C$ , and the value  $120 W/m \cdot ^\circ C$  reflects the anticipation that the temperature of the silicon chip will be close to  $100^\circ C$ .

- A fan blows air at  $30^\circ C$  at a velocity of  $200 m/min$  over a  $1.2-W$  plastic DIP with 16 leads mounted on a PCB, as shown in Fig. 2.1. Using data from Fig. 2.2, determine the junction temperature of the electronic device. What would the junction temperature be if the fan were to fail?

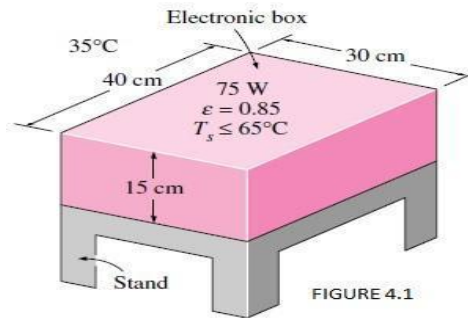


- Heat is to be conducted along a PCB with copper cladding on one side. The PCB is  $10 cm$  long and  $10 cm$  wide, and the thickness of the copper and epoxy layers are  $0.04 mm$  and  $0.16 mm$ , respectively, as shown in Fig. 2.3. Disregarding heat transfer from side surfaces, determine the percentages of heat conduction along the copper ( $k = 386 W/m \cdot ^\circ C$ ) and epoxy ( $k = 0.26 W/m \cdot ^\circ C$ ) layers. Also, determine the effective thermal conductivity of the PCB.



#### Course Outcome 4 (CO4):

- Consider a sealed electronic box whose dimensions are  $15 cm$   $30 cm$   $40 cm$  placed on top of a stand in a room at  $35^\circ C$ , as shown in Fig. 4.1. The box is painted, and the emissivity of its outer surface is  $0.85$ . If the electronic components in the box dissipate  $75 W$  of power and the outer surface temperature of the box is not to exceed  $65^\circ C$ , determine if this box can be cooled by natural convection and radiation alone. Assume the heat transfer from the bottom surface of the box to the stand to be negligible.



2. A cylindrical electronic component whose diameter is 2 cm and length is 4 cm is mounted on a board with its axis in the vertical direction and is dissipating 3 W of power. The emissivity of the surface of the component is 0.8, and the temperature of the ambient air is 30°C. Assuming the temperature of the surrounding surfaces to be 20°C, determine the average surface temperature of the component under combined natural convection and radiation cooling.
3. If an electronic system can be cooled adequately by either forced-air cooling or liquid cooling, which one would you prefer? Why?
4. A logic chip used in a computer dissipates 4 W of power and has a heat transfer surface area of 0.3 cm<sup>2</sup>. If the surface of the chip is to be maintained at 70°C while being cooled by immersion in a dielectric fluid at 20°C, determine the necessary heat transfer coefficient and the type of cooling mechanism that needs to be used to achieve that heat transfer coefficient.

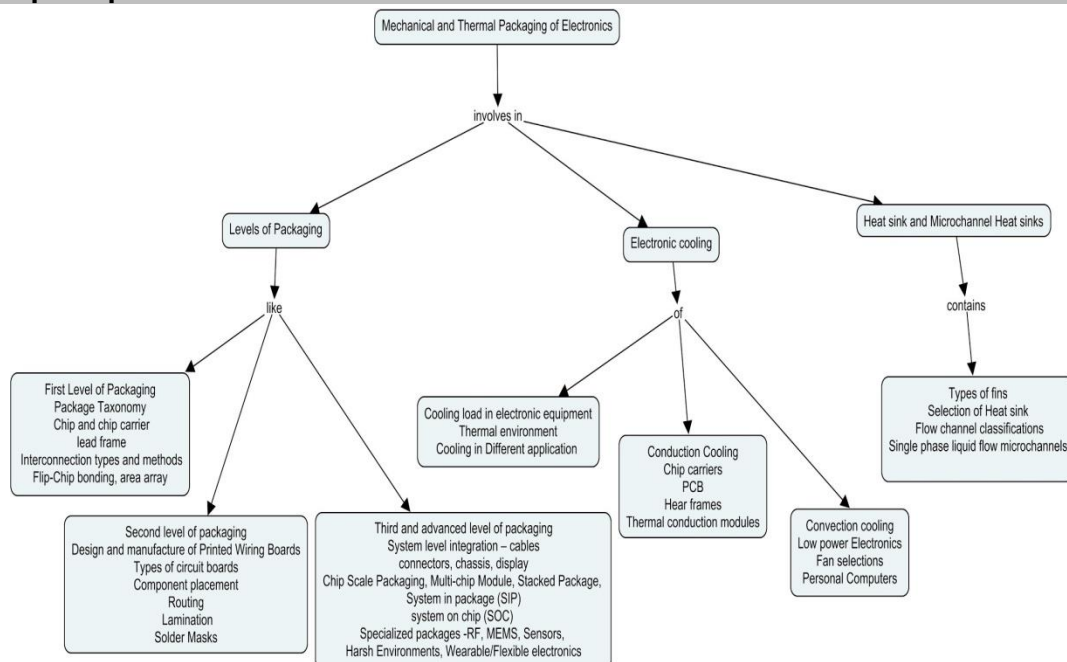
**Course Outcome 5 (CO5):**

1. Define Heat sink?
2. Select a suitable heat sink for Natural convection of any electronic gadgets and interpret the results.
3. Select a suitable heat sink for forced convection of any electronic gadgets and interpret the results.

**Course Outcome 6 (CO6):**

1. Explain the need for small passages in electronic cooling.
2. Prepare a single-phase liquid flow microchannel heat sink for a packaging equipment with specifications.
3. Explain the pressure drop and heat transfer in fully developed laminar flow.

**Concept Map**



## Syllabus

**First and second Level of Electronic Packaging:** Introduction - Electronic Packaging, Levels of Packaging, Wafer fabrication, Recap of Basic Electronics First level packaging – Package Taxonomy, Chip and chip carrier, lead frame, Interconnection types and methods, Flip-Chip bonding, area arrays Second level packaging - Design and manufacture of Printed Wiring Boards, Types of circuit boards, Component placement, Routing, Lamination, Solder Masks

**Third level and advanced Packaging:** Third level packaging and System level integration – cables, connectors, chassis, display - Types of electronics Racks. Advanced Packaging - Chip Scale Packaging, Multi-chip Module, Stacked Package, System in package (SIP), system on chip (SOC) Specialized packages -RF, MEMS, Sensors, Harsh Environments, Wearable/Flexible electronics.

**Electronics cooling-** Introduction-cooling load in electronic equipment, thermal environment and electronics cooling in different applications. Conduction cooling: conduction in chip carriers, conduction in Printed Circuit Boards, Heat frames.

**Convection Cooling:** Air cooling-cooling of low power electronics by natural convection and radiation- cooling of electronics by forced convection-fan selections-cooling of personal computers, liquid cooling.

**Heat sinks** –Fin theory – very long Fin – temperature distribution in fins-heat transfer from fins-fin efficiency – fin effectiveness- selection of heat sink for natural convection and forced convection cooling.

**Microchannel Heat sinks:**Need for small passages-Flow channel Classification-Single phase liquid flow in microchannels-pressure drop and heat transfer in fully developed laminar flow - Advanced cooling techniques: Thermoelectric coolers and Heat pipes - Working Principles and Applications.

## Learning Resources

1. James W. Dally, “**Packaging of Electronic Systems**”, McGraw-Hill Publishing Company
2. Yunus A Cengel, “**Heat Transfer a Practical Approach**”, Tata Mcgraw Hill, 2002
3. Satheesh Kandlikar, Srinivas Garimells, Dongqing Lee and Stephane Colin, “**Heat Transfer and Fluid Flow in minichannels and microchannels**”, Butterworth-Heinemann, an imprint of Elsevier,2014.
4. Rao R Tummala, “**Fundamentals of Microsystems Packaging**”, McGraw-Hill, 2001
5. Puligandla Viswanatham, Essentials of Electronic packaging”, ASME Press, 2011
6. Allan D Kraus and Avram Bar-Cohen “**Thermal Analysis and Control of Electronic Equipment**” Hemisphere Publishing Corporation, 1983.
7. Ralph Remsberg, “**Thermal Design of Electronic Equipment**”, CRC Press, 2001
8. <https://nptel.ac.in/courses/112/105/112105267/> - NPTEL Course on Electronic Packaging and Manufacturing
9. <https://nptel.ac.in/courses/108/108/108108031/> - NPTEL Course on An introduction to Electronic system packaging.
10. [www.electronics-cooling.com](http://www.electronics-cooling.com) – A web resource on cooling of electronics

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>First and second Level of Electronic Packaging</b>		CO1
1.1	Introduction - Electronic Packaging, Levels of Packaging,	1	CO1
1.2	Wafer fabrication, Recap of Basic Electronics First level packaging	1	CO1
1.3	Package Taxonomy, Chip and chip carrier, lead frame, Interconnection types and methods	1	CO1
1.4	Flip-Chip bonding, area arrays	1	CO1
1.5	Second level packaging: Design and manufacture of Printed Wiring Boards	1	CO1
1.6	Types of circuit boards, Component placement, Routing, Lamination, Solder Masks	1	CO1
<b>2.0</b>	<b>Third level and advanced Packaging</b>		CO2
2.1	Third level packaging and System level integration	1	CO2
2.2	cables, connectors, chassis, display, Types of electronic Racks	1	CO2
2.3	Advanced Packaging, Chip Scale Packaging	1	CO2
2.4	Multi-chip Module, Stacked Package	1	CO2
2.5	System in package (SIP), system on chip (SOC)	1	CO2
2.6	Specialized packages, RF, MEMS, Sensors	1	CO2
2.7	Harsh Environments, Wearable/Flexible electronics.	1	CO2
<b>3.0</b>	<b>Electronics cooling</b>		CO3
3.1	Introduction-cooling load in electronic equipment	1	CO3
3.2	thermal environment and electronics cooling, applications	1	CO3
3.3	Conduction cooling: conduction in chip carriers	1	CO3
3.4	conduction in Printed Circuit Boards, Heat frames.	2	CO3
<b>4.0</b>	<b>Convection Cooling</b>		CO4
4.1	Air cooling	1	CO4
	cooling of low power electronics by natural convection and radiation	1	CO4
4.2	cooling of electronics by forced convection	2	CO4
4.3	fan selections	1	CO4
4.4	cooling of personal computers, liquid cooling, immersion cooling.	2	CO4
<b>5.0</b>	<b>Heat sinks</b>		CO5
5.1	Fin theory, very long Fin	1	CO5
5.2	temperature distribution in fins, heat transfer from fins, fin efficiency , fin effectiveness	1	CO5
5.3	selection of heat sink for natural convection	1	CO5
5.4	selection of heat sink for forced convection cooling.	2	CO5
<b>6.0</b>	<b>Microchannel Heat sinks</b>		CO6
6.1	Need for small passages, Flow channel Classification	1	CO6
6.2	Single phase liquid flow in microchannels	2	CO6
6.3	pressure drop and heat transfer in fully developed laminar flow.	2	CO6
6.4	Advanced cooling techniques: Thermoelectric coolers and Heat pipes - Working Principles and Applications.	1	CO6
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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<b>18MTPM0</b>	<b>MOBILE APPLICATION DEVELOPMENT</b>	Category	L	T	P	Credit(s)
		PEES	2	0	2	3

### Preamble

This course provides the basic knowledge and skill to develop mobile applications using Android Programming and also it includes the Android Studio environment setup, APIs for UI design and navigation concepts.

### Prerequisite

- 18MTPK0 - Object Oriented Programming

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Use different data types and appropriate looping structures for the given scenarios	40
CO2	Summarize the object-oriented programming concepts	12
CO3	Demonstrate the architecture of Android and its environment	10
CO4	Apply variety of UI components for designing Mobile Applications	10
CO5	Illustrate the ways to design different types of menus and navigations for a chosen mobile application	12
CO6	Apply appropriate framework and API for developing applications based on the societal or business requirements	16

\*\*\* Weightage depends on number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.5, 2.4.6, 2.5, 4.1, 4.5.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	M	-	-	L	L	L	-	L	M	L
CO2	S	M	L	-	M	-	-	L	L	L	-	L	M	L
CO3	S	M	L	-	M	-	-	L	L	L	-	L	M	L
CO4	S	M	L	-	M	-	-	L	L	L	-	L	M	L
CO5	S	M	L	-	M	-	-	L	L	L	-	L	M	L
CO6	S	M	L	-	M	-	-	L	L	L	-	L	M	L

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	-	-	-	-	-	-
Understand	60	20	20	-	-	-	40
Apply	20	80	80	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	40
Mechanism	60
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Write an android code for generate a notification when the particular location reached.
2. Design a Feedback form of an event and perform validation. Write code.
3. Design two activities to with proper navigation mechanisms such as link, button, menu etc. Write code.

**Course Outcome 2 (CO2):**

1. Design an app to enter the Name of the book and ISBN number and click on Add Book. Write code.
2. Design an app to click on Show Books to view the contents added so far.
3. Design an app to search for a book from querying author details.

**Course Outcome 3 (CO3):**

1. Design an app with music player.
2. Design an app to play, stop, and pause a video.

3. Design an animated app for demonstrating the working principle of an algorithm

**Course Outcome 4 (CO4):**

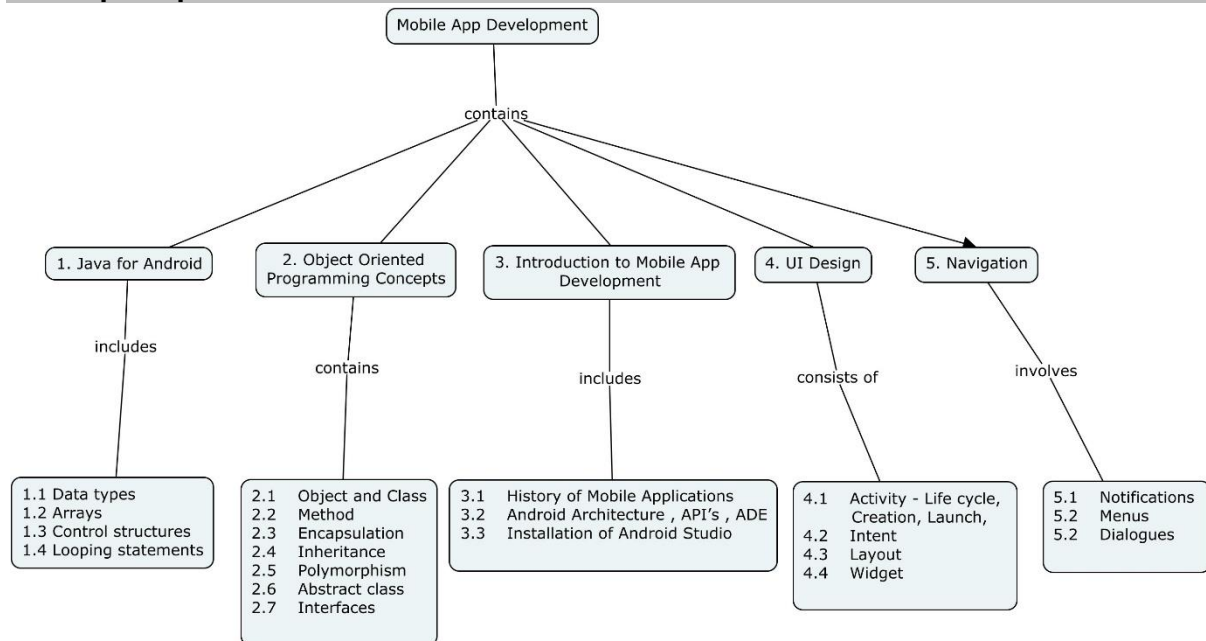
1. Implement a camera enabled application for capturing video or image.
2. Implement a Bluetooth enabled application for controlling a system.
3. Design an app with WiFi support API for transmitting signals to a system.

**Course Outcome 5 (CO5):**

1. Create a web service for providing a hall booking service in a company.
2. Implement JSON parsing of a book store application.
3. Implement XML parsing of a bus reservation application.

**Course Outcome 6 (CO6):**

CO6 is assessed using Assignments

**Concept Map****Syllabus**

**Java for Android** -Data types, Arrays, Control structures, Looping statements

**Object Oriented Programming Concepts** - Object and Class, Method, Encapsulation, Inheritance, Polymorphism, Abstract class and Interfaces

**Introduction to Android** - History of Mobile Applications, Android Architecture, API's, ADE, Installation of Android Studio

**UI Design** - Activity - Life cycle, Creation, Launch, Intent, Layout , Widget

**Navigation** - Notifications, Menus, Dialogues

**Learning Resources**

1. Herbert Schildt, "Java : The Complete Reference", McGraw-Hill. Ninth Edition, 2014.
2. RetoMeier, "Professional Android Application Development 4", Wrox, 2012.
3. Dawn Griffiths, David Griffiths, "Head First Android Development", Shroff/O'Reilly 2<sup>nd</sup> Edition, 2017.
4. <https://developer.android.com>

**Course Contents and Lecture Schedule**

Module No	Topic	No. of Lecture Hours	Course Outcome
<b>1</b>	<b>Java for Android</b>		
1.1	Data types	1	CO1
1.2	Arrays	2	
1.3	Control structures	1	
1.4	Looping statements	1	
<b>2</b>	<b>Object Oriented Programming Concepts</b>		
2.1	Object and Class	2	CO2
2.2	Method	2	
2.3	Encapsulation	2	
2.4	Inheritance	2	
2.5	Polymorphism	2	
2.6	Abstract class	2	
2.7	Interfaces	2	
<b>3</b>	<b>Introduction to Mobile App Development</b>		
3.1	History of Mobile Applications	1	CO3
3.2	Android Architecture , API's , ADE	1	
3.3	Installation of Android Studio	1	
<b>4</b>	<b>UI Design</b>		
4.1	Activity - Life cycle, Creation, Launch,	2	CO4
4.2	Intent	2	
4.3	Layout	2	
4.4	Widget	2	
<b>5</b>	<b>Navigation</b>		
5.1	Notifications	2	CO5
5.2	Menus	2	
5.2	Dialogues	2	
	<b>Total Hours</b>	<b>36</b>	

**Course Designers:**

Sl. No.	Name	E-mail Id
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**18MTPQ0 DEEP LEARNING AND ITS APPLICATIONS** Category L T P Credit(s)  
PEES 3 0 0 3

**Preamble**

Deep learning transmits out the machine learning process using an artificial neural network that is self-possessed of a number of stages arranged in a hierarchy. The network learns something simple at the initial level in the hierarchy and then sends this information to the next level. Currently many industrial applications introduced deep learning networks to power image recognition and tagging etc.

**Prerequisite**

- 18MT350 - Programming for problem solving
- 18MT410 - Probability and Statistics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the architecture and basic concepts of deep learning	10
CO2	Describe the various topologies of neural network system.	20
CO3	Illustrate the classification and functional parameters of deep learning network	10
CO4	Develop an algorithm and functional parameters for deep learning network.	20
CO5	Select appropriate deep learning network for given applications.	20
CO6	Design deep learning network algorithm and characteristics for given industrial application.	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO2	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6
CO3	TPS3	Apply	Value	Mechanism	2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4,2.5.4,3.1.5
CO4	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	L	-	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO3	S	M	L	-	-	L	-	-	M	-	-	L	M	M
CO4	S	M	L	-	M	-	-	-	M	-	-	L	M	M
CO5	S	M	L	-	M	L	-	-	M	-	-	L	S	M
CO6	S	M	L	-	M	L	-	-	M	L	-	L	S	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	
Set	
Guided Response	Flipped classroom, Active Learning Techniques.
Mechanism	Simulation design, Mini Projects
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Compare the significance of deep learning over machine learning.
2. Describe the architecture of neural network system.

**Course Outcome 2 (CO2):**

1. Explain the feed forward multi neural network topology with neat flow diagram.
2. Explain the single layer and multi-layer perceptron.

**Course Outcome 3 (CO3):**

1. Illustrate the activation function and loss function in neural network system with examples.
2. Illustrate the role of ReLu and tanh in deep learning application with neat block diagram

**Course Outcome 4 (CO4):**

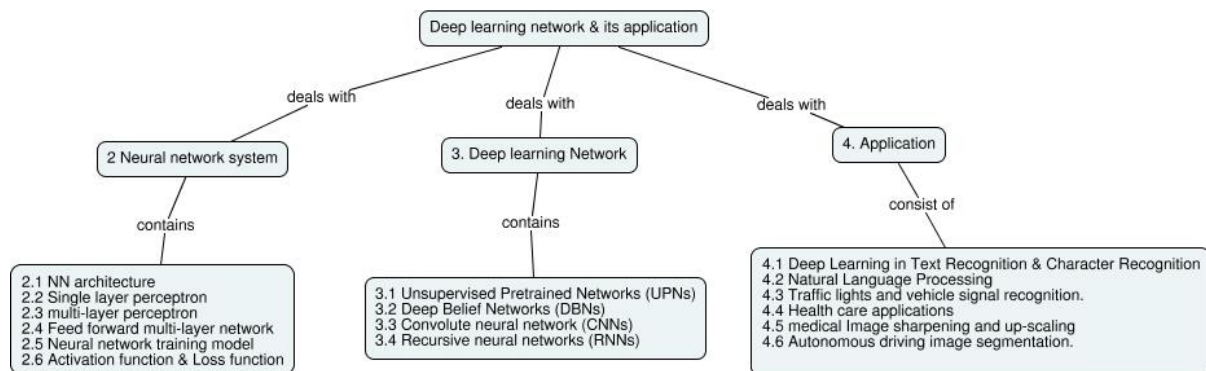
1. Design and develop the pseudocode for the convolute neural network with neat topology sketch.
2. Design and develop the pseudocode and activation function parameter for Regression neural network with appropriate topology graph.

**Course Outcome 5 (CO5):**

1. Select suitable deep learning network and algorithm pseudocode for character recognition in vehicle number plate application.
2. Develop appropriate deep learning topology for city traffic control system in congested environment.

**Course Outcome6(CO6):**

1. Design unsupervised learning algorithm for autonomous vehicle vision-based navigation system.
2. Design deep learning network algorithm for image sharpening and diagnosing of cancer patient images as provided as dataset. Justify the need of deep learning algorithm in this medical application.

**Concept Map****Syllabus**

**Introduction:** Learning Machines - difference between Machine learning and Deep Learning -Role of deep learning in Mechatronics application - Introduction to regression, classification, clustering, optimization and confusion matrix – building machine learning models - evaluation of Machine learning models.

**Neural Network and its architecture:** Biological to artificial – NN architecture - single layer perceptron – Multi layer perceptron –feed forward multi-layer network topology - Training of Neural network – Learning techniques – Activation functions like sigmoid, tanh, linear, rectified linear (ReLU) and Loss functions.

**Deep learning Networks:**Unsupervised Pretrained Networks (UPNs) - Deep Belief Networks (DBNs) -Convolute neural network (CNNs) - Recursive neural networks (RNNs) – convolution layers- Max pooling.

**Applications of Deep learning:**Deep Learning in Text Recognition - Character Recognition -Natural Language Processing – Traffic lights and vehicle signal recognition.

Health care applications – medical Image sharpening and upscaling – Autonomous driving image segmentation.

**Learning Resources**

1. Kaizhu Huang, Amir Hussain, Qiu-Feng Wang, Rui Zhang - Deep Learning\_ Fundamentals, Theory and Applications-Springer International Publishing (2019)
2. Josh Patterson, Adam Gibson - Deep Learning\_ A Practitioner's Approach-O'Reilly Media (2017)
3. Witold Pedrycz, Shyi-Ming Chen - Deep Learning\_ Algorithms And Applications-Springer (2020)

4. Valentina Emilia Balas, Sanjiban Sekhar Roy, Dharmendra Sharma, Pijush Samui - Handbook of Deep Learning Applications-Springer (2019)
5. Leondes C.T. (Ed.) - Neural Network Systems Techniques and Applications. Volume 1. Algorithms and Architectures
6. <https://www.coursera.org/learn/neural-networks-deep-learning>
7. <https://www.coursera.org/specializations/deep-learning>
8. <https://nptel.ac.in/courses/106/106/106106184/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	<b>Introduction:</b>		
	Learning Machines - difference between Machine learning and Deep Learning - Role of deep learning in Mechatronics application	2	CO1
	Introduction to regression, classification, clustering, optimization and confusion matrix	2	CO1
	Building machine learning models	1	CO2
	Evaluation of Machine learning models.	1	CO2
2	<b>Neural Network and its architecture:</b>		
	Biological to artificial – NN architecture	1	CO1
	Single layer perceptron & Multi-layer perceptron	2	CO2
	Feed forward multi-layer network topology -	1	CO2
	Training of Neural network – Learning techniques	2	CO3
	Activation functions like sigmoid, tanh, linear, rectified linear (ReLU) and Loss functions.	2	CO3
3	<b>Deep learning Networks:</b>		
	Unsupervised Pretrained Networks (UPNs)	2	CO4
	Deep Belief Networks (DBNs)	2	CO4
	Convolute neural network (CNNs)	2	CO4
	Recursive neural networks (RNNs) – convolution layers- Max pooling.	3	CO4
4	<b>Applications of Deep learning:</b>		
	Deep Learning in Text Recognition - Character Recognition	3	CO5
	Natural Language Processing –	1	CO5
	Traffic lights and vehicle signal recognition.	2	CO6
	Health care applications	2	CO6
	medical Image sharpening and upscaling	2	CO5
	Autonomous driving image segmentation.	3	CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

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**18MTPR0 CONTROL OF MOBILE ROBOTS**

Category	L	T	P	Credit(s)
PEES	3	0	0	3

**Preamble**

Robotics is the interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation as well as control, sensory feedback, and information processing. In the 20<sup>th</sup> century, engineers have mastered almost all forms of motion control and have proven that robots and machines can perform almost any job made by humans. Control of Mobile Robots deals with the types of control algorithms used in by mobile robots in industries to do a particular task.

**Prerequisite**

- 18MT510 - Control System

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Review the control parameters of mobile robot	5
CO2	Interpret the conventional models used in algorithm design	20
CO3	Compute PID regulation and state space model to control the actuators	20
CO4	Predict the controllability, observability and stability of a mobile robot	15
CO5	Develop an appropriate control system for an application	20
CO6	Implement the developed control algorithm to a particular robot environment	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1, 4.3.2
CO3	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.1,2.1.2, 2.1.4, 2.1.5, 2.4.6, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.6, 4.3.1, 4.3.2
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 2.4.6, 4.3.1, 4.3.2
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3, 2.1.4,2.1.5, 2.3.2, 2.4.3,2.4.4,2.4.6, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 4.3.1, 4.3.2, 4.4.5,4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	L	L	-	-	-	-	-	S	S	S
CO2	M	L	-	-	L	L	-	-	-	-	-	S	S	S
CO3	S	M	L	-	S	M	-	-	S	-	-	S	S	S
CO4	S	M	L	-	S	M	-	-	S	-	-	S	S	S
CO5	S	M	L	-	S	M	-	-	S	-	-	S	S	S
CO6	S	M	L	-	S	M	-	-	S	-	S	S	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	40	20	20	-	-	-	20
Understand	40	40	40	100	-	-	20
Apply	20	40	40	-	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	
Set	
Guided Response	
Mechanism	Mini Project
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

- List the control parameters of the mobile robot used in autonomous floor cleaning robot.
- Is the number of parameters fixed for a particular application? Justify with reasons.
- Describe the effect of slip in ground mobile robots.

**Course Outcome 2 (CO2):**

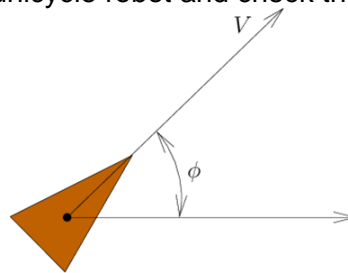
- Draw the Odometry model and explain its control logic to localize the robot for navigation
- Explain the unicycle robot with its control model
- List the general assumptions used to model an autonomous ground robot

**Course Outcome 3 (CO3):**

- Compute the PID control parameters to control the actuators and the trajectory of the mobile robot.
- Apply the state space control model to the point robot and analyse the behavior of the robot
- Apply the PID control and state space control to control the actuators and sensors of the mobile robot

**Course Outcome 4 (CO4):**

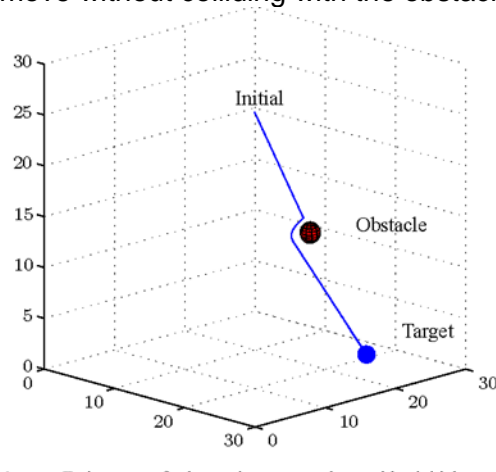
1. Derive Lyapunov function and explain how does this improve the stability of the developed control algorithm
2. Derive Eigen values for the unicycle robot and check the stability of the robot



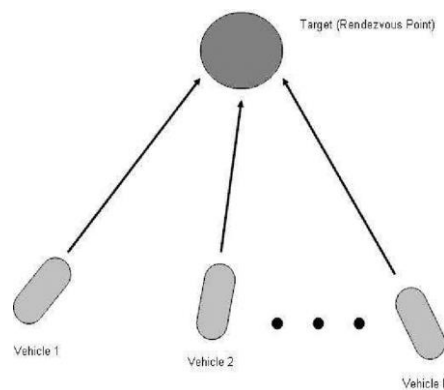
3. Derive the Eigen values of the state space model of point mass robot and predict the stability of the robot. Use pole placement method to make the robot completely controllable.

**Course Outcome 5 (CO5):**

1. A robot wants to move from initial position to target position in an indoor environment. The robot uses odometry and lidar sensors for localization. Develop a control algorithm to use the senses and move without colliding with the obstacle.

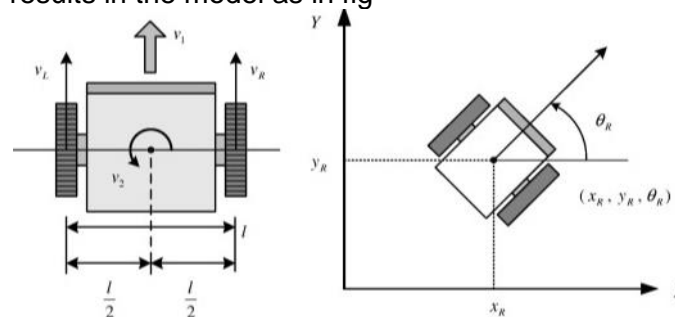


2. Apply sliding mode control to make a differential robot completely controllable and completely observable
3. Derive the rendezvous problem for a set of 3 robots and develop a control algorithm for the same

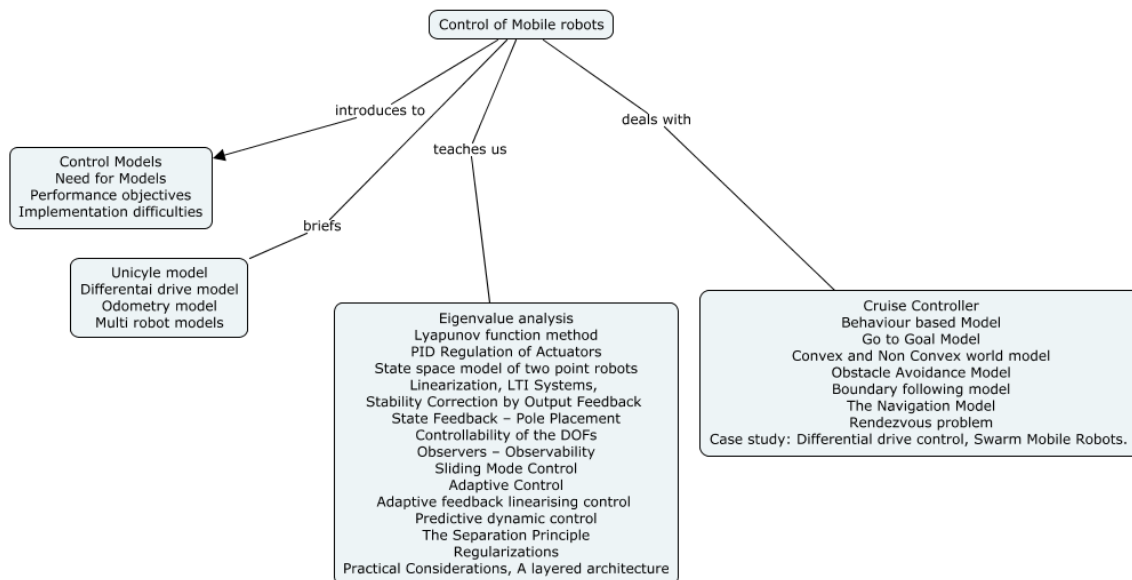


**Course Outcome 6 (CO6):**

1. Implement a control algorithm to avoid rendezvous problem and analyze the stability, controllability and observability. Suggest some methods to improve the control parameters.
2. Analyze the goto goal model and list the practical considerations. Implement the model and analyze the results in the model as in fig



**Concept Map**



**Syllabus**

**Introduction**

Need for control in Mobile robots, Mobility - Wheeled – legged, Issues in locomotion, Control Design – Performance objectives – Control methods in robotics – Implementation difficulties.

**Robot Parameters for Modelling**

Control Parameters, General Assumptions, and Models – Sensors - Odometry – LIDAR - GPS - Single point robot - Unicycle robot - Differential drive robot Car like Robots – Multi Robot models.

**Control Algorithm design for Robotic systems**

Stability Analysis of actuators- Eigenvalue analysis and Lyapunov function method, PID Regulation of Actuators, State space model of two point robots, Linearization, LTI Systems, Stability Correction of by Output Feedback – State Feedback – Pole Placement, Controllability of the DOFs – Observers – Observability, Sliding Mode Control, Adaptive Control – Adaptive



feedback linearising control, Predictive dynamic control, The Separation Principle, Regularizations, Practical Considerations, A layered architecture.

### Robot Control Models

Cruise Controller, Behaviour based Model - Go to Goal Model by A\* Algorithm– Convex and Non Convex world model – Obstacle Avoidance Model - Boundary following model – The Navigation Model using Neural Networks– Rendezvous problem - **Case study:** Differential drive control, Swarm Mobile Robots coordination.

### Learning Resources

1. Shuai Li, Long Jin, Mohammed Aquil Mirza, "Kinematic Control of Redundant Robot Arms Using Neural Networks", IEEE press, April 29, 2019.
2. John J Craig, "Introduction to Robotics, Mechanics and Control, third edition, Pearson education, 2005
3. K.S.Fu, R.C Gonzalez and C.S Lee, Robotics – Control, sensing Vision and Intelligence, Tata McGraw – Hill Editions, 2008.
4. Roland Siegwart and Illah R Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2004.
5. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008.
6. Saeed B Niku, "Introduction to Robotics, Analysis, System, Applications," second edition, John Wiley, 2010.
7. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, "Industrial Robotics – Technology, Programming and Applications", Tata McGraw Hill Edition, 2008.
8. Robert J Schilling, Fundamentals of Robotics: Analysis and Control", Indian reprint, Prentice hall of India Private Limited, 1996

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction</b>		
1.1	Need for control in Mobile robots	1	CO <sub>1</sub>
1.2	Mobility - Wheeled – legged, Issues in locomotion Control Design	1	CO <sub>1</sub>
1.3	Performance objectives	1	CO <sub>1</sub>
1.4	Control methods in robotics	1	CO <sub>1</sub>
1.5	Implementation difficulties	1	CO <sub>1</sub>
1.6	Application of robots in machining - Welding - Assembly	1	CO <sub>1</sub>
1.7	Material handling - Loading and unloading Inspection	1	CO <sub>1</sub>
1.8	Palletizing - Hostile and remote environments	1	CO <sub>1</sub>
<b>2.0</b>	<b>Robot Parameters for Modelling</b>		
2.1	Control Parameters, General Assumptions	1	CO <sub>2</sub>
2.2	Models – Sensors – Odometry	1	CO <sub>2</sub>
2.3	Single point robot - Unicycle robot	1	CO <sub>2</sub>
2.4	Differential drive robot Car like Robots	1	CO <sub>2</sub>
2.5	Multi Robot models	1	CO <sub>2</sub>
<b>3.0</b>	<b>Control Algorithm design for Robotic systems</b>		
3.1	Stability Analysis of actuators - Eigenvalue analysis	1	CO <sub>3</sub>
3.2	Lyapunov function method	1	CO <sub>3</sub>
3.3	PID Regulation of Actuators	1	CO <sub>3</sub>
3.4	State space model of two point robots	1	CO <sub>3</sub>

3.5	Linearization, LTI Systems	1	CO <sub>3</sub>
3.6	Stability Correction by Output Feedback	1	CO <sub>4</sub>
3.7	State Feedback – Pole Placement	1	CO <sub>4</sub>
3.8	Controllability of the DOFs – Observers	1	CO <sub>4</sub>
3.9	Observability	1	CO <sub>4</sub>
3.10	Sliding Mode Control, Adaptive Control	1	CO <sub>4</sub>
3.11	Adaptive feedback linearising control	1	CO <sub>4</sub>
3.12	Predictive dynamic control	1	CO <sub>4</sub>
3.13	The Separation Principle	1	CO <sub>4</sub>
3.14	Regularizations, Practical Considerations	1	CO <sub>4</sub>
3.15	A layered architecture.	1	CO <sub>4</sub>
4.0	<b>Robot Control Models</b>		
4.1	Cruise Controller, Behaviour based Model	1	CO <sub>5</sub>
4.2	Go to Goal Model by A* Algorithm – Convex and Non Convex world model	1	CO <sub>5</sub>
4.3	Obstacle Avoidance Model - Boundary following model	1	CO <sub>5</sub>
4.5	The Navigation Model using Neural Networks	1	CO <sub>5</sub>
4.6	Rendezvous problem	1	CO <sub>5</sub>
4.7	Case study: Differential drive control, Swarm Mobile Robots coordination	1	CO <sub>6</sub>
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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SYLLABI

For

**B.E. Mechatronics Program**

General Electives

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 59<sup>th</sup> Academic Council Meeting on 07.12.2019

**18MTGA0****MECHATRONICS**

Category	L	T	P	Credit(s)
GE	3	0	0	3

**Preamble**

Mechatronics is the synergistic combination of mechanical and electrical engineering, computer science, and information technology, which includes the use of control systems as well as numerical methods to design products with built-in intelligence. It involves study of sensors, actuators, controlling mechanism/algorithm and common Mechatronics applications. the synergistic combination of all the aspects of Mechatronics which would be useful in developing a particular application.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe mechatronics and appreciate design process.	5
CO2	Illustrate the working of sensors used in the measurement of position, velocity, force, fluid pressure and temperature.	15
CO3	Demonstrate the working of electrical, mechanical, hydraulic and pneumatic actuator.	20
CO4	Illustrate the open loop and closed loop system determine the transfer function.	20
CO5	Describe the working principle, selection criteria, I/O modules of PLC.	15
CO6	Develop a program using PLC to solve given problem.	10
CO7	Demonstrate the working conventional mechatronics systems	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO2	TPS2	Understand	Respond	-	1.1,1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.3, 2.4.3, 2.4.4, 3.2.6, 3.3.1, 4.4.5
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.3, 2.4.3, 2.4.4, 3.2.6, 3.3.1, 4.4.5
CO5	TPS2	Understand	Respond	-	1.1,1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.3, 2.4.3, 2.4.4, 3.2.6, 3.3.1, 4.4.5
CO7	TPS2	Understand	Respond	-	1.1,1.2, 2.1.1, 2.1.2, 2.4.3, 2.4.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	-	M	M	-	-
CO4	S	M	L	-	-	-	-	-	L	L	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-
CO6	S	M	L	-	-	-	-	-	M	M	-	-
CO7	M	L	-	-	-	-	-	-	-	-	-	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	80	50	50	100	-	-	50
Apply	-	30	30		100		30
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment I
Mechanism	Assignment II & III - Mini-project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define Mechatronics
2. List the key elements of mechatronics system.
3. Difference between the traditional and mechatronics designs.

**Course Outcome 2(CO2):**

1. List the types of position sensors.
2. Explain the significance of incremental optical encoder.
3. Elucidate difference of RTD from Thermocouple

**Course Outcome 3(CO3):**

1. Make Difference between pressure relief valve and pressure reducing valve
2. Develop a hydraulic circuit for Clamp and drilling operation. use at least two cylinders. One-cylinder advances first and clamps the work piece in a fixture. Then the other cylinder moves in with tools for drilling operation on the work piece cylinder
3. Describe about unipolar and bipolar stepper motor drive.

**Course Outcome 4 (CO4):**

1. Define control system.
2. List the advantages of PID controller.
3. Describe about the effect of step signal on first order systems.

**Course Outcome 5 (CO5):**

1. Define PLC.
2. Name the different language of programming in PLC.
3. Explain the parts and functions of PLC.
4. Illustrate the discrete I/O module of PLC with neat diagram.

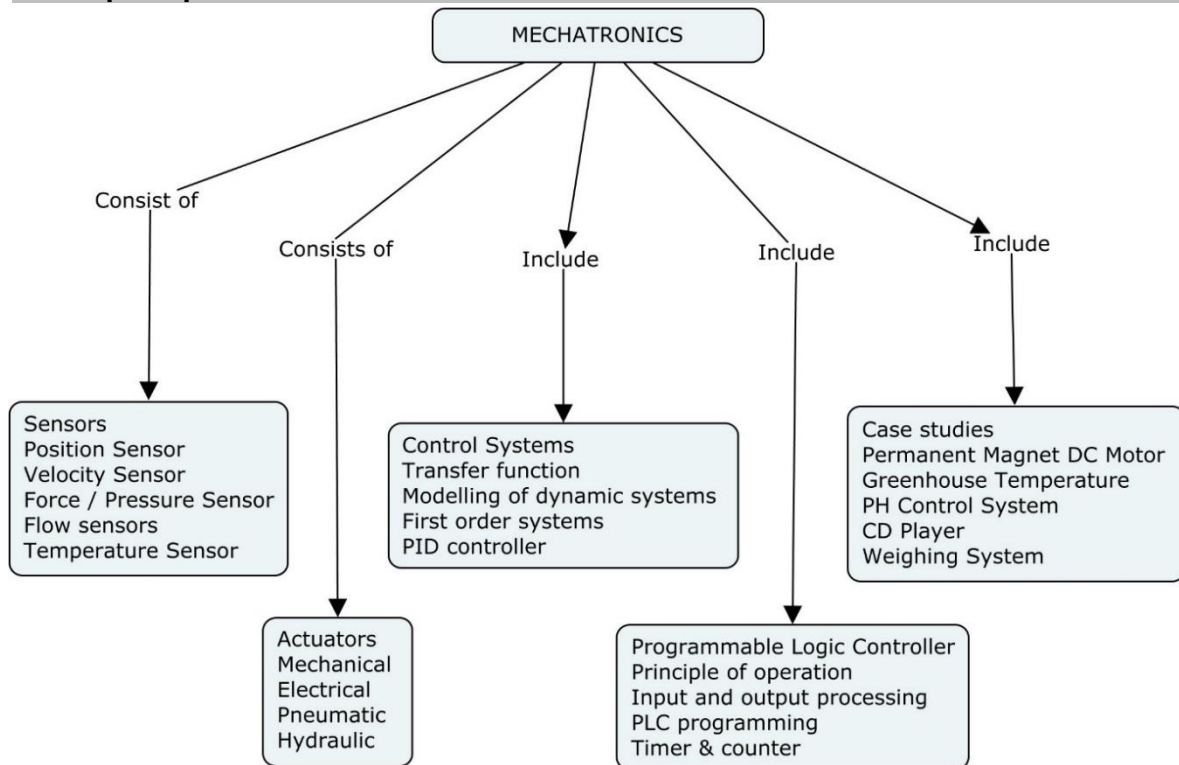
**Course Outcome 6 (CO6):**

1. Develop a ladder diagram for Sequential delay output (starting 3 motors sequentially) system having the following conditions. Starting the oil pump motor immediately when START is pressed. The main motor will be started after a 10 sec delay and then the auxiliary motor will be started after a 5 sec delay. In addition, stopping all motors immediately when STOP is pressed.
2. When the lights are turned off in a building, an exit door light is to remain on for an additional 2 min, and the parking lot lights are to remain on for an additional 3 min after the door light goes out. Write a program to implement this process.

**Course Outcome 7 (CO7):**

1. Design a system to control the water temperature of a mixing valve fed by two reservoirs. Output temperature is measured by a thermistor. The voltage of thermistor is utilized as an analog input to data acquisition cards. The simulation returns the temperature of water. The position of the valve is monitored by reading voltage across the potentiometer. The simulation and control program determine the position of the valve. The valve is controlled by 0 to 5 volt output. The thermistor is 0 to 2.5 volts.
2. Illustrate about the wiper control in automobile.

**Concept Map**



## Syllabus

### Introduction to Mechatronics

Introduction, Need, design process -Electrical, Mechanical, Electronics systems, Software, Interfacing.

### Sensors

Performance terminology - Position Sensors - Potentiometer, Differential transformers, Proximity sensor, Hall effect sensors - Velocity Sensors: - Optical encoders, Tachogenerator; Force / Pressure Sensors -Strain gauges - Flow sensors - Turbine meter - Temperature Sensor - Bimetallic strips, RTD, Thermistors, Thermocouples.

### Actuators

Mechanical Actuating Systems - Mechanical systems - Cams, Gears, Ratchet and Pawl, Belt & chain drives - Electrical Actuating Systems - Solenoids, DC Motors, Servomotors, Stepper motors - Pneumatic and Hydraulic systems - directional control valves, pressure control valves, Cylinders, Pneumatics & Hydraulic circuits

### Control Systems

System - Transfer function - open loop and closed loop system - Modelling of dynamic systems - First order systems – Controllers - ON – OFF Control - Effect of P, I, D on PID controller.

### Programmable Logic Controller

Introduction to PLC - Basic structure of PLC - Principle of operation - input and output processing - PLC programming language - ladder diagram – timer – counter - internal relay - selection of PLC for application.

### Case studies

Washing machine - Automated Teller Machine - Air bag system - Cruise control - Wiper motion control - PH Control System - pick and place robot

## Learning Resources

1. W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd., 2015.
2. Shetty and Kolk, "Mechatronics System Design", Cengage learning, India, second edition, 2011.
3. Frank D petruzella, "Programmable logic controllers", Fourth edition, McGraw Hill higher education ,2016
4. Richard C. Dorf, Robert H. Bishop, "Modern Control Systems" Twelfth Edition, Pearson Education, 2014.

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	Introduction to Mechatronics		
1.1	Introduction, Need, design process -Electrical, Mechanical, Electronics systems, Software, Interfacing	2	CO1
2	Sensors		
2.1	Performance terminology	1	CO2
2.2	Position Sensors - Potentiometer, Differential transformers, Proximity sensor, Hall effect sensors	2	CO2
2.3	Velocity Sensors: - Optical encoders, Tachogenerator; Force / Pressure Sensors -Strain gauges	1	CO2

2.4	Flow sensors - Turbine meter - Temperature Sensor - Bimetallic strips, RTD, Thermistors, Thermocouples	2	CO2
3	Actuators		
3.1	Mechanical Actuating Systems - Mechanical systems - Cams, Gears	1	CO3
3.2	Ratchet and Pawl, Belt & chain drives	2	CO3
3.3	Electrical Actuating Systems - Solenoids, DC Motors,	1	CO3
3.4	Servomotors, Stepper motors	1	CO3
3.5	Pneumatic and Hydraulic systems - directional control valves	2	CO3
3.6	pressure control valves, Cylinders	1	CO3
3.7	Pneumatics & Hydraulic circuits	2	CO3
4	Control Systems		
4.1	System - Transfer function - open loop and closed loop system	2	CO4
4.2	Modelling of dynamic systems - First order systems	2	CO4
4.3	Controllers - ON – OFF Control - Effect of P, I, D on PID controller	2	CO4
5	Programmable Logic Controller		
5.1	Introduction to PLC - Basic structure of PLC - Principle of operation	2	CO5
5.2	input and output processing	1	CO5
5.3	PLC programming language - ladder diagram	2	CO5, CO6
5.4	timer – counter - internal relay - selection of PLC for application	2	CO5, CO6
6	Case studies		
6.1	Washing machine - Automated Teller Machine- PH Control System	2	CO7
6.2	Air bag system - cruise control - wiper motion control	2	CO7
6.3	pick and place robot	1	CO7
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**18MTGB0****SENSORS**

Category	L	T	P	Credit(s)
GE	3	0	0	3

**Preamble**

Sensors find wide range of applications in the area of Industry, Robotics, Home automation, Consumer electronics, Medicine, etc. Sensors helps measurements by generating electric signals with embedded information about the measurand. Processing is done on the signals obtained from the sensors by using electronic circuits to extract that information. This course describes the basics of sensors, their static and dynamic characteristics, Signal conditioning, Sensor working principles and smart sensors.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Classify the sensors and transducers.	10
CO2	Determine the static and dynamic characteristics of sensors	10
CO3	Illustrate the basic principles of sensors	25
CO4	Select appropriate signal conditioning circuit for a sensor system	15
CO5	Determine the sensor measurements for the given parameters	30
CO6	Demonstrate the functionality of smart sensors	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2,4.3.2
CO2	TPS3	Apply	Value	-	1.2,4.3.2
CO3	TPS2	Understand	Respond	-	1.1.2,1.1.3,1.1.4, 1.2
CO4	TPS3	Apply	Value	-	1.2, 1.2
CO5	TPS3	Apply	Value	Mechanism	1.1.2,1.1.3,1.1.4, 1.2, 2.1.3,4.1.2, 4.4.3
CO6	TPS2	Understand	Respond	-	1.1.2,1.1.3, 1.2, 4.1.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	-	M	-	-	-	-	-	-	-	-	-
CO2	S	S	-	-	-	-	-	-	-	-	-	-
CO3	S	-	M	-	-	-	-	-	-	-	-	M
CO4	S	S	M	-	-	-	-	-	-	-	-	-
CO5	S	S	M	-	S	M	M	-	S	S	-	M
CO6	S	M	M	-	-	M	M	-	-	-	-	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	60	60	60	100	100	-	50
Apply	20	20	20	-	-	100	30
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Quiz
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define sensor.
2. Distinguish between active and passive sensor.
3. List any three physical conversion phenomenon employed in a sensor.

**Course Outcome 2(CO2):**

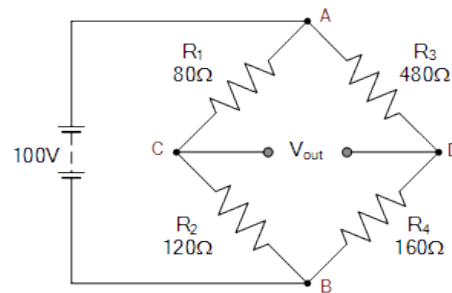
1. A pressure transducer has a natural frequency of 30 rad/s, damping ratio of 0.1 and static sensitivity of 1.0  $\mu\text{V}/\text{Pa}$ . A step pressure input of  $8 \times 10^5 \text{ N/m}^2$  is applied. Determine the output of a transducer
2. A sensor has a scale of 0 - 2.50 V. It shows a voltage 1.5 V while the true value is 1.75. Find absolute error, absolute correction and relative error
3. The rise time of a thermistor response is 0.5 s and the relation between the rise time and the bandwidth is  $\tau_{rise} = 1/(4\Delta f)$ .
  - a. Calculate the magnitude of the thermal noise. The ambient temperature is 27°C and the thermistor resistance is 10 k $\Omega$  at this temperature.
  - b. Find the signal-to noise ratio, if the average of current passing through the resistor is 0.2 mA.

**Course Outcome 3(CO3):**

1. Explain about Seebeck, Peltier and Thomson Effects.
2. Discuss about Capacitance and dielectric constant.
3. List the various methods of heat transfer.

**Course Outcome 4(CO4):**

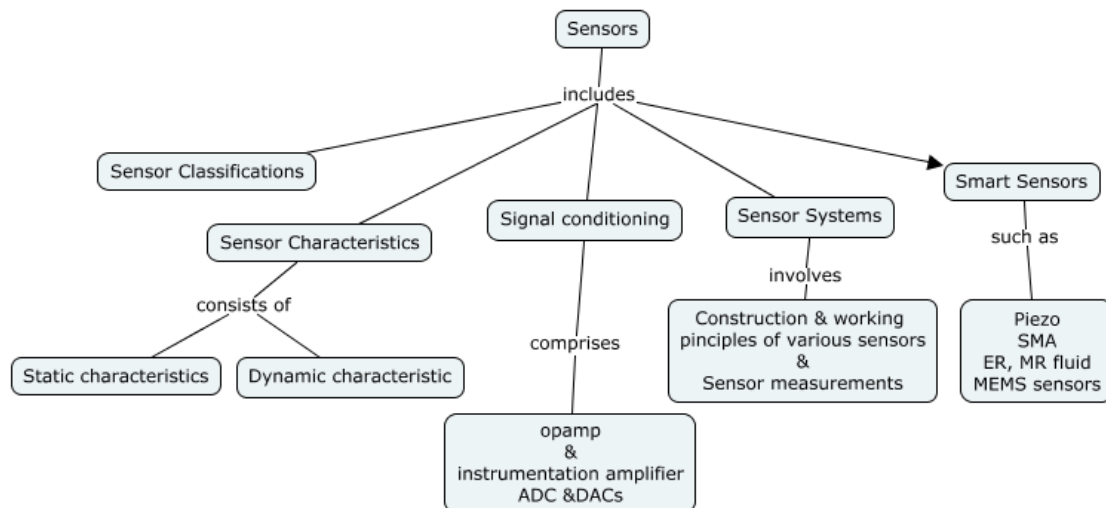
1. Illustrate how instrumentation amplifier can be used for conditioning a sensor signal.
2. Find the resolution of a linear 8-bit ADC with 1 v Full scale input
3. The following is an unbalanced Wheatstone Bridge. Calculate the output voltage across points C and D. Also find the value of resistor R<sub>4</sub> required to balance the bridge circuit.

**Course Outcome 5 (CO5):**

1. A strain gauge having an unstrained resistance of  $120\ \Omega$  and a gauge factor of 2.1 is bonded onto a steel girder so that it experiences a tensile stress of  $10^8\ \text{Pa}$ . If Young's modulus for steel is  $2 \times 10^{11}\ \text{Pa}$ . Calculate the strained resistance of the gauge.
2. A linear displacement transducer made of potentiometer whose length is 8 cm produces an output voltage of 5V for the input voltage of 10V. Find the linear displacement.
3. An accelerometer has the following specifications:  $M= 0.0156\text{kg}$ ,  $k=260\text{N/m}$ ,  $b= 2.4\ \text{Ns/m}$ ,  $X_{\text{max}}=0.3\text{cm}$ . Find maximum acceleration that can be measured.

**Course Outcome 6 (CO6):**

1. Discuss the role of MR and ER fluids as dampers in automobiles
2. Explain the different phases in a shape memory alloy.
3. Describe the operation of MEMS accelerometer sensor.

**Concept Map****Syllabus**

**Introduction to Sensor:** Measurement systems, Transducers, sensors and actuators, Sensor Classification

**Sensor Characteristics:** Static Characteristics and Dynamic Characteristics of Measurement Systems, Noises in sensor circuits

**Sensor Principles:** Electric charge, field and potentials, capacitor and dielectric constant, Magnetism, Induction, resistance, Seebeck, Peltier and Thomson effects, Heat transfer, light and ultrasonic.

**Signal conditioning:** op-amp and Instrumentation amplifier, Excitation circuits, A/D and D/A converters and bridge circuits.

**Sensing Systems:** Force, Flow, pressure, acoustic, humidity, moisture, temperature, ultrasonic, optical, image and bio sensors. Position, displacement, motion, velocity, acceleration sensors based system - Electrochemical, Hall-Effect sensors

**Smart Sensors:** Piezoelectric, Piezo-resistive, Shape memory alloys, MR and ER fluids, and MEMS sensors.

**Learning Resources**

1. Jacob Fraden, "Hand book of modern sensors: Physics design and applications", Springer, 5<sup>th</sup> edition, 2015
2. John P. Bentley, "Principle of measurement systems", Pearson education, Prentice Hall publication, 2004, 4th edition.
3. Ian R. Sinclair, "Sensors and transducers", Newness, Oxford, 2001, 3rd edition
4. Patranabis, D., "Sensors and Transducers", 2nd Edition, Prentice Hall of India, 2010
5. <https://nptel.ac.in/courses/108/108/108108147/>

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction to Sensor</b>		
1.1	Measurement systems, Transducers, sensors & actuators	2	CO1
1.3	Sensor Classification	2	CO1
<b>2</b>	<b>Sensor Characteristics:</b>		
2.1	Static Characteristics	2	CO2
2.2	Dynamic Characteristics of Measurement Systems, Noises in sensor circuits	2	CO2
<b>3</b>	<b>Sensor Principles:</b>		
3.1	Electric charge, field and potentials	2	CO3
3.2	capacitor and dielectric constant	1	CO3
3.3	magnetism, Induction, resistance	2	CO3
3.4	Seebeck, Peltier and Thomson effects	1	CO3
3.5	Heat transfer, light and ultrasonic	1	CO3
3.6	Resistive, Capacitive and inductive sensors	2	CO3
<b>4</b>	<b>Sensor signal conditioning</b>		
4.1	op-amp and Instrumentation amplifier,	2	CO4
4.2	A/D and D/A converters	2	CO4
4.3	bridge circuits	1	CO4
<b>5</b>	<b>Sensing Systems</b>		
5.1	Force, Flow, pressure	2	CO5
5.2	optical ,acoustic	2	CO5
5.3	humidity, moisture, temperature	1	CO5
5.4	ultrasonic, image and bio sensor	1	CO5
5.5	Position, displacement,	2	CO5
5.6	motion, velocity, acceleration sensors based system	1	CO5
5.7	Electrochemical, Hall-Effect sensors	2	CO5
<b>6</b>	<b>Smart Sensors</b>		
6.1	Piezoelectric- Piezoresistive	1	CO6
6.2	Shape memory alloys	1	CO6
6.3	MR and ER fluids, and MEMS sensors	1	CO6
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**18MTGC0****VALUE ENGINEERING**

Category	L	T	P	Credit(s)
GE	3	0	0	3

**Preamble**

New Product development is on rise and developing these products without compromising quality and cost is a challenge. In such development, it has become necessary to reduce the cost or eliminating the unnecessary cost, while improving the product performance or otherwise quality. This course deals with improving the quality in terms of the requirements of customer at the same or reduced cost by ensuring adequate system performance. Value engineering is a systematic approach for value improvement and contains seven broader phases. Hence, for product development, both cost and quality related issues need to be tackled concurrently.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the life cycle of Value engineering methodology	10
CO2	Identify the various phases of value engineering	15
CO3	Perform function cost worth analysis for a given application	25
CO4	Create the ideas for solving the problems for an environmental issue.	20
CO5	Analyse the functional importance and functional cost of the product	20
CO6	Build the FAST diagram for a given application	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1, 2.3.1,4.1.5
CO2	TPS2	Understand	Respond	Guided Response	1.1,2.3.1,4.1.5
CO3	TPS3	Apply	Value	Mechanism	1.1,2.1.4,2.2.4,4.1.5, 4.3.4
CO4	TPS3	Apply	Value	Mechanism	1.1,2.1.2,2.2.4,2.4.3,3.1,4.1.5, 4.3.4
CO5	TPS3	Apply	Value	Mechanism	1.1,2.1.2,2.1.4,2.2.4,2.4.3,3.1, 4.1.5,4.3.4
CO6	TPS3	Apply	Value	Mechanism	1.1,2.1.5,2.2.4,2.4,3,3.1,4.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	-	-	-	-	-	-	-	-	-	-	-
CO2	M	-	-	-	-	-	-	-	-	-	-	-
CO3	M	S	S	-	-	-	-	-	-	-	M	-
CO4	S	S	S	-	-	-	-	-	-	-	M	M
CO5	S	S	S	-	-	-	-	-	M	-	M	-
CO6	S	S	S	-	-	-	-	-	-	S	-	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3*	1	2	3	
Remember	20	20	-	-	-	-	10
Understand	80	40	-	100	-	-	20
Apply	-	40	40		100	100	30
Analyse	-	-	40	-	-	-	30
Evaluate	-	-	-	-	-	-	-
Create	-	-	20	-	-	-	10

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	<b>Mini-project</b>
Complex Overt Responses	-
Adaptation	-
Origination	-

**CAT3\*: Mini project (50 Marks)**

Students are combined into a group of 3 or 4 to provide a mini project on a real time example.(Only for Continuous assessment test)

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. What are the objectives of value engineering?
2. Name the types of value
3. Define : Function
4. What do you meant by functional worth?

**Course Outcome 2(CO2):**

1. Outline the techniques of value engineering plan
2. Differentiate between ex-factory selling price and life cycle cost of a product
3. Compare real savings and false savings

**Course Outcome 3(CO3):**

1. How would you determine the costs required to accomplish various functions of a product? Explain with an example.

2. Explain how the low cost promising ideas for various customer desired functions combined together to develop a number of workable solutions.
3. A product is manufactured at the break-even point. The management is considering a change in the product design in spite of the fact that the fixed costs will increase 50%. The sale of the new product is expected to shoot up by 100%. What should be the profitability of the new design (as compared to the present design) so that the company realizes a profit equal to the initial fixed cost per year?

**Course Outcome 4 (CO4):**

1. Consider the following decision making situation involving alternatives A & B

	<b>A (RS.)</b>	<b>B(RS.)</b>
Investment	20000	30000
Salvage Value	4000	0
Annual receipts	10000	14000
Annual costs	4400	8600
Life (years)	5	10

If minimum acceptable rate of return (MARR) is 15% and period of analysis is 10 years, alternative is to be chosen (use NPW method)

2. Consider the following three alternatives

	ALT A	ALTB	ALTC
Investment cost	28000	16000	
23500			
Net cash flow per year	5500	3300	
4800			
Salvage value	1500	0	500
Life ( Years)	10	10	10

Assuming MARR = 15% and using IRR method, choose the best alternative of the above.

3. Assume an initial investment of an asset as Rs.100000 and salvage value of Rs.10000 with the life of the assets as 10 years

Consider the following three methods of depreciation:

- i) Straight line
- ii) SYD
- iii) Declining balance method (with 10% rate)

For these methods, plot the profile of book value as a function of life. Assuming interest rate of 15%, Compute the net present worth of cash flows if above methods are to be used. Incremental tax rate is 50%. Also rank the depreciation methods.

**Course Outcome 5 (CO5):**

1. An equipment is purchased for Rs.50000 that will reduce materials and labour cost by Rs.14000 each year for N years. After N years, there will be no need for the equipment and since it is specially designed, it will have no salvage value at any time. However, according to the company tax procedure, this equipment must be depreciated on a straight line basis for the tax life of 5 years. If the tax rate is 50%, what is the minimum number of years (that is N) that the company must operate the equipment to earn a minimum 10% after tax return/

2. Consider the following data for two machines X & Y

Machine	Initial Cost	Annual costs	Salvage value
X	25000	4000	0

Y	15000	8000	0
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The machines can be used for 5 years or they can be retained for use after the 5<sup>th</sup> year. If so, the total useful life will be 20 years. The company is permitted to write off the machine in 5 years for tax purpose, or it can write off the machine in 20 years. Compare the results of using the long (20 years) or short (5 years) write off periods of the tax rate is 50% and sum of year's digits (SYD) method is used for depreciation. Assume interest rate of 10%.

3. A plant manager is attempting to determine whether his firm should purchase a component part or make it at its own facilities. If he purchases the item, it will cost the company Rs.10 per unit. The company can make the item on an assembly line at a variable cost of Rs.2.50 per unit with a fixed cost of Rs.20000/- per year, or it can make it at individual stations at a variable cost of Rs.5.00 per unit with a fixed cost of Rs.10000 per year. Assuming that the annual demand is expected to be 3500 units, determine which alternative the plant manager should select. Also, frame decision rules for MAKE/BUY for various levels of annual demand

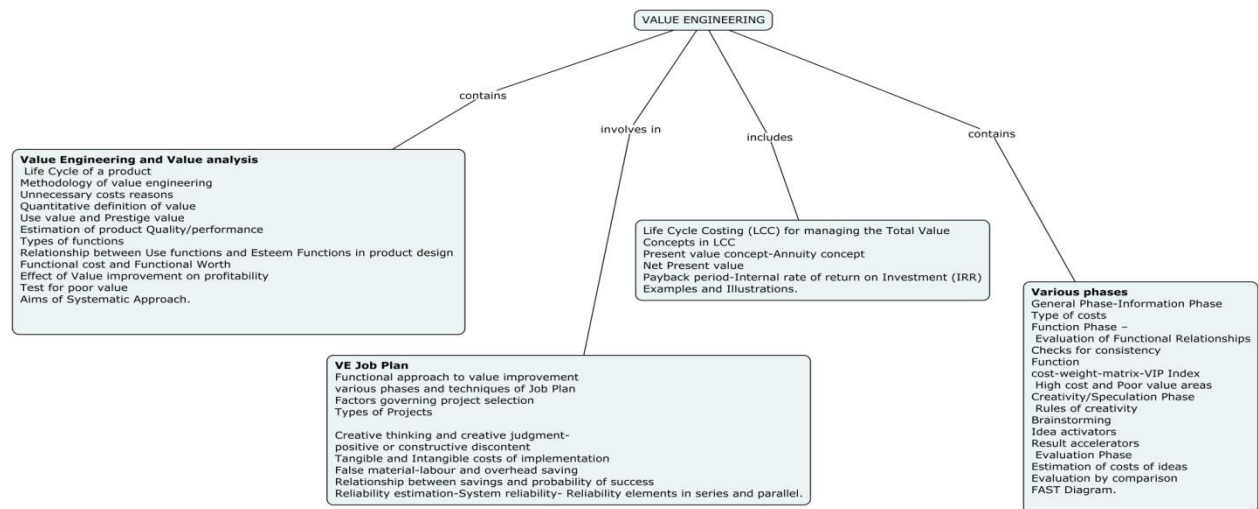
#### Course Outcome 6 (CO6):

1. A company proposes to invest Rs.40000 in a new machine. The service life of machine is 10 years.
  - a) What should be the annual savings if the minimum acceptable rate of return is 20%?
  - b) If the actual savings over this period are Rs.8000/- per year. What is the actual rate of return (internal) on investment?
2. A man needs Rs.300000 immediately for the purchase of a house. He will be required to repay the loan in equal six monthly installments over the next 10 years. What are the required payments at
  - a) 6% interest compounded semi annually
  - b) 10% interest compounded semi annually.
3. A new office copying machine costing \$5600 will enable a company to save \$0.03 per sheet on some duplicating work. The present usage is approximately 9000 sheets per month. Calculate the after tax IRR
 

Economic life	8 years
Depreciation term	10 Years
Depreciation method	Straight line
Incremental tax rate	50 percent
Interest rate	10 percent



## Concept Map



## Syllabus

### Introduction:

Value Engineering (VE) and Value Analysis(VA) - Life Cycle of a product-Methodology of value engineering – Difference from the conventional methods of cost reduction.

**Unnecessary costs reasons-** Quantitative definition of value- Use value and Prestige value - Estimation of product Quality/performance-Types of functions- Relationship between Use functions and Esteem Functions in product design – Functional cost and Functional Worth – Effect of Value improvement on profitability-Test for poor value –Aims of Systematic Approach.

### VE Job Plan:

Functional approach to value improvement - various phases and techniques of Job Plan – Factors governing project selection – Types of Projects-Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC – Present value concept-Annuity concept- Net Present value-Payback period-Internal rate of return on Investment (IRR)-Examples and Illustrations. Creative thinking and creative judgment- positive or constructive discontent-Tangible and Intangible costs of implementation-False material-labour and overhead saving – Relationship between savings and probability of success-Reliability estimation-System reliability- Reliability elements in series and parallel.

### Various phases:

General Phase-Information Phase – Type of costs- Function Phase – Evaluation of Functional Relationships- Checks for consistency-Function –cost-weight-matrix-VIP Index – High cost and Poor value areas- Creativity/Speculation Phase – Rules of creativity-Brainstorming- Idea activators- Result accelerators – Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison – FAST Diagram.

### Mini Project presentation and Case Studies.

## Learning Resources

1. Value Engineering – A How to Manual by S Slyer, 3<sup>rd</sup> edition, New Age Publishers, Chennai, 2019, ISBN: 978-81-224-2405-8
2. Value engineering, Mukhopadhyaya, Anil Kumar, Response Books, New Delhi ,2009, ISBN: 0-7619-9788-1
3. Techniques of training in value Engineering- a trainers manual, R.G.Chaudari, Notion press, Chennai, 2018,ISBN: 978-1-64249-128-9
4. Richard J Park, “Value Engineering – A Plan for Inventions”, St.Lucie Press, London, 1999.

5. Profit Improvement through Value Analysis, value Engineering and Purchase Price Analysis, A.D.Raven, (1971), Cassell and Co. London.
6. Arthur E Mudge, "Value Engineering", McGraw Hill Book Company, 1989.
7. <https://nptel.ac.in/courses/112/107/112107282/>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction</b>		
1.1	Value Engineering and Value analysis	1	CO1
1.2	Life cycle of a product	1	CO1
1.3	Value Engineering methodology	2	CO1
1.4	Difference from the conventional methods of Cost reduction	1	CO1
<b>2</b>	<b>Reasons for unnecessary costs</b>		
2.1	Definition of value	1	CO3
2.2	Use value and Prestige value	1	CO3
2.3	Estimation of Quality /Performance	1	CO3
2.4	Types of functions	1	CO3
2.5	Relationship between Use functions and Esteem Functions in product design	2	CO5
2.6	Functional cost and Functional Worth	2	CO5
2.7	Effect of Value improvement on profitability	1	CO5
2.8	Test for poor value	1	CO5
2.9	Aims of Systematic Approach. Functional approach to value improvement	1	CO5
<b>3</b>	<b>VE Job Plan</b>		
3.1	Functional approach to value improvement	1	CO3
3.2	Orientation and Information Phases	2	CO3
3.3	Techniques of Job Plan	1	CO3
3.4	Factors governing project selection – Types of Projects	1	CO3
3.5	Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC –	1	CO3
3.6	Present value concept-Annuity concept- Net Present value	1	CO3
3.7	Payback period-Internal rate of return on Investment (IRR)-Examples and Illustrations	1	CO3
<b>4</b>	<b>Various phases</b>		
4.1	Creative thinking and creative judgment- positive or constructive discontent	2	CO4
4.2	Tangible and Intangible costs of implementation-False material-labour and overhead saving	1	CO4
4.3	Relationship between savings and probability of success-Reliability Estimation-System reliability-Reliability elements in series and parallel.	1	CO4
4.4	General Phase-Information Phase – Type of costs - Function Phase	1	CO2
4.5	Evaluation of Functional Relationships - Checks for consistency- Function – cost-weight-matrix - VIP Index – High cost and Poor value areas-	1	CO2

4.6	Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.	1	CO2
4.7	FAST Diagram	2	CO6
4.7	Mini Project presentation and Case Studies	3	CO6
<b>Total</b>		<b>36</b>	

**Course Designers:**

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SYLLABI

For

**B.E. Mechatronics Program**

Engineering Science Electives

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 60<sup>th</sup> Academic Council Meeting on 25.07.2020

<b>18MTEA0 INTEGRATED PRODUCT DEVELOPMENT</b>	Category	L	T	P	Credit(s)
	ES	3	0	0	3

### Preamble

A dynamic and highly competitive business environment requires an increasingly efficient and controllable product development process. This dynamic process demands more creative and innovative solutions that provide the challenging and diverse requirements of the customer.

IPD represents a critical opportunity to re-organize product development on a sounder basis. Development and product costs can be reduced, product quality and performance improved, and time-to-market reduced with an aggressive, purposeful approach to IPD. This requires a formal, structured approach to implementing IPD. This must be based on a comprehensive and complete understanding of what IPD involves. This course shall help familiarize students with the key concepts on the IPD, and equip them with skills and knowledge that would make them highly suitable for the industry.

### Prerequisite

- 18ES290 - Lateral Thinking
- 18ES390 - Design Thinking

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Familiar with the global trends and development methodologies of various types of products and services	17
CO2	Conceptualize, Design, prototype and develop product management plan for a new product.	32
CO3	Transform customer needs into technical specification of a product.	6
CO4	Perform the PESTLE Analysis and Requirement Engineering Analysis.	17
CO5	Develop System Integration, Testing, Certification and Documentation.	17
CO6	Coordinate with various teams to verify, validate and sustain up to the End of Life support activities for engineering customer	11

\*\*\* Weightage depends on number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.2.2,2.3.1,2.4.4,2.4.7,2.5.1,2.5.2,3.1.1,3.2.1,3.3.1,4.1,4.2
CO2	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,1.2,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.3,2.4,2.5,3.1,3.2,4.1,4.2,4.3,4.4,4.5,4.6

CO3	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,1.2,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.3,2.4,2.5,3.1,3.2,4.1,4.2,4.3,4.4,4.5,4.6
CO4	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,1.2,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.3,2.4,2.5,3.1,3.2,4.1,4.2,4.3,4.4,4.5,4.6
CO5	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,1.2,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.3,2.4,2.5,3.1,3.2,4.1,4.2,4.3,4.4,4.5,4.6
CO6	TPS3	Apply	Value	Mechanism	1.1.1,1.1.2,1.2,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.3,2.4,2.5,3.1,3.2,4.1,4.2,4.3,4.4,4.5,4.6

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	S	M	-	S	S	-	-	-	-	-	-	-
CO2	M	M	S	M	-	S	S	-	S	S	S	S	S	S
CO3	M	M	S	M	-	S	S	-	S	S	S	S	S	S
CO4	M	M	S	M	-	S	S	-	S	S	S	S	S	S
CO5	M	M	S	M	-	S	S	-	S	S	S	S	S	S
CO6	M	M	S	M	-	S	S	-	S	S	S	S	S	S

S – Strong

M – Medium

L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	Development of Prototype 100	Development of working model 100	-
Understand	-	-	-	-			40
Apply	100	100	100	100			60
Analyse	-	-	-	-			-
Evaluate	-	-	-	-			-
Create	-	-	-	-			-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	
Set	
Guided Response	Prototype
Mechanism	New Product
Complex Overt Responses	
Adaptation	
Origination	

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. List the factors affecting New product design.
2. Classify types of products.
3. Brief about product design.

**Course Outcome 2(CO2):**

1. Distinguish between functional design and production design, with suitable examples.
2. Discuss the different types of product validation techniques.
3. Explain the concept selection process with example.

**Course Outcome 3(CO3):**

1. As a customer identify the basic needs in the selection of a new car.
2. Select the suitable product development methodology for software companies and criticize your selection.
3. List your needs with respect to two wheeler motorcycle suspension and convert to a product specification.

**Course Outcome 4 (CO4):**

1. Select the innovation criteria for product success in the life cycle of a product.
2. How concept selection methods can be used to benchmark or evaluate the existing product?
3. Evaluate concept selection methods for five automobiles you might consider for purchasing.

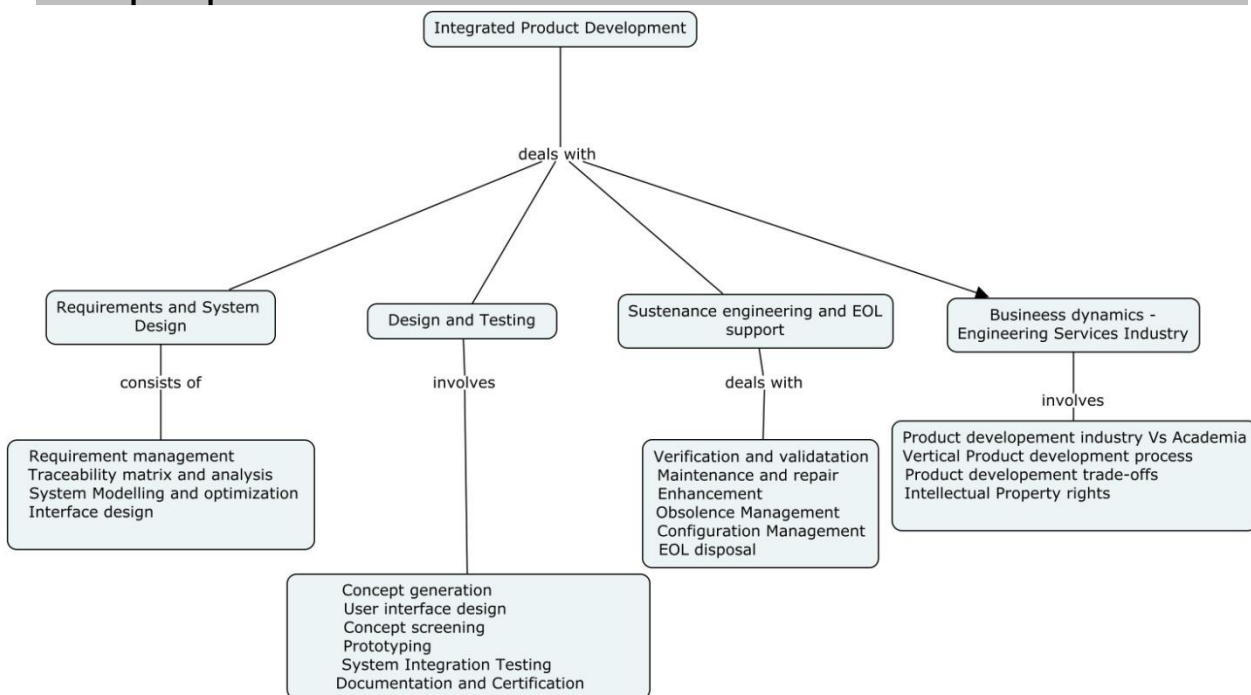
**Course Outcome 5 (CO5):**

1. As a customer Identify the basic needs while selection a new car
2. Decompose a micro oven into its assemblies, components, electrical circuits.
3. Draw the product architecture for a ink jet printer

**Course Outcome 6 (CO6):**

1. Develop the obsolescence management process for a android smart phone.
2. Explain PDCA cycle.
3. Explain configuration Management.

**Concept Map**



## Syllabus

### Fundamentals of Product Development

Global Trends Analysis and Product decision - Social Trends - Technical Trends-  
Economic

Trends - Environmental Trends - Political/Policy Trends –PESTEL Analysis- Introduction to  
Product Development Methodologies and Management - Overview of Products and Services  
- Types of Product Development - Overview of Product Development methodologies -  
Product Life Cycle – Product Development Planning and Management.

### Requirements and System Design

Requirement Engineering - Types of Requirements- Traceability Matrix and Analysis -  
Requirement Management - System Design & Modelling - Introduction to System Modelling -  
System Optimization - System Specification - Sub-System Design - Interface Design.

### Design and Testing

Conceptualization - Industrial Design and User Interface Design - Introduction to Concept  
generation Techniques – Challenges in Integration of Engineering Disciplines - Concept  
Screening & Evaluation - Detailed Design - Component Design and Verification –  
Mechanical, Electronics and Software Subsystems - High Level Design/Low Level Design of  
S/W Program - Types of Prototypes, S/W Testing- Hardware Schematic, Component design,  
Layout and Hardware Testing – Prototyping - Introduction to Rapid Prototyping and Rapid  
Manufacturing - System Integration, Testing, Certification and Documentation

### Sustenance Engineering and End-of-Life (EoL) Support

Introduction to Product verification processes and stages - Introduction to Product validation  
processes and stages - Product Testing standards and Certification - Product Documentation  
- Sustenance - Maintenance and Repair – Enhancements - Product EOL - Obsolescence  
Management – Configuration Management - EOL Disposal

### Business Dynamics – Engineering Services Industry

The Industry - Engineering Services Industry - Product development in Industry versus  
Academia – The IPD Essentials - Introduction to vertical specific product development  
processes - Manufacturing/Purchase and Assembly of Systems - Integration of Mechanical,  
Embedded and S/W systems – Product development Trade-offs - Intellectual Property Rights  
and Confidentiality – Security and configuration management

## Learning Resources

1. Foundation skills in Integrated product development (FSIPD), NASSCOM, Edition 2015
2. Karl T Ulrich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, New Delhi, 2011
3. John W Newstorm and Keith Davis, "Organizational Behavior", Tata McGraw Hill,
4. Eleventh Edition, New Delhi, 2005
5. Hiriappa B, "Corporate Strategy – Managing the Business", Author house, USA, 2013
6. Peter F Drucker, "People and Performance", Butterworth – Heinemann [Elsevier],
7. Oxford, UK, 2004.
8. Vinod Kumar Garg and Venkitakrishnan N K, "Enterprise Resource Planning – Concepts and Practice", Prentice Hall India, New Delhi, 2003
1. Mark S Sanders and Ernest J McCormick, "Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, New Delhi, 2013.



### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	<b>Fundamentals of Product development</b>		
1.1	Types of various trends affecting product decision - Social Trends (Demographic, Behavioural, Psychographic), Technical Trends(Technology, Applications, Tools, Methods )	1	CO1
1.2	Economical Trends(Market, Economy, Gross Domestic Product, Income Levels, Spending Pattern, target cost, Total Cost of Ownership)	1	CO1
1.3	Environmental Trends(Environmental Regulations and Compliance), Political/Policy Trends(Regulations, Political Scenario, IP Trends and Company Policies.	1	CO1
1.4	PESTLE Analysis	2	CO4
1.5	Product development methodologies, types of product development.	1	CO1
1.6	Product Life Cycle – Product Development Planning and Management.	1	CO1
2	<b>Requirements and System Design</b>		
2.1	Requirement Engineering - Types of Requirements	2	CO4
2.2	Traceability Matrix and Analysis	1	CO4
2.3	Requirement Management	1	CO4
2.4	System Design & Modeling - Introduction to System Modeling	1	CO2
2.5	System Optimization - System Specification	2	CO3
2.6	Sub-System Design - Interface Design.	1	CO2
3	<b>Design and Testing</b>		
3.1	Conceptualization - Industrial Design and User Interface Design	1	CO2
3.2	Introduction to Concept generationTechniques	1	CO2
3.3	Challenges in Integration of Engineering Disciplines - Concept Screening & Evaluation -Detailed Design	2	CO2
3.4	Detailed Design - Component Design and Verification – Mechanical, Electronics and SoftwareSubsystems	2	CO2
3.5	High Level Design/Low Level Design of S/W Program	1	CO2
3.6	Types of Prototypes, S/W Testing- Hardware Schematic, Component design, Layout and Hardware Testing	2	CO2
3.7	Introduction toRapid Prototyping and Rapid Manufacturing	1	CO2
3.8	System Integration, Testing, Certification andDocumentation	2	CO5
4	<b>Sustenance Engineering and End-of-Life (EoL) Support</b>		
4.1	Introduction to Product verification processes and stages	1	CO6
4.2	Introduction to Product validation processes and stages	1	CO6
4.3	Product Testing standards and Certification - Product Documentation	1	CO5
4.4	Sustenance -Maintenance and Repair – Enhancements - Product EOL	1	CO6

4.5	Obsolescence Management – Configuration Management - EOL Disposal	1	CO6
5	<b>Business Dynamics – Engineering Services Industry</b>		
5.1	The Industry - Engineering Services Industry - Product development in Industry versus Academia	1	CO1
5.2	The IPD Essentials - Introduction to vertical specific product development processes - Manufacturing/Purchase and Assembly of Systems	1	CO5
5.3	Integration of Mechanical, Embedded and S/W systems – Product development Trade-offs	1	CO5
5.4	Intellectual Property Rights and Confidentiality – Security and configuration management.	1	CO5
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**18MTEB0 BATTERY MANAGEMENT SYSTEM**

Category	L	T	P	Credit(s)
ES	3	0	0	3

**Preamble**

When the green movement grows in popularity, more and more electric vehicles ( EVs) of all kinds from electric scooters to buses, busses, and freight trucks will grace the highways. Technology manufacturers must be tested to have solutions that can be tailored to a broad range of specific styles of batteries and automobiles with a large range of efficiency specifications. This course discusses key factors that are ideally suited to meeting the challenges of including battery capacity, lifetime and, of course, protection when developing smart battery management and charging systems. EV battery packs consist of several series and parallel arranged cell modules. The battery management system ( BMS) consists of many components organized throughout the battery pack and in the car, including monitoring components close to the battery cells themselves, one or more power conversion stages determined by the vehicle's needs, and intelligent controllers.

**Prerequisite**

- Analog Electronics, Digital Electronics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify the major Components in Lithium-ion cell and their Purpose.	15
CO2	Develop Equivalent Circuit model of Li-ion Battery pack and Compute Circuit Model Parameters for given vehicle Dynamics	15
CO3	Adhere Mathematical Models of Different State of Charge (SOC) Estimators and their Limitations.	10
CO4	Adhere Mathematical Models of Different State of Health (SOH) Estimators and their Limitations.	10
CO5	Design Battery balancing systems with thermal management for Desired battery configurations.	30
CO6	Estimate Remaining Energy and Available Power for a battery	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1
CO2	TPS3	Apply	Value	Mechanism	1.2,1,3
CO3	TPS3	Apply	Value	Mechanism	1.3,2.1
CO4	TPS3	Apply	Value	Mechanism	1.3,2.1
CO5	TPS3	Apply	Value	Mechanism	2.2,3.1,4.4
CO6	TPS4	Analyse	Organise	Complex Overt Responses	2.3,4.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	L	-	-	-	-	-	M	-
CO2	S	M	L	-	-	-	L	-	-	-	-	-	L	-
CO3	S	M	L	-	M	-	L	-	-	L	M	-	-	S
CO4	S	M	L	-	M	-	L	-	M	-	M	-	-	S
CO5	S	M	L	-	M	-	L	-	M	-	L	M	-	S
CO6	S	S	M	L	M	-	L	-	-	L	L	M	-	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	-
Understand	50	-	-	50	-	-	25
Apply	50	100	50	50	100	50	50
Analyse	-	-	50	-	-	50	25
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	
Set	
Guided Response	Programming Assignment
Mechanism	Practical Component
Complex Overt Responses	Mini Project
Adaptation	
Orignation	

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Draw the Architecture of Li-ion Cell.
2. Draw the electron Configuration of Lithium Molecule.
3. Define Equivalent Series Resistance.

**Course Outcome 2(CO2):**

1. Discuss in Detail about the ESC Cell model.
2. List the Requirements of Battery Management Systems
3. Brief About Isolation sensing

**Course Outcome 3(CO3):**

1. Differentiate Empirical and Physics based Modelling
2. Derive the Equations Involving Vehicle Dynamics
3. Illustrate the simulation Strategy for Battery pack estimation

**Course Outcome 4 (CO4):**

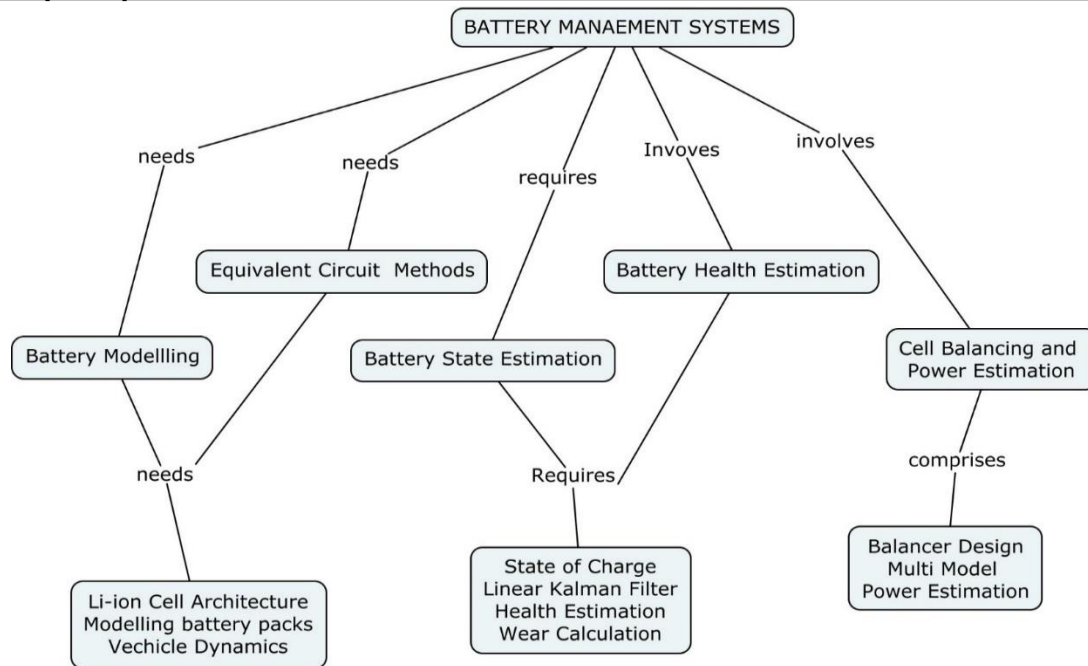
1. Define SOC.
2. What are the six steps involved in Sequential Probabilistic Inference?
3. Illustrate Kalman filter recursion with neat diagram.

**Course Outcome 5 (CO5):**

1. Define Equivalent Series Resistance.
2. Differentiate Positive and Negative Electrode Aging.
3. Derive the Weighted least square methods for Predic

**Course Outcome 6 (CO5):**

1. List the Causes for Cell Imbalance.
2. Illustrate the Working of Passive Resistor Balancing Circuit
3. Define Voltage Based Rate Limits

**Concept Map****Syllabus****Battery Modelling:**

Battery boot camp-Lithium-ion cell Preview, Equivalent Circuit Models, Introduction to microscale Cell Models.

**Equivalent Circuit Methods:**

Battery Management Systems – Requirements, Modelling and Simulation of Battery Packs (empirical and Physics based), Vehicle Dynamics

**Battery-State Estimation:**

SOC Estimation – Sequential Probabilistic Inference- Linear Kalman Filter – Extended Kalman Filter

**Battery Health Estimation:**

Need for Health Estimates – electrode aging- Parameter Estimation using Kalman Filter

**Cell Balancing:**

Causes of Cell Imbalance – Balancer Design - Circuits for Balancing.

**Power Estimation:**

Simple cell Model Power Estimation, Full Cell model Power Estimation.

**Learning Resources**

1. Battery Management Systems, Volume I: Battery Modeling by Gregory L. Plett, Publisher: ARTECH HOUSE PUBLISHERS; Unabridged edition (2015) Language: English ISBN-10: 1630810231 ISBN-13: 978-1630810238

2. Battery Management Systems, Volume II: Equivalent-Circuit Methods Gregory L. Plett, Publisher: Artech House Publishers; Unabridged edition (2016). Language: English ISBN-10: 1630810274 ISBN-13: 978-1630810276
3. ECE4710/5710: Modeling, Simulation, and Identification of Battery Dynamics, University of Colorado, Colorado Springs. <http://mocha-java.uccs.edu/ECE5710/index.html>
4. ECE5720: Modelling, Simulation, and Identification of Battery Dynamics., University of Colorado, Colorado Springs. <http://mocha-java.uccs.edu/BMS2/index.html>
5. Battery Management Algorithm for Electric Vehicle, Rui Xion, Springer Nature, 2019, ISBN 981150248X, 9789811502484
6. Thermal Management of Electric Vehicle Battery Systems, Ibrahim Dincer, Halil S. Hamut, Nader Javani, John Wiley & Sons, 2017

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Battery Modelling:</b>		
1.1	Battery boot camp	1	CO1
1.2	Cell Preview – chemical battery (Different types)	2	CO1
1.3	Equivalent Circuit Models	2	CO1
1.4	Introduction to microscale Cell Models.	1	CO1
<b>2</b>	<b>Equivalent Circuit Methods:</b>		
2.1	Battery Management Systems	1	CO2
2.2	Requirements of BMS	1	CO2
2.3	Modelling and Simulation of Battery Packs (empirical and Physics based)	2	CO2
2.4	Vehicle Dynamic and Vehicle Range Calculation	1	CO2
<b>3</b>	<b>Battery-State Estimation:</b>		
3.1	SOC Estimation	2	CO3
3.2	Linear Kalman Filter	1	CO3
<b>4</b>	<b>Battery Health Estimation:</b>		
4.1	Need for Health Estimates	2	CO4
4.2	Electrode aging	1	CO4
<b>5</b>	<b>Cell Balancing:</b>		
5.1	Causes of Cell Imbalance	2	CO5
5.2	Balancer Design choices	2	CO5
5.3	Circuits for Balancing – Passive, Resistive	2	CO5
5.4	Circuits for Balancing – Active, Capacitive	2	CO5
5.5	Circuits for Balancing – Active, Inductive	2	CO5
5.6	Thermal Management of Battery (Charging and Discharging)	2	CO5
<b>6</b>	<b>Power Estimation:</b>		
6.1	Simple cell Model	2	CO6
6.2	Power Estimation	2	CO6
6.3	Full Cell model	2	CO6
6.4	Power Estimation	1	CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

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SYLLABI

For

**B.E. Mechatronics Program**

Industry Supported Courses

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 60<sup>th</sup> Academic Council Meeting on 25.07.2020

**18MT1A0 BUILDING AUTOMATION AND CONTROLS**

Category L T P Credit(s)  
PEES 1 0 0 1

**Preamble**

Market research analysts predict that the global building automation and controls market will grow steadily during the next four years and post a Compound Annual Growth Rate (CAGR) of more than 12% by 2021. This market research analysis identifies the degree of flexibility offered by open integrated building management systems as one of the primary growth factors for this market. In addition to the textbook knowledge, it is essential to expose the students and train them on the application part of Building automation and controls as seen in the industry. When got exposed and trained students will come forward to take up Building automation and controls for their career. Which in will turn benefit the society in energy saving aspects.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the Basics of Building automation and controls	20
CO2	Develop System Architecture of Building automation and controls	20
CO3	Develop an IO Point Summary and select DDC Controllers	30
CO4	Prepare Building automation and controls in Industries, Commercial and Residential Building	30

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2,4.1.4
CO2	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.4.1
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.1.2,4.4.1
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,3.1.1,4.1.1,4.4.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	L	L
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	S
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	20
Understand	-	-	-	-	-	-	50



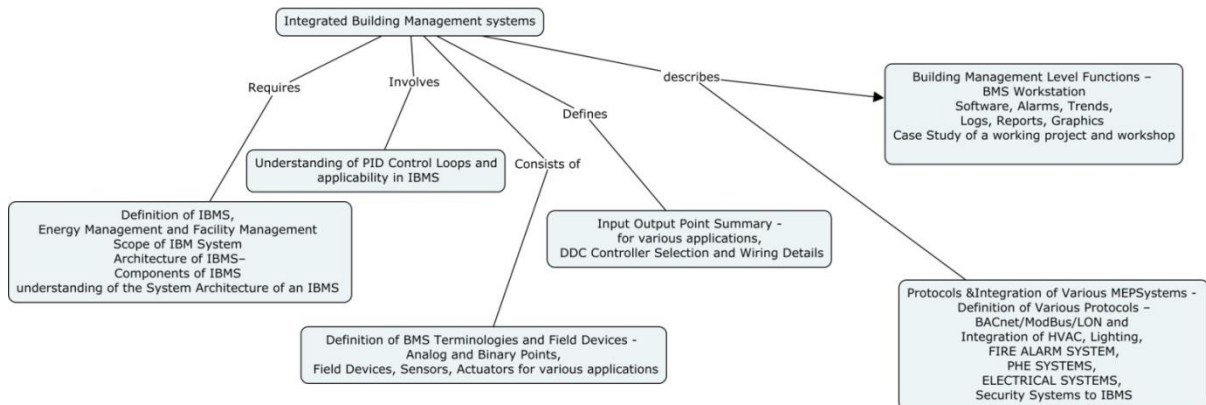
Apply	-	-	-	100	-	-	30
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

1. Out of 100 Marks, 50 Marks (Internal) will be for Mini-project/Assignments and 50 Marks will be for End Semester Exam.
2. End semester question paper will be combination of Short questions descriptive and problematic question

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini project/quiz
Complex Overt Responses	-
Adaptation	-
Origination	-

### Concept Map



### Syllabus

**Overview of Building automation and controls** – Definition, Energy Management and Facility Management and Scope of Building automation and controls **System**

**Architecture of Building automation and controls** – Components of Building automation and controls and understanding of the System Architecture of Building automation and controls

**Control Loop Logic** – Understanding of PID Control Loops and applicability in Building automation and controls

**Definition of Terminologies and Field Devices** - Analog and Binary Points, Field Devices, Sensors, Actuators for various applications **Input Output Point Summary** - for various applications, DDC Controller Selection and Wiring Details

**Protocols & Integration of Various MEP Systems** - Definition of Various Protocols – BACnet/Mod Bus/LON and Integration of HVAC, Lighting, Fire Alarm System, PHE Systems, Electrical Systems, Security Systems

**Building Management Level Functions** – BMS Workstation Software, Alarms, Trends, Logs, Reports, Graphics

**Workshop on Integrated Building automation and controls –Case Study of a working project and workshop**

**Learning Resources**

1. Hand out – all materials presented in the class to be shared

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Overview of Building automation and controls</b>		
1.1	Definition, Scope of IBMS, Energy and Facility Management	1	CO1
<b>2</b>	<b>System Architecture of Building automation and controls</b>		
2.1	Components of Building automation and controls & Understanding of System Architecture	1	CO2
<b>3</b>	<b>Control Loop Logic</b>		
3.1	Understanding of PID Loops	1	CO2
3.2	Application of Control Loops in Building automation and controls with some examples	1	CO2
<b>4</b>	<b>Definition of Building automation and controls Terminologies and Field Devices</b>		
4.1	Definition of Analog – Binary – Input – Output Points (AI, BI, AO & BO)	1	CO1
4.2	Field Devices, Sensors, Actuators etc., used in Building automation and controls	1	CO1
<b>5</b>	<b>Input Output Point Summary</b>		
5.1	Building up of an IO Point Summary	1	CO3
5.2	DDC Controller Selection	1	CO3
5.3	Wiring Details	1	CO3
5.4	Practical Example of an IO Point Summary – Work out – Tutorial	1	CO3
<b>6</b>	<b>Protocols &amp; Integration of Various M E P Systems</b>		
6.1	Definition of BACnet, ModBus, LON & Interoperability	1	CO4
6.2	Integration of HVAC, FAS, Electrical & other 3 <sup>rd</sup> Party Systems	1	CO4
<b>7</b>	<b>Building Management Level Functions</b>		
7.1	BMS Workstation Software & Graphics, Trends, Reports, Alarms, Logs	1	CO4
<b>8</b>	<b>Workshop on Building automation and controls</b>		
8.1	Case Study and Example	1	CO4
	<b>Total</b>	<b>14</b>	

**Course Designers:**

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18MT2A0

**DESIGN FOR ENVIRONMENTAL  
COMPATIBILITY**Category L T P Credit(s)  
PEES 2 0 0 2**Preamble**

In today's technology era, every product is getting commoditized with pressure to deliver more functionality at lesser cost. While physics behind engineering products designed over last 5 decades remain the same, the user expectation has seen drastic change that makes product designed a couple of years obsolete / not sellable. We as engineers need to design a product with features and functionalities that the customer wants. For even a simple product such as fan/blower, there will be number of designs based on specific application, type of market, segment of users, etc. This course will bring those aspects of technical specification that derives the product boundary, but also the implied requirements of end customer. Products are getting more complex that could not be generically expressed as mechanical equipment, electrical apparatus for the reason that each of them has got electrical / printed wiring, electronics controls and a piece of software, etc. This course will navigate through multiple engineering disciplines, multiple applications and compatibility of the design to meet those requirements.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify product requirement based on application, environment and statutory requirement.	15
CO2	Select statutory, generic, application specific, country specific standards that product is expected to comply	15
CO3	Access External factors such as temperature, humidity, pressure, road condition and their influence on the choice of components, materials in designing products	20
CO4	Design for X (X stands for manufacturability, testability, scalability, EMC, environment, Serviceability, reliability, etc..)	50

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	4.3.1, 4.3.2
CO2	TPS3	Apply	Value	-	4.5.5
CO3	TPS3	Apply	Value	-	4.3.1
CO4	TPS3	Apply	Value	-	4.3.1,4.3.2,4.3.3,4.4.1,4.4.2, 4.4.3,4.4.6,4.5.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	L	S	S	M	-	-	-	M	M	M
CO2	S	M	L	-	L	S	S	M	-	-	-	M	-	-
CO3	S	M	L	-	L	S	S	M	-	-	-	M	M	M
CO4	S	M	L	-	L	S	S	M	-	-	-	M	M	M

S – Strong                      M – Medium                      L – Low

### Assessment Pattern: Cognitive Domain

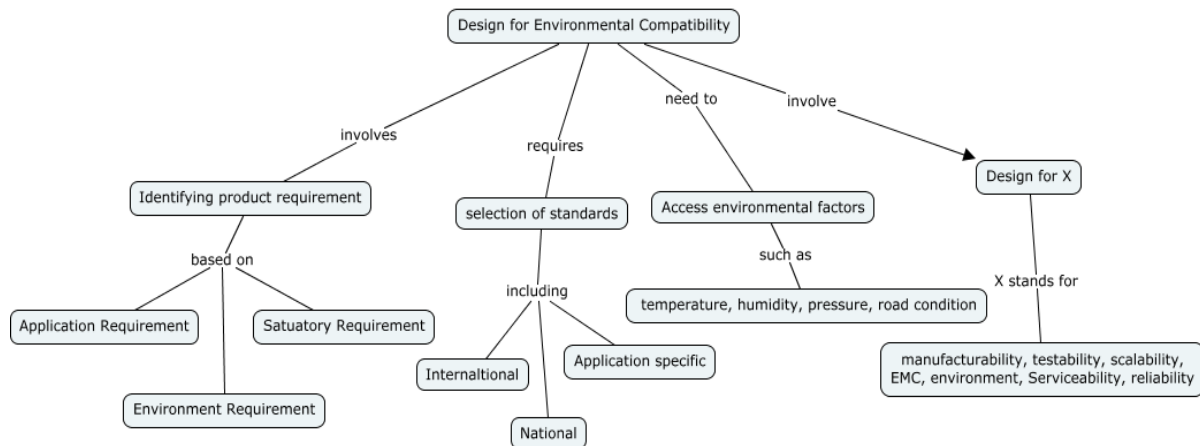
Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	20
Understand	-	-	-	-	-	-	60
Apply	-	-	-	100	-	-	20
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

1. Out of 100 Marks, 50 Marks (Internal) will be for Mini project/Assignments and 50 Marks will be for End Semester Exam.
2. End semester question paper will be combination of Short questions descriptive and problematic questions

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

### Concept Map



### Syllabus

**Background** - Why should we focus on Environmental compatibility, while designing a product, Design of product for requirement, Technical specification Vs actual product usage, End Application, End user profile, external environment factors

**External environmental factors influence on design** - Physical environment: Temperature, Humidity, Altitude, rain, radiation, etc., Application environment: Handheld, fixed/static, mobile/transport, etc., User /Implied Environment-Varied use/abuse profile, Electromagnetic environment

**Standards and Environment (all types including EMC)**-International Generic suggestive standards, National Statutory standards, Application oriented standards

**Design for Environment (all types including EMC)** - Tools, processes, techniques, Analysis, validation, verification methods

**Testing for environment (all types including EMC)** - Test methods and Standards, Results interpretation, Root cause analysis, Problem solving and mitigation

**Product Realization** - Brainstorming of ideas, selection of concept and conceptual designing, Selection of material, components, supplier quality and Bill of material, Journey from design to actual product for usage

**Lessons learned and how to use for intern projects**

### Learning Resources

1. Electronic Packaging and Interconnection Handbook”, Charles A Harper, 4<sup>th</sup> Edition, 2004, McGrawHill Education

### Course Contents and Lecture Schedule

Module No.	Topic	No of hours Lectures	Course Outcome
<b>1</b>	<b>Background</b>		
1.1	Why should we focus on Environmental compatibility, while designing a product	1	CO1
1.2	Design of product for requirement		
1.3	Technical specification Vs actual product usage	1	CO1
1.4	End Application, End user profile, external environment factors	1	CO1
<b>2</b>	<b>External environmental factors influence on design</b>		
2.1	Physical Environment: Temperature, Humidity, Altitude, rain, radiation, etc.	1	CO3
2.2	Application environment: Handheld, fixed/static, mobile/transport, etc.	1	CO3
2.3	User/Implied Environment : Varied use/abuse profile, Electromagnetic environment	1	CO3
<b>3</b>	<b>Standards and Environment ( all types including EMC)</b>		
3.1	International Generic suggestive standards	1	CO2
3.2	National Statutory standards	1	CO2
3.3	Application oriented standards	1	CO2
<b>4</b>	<b>Design for Environment ( all types including EMC)</b>		
4.1	Tools, processes, techniques	3	CO4
4.2	Analysis, validation, verification methods	3	CO4
<b>5</b>	<b>Testing for environment ( all types including EMC)</b>		
5.1	Test methods and Standards, Results interpretation	1	CO4
5.2	Root cause analysis, Problem solving and mitigation	2	CO4

<b>Module No.</b>	<b>Topic</b>	<b>No of hours Lectures</b>	<b>Course Outcome</b>
<b>6</b>	<b>Product Realization</b>		
6.1	Brainstorming of ideas, selection of concept and conceptual designing	2	CO4
6.2	Selection of material, components, supplier quality and Bill of material,	2	CO4
6.3	Journey from design to actual product for usage	1	CO4
<b>7</b>	<b>Lessons learned and how to use for intern projects</b>	1	CO4
<b>Total</b>		<b>24</b>	

#### **Course Designers:**

<b>Sl. No.</b>	<b>Name</b>	<b>E-mail Id</b>
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2	Dr G Kumaraguruparan	gkgmech@tce.edu

SYLLABI

For

**B.E. Mechatronics Program**

Program Elective

For the students admitted from the  
academic year 2018-2019 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

**THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015**  
**DEPARTMENT OF MECHATRONICS ENGINEERING**

**Vision:**

“Be a globally renowned school of engineering in Mechatronics”

**Mission:**

As a department, we are committed to

- Develop ethical and competent engineers by synergizing world class teaching, learning and research
- Establish state-of-art laboratories and to provide consultancy services to fulfil the expectations of industry and needs of the society
- Inculcate entrepreneurial qualities for creating, developing and managing global engineering ventures
- Motivate the students to pursue higher studies and research

**Programme Educational Objectives (PEOs) of B.E. (Mechatronics)**

**PEO 1**

The programme will prepare graduates to synergistically integrate mechanical engineering with electronic and intelligent computer control in the design and manufacture of industrial products and processes.

**PEO 2**

The programme will prepare graduates with strong team skills to solve multi-disciplinary problems using Mechatronics approach.

**PEO 3**

The programme will prepare graduates with an understanding of their ethical and social responsibility.



**Programme Outcomes (POs) of B.E. (Mechatronics)**

<b>PO1</b>	<b>Engineering knowledge</b>	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
<b>PO2</b>	<b>Problem analysis</b>	Identify, formulate, research literature, and analyze Complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
<b>PO3</b>	<b>Design/development of solutions</b>	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
<b>PO4</b>	<b>Conduct investigations of complex problems</b>	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
<b>PO5</b>	<b>Modern tool usage</b>	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
<b>PO6</b>	<b>The engineer and society</b>	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
<b>PO7</b>	<b>Environment and sustainability</b>	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
<b>PO8</b>	<b>Ethics</b>	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
<b>PO9</b>	<b>Individual and team work</b>	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
<b>PO10</b>	<b>Communication</b>	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
<b>PO11</b>	<b>Project management and finance</b>	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
<b>PO12</b>	<b>Life-long learning</b>	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

**PEO – PO Matrix**

POs PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1	S	S	S	S	S	M	S	M	L	M	M	M
PEO2	S	S	S	S	S	S	M	M	S	S	S	L
PEO3	L	M	M	L	L	S	S	S	S	M	S	M

*S – Strong**M-Medium**L-Low***Programme Specific Outcomes (PSO):**

After the successful completion of the B.E. Mechatronics Engineering degree programme, the students will be able to:

**PSO1:** Design, develop and retrofit conventional mechanical system into low cost automated system using sensors and controllers

**PSO2:** Design, develop and analyse mechatronics system using hardware and software tools.

**SCHEDULING OF COURSES**

Sem	Theory / Theory cum Practical / Laboratory Courses									Mandatory Audit Courses	Total Credits
I	18MA110 Engineering Calculus 4	18PHA20 Physics 3	18CHA30 Chemistry 3	18EG140 English 2	18ES150 Engineering Exploration 3	18ME160 Engineering Graphics 4	18EG170 English Laboratory 1	18PH180 Physics Laboratory 1	18CH190 Chemistry Laboratory 1	---	22
II	18MA210 Matrices and Ordinary Differential Equations 3	18MT220 Electrical Machines 3	18MT230 Analog Electronics 3	18MT240 Free Body Mechanics 3	---	18MT260 Manufacturing Processes (TCP) 3	18MT271 Electrical Machines Laboratory 1	18MT280 Workshop 1	18ES290 Lateral Thinking 1	18CHAA0 Environmental Science	18
III	18MT310 Partial differential equations 3	18MT320 Kinematics and Dynamics of Machinery 3	18MT330 Digital Electronics 3	18MT340 Thermal Fluid Engineering 3	18MT350 Programming for problem solving 2	18MT360 Programming and Coding Laboratory 1	18MT370 Thermal Fluid Engineering Laboratory 1	18MT380 Digital Electronics Laboratory 1	18ES390 Design Thinking 2	---	19
IV	18MT410 Probability and Statistics 3	18MT420 Power Electronics and Drives 3	18MT430 Micro Controller 3	18MT440 Sensors and Measurements 3	18YYFX0 Foundation Elective 3	18EG460 Professional Communication (TCP) * 2	18MT470 Sensors and Measurements Laboratory 1	18MT480 Micro Controller Laboratory 1	18MT490 Project Management 3	18CHAB0 Constitution of India	22
V	18MT510 Control System 3	18MT520 Industrial Automation 3	18MT530 Design of Machine Elements 3	18MTPX0 Program Elective I 3	18YYGX0 General Elective 3	18MT560 Accounting and Finance 3	18MT570 Industrial Automation Laboratory 1	18MT580 Dynamics and Control Laboratory 1	18ES590 System Thinking 2	Essence of Indian Knowledge	22
VI	18MT610 Industrial Robotics 3	18MT620 CNC Technology 3	18YYEX0 Engineering Science Elective 3	18MTPX0 Program Elective II 3	Program / Foundation Elective 3	18MT660 Virtual Instrumentation (TCP) 3	18MT670 CAD / CAM Laboratory 1	18MT680 Robotics Laboratory 1	18ES690 Engineering Design Project 3	---	23
VII	18MT710 Mechatronics System Design 3	18MTPX0 Program Elective III 3	18MTPX0 Program Elective IV 3	18MTPX0 Program Elective V 3	Program / General Elective 3	18MT760 System Integration Laboratory 1	---	---	18ES790 Capstone Design Project 3	---	19
VIII	18MT810 Project 9	18MTPX0 Program Elective VI 3	18MTPX0 Program Elective VII 3	---	---	---	---	---	---	---	15
<b>Total Credits</b>											<b>160</b>

<b>PROGRAM ELECTIVES</b>						
Course code	Name of the Course	Category	L	T	P	Credits
18MTPS0	Total Quality Management	PE	3	0	0	3
18MTPPT0	Smart Building Systems	PE	3	0	0	3
18MTPU0	Wireless Sensor Networks	PE	3	0	0	3
18MTPV0	Autonomous Robot Navigation	PE	3	0	0	3
18MTPW0	Simulation of Mechatronics Systems	PE	3	0	0	3
18MTPY0	Introduction to Photonics	PE	3	0	0	3
18MTPZ0	Electric Vehicle Technology	PE	3	0	0	3
18MTRA0	Intelligent Control of Motion Drives	PE	3	0	0	3
18MTRB0	Introduction to Biomechatronics	PE	3	0	0	3
18MTRC0	Smart Materials for Mechatronics	PE	3	0	0	3

**18MTPS0 TOTAL QUALITY MANAGEMENT**

Category L T P Credit(s)  
PE 3 0 0 3

**Preamble**

Quality is the mantra for success or even for the survival of any organization in this competitive global market. Total Quality Management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world-class competition. It integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach. At the end of the course the students are expected to recognize the quality issues in an organization and analyze the ways to solve those using TQM techniques, and demonstrate skills in using modern TQM tools and software to analyze problems.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the fundamentals on quality management philosophies and frameworks.	15
CO2	Adopt TQM methodologies for continuous improvement of quality.	15
CO3	Measure the cost of poor quality, process effectiveness and efficiency to identify areas for improvement.	20
CO4	Interpret the variable and attribute control charts	20
CO5	Identify the suitable tools and techniques of TQM in an organization for a problem.	20
CO6	Determine the set of indicators to evaluate performance excellence of an organization	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2,4.1.4
CO2	TPS2	Understand	Respond	Guided Response	1.1,1.2,2.1,4.1.1,4.4.1
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.1.2,4.4.1
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,3.1.1,4.1.1,4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	L	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	L	-	-	-
CO3	S	M	L	-	-	-	-	L	L	L	M	-	-	-
CO4	S	M	L	-	L	-	-	-	L	L	M	L	-	-
CO5	S	M	L	-	L	-	-	-	L	L	M	L	-	-
CO6	S	M	L	-	L	-	-	-	L	L	M	L	-	-

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	50	30	30	-	-	-	30
Apply	30	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini project/quiz
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. List out the various dimensions of product and service quality.
2. Describe about various Quality Statements.
3. Explain the basic steps in bench marking process.
4. Explain about implementation stages of Quality circles.

**Course Outcome 2 (CO2):**

1. What are the important factors that a customer will think about while purchasing a product?
2. Explain how would you make the employees in an organization to work together to achieve the common goal.
3. Mention about work place management in terms of 5S.
4. Explain Kaizen.

**Course Outcome 3 (CO3):**

1. Define quality cost.
2. Explain the different techniques for Quality cost analysis.
3. Prepare a cost analysis on the purchase of a product from another country. If the product cost is Rs.50000. It increases in price by 20% every year, identify the Trend for 5 years.

**Course Outcome 4 (CO4):**

1. A machine is working to a specification of  $12.58 \pm 0.05$  mm. A study of 50 consecutive pieces shows the following measurements put into 10 groups of 3 each:

1	2	3	4	5	6	7	8	9	10
12.62	12.63	12.62	12.61	12.59	12.57	12.57	12.58	12.61	12.56
12.60	12.56	12.56	12.66	12.58	12.63	12.56	12.57	12.60	12.59
12.62	12.60	12.57	12.62	12.57	12.60	12.61	12.60	12.62	12.62
12.61	12.59	12.58	12.61	12.59	12.60	12.59	12.60	12.60	12.58
12.65	12.60	12.63	12.60	12.56	12.59	12.59	12.61	12.65	12.54

- Determine Control Limits and draw  $\bar{X}$  and R chart.
- Determine Process capability.
- Does it appear that the machine is capable of meeting the specification requirements?
- Calculate % defective if any.
- Suggest possible way to reduce the percent defectives.

2. Following are the inspection results of magnets for 16 hours.

Hour	1	2	3	4	5	6	7	8	9
No. of magnets inspected	48	36	50	47	48	54	50	42	32
No. of defective units	5	5	0	5	0	3	0	1	5

- Construct appropriate control charts.
  - State whether the process is in statistical control.
  - Indicate the values that are out of control.
3. Suppose that a product is shipped in lots of size  $N=5000$ . The receiving inspection procedure used is single sampling with  $n=50$  and  $c=1$ .
- Draw the type-A OC curve for the plan.
  - Draw the type-B OC curve for this plan and compare it to the type-A OC curve found in part (a).
  - Which curve is appropriate for the situation?

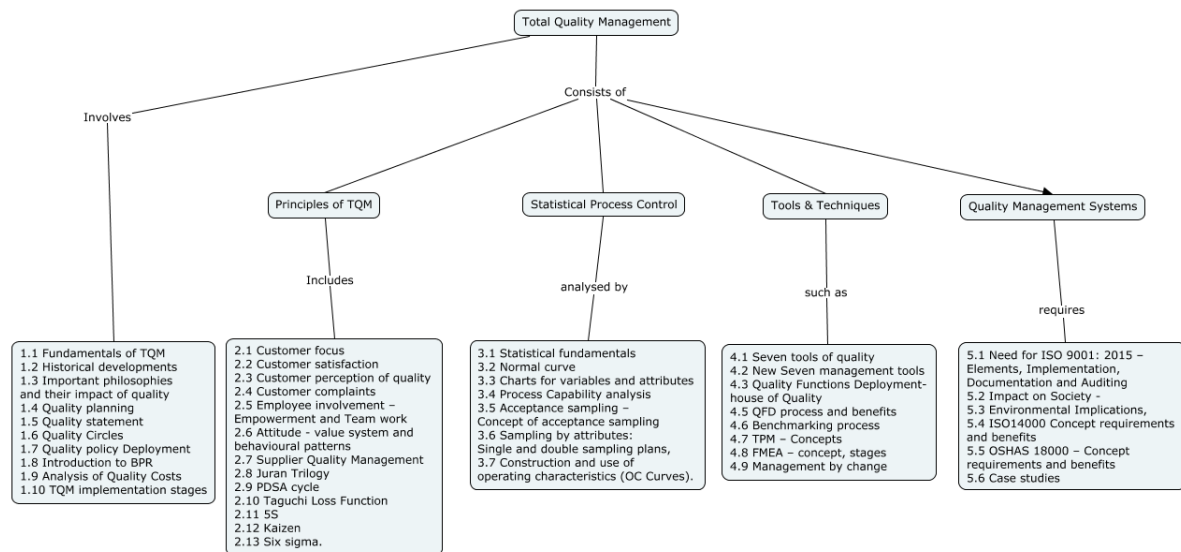
#### Course Outcome 5 (CO5):

- Explain about new seven management tools.
- Design a FMEA document by identifying the failure modes in Hole drilling process. In the process, Consider  $S=5$ ,  $O=9$ ,  $D=4$ , Find RPN. After action plan  $S=5$ ,  $O=1$ ,  $D=1$ . Recalculate RPN After Completion of Action Plans and Validate Improvements.
- Build the house of quality matrix to show the inter relationship between the customer requirements and technical descriptors for a manufacturing system.

#### Course Outcome 6 (CO6):

- Explain what is the need of ISO 9001: 2015 and how will you implement it in your organisation.
- Explain about the environmental implications on the society. Discuss the mandatory items of ISO 14000.
- Discuss about the requirements and the benefits of implementing OSHAS 18000.

## Concept Map



## Syllabus

**Introduction:** Fundamentals of TQM – Historical developments – important philosophies-(Deming, Juran, Crosby, Ishikawa) and their impact of quality – Quality planning, Quality statement, Quality Circles, Quality policy Deployment, introduction to BPR - TQM implementation stages

**Principles of TQM:** Customer focus - Customer satisfaction – customer perception of quality, customer complaints, Employee involvement – Empowerment and Team work, Attitude - value system and behavioural patterns, Supplier Quality Management, Juran Trilogy, PDSA cycle, Taguchi Loss Function, 5S, Kaizen, Six sigma. Quality Planning,

**Quality costs** – Analysis, Techniques for Quality Costs, Basic concepts of Total Quality Management, Quality aspects of Electronic systems. Software Quality.

**Statistical Quality Control (SQC):** Statistical fundamentals – Normal curve, charts for variables and attributes, Process Capability analysis, Acceptance sampling – Concept of acceptance sampling, Sampling by attributes: Single and double sampling plans, Construction and use of operating characteristics (OC Curves).

**TQM Tools and Techniques:** Seven tools of quality, New Seven management tools, Quality Functions Deployment (QFD) – house of Quality, QFD process and benefits, Benchmarking process, TPM – Concepts, FMEA – concept, stages, Management by change.

**Quality Management Systems:** Need for ISO 9001: 2015 – Elements, Implementation, Documentation and Auditing, Impact on Society - Environmental Implications, ISO14000 and OSHAS 18000 – Concept requirements and benefits – Case studies.



### Learning Resources

1. Dale H.Besterfield, Carol Besterfield-Michna. Glen H. Beseterfield and Mary Besterfield-Sacre., "**Total Quality Management**", Pearson Education Asia, 3<sup>rd</sup> edition, 2011.
2. D.C.Montgomery, "**Introduction to Statistical Quality Control**", John-Wiley & Sons Inc.New York, 6<sup>th</sup> edition, 2009
3. Shridhara Bhat, "**TQM – Text and Cases**", Himalaya publishing House, 2002.
4. Janakiraman.B and Gopal. R.K, "**Total Quality Management – Text and Cases**", Prentice Hall (India) Pvt. Ltd., 2006.
5. James R. Evans and William M.Lindsay, "**The management and control of Quality**", 8<sup>th</sup> edition, 2012
6. Sharma, D.D, "**Total Quality Management**", Sultan Chand & Sons, 2005.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction</b>		
1.1	Fundamentals of TQM – Historical developments	1	CO1
1.2	Important philosophies- (Deming, Juran, Crosby, Ishikawa) and their impact of quality –	1	CO1
1.3	Quality planning, Quality statement	1	CO1
1.4	Quality Circles	1	CO1
1.5	Quality policy Deployment	1	CO1
1.6	Introduction to BPR	1	CO1
1.7	TQM implementation stages	1	CO1
<b>2.0</b>	<b>Principles of TQM</b>		
2.1	Customer focus - Customer satisfaction, Customer perception of quality, customer complaints	1	CO2
2.2	Employee involvement – Empowerment and Team work	1	CO2
2.3	Attitude - value system and behavioural patterns	1	CO2
2.4	Supplier Quality Management	1	CO2
2.5	Juran Trilogy, PDSA cycle, Taguchi Loss Function	1	CO2
2.6	5S, Kaizen	1	CO2
2.7	Six sigma	1	CO2
<b>3.0</b>	<b>Quality Cost</b>		
3.1	Analysis of Quality Costs	1	CO3
3.2	Techniques for Quality Costs	1	CO3
3.3	Basic concepts of Total Quality Management	1	CO3
3.4	Quality aspects of Electronic systems, Software Quality	1	CO3
<b>4.0</b>	<b>Statistical Quality Control (SQC)</b>		
4.1	Statistical fundamentals- Normal curve	1	CO4

Module No.	Topic	No. of Hours	Course Outcome
4.2	Charts for variables	1	CO4
4.3	Charts for attributes	1	CO4
4.4	Process Capability analysis,	1	CO4
4.5	Acceptance sampling – Concept of acceptance sampling, Sampling by attributes: Single and double sampling plans	2	CO4
4.6	Construction and use of operating characteristics (OC Curves).	1	CO4
<b>4.0</b>	<b>TQM Tools and Techniques</b>		
4.1	Seven tools of quality, New Seven management tools	1	CO5
4.2	Quality Functions Deployment (QFD) – house of Quality, QFD process and benefits	1	CO5
4.3	Benchmarking process	1	CO5
4.4	TPM – Concepts	1	CO5
4.5	FMEA – concept, stages	1	CO5
4.6	Management by change.	1	CO5
<b>5.0</b>	<b>Quality Management Systems:</b>		
5.1	Need for ISO 9001: 2015 – Elements, Implementation, Documentation and Auditing	1	CO6
5.2	Impact on Society - Environmental Implications	1	CO6
5.3	ISO14000 - Concept requirements and benefits	1	CO6
5.4	OSHAS 18000 – Concept requirements and benefits	1	CO6
5.5	Case studies.	1	CO6
	<b>TOTAL</b>	<b>36</b>	

**Course Designers:**

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**18MTPT0 SMART BUILDING SYSTEMS**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

A smart building is one that is using technology to share information about what goes on in the building between systems so as to optimise the building's performance. This information is then used to automate various processes, from heating and ventilation to air conditioning and security. It includes the calculation of load while cooling various systems, designing of fire protection system, designing of electrical service system and plumbing system. By controlling the systems through a single system makes the building as a smart building

**Prerequisite**

- 18MT340 – Thermal Fluid Engineering

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the Significance of smart building systems	15
CO2	Perform cooling load calculation for a building	15
CO3	Design a fire protection system for a building	20
CO4	Develop access control system for a building	20
CO5	Design electrical services for a building	15
CO6	Design the plumbing system for a building	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2,4.1.4
CO2	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.1.2,4.4.1
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,4.1.1,4.1.2,4.4.1
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,3.1.1,4.1.1,4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,2.1,2.4.3,4.1.1,4.4.1

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	L	M	L
CO3	S	M	L	-	-	-	L	-	L	-	-	L	M	L
CO4	S	M	L	-	-	-	L	-	L	-	-	L	M	L
CO5	S	M	L	-	-	-	L	-	L	-	-	L	M	L
CO6	S	M	L	-	-	-	L	-	L	-	-	L	M	L

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	50	30	30	-	-	-	30
Apply	30	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini Project (Only design)
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define the term Smart Building.
2. Explain the significance of Smart Building.
3. Discuss the Essential attributes of smart building.

**Course Outcome 2(CO2):**

1. Define Dry bulb Temperature.
2. Explain cooling and Dehumidification process using Psychrometric chart.
3. An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 3 m high and 6 m deep. One of the two 3 m walls faces west and contains a double-glazed glass window of size 1.5 m by 1.5 m, mounted flush with the wall with no external shading. There are no heat gains through the walls other than the one facing west. Calculate the sensible, latent and total heat gains on the room, room sensible heat factor from the following information. What is the required cooling capacity?  
 Inside conditions: 25o C dry bulb, 50 percent RH  
 Outside conditions: 43o C dry bulb, 24o C wet bulb  
 U-value for wall: 1.78 W/m2 .K  
 U-value for roof: 1.316 W/m2 .K  
 U-value for floor : 1.2 W/m2 .K  
 Effective Temp. Difference (ETD) for wall: 25o C  
 Effective Temp. Difference (ETD) for roof: 30o C  
 U-value for glass ; 3.12 W/m2 .K  
 Solar Heat Gain (SHG) of glass ; 300 W/m2  
 Internal Shading Coefficient (SC) of glass: 0.86  
 Occupancy : 4 (90 W sensible heat/person)  
 (40 W latent heat/person)  
 Lighting load : 33 W/m2 of floor area

Appliance load : 600 W (Sensible) + 300 W(latent)  
 Infiltration : 0.5 Air Changes per Hour  
 Barometric pressure : 101 kPa

**Course Outcome 3(CO3):**

1. Define fire protection system.
2. Explain the steps and working of Hand held fire extinguisher.
3. Prepare an fire emergency evacuation plan for an Emergency system in a College.

**Course Outcome 4 (CO4):**

1. Define DVM.
2. Explain the components of a CCTV system.
3. Prepare the selection criteria of a camera which is used in a traffic signal.

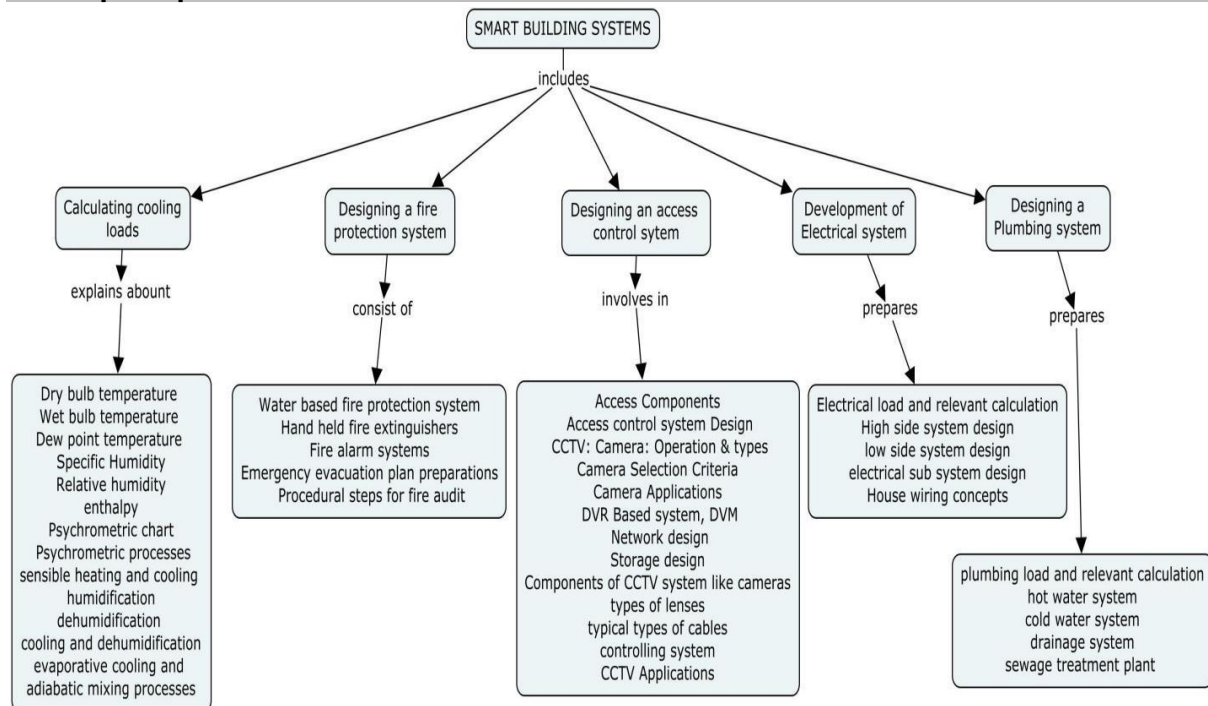
**Course Outcome 5 (CO5)**

1. Explain the High side system design in detail.
2. Explain the Low side system design in detail.
3. Prepare house wiring system for a two floor building.

**Course Outcome 6(CO6):**

1. Explain the Hot water system in detail.
2. Explain the cold system design in detail.
3. Prepare a sewage water treatment plan for an apartment.

**Concept Map**



## Syllabus

**Significance of smart building systems:** Definition of smart building. Essential attributes of smart building-Cabling Infrastructure, Lighting Control Systems, and Facility Management Systems, System Integration, Audio-Visual Systems, and Water, Occupant Satisfaction, Fire Alarm, Networks and Security, Electrical, Building Metering, and Video Surveillance Systems, Advanced Building Management Systems, Communication, Data Infrastructure and HVAC, Access Control and Sustainability, The Constantly Evolving Smart Building. Sensing and actuation systems for Smart structures. Green Energy, IOT for smart buildings.

**Cooling load calculation:** psychrometric properties-Definition of psychrometry, Dry bulb temperature, Wet bulb temperature, Dew point temperature, Specific Humidity, Relative humidity, enthalpy, Psychrometric chart. Psychrometric processes-sensible heating and cooling, humidification, dehumidification, cooling and dehumidification, evaporative cooling and adiabatic mixing processes, procedure for performing cooling load calculation for a building using psychrometric chart.

**Fire Protection System:** Theory of fire and calculation, Water based fire protection system- Hand held fire extinguishers- Fire alarm systems- Emergency evacuation plan preparations Procedural steps for fire audit.

**Access Control System:** Access Components, Access control system Design. CCTV: Camera: Operation & types, Camera Selection Criteria, Camera Applications, DVR Based system, DVM, Network design, Storage design. Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system. **CCTV Applications:** CCTV Applications.

**Electrical Services Design** – Electrical load and relevant calculation, High side system design, low side system design, electrical sub system design, House wiring concepts

**Plumbing Design** – plumbing load and relevant calculation, hot water system, cold water system, drainage system, sewage treatment plant.

## Learning Resources

1. James Sinopoli, "Smart building systems for Architects, owners and Builders", Butterworth-Heinemann an imprint of Elsevier, 2010.
2. James Sinopoli, "Advanced Technology for Smart Buildings", Artech House, 2016.
3. Nilesh Y Jadhav, "Green and Smart buildings - Advanced Techonology options", Springer, 2016.
4. Albert Ting- Pat so, WaiLok Chan, "Intelligent Building systems", Third Edition, Kluwer Academic Publisher, 2012.
5. Gerald C. Holst; Terrence S. Lomheim, "CMOS/CCD Sensors and Camera Systems", Second Edition, SPIE PRESS BOOK, 2011.
6. C P Arora, Refrigeration and Air conditioning, Third Edition, Mc Graw Hill India, 2012

### Course Contents and Lecture Schedule

Module No.	Topic	No. Of Hours	Course Outcome
1	<b>Significance of smart building systems</b>		
1.1	Definition of smart building	1	CO1
1.2	Essential attributes of smart building	1	CO1
1.3	Cabling Infrastructure, Lighting Control Systems, and Facility Management Systems, System Integration, Audio-Visual Systems, and Water	1	CO1
1.4	Occupant Satisfaction, Fire Alarm, Networks and Security, Electrical, Building Metering, and Video Surveillance Systems	1	CO1
1.5	Advanced Building Management Systems, Communication, Data Infrastructure and HVAC, Access Control and Sustainability	1	CO1
1.6	The Constantly Evolving Smart Building	1	CO1
1.7	Sensing and actuation systems for Smart structures. Green Energy, IOT for smart buildings.	1	CO1
2	<b>Cooling load calculation</b>		
2.1	Psychrometric properties-Definition of psychrometry	1	CO2
2.2	Dry bulb temperature, Wet bulb temperature, Dew point temperature	1	CO2
2.3	Specific Humidity, Relative humidity, enthalpy, Psychrometric chart.	1	CO2
2.4	Psychrometric processes-sensible heating and cooling	1	CO2
2.5	Humidification, dehumidification, cooling and dehumidification	1	CO2
2.6	Evaporative cooling and adiabatic mixing processes	1	CO2
2.7	Procedure for performing cooling load calculation for a building using psychrometric chart.	1	CO2
3	<b>Fire Protection System</b>		
3.1	Theory of fire and calculation	1	CO3
3.2	Water based fire protection system	1	CO3
3.3	Hand held fire extinguishers	1	CO3
3.4	Fire alarm systems	1	CO3
3.5	Emergency evacuation plan preparations	1	CO3
3.6	Procedural steps for fire audit.	1	CO3
4	<b>Access Control System</b>		
4.1	Access Components, Access control system Design.	1	CO4
4.2	CCTV: Camera: Operation & types, Camera Selection Criteria, Camera Applications	1	CO4
4.3	DVR Based system, DVM	1	CO4
4.4	Network design, Storage design.	1	CO4
4.5	Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system.	1	CO4
4.6	<b>CCTV Applications:</b> CCTV Applications.	1	CO4
5	<b>Electrical Services Design</b>		
5.1	Electrical load and relevant calculation	1	CO5
5.2	High side system design	1	CO5
5.3	Low side system design	1	CO5
5.4	Electrical sub system design	1	CO5

<b>Module No.</b>	<b>Topic</b>	<b>No. Of Hours</b>	<b>Course Outcome</b>
5.5	House wiring concepts	1	CO5
6	<b>Plumbing Design</b>		
6.1	Plumbing load and relevant calculation	1	CO6
6.2	Hot water system	1	CO6
6.3	Cold water system	1	CO6
6.4	Drainage system	1	CO6
6.5	Sewage treatment plant	1	CO6
	<b>TOTAL</b>	36	

**Course Designers:**

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**18MTPU0****WIRELESS SENSOR NETWORKS**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Wireless Sensor Network (WSN) is an infrastructure-less wireless network that is deployed in a large number of wireless sensors in an ad-hoc manner that is used to monitor the system, physical or environmental conditions.

Sensor nodes are used in WSN with the onboard processor that manages and monitors the environment in a particular area. They are connected to the Base Station which acts as a processing unit in the WSN System.

Base Station in a WSN System is connected through the Internet to share data.

**Prerequisite**

- 18MT330 – Digital Electronics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe fundamental architecture of OSI model for Wired and Wireless Networks	10
CO2	Classify Different IEEE Standards for Wireless personal Area Networks	25
CO3	Select a Wireless sensor node hardware for the Desired Network Architecture	20
CO4	Articulate Different MAC protocols used in Wireless Sensor Networks	15
CO5	Use Different Routing Protocols for Different Scenarios	15
CO6	Manipulate the Network parameters to Provide Quality of Service	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,1.2,1.3,2.1.4,2.1.5,2.3.1
CO2	TPS2	Understand	Respond	Guided Response	1.1,1.2,1.3,2.1.4,2.1.5,2.3.1
CO3	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2,4.3.4
CO4	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3,4.3.1,4.3.2,4.4.1,4.5.3
CO5	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.5.6
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.6.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	L	-	-	-	-	-	M	S	-
CO2	M	L	-	-	-	-	-	-	-	-	-	M	S	-
CO3	S	M	L	-	-	L	-	-	M	-	-	M	M	M
CO4	S	M	L	-	L	-	-	-	M	-	-	S	M	M
CO5	S	M	L	-	L	L	-	-	M	-	-	S	S	S
CO6	S	M	L	-	L	-	-	-	M	-	-	S	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	-
Understand	100	50	25	100	50	25	40
Apply	-	50	75	-	50	75	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Programming Assignment
Mechanism	Practical Component
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Describe about the OSI model in communication system
2. List the network layer protocols used in communication networks
3. Give the significance of physical layer in communication model

**Course Outcome 2(CO2):**

1. Illustrate the IEEE 802.15.1 protocol
2. Demonstrate operation mechanism of WiFi protocol
3. Explain the IEEE standard for Zigbee

**Course Outcome 3(CO3):**

1. Mention the hardware components of a Wireless sensor network
2. List the various applications of wireless sensor networks and explain any two with an example each.
3. With a neat diagram, illustrate the sensor network architecture

**Course Outcome 4(CO4):**

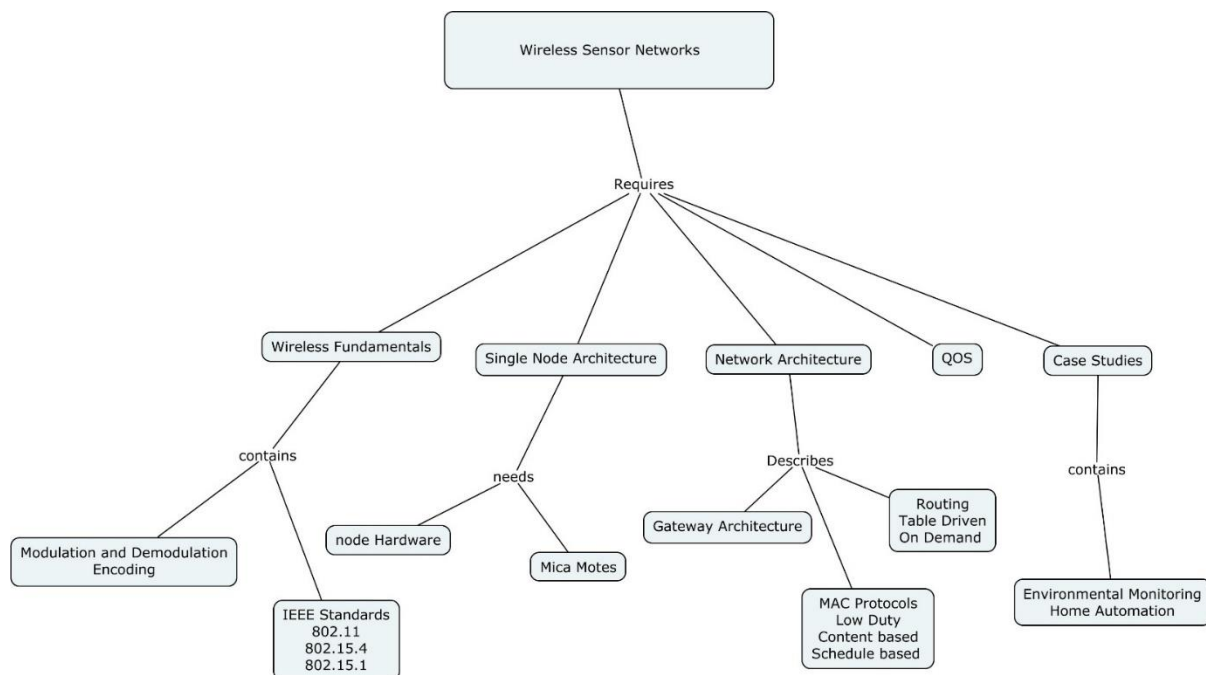
1. Enumerate the requirements of a MAC protocol
2. Explain about various clustering mechanisms in WSN. Also detail about the sensor tasking and Control
3. Discuss the distributed assignment of network wide unique MAC address for WSN

**Course Outcome 5(CO5):**

1. Compare various routing protocols used in WSN
2. Explain energy efficient routing protocol
3. Illustrate about table-driven routing protocol

**Course Outcome 6(CO6):**

1. Define QoS
2. Discuss the need for energy management in WSN
3. Explain the issues and challenges in providing QoS

**Concept Map****Syllabus**

**Introduction** - A vision of Ambient Intelligence - **Network Architecture** – OSI Layer Model Wired Vs Wireless – Direct Link Networks - Physical Layer –Wireless Channel and Communication fundamentals

**IEEE Standards** -802.11 (WIFI), 802.15.1 (Bluetooth), 802.15.4 (LoRaPAN) and Zigbee-Internetworking – Subnetting

**Single node Architecture** – Mica Mote family - **Sensor Network architecture** – scenarios – Design Principles- Gateway Concepts – WSN to Internet and Vice versa–

**MAC protocols** – Low duty Cycle – Content based – Schedule based - **Routing** - classification – Table Driven – on demand Routing - Data Dissemination – Data Gathering– Quality of Service – Time Synchronization – Evolving Standards

**Case Studies:** Temperature Monitoring, Air Pollution Monitoring, Home and Industrial Automation, IoT on Agriculture

### Learning Resources

1. Jun Zheng, Abbas, "Wireless sensor networks A networking perspective", WILEY, 2009.
2. Kazem Sohraby, Daniel Minoli, & Taieb Znati, —Wireless Sensor Networks- Technology, Protocols, And Applicationsll, John Wiley, 2007
3. Thomas Haenselmann, —Wireless Sensor Networks: Design Principles for Scattered Systemsll, Oldenbourg Verlag, 2011
4. Vijay Madiseti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st 9 Edition, VPT, 2014.
5. E. H. Callaway, Jr. E. H. Callaway, Wireless Sensor Networks Architecture and Protocols: CRC Press.
6. C.SivaRamamurty, B.S.Manoj, "Ad HocWireless Networks – Architectures and Protocols, Pearson Education ,2013.
7. Larry L. Peterson, Bruce S. Davie," Computer Networks-A Systems Approach", Elsevier Science, ISBN: 9780080476674, 0080476678

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
1	<b>Introduction</b>		
1.1	A vision of Ambient Intelligence	1	CO1
	<b>Network Architecture</b>		
1.2	OSI Layer Model (Wired vs Wireless)	1	CO1
1.3	Direct Link Networks	2	CO1
1.4	Physical Layer	1	CO1
1.5	Wireless Channel and Communication fundamentals	2	CO1
2	<b>IEEE Standards</b>		
2.1	802.11 (WIFI)	1	CO2
2.2	802.15.1 (Bluetooth)	1	CO2
2.3	802.15.4 (LoRaPAN) - Zigbee	1	CO2
2.4	Internetworking – Subnetting	2	CO2
3	<b>Single node Architecture</b>		
3.1	Wireless Sensor Nodes list - Mica Mote family	2	CO3
4	<b>Sensor Network architecture.</b>		
4.1	Design Principles- Gateway Concepts	1	CO3
4.2	WSN to Internet and Vice versa	2	CO3
5	<b>MAC protocols</b>		
5.1	Low duty Cycle	2	CO4
5.2	Content based	2	CO4

Module No.	Topic	No. of Lectures	CO
5.3	Schedule based	1	CO4
6	<b>Routing</b>		
6.1	Classification	1	CO5
6.2	Table Driven	2	CO5
6.3	on Demand Routing	2	CO5
6.4	Data Dissemination – Data Gathering	1	CO5
6.5	Quality of Service – Time Synchronization – Evolving Standards	2	CO6
7	<b>Case Studies</b>		
7.1	Temperature Monitoring,	2	CO6
7.2	Air Pollution Monitoring,	2	CO6
7.3	Home and Industrial Automation	2	CO6
TOTAL		36	

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**18MTPV0 AUTONOMOUS ROBOT NAVIGATION**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Mobile Robotics is a fast evolving, solutions orientated, industry within which the robotics engineer is a significant and growing work role. Mobile robotics is an important part of the industry, with applications in diverse industries, including manufacturing, agriculture, aerospace, mining, and medicine. In this course, the students would learn the types of mobile robots, its kinematics and important functionalities.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Derive the kinematics of various mobile robots	20
CO2	Select the suitable sensor and perceive the environment	10
CO3	Develop Maps with the robot for a particular environment	10
CO4	Localize the robot in an environment	20
CO5	Implement SLAM algorithm for navigation	20
CO6	Implement path planning algorithms for a given environment	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5,2.3.1
CO2	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2,4.3.4
CO3	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3,4.3.1,4.3.2,4.4.1,4.5.3
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.5.6
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.6.2
CO6	TPS3	Apply	Value	-	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3, 2.4.4,4.3.1,4.3.2, 4.3.4,4.4.1,4.5.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO2	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO3	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO4	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO5	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO6	S	M	L	-	S	-	-	-	S	-	-	S	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	40	20	20	-	-	-	20
Understand	40	40	40	100	-	-	30
Apply	20	40	40	-	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Mapping and Navigation Assignment
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. List the types of kinematics in a mobile robot
2. Describe the basic constraints to be considered while developing a kinematic model.
3. Derive the kinematic model of a two wheeled robot shown below

**Course Outcome 2 (CO2):**

1. Describe the factors considered while selecting a vision sensor based on the features of the environment.
2. List the common issues occurred while interfacing the sensor with the robotic circuitry.
3. Develop the control architecture of a mobile robot which moves along a room and paints the wall at a height of 3m from the ground. Consider all the mechanical alternatives and draw all possible designs. Choose sensor, actuator, communication and interface method for all designs. The robot of mass 3 kg should reach the maximum velocity in 1 s, so an acceleration of  $0.15\text{m/s}^2$  is desired. The wheel radius is assumed to be 3 cm. Calculate the maximum torque and required power. According to the design considered, a differential (gear reduction mechanism) of gear ratio 12.5:1 is used to raise the spray gun to a particular height. Design optimum motor driving circuitry, signal conditioning circuit and algorithm for smooth functioning of the robot.

**Course Outcome 3 (CO3):**

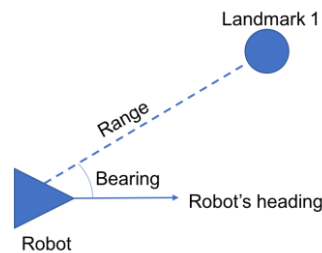
1. What the factors to consider while we develop a map.



2. Consider a robot to be used for mapping an environment in an outdoor environment. What is the sensor used in rainy season and what features will you extract.
3. Explain the SIFT algorithm to capture the features from the night images

**Course Outcome 4 (CO4):**

1. .Explain the factors which affects the localisation module in Kalmar filter localisation
2. Explain the landmark recognition process and the robot turning process to move towards the corresponding landmark



3. To increase the localization in when the threshold of similarity in images are 50%, which algorithm should be considered?

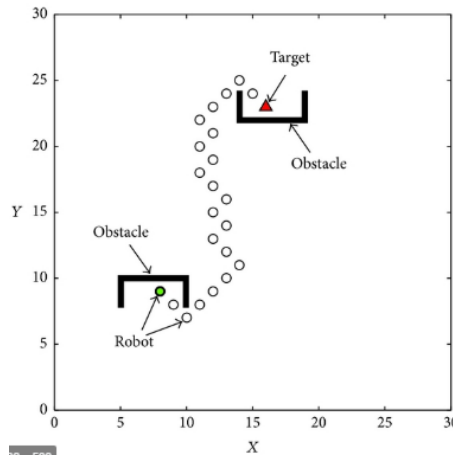
**Course Outcome 5 (CO5):**

1. Using the vision sensor on board, determine recognise the place with A\* algorithm and explain the algorithm to code.
2. Explain the MONO SLAM algorithm with respect to a three wheeled robot.
3. What is the process of State estimation and the landmark estimation if the robot is used in night

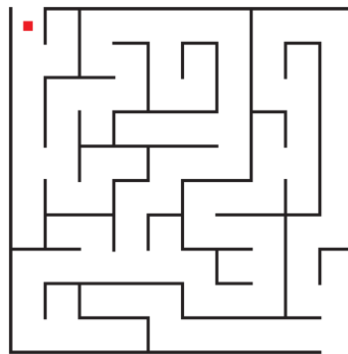
**Course Outcome 6 (CO6):**

1. Consider the following environment to move the mobile robot from green point to red triangle. Design an algorithm to detect the obstacle and move to the corresponding position. The sensor on board the vehicle is bumper sensor.



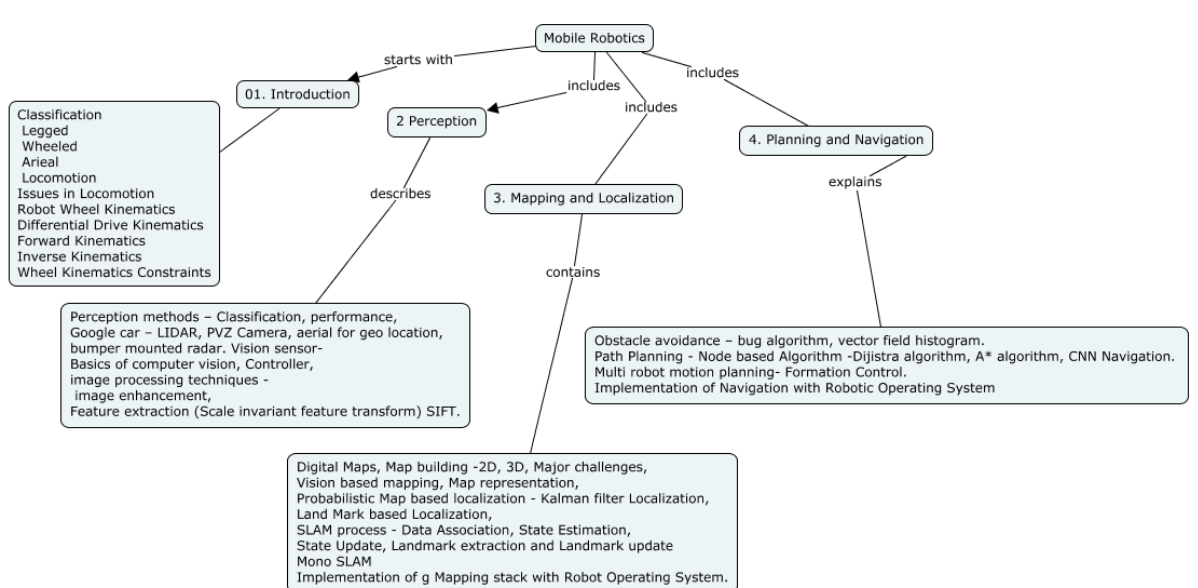


2. Select the number of input layer, hidden layer and output layer neurons to detect the obstacle solve a maze using three proximity sensors on the mobile robot. The robot moves in an indoor environment without any slippage. The robot should move from the red dot to the exit point.



3. Design a algorithm such that three robots follow each other with a safe distance of 3 meters. The second and the third robot has to follow the master robot.

**Concept Map**



## Syllabus

### Introduction to Mobile Robots

Introduction to Mobile robots - Locomotion, Classification - Legged, Wheeled, Aerial - Key issues in locomotion. Kinematic model- Differential drive Kinematics - Forward Wheel Kinematic model, Representing position, Wheel kinematic constraints. Motion control.

### Perception

Perception methods – Classification, performance, **Google car** – LIDAR, PVZ Camera, aerial for geo location, bumper mounted radar. Vision sensor- Basics of computer vision, Controller, image processing techniques - image enhancement, Feature extraction (Scale invariant feature transform) SIFT.

### Mapping and Localization

Digital Maps, Map building -2D, 3D, Major challenges, Vision based mapping, Map representation, Probabilistic Map based localization - Kalman filter Localization, Land Mark based Localization, - SLAM process - Data Association, State Estimation, State Update, Landmark extraction and Landmark update. Mono SLAM, Implementation of g Mapping stack with Robot Operating System.

### Planning and Navigation

Obstacle avoidance – bug algorithm, vector field histogram. Path Planning - Node based Algorithm - Dijkstra algorithm, A\* algorithm, CNN Navigation. Multi robot motion planning- Formation Control. Implementation of Navigation with Robotic Operating System

## Learning Resources

1. Luc Jaulin, "Mobile Robotics", 2nd Edition, December 2019
2. Ronald Siegwart, Illah R. Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", MIT Press Publication, 2nd edition, 2011.
3. Janusz Będkowski "Mobile Robots - Control Architectures, Bio-Interfacing, Navigation, Multi Robot Motion Planning and Operator Training", InTech Publication, 2011.
4. W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd., 2003.

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
<b>1</b>	<b>Introduction to Mobile Robots</b>		
1.1	Introduction to Mobile robots	1	CO1
1.2	Locomotion, Classification - Legged, Wheeled, Aerial.	1	CO1
1.3	Key issues in locomotion	1	CO1
1.4	Mobile Robot wheel Kinematics – Wheel Kinematic model	1	CO1
1.5	Differential drive Wheel kinematic model	1	CO1
1.6	Forward Wheel Kinematic model	1	CO1
1.7	Inverse Wheel Kinematic model	1	CO1
1.8	Representing position, Wheel kinematic constraints. Motion control	2	CO1
<b>3</b>	<b>Perception</b>		
3.1	Perception methods – Classification, performance	1	CO2

Module No.	Topic	No. of Lectures	CO
3.2	Google car – LIDAR, PVZ Camera, aerial for geo location, bumper mounted radar	1	CO2
3.3	Vision sensor-	1	CO2
3.4	Basics of computer vision	1	CO2
3.5	Controller	1	CO2
3.6	Vision sensor	1	CO2
3.7	Basics of computer vision	1	CO3
3.8	image processing techniques - image enhancement	1	CO3
3.9	Feature extraction (Scale invariant feature transform) SIFT	1	CO3
<b>4</b>	<b>Mapping and Localization</b>		
4.1	Digital Maps, Map building -2D, 3D	1	CO3
4.2	Major challenges	1	CO3
4.3	Vision based mapping, Map representation	1	CO3
4.4	Probabilistic Map based localization	1	CO4
4.5	Odometric Localization, Localization	1	CO4
4.6	Kalman filter Localization	1	CO4
4.7	SLAM process - Data Association, State Estimation,	1	CO5
4.8	State Update, Landmark extraction and Landmark update	1	CO5
4.9	MonoSLAM	1	CO5
4.10	Implementation of g Mapping stack with Robot Operating System.	1	CO5
<b>5</b>	<b>Planning and Navigation</b>		
5.1	Obstacle avoidance – bug algorithm, vector field histogram	1	CO6
5.2	Path Planning - Node based Algorithm -Dijkstra algorithm,	1	CO6
5.3	A* algorithm	1	CO6
5.4	CNN Navigation	1	CO6
5.5	Multi robot motion planning	1	CO6
5.6	Formation Control	1	CO6
5.7	Implementation of Navigation with Robotic Operating System	2	CO6
<b>Total Hours</b>		<b>36</b>	

**Course Designers:**

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18MTPW0

**SIMULATION OF MECHATRONICS  
SYSTEMS**Category L T P Credit(s)  
PE 3 0 0 3**Preamble**

Mechatronic system is a synergistic integration of mechanisms, sensors, actuators and control to perform complex tasks in a metaphysical environment.

An important characteristic of Mechatronic devices and systems is their built-in intelligence, which results through a combination of precision mechanical and electrical engineering and real-time programming integrated with the design process. The design process includes modelling and simulation. Modelling of such Mechatronic systems is the primary step to develop a system. This course teaches the basic concepts of interdisciplinary modelling and simulation of Electrical, Electronics, Mechanical and Hydraulic systems thus combining to Mechatronic Systems. To achieve this proven techniques like bond graphs is used.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain various methods of modelling and simulation for Mechatronic system	10
CO2	Describe the basics of modelling and simulation using bond graph	10
CO3	Model and Simulate Electrical and Mechanical systems	20
CO4	Model and Simulate Hydraulic and Electronic systems	20
CO5	Derive the system equation from bond graphs of a system	20
CO6	Develop bond graphs for a particular Mechatronic System	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5,2.3.1
CO2	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2,4.3.4
CO3	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3,4.3.1,4.3.2,4.4.1,4.5.3
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.5.6
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 2.4.3, 4.3.1,4.3.2, 4.3.4, 4.4.1, 4.5.3, 4.6.2
CO6	TPS3	Apply	Value	-	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3, 2.4.4,4.3.1,4.3.2, 4.3.4,4.4.1,4.5.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO2	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO3	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO4	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO5	S	M	L	-	S	-	-	-	S	-	-	S	M	M
CO6	S	M	L	-	S	-	-	-	S	-	-	S	M	M

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	40	20	20	-	-	-	20
Understand	40	40	40	100	-	-	20
Apply	20	40	40	-	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Modelling Assignment
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

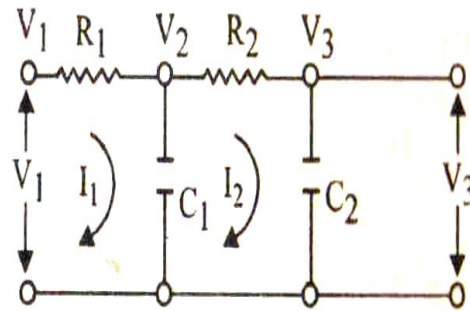
1. Define Transfer Function
2. List the type of mathematical models
3. Define Linearization models

**Course Outcome 2 (CO2):**

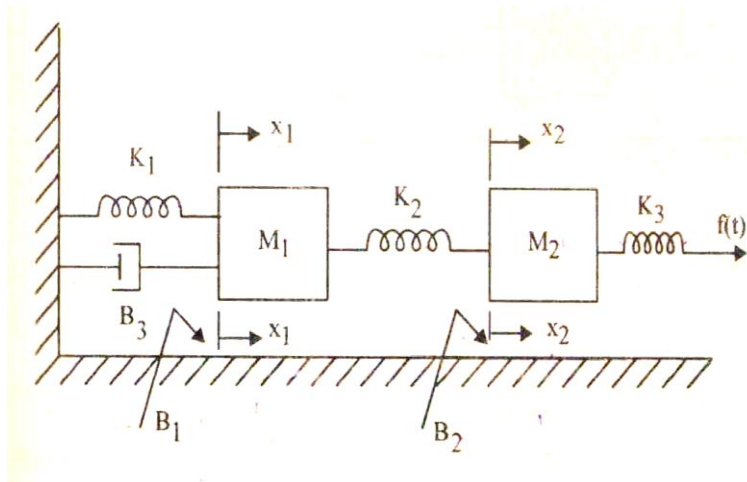
1. Discuss about Power Variables used in bond graph
2. Define components in physical systems
3. Explain about Transformer Element and Gyrator Element

**Course Outcome 3 (CO3):**

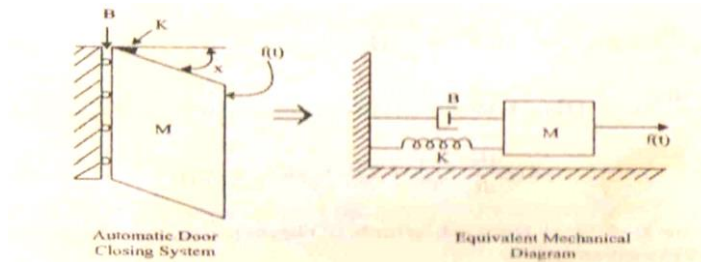
1. Develop a model for the physical system shown below using bond graph



2. Develop a model for the physical system shown below using bond graph

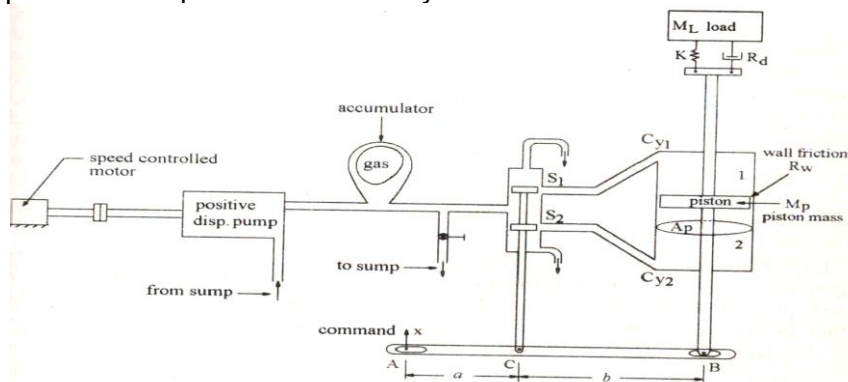


3. Develop a model for the physical system shown below using bond graph

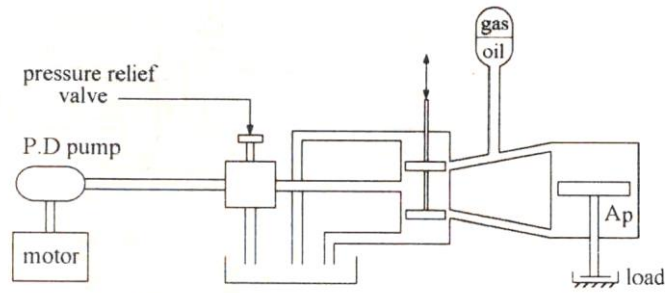


**Course Outcome 4 (CO4):**

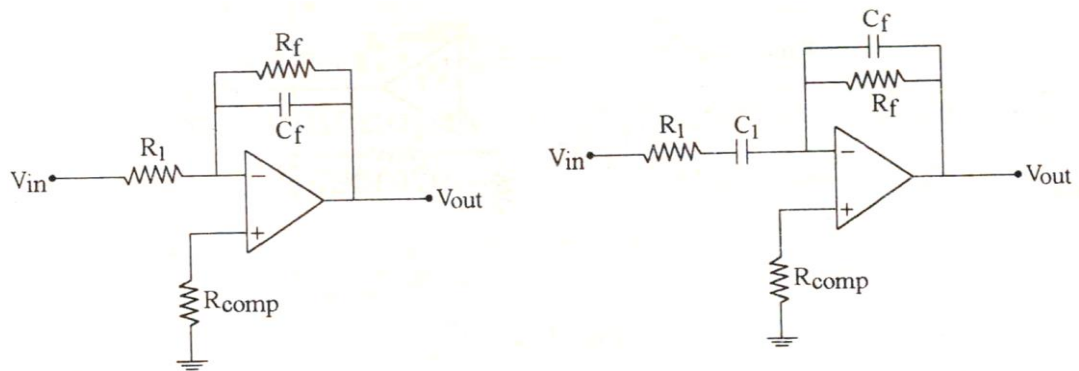
1. Develop a Bond Graph model for the Hydraulic Servo motor



2. Make a bond graph model of the hydraulic system used for metal forming operation

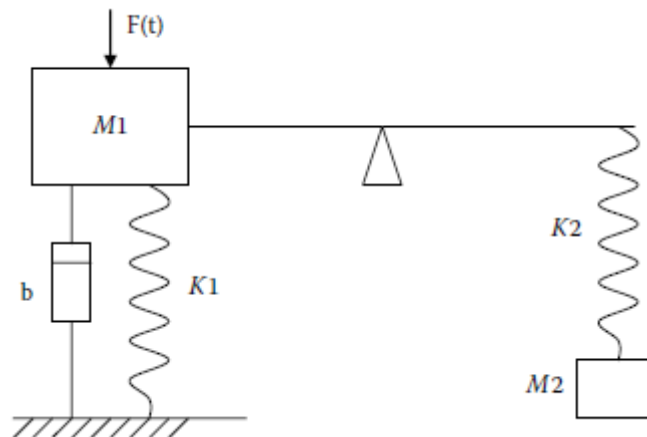


3. Draw a bond graph model for Practical integrator and differentiator circuit shown in below

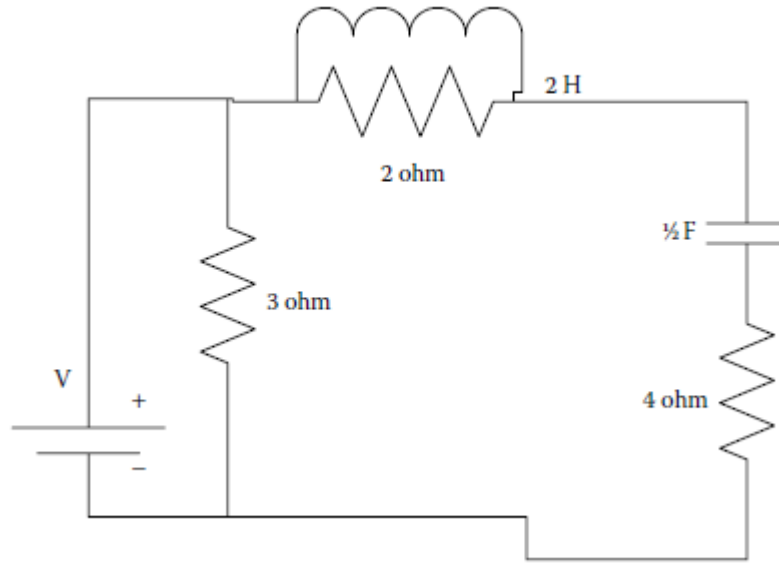


**Course Outcome 5 (CO5):**

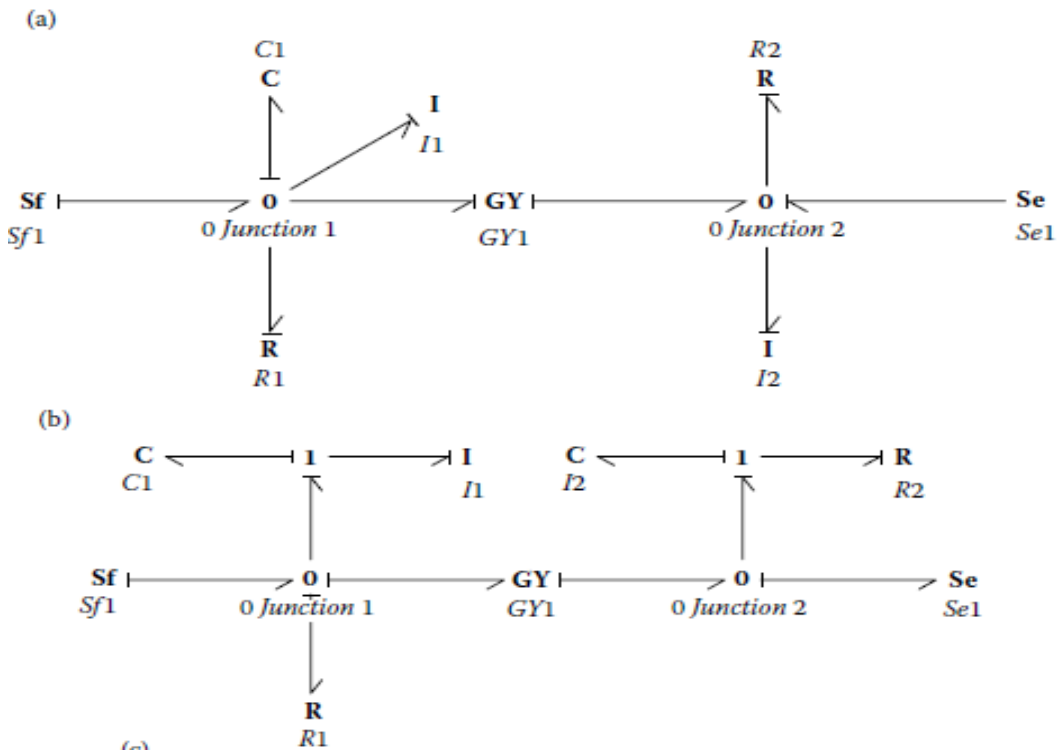
1. Derive the system equation for the following system. Follow the procedure and obtain the equations.



2. Consider the differential causality and derive the system equation for the following system.



3. Derive the governing equations for the bond graphs below:

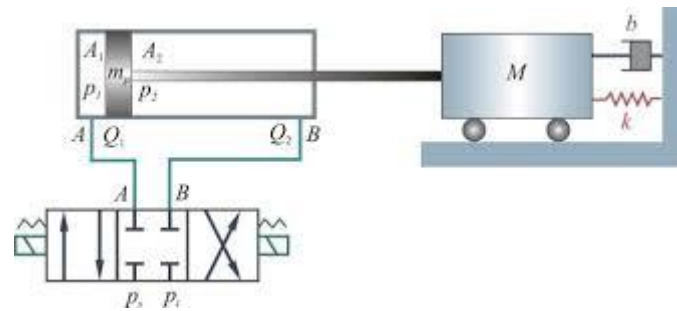


**Course Outcome 6 (CO6):**

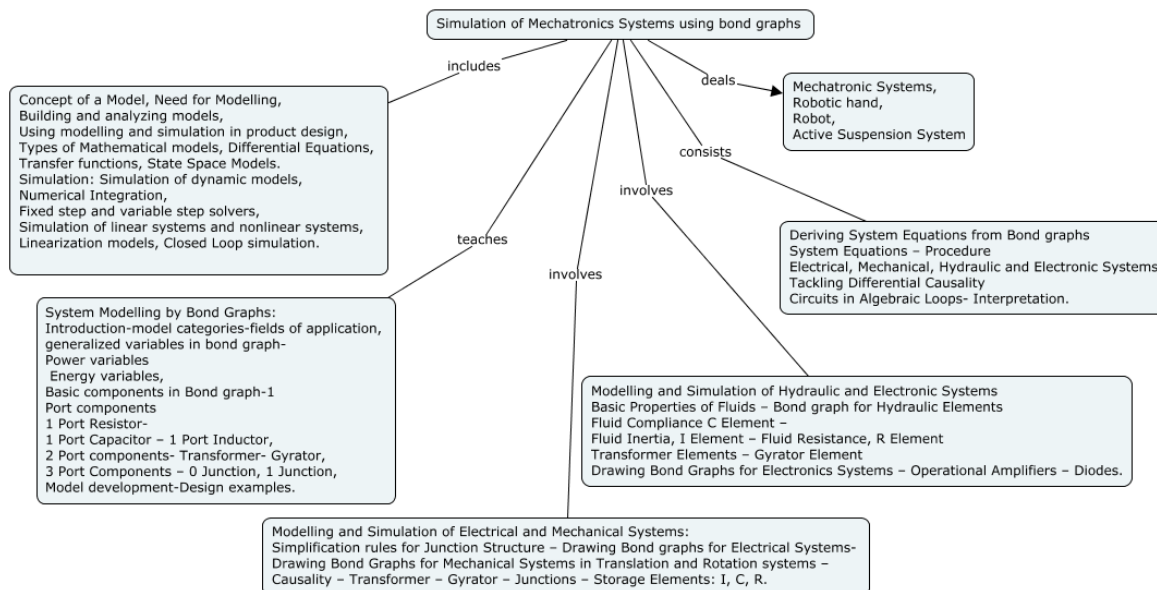
1. Develop a bond graph for the robotic hand. Consider a two finger gripper to grab an object of 2 kg. Consider the frictional coefficient of 0.2 and damping coefficient of 0.1 .
2. Develop a bong graph for a biped robot which is operated at a speed of 12 m/s and driven by motors of bearing resistance of 0.1 ohms. Consider the robot is moving with a frictional coefficient of 0.1.



3. Develop a bond graph for



**Concept Map**



**Syllabus**

**Introduction to Mechatronic System Modelling and Simulation:**

Concept of a Model, Need for Modelling, Building and analyzing models, Using modelling and simulation in product design, Types of Mathematical models, Differential Equations, Transfer functions, State Space Models. **Simulation:** Simulation of dynamic models, Numerical Integration, Fixed step and variable step solvers, Simulation of linear systems and nonlinear systems, Linearization models, Closed Loop simulation.

**System Modelling by Bond Graphs:**

Introduction-model categories-fields of application, generalized variables in bond graph- Power variables – Energy variables, Basic components in Bond graph-1 Port components- 1 Port Resistor- 1 Port Capacitor – 1 Port Inductor, 2 Port components- Transformer- Gyrator, 3 Port Components – 0 Junction, 1 Junction, Model development-Design examples.

**Modelling and Simulation of Electrical and Mechanical Systems:**

Simplification rules for Junction Structure – Drawing Bond graphs for Electrical Systems- Drawing Bond Graphs for Mechanical Systems in Translation and Rotation systems – Causality – Transformer – Gyrator – Junctions – Storage Elements: I, C, R.

### Modelling and Simulation of Hydraulic and Electronic Systems

Basic Properties of Fluids – Bond graph for Hydraulic Elements – Fluid Compliance C Element – Fluid Inertia, I Element – Fluid Resistance, R Element – Transformer Elements – Gyrator Element – Drawing Bond Graphs for Electronics Systems – Operational Amplifiers – Diodes.

### Deriving System Equations from Bond graphs

System Equations – Procedure – Electrical, Mechanical, Hydraulic and Electronic Systems, Tackling Differential Causality - Circuits in Algebraic Loops- Interpretation.

### Mechatronic Systems

Robotic hand, Biped Robot, Active Suspension System

### Learning Resources

1. Wolfgang Borutzky, “Bond Graphs for Modelling, Control and Fault Diagnosis of Engineering Systems”, Springer, 2016
2. Shuvra Das., “**Mechatronic Modeling and Simulation Using Bond Graphs**”, CRC Press, 2009.
3. Amalendu Mukherjee, Ranjit Karmakar, Arun kumar samantaray, “**Bond Graph in Modeling, Simulation and Fault Identification**” I.K International Pvt Ltd, Jan 2006.
4. Dean C Karnopp, Donal L Morgolis, Ronald C Rosenberg “**System Dynamics; Modeling, Simulation and Control of Mechatronic systems**”, John Wiley & Sons, Inc, 5<sup>th</sup> Edition, 2012.
5. Jacqueline Wilkie., Michael Johnson., Reza Katebi., “ **Control Engineering an Introductory course** “ Palgrave Publication, 2003.
6. Wayne Bequette. B., “**Process Control: Modeling, Design and Simulation**” ., Prentice Hall PTR, 2002.
7. Peter Fritzson., “**Principles of object oriented modeling and Simulation with Modelica 2.1**”, IEEE Press, 2004.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
<b>1.0</b>	<b>Introduction to Mechatronic System Modelling and Simulation</b>		
1.1	Concept of Model, Need for modelling. Building and analysing models,	1	CO1
1.2	Types of mathematical models, Differential equations, Differential Algebraic equations,	1	CO1
1.3	Transfer functions, State space models	1	CO1
1.4	Using modeling and simulation in product design	1	CO1
1.5	Simulation of dynamic models, Numerical Integration, Fixed step and variable step solvers	1	CO1
1.6	Simulation of linear systems and Nonlinear systems	2	CO1
1.7	Linearization models	1	CO1
1.8	Closed loop simulation	1	CO1
<b>2.0</b>	<b>Introduction to Bond Graph</b>		
2.1	Engineering Systems – Ports - Generalized Variables - Power Variables - Energy Variables	1	CO2
2.2	Tetrahedron of State - Bond Graphs - Word Bond Graphs - Basic Components in Systems	1	CO2

Module No.	Topic	No. of Lectures	CO
2.3	1 Port Components - 1 Port Resistor - 1 Port Capacitor- 1 Port Inductor/Inertia	2	C02
2.4	2 Port Components - Transformer Element - Gyrator Element	2	C02
2.5	3 Port Components - 0 Junction, 1 Junction.	2	C02
<b>3.0</b>	<b>Modelling and Simulation of Electrical and Mechanical Systems</b>		
3.1	Simplification Rules for Junction Structure	1	C03
3.2	Drawing Bond Graphs for Electrical Systems	1	C03
3.3	Drawing Bond Graphs for Mechanical Systems in Translation and Rotation	2	C03
3.4	Causality – Transformer – Gyrator – Junctions	1	C03
3.5	Storage Elements: L, C - R, for Resistive Elements -	1	C03
<b>4.0</b>	<b>Modelling and Simulation of Hydraulic and Electronic Systems</b>		
4.1	Basic Properties of Fluids	1	C04
4.2	Bond Graph model for Hydraulic Elements	1	C04
4.3	Fluid Compliance, C Element – Fluid Inertia, L Element – Fluid Resistances, R Element	1	C04
4.4	Transformer Elements – Gyrator Element	1	C04
4.5	Drawing Bond Graphs for Electronic Systems	1	C04
4.6	Operational Amplifiers – Diodes	1	C04
<b>5.0</b>	<b>Deriving System Equations from Bond graphs</b>		
5.1	System Equations – Procedure	1	C05
5.2	Electrical, Mechanical, Hydraulic and Electronic Systems	2	C05
5.3	Tackling Differential Causality	1	C05
5.4	Circuits in Algebraic Loops- Interpretation.	1	C05
5.5	Robotic hand	1	C06
5.6	Biped Robot, Active Suspension System	1	C06
<b>Total</b>		<b>36 Hours</b>	

**Course Designers:**

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1	Dr G Kumaraguruparan	gkgmech@tce.edu
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**18MTPY0 INTRODUCTION TO PHOTONICS**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Photonics is the science and technology of generating, controlling and detecting photons. Photonics find diverse applications including optical data communication, imaging and lightning systems. This course work aims in imparting fundamental knowledge of optics, quantum mechanics and semiconductor which are essential in understanding and explaining photonic devices. Learners' will be able to appreciate the role of photonics and its products

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the behaviour of light and optical phenomena involved in Lasers and Fibre optics	30
CO2	Apply the basic principles of Quantum mechanics used for Photonic devices	10
CO3	Make use of the properties of light for light manipulation	10
CO4	Understand the basics principle in non-linear optics	10
CO5	Apply the knowledge of semiconductor theory for photonic devices	10
CO6	Illustrate the role of various photonic devices	30

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Understand	Respond	-	1.1 ,3.2.3
CO2	TPS2	Apply	Value	-	1.1,1,2
CO3	TPS3	Apply	Value	-	1.1,3.1
CO4	TPS3	Understand	Respond	-	1.1,1.2
CO5	TPS2	Apply	Value	-	1.1,3.2
CO6	TPS3	Understand	Respond	-	1.1,1.2,1.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	-	-	-	-	L	L	-	-	-	-
CO2	M	L	L	-	-	-	-	-	L	L	-	-	-	-
CO3	M	L	L	L	-	-	-	-	L	L	-	-	-	-
CO4	S	M	L	L	-	-	-	-	L	L	-	-	-	-
CO5	M	L	L	-	-	-	-	-	L	L	-	-	-	-
CO6	S	M	L	L	-	-	-	-	L	L	-	-	-	-

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

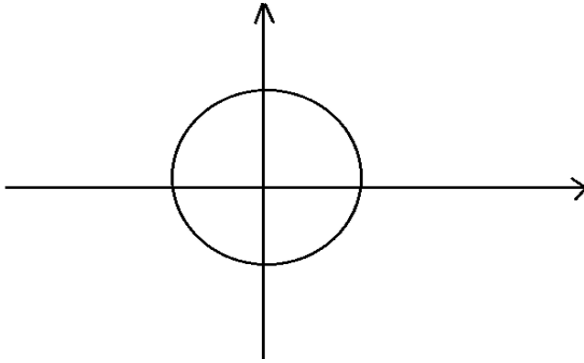
1. If the refractive index of the core of an optical fibre is 1.5 and cladding is 1.46, calculate the numerical aperture, critical angle at core cladding interface.
2. Write the Maxwell's equation in differential and Integral form
3. During normal beating, the heart creates a maximum 4.00-mV potential across 0.300 m of a person's chest, creating a 1.00-Hz electromagnetic wave. What is the maximum electric field strength created? What is the corresponding maximum magnetic field strength in the electromagnetic wave?

**Course Outcome 2(CO2):**

1. Compute the smallest possible uncertainty in position of an electron moving with a velocity of  $3 \times 10^7$  m/s.
2. An electron is constrained to a one dimensional box of side 1nm. Calculate the first four Eigen values in electron volt.
3. Explain the phenomenon of Quantum mechanical tunnelling and its advantages

**Course Outcome 3(CO3):**

1. An unpolarised light passes through two successive polaroids ( $P_1$  and  $P_2$ ) the polaroid  $P_1$  makes angle  $\theta$  with the axis of the polaroid  $P_2$ . if  $\theta$  is varied from 0 to  $37^\circ$ . Plot the intensity variation graph
2. Give examples of biaxial crystals
3. Identify the type of polarized light if the vibrations of light are restricted to x-y plane

**Course Outcome 4 (CO4):**

1. Define Kerr effect
2. Give two differences between linear and non-linear optics
3. Mention any two materials used as Electro optic modulators

**Course Outcome 5 (CO5):**

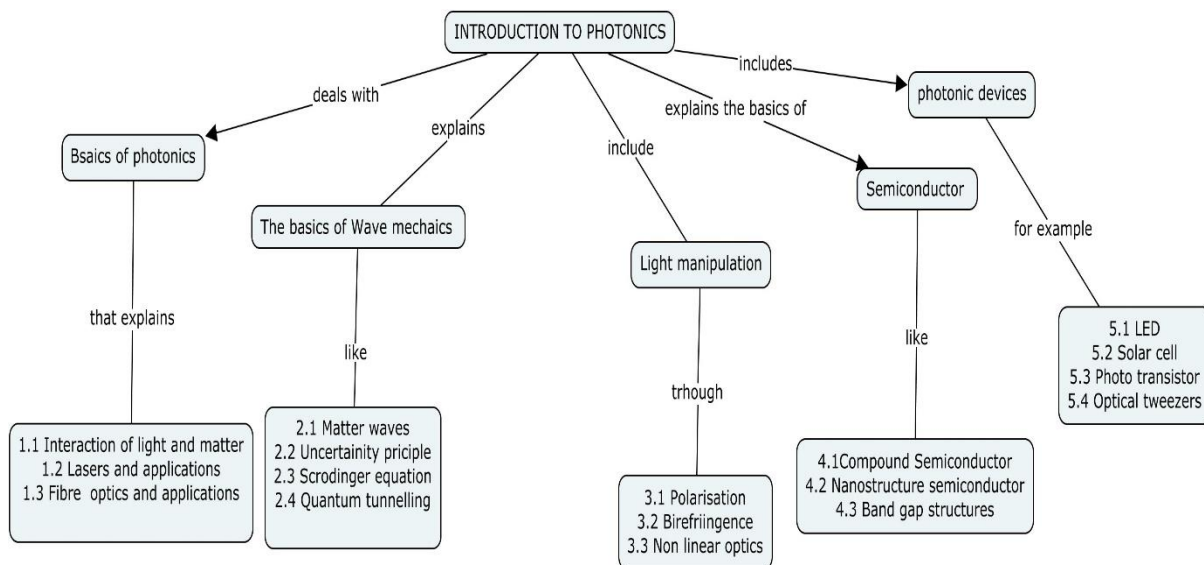
1. Give the mathematical expression for Bloch's function
2. Differentiate between elemental and compound semiconductors
3. From the given table make a list of III-V compound semiconductor, I-VI nitride semiconductors  
Also identify whether they are narrow band gap or wide band gap

II	III	IV	V	VI
	B	C	N	
	Al	Si	P	
Zn	Ga	Ge	As	Se
Cd	In	Sn	Sb	Te

**Course Outcome 6 (CO6):**

1. Define luminescence and mention any three types of luminescence
2. Mention the most appropriate band gap of semiconductors used for making LED and suggest one binary and one ternary compound semiconductor material for making LED
3. Mention any four applications of optical tweezers

## Concept Map



## Syllabus

**Basics of photonics:** Properties of Light, Light Light-material interaction, Maxwell's Equations waves, Polarization of light, Interference, Absorption, Dispersion of light, Plasmon's, Lasers, Types of Laser, Laser holography, Laser micromachining, Laser Doppler Velocimetry, Laser vibrometer Fibre optics-Types of fibre, Fibre optic sensors.

**Wave Mechanics:** Matter waves, Uncertainty principle, Schrodinger equation, Particle in a box, Quantum Tunnelling, Quantum efficiency

**Light manipulation:** Mallus Law, Birefringence, Non Linear optics-Pockels effect, Kerr effect, Electro optic Modulator

**Semiconductors:** Density of states, Blochs theorm, Kroing-Penny I(Qualitative),Compound semiconductors, Nanostructure Semiconductors, Semiconductor Detectors

**Photonics devices:** Photonic crystals, Luminescence, Photorefractive materials, LED, Solar cells, photodiodes, photo detectors, photoconductors, Laser diodes, photo transistor, Charge coupled Device, Optical sensors and Actuators Optical bio sensor. Optoelectronic tweezers.

## Learning Resources

1. <https://nptel.ac.in/courses/108/106/108106135>
2. Introducing photonics, Brian Culshaw, July 2020, Cambridge University Press, <https://doi.org/10.1017/9781316659182>
3. Photonics: An Introduction, Georg A Reide, Feb 2016, Springer Book, <https://doi.org/10.1007/978-3-319-26076-1>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	<b>Basics of photonics</b>		
1.1	Properties of Light, Light Light-material interaction, Electrodynamics: Maxwell's equations	2	CO1
1.2	Electromagnetic waves, Polarization of light, Interference, Absorption	2	CO1
1.3	Lasers, Types of Laser, Laser holography, Laser micromachining, Laser Doppler Velocimetry, Laser vibrometer	2	CO1
1.4	Fibber optics-Types of fibre, Numerical aperture, Fibre optic sensors	2	CO1
2	<b>Wave Mechanics</b>		
2.1	Matter waves, Heisenberg's Uncertainty principle	2	CO2
2.2	Schrödinger's wave equation, Particle in potential box,	1	CO2
2.3	Quantum Tunnelling,	2	CO2
2.4	Quantum efficiency	2	CO2
3	<b>Light manipulation</b>		
3.1	Mallu's law, Birefringence,	1	CO3
3.2	Nonlinear optics pockels effect, Kerr effect,	2	CO3
3.3	Electro optic Modulator	2	CO4
4	<b>Semiconductors</b>		
4.1	Density of states, Bloch's theorem, Kronig-Penny mode(qualitative)	2	CO5
4.2	Compound semiconductors-nanostructure semiconductors,	2	CO5
4.3	semiconductor detectors	2	CO5
5	<b>Photonics devices:</b>		
5.1	Photonic crystals, Luminescence, Photorefractive materials	2	CO6
5.2	LED, Solar cells, photodiodes, photo detectors, photoconductors	2	CO6
5.3	Laser diodes, photo transistor, Charge coupled Device,	2	CO6
5.4	Optical sensors and Actuators, Optical bio Sensor. Optoelectronic tweezers	2	CO6
<b>TOTAL</b>		<b>36</b>	

### Course Designers:

Sl. No.	Name	E-mail Id
1	Dr M. Mahendran	mmphy@tce.edu
2	Dr A.L. Subramaniyan	alsphy@tce.edu



**18MTPZ0 ELECTRIC VEHICLE TECHNOLOGY**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

In recent decades, the research and development activities related to transportation have emphasized the development of high efficiency, clean, and safe transportation. Electric vehicles, hybrid electric vehicles, and fuel cell vehicles have been typically proposed to replace conventional vehicles in the near future. In the course details about vehicle system analysis, ICE-based drive trains, EV design, HEV configurations, electric propulsion systems, series/parallel/mild hybrid electric drive train design methodologies, energy storage systems, regenerative braking, fuel cells and their applications in vehicles, and fuel cell hybrid electric drive train design. It emphasizes the overall drive train system and not just specific components. The design methodology is described by step-by-step mathematical equations and simulations.

**Prerequisite**

- 18MT420-Power Electronics and Drives

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Demonstrate the electric traction, electric drive and train topology	10
CO2	Illustrate the various electric vehicle components modelling approach and its consideration	25
CO3	Explain the construction and working of various converters and control techniques in electric vehicles.	15
CO4	Illustrate the various electric vehicle energy storage systems and its calculations.	25
CO5	Select the suitable actuator, controller, and energy storage system for given electric vehicle application.	15
CO6	Choose the suitable components of electric vehicle system for the given applications such as electric bicycle, hybrid electric vehicle and battery electric vehicle.	10

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO2	TPS 3	Apply	Value	---	1.1, 1.2, 4.3.2
CO3	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO4	TPS 3	Apply	Value	Mechanism	1.1, 1.2, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO6	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO2	S	M	L	-	L	-	-	-	-	-	-	-	-	S
CO3	M	L	-	-	-	-	-	-	-	-	-	-	-	S
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	S
CO5	S	M	L	-	L	-	-	-	M	M	-	-	S	S
CO6	S	M	L	-	L	-	-	-	M	M	-	-	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	60	60	40	100	-	-	40
Apply	20	20	40	-	100	100	-
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment - I Simulation
Mechanism	Assignment II, III – Mini Projects & Presentation
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Explain the Various types of Electric Vehicle
2. Explain the working principle of Electric Traction
3. Distinguish the Conventional vehicle with Electric vehicle.

**Course Outcome 2 (CO2):**

1. Illustrate the modelling of vehicle acceleration systems.
2. Derive the rolling resistance and transmission efficiency equations.
3. The mechanical sub system of a position-controlled system is described by  $J=0.01 \text{ kgm}^2$  and  $B=0.01 \text{ Nm}/(\text{rad/s})$ . The torque actuator gain is  $K_M=1$ . Assuming the sampling time of 10 ms, obtain the pulse transfer function  $W_P(z)$  of the control object.
4. Discuss the torque control of sensorless BLDC motor.

**Course Outcome 3 (CO3):**

1. Explain the DC-DC converter for Electric drive control systems.
2. Explain the four-quadrant operation for the Electric vehicle drive control system.
3. Explain the Three phase inverter circuit with RLE load Applications.

**Course Outcome 4 (CO4):**

1. Calculate the battery voltage and ampere hour values for e-bicycle with BLDC motor load.
2. Derive the mathematical modeling of Battery management systems for given electric vehicle specifications.
3. Interpret the selection of Fuel cell over the Lead acid battery in E-vehicle applications.

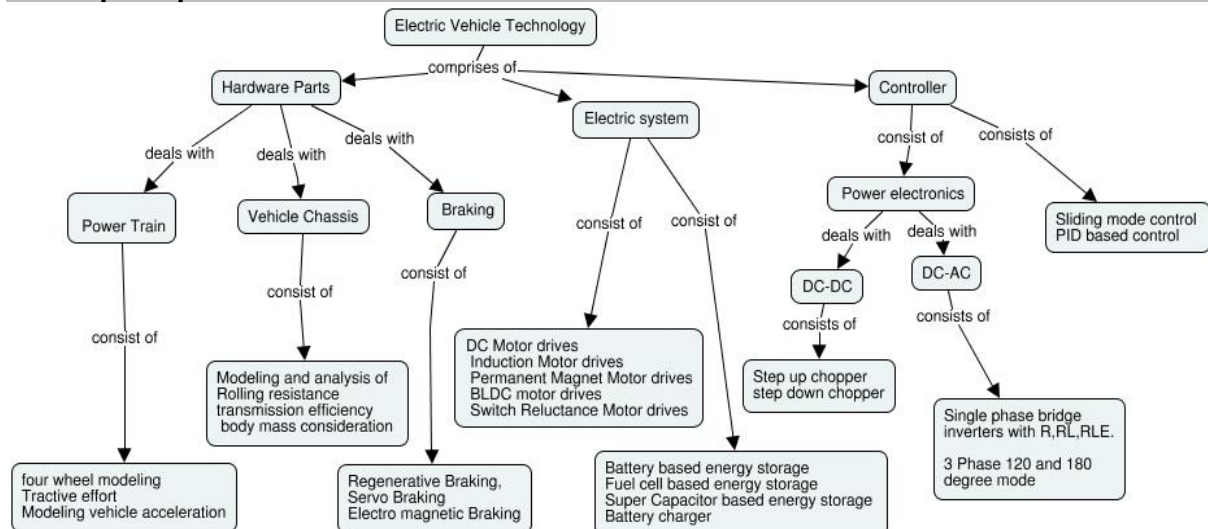
**Course Outcome 5 (CO5):**

1. Select suitable actuator and control circuit for high initial torque electric racing bike applications.
2. Select the appropriate DC-DC converter for solar powered Electric vehicles in packers and movers vehicles in industries.
3. choose an appropriate Battery management system for Electric vehicles for hill climbing application.

**Course Outcome 6 (CO6):**

1. Choose an appropriate aerodynamic power train model for Electric car applications.
2. Choose an appropriate battery management system and its selection calculation for an electric bicycle.
3. Select the appropriate converter and its PWM control techniques for charging points in electric vehicles.

**Concept Map**



## Syllabus

**Introduction:** Introduction – need for electric vehicle-Comparison of Electric Vehicle over conventional vehicle – Various types of Electric vehicle- Hybrid Electric Vehicles - Types of EVs, Hybrid Electric Drive-train - Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

**Electric Vehicle Modelling:** Tractive effort- Modeling vehicle acceleration- Modeling electric vehicle range- Rolling resistance- transmission efficiency- body mass consideration and vehicle chassis modeling.

**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives - Induction Motor drives - Permanent Magnet Motor drives – BLDC motor drives- Switch Reluctance Motor drives, drive system efficiency- Types of Braking System-Regenerative braking system-Servo braking system.

**Vehicle motor drives & control:** DC-DC converter- step up and step down – DC to AC Converter- Single phase and Three phase inverter- sliding mode control- PID based control.

**Energy Storage:** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis - PHEV & BEV Battery charger.

**Case Studies:** Design of Electric Bicycle- Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

## Learning Resources

1. John G. Hayes and A. Goodarzi Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles, Wiley Publication,
2. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, John Wiley & Sons Inc 2017.
3. James Larminie, John Lowry- Electric Vehicle Technology Explained, 2nd Edition, John Wiley & Sons Inc 2012.
4. <https://nptel.ac.in/courses/108/106/108106170/>

## Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
1	<b>Introduction</b>		
1.1	Need for electric vehicle-Comparison of Electric Vehicle over conventional vehicle.	1	CO1
1.2	Various types of Electric vehicle	1	CO1
1.3	Hybrid Electric Vehicles	1	CO1
1.4	Types of EVs, Hybrid Electric Drive-train	1	CO1
1.5	Basic concept of electric traction	1	CO1
1.6	Introduction to various electric drive-train topologies	1	CO1
1.7	Self-diagnose in electric vehicles.	1	CO1
2	<b>Electric Vehicle Modelling</b>		
2.1	Tractive effort	1	CO2

Module No.	Topic	No. of Lectures	CO
2.2	Modelling vehicle acceleration	1	CO2
2.3	Modelling electric vehicle range	1	CO2
2.4	Rolling resistance- transmission efficiency	1	CO2
2.5	Body mass consideration	1	CO2
2.6	Vehicle chassis modelling.	1	CO2
<b>3</b>	<b>Electric Propulsion unit</b>		
3.1	Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives	2	CO5
3.2	Induction Motor drives	1	CO5
3.3	Permanent Magnet Motor drives – BLDC motor drives- Switch Reluctance Motor drives	1	CO5
3.4	Drive system efficiency	1	CO5
3.5	Types of Braking System-Regenerative braking system- Servo braking system	1	CO5
<b>4</b>	<b>Vehicle motor drives &amp; control</b>		
4.1	DC-DC converter- four quadrant operation	1	CO3
4.2	step up and step-down chopper with RLE loads	1	CO3
4.3	DC to AC Converter	1	CO3
4.4	Single phase and Three phase inverter with RLE loads	1	CO3
4.5	Sliding mode control- PID based control.	1	CO3
<b>5</b>	<b>Energy Storage</b>		
5.1	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, selection of battery and its electrical consideration	1	CO4
5.2	Battery based energy storage and its analysis	1	CO4
5.3	Fuel Cell based energy storage and its analysis	1	CO4
5.4	Super Capacitor based energy storage and its analysis	2	CO5
5.5	PHEV & BEV Battery charger	2	CO5
<b>6</b>	<b>Case Studies</b>		
6.1	Design of Electric Bicycle	1	CO6
6.2	Design of a Hybrid Electric Vehicle (HEV)	2	CO6
6.3	Design of a Battery Electric Vehicle (BEV)	2	CO6
<b>Total</b>		<b>36 Hours</b>	

**Course Designers:**

Sl. No.	Name	E-mail Id
1	Mr. Julius Fusic S	<a href="mailto:sjf@tce.edu">sjf@tce.edu</a>
2	Mr. Ramesh H	<a href="mailto:rameshh@tce.edu">rameshh@tce.edu</a>

<b>18MTRA0</b>	<b>INTELLIGENT CONTROL OF MOTION DRIVES</b>	Category	L	T	P	Credit(s)
		PE	3	0	0	3

**Preamble**

Today, Industries are increasingly demanding process automation in all sectors. Automation results into better quality, increased production and reduced costs. Machine tools and Robots are become fundamental components of any automated Manufacturing work cell. The controlling parameters like motion, Speed, Position and torque are paramount in raising productivity and quality and reducing energy and equipment costs in all industries. Electric drives share most of industrial machine control applications

**Prerequisite**

- 18MT420 - Power Electronics and Drives
- 18MT510 - Control System

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Perform Dynamic Modelling of Permanent Magnet AC Machines	Understand
CO2	Design and evaluate the digital position, speed and current controller.	Apply
CO3	Develop Predictive control strategies for PMAC drives	Apply
CO4	Design sensor less control of PMAC Drives	Apply
CO5	Develop the optimization algorithm for optimal controller design and rotor position estimation	Apply
CO6	Develop the trajectory generation and tracking algorithms.	Apply

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO2	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO3	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO4	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.1,3.1.5
CO6	TPS3	Apply	Value	-	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	L	L	-	L	L	L
CO3	S	M	L	-	-	-	-	-	L	L	-	L	-	-
CO4	S	M	L	-	M	-	-	-	L	L	-	L	L	L
CO5	S	M	L	-	M	-	-	-	L	L	-	L	-	-
CO6	S	M	L	-	M	-	-	-	-	-	-	-	-	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3*	1	2	3	
Remember	20	20	-	-	-	-	20
Understand	20	20	-	-	-	-	20
Apply	60	60	100	-	-	-	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

\* CAT 3 evaluated as mini project

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	Simulation of drives operation
Set	-
Guided Response	Flipped classroom, Active Learning Techniques.
Mechanism	Hands On assignments using hardware, Mini project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Explain the basic elements of Position control system
2. Explain the basic elements of speed control system.
3. Describe the structure of Torque control in Servo Drive.
4. Write the important specifications of servo drive.
5. Describe the features of servo drive.

**Course Outcome 2 (CO2):**

1. Explain the derivative action in position controller.
2. Design the nonlinear position controller for CNC applications.

3. The mechanical sub system of a position-controlled system is described by  $J=0.01 \text{ kgm}^2$  and  $B=0.01 \text{ Nm/(rad/s)}$ . The torque actuator gain is  $K_M=1$ . Assuming the sampling time of 10 ms, obtain the pulse transfer function  $W_P(z)$  of the control object.
4. Develop a Simulink model of nonlinear position controller.
5. Discuss the step response and bandwidth of the PD and PID controller.

**Course Outcome 3 (CO3):**

1. Select a drive and program servo drive using PLC for a robotic application with a payload of 10 Kg.
2. Develop servo drive program for driving axis motor of CNC turning Machine.
3. Explain the step response of a integral speed controller.
4. Explain the Feed forward compensation of Integral speed controller.
5. Brief the components of Sliding mode motion control system

**Course Outcome 4 (CO4):**

1. Explain the vector control methods in detail
2. Discuss the direct torque and flux control methods in drives.
3. Explain the structure of closed loop torque control in electric drives.
4. Design the sensorless control of PMSM motor

**Course Outcome 5 (CO5):**

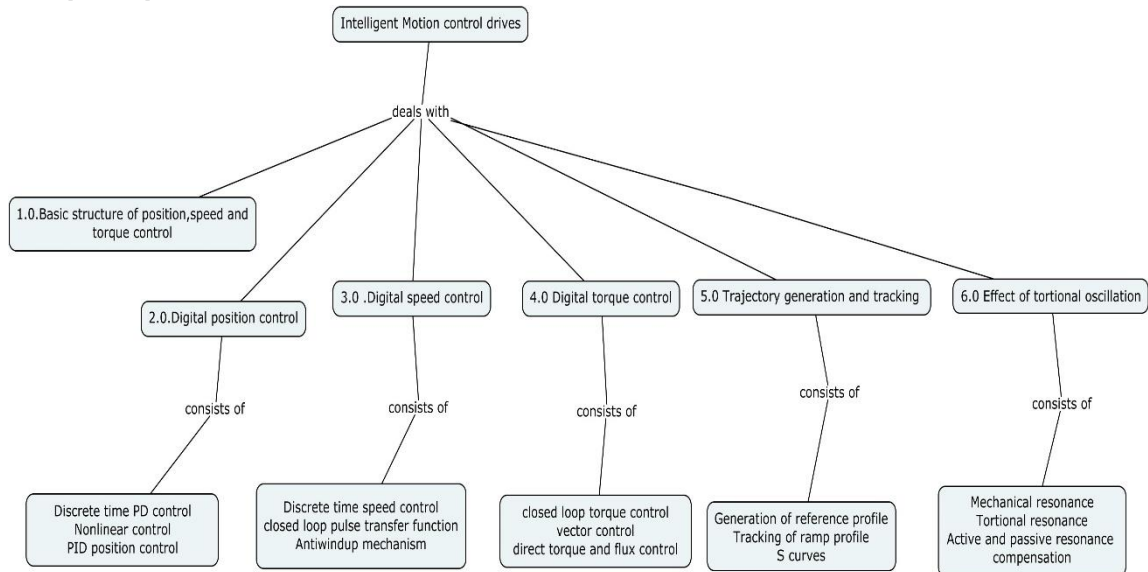
1. Develop an experimental setup for the ramp tracking of PID controller.
2. Discuss the coordinated motion in multiaxis systems
3. Explain the spline interpolation of course reference profiles.
4. Consider the linear PID position controller with proportional and derivative actions replaced in to the feedback path. Assume that the reference profile has a ramp shape, with the position reference samples  $\Theta_k^* = kR^*$ . Calculate the steady state position error  $\Delta$ ,  $\Theta$ . calculate the error for the case when the integral and proportional gains are in the direct path, when the derivative gain resides in the feedback path.
5. Develop the machine learning algorithm for PMSM Motor

**Course Outcome 6 (CO6):**

1. Discuss the application of learning algorithms in trajectory tracking
2. Develop the control algorithm based on machine algorithm for tracking trajectory of industrial robot.
3. Formulate an optimal path planning algorithm using Deep learning concept.



## Concept Map



## Syllabus

**Modelling of PMAC drive-**Real time model of a Two-phase PMSM-Transformation to Rotor reference frames-Three phase to two phase transformation-Steady state torque characteristics-control characteristic of PMSM-computation of time responses-space phasor Model-Modelling of BLDC –Normalized system Equations-Dynamic Simulation

**Control Structure of Motion drives-** Basic structure of position controller, speed controller and torque controller-structure of cascaded control- vector control –Flux weakening operation-Design of current and speed controller-overview of Fuzzy, neural and genetic algorithms. - Case Study: Applications of optimization algorithm for optimal design of controller.

**Sensor less control of PMAC drives-** current sensing-position estimation- current model adaptive scheme-sensing by external signal injection-position estimation using PWM carrier components-Case study: -Optimization algorithms for rotor position estimation.

**Trajectory generation and tracking:** Tracking of ramp profiles with the PID position controller-steady state error in ramp profile tracking-generation of reference profiles-coordinated motion in multi axis systems-trajectories with trapezoidal speed change-Application of Kalman filter in trajectory tracking.

**Motion control Algorithms:** Predictive control algorithm-sliding mode motion control system for robot arm- -state space motion control-motion control by fuzzy systems, neural networks. Case study: Applications of Machine learning and reinforced learning in motion control drives.

**Learning Resources**

1. R Krishnan, "Permanent Magnet synchronous and Brushless DC Motor" CRC press 2016.
2. Teresa orlowka-kowalska, "Advanced and Intelligent control in Power Electronics and Drives" springer 2014
3. Slobodan N.Vukosavic "Digital control of electric drives" Springer international edition, 2012.
4. M.N. Cirstea, A. Dinu, J.G. Khor, M. McCormick, "Neural and fuzzy logic control of drives and power systems" newness publications, 2002
5. Frederick F. Ling, "Servo motors and industrial control theory", springer, 2009.
6. Gopal k. dubey, "Power semiconductor controlled drives", prentice hall, 1988.
7. Ion Boldea, S.A Naser "Electric Drives" CRC Taylor & Francis group edition, 2009

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Lectures	CO
<b>1</b>	<b>Modelling of PMAC drive</b>		
1.1	Real time model of a Two-phase PMSM	1	CO1
1.2	Transformation to Rotor reference frames	1	CO1
1.3	Three phase to two phase transformation	1	CO1
1.4	control characteristic of PMSM-	1	CO1
1.5	computation of time responses-space phasor Model	1	CO1
1.6	Modelling of BLDC –Normalized system Equations-Dynamic Simulation	2	CO1
<b>2</b>	<b>Control Structure of Motion drives</b>		
2.1	Basic structure of position controller, speed controller and torque controller	2	CO2
2.2	structure of cascaded control	1	CO2
2.3	Vector control –Direct, Indirect	2	CO2
2.4	Flux weakening operation	2	CO2
2.5	Design of current and speed controller	2	CO2
2.6	Overview of Fuzzy, neural and genetic algorithms	2	CO5
2.7	Applications of optimization algorithm for optimal design of controller –case study	1	CO5
<b>3</b>	<b>Sensor less control of PMAC drives</b>		
3.1	current sensing-position estimation	1	CO4
3.2	current model adaptive scheme	1	CO4
3.3	sensing by external signal injection	1	CO4
3.4	position estimation using PWM carrier components	1	CO4
3.5	Optimization algorithms for rotor position estimation-case study	1	CO5
<b>4</b>	<b>Trajectory generation and tracking</b>		
4.1	Tracking of ramp profiles with the PID position controller	1	CO6

<b>Module No.</b>	<b>Topic</b>	<b>No. of Lectures</b>	<b>CO</b>
4.2	Steady state error in ramp profile tracking-generation of reference profiles	1	CO6
4.3	coordinated motion in multi axis systems-	1	CO6
4.4	Trajectories with trapezoidal speed change.	1	CO6
4.5	Applications of Kalman filter in trajectory tracking-case study	1	CO3
<b>5</b>	<b>Motion control Algorithms</b>		
5.1	Predictive Motion control algorithm	1	CO3
5.2	Sliding mode motion control system for robot arm	1	CO3
5.3	State space control of Motion drives	1	CO3
5.4	Motion control by fuzzy systems, neural networks.	2	CO5
5.5	Case study: Applications of Machine learning and reinforced learning in motion control drives.	2	CO5
<b>Total</b>		<b>36 Hours</b>	

#### Course Designers:

<b>Sl. No.</b>	<b>Name</b>	<b>E-mail Id</b>
1	Mr. H. Ramesh	rameshh@tce.edu
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**18MTRB0 INTRODUCTION TO BIOMECHATRONICS**

Category	L	T	P	Credit(s)
PE	3	0	0	3

**Preamble**

Nowadays health issues are increasing in human beings, as well the technologies are also rapidly developing for medical treatments. Mechatronics plays a vital role in medical industries. Bio-mechatronics devices such as active prosthetic limbs, brain computer interfaces and exoskeletons are contributing a lot for medical field. This course would provide an essence on vital technologies currently growing in bio-mechatronics and also facilitate future engineers to conduce for the better living.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Suggest suitable sensing and actuation mechanism for biomechatronic system	10
CO2	Explain the control mechanisms of biological systems	10
CO3	Discuss the hearing aid implants and the visual prosthetic devices	20
CO4	Demonstrate the working of Prosthetic and Orthotic devices	20
CO5	Illustrate about the wearable biomechatronic devices	20
CO6	Select and apply appropriate dynamic models to simulate and analyse biomechatronic systems	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Respond	Mechanism	2.3.1, 4.3.1,4.3.2,4.3.3
CO2	TPS2	Understand	Respond	Guided Response	2.3.1, 4.3.1,4.3.2
CO3	TPS2	Understand	Respond	Guided Response	2.3.1, 4.3.1,4.3.2,4.3.3
CO4	TPS3	Apply	Value	Mechanism	4.3.1,4.3.2,4.3.3
CO5	TPS3	Apply	Value	Mechanism	4.3.1,4.3.2,4.3.3
CO6	TPS3	Apply	Value	Mechanism	4.3.1,4.3.2,4.3.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	M	-	-	-	-	-	-	M	M
CO2	M	L	-	-	-	M	-	-	-	-	-	-	M	M
CO3	M	L	-	-	-	S	-	-	-	-	-	-	M	M
CO4	S	M	L	-	-	S	-	-	-	-	-	-	S	S
CO5	S	M	L	-	-	S	-	-	-	-	-	-	M	M
CO6	S	M	L	-	S	S	-	-	-	-	-	-	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	-
Understand	60	60	60	-	-	-	60
Apply	40	40	40	100	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. List few bio-mechatronic applications
2. Explain the types of biomedical signals and the need for signal conditioning
3. Name the materials that can be used for sensing and actuation with example

**Course Outcome 2(CO2):**

1. List the different types of skeletal system with examples
2. Explain about cardio-vascular control system
3. Demonstrate the respiratory control mechanism

**Course Outcome 3(CO3):**

1. Describe about the various hearing aids
2. Discuss about optical prosthesis
3. Summarize about visual neuro prosthesis

**Course Outcome 4 (CO4):**

1. List few orthotic devices and mention its application
2. Demonstrate the advanced actuation methodologies that can be used for mind controlled hand prosthesis.
3. Describe in detail about gait procedure and analysis

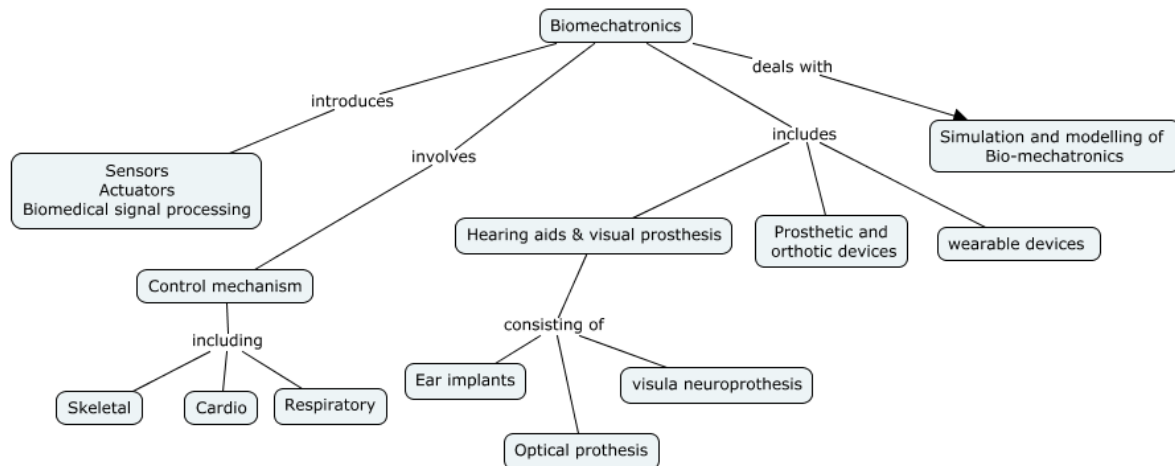
**Course Outcome 5 (CO5):**

1. Illustrate the procedure in detail for making an artificial third thumb
2. Discuss in detail about wearable artificial kidney
3. State about rehabilitation

**Course Outcome 6 (CO6):**

1. Illustrate Model development and capabilities of Opensim software.
2. Develop an upper extremity kinematic model with Opensim software.
3. Conduct a normal gait vs prosthesis leg analysis

## Concept Map



## Syllabus

### Introduction to Bio-mechatronics

Highlights of technology- Cardiovascular, musculoskeletal & orthopedic biomechanics- Sensors, power sources and control used in bio-mechatronics-Advanced actuation technologies - Biomedical signals and signal processing

### Control mechanism of biological systems

Skeletal muscles servo mechanism, cardio vascular control mechanism, respiratory control mechanism

### Hearing aids and visual prosthesis

Bone Conduction Devices, Middle Ear Implants, Direct Acoustic Cochlear Stimulatory Devices, Cochlear Implants, Auditory Brainstem Implants, Optical Prosthetics, Visual Neuro-prosthesis

### Prosthetic and orthotic devices

Introduction to prosthetics, Passive Prosthetics – walking dynamics, Knee and foot prosthesis. Active prosthesis - Control of Prosthetic Arms and Hands, Leg Mechanisms-Orthotic devices

### Wearable mechatronics devices

Wearable artificial kidney, wireless capsule endoscope, wearable exoskeletal rehabilitation system, wearable hand rehabilitation

### Simulation and modelling of Bio-mechatronics

Introduction to model the skeletal system using open source software– human leg prosthesis and normal gait vs prosthesis leg analysis - upper extremity kinematic model

## Learning Resources

1. Graham M. Brooker, "Introduction to Bio-Mechatronics", Sci Tech Publishing, 2012
2. Scott L. Delp et L., "OpenSim: Open-Source Software to Create and Analyze Dynamic Simulations of Movement", IEEE Transaction on biomedical engineering vol.54 no.11, 2007
3. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "Bio-Medical Instrumentation and Measurements", II edition, Pearson Education, 2009

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Introduction to Bio-mechatronics</b>		
1.1	Highlights of technology	1	CO1
1.2	Cardiovascular, musculoskeletal & orthopaedic mechanics	2	CO1
1.3	Sensors, power sources and control used in bio-mechatronics-Advanced actuation technologies	2	CO1
1.4	Biomedical signals and signal processing	1	CO1
<b>2</b>	<b>Control mechanism of biological systems</b>		
2.1	Skeletal muscles servo mechanism	1	CO2
2.2	cardio vascular control mechanism	1	CO2
2.3	respiratory control mechanism	2	CO2
<b>3</b>	<b>Hearing aids and visual prosthesis</b>		
3.1	Bone Conduction Devices, Middle Ear Implants	2	CO3
3.2	Direct Acoustic Cochlear Stimulatory Devices	2	CO3
3.3	Cochlear Implants, Auditory Brainstem Implants	2	CO3
3.4	Optical Prosthetics, Visual Neuroprostheses	2	CO3
<b>4</b>	<b>Prosthetic and orthotic devices</b>		
4.1	Passive Prosthetic-walking dynamics, Knee and foot prosthesis.	2	CO4
4.2	Active prosthesis - Control of Prosthetic Arms and Hands, Leg Mechanisms-	2	CO4
4.3	Orthotic devices	2	CO4
<b>5</b>	<b>Wearable mechatronics devices</b>		
5.1	Wearable artificial kidney, wireless capsule endoscope,	2	CO5
5.2	wearable exoskeletal rehabilitation system	2	CO5
5.3	wearable hand rehabilitation	2	CO5
<b>6</b>	<b>Simulation and modelling of Bio-mechatronics</b>		
6.1	Model the skeletal system using open source software	2	CO6
6.2	leg prosthesis and normal gait vs prosthesis leg analysis	2	CO6
6.3	Upper extremity kinematic model	2	CO6
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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1	Praveen Kumar B	bpkmech@tce.edu
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<b>18MTRC0 SMART MATERIALS FOR MECHATRONICS</b>	Category	L	T	P	Credit(s)
	PE	3	0	0	3

### Preamble

Smart Materials have properties that can be altered by temperature, moisture, electric or magnetic fields, pH, stress. They can change shape and color, become stronger, or produce voltage as a result of external stimuli. Smart materials which find widespread applications today should be recognized along with familiar metals, plastics, ceramics, composites, powder metals, and specialty-type and multifunctional materials, functionally graded materials. Smart materials have emerged as the novel materials for engineering applications. By using smart materials, one can endow structures with built-in responses to innumerable contingencies. In their various forms, these materials can perform as actuators, which can adapt to their environments by changing characteristics such as shape and stiffness, or as sensors, which provide the actuators with information about structural and environmental changes. This course introduces the different types of smart materials to students and some applications of smart materials as actuators, sensors, vibration dampers etc.,

### Prerequisite

- 14PH120- Physics

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Understand the basic mechanisms of Smart Materials	20%
CO2	Select the Smart Materials for Magneto-Thermo-Mechanical Applications	20%
CO3	Investigate the parameters used in strain measurements	20%
CO4	Analyse the Smart Materials based micro sensors and micro actuators	20%
CO5	Review the newly discovered smart materials	20%

\*\*\* Weightage depends on number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS1	Understand	Respond	-	1.1 ,3.2.3
CO2	TPS2	Apply	Value	-	1.1,1,2
CO3	TPS3	Apply	Value	-	1.1,3.1
CO4	TPS3	Apply	Value	-	1.1,1.2
CO5	TPS2	Understand	Respond	-	1.1,3.2



**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	-	-	-	-	L	L	-	-	-	-
CO2	M	L	L	-	-	-	-	-	L	L	-	-	-	-
CO3	M	L	L	L	-	-	-	-	L	L	-	-	-	-
CO4	S	M	L	L	-	-	-	-	L	L	-	-	-	-
CO5	M	L	L	-	-	-	-	-	L	L	-	-	-	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	30
Apply	50	50	50	100	100	100	50
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. What are Smart Materials?
2. Distinguish between the conventional shape memory alloys and the magnetic shape memory alloys.
3. Outline the importance of Villari effect and Joule effect.
4. Write constitutive equations used in piezoelectric and magneto strictive materials.
5. Group the emerging smart materials.

**Course Outcome 2 (CO2):**

1. Identify the various classes of smart materials pertaining to Mechatronics Applications.
2. Illustrate the macroscopic and microscopic mechanisms of shape memory alloys.
3. Interpret the piezoelectric coefficients used for making micro actuator.
4. Summarize the similarities and dissimilarities of Ferromagnetic shape memory alloys and magneto strictive materials
5. Research the latest developments in energy harvesting materials.

**Course Outcome 3 (CO3):**

1. Manipulate the differences between the one-way shape memory alloys and two-way shape memory alloys.
2. Compute the amount of strain (in %) required for the construction of the piezoelectric actuators.
3. Exhibit the large magnetic field induced strain in ferromagnetic shape memory alloys and saturation magnetization in magnetostrictive materials.
4. Apply the 'longitudinal loading' in smart polymer composites.

**Course Outcome 4 (CO4):**

1. Compute the maximum temperature required for a Shape Memory Alloy (SMA) rod. A SMA rod is to be used in an application requiring its ends to be held rigid. If the SMA rod is stress free at room temperature, what is the maximum temperature to which the SMA rod may be heated without exceeding a compressive stress of 185 MPa. Assume the modulus of elasticity of 125 GPa.
2. Construct a cubic austenitic ferromagnetic shape memory alloy that has a saturation magnetization of  $5.25 \times 10^5 \text{ Am}^{-1}$  for micro actuator applications. Assume that the phase transformations between the cubic austenite and the tetragonal martensite is occurred at room temperature.
3. Demonstrate the force generation of a piezo actuator with nominal displacement of  $30 \mu\text{m}$  and stiffness of  $200 \text{ N}/\mu\text{m}$ ? The piezo actuator can produce a maximum force of  $30 \mu\text{m} \times 200 \text{ N}/\mu\text{m} = 6000 \text{ N}$ . When force generation is maximum, displacement is zero and vice versa.

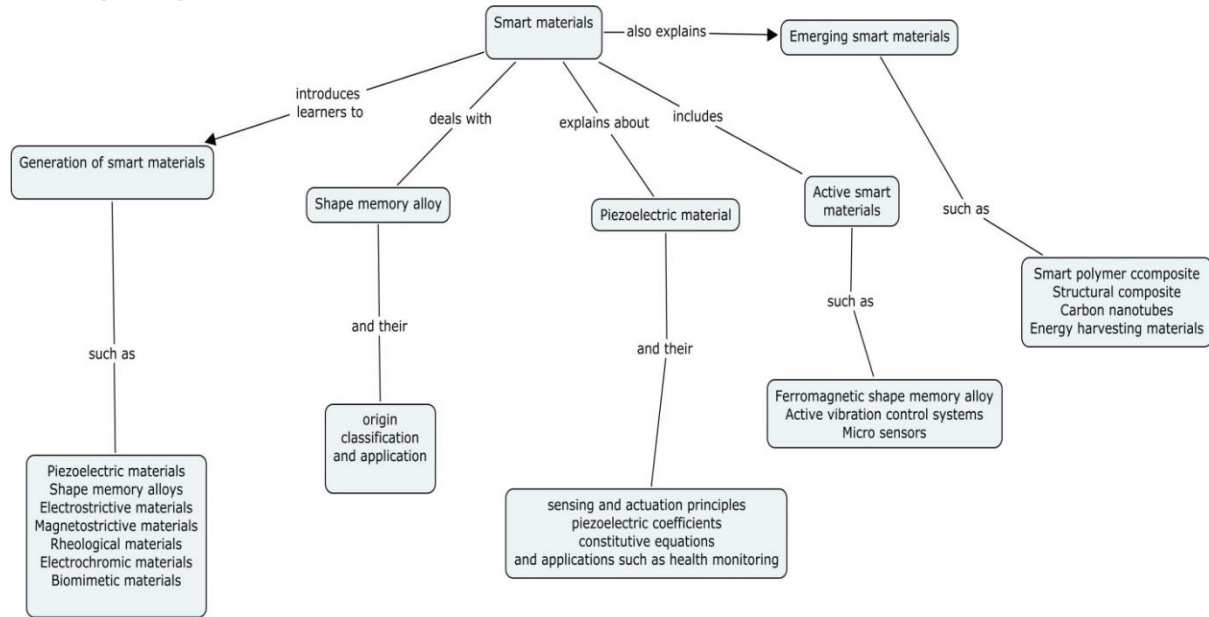
**Course Outcome 5 (CO5):**

1. Comprehend the fabrication of three-dimensional nanostructures.
2. Describe the size dependent macroscopic properties of intelligent materials, with examples.
3. Discuss the role of smart materials in 'structural health monitoring'.
4. Consider the following actuation principles and corresponding smart materials and match them.

Actuation PrincipleSmart Material

- |                              |   |                          |
|------------------------------|---|--------------------------|
| a. Martensite transformation | - | Lead Zirconate Titanate  |
| b. Twin boundary motion      | - | Terfenol-D               |
| c. Piezoelectric effect      | - | $\text{Ni}_2\text{MnGa}$ |
| d. Magnetostriction          | - | Nitinol                  |
5. Consider the following statements
    - A. Ferromagnetic shape memory effect is due to twin boundary motion
    - B. Shape memory effect in Nitinol is due to martensite transformation
      - a. A only true
      - b. B only true
      - c. Both A and B are true
      - d. Both A and B are false

## Concept Map



## Syllabus

**Overview of Smart Materials:** Definition - Generation of Smart Materials - Piezoelectric Materials - Shape Memory Alloys - Electro/Magneto strictive Materials - Electro/Magneto Rheological Materials - Electrochromic Materials - Biomimetic Materials- Comparison of the performances and limitations of various actuators (Numerical assessments).

**Shape Memory Materials:** Basics of Macro and Micro Mechanics -Origin of Shape Memory Alloy – Pseudoplasticity and Super elasticity – Types of Shape Memory Effect – Classes of SMAs- Fine Motion Systems; Automobiles, Trains, Medical and House Hold Devices.

**Piezoelectric Materials:** Sensing and Actuation Principles -Piezoelectricity and Materials – Piezoelectric Ceramics - Piezoelectric Coefficients – Constitutive Equations- Villari Effect - Matteuci Effect- Piezoelectric Sensors and Actuators in Positioning Devices- Structural Health Monitoring – Design of Piezo Stack Actuators for Smart Phones-Problems.

**Active Smart Materials:** Overview of Magnetic Materials - Joule Effect - Wiedemann Effect - Ferromagnetic Shape Memory Alloys -Magneto strictive Materials - Constitutive Equations - Micro Sensors and Micro Actuators - Active Vibration Control Systems - Problems. Energy density and power density of smart materials

**Emerging Smart Materials:** Smart Polymer Composite Materials –Stress-Strain Behaviour of composites– Structural Composites – Carbon Nano Tubes - Energy Harvesting Materials – Intelligent Materials – Self-Sensing Polymers/ Electro Active Polymers. Case studies in smart material.

## Learning Resources

1. M.V. Gandhi and B.S. Thompson, "**Smart Materials and Structures**", Chapman & Hall UK, 1992
2. M. Kohl, "**Shape Memory Microactuators**", Springer, New York, 2004
3. V.K. Wadhawan, "**Smart Structures**", Oxford University Press, UK, 2007
4. V.K. Varadhan, K.J.Vinoy and S. Gopalakrishanan, Smart "Materials and MEMS", John Wiley & Sons, UK, 2006
5. Ashwin Rao, A.R.Srinivasa and J. N. Reddy, "**Design of Shape Memory Actuators**", Springer Cham Heidelberg, New York, 2015

**Course Contents and Lecture Schedule**

Sl. No.	Topic	No. of Lectures	CO
1	<b>Overview of Smart Materials</b>		
1.1	Generation of Smart Materials - Piezoelectric Materials - Shape Memory Alloys	2	CO1
1.2	Electrostrictive/Magnetostrictive Materials - Electro/Magneto Rheological Materials	2	CO1
1.3	Electrochromic Materials - Biomimetic Materials- Comparison of the performances and limitations of various actuators (Numerical assessments)	2	CO1
2	<b>Shape Memory Materials</b>		
2.1	Basics of Macro and Micro Mechanics -Origin of Shape Memory Alloy	2	CO2
2.2	Pesudoelasticity and Superelasticity – Types of Shape Memory Effect , One-way and Two-way SME	3	CO2
2.3	Classes of SMAs: NiTi, Cu-based, Magnetic- based	1	CO2
2.4	Fine Motion Systems; Automobiles, Trains, Medical and House Hold Devices.	2	CO2
3	<b>Piezoelectric Materials</b>		
3.1	Sensing and Actuation Principles -Piezoelectricity and Materials – Piezoelectric Ceramics	3	CO3
3.2	Piezoelectric Coefficients – Constitutive Equations- Villari Effect - Matteuci Effect	3	CO3
3.3	Piezoelectric Sensors and Actuators in Positioning Devices- Structural Health Monitoring	2	CO3
3.4	Design of Piezo Stack Actuators for Smart Phones - Problems	2	CO3
4	<b>Active Smart Materials</b>		
4.1	Overview of Magnetic Materials - Joule Effect - Wiedemann Effect	2	CO4
4.2	Ferromagnetic Shape Memory Alloys -Magnetostrictive Materials - Constitutive Equations	2	CO4
4.3	Micro Sensors and Micro Actuators - Active Vibration Control Systems, Energy density and power density of smart materials	1	CO4
5	<b>Emerging Smart Materials</b>		
5.1	Smart Polymer Composite Materials –Stress-Strain Behaviour of composites– Structural Composites	2	CO5
5.2	Carbon Nano Tubes - Energy Harvesting Materials	2	CO5
5.3	Intelligent Materials – Self-Sensing Polymers/Electro Active Polymers, Case studies in smart material	2	CO5
<b>Total</b>		<b>36</b>	
<b>Hours</b>			

**Course Designers:**

Sl. No.	Name	E-mail Id
1	Dr. M.Mahendran	manickam-mahendran@tce.edu

<b>INDUSTRY SUPPORTED COURSES</b>						
Course code	Name of the Course	Category	L	T	P	Credits
18MT1B0	Quality Practices for Mechatronics Engineers	PEES	1	0	0	1
18MT1C0	IOT Based Cartridge Valves	PEES	1	0	0	1

18MT1B0

**QUALITY PRACTICES FOR  
MECHATRONICS ENGINEERS**Category L T P Credit(s)  
PEES 1 0 0 1**Preamble**

Ever since Industrial revolution has begun, Quality has become important aspect of design and production of products. More so, in electrical and electronics products where most of the major components have become commodities. In today's buyer's market, quality becomes a differentiating factor for the customer to choose from competing products in the market. With commoditization and mass production technology, quality engineering requires a different paradigm approach than the conventional control methods of pass/reject criteria. With the advent of computerization, a lot of computer-based aides and tools provide good process approach in quality prediction and assurance. Supplier quality and cost of quality are important parameters for quality control measure that determine warranty costs. This course will navigate through engineering aspects of quality, tools and process required to ensure high quality in engineering products.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the definition and basics of quality, historical development of quality activities and practices in industry	25
CO2	Describe the types of quality costs, application of quality costs in planning product development and quality management process	25
CO3	Solve problems through systematic understanding and application of quality tools that are widely used in the design and production phase	25
CO4	Implement the metrology concepts in evaluating quality through measurements	25

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.1.3, 4.4.6
CO2	TPS2	Understand	Respond	-	2.1.3, 4.3.3,4.4.6
CO3	TPS3	Apply	Value	Mechanism	2.1.3, 4.4.6, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	2.1.3, 4.4.6, 4.5.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	M

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	-
Understand	-	-	-	-	-	-	60
Apply	-	-	-	100	-	-	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

1. Out of 100 Marks, 50 Marks (Internal) will be for Mini project/Assignments and 50 Marks will be for End Semester Exam.
2. End semester question paper will be of MCQ type

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini Project
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Define Quality
2. Mention the practices followed in industry to ensure total quality
3. Mention the importance of quality of a product

**Course Outcome 2(CO2):**

1. List the types of quality costs, , cost of quality profile,
2. Describe the implication of cost of quality in bottom line profitability
3. Explain about quality performance models

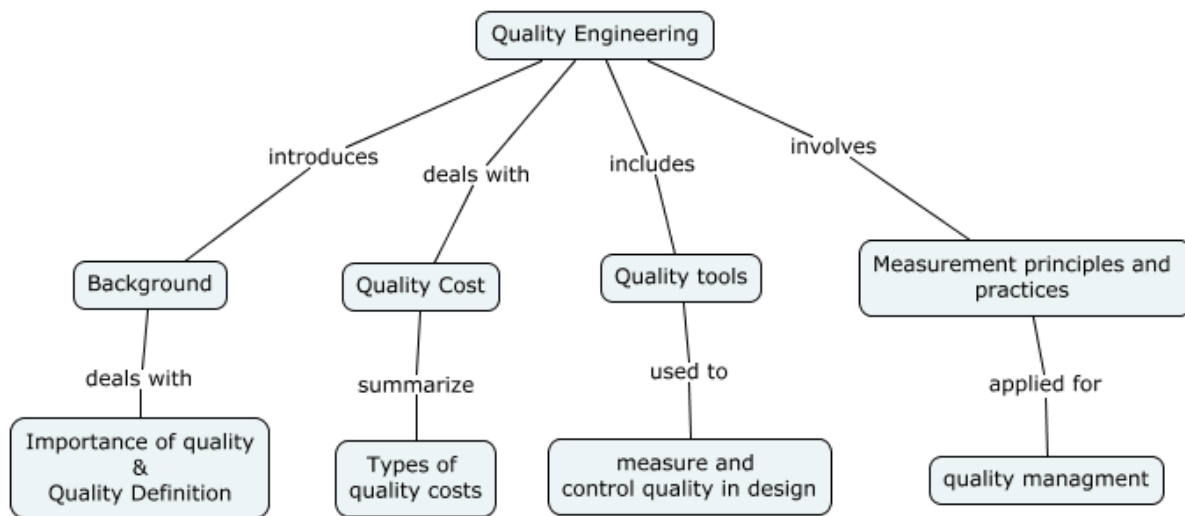
**Course Outcome 3(CO3):**

1. Demonstrate how quality control tools used to measure and control quality in design and production environment
2. Illustrate the quality improvement methodology : Kaizen
3. Summarize about Total Quality management

**Course Outcome 4 (CO4):**

1. Explain about traceability
2. Select appropriate measuring and test equipment for quality management
3. List the uncertainty in measurement

## Concept Map



## Syllabus

**Background** - Why quality assumes importance in today's buyer's market. How quality activities have evolved over the years historically with industrial growth. Definition of quality, total quality, practices followed in industry to ensure total quality. Product quality and service quality

**Quality cost** – Types of quality costs, implication of cost of quality in bottom line profitability, cost of quality profile, benefits and quality performance models

**QC Tools** – Problem solving to improve quality, quality control tools to measure and control quality in design and production environment, quality improvement methodologies such as Kaizen, Kanban, Customer satisfaction index and methodologies. Total Quality management

**Measurement and calibration as foundation for quality management** Fundamentals of measurement, definition and traceability. Selection of measuring and test equipment, uncertainty in measurement.

## Learning Resources

1. Hand out.
2. D.D. Sharma, "Total Quality Management Principles, practice and cases", Sultan Chand & Sons, 2011
3. Poornima M. Charantimath, "Total Quality Management", Pearson, 2017
4. Nancy R. Tague, "The Quality Toolbox", ASQ, 2005



**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Background</b>		
1.1	Why quality assumes importance in today's buyer's market.	1	CO1
1.2	How quality activities have evolved over the years historically with industrial growth.		
1.3	Definition of quality, total quality, practices followed in industry to ensure total quality.	1	CO1
1.4	Product quality and service quality	1	CO1
<b>2</b>	<b>Quality Cost</b>		
2.1	Types of quality costs, implication of cost of quality in bottom line profitability,	1	CO2
2.2	cost of quality profile,	1	CO2
2.3	benefits and quality performance models	1	CO2
<b>3</b>	<b>Problem solving through quality tools</b>		
3.1	Problem solving to improve quality, quality control tools to measure and control quality in design and production environment,	1	CO3
3.2	quality improvement methodologies such as Kaizen, Kanban, Customer satisfaction index and methodologies.	1	CO3
3.3	Total Quality management	1	CO3
<b>4</b>	<b>Measurement principles and practices for quality management</b>		
4.1	Fundamentals of measurement, definition and traceability.	1	CO4
4.2	Selection of measuring and test equipment, uncertainty in measurement.	2	CO4
<b>TOTAL</b>		<b>12</b>	

**Course Designers:**

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**18MT1C0 IOT BASED CARTRIDGE VALVES**

Category L T P Credit(s)  
PEES 1 0 0 1

**Preamble**

Hydraulics and Pneumatics are applied in a wide range of Industries: From construction machinery, automobiles, and air planes (outdoor) to machine tools and Press machines (Indoor). Hydraulic systems are extremely important to the operation of heavy equipment. Hydraulic principles are used when designing steering systems, brake systems, power train systems and automatic transmissions. Cartridge valves play a major role in mining, construction, agricultural and material handling equipment's and so on.

**Prerequisite**

- 18MT520 - Industrial Automation

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify different cartridge valve components used in pneumatics & Hydraulics	20
CO2	Design and develop custom manifolds for Cartridge valves.	30
CO3	Explain construction, functioning and maintenance of hydraulic cartridge electronics and control unit.	20
CO4	Develop IOT Circuits for Different types cartridge valves used in Mobile vehicle applications.	30

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 1	Understand	Respond	---	1.1, 1.2, 4.3.2
CO2	TPS 2	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4
CO3	TPS 2	Understand	Respond	---	1.1, 1.2, 4.3.2
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.3, 3.2.6, 4.4.1, 4.4.4, 4.4.5, 4.5.3, 4.5.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	---	---	---	---	---	---	---	---	---	M	M
CO2	M	M	L	---	M	---	---	---	---	---	---	---	S	S
CO3	M	M	L	---	---	---	---	---	---	---	---	---	S	S
CO4	S	S	M	---	S	---	---	---	---	---	---	---	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	-	-	-	-	-	20
Understand	40	-	-	-	-	-	40
Apply	20	-	-	-	-	-	20
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	---
Set	---
Guided Response	Online Quiz
Mechanism	Simulation & Presentation
Complex Overt Responses	---
Adaptation	---
Origination	---

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. List the types of Pneumatic cylinders
2. List the types of Hydraulic Pumps used in IIOT applications.
3. List the types of hydraulic motors used in Mobile applications.

**Course Outcome 2 (CO2):**

1. Explain throttle control used in industrial pneumatic application.
2. Explain Load sensing Valve control.
3. Explain direct acting sequence control valves

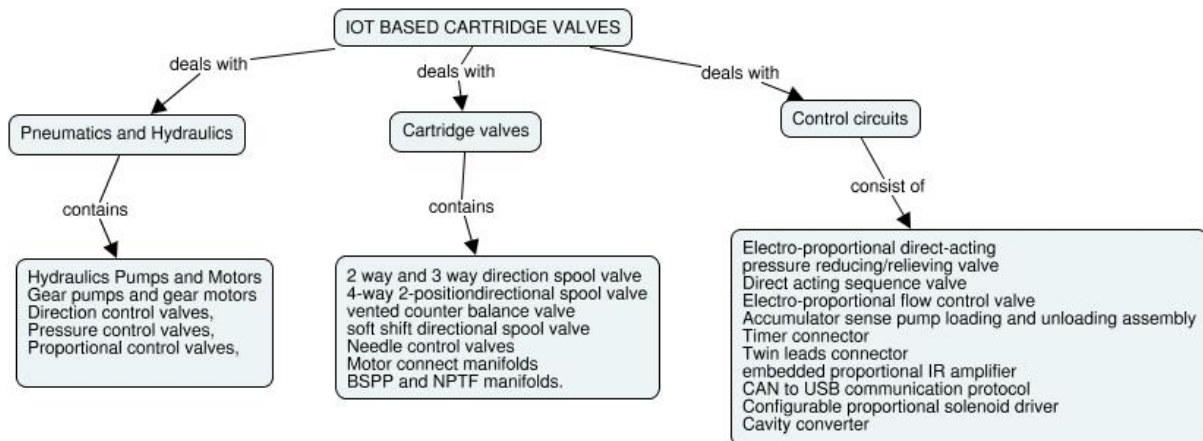
**Course Outcome 3 (CO3):**

1. List the technical Specifications of the hydraulic Cylinder.
2. Explain the function of flow control valve.
3. Explain proportional and servo technology for mobile applications.

**Course Outcome 4 (CO4):**

1. Develop a Pressure control circuit for Forklift
2. Describe the function of CAN bus in industrial hydraulics application.
3. Develop the proportional IR amplifier.

## Concept Map



## Syllabus

**Pumps and Motors:** Basics of pneumatics and hydraulics – Hydraulics Pumps and Motors - Gear pumps and gear motors- Pressure control valves, Flow control valves, Directional Control valves.

**Cartridge Valves:** 2 way and 3-way direction spool valve- 4-way 2-position solenoid operated directional spool valve- vented counter balance valve- soft shift directional spool valve- Needle control valves- Motor connect manifolds- BSP and NPTF manifolds-Design of custom manifolds for cartridge valves- Electro-proportional direct-acting pressure reducing/relieving valve – Direct acting sequence valve - Electro-proportional flow control valve

**Controls and Circuits of Cartridge valves:** Design of control circuit for cartridge proportional valves - Basics of IOT circuits- Accumulator sense pump loading and unloading assembly- Timer connector- Twin leads connector- embedded proportional IR amplifier- CAN to USB communication protocol- configurable proportional solenoid driver- Cavity converter- Electro hydraulic hitch control for tractors- Applications of IOT based cartridge valves in mobile machines and its typical control circuits.

## Learning Resources

1. <https://www.sunhydraulics.com/models/cartridges>.
2. Ian C. Turner, **Engineering Applications of Pneumatics and Hydraulics**, Routledge, 2020
3. Marian Muste, **Experimental Hydraulics: Methods, Instrumentation, Data Processing and Management**, CRC Press, 2017.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
<b>1</b>	<b>Pumps and Motors used in Mobile Hydraulics</b>		
1.1	Hydraulic pumps and motors for Mobile Applications	1	CO1
1.2	Gear Pumps and Gear Motors		
1.3	Electro hydraulic pumps	1	CO1
1.4	Pressure valves		CO1
1.5	Flow Control valves	1	CO1
1.6	Directional Control Valves		CO1
<b>2</b>	<b>Cartridge Valves</b>		
2.1	2 way and 3-way direction spool valve-	1	CO2
2.2	4-way 2-position solenoid operated directional spool valve	1	CO2
2.3	Vented counter balance valve-	1	CO2
2.4	Soft shift directional spool valve-	1	CO2
2.5	Needle control valves		CO2
2.6	Motor connect manifolds- BSPP and NPTF manifolds.	1	CO2
<b>3</b>	<b>Controls and circuits of Mobile hydraulics</b>		
3.1	Design of control circuit for cartridge proportional valves	1	CO3
3.2	Basics of IOT circuits	1	CO4
3.3	Accumulator sense pump loading and unloading assembly	1	CO3
3.4	Timer connector- Twin leads connector- embedded proportional IR amplifier	1	CO3
3.5	CAN to USB communication protocol- configurable proportional solenoid driver- Cavity converter	1	CO3
3.6	Electro hydraulic hitch control for tractors- Applications of IOT based cartridge valves in mobile machines and its typical control circuits.	1	CO4
<b>Total</b>		<b>14</b>	

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<b>REVISED LABORATORY COURSES</b>						
Course code	Name of the Course	Category	L	T	P	Credits
18MT471	Sensors and Measurements Laboratory	PC	0	0	2	1
18MT481	Micro Controller Laboratory	PC	0	0	2	1

**REVISED LABORATORY COURSES**

<b>18MT471</b>	<b>SENSORS AND MEASUREMENTS LABORATORY</b>	Category	L	T	P	Credit(s)
		PC	0	0	2	1

**Preamble**

A sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment. Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micromachinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life. There are a wide range of other sensors, measuring chemical & physical properties of materials. A few examples include optical sensors for Refractive index measurement, vibrational sensors for fluid viscosity measurement and electro-chemical sensor for monitoring pH of fluids.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage *** in %
CO1	Select Appropriate Resolution ADC for Sensor Measurements	10
CO2	Prepare Signal conditioning Circuits for the Active and Passive Sensors	10
CO3	Measure change of capacitance using Touch and Proximity based Capacitance Sensors	10
CO4	Measure luminescence, Temperature, Force and calibrate for Error	20
CO5	Construct a Pressure and strain measurement system	20
CO6	Collect Vibration measurement and AC Power Measurement for Real Time Monitoring	10
CO7	Measure Linear, angular, thread elements, 2D & 3D profiles, surface roughness, flatness and straightness	10
CO8	Check and calibrate different dimensions for given components	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4
CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO7	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3
CO8	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.2.4

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	-	-	-	M	M	-	L	M	-
CO2	S	M	L	-	L	-	-	-	M	M	-	M	M	-
CO3	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO4	S	M	L	-	L	-	-	L	M	M	-	L	M	S
CO5	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO6	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO7	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO8	S	M	L	-	L	-	-	-	M	M	-	M	M	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Practical Component
Complex Overt Responses	-
Adaptation	-
Origination	-

**List of Experiments/Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No of Hrs	COs
1	Design of Signal Conditioning circuits -1 Adder and Subtractor for AC and DC Signals.	2	CO2
2	Design of Signal Conditioning circuits -2 Comparator and Instrumentation amplifier		CO2
3	Experimenting with Analog to Digital Conversion and Digital to Analog conversion	2	CO2
4	Measurement of Power and Energy of AC and DC source	2	CO1
case studies/ mini project submission Design of Energy meters, Power factor meters, Metal Detector			
5	Experimenting with capacitive and Inductive Proximity Sensors	2	CO3
6	Characterisation and Calibration of Thermistor and Thermocouple		CO4
7	Characterisation and Calibration of Light Dependent Resistor, Photodiode		CO4
8	Characterisation and Calibration of Strain Gauge - Load cell	2	CO5



Sl. No.	Exercises / Experiments	No of Hrs	COs
9	Measurement of Acceleration and Characterisation using Acceleration Sensors	2	CO6
10	Characterisation and Calibration Flow Sensor.	2	CO4
case studies: soil moisture measurement, fuel level, pH sensor, Oxygen sensors			
11	Characterisation and Calibration of Force Sensor using ANOVA	2	CO6
12	Profile measurement of linear, angular and thread elements using Profile Projector.	2	CO6
13	Straightness / Flatness Testing using Autocollimator	2	CO7
14	2D & 3D measurements using Coordinate Measuring Machine		CO7
15	Profile measurement of linear, angular and thread elements using Tool Makers Microscope	2	CO8
Case study Displacement Measurement sensor, Pressure Sensor, Torque Measurement			
Total		24	

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**18MT481 MICRO CONTROLLER LABORATORY**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

Microcontrollers based embedded systems are involved in almost every facet of modern life. Consumer gadgets, entertainments gadgets, medical devices and automobiles all contain embedded Microcontroller. The tremendous number of applications for embedded computing has given rise to high demand for engineers with experience in designing and implementing embedded systems with microcontroller. This course is designed to provide an introduction to microcontroller architecture, internal and external peripherals, assembly language programming and embedded c programming. Students will be taught the basic use of a programming environment and how to develop the basic C programming for embedded application. This course highlights the general interfacing techniques and concepts through peripheral's data representation from input/output, and memory usage in the microcontroller in embedded C.

**Prerequisite**

- 18MT330 - Digital Electronics
- 18MT380 - Digital Electronics laboratory

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Develop program in 8051 to perform arithmetic and memory related operations	10
CO2	Develop program using timers and counters in 8051	20
CO3	Develop program using interrupts in 8051	20
CO4	Develop programs to interface external peripherals with 8051 microcontrollers	20
CO5	Develop programs in 8051 for applications such as temperature logging, DC motor control, traffic light control, frequency counter, digital clock, etc	20
CO6	Develop program for other microcontrollers such as ATMEGA, PIC	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO2	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO3	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO4	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5
CO5	TPS 3	Apply	Value	Mechanism	1.2, 2.1.1, 4.4.1, 4.4.2, 4.4.3, 4.5.1, 4.5.3, 4.5.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	L	M	-	-	L	M	M	-	L	-	L
CO2	S	S	S	L	M	-	-	L	M	M	-	L	-	L
CO3	S	S	S	L	M	-	-	L	M	M	-	L	-	L
CO4	S	S	S	L	M	-	-	L	M	M	-	L	-	L
CO5	S	S	S	L	M	-	-	L	M	M	-	L	-	L

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	100	100
Analyse	-	-
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Practical Component
Complex Overt Responses	-
Adaptation	-
Origination	-

**List of Experiments/Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No of Hours.	COs
1	Single and double precision arithmetic operations	2	CO1
2	Searching, sorting and memory operations	2	CO1
3	Timer and counter Programming	2	CO1
4	Input and output port operations	2	CO2
5	Applications of Serial Communication	2	CO2
6	Programming using Interrupts	2	CO2
7	Interfacing External Peripherals like LED and LCD	2	CO2
8	Interfacing External Peripherals like keyboard and 7 segment displays	2	CO2
9	Interfacing ADC and DAC	2	CO3
10	Programming for controlling the speed of the motor	2	CO3
11	Programming for Traffic light control	2	CO3
12	Programming for data logging from sensors	2	CO3
13	Additional applications such as frequency counter, digital clock, etc	2	CO3
14	Programming using other microcontrollers	2	CO3

**Learning Resources**

1. The 8051 Microcontroller and Embedded Systems Using Assembly and C, 2nd Edition, Pearson, Muhammed Ali Mazidi. 2007
2. The 8051 Microcontroller 3rd Edition, Kenneth J. Ayala.2007, Cengage publications.
3. AVR Microcontroller and Embedded Systems: Using Assembly and C: using Arduino uno and atmel studio, Muhammed Ali Mazidi, sepehr naimi and Armad naimi, 2017.
4. PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18, 1e, Muhammed Ali Mazidi 2008

**Course Designers:**

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<b>GENERAL ELECTIVE</b>						
Course code	Name of the Course	Category	L	T	P	Credits
18MTGD0	Design of Experiments	GE	3	0	0	3
18MTGE0	Robot based automation	GE	3	0	0	3

**18MTGD0****DESIGN OF EXPERIMENTS**

Category	L	T	P	Credit(s)
GE	3	0	0	3

**Preamble**

This course is an introduction to the statistical design of experiments and the role of random effects in data analysis. This course is created to provide an understanding of how experiments should be designed so that when the data are collected that can be used in a variety of experimental situations. A strategically planned and Structured experiment may provide a great deal of information about the effect on a response variable due to one or more factors.

**Prerequisite**

- Probability and statistics

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the concept of variability and Different types of experimental designs	15
CO2	Interpret ANOVA results and identify significant factors that influence the experiments	15
CO3	Design the full factorial and fractional factorial experiments and determine how to assign the experimental units and levels of factors	20
CO4	Apply experimental techniques to practical problems to improve quality of processes / products by optimizing the process / product parameters.	20
CO5	Introduce Taguchi methods, and compare and contrast them with traditional techniques.	15
CO6	Use the statistical packages	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS2	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO5	TPS4	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO6	TPS6	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	L		-	-	-	-	-	M	M	M
CO2	S	M	L	-	S		-	-	-	-	-	M	S	S
CO3	S	M	L	-	L		-	-	-	-	-	M	S	S
CO4	S	M	L	-	S		-	-	-	-	-	M	S	S
CO5	S	S	M	L	S		-	-	S	S	L	S	S	S
CO6	S	S	S	S	S		-	-	S	S	L	S	S	S

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	20	40	40	100	-	-	40
Apply	60	40	40	-	100	100	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Case study presentation
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

- Brief: Repetition in experimental design
- Brief: Blocking in experimental design
- What is the advantage of doing replication in experiments?

**Course Outcome 2(CO2):**

- The lifetime of LED bulb is being studied. Four different brands are being investigated. The following data have been collected.

Brands	Life time in days			
<b>A</b>	20.5	17.7	20.0	19.2
<b>B</b>	24.0	26.2	21.2	26.1
<b>C</b>	27.4	35.2	31.2	28.2
<b>D</b>	17.1	18.1	18.5	16.7

Test the hypothesis that which brand affect the life time of LED. Use  $\alpha = 0.5$

2. The delivery of a pump is being studied. Four different types are being investigated. The following data (unbalanced) have been collected.

Types	Delivery in liters /min			
A	--	17.7	14.7	16.3
B	14.0	16.2	--	13.3
C	12.6	--	13.2	12.2
D	17.1	12.8	11.8	--

Interpret the data from this experiment (use  $\alpha=0.05$ ) and draw conclusions.

**Course Outcome 3(CO3):**

1. An automobile engineer is trying to improve the life of a braking pad. He has run a  $2^3$  experiment using wheel speed (A), shoe hardness (B) and friction (C) as the factors. The data from two replicates are shown here.

Run	Replicate	
	I	II
(1)	423	468
A	341	378
B	331	315
AB	205	223
C	486	478
AC	360	341
BC	241	260
ABC	492	392

- I. Do any of the factors affect Brake shoe life
- II. What combination of factor levels produces the longest tool life?

Is there a combination of wheel speed and friction that always gives good results regardless of shore hardness?

2. A  $2^3$  has been used to investigate the effect of four acids on several cement properties. The data from this experiment are shown here.

Run	A	B	C	D	Adhesive
1	-	-	-	-	2.001
2	+	-	-	+	2.062
3	-	+	-	+	2.019
4	+	+	-	-	2.059
5	-	-	+	+	1.990
6	+	-	+	-	2.076
7	-	+	+	-	2.038
8	+	+	+	+	2.118

- I. Estimate the factor effects. Plot the effect estimates on a normal probability scale.
  - II. Plot the residuals from the model Vs the predicted adhesive.
- Is there any indication on this plot of model adequacy?



**Course Outcome 4 (CO4):**

1. An experiment was conducted to determine the effects of three factors on warpage in an injection moulding process. The three factors of interests (each at two levels) are A= melt temperature, B= Injection speed and C= Injection process. A complete  $2^3$  factorial design was carried out with replication. Two replicates are provided in the table below. Analyse the data using Yate's algorithm from this experiment.

A	B	C	I	II
-1	-1	-1	1.35	1.40
1	-1	-1	2.15	2.20
-1	1	-1	1.50	1.50
1	1	-1	1.10	1.20
-1	-1	1	0.70	0.70
1	-1	1	1.40	1.35
-1	1	1	1.20	1.35
1	1	1	1.10	1.00

2. An experiment was run using two factors. Gas flow rate (A) and Power applied (B). Four replicates were run and the epitaxial layer thickness was measured in (microns). The data are shown below.

A	B	Replicate			
		I	II	III	IV
-	-	550	669	604	650
+	+	633	642	601	635
-	+	1037	749	1052	868
+	+	1075	860	1063	729

Analyse this experiment assuming that each one of the four replicates represents a block. Conduct an ANOVA to confirm your findings,

**Course Outcome 5 (CO5)**

1. A two-wheeler Magneto Rheological shock absorber property were experimented by using orthogonal array. There are 7 velocities and the 2 states of magnetic field are represented in the following manner by alphabets and numbers respectively:  
1: OFF State 2: ON State  
A- 0.05 m/s B- 0.10 m/s C- 0.26 m/s D- 0.30 m/s E- 0.40 m/s F- 0.52 m/s

This array is represented in the table given below:

Trial	A	B	C	D	E	F	$y_1$	$y_2$
1	1	1	1	1	1	1	32.63	7.30
2	1	1	1	2	2	2	32.99	9.09
3	1	2	2	1	1	2	32.60	9.18
4	1	2	2	2	2	1	34.46	9.38
5	2	1	2	1	2	1	32.78	9.36
6	2	1	2	2	1	2	34.36	9.38
7	2	2	1	1	2	2	33.21	9.56
8	2	2	1	2	1	1	33.66	9.56

**L8 Orthogonal Array**

Where

$y_1$  = Sum of Rebound forces in each Trial (kgf)

$y_2$  = Sum of Active forces in each trial (Kgf)

Analyse and draw appropriate conclusions and find the overall effect by using L8 Orthogonal array.

**Course Outcome 6(CO6):**

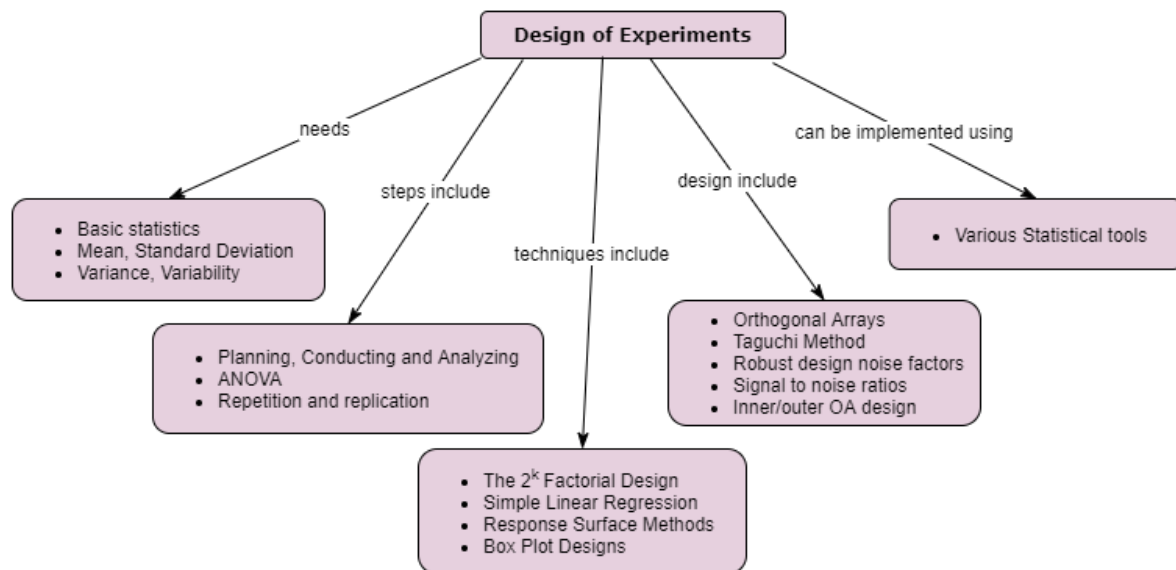
1. Objective: To design and analyse a fractional factorial experiment using Minitab [Taguchi Design]

Output Variable: % Reacted

Inputs:

- |                                |          |
|--------------------------------|----------|
| • Feed Rate (liters/minute)[A] | 10, 15   |
| • Catalyst (%) [B]             | 1,2      |
| • Agitation Rate (rpm) [C]     | 100, 120 |
| • Temperature (C) [D]          | 140,180  |
| • Concentration (%) [E]        | 3, 6     |

Use Minitab to setup the Design Matrix

**Concept Map****Syllabus**

Basic statistics - Mean - Standard Deviation - variance Variability – causes – Errors

Introduction to experimental design - Basic techniques - Standard types of experimental design. Steps for Planning, Conducting and Analyzing an experiment – ANOVA - attribute data analysis - Repetition and replication.

Introduction to Factorial Design - The  $2^k$  Factorial Design - Confounding and Aliasing in  $2^k$  Factorial Design 3-level and Mixed-level full Factorials and Fractional Factorials- Simple Linear Regression - Response Surface Methods and Designs - Robust Parameter Designs - Experiments with Random Factors - Box Plot Designs.

Main and Interaction effects - Fixed effects and random effects model - Design of experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Taguchi Method, Robust design noise factors, Signal to noise ratios, Inner/outer OA design – Uses of statistical packages

### Learning Resources

1. Douglas C Montgomery (2019), **Design and Analysis of Experiments**, 10<sup>th</sup> edition, John Wiley & Sons
2. Colin Hardwick (2019), **Practical Design of Experiments - Done Made Easy**, Lulu.com
3. Angela Dean, Daniel Voss, Danel Draguljic (2017), **Design and Analysis of Experiments**, Second Edition, Springer Texts in Statistics, Springer.
4. John Lawson (2015), **Design and Analysis of Experiments with R, Texts in Statistical Science**, Chapman & Hall / CRC.
5. Roger Mead, S. G. Gilmour, A. Mead (2012), **Statistical Principles for the Design of Experiments**, Cambridge Series in Statistical and Probabilistic Mathematics, Cambridge University Press.
6. Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook (2009), **Response Surface Methodology**, Third Edition, John Wiley & Sons

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	Basic statistics-Mean-Standard Deviation-variance Variability	1	CO1
2.	Causes – Errors	1	CO1
3.	Introduction to experimental design - Basic techniques	2	CO1
4.	Standard types of experimental design	1	CO1
5.	Steps for Planning, Conducting and Analyzing an experiment	2	CO2
6.	ANOVA	2	CO2
7.	attribute data analysis	1	CO2
8.	Introduction to Factorial Design	1	CO3
9.	The 2k Factorial Design	1	CO3
10.	Confounding and Aliasing in 2k Factorial Design 3-level and Mixed-level Factorials	2	CO3
11.	Fractional Factorials	1	CO3
12.	Simple Linear Regression	1	CO3
13.	Response Surface Methods	1	CO4
14.	Robust Parameter Designs	1	CO4
15.	Experiments with Random Factors-Nested and Split Plot Designs	2	CO4
16.	Main and Interaction effects	1	CO5
17.	Fixed effects and random effects model	1	CO5
18.	Design of experiments using Orthogonal Arrays,	1	CO5
19.	Data analysis from Orthogonal experiments	1	CO5
20.	Taguchi Method	2	CO5
21.	Robust design noise factors	1	CO6
22.	Signal to noise ratios	1	CO6
23.	Inner/outer OA design.	1	CO6
24.	Uses of statistical packages	1	CO6
<b>TOTAL</b>		<b>30</b>	

### Course Designers:

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**18MTGE0****ROBOT BASED AUTOMATION**

Category	L	T	P	Credit(s)
GE	3	0	0	3

**Preamble**

Industrial Robot Automation is one of the significant domains of 21st century. The use of industrial robots and automation has seen exponential growth in the manufacturing sector over recent years. With improved production efficiency, safety, and quality assurance at the forefront of companies' interests, it's unsurprising that there is substantial ongoing investment and implementation of robotics in manufacturing facilities around the globe. While some may see robot automation as a potential threat, the reality is that when combined with employees, the benefits of industrial robotic automation are amplified and can help ensure manufacturers meet their production goals more efficiently.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the level of automation in automated industries	10
CO2	Explain the anatomy of industrial robot	10
CO3	Brief the role of Automated Guided vehicles in industrial automation	20
CO4	Describe the Interface of PLC with the industrial robot	20
CO5	Develop basic logical sequences to interface with conveyor and actuators	20
CO6	Develop mobile robot automation process for a particular application	20

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS2	Understand	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS2	Understand	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS2	Understand	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO5	TPS3	Apply	Value	-	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3, 2.4.4, 4.3.1, 4.3.2
CO6	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3, 2.4.4, 4.3.1, 4.3.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	M	M	M
CO2	S	M	L	-	S	-	-	-	-	-	-	M	M	M
CO3	S	M	L	-	S	-	-	-	-	-	-	M	M	M
CO4	S	M	L	-	S	-	-	-	-	-	-	S	M	M
CO5	S	M	L	-	S	-	-	-	-	-	-	S	M	M
CO6	S	M	L	-	S	-	-	-	S	S	-	S	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	40	40	40	-	-	-	20
Understand	50	40	40	100	-	-	40
Apply	10	20	20	-	100	-	40
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	100	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Case study implementation as Assignment 3
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

1. Describe the levels of automation
2. Explain the classification and the performance of Robots in automation.
3. Describe the growth of industry 4.0

**Course Outcome 2(CO2):**

1. Define Robot
2. Explain the anatomy of industrial robot.
3. Describe the difference between the industrial robot and cobot.

**Course Outcome 3(CO3):**

1. List the Automated Guided vehicles used in mobile automation
2. Explain the sensor used in Ware House Automation
3. Brief how LIDAR is used in mobile automation

**Course Outcome 4 (CO4):**

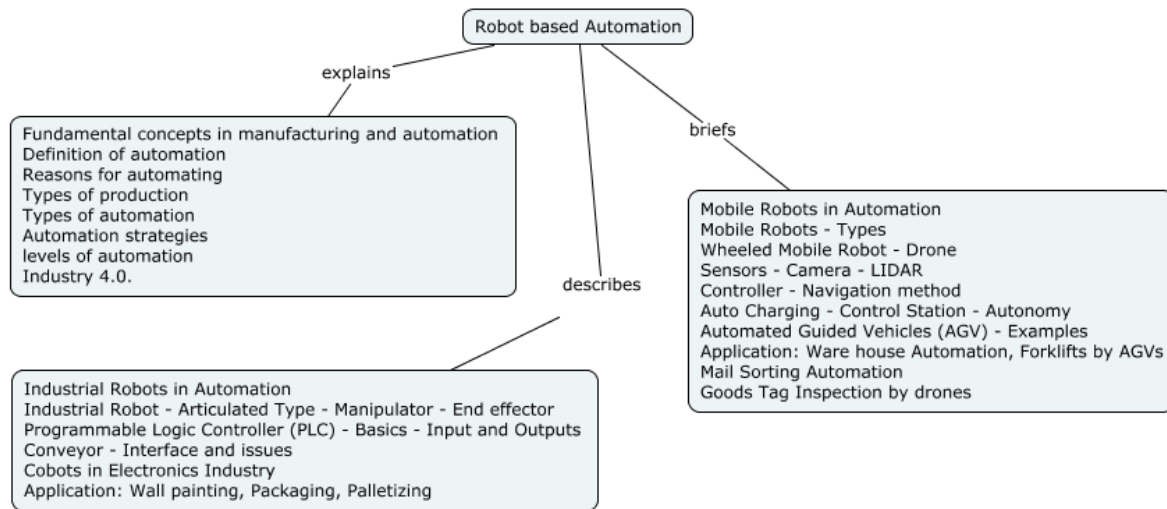
1. How do we need to control an automation setup for palletizing operation with a conveyor, a robot and a PLC. Draw the wire diagram of the setup?
2. Interface the PLC with the robot and conveyor. Write a PLC program to access the industrial robots and conveyors to perform the cooperative assembly operation. The parts coming through the conveyor has to be picked up and assembled.
3. Explain the inputs and outputs connections for cooperative robot operation. Use the details to write a cooperative assembly operation pendant program and the PLC program to access both the robots

**Course Outcome 5 (CO5)**

1. Write a PLC program to count the number of parts moved through a conveyor with a proximity sensor.
2. Write a PLC program using the TIA portal software to access the deburring station and close the deburring cylinder when the conveyor has rotated for 30 seconds.
3. Write a PLC program to trigger the camera to click when the vibro feeder is turned off

**Course Outcome 6(CO6):**

1. In a ware house automation 2 mobile robots are used to pick an object from a rack. Develop a mobile automation process and the AGVs used.
2. A mobile sorting automation process uses an AGV for a particular region. Select sensor and actuator to navigate without collision to pick the mails from a location A and drop to a location B
3. Develop a mobile automation process to move a mobile robot to a point A and fork lift a box of mass 5 kg. The robot has to move over a magnetic strip and drop at a location B. Develop the navigation method

**Concept Map****Syllabus**

**Basics of Automation:** Fundamental concepts in manufacturing and automation, definition of automation, Reasons for automating. Need of robots in automation, Automation strategies, levels of automation, Industry 4.0.

**Industrial Robots in Automation:** Industrial Robot - Articulated Type - Manipulator - End effector, Programmable Logic Controller (PLC) - Basics - Input and Outputs, Conveyor - Interface and issues, Cobots in Electronics Industry, **Application:** Wall painting, Packaging, Palletizing

**Mobile Robots in Automation:** Mobile Robots - Types - Wheeled Mobile Robot - Drone, Sensors - Camera - LIDAR, Controller - Navigation method - Auto Charging - Control Station - Autonomy - Automated Guided Vehicles (AGV) - Examples.

**Application:** Ware house Automation, Forklifts by AGVs, Mail Sorting Automation, Goods Tag Inspection by drones

**Learning Resources**

1. Michal Gurgul, **Industrial robots and cobots: Everything you need to know about your future co-worker**, 2018
2. Frank D Petruzella, **Programmable logic controllers**, Fourth edition, McGraw Hill higher education ,2016
3. John J Craig, **Introduction to Robotics, Mechanics and Control**, third edition, Pearson education, 2005
4. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, **Industrial Robotics – Technology, Programming and Applications**, Tata McGraw Hill Edition, 2008.
5. Robert J Schiling, **Fundamentals of Robotics: Analysis and Control**, Indian reprint, Prentice hall of India Private Limited, 1996

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
<b>1.0</b>	<b>Introduction to Industrial Robot Automation</b>		
1.1	Fundamental concepts in manufacturing and automation	1	CO1
1.2	Definition of automation	1	CO1
1.3	Reasons for automating	1	CO1
1.4	Types of production and types of automation	1	CO1
1.5	Automation strategies	1	CO1
1.6	Levels of automation	1	CO1
1.7	Schematics of Industry 4.0	1	CO1
1.8	<b>Application</b> - Palletizing, Deburring, Inspection, Assembly.	1	CO1
<b>2.0</b>	<b>Industrial Robots in Automation</b>		
2.1	Industrial Robot - Articulated Type	1	CO2
2.2	Manipulator	2	CO2
2.3	End effector	2	CO2
2.4	Programmable Logic Controller (PLC) - Basics	1	CO4
2.5	Input and Outputs	2	CO4
2.6	Conveyor	2	CO4
2.7	Interface and issues	2	CO5
2.8	Cobots in Electronics Industry	1	CO5
2.9	<b>Application:</b> Wall painting, Packaging, Palletizing	2	CO5
<b>3.0</b>	<b>Mobile Robots in Automation</b>		
3.1	Mobile Robots - Types	1	CO3
3.2	Wheeled Mobile Robot, Drones	2	CO3
3.3	Sensors - Camera - LIDAR	2	CO3
3.4	Controller	1	CO2
3.5	Navigation method, Auto charging	2	CO5
3.6	Control Station, Autonomy	2	CO6
3.7	Automated Guided Vehicles (AGV), examples	3	CO6
<b>TOTAL</b>		<b>36</b>	

**Course Designers:**

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**REVISED LABORATORY COURSE(S)****18MT281****WORKSHOP**

Category	L	T	P	Credit(s)
PC	0	0	2	1

**Preamble**

Workshop is a hands-on training practice to engineering students. The aim of this course is to impart fundamental hands-on skill in carrying out experiments at higher semester practical courses

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage *** in %
CO1	Make different types of wooden joints/sheet metal components	30
CO2	Construct protection circuits using Fuse, MCB, MCCB, ELCB	10
CO3	Prepare and test an Ethernet cable for Local Area Network connection	10
CO4	Construct Switch circuits using Transistor, MOSFET and Thyristors	30
CO5	Design a Printed Circuit Board Layout for given schematic Diagram	10
CO6	Fabricate circuits using Soldering Techniques	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO4	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.2, 3.1, 4.4.2,5.4.3
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.2, 3.1, 4.4.2
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.2, 3.1, 4.4.2,5.4.3

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	L	-	-	M	M	-	L	L	M
CO2	S	M	L	-	-	-	-	-	M	M	-	L	L	M
CO3	S	M	L	-	-	-	-	-	M	M	-	L	L	M
CO4	S	S	M	L	-	-	-	-	M	M	-	S	S	S
CO5	S	M	L	-	S	-	-	-	M	M	-	L	L	M
CO6	S	S	L	L	S	-	-	-	M	M	-	S	S	S

S – Strong                      M – Medium                      L – Low



**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	Terminal Examination
Remember	-	-
Understand	-	-
Apply	75	75
Analyse	25	25
Evaluate	-	-
Create	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	Practical Component
Complex Overt Responses	-
Adaptation	-
Origination	-

**List of Experiments/Activities with CO Mapping**

Sl. No.	Exercises / Experiments	No of Hrs	COs
Phase - I			
1	Preparation of wooden parts like Door frame/Office tray	4	CO1
2	Preparation of Sheet metals like Litre Cone/Dustpan (Straight, Taper)/Tray (Straight, Taper).	4	CO1
3	Electrical Wiring practices (One way switch and Two-way switch)	2	CO2
4	Electrical Wiring practices and testing with circuit breakers using Fuse, MCB, MCCB, ELCB		CO2
5	Structure cabling. (LAN)	2	CO3
Phase - II			
6	Breadboard wiring and Verifying simple Transistor switching circuits	2	CO4
7	Breadboard wiring and Verifying simple MOSFET/Thyristor switching circuits	2	CO4
8	Realisation of IC based 555 Timer in breadboard from Schematic Diagram.	2	CO4
9	Identifying electronic components and understanding PCB glossary	2	CO5
10	Conversion of schematic into PCB layout	2	CO5
11	PCB fabrication using wet Etching methodology	2	CO6
12	Practicing of soldering and de-soldering	2	CO6
	Total	24	

### **Learning Resources**

1. John K.C “Mechanical Workshop”, Practice by Prentice Hall India Learning Private Limited, Second edition, 2010.
2. Printed Circuit Boards: Design, Fabrication, Assembly and Testing, R S Khandpur, Tata McGraw-Hill Education, 2005

### **Course Designers:**

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<b>ELECTIVE COURSE</b>						
Course code	Name of the Course	Category	L	T	P	Credits
18MTRD0	Air Mobility Systems	PEES	2	0	2	3

18MTRD0	AIR MOBILITY SYSTEMS	Category	L	T	P	Credit(s)
		PEES	2	0	2	3

### Preamble

The introduction of disruptive automated and autonomous technologies in both crewed and uncrewed air traffic management systems, as well as new, sustainable, and intelligent aerial platforms to transport people and commodities, is the next step in the aerospace industry's evolution. The rise of revolutionary, automated, and self-driving vehicles the Advanced Air Mobility Systems programme is designed to provide you with the skills need to succeed in transforming the aviation industry by applying the learned to introduce new automated and autonomous solutions that will enable a safe, orderly, and efficient integrated airspace where unmanned aerial systems coexist with crewed aircraft.

### Prerequisite

- Nil

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage *** in %
CO1	Summarize the need and overview of Air mobility system	20
CO2	Illustrate the selection of components used in Air mobility systems.	30
CO3	Design the UAV air craft, propeller model and suitable motor drives.	10
CO4	Integrate the drone model and compare the testing results with various algorithm models.	40

\*\*\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1,1.2,1.3, 2.1.4,2.1.5, 2.4.3,2.4.4,4.3.1,4.3.2
CO2	TPS3	Apply	Value	Mechanism	1.2,2.1.1,2.12,2.2.3,2.3.1, 2.3.2,2.4.3,2.4.5,2.4.6,2.5.4
CO3	TPS3	Apply	Value	Mechanism	2.1.1,2.1.3,2.1.5,2.2.3,2.3, 2.4.1,2.4.3,2.4.4,2.4.6
CO4	TPS4	Analyse	Organise	Complex Overt Responses	2,2.1.1,2.12,2.2.3,2.3.1, 2.3.2,2.4.3,2.4.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	L	L	-	L	L	L	L	M	S	M
CO2	S	M	L	-	-	L	-	-	L	L	L	M	S	M
CO3	S	M	L	-	-	L	L	-	L	L	L	M	S	M
CO4	S	S	M	L	M	L	L	L	L	L	L	S	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	5	5	-	-	-	-	10
Understand	10	10	-	-	-	-	20
Apply	35	35	20	100			70
Analyse	-	-	30	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment I & II
Mechanism	Model Drone fabrication
Complex Overt Responses	-
Adaptation	-
Origination	-

**Syllabus**

**Introduction:** Principle of flight- Drones, Categories and applications, Govt. Regulations, air mobility framework

**Components of AAM system:** Elemental forces on aircraft - Different types of rotorcraft airframes - Types of fixed pitch propellers - Brushed DC motor - Brushless DC motor - Multi rotor operation - Li-Po Battery and chargers - MEMS Accelerometers - MEMS Gyroscope - MEMS Magnetometer - 2.4 GHz Radio transmitter-receiver- GPS -Electronic speed controllers - Flight controllers - DJI - Arducopter - Three-axis gimbal.

**UAV system design and control:** UAV Safety calculation – Required thrust calculation - payload - endurance - battery capacity -voltage and current - selection of airframe and motors - Selection of speed controllers – Assembling the UAV - PID tuning - GEO fencing - Return to home- Auto land - Altitude hold- position hold - loitering - FPV with Gimbal- GPS waypoint navigation, Advanced Sensors.

**Flight control and measurement:** Radio Binding - Flight controller flashing - ESC flashing - Motor ESC assembling-Thrust measurement using weighing scale - Current and voltage measurement - Fail safe- Battery charging.

Drone Handling & Drone Safety Precautions – Drone ground and inflight testing.

**Learning Resources**

1. Honeywell and TCE handouts.
2. Daniel tal asla, Jon altschuld "Drone technology in architecture, engineering and construction", Atlantic press, Wiley ,2021.
3. Adam juniper, "Complete guide to drones", Ilex press ,2018.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours		CO
		In-Class	Hands-on	
1.1	Principle of flight- Drones	1		CO1
1.2	Categories and applications – Govt. Regulations	1		CO1
1.3	Air mobility framework	1		CO1
2.1	Elemental forces on aircraft - Different types of rotorcraft airframes - Types of fixed pitch propellers.	1		CO1
2.2	Brushed DC motor - Brushless DC motor - Multi rotor operation – Li-Po Battery and chargers.	1		CO2
2.3	MEMS Accelerometers - MEMS Gyroscope - MEMS Magnetometer.	1		CO2
2.4	2.4 GHz Radio transmitter-receiver – GPS	1		CO2
2.5	Electronic speed controllers - Flight controllers	1		CO2
2.6	DJI - Arducopter - Three-axis gimbal.	1		CO3
3.1	Radio Binding - Flight controller flashing - ESC flashing	1		CO3
3.2	Motor ESC assembling-Thrust measurement using weighing scale	1		CO3
3.3	Current and voltage measurement - Fail safe- Battery charging.	1		CO3
4.1	UAV Safety calculation – Required thrust calculation - payload - endurance	1		CO3
4.2	Battery calculation- battery capacity	1		CO2
4.3	Voltage and current - selection of airframe and motors	1		CO2
4.4	Selection of speed controllers	1		CO2
5.1	Assembling the UAV - PID tuning - GEO fencing - Return to home	1		CO4
5.2	Auto land - Altitude hold- position hold - loitering - FPV with Gimbal	1		CO4
5.3	GPS waypoint navigation	1		CO4
5.4	Advanced Sensors and applications	1		CO4
6.1	Drone Handling & Drone Safety Precautions	1		CO4
6.2	Drone ground and inflight testing	1		CO4
6.3	Drone applications case study	2		CO4
<b>List of Experiments / Activities with CO Mapping</b>				
7	Design and analysis of drone airframe model		2	CO2
8	Integration and configuration of motors and controller.		2	
9	Integration and configuration of sensors and ESC with flight controller		2	CO4
10	PID Tuning for pitch, yaw and roll factors in drone.		2	CO4
11	Develop the auto lifting and auto landing algorithm in drone model		2	CO4
12	Testing and implementation of drone model in indoor and outdoor environment.		2	CO4
<b>Total</b>		<b>24</b>	<b>12</b>	

### Course Designers:

Sl. No.	Name	E-mail Id
1	Honeywell Drone team	-
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3	Dr. S Julius Fusic	sjf@tce.edu

<b>REVISED COURSE(S)</b>						
Course code	Name of the Course	Category	L	T	P	Credits
21MT410	Partial Differential Equations and Probability	BS	3	0	0	3

21MT410	<b>PARTIAL DIFFERENTIAL EQUATIONS AND PROBABILITY</b>	Category	L	T	P	Credit(s)
		BS	3	0	0	0

**Preamble**

Many physical processes fundamental to science and engineering are governed by partial differential equations (PDE) that is equations involving partial derivatives. The most familiar of these processes are heat conduction and wave propagation. To describe such phenomena, we make assumptions about gradient and we write down balance equations; PDE are those produced in a natural way. The goal for this course is to gain the skill of using Fourier series. Moreover, we aim to gain the ability to form PDE and solve them.

Statistics, as a subject, is a science of learning from data and provides tools for making decisions when conditions of uncertainty prevail. The Mechatronics engineers play a significant role in designing and developing new products and manufacturing systems and processes, and they also improve existing systems. Statistical techniques are an important tool in these activities because they provide the engineers with both descriptive and analytical methods for dealing with the variability in observed data. The course is designed to impart the knowledge and understanding of the statistical techniques to Mechatronics Engineers and apply them in their areas of specialization.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage *** in %
CO1	Understand the concept of periodic functions, Fourier series of odd and even extensions.	10
CO2	Obtain the periodic functions arising in the study of	15
CO3	engineering problems in terms of Fourier series and solve the discrete data using harmonic analysis.	25
CO4	Formulate and solve Partial Differential Equations (linear, nonlinear, homogeneous) using various methods.	25
CO5	Compute probability, probability mass and density function, cumulative distribution function for random variables	15
CO6	Test the hypothesis on mean, variance for small	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	---	1.1
CO2	TPS3	Apply	Value	---	1.1
CO3	TPS3	Apply	Value	---	1.1
CO4	TPS3	Apply	Value	---	1.1.1, 2.1.4
CO5	TPS3	Apply	Value	---	1.1.1, 2.1.5, 2.2.1, 2.2.4
CO6	TPS3	Apply	Value	---	1.1.1, 2.1.4



**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	-	-	-	-	-	-	-	-	-	-	-
CO2	S	S	S	-	-	-	-	-	-	-	-	-	-	-
CO3	S	S	S	-	-	-	-	-	-	-	-	-	-	-
CO4	S	S	S	S	-	-	-	-	-	-	-	-	-	-
CO5	S	S	S	S	-	-	-	-	-	-	-	-	-	-
CO6	S	S	S	S	-	-	-	-	-	-	-	-	-	-

S – Strong                      M – Medium                      L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	-
Understand	20	20	20	-	-	-	30
Apply	70	70	70	100	100	100	70
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

- List few bio-mechatronic applications
- Find half range cosine and sine series for  $f(x) = e^{ax}, 0 < x < \pi$ .
- Find the Fourier Series expansion of  $f(x) = \begin{cases} x, & 0 \leq x \leq 1 \\ 2-x, & 1 \leq x \leq 2 \end{cases}$

**Course Outcome 2(CO2):**

- Find the sine series of function  $f(x) = 1, 0 \leq x \leq \pi$ .
- Find the half range sine series of  $f(x) = \begin{cases} x, & 0 < x < \frac{\pi}{2} \\ \pi - x, & \frac{\pi}{2} < x < \pi \end{cases}$
- Find the Fourier series as far as the second harmonic to represent the function f(x) with period 6, given in the following table:  

X:	0	1	2	3	4	5
Y:	9	18	24	28	26	20

**Course Outcome 3(CO3):**

- Form a PDE by eliminating the arbitrary constants in  $(x-a)^2 + (y-b)^2 + z^2 = 1$
- Find the Singular solution of  $z = px + qy + \sqrt{p^2 + q^2 + 1}$
- Solve  $(D^3 - 7DD'^2 - 6D'^3)z = e^{2x+y}$

**Course Outcome 4 (CO4):**

- Identify the following as discrete or continuous random variables:
  - Total number gold medals won by India in Asian games 2018.
  - Height of the ocean's tide at Kanyakumari.
  - Number of deer born per year in a state wild life preserve
  - The amount of water released from Mettur dam this month.
- A random variable  $X$  has the following probability distribution

$X$	0	1	2	3	4	5	6	7
$P(X)$	0	$K$	$2K$	$2K$	$3K$	$K^2$	$2K^2$	$7K^2+K$

Find (i) the value of  $K$ , (ii)  $P(1.5 < X < 4.5 / X > 2)$  and (iii) the smallest value of  $n$  for which

$$P(X \leq n) > \frac{1}{2}.$$

- In a test of 2000 electric bulbs, it was found that the life of Philips bulbs was normally distributed with an average of 2400 hours and S.D of 60 hours. Estimate the number of bulbs likely to burn for
  - more than 2150 hours
  - less than 1950 hours.

**Course Outcome 5 (CO5):**

- Define Type I Error and Type II Error
- The mean value of a random sample of 60 items was found to be 145., with a S.D of 40. Find the 95% confidence limits for the population mean. What size of the sample is required to estimate the population mean within 5 of its actual value with 95% or more confidence, using sample mean?
- Time taken by works in performing a job are given below

Type I	1	7	7	8	4	3	5
Type II	8	4	3	6	3	5	9

Test whether there is any significant difference between the variances of time distribution

**Course Outcome 6 (CO6):**

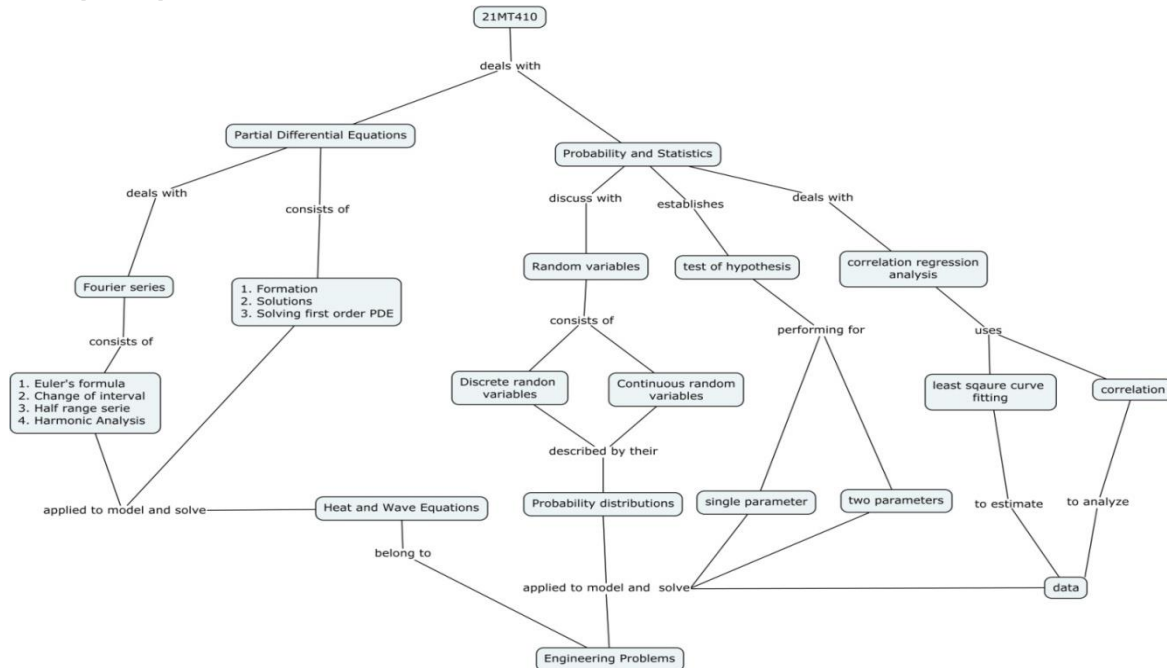
- Define correlation coefficient.
- Fit a least-squares line to the data of

$x$	1	3	4	6	8	9	11	14
$y$	1	2	4	4	5	7	8	9

Using (a)  $x$  as independent variable, (b)  $x$  as dependent variable.

- Find the coefficient of correlation for the data given in the above problem.

## Concept Map



## Syllabus

**Fourier series:** Conditions for Fourier expansion - Euler's formula –Change of interval- Expansions of odd or even periodic functions–Half range series –Harmonic analysis.

**Partial differential equations (PDE):** Formation of PDE – Solutions of PDE –Linear equations of the first order and Non-linear equations of first order – Homogeneous linear equations with constant coefficients – Rules for finding the complementary functions - Rules for finding the particular integral –Solution methods to solve homogeneous equations – Classifications of PDE – Introduction to boundary value problem: Heat & Wave equations with simple applications.

**Random Variables and Probability Distributions:** Discrete random variables-probability mass function-continuous random variables- probability density functions - cumulative distribution function - expected values for discrete and continuous random variables - Binomial probability distribution - Normal distribution

**Tests of Hypotheses:** Hypotheses and test procedures - tests concerning a population proportion - z tests and confidence intervals for a difference between two Population means-the two-sample *t* Test and confidence interval - inferences concerning two population variances.

**Regression Analysis:** Method of least squares - Fitting a straight line – Coefficient of correlation - Line of Regression.

## Learning Resources

1. Grewal.B.S, Higher Engineering Mathematics, 42<sup>st</sup> Edition, Khanna Publications, Delhi, 2012.
2. Jay L.Devore, Probability and Statistics for Engineering and Sciences (English) 8<sup>th</sup> Edition, Cengage Learning India Pvt Ltd,New Delhi, 2012.
3. Ronald E.Walpole, Sharon L.Myers, Keying Ye, Probability & Statistics for Engineers & Scientists,9<sup>th</sup> Edition,Pearson Education,New Delhi,2012.
4. N.Balakrishnan, Markos V. Koutras, Kanstadinos G. Polotis, Introduction to probability: Models and applications, Wiley, 2019.
5. B.V.Ramana, Higher Engineering Mathematics, Tata McGraw Hill, NewDelhi.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome
<b>1</b>	<b>Fourier Series</b>		
1.1	Conditions for Fourier expansion, Euler's formula	2	CO1
1.2	Change of interval, expansions of odd or even periodic functions	3	CO1
1.3	Half range series	2	CO2
1.4	Harmonic analysis	2	CO2
<b>2</b>	<b>Partial differential equations (PDE)</b>		
2.1	Formation of PDE, Solutions of PDE	2	CO3
2.2	Equations solvable by direct integration, Linear Equations of the first order, Non-linear equations of the first order	2	CO3
2.3	Homogeneous linear equations with constant coefficients, Rules for finding the complementary functions	2	CO3
2.4	Rules for finding the particular integral	2	CO3
2.5	Solve homogeneous and linear equations.	1	CO3
<b>3</b>	<b>Random Variables and Probability distributions</b>		
3.1	Discrete Random variables, probability mass function	2	CO4
3.2	Continuous random variables probability density functions	1	CO4
3.3	Cumulative distribution for discrete and continuous Random variables	1	CO4
3.4	Expected values for discrete and continuous random variables	2	CO4
3.5	The Binomial probability distribution	1	CO4
3.6	The Normal distribution	2	CO4
<b>4</b>	<b>Tests of Hypotheses</b>		
4.1	Hypotheses and test procedures	1	CO5
4.2	Tests concerning a population mean	1	CO5
4.3	z Tests and confidence intervals for difference between two population means	1	CO5
4.4	The two-Sample <i>t</i> Test and confidence interval	2	CO5
4.5	Inferences concerning two population variances	1	CO5
4.6	Method of least squares: Fitting a straight line	1	CO6
4.7	Coefficient of correlation	1	CO6
4.8	Line of Regression	1	CO6
	<b>Total</b>	<b>36</b>	

### Course Designers:

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SYLLABI

For

**B.E. Mechatronics Program**

Program Electives

For the students admitted from the  
academic year 2019 - 2020 onwards



**THIAGARAJAR COLLEGE OF ENGINEERING**

(A Govt. Aided, Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

18MTRE0/ 21MTRE0	INDUSTRY 4.0	Category	L	T	P	Credit(s)
		PE	3	0	0	3

**Preamble**

Industry 4.0 refers to a new phase in the Industrial Revolution that places strong emphasis on interconnectivity, automation, machine learning, and real-time data. Industry 4.0, which includes Industrial internet of things (IIOT) and smart manufacturing, combines physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better-connected ecosystem for companies that focus on manufacturing and supply chain management. This course focusses on the components and applications of industry 4.0 for manufacturing sector.

**Prerequisite**

- 18MT520 - Industrial Automation

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage * in %
CO1	Explain different technologies used in industry 4.0 and its applications.	10
CO2	Perform AI and ML based analytics in Industry 4.0 frame work.	15
CO3	Develop model for Cyber physical systems	15
CO4	Solve interoperable issues in connected factory using OPC, OPC-UA and TSN.	20
CO5	Design AR based operation and Maintenance sequence.	20
CO6	Develop cloud-based ERP for Smart Manufacturing Industry	20

\* Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2,2.1.1,2.12,2.2.3,2.3.1,2.3.2,2.4.3,2.4.5.
CO2	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO3	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO4	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO5	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5
CO6	TPS3	Apply	Value	Mechanism	2.1.1,2.1.2,2.1.3,2.1.5,2.2.3,2.3.1,2.3.2,2.4.1,2.4.3,2.4.4,2.4.6,2.5.4,3.1.5

**Mapping with Programme Outcomes and Programme Specific Outcomes**

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	-	-	-	M	L	-	-	-	L	M	M
CO2	S	S	M	-	-	-	-	-	-	-	-	L	S	M
CO3	S	S	M	-	-	-	-	-	-	-	-	L	M	M
CO4	S	S	M	-	-	-	-	-	-	-	-	L	S	M
CO5	S	S	M	-	-	-	-	-	-	M	-	S	S	S
CO6	S	S	M	-	-	-	-	-	-	M	-	S	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests		Assignment		Terminal Examination
	1	2	1	2	
Remember	20	20	-	-	20
Understand	60	40	-	-	40
Apply	20	40	100	100	40
Analyze	-	-	-	-	-
Evaluate	-	-	-	-	-
Create	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	Simulation using software
Set	-
Guided Response	Assignments
Mechanism	Mini projects, flipped classroom, Quiz, Active Learning Techniques.
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1 (CO1):**

1. Write the components of Industry 4.0.
2. Differentiate conventional and Industry 4.0 Automation.
3. Explain the developments of Industry 4.0 in different countries.
4. Brief the drivers and challenges of Industry 4.0.

**Course Outcome 2 (CO2):**

1. Differentiate IOT, IIOT and IOS.
2. Discuss in detail the application of AI and ML in manufacturing data analysis.
3. Define the term Digital Twin.

**Course Outcome 3 (CO3):**

1. Write the core elements of CPS.
2. Explain the use of cloud computing in industrial applications with an example.
3. Design a model integrated CPS system for an industry 4.0 connected factory.

**Course Outcome 4 (CO4):**

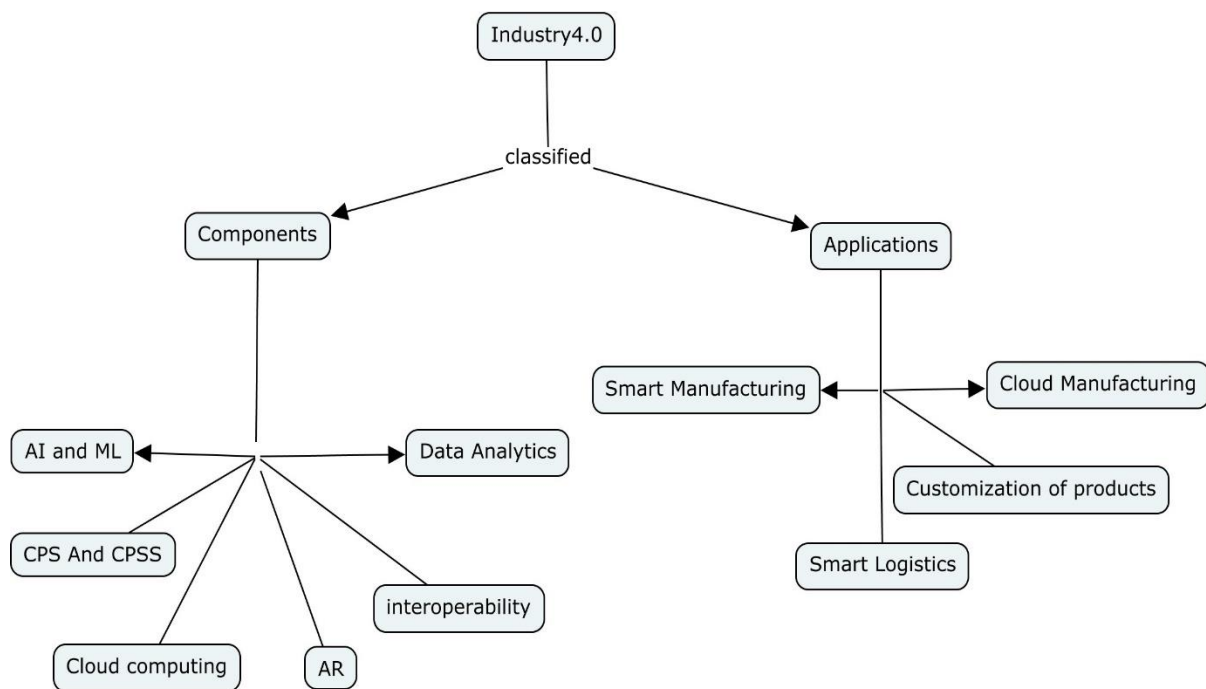
1. Discuss the components of industry 4.0 reference architecture model.
2. Explain how data can be collected and analysed using OPC/UA.
3. Explain the advantages and applications of TSN networks

**Course Outcome 5(CO5):**

1. Design an AR based operation manual for washing machine operation.
2. Design an AR based maintenance manual for testing the CNC machine.
3. Write the application of AR in production systems

**Course Outcome 6(CO6):**

1. Design a cloud-based ERP solution for a automobile sector
2. Explain the communication of workpiece with the environment using QR code and RFID.
3. Design an automated MES for a mobile phone manufacturing factory

**Concept Map****Syllabus****Introduction to Industry 4.0**

The different Industrial revolutions-definition of Industry 4.0-comparison of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0-Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy- Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.

**Basic principles and components of Industry 4.0**

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services (IOS)- Big Data- Cyber-Physical Systems- Smart Manufacturing- Smart Logistics- Customization of products- Digital Twins- Cloud applications in manufacturing.

**Cyber physical systems (CPS)**

Core elements of CPS -control theory and real time requirements-self organization principles-communication in cyber physical systems-Modelling, programming and model-integrated development of CPS- AI and ML based analytics.

**Interoperability: Communication standards for Industry 4.0**

Industrial communication Networks - IEEE 802.3 standards - Reference Architecture Model Industry 4.0 (RAMI4.0) - Basics on Service oriented Architecture- Introduction into Open



platform communications (OPC) - Classic OPC vs. OPC- Unified Architecture (UA) - OPC Services- System Architecture- OPC- UA and the Cloud-Time Sensitive Networking (TSN)-architecture-Standards-Benefits of adopting TSN.

Case study on OPC-UA applications

### Connected Factory

Virtualization-Augmented Reality (AR) in Manufacturing-integrating design and manufacturing-Data Visualization-Work piece traceability using QR codes, RFID and beacon tags - Big data in production- Cloud-based Enterprise resource planning (ERP) and Manufacturing Execution system (MES) solutions.

### Learning Resources

1. Introduction to industrial internet of things and industry 4.0 by Sudip Misra, Chandana Roy and Anandarup Mukherjee, CRC Press,2020.
2. "Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2016.
3. "Industrial Internet of Things: Cyber manufacturing Systems "by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer),2017
4. Hands-on Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0, Giacomo veneri, Antonio capasso, Packt,2018.
5. Hand book of Industry 4.0 and SMART Systems, Diego Galar Pascual, Pasquale Daponte, Uday Kumar, CRC Press, 2019.
6. <https://nptel.ac.in/courses/106105195>

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	<b>Introduction to Industry 4.0</b>		
1.1	The different Industrial revolutions-definition of Industry 4.0	1	CO1
1.2	comparison of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0	1	CO1
1.3	Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy	1	CO1
1.4	Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.	1	CO1
2.	<b>Basic principles and components of Industry 4.0</b>		
2.1	Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services	1	CO2
2.2	Big Data- Cyber-Physical Systems-	1	CO2
2.3	Smart Manufacturing- Smart Logistics	1	CO2
2.4	Customization of products- Digital Twins	1	CO2
2.5	Cloud applications in manufacturing	1	CO2
3.	<b>Cyber physical systems (CPS)</b>		
3.1	Core elements of CPS	1	CO3
3.2	Control theory and real time requirements	1	CO3
3.3	Self-organization principles-communication in cyber physical systems	1	CO3
3.4	Modelling, programming and model-integrated development of CPS	1	CO3

Module No.	Topic	No. of Hours	Course Outcome
3.5	AI and ML based analytics	2	CO3
4.	<b>Interoperability: Communication standards for Industry 4.0</b>		
4.1	Industrial communication Networks - IEEE 802.3 standards	2	CO4
4.2	Industry 4.0 Reference Architecture Model RAMI4.0	1	CO4
4.3	Basics on Service oriented Architecture	1	CO4
4.4	Introduction into OPC- Classic OPC vs. OPC-UA- OPC Services- System Architecture	2	CO4
4.5	OPC-UA and the Cloud	1	CO4
4.6	Time Sensitive Networking (TSN)-architecture- Standards-Benefits of adopting TSN	1	CO4
4.7	Case study on OPC-UA applications.	2	CO4
5.	<b>Connected factory</b>		
5.1	Virtualization-AR in Manufacturing	2	CO5
5.2	Integrating design and manufacturing	2	CO5
5.3	Data visualization	2	CO5
5.4	Work piece traceability using QR codes, RFID and beacon tags	2	CO5
5.5	Big data in production	1	CO6
5.6	Cloud-based ERP and MES solutions	2	CO6
<b>Total</b>		<b>36</b>	

**Course Designers:**

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18MTRF0/ 21MTRF0	SEMICONDUCTOR MANUFACTURING	Category	L	T	P	Credit(s)
		PE	3	0	0	3

### Preamble

Semiconductor technology is the engine room of the New Economy. For 45 years there was a continuous improvement in IC functional capability with smaller size, increased reliability and lower cost. Silicon integrated circuit fabrication technology requires many diverse fields of science and engineering. This course will teach the key fabrication technologies and the scientific foundations that carries fabrication of Transistors, ICs, Facilities required for Semiconductor Manufacturing, and microelectronics well into MEMS technology

### Prerequisite

- Nil

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage * in %
CO1	Explain the processing methods of electronic materials	10
CO2	Describe the formation and function of resistors, capacitors and diodes	10
CO3	Select appropriate processes to fabricate transistors	20
CO4	Illustrate the fabrication of ICs for devices like solar Cells, LEDs, Flat Panel Displays	20
CO5	Prepare specification for clean rooms suitable for the given electronic device.	20
CO6	Select appropriate process between bulk (Wet and Dry Etching) and surface micromachining for MEMS fabrication.	20

\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO2	TPS2	Understand	Respond	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO3	TPS3	Apply	Value	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO4	TPS3	Apply	Value	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO5	TPS3	Apply	Value	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3
CO6	TPS3	Apply	Value	---	1.1.1,1.1.2,2.1.1,2.1.2,2.3.1,2.3.2,2.3.3, 4.3.2, 4.3.3

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-
CO3	S	S	M	L	-	-	L	-	-	-	-	L	L	L
CO4	S	S	M	L	-	L	-	-	-	-	-	L	M	M
CO5	S	S	M	L	-	L	L	-	-	-	-	L	M	M
CO6	S	S	M	L	-	L	L	-	-	-	-	L	L	L

S – Strong

M – Medium

L – Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests		Assignment		Terminal Examination
	1	2	1	2	
Remember	20	20	-	-	20
Understand	30	30	-	-	30
Apply	50	50	100	100	50
Analyse	-	-	-	-	-
Evaluate	-	-	-	-	-
Create	-	-	-	-	-

### Assessment Pattern: Psychomotor

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Assignment
Mechanism	Mini project
Complex Overt Responses	-
Adaptation	-
Origination	-

### Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

1. Define Lithography.
2. Explain the wet etching and dry etching process in detail.
3. Explain the doping process in semiconductors.

#### Course Outcome 2 (CO2):

1. Explain the operations and formation of resistors in detail.
2. Define EPI resistor.
3. Explain the process in fabrication of oxide silicon capacitor.
4. Explain the function of Schottky barrier diode.

#### Course Outcome 3 (CO3):

1. Explain the fabrication of FET in detail.
2. Prepare a fabrication process for MOSFET.
3. Prepare fabrication process for MESFET.

#### Course Outcome 4 (CO4):

1. Prepare fabrication process for ICs used in LEDs.

2. Define LOCOS
3. Illustrate the fabrication of ICs for solar cells.
4. Explain the challenges in IC manufacturing in detail.

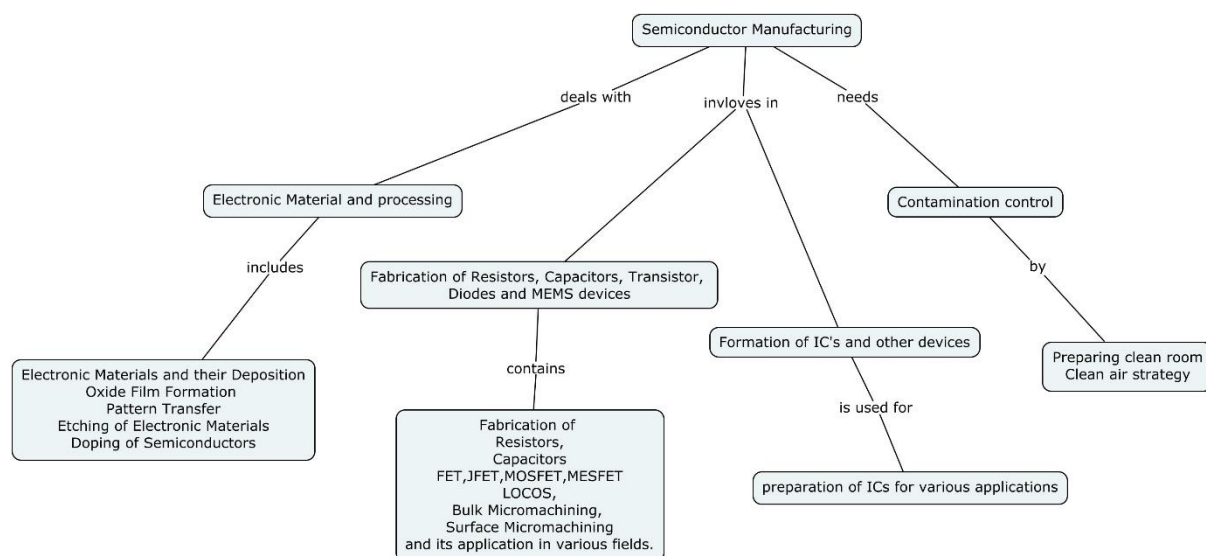
#### Course Outcome 5 (CO5):

1. Prepare a specification for constructing a clean room in semiconductor industry.
2. Explain the need for clean air strategy.
3. Define the purpose of clean room construction

#### Course Outcome 6 (CO6):

1. Define bulk micromachining.
2. Explain the surface micromachining process in detail
3. Select a suitable micromachining process for a cantilever.

### Concept Map



### Syllabus

#### Electronic Materials and Processing

Introduction, Electronic Materials and their Deposition, Oxide Film Formation by Thermal Oxidation, Deposition of Silicon Dioxide and Silicon Nitride, Polysilicon Film Deposition, Pattern Transfer: The Lithographic Process, Mask Formation, Resist, Lift-off Technique, Etching Electronic Materials: Wet Chemical Etching, Dry Etching, Doping Semiconductors: Diffusion, Ion Implantation

**Operation and Formation of resistors, capacitors and diodes:** Resistors: doped resistor, EPI resistor, pinched resistor, thin film resistor Capacitors: oxide silicon capacitor, junction capacitor, trench capacitor, stacked capacitor Diodes: doped diodes, Schottky barrier diodes

**Fabrication of Transistors:** Operational analogy, bipolar transistor, Schottky barrier bipolar transistor Field Effect Transistors (FET): metal gate MOSFET, silicon gate MOS, polycide gate MOS, Salicide gate MOS, diffused MOS, memory MOS, Junction Field Effect transistors (JFET), Metal Semiconductor Field Effect Transistors (MESFET)

**Formation of Integrated Circuit and other devices:** bipolar circuit formation: junction isolation, dielectric isolation, localized oxidation of silicon (LOCOS), collector contact MOS

integrated circuit formation: MOS LOCOS isolation, trench isolation CMOS, Bi-MOS, Silicon on Insulator, strain gages, batteries, LEDs, optoelectronics, solar cells, temperature sensors, acoustic wave devices, micro machines, flat panel displays

IC Manufacturing: Electrical Testing, Yield, Future trends and Challenges: Challenges for integration, system on chip.

**Contamination control:** Introduction, types of contaminants, contamination caused problems, contamination sources, clean air strategies: clean workstations, Tunnel design, Total cleanroom Mini-environments, clean room construction and maintenance

**MEMS fabrication:** Introduction to bulk micromachining and surface micromachining, fabrication micro cantilever by bulk micromachining and surface micromachining, comparison between bulk and surface micromachining

### Text Book(s)

1. Parasuraman Swaminathan, Semiconductor Materials, devices and Fabrication, 1<sup>st</sup> edition, Wiley, 2019
2. Peter Van Zant, Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6<sup>th</sup> edition, McGrawHill, 2013

### Learning Resources

1. Simon M. Sze, Gary S May, Fundamentals of semiconductor fabrication, Wiley student edition, 2012
2. James D Plummer, Michael D Deal, Peter B Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling, 1<sup>st</sup> edition, Pearson India, 2009
3. Vijay K Varadhan, K.J. Vinoy, S.Gopalakrishnan, Smart Material Systems and MEMS – Design and Development Methodologies, 1<sup>st</sup> edition, John Wiley and Sons, 2006
4. Julian W Gardner, Vijay K Varadhan, Osama O Awadelkarim, Microsensors, MEMS and Smart Devices, 1<sup>st</sup> edition, John Wiley & sons Ltd, 2001
5. Simon. M. Sze, Yiming Li, Kwok K. Ng, Physics of Semiconductor Devices, 4th Edition., Wiley India, 2021.

### Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
<b>1</b>	<b>Electronic Materials and Processing</b>	
1.1	Introduction, Electronic Materials and their Deposition, Oxide Film Formation by Thermal Oxidation	1
1.2	Deposition of Silicon Dioxide and Silicon Nitride, Polysilicon Film Deposition	1
1.3	Pattern Transfer: The Lithographic Process, Mask Formation, Resist, Lift-off Technique	1
1.4	Etching Electronic Materials: Wet Chemical Etching, Dry Etching	1
1.5	Doping Semiconductors: Diffusion, Ion Implantation	1
<b>2</b>	<b>Operation and Formation of resistors, capacitors and diodes:</b>	
2.1	Resistors: doped resistor, EPI resistor, pinched resistor	1
2.2	Thin film resistor Capacitors: oxide silicon capacitor, junction capacitor, trench capacitor	2
2.3	stacked capacitor Diodes: doped diodes, Schottky barrier diodes	1

Module No.	Topic	No. of Periods
<b>3</b>	<b>Fabrication of Transistors:</b>	
3.1	Operational analogy, bipolar transistor, Schottky barrier bipolar transistor	1
3.2	Field Effect Transistors (FET): metal gate MOSFET, silicon gate MOS, polycide gate MOS, Salicide gate MOS, diffused MOS, memory MOS	2
3.3	Junction Field Effect transistors (JFET)	1
3.4	Metal Semiconductor Field Effect Transistors (MESFET)	1
<b>4</b>	<b>Formation of Integrated Circuit and other devices:</b>	
4.1	Bipolar circuit formation: junction isolation, dielectric isolation, localized oxidation of silicon (LOCOS),	1
4.2	Collector contact MOS integrated circuit formation: MOS LOCOS isolation, trench isolation CMOS,	2
4.3	Bi-MOS, Silicon On Insulator, strain gages, batteries, LEDs, optoelectronics, solar cells, temperature sensors, acoustic wave devices, micro machines, flat panel displays	3
4.4	IC Manufacturing: Electrical Testing, Yield	2
4.5	Future trends and Challenges: Challenges for integration, system on chip.	2
<b>5</b>	<b>Contamination control</b>	
5.1	Introduction, types of contaminants	1
5.2	Contamination caused problems, contamination sources	1
5.3	Clean air strategies: clean workstations, Tunnel design	2
5.4	Total cleanroom Mini-environments, clean room construction and maintenance	2
<b>6</b>	<b>MEMS fabrication</b>	
6.1	Introduction to bulk micromachining and surface micromachining	2
6.2	Fabrication micro cantilever by bulk micromachining and surface micromachining	2
6.3	Comparison between bulk and surface micromachining.	2
	<b>Total</b>	<b>36</b>

**Course Designers:**

Sl. No.	Name	E-mail Id
1	Dr. G. Kumaraguruparan	gkgmech@tce.edu
2	Mr. M.M. Devarajan	mmdmech@tce.edu

18MTRG0/ 21MTRG0	OOP AND DATA STRUCTURES USING C++	Category	L	T	P	Credit(s)
		PE	2	0	2	3

### Preamble

Object-Oriented Programming (OOP) have proved to be effective solutions in handling the inherent complexity of software design, development, testing and maintenance. Instead of viewing a program as a series of steps to be carried out, it views it as a group of objects that have certain properties and can take certain actions. Many object-oriented languages have become available and have been widely adopted like Java, C++, Python, VB / VB.NET, C#, Perl, Ruby – to name a few. For an Engineer, solving any real time problem is not just about designing an algorithm and solving it, but also the ability to select appropriate data structures to solve the problem efficiently.

This course introduces the concept of OOP using C++ along with ability to manipulate data using data structures.

### Prerequisite

- 18MT350 - Programming for Problem Solving
- 18MT360 - Programming and Coding Laboratory

### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage * in %
CO1	Explain the various programming concepts of C++ language	10
CO2	Develop a C++ program for solving engineering problems	15
CO3	Explain the various concepts in Object-Oriented Programming	25
CO4	Apply the concept Object-Oriented Programming and develop program in C++ for solving engineering problems	25
CO5	Analyze and debug the developed C++ program	15
CO6	Implement linear and nonlinear data structures such as stack, queue, linked lists, trees for a given application	10

\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	---	1.3, 2.1.5, 3.2.3
CO2	TPS3	Apply	Value	---	1.3, 2.1.5, 3.2.3, 4.4.5
CO3	TPS2	Understand	Respond	---	1.3, 2.1.5, 3.2.3
CO4	TPS3	Apply	Value	---	1.3, 2.1.5, 3.2.3, 4.4.5
CO5	TPS3	Apply	Value	---	1.3, 2.1.5, 3.2.3, 4.4.5
CO6	TPS3	Apply	Value	---	1.3, 2.1.5, 3.2.3, 4.4.5

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	M
CO2	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	M
CO4	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO5	S	M	L	-	S	-	-	-	S	M	-	-	M	S
CO6	S	M	L	-	S	-	-	-	S	M	-	-	M	S

S – Strong                      M – Medium                      L – Low



**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Test (CAT)	Terminal Examination (Practical)
Remember	-	-
Understand	-	-
Apply	100*	100
Analyse	-	-
Evaluate	-	-
Create	-	-

\* - Details are as follows

Sl. No.	Continuous Assessment Test	Marks
1	Laboratory Experiments	20
2	CAT 1 – Theory Examination	30
3	CAT 2 – Model Laboratory Examination - Practical	50
	<b>Total</b>	<b>100</b>

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Syllabus**

**Introduction to Object Oriented Programming (OOP):** Procedural Languages - The Object-Oriented approach - Characteristics of Object-Oriented Languages – Objects - Classes - Inheritance – Reusability – Creating New Data Types - Polymorphism and Overloading

**C++ Programming Basics:** C++ programming basics – Pre-processor Directives – Header Files – Namespace – Manipulators – Loops – Structures – Functions – Inline Functions - Arrays – Strings – Pointers

**C++ OOP:** Objects and Classes - C++ Objects as Physical Objects - Objects as Data Types - Constructors - Destructors - Structures and Classes

Overloading: Operator Overloading - Overloaded Functions - Overloading Unary & binary operators - Data Conversion

Inheritance: Derived Class and Base Class - Class Hierarchies - Public and Private Inheritance - Levels of Inheritance - Multiple Inheritance - Classes within Classes Inheritance – UML Diagram

Memory Management – new, delete operators – Virtual Functions – Friend Functions – Static Functions – Function Templates - Exceptions

**Data Structures:** Linear Data structures - Stacks - Queues - Linked Lists; Non-Linear Data structures - Trees - Applications

**Learning Resources**

1. E. Balagurusamy, **Object-Oriented Programming with C++**, 8<sup>th</sup> edition, Mc Graw Hill, 2020
2. Mark Allen Weiss, **Data Structures and Algorithm Analysis in C++**, 4th edition, Pearson Education, 2014
3. Robert Lafore, **Object-Oriented Programming in C++**, Pearson Education, 2002
4. Programming in C++ in Swayam:  
[https://swayam.gov.in/nd1\\_noc20\\_cs07/preview](https://swayam.gov.in/nd1_noc20_cs07/preview)
5. C++ Programming in Tutorials Point:  
<https://www.tutorialspoint.com/cplusplus/index.htm>

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours		Course Outcome
		Theory	Practical	
1	<b>Introduction to Object Oriented Programming (OOP)</b>	2	-	CO1, CO3
2	<b>C++ Programming Basics:</b>	-	-	-
2.1	C++ programming basics – Pre-processor Directives – Header Files – Namespace – Manipulators	2	-	CO1
2.2	Loops – Structures – Functions – Inline Functions - Arrays – Strings – Pointers	2	-	CO1
2.3	Programs to apply the concept of C++ to solve engineering problems	-	4	CO2, CO5
3	<b>C++ OOP</b>	-	-	-
3.1	Objects and Classes - C++ Objects as Physical Objects - Objects as Data Types - Constructors - Destructors - Structures and Classes	3	-	CO3
3.2	Overloading	3	-	CO3
3.3	Inheritance	2	-	CO3
3.4	Memory Management – new, delete operators – Virtual Functions – Friend Functions – Static Functions –	2	-	CO1, CO3
3.5	Function Templates - Exceptions	2	-	CO1, CO3
3.6	C++ Programs using the various concepts of OOP to solve engineering problems	-	12	CO4, CO5
4	<b>Data Structures</b>	-	-	-
4.1	Linear Data structures - Stacks - Queues - Linked Lists	3	-	CO6
4.2	Non-Linear Data structures - Trees	3	-	CO6
4.3	C++ Programs to implement Linear and nonlinear data structures	-	8	CO6
<b>Total</b>		<b>24</b>	<b>24</b>	

**Course Designers:**

Sl. No.	Name	E-mail Id
1	Mr. Sheik Masthan S.A.R	sarsmech@tce.edu

18MTRH0/  
21MTRH0**DESIGN AND ANALYSIS OF  
EXPERIMENTS**Category L T P Credit(s)  
PE 3 0 0 3**Preamble**

This course is an introduction to the statistical design of experiments and the role of random effects in data analysis. This course is created to provide an understanding of how experiments should be designed so that when the data are collected that can be used in a variety of experimental situations. A strategically planned and Structured experiment may provide a great deal of information about the effect on a response variable due to one or more factors.

**Prerequisite**

- NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the concept of variability and Different types of experimental designs	15
CO2	Interpret ANOVA results and identify significant factors that influence the experiments	15
CO3	Design the full factorial and fractional factorial experiments and determine how to assign the experimental units and levels of factors	20
CO4	Apply experimental techniques to practical problems to improve quality of processes / products by optimizing the process / product parameters.	20
CO5	Introduce Taguchi methods, and compare and contrast them with traditional techniques.	15
CO6	Use the statistical packages	15

\*\*\* Weightage depends on number of contact hours

**CO Mapping with CDIO Curriculum Framework**

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO2	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO3	TPS2	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO4	TPS3	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO5	TPS4	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2
CO6	TPS6	Apply	Value	-	1.1,1.2,1.3,2.1.4,2.1.5, 4.3.1,4.3.2

**Mapping with Programme Outcomes and Programme Specific Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	L	-	-	-	-	-	-	M	M	M
CO2	S	M	L	-	S	-	-	-	-	-	-	M	S	S
CO3	S	M	L	-	L	-	-	-	-	-	-	M	S	S
CO4	S	M	L	-	S	-	-	-	-	-	-	M	S	S
CO5	S	S	M	L	S	-	-	-	S	S	L	S	S	S
CO6	S	S	S	S	S	-	-	-	S	S	L	S	S	S

S – Strong

M – Medium

L – Low

**Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests		Assignment		Terminal Examination
	1	2	1	2	
Remember	20	20	-	-	20
Understand	20	40	100	-	40
Apply	60	40	-	100	40
Analyse	-	-	-	-	-
Evaluate	-	-	-	-	-
Create	-	-	-	-	-

**Assessment Pattern: Psychomotor**

Psychomotor Skill	Mini-project / Assignment / Practical Component
Perception	-
Set	-
Guided Response	Case study presentation
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

**Sample Questions for Course Outcome Assessment****Course Outcome 1(CO1):**

- Brief: Repetition in experimental design
- Brief: Blocking in experimental design
- What is the advantage of doing replication in experiments?

**Course Outcome 2(CO2):**

- The lifetime of LED bulb is being studied. Four different brands are being investigated. The following data have been collected.

Brands	Life time in days			
<b>A</b>	20.5	17.7	20.0	19.2
<b>B</b>	24.0	26.2	21.2	26.1
<b>C</b>	27.4	35.2	31.2	28.2
<b>D</b>	17.1	18.1	18.5	16.7

Test the hypothesis that which brand affect the life time of LED. Use  $\alpha = 0.5$

2. The delivery of a pump is being studied. Four different types are being investigated. The following data (unbalanced) have been collected.

Types	Delivery in liters /min			
	A	--	17.7	14.7
B	14.0	16.2	--	13.3
C	12.6	--	13.2	12.2
D	17.1	12.8	11.8	--

Interpret the data from this experiment (use  $\alpha=0.05$ ) and draw conclusions.

**Course Outcome 3(CO3):**

1. An automobile engineer is trying to improve the life of a braking pad. He has run a  $2^3$  experiment using wheel speed (A), shoe hardness (B) and friction (C) as the factors. The data from two replicates are shown here.

Run	Replicate	
	I	II
(1)	423	468
A	341	378
B	331	315
AB	205	223
C	486	478
AC	360	341
BC	241	260
ABC	492	392

- I. Do any of the factors affect Brake shoe life
  - II. What combination of factor levels produces the longest tool life?
- Is there a combination of wheel speed and friction that always gives good results regardless of shore hardness?
2. A  $2^3$  has been used to investigate the effect of four acids on several cement properties. The data from this experiment are shown here.

Run	A	B	C	D	Adhesive
1	-	-	-	-	2.001
2	+	-	-	+	2.062
3	-	+	-	+	2.019
4	+	+	-	-	2.059
5	-	-	+	+	1.990
6	+	-	+	-	2.076
7	-	+	+	-	2.038
8	+	+	+	+	2.118

- I. Estimate the factor effects. Plot the effect estimates on a normal probability scale.
  - II. Plot the residuals from the model Vs the predicted adhesive.
- Is there any indication on this plot of model adequacy?

**Course Outcome 4 (CO4):**

1. An experiment was conducted to determine the effects of three factors on warpage in an injection moulding process. The three factors of interests (each at two levels) are A= melt temperature, B= Injection speed and C= Injection process. A complete  $2^3$  factorial design was carried out with replication. Two replicates are provided in the table below. Analyse the data using Yate's algorithm from this experiment.

A	B	C	I	II
-1	-1	-1	1.35	1.40
1	-1	-1	2.15	2.20
-1	1	-1	1.50	1.50
1	1	-1	1.10	1.20
-1	-1	1	0.70	0.70
1	-1	1	1.40	1.35
-1	1	1	1.20	1.35
1	1	1	1.10	1.00

2. An experiment was run using two factors. Gas flow rate (A) and Power applied (B). Four replicates were run and the epitaxial layer thickness was measured in (microns). The data are shown below.

A	B	Replicate			
		I	II	III	IV
-	-	550	669	604	650
+	+	633	642	601	635
-	+	1037	749	1052	868
+	+	1075	860	1063	729

Analyse this experiment assuming that each one of the four replicates represents a block. Conduct an ANOVA to confirm your findings,

**Course Outcome 5 (CO5)**

1. A two-wheeler Magneto Rheological shock absorber property were experimented by using orthogonal array. There are 7 velocities and the 2 states of magnetic field are represented in the following manner by alphabets and numbers respectively:  
 1: OFF State 2: ON State  
 A- 0.05 m/s B- 0.10 m/s C- 0.26 m/s D- 0.30 m/s E- 0.40 m/s F- 0.52 m/s

This array is represented in the table given below:

Trial	A	B	C	D	E	F	$y_1$	$y_2$
1	1	1	1	1	1	1	32.63	7.30
2	1	1	1	2	2	2	32.99	9.09
3	1	2	2	1	1	2	32.60	9.18
4	1	2	2	2	2	1	34.46	9.38
5	2	1	2	1	2	1	32.78	9.36
6	2	1	2	2	1	2	34.36	9.38
7	2	2	1	1	2	2	33.21	9.56
8	2	2	1	2	1	1	33.66	9.56

**L8 Orthogonal Array**

Where

$y_1$  = Sum of Rebound forces in each Trial (kgf)

$y_2$  = Sum of Active forces in each trial (Kgf)

Analyse and draw appropriate conclusions and find the overall effect by using L8 Orthogonal array.

**Course Outcome 6(CO6):**

1. Objective: To design and analyse a fractional factorial experiment using Minitab [Taguchi Design]

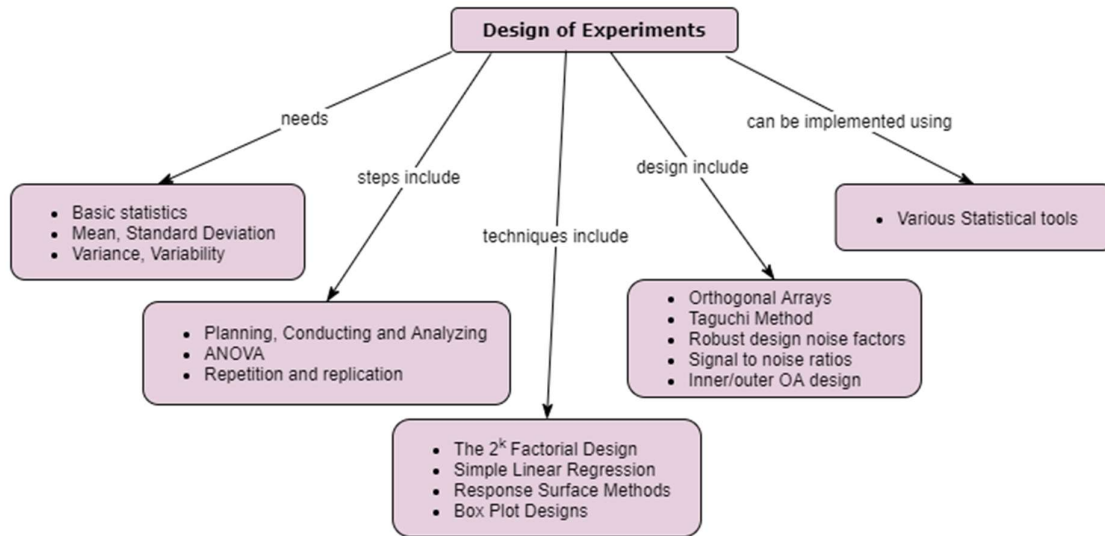
Output Variable: % Reacted

Inputs:

- Feed Rate (liters/minute)[A]            10, 15
- Catalyst (%)                                [B]            1,2
- Agitation Rate (rpm) [C]                100, 120
- Temperature (C)                        [D]            140,180
- Concentration (%)                      [E]            3, 6

Use Minitab to setup the Design Matrix

**Concept Map**



**Syllabus**

Basic statistics - Mean - Standard Deviation - variance Variability – causes – Errors

Introduction to experimental design - Basic techniques - Standard types of experimental design. Steps for Planning, Conducting and Analyzing an experiment – ANOVA - attribute data analysis - Repetition and replication.

Introduction to Factorial Design - The 2<sup>k</sup> Factorial Design - Confounding and Aliasing in 2<sup>k</sup> Factorial Design 3-level and Mixed-level full Factorials and Fractional Factorials- Simple Linear Regression - Response Surface Methods and Designs - Robust Parameter Designs - Experiments with Random Factors - Box Plot Designs.

Main and Interaction effects - Fixed effects and random effects model - Design of experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Taguchi Method, Robust design noise factors, Signal to noise ratios, Inner/outer OA design – Uses of statistical packages

**Learning Resources**

1. Douglas C Montgomery (2019), **Design and Analysis of Experiments**, 10<sup>th</sup> edition, John Wiley & Sons
2. Colin Hardwick (2019), **Practical Design of Experiments - Doe Made Easy**, Lulu.com
3. Angela Dean, Daniel Voss, Danel Draguljic (2017), **Design and Analysis of Experiments**, Second Edition, Springer Texts in Statistics, Springer.
4. John Lawson (2015), **Design and Analysis of Experiments with R, Texts in Statistical Science**, Chapman & Hall / CRC.
5. Roger Mead, S. G. Gilmour, A. Mead (2012), **Statistical Principles for the Design of Experiments**, Cambridge Series in Statistical and Probabilistic Mathematics, Cambridge University Press.
6. Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook (2009), **Response Surface Methodology**, Third Edition, John Wiley & Sons

**Course Contents and Lecture Schedule**

Module No.	Topic	No. of Hours	Course Outcome
1.	Basic statistics-Mean-Standard Deviation-variance Variability	1	CO1
2.	Causes – Errors	1	CO1
3.	Introduction to experimental design - Basic techniques	2	CO1
4.	Standard types of experimental design	1	CO1
5.	Steps for Planning, Conducting and Analyzing an experiment	2	CO2
6.	ANOVA	2	CO2
7.	attribute data analysis	1	CO2
8.	Introduction to Factorial Design	1	CO3
9.	The 2k Factorial Design	1	CO3
10.	Confounding and Aliasing in 2k Factorial Design 3-level and Mixed-level Factorials	2	CO3
11.	Fractional Factorials	1	CO3
12.	Simple Linear Regression	1	CO3
13.	Response Surface Methods	1	CO4
14.	Robust Parameter Designs	1	CO4
15.	Experiments with Random Factors-Nested and Split Plot Designs	2	CO4
16.	Main and Interaction effects	1	CO5
17.	Fixed effects and random effects model	1	CO5
18.	Design of experiments using Orthogonal Arrays,	1	CO5
19.	Data analysis from Orthogonal experiments	1	CO5
20.	Taguchi Method	2	CO5
21.	Robust design noise factors	1	CO6
22.	Signal to noise ratios	1	CO6
23.	Inner/outer OA design.	1	CO6
24.	Uses of statistical packages	1	CO6
<b>TOTAL</b>		<b>30</b>	

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