CURRICULUM AND SYLLABI

For

M.E. Mechatronics Program

First to 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

Approved in 56th Academic Council Meeting on 21.07.2018

Approved in 57th Academic Council Meeting on 05.01.2019

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 fulfill 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 Outcomes (POs) of M.E. (Mechatronics)

PO1	**Scholarship of Knowledge**	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	**Critical Thinking**	Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
PO3	**Problem Solving**	Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

PO4	**Research Skill**	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering
PO5	**Usage of modern tools**	Create, select, learn 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.
PO6	**Collaborative and Multidisciplinary work**	Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	**Project Management and Finance**	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.
PO8	**Communication**	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	**Life-long Learning**	Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	**Ethical Practices and Social Responsibility**	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	**Independent and Reflective Learning**	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

M.E. DEGREE (Mechatronics) PROGRAMME

Scheduling of Courses

(Students admitted from the academic year 2018 – 2019 onwards)

	Theory						Theory cum Practical	Laboratory	Project	Total Credits
I	18MC110 Linear Algebra 3	18MC120 Sensors and Actuators 3	18MC130 Digital Control System 3	18MCPX0 Program Elective I 3	---	---	18MC160 Embedded Systems 3	18MC170 Automation and Control Laboratory 2	---	17
II	18MC210 Robotics Concepts and Analysis 3	18MCPX0 Program Elective II 3	18MCPX0 Program Elective III 3	18MCPX0 Program Elective IV 3	18MCPX0 Program Elective V 3	18PG250 Research Methodology and IPR 2	---	18MC270 Sensors and Robotics Laboratory 2	18MC280 Mini Project 2	21
III	---	---	---	---	---	18YYGX0 Open Elective 2	18MC360 Mechatronics System Design 3	---	18MC380 Dissertation Phase I 10	15
IV	---	---	---	---	---	---	---	---	18MC480 Dissertation Phase II 15	15
							Total Credits			68

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Mechatronics) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2018-2019 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
18MC110	Linear Algebra	FC	3	0	0	3
18MC120	Sensors and Actuators	PC	3	0	0	3
18MC130	Digital Control System	PC	3	0	0	3
18MCPX0	Program Elective I	PE	3	0	0	3
THEORY CUM PRACTICAL						
18MC160	Embedded Systems	PC	2	0	2	3
PRACTICAL						
18MC170	Automation and Control Laboratory	PC	0	0	4	2
Total			**14**	**0**	**6**	**17**

FC : Foundation Course

PC : Program Core

PE : Program Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

FIRST SEMESTER

S.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
THEORY								
1	18MC110	Linear Algebra	3	50	50	100	25	50
2	18MC120	Sensors and Actuators	3	50	50	100	25	50
3	18MC130	Digital Control System	3	50	50	100	25	50
4	18MCPX0	Program Elective I	3	50	50	100	25	50
THEORY CUM PRACTICAL								
5	18MC160	Embedded Systems	3	50	50	100	25	50
PRACTICAL								
6	18MC170	Automation and Control 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.

M.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	
THEORY						
18MC210	Robotics Concepts and Analysis	PC	3	0	0	3
18MCPX0	Program Elective II	PE	3	0	0	3
18MCPX0	Program Elective III	PE	3	0	0	3
18MCPX0	Program Elective IV	PE	3	0	0	3
18MCPX0	Program Elective V	PE	3	0	0	3
18PG250	Research Methodology and IPR	CC	2	0	0	2
PRACTICAL						
18MC270	Sensors and Robotics Laboratory	PC	0	0	4	2
18MC280	Mini Project	MD	0	0	4	2
Total			**17**	**0**	**8**	**21**

PC : Professional Core Course

PE : Program Elective

CC : Common Core Course

MD : Mini Project & Dissertation

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.

M.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

SECOND SEMESTER

S.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
THEORY								
1	18MC210	Robotics Concepts and Analysis	3	50	50	100	25	50
2	18MCPX0	Program Elective II	3	50	50	100	25	50
3	18MCPX0	Program Elective III	3	50	50	100	25	50
4	18MCPX0	Program Elective IV	3	50	50	100	25	50
5	18MCPX0	Program Elective V	3	50	50	100	25	50
6	18PG250	Research Methodology and IPR	3	50	50	100	25	50
PRACTICAL								
7	18MC270	Sensors and Robotics Laboratory	3	50	50	100	25	50
8	18MC280	Mini Project	-	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.

M.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	
THEORY						
18YYGX0	Open Elective	OE	2	0	0	2
THEORY CUM PRACTICAL						
18MC360	Mechatronics System Design	PC	2	0	2	3
PRACTICAL						
18MC380	Dissertation Phase I	MD	0	0	20	10
Total			**4**	**0**	**22**	**15**

PE : Program Elective

OE : Open Elective

CC : Common Core Course

MD : Mini Project & Dissertation

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.

M.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

THIRD SEMESTER

S.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
THEORY								
1	18YYGX0	Open Elective	3	50	50	100	25	50
THEORY CUM PRACTICAL								
2	18MC360	Mechatronics System Design	3	50	50	100	25	50
PRACTICAL								
3	18MC380	Dissertation Phase I	-	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.

M.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	
PRACTICAL						
18MC480	Dissertation Phase II	MD	0	0	30	15
Total			**0**	**0**	**30**	**15**

PE : Program Elective

OE : Open Elective

CC : Common Core Course

MD : Mini Project & Dissertation

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.

M.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

FOURTH SEMESTER

S.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
PRACTICAL								
1	18MC480	Dissertation Phase II	-	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.

PROGRAM ELECTIVES						
Course code	Name of the Course	Category	L	T	P	Credits
18MCPA0	Principles of Mechanical Systems	PE	3	0	0	3
18MCPB0	Principles of Electronic Systems	PE	3	0	0	3
18MCPC0	Internet of Things	PE	3	0	0	3
18MCPD0	Virtual Instrumentation	PE	3	0	0	3
18MCPE0	Machine Vision Systems	PE	3	0	0	3
18MCPF0	Micro Electro Mechanical System	PE	3	0	0	3
18MCPH0	Automotive Electronics	PE	3	0	0	3
18MCPI0	Autonomous Mobile Robots	PE	3	0	0	3
18MCPJ0	Intelligent Motion Control Drives	PE	3	0	0	3
18MCPK0	Soft Computing	PE	3	0	0	3
18MCPL0	Thermal Packaging for Electronics	PE	3	0	0	3
18MCPM0	Professional Practice	PE	0	0	6	3
18MCPN0	CNC Technology	PE	3	0	0	3

OPEN ELECTIVE						
Course code	Name of the Course	Category	L	T	P	Credits
18MCGA0	Value Engineering	OE	2	0	0	2

AUDIT COURSE						
Course code	Name of the Course	Category	L	T	P	Credits
18PGAA0	Professional Authoring	AC	2	0	0	2
18PGAB0	Value Education	AC	2	0	0	2

CATEGORIZATION OF COURSES

Degree: M.E. **Program: Mechatronics**

Sl. No.	Category	Credits
A	**Foundation Courses (FC)**	**3 – 6**
B	**Professional Core Courses (PC)**	**19 – 25**
C	**Elective Courses**	**17 – 23**
	Program Elective (PE)	**15 – 21**
	Open Elective (OE)	**2 – 6**
D	**Common Core Course**	**2**
E	**Mini Project & Dissertation**	**27**
F	**Audit Courses (not included in CGPA)- Mandatory**	**4**
	Total	**68**

Foundation Courses (FC)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MC110	Linear Algebra	3	0	0	3	Nil

Professional Core Courses (PC)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
THEORY							
1	18MC120	Sensors and Actuators	3	0	0	3	Nil
2	18MC130	Digital Control System	3	0	0	3	Nil
3	18MC210	Robotics Concepts and Analysis	3	0	0	3	18MC110
THEORY CUM PRACTICAL							
4	18MC160	Embedded Systems	2	0	2	3	Nil
5	18MC360	Mechatronics System Design	2	0	2	3	18MCPA0/ 18MCPB0, 18MC120, 18MC130
PRACTICAL							
6	18MC170	Automation and Control Laboratory	0	0	4	2	Nil
7	18MC270	Sensors and Robotics Laboratory	0	0	4	2	18MC120, 18MC210

Elective Courses

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MCPA0	Principles of Mechanical Systems	3	0	0	3	Nil
2	18MCPB0	Principles of Electronic Systems	3	0	0	3	Nil
3	18MCPC0	Internet of Things	3	0	0	3	18MC120
4	18MCPD0	Virtual Instrumentation	3	0	0	3	Nil
5	18MCPE0	Machine Vision Systems	3	0	0	3	Nil
6	18MCPF0	Micro Electro Mechanical System	3	0	0	3	Nil
7	18MCPH0	Automotive Electronics	3	0	0	3	Nil

8	18MCPI0	Autonomous Mobile Robots	3	0	0	3	Nil
9	18MCPJ0	Intelligent Motion Control Drives	3	0	0	3	18MCPA0, 18MC120, 18MC170
10	18MCPK0	Soft Computing	3	0	0	3	Nil
11	18MCPL0	Thermal Packaging for Electronics	3	0	0	3	Nil
12	18MCPM0	Professional Practice	3	0	0	3	Nil
13	18MCPN0	CNC Technology	3	0	0	3	18MCPA0, 18MC120

Open Elective (OE)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MCGA0	Value Engineering	2	0	0	2	Nil

Common Core Course (CC)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18PG250	Research Methodology and IPR	2	0	0	2	Nil

Mini Project & Dissertation (MD)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18MC280	Mini Project	0	0	4	2	Nil
2	18MC380	Dissertation Phase I	0	0	20	10	Nil
3	18MC480	Dissertation Phase II	0	0	30	15	Nil

Audit Course (AC)

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credits	Prerequisite
			L	T	P		
1	18PGAA0	Professional Authoring	2	0	0	2	Nil
2	18PGAB0	Value Education	2	0	0	2	Nil

18MC110	LINEAR ALGEBRA	Category	L	T	P	Credit(s)
		FC	3	0	0	3

Preamble

Mathematicians define Linear Algebra as a branch of mathematics that deals with the study of vectors, vector spaces and linear equations. Modern mathematics also relies upon linear transformations and systems of vector matrix. A PG Mechatronics student needs some basic linear algebra to understand design methodology. It is possible to consider the analysis of rotations in space, selected curve fitting techniques, differential equation solutions, as well as many other problems in science and engineering using techniques of linear algebra. Analytic geometry utilizes the techniques learned during a study of linear algebra, for analytically computing complex geometrical shapes. The main objective of this course is to introduce the basic terminology used in Linear Algebra. Based on this, the course aims at giving adequate exposure in vector spaces, orthogonality, linear transformation, generalized eigen values and vectors, Singular value decomposition and QR algorithm.

Prerequisite

Nil

Course Outcomes

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

CO1	Verify whether the given set is a vector space or not. If So, determine its dimension.	Apply
CO2	Determine the matrix for the given linear transformation	Understand
CO3	Predict ortho normal basis	Apply
CO4	Perform diagonalization of a given matrix	Apply
CO5	Compute Pseudo inverse for the given matrix and Construct a QR decomposition for the given matrix	Apply
CO6	Solve the given system of linear differential equations	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

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

Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Let x,y,z be vectors in a vector space V. If $x+y=x+z$, then prove that y = z
2. Prove that R$\times$R is a vector space over R.
3. Estimate the row space and column space of the matrix $A=\begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\end{pmatrix}$
4. Estimate the dimension of the row space of the matrix $A=\begin{pmatrix}1 & -2 & 3\\ 2 & -5 & 1\\ 1 & -4 & -7\end{pmatrix}$
5. Compute the dimension of the subspace of R^4 spanned by

$$X_1=\begin{pmatrix}1\\2\\-1\\0\end{pmatrix}, X_2=\begin{pmatrix}2\\5\\-3\\2\end{pmatrix}, X_3=\begin{pmatrix}2\\4\\-2\\0\end{pmatrix}, X_4=\begin{pmatrix}3\\8\\-5\\4\end{pmatrix}$$

Course Outcome 2 (CO2):

1. Let L: $R^2 \to R$ be defined by $L(x_1, x_2)^T = \sqrt{{x_1}^2 + {x_2}^2}$. Determine whether L is a linear operator or not.
2. Let L: $R^3 \to R^3$ be defined by $L(x_1, x_2, x_3)^T = (x_1, x_1+x_2, x_1+x_2+x_3)^T$. Check whether L is a linear operator or not. If so, find the corresponding matrix A such that L(x) = Ax
3. Prove that Ker L is a subspace.
4. Let $L: R^3 \to R^3$ be defined by $L(x_1, x_2, x_3)^T = (2x_1 - x_2 - x_3, 2x_2 - x_1 - x_3, 2x_3 - x_1 - x_2)^T$ Discuss whether or not
L is a linear transformation. If so, find the corresponding matrix A such that L(x)=Ax
5. Let $L: R^2 \to R^2$ be defined by $L(x_1, x_2)^T = (x_1, -x_2)$. Prove that L is a linear transformation.

Course Outcome 3 (CO3):

1. Consider the vector space $C[-1, 1]$ with inner product defined by
$< f, g >= \int_{-1}^{1} f(x)g(x)dx$ Calculate orthonormal basis for subspace spanned by $\{1, x, x^2\}$
2. Show that $\left\{\frac{(1,1,1)^T}{\sqrt{3}}, \frac{(2,1,-3)^T}{\sqrt{14}}, \frac{(4,-5,1)^T}{\sqrt{42}}\right\}$ is an orthonormal set in R^3

3. Estimate the best quadratic least square fit to the data

x	0	3	6
y	1	4	5

4. Given the basis $\{(1,1,1)^T, (1,2,2)^T, (1,1,0)^T\}$ for R^3, construct an orthonormal basis for R^3.
5. Solve the following system of equations in the least –square sense:

$x_3 + 2x_4 = 1; x_1 + 2x_2 + 2x_3 + 3x_4 = 2.$

Course Outcome 4 (CO4):

1. Diagonaize the matrix $\begin{bmatrix} 2 & 2 & -2 \\ 2 & 2 & -2 \\ -2 & -2 & 6 \end{bmatrix}$
2. Identify the following matrix are in Jordan canonical form or not, where $A = \begin{bmatrix} 3 & 1 & 0 & 0 & 0 \\ 0 & 3 & 1 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 4 & 1 \\ 0 & 0 & 0 & 1 & 4 \end{bmatrix}$.
3. Compute the chain that is generated by the generalized eigen vector of rank 3 for the matrix $A = \begin{pmatrix} 7 & 1 & 2 \\ 0 & 7 & 1 \\ 0 & 0 & 7 \end{pmatrix}$
4. Diagonalise the matrix $\begin{pmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{pmatrix}$
5. Diagonalise the matrix $A = \begin{pmatrix} 3 & -1 & -2 \\ 2 & 0 & -2 \\ 2 & -1 & -1 \end{pmatrix}$

Course Outcome 5 (CO5):

1. Obtain singular value decomposition for the matrix A = $\begin{pmatrix} 1 & 1 \\ 1 & 1 \\ 0 & 0 \end{pmatrix}$ and hence find its pseudo inverse

2. Compute a singular value decomposition for the matrix $\begin{bmatrix} 2 & 2 & -2 \\ 2 & 2 & -2 \\ -2 & -2 & 6 \end{bmatrix}$

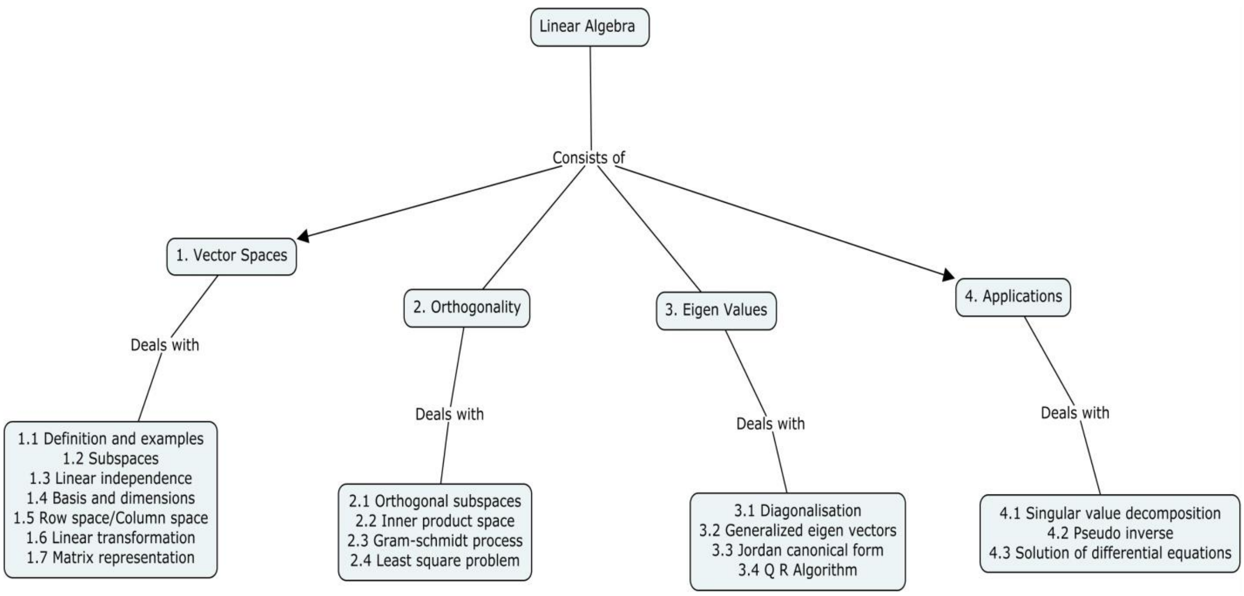
3. Obtain pseudo inverse for the matrix $\begin{pmatrix} 1 & 3 \\ 3 & 1 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$

4. Construct a QR decomposition for the matrix $\begin{bmatrix} -4 & 2 & 2 \\ 3 & -3 & 3 \\ 6 & 6 & 0 \end{bmatrix}$

Course Outcome 6 (CO6):

1. Solve the system $y_1^{\,1} = 3y_1 + 4y_2$ and $y_2^{\,1} = 3y_1 + 3y_2$
2. Solve the initial value problem $y_1^{\,1} = y_1 - 2y_2$ and $y_2^{\,1} = 2y_1 + y_2$, $y_1(0)=1$, $y_2(0) = -2$
3. Solve the system $y_1^{\,1} = -y_1 + 2y_2$ and $y_2^{\,1} = 2y_1 - y_2$

Concept Map



Syllabus

Vector space and Linear Transformations: Definition and examples, Subspaces, the null space, linear independence, basis and Dimension. Linear transformation, Matrix representation of linear transformation. **Orthogonality:** Orthogonal subspaces, Inner Product spaces, orthogonal bases and Gram Schmidt process, Least square approximations. **Advanced Matrix Theory:** Diagonalization, Generalized Eigen vectors, Jordan Canonical form, QR algorithm. **Applications:** Singular value decomposition and Pseudo inverse, Solving Differential equations, MATLAB- simple problems.

Reference Book(s)

1. Steven J. Leon, "Linear Algebra with Applications", Macmillan publishing company, New York, 1990.

2. Gilbert Strang, “Introduction to Linear Algebra”, Third edition, Wellesley, Cambridge Press,2003
3. Seymour Lipschutz , “Theory and Problems of Linear Algebra, Schaum’s Outline Series”, McGraw Hill, New York, II Edition, 1991
4. David C.Lay , Steven R.Lay and Judi J. McDonald, “Linear Algebra and its Applications” Fifth Edition, Addison-Wesley, 2015
5. Gilbert Strang, “Linear Algebra and Its Applications”, 4th Edition,Thomson Learning Inc, 2006
6. Prof. Vittal Rao, “Advanced Matrix Theory and Linear Algebra for Engineers”

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Vector Spaces and Linear Transformations**	
1.1	Vector spaces: axioms; properties examples of vector spaces	2
1.2	Sub-spaces: Null space of matrix examples	1
1.3	Linear combinations; span of a set properties; Examples, Linear independence and dependence-definition	1
1.4	Basis and dimension; properties; examples	2
1.5	The row and column space	1
1.6	Linear transformation: Image and kernel properties; Examples	2
1.7	Matrix representation of linear transformation	1
2	**Orthogonality**	
2.1	Orthogonal subspaces	1
2.2	Inner product space, normed linear space; orthogonal complements-properties	2
2.3	Orthogonal bases: Gram Schmidt orthonormalisation process	3
2.4	Least square approximations.	2
3	**Advanced Matrix Theory**	
3.1	Diagonalisation of matrices	2
3.2	Generalized Eigen vectors	2
3.3	Jordan Canonical form	2
3.4	QR algorithm.	2
4	**Applications**	
4.1	Singular value decomposition	2
4.2	Pseudo inverse	2
4.3	Solving Differential equations	2
	MATLAB (Digital image processing)	4
	TOTAL	36

Course Designers:

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18MC120 **SENSORS AND ACTUATORS**

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

Preamble

This course provides engineering students with basic understanding of two of the main components of any modern electrical or electromechanical system; sensors as inputs and actuators as outputs. The covered topics include error and uncertainty analysis, also performance specification of sensors: position, speed, stress, strain, temperature, vibration, acceleration, pressure, flow, exhaust gas sensors, engine knock sensors, torque, vision based sensors and GPS sensors. Actuators: Solenoids and relays, electric motors, DC motors, stepper motors, Hydraulic Valves, Hydraulic actuators, Pneumatic actuators. Introduction to interfacing methods: bridge circuits, A/D and D/A converters, microcontrollers. 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

CO1	Comprehend the static characteristics, standards, errors and uncertainty of measuring instruments	Understand
CO2	Explain the functions of the sensors for the following applications	Understand
CO3	Select/Design suitable signal conditioning circuits and sensors for the following applications: Force, Temperature.	Apply
CO4	Select/Design the suitable sensor for following applications: Vibration, Proximity, Photonic, Level and special sensors.	Apply
CO5	Choose appropriate actuators such as solenoids and relays, DC motors, stepper motors, hydraulic and pneumatic for the specified applications	Apply

Mapping with Program Outcomes

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

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
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define international standard for length.
2. Define ‘precision and ‘accuracy’.
3. Define Resolution.
4. A voltmeter is used to measure the electrical output signal from a pressure transducer. The nominal pressure is expected to be about 3 psi (3 lb/in.2¼0.2 bar). Estimate the design-stage uncertainty in this combination. The following information is available:
   Voltmeter Resolution: 10 mV; Accuracy: within 0.001% of reading
   Transducer Range: ±5 psi (~±0.35 bar); Sensitivity: 1 V/psi; Input power: 10 VDC ±1%; Output: ±5 V Linearity error: within 2.5 mV/psi over range; Sensitivity error: within 2 mV/psi over range Resolution: negligible

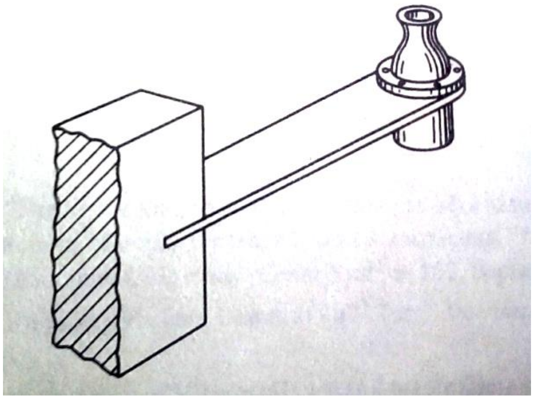
Course Outcome 2 (CO2):

1. The four arms of a wheat stone bridge are as follows: AB=100Ω, BC=1000Ω, CD=4000Ω and DA=400Ω. The galvanometer has a resistance of 100Ω, a sensitivity of 100mm/μA and is connected across AC. A source of 4 V d.c is connected across BD. Calculate the current through the galvanometer and its deflection if the resistance of arm DA is changed from 400Ω to 401Ω.
2. Explain the working of charge amplifier.
3. Brief the construction and working of instrumentation amplifier.
4. Construct 4-bit ADC and DAC

Course Outcome 3 (CO3):

1. Explain construction, working, merits and demerits of ultrasonic type flow meters.
2. A thermometer is initially at room temperature of 23 deg C. it is immersed in an oil bath at 151˚ C. After 3 seconds it shows a reading of 95 deg c. find its time constant. After what time from the start will be thermometer read 150˚ C.
3. Design a strain-gauge thrust transducer for small experimental rocket engines which are roughly in shape of a cylinder 6 inch in diameter by 12 inch long. The following information is given:

i. Weight of motor and mounting bracket, 20lbf.
ii. Maximum steady thrust, 50 lbf.
iii. Oscillating component of thrust, ± 10 lbf maximum.
iv. Oscillating components of thrust up to 100 Hz must be measured with a flat amplitude ratio within ±5 %.
v. A recorder with the sensitivity of 0.1V/in, frequency response flat to 120 Hz and input resistance of 10,000 Ω is available.
vi. Thrust changes of 0.5 lbf must be clearly detected.
vii. Gauges with a resistance of 120 Ω and gauge factor of 2.1 are available. They are 0.5×0.1 inch in size.
viii. An amplifier (to be placed between transducer and recorder) is available with a gain up to 1,000.
ix. Design the transducer as so to require a minimum of amplifier gain. If damping is employed, calculated the required damping coefficient B, but do not design the damper. Use the cantilever-beam arrangement below.



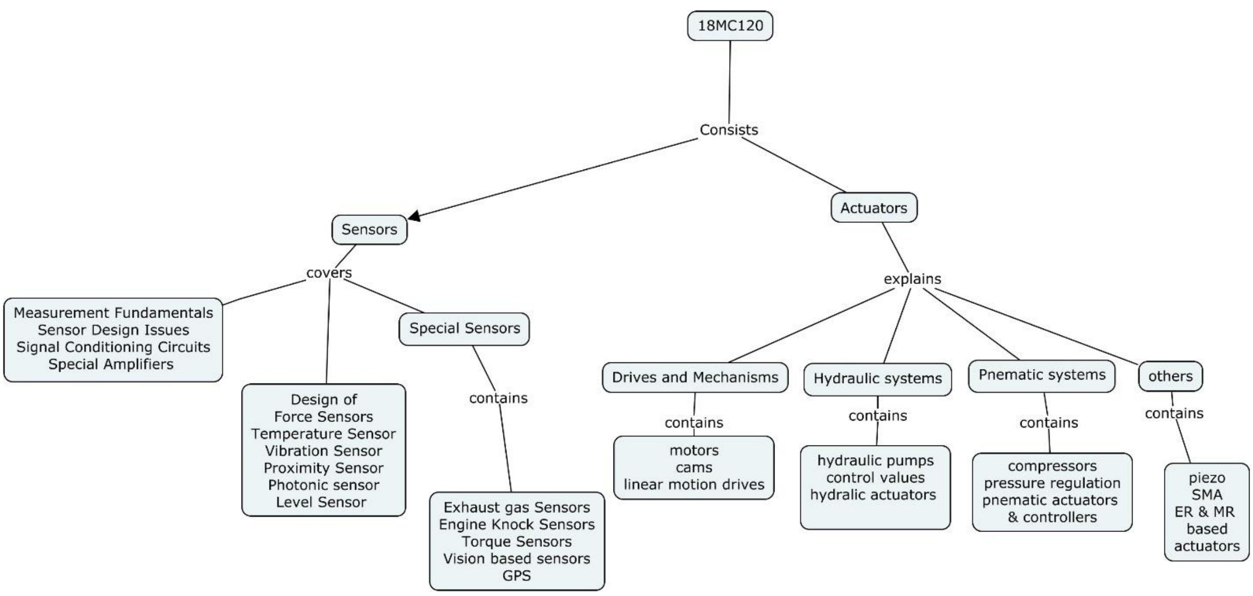
Course Outcome 4 (CO4):

1. Find the specifications for a pneumatic valve capable of handling 100 psi, and draw a schematic showing how you would interface it to a digital system.
2. If a machine requires that a 1 cm inner diameter single-acting hydraulic cylinder produce 2000 N of force, what is the minimum required system pressure in MPa?
3. For each of the following applications, what is a good choice for the type of electric motor used? Justify your choice.
   a. robot arm joint
   b. ceiling fan
   c. electric trolley
   d. circular saw

Course Outcome 5 (CO5):

1. Explain Hall Effect displacement sensor with neat diagram.
2. Discuss the semiconductor's gauge factor.
3. Explain the temperature compensation in strain gauge
4. A solenoid can be modeled as an inductor in series with a resistor. Design a circuit to use a digital output to control a 24 V solenoid.

Concept Map



Syllabus

*(*Design case studies are intended to give expertise to students about selection of sensors from available catalog and able to solve practical difficulties in interfacing)*

Measurement: System of units, conversion factors, significant figures, error analysis, probability and statics, Uncertainty analysis

Signal conditioning: resistance bridges, impedance bridges, resonant circuits, op-amps, **Special Amplifiers:** Charge amplifiers, instrumentation amplifier, shielding and grounding, filters, A/D and D/A converters, microcontroller interfacing.

Sensors: Exhaust gas sensors, engine knock sensors, torque sensor, vision based sensors, GPS.

Force and Temperature sensors design: Types of force sensors, selection of sensors, signal conditioning, interfacing circuit, Design of force sensors: Determine the stress situation near a pressure vessel nozzle, Determine power transmission through the shaft-types of temperature sensors, selection of sensors, signal conditioning, interfacing circuit, Design of temperature sensors: temperature measurement inside the boiler, design of sensor for quality automatic welding systems, room temperature measurement.

Vibration sensor design: types of vibration sensors, selection of sensors, signal conditioning, interfacing circuit, Design of vibration sensors: Building vibration measurement, beam vibration measurement, modeling of piezo electric accelerometer.

Proximity sensor design: types of proximity sensors, selection of sensors, signal conditioning, interfacing circuit, Design of proximity sensor: obstacle detection, Speed measurement of shaft.

Photonic sensor design: types of photonic sensors, selection of sensors, signal conditioning, interfacing circuit, Design of photonic sensor: optical encoder for speed measurement.

Level sensor design: types of level sensors, selection of sensors, signal conditioning, interfacing circuit, Design of level sensor: water level in boiler, storage level of solid particles.

Actuators:

Drives and Mechanisms: Electric motors, DC motors, stepper motors, cams, linear motion drives, indexing Mechanisms

Hydraulic systems: Introduction, Hydraulic pumps -types, control values, types, graphical representation of hydraulic elements, hydraulic valves, hydraulic actuators

Pneumatic systems: Introduction- compressors – types, Air treatment and pressure regulation – pneumatic actuators actuators – Pneumatic controllers

Other actuators: piezo, SMA, ER & MR based actuators.

Reference Book(s)

1. David G.Alciatore et. al.,"Introduction to Mechatronics and Measurement systems", fourth edition, McGraw-Hill, 2012.
2. Richard S.Figliola et.al.,"Theory and Design for Mechanical Measurements", Fifth edition John Wiley & Sons, Inc, 2011.
3. Walt Boyes,"Instrumentation Reference Book", Fourth Edition, Elsevier Inc., 2010.
4. John P.Bentley,"Principles of Measurement Systems", Fourth Edition, Prentice Hall, 2004.
5. Ernest O.Dobline et. al.,"Measurement systems", Sixth Edition, McGraw Hill Education, 2011.
6. Gregory K. McMillan, Douglas M.Considine, "Process/Industrial Instruments and controls Handbook", Fifth edition, McGraw Hill, 1999.
7. Sabrie Solomon, "Sensors and control systems in manufacturing", McGraw Hill international Editions, 1994.
8. Singh S.K., "Industrial Instrumentation and Control", Tata McGraw Hill Edition, 2003

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Measurement**	
1.1	System of units, conversion factors, significant figures	1
1.2	Error analysis, probability and statics	1
1.3	Uncertainty analysis	
2	Signal conditioning	
2.1	Resistance bridges, Impedance bridges	1
2.2	Resonant circuits, op-amps	1
2.3	Special Amplifiers: Charge amplifiers, instrumentation amplifier	1
2.4	Shielding and grounding	1
2.5	Filters, A/D and D/A converters, Microcontroller interfacing	1
3.	Sensors	
3.1	Selection of sensors, signal conditioning, Interfacing circuit	2
4	**Force sensors design**	
4.1	Design of force sensors: Determine the stress situation near a pressure vessel nozzle	1
4.2	Determine power transmission through the shaft	1
5	**Temperature sensor design**	
5.1	Design of temperature sensors: temperature measurement inside the boiler	2
5.2	design of sensor for quality automatic welding systems, room temperature measurement	1
6	**Vibration sensor design**	
6.1	Design of vibration sensors: Building vibration measurement	2
6.2	Beam vibration measurement	1
6.3	Modeling of piezo electric accelerometer	1
7	**Proximity sensor design**	
7.1	Design of proximity sensor: obstacle detection	2
7.2	Shaft speed measurement	1
8	**Photonic sensor design**	
8.1	Design of photonic sensor: optical encoder for speed measurement	1
9	**Level sensor design**	
9.1	Design of level sensor: water level in boiler	1

Module No.	Topic	No. of Lectures
9.2	Storage level of solid particles	1
	Actuators	
10	**Drives and Mechanisms**	1
10.1	electric motors, DC Motors	1
10.2	Stepper motors	1
10.3	Cams	1
10.4	Linear motion Drives	1
10.5	Indexing systems	
11	**Hydraulic systems**	
11.1	Introduction – Hydraulic pumps - types	1
11.2	control valves -types, graphical representation of hydraulic elements	1
11.3	Hydraulic Valves, Hydraulic actuators.	1
12	**Pneumatic systems**	
12.1	Introduction- compressors – types	1
12.2	Air treatment and pressure regulation	1
12.3	pneumatic actuators actuators	1
12.4	Pneumatic controllers	1
13	Piezo, SMA, ER & MR based actuators.	2
	Total	**38**

Course Designers:

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18MC130 **DIGITAL 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. Digital control is a branch of control theory that uses digital computers to act as system controllers. This course provides the students with the needed background for analysing, designing and implementing digital controllers. Modern embedded solutions allow for better performance and lower cost control of dynamic systems such as servomechanisms, chemical processes, and vehicles that move over water, land, air, or space.

Digital control theory is here an enabling factor as it can exploit steadily increasing computational capabilities to shift emphasis from hardware to software and thus to take full advantage of modern embedded solutions. The aim is to provide basic notions required for the design and implementation of a digital control system. This knowledge is necessary for the selection of an appropriate controller for the correct design of a control system

Prerequisite

Nil

Course Outcomes

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

CO1	Find the Transfer function for given Physical system	Apply
CO2	Implement the time domain specification methods for analysis the performance of systems	Apply
CO3	Implement the frequency domain specification methods for analysis the performance of systems	Apply
CO4	Find the State space model for given physical system	Apply
CO5	Illustrate the system controllability and observability using state space approach	Understand

Mapping with Program Outcomes

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

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
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Transfer Function.
2. Draw the block diagram and signal flow graph for field-controlled DC motor.
3. State Mason's gain formula.

Course Outcome 2 (CO2):

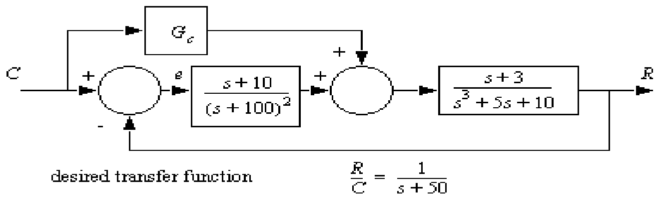
1. Define settling time of a second order system with relevant equation.
2. Define peak overshoot of a second order system with relevant equation.
3. Define rise time and delay time of a second order system with relevant equation
4. Derive the response of under damped and over damped second order system with unit step input.
5. Derive the response of critically damped second order system with unit step input.

Course Outcome 3 (CO3):

1. Define Phase Margin
2. List the frequency domain specifications.
3. Draw root locus for the following system $G(s)=k/s^2(.5s+1)$.
4. Construct the Routh array and determine the stability of the system whose characteristic equation is $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$. Also determine the number of roots lying on right half of s-plane
5. Draw bode plot for the following system. $G(s)=100/s(.5s+1)(10s+1)$.

Course Outcome 4 (CO4):

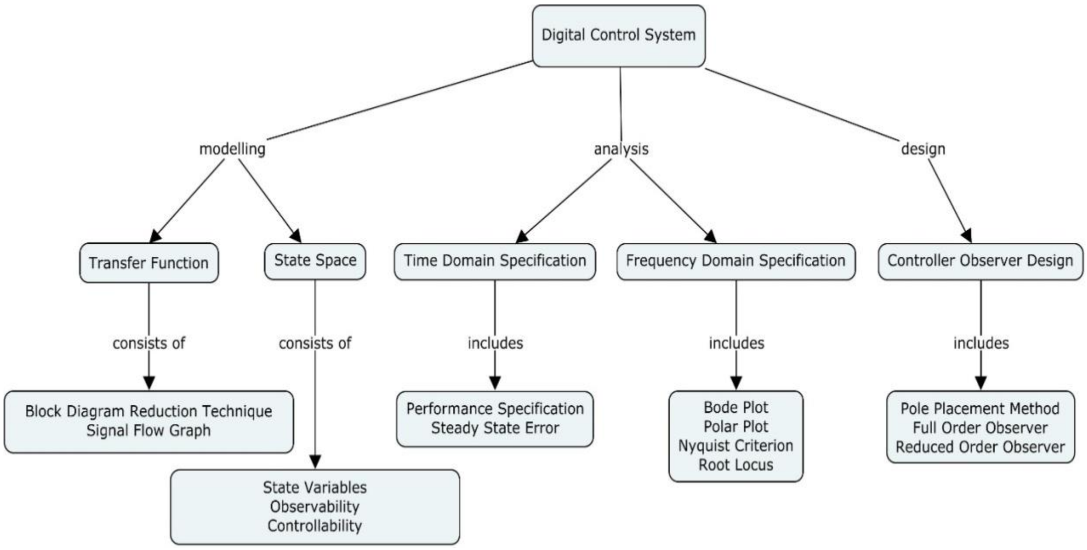
1. Differentiate state space and transfer function approach.
2. Determine the overall transfer function for the system shown below.



Course Outcome 5 (CO5):

1. Define State controllability.
2. Determine the controllability characteristics of the following system $G(z)=z+2/(z+1)(z+3)$.
3. Determine the observability of the following system $G(z)=z/(z+1)^2$

Concept Map



Syllabus

Introduction and Mathematical Models of system:

Introduction, Examples of control system, Differential equations of physical system, linear approximation, transfer function of linear systems, block diagram reduction technique, Signal flow graph method, developing transfer function from physical system.

Time and Frequency Domain Analysis:

Types of input, Performance specifications, Step response of first order and second order system, steady state error: static and dynamic error coefficients. Routh-Hurwitz stability criterion, Root locus, Frequency response methods: Bode plot and polar plot, Nyquist criterion.

State space Methods: sampling and data hold circuit, State variables of a dynamic system, various canonical forms, similarity transformation, Solution of state equation, transfer function to state space conversion, Mapping between s-plane and z-plane, Jury's Stability test, State controllability, output controllability, observability, Effect of discretization on controllability and observability.

Controller and Observer Design. Controller design-Pole placement. **Observer Design:** Full order and reduced order, Realization of digital Controller, Stabilization of an antenna dish.

Reference Book(s)

1. Richard C.Bishop, Robert H. Bishop, "Modern Control Systems" Twelfth Edition, Pearson Education, 2014.
2. Katsuhiko Ogata,"Discrete time control systems" second edition, Pearson Education Asia Pte Ltd, 2002.
3. George Stephanopoulos, "Chemical process control: An introduction to theory and practice", Prentice hall of India private limited,1999.
4. Elbert Hendricks, Ole Janner up, Paul Hasse Sorenson, "Linear systems control" Springer.2008.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction and Mathematical Models of system.**	
1.1	Introduction, Examples of control system.	1
1.2	Differential equations of physical system, linear approximation.	1
1.3	Transfer function of linear systems.	1
1.4	Block diagram reduction technique.	2
1.5	Signal flow graph method.	1
1.6	Developing transfer function from physical system	2
2	**Time and Frequency Domain Analysis**	
2.1	Types of input, Performance specifications.	2
2.2	Step response of first order and second order system.	2
2.3	Steady state error: static and dynamic error coefficients	1
2.4	Routh-Hurwitz stability criterion.	1
2.5	Root locus method	2
2.6	Frequency response methods: Bode plot and polar plot.	2
2.7	Nyquist criterion	2
3	**State space Methods**	
3.1	State variables of a dynamic system	1
3.2	Various canonical forms, similarity transformation	1
3.3	Solution of state equation, Transfer function to state space conversion.	1
3.4	Mapping between s-plane and z-plane.	1
3.5	Jury's Stability test.	1
3.6	State controllability, output controllability.	1
3.7	Observability.	1
3.8	Effect of discretization on controllability and observability.	1
4	**Controller and Observer Design.**	
4.1	**Controller design-** Pole placement.	2
4.2	**Observer Design:** Full order and reduced order.	2
4.3	Realization of digital PID Controller.	2
4.4	**Example:** Stabilization of an antenna dish.	2
	Total	**36 Hours**

Course Designers:

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18MC160 **EMBEDDED SYSTEMS**

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

Preamble

Digital system design has entered a new era. At a time when the design of microprocessors has shifted into a classical optimization exercise, the design of embedded computing systems in which microprocessors are merely components has become a wide-open frontier. Driven by advances in sensors, transducers, microelectronics, processor performance, operating systems, communications technology, user interfaces, and packaging technology on the one hand, and by a deeper understanding of human needs and market possibilities on the other, a vast new range of systems and applications is opening up. It is now up to the architects and designers of embedded systems to make these possibilities a reality.

Prerequisite

Nil

Course Outcomes

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

CO1	Illustrate the embedded concepts & its computing platform design.	Understand
CO2	Explain the architecture and Instruction set ARM	Understand
CO3	Design & Program ARM microcontroller-based systems	Apply
CO4	Design a real time operating system based embedded system	Apply

Mapping with Program Outcomes

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

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	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the Embedded system architecture.
2. Differentiate RISC and CISC processors.
3. Compare Vonneuman/Harvard architectures
4. Discuss about challenges and design issues in embedded systems.

Course Outcome 2 (CO2):

1. Explain briefly about ARM instruction set.
2. Discuss briefly about THUMB instruction.
3. Discuss about various Data Processing Instructions in ARM.
4. List out the logical instruction and explain it.

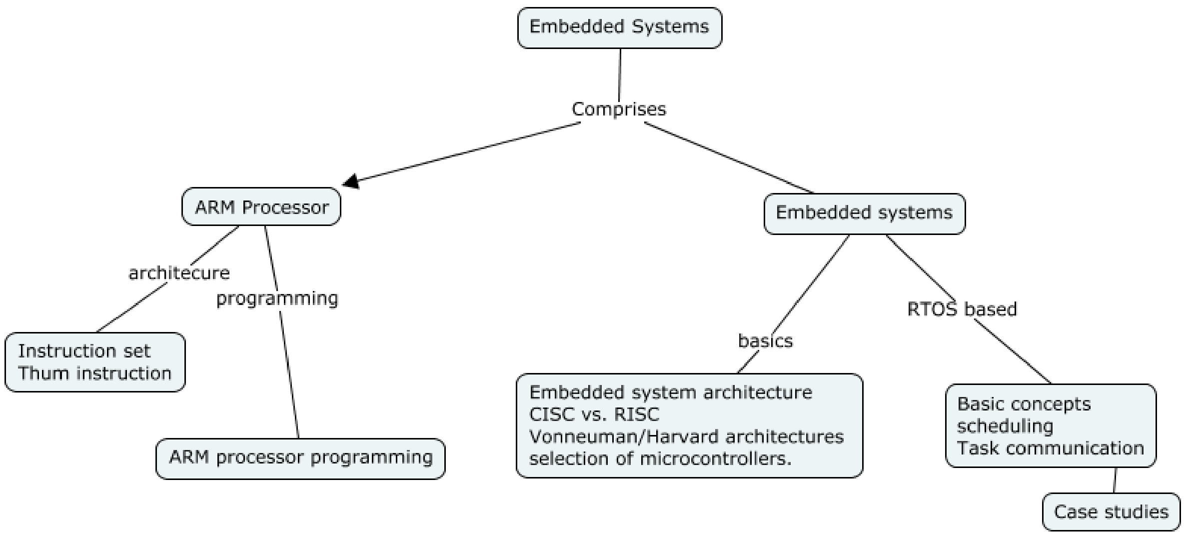
Course Outcome 3 (CO3):

1. Illustrate Exception and Interrupt Handling
2. Write IO program with interrupts using ARM Processor.
3. Write the program to display the digital equivalent of the analog signal applied in ADC channel in the UART
4. Write the program to interface LCD display with ARM.

Course Outcome 4 (CO4):

1. Explain in detail the various scheduling policies with example
2. With appropriate diagrams explain multiple tasks and multiple processes
3. Illustrate Inter process communication
4. Design a real time automotive cruise control system.

Concept Map



Syllabus

EMBEDDED SYSTEM
Embedded system architecture- classifications of embedded systems - challenges and design issues in embedded systems - fundamentals of embedded processor and microcontrollers - CISC vs. RISC - fundamentals of Vonneuman/Harvard architectures - types of microcontrollers - selection of microcontrollers.

ARM PROCESSOR
ARM Processor Fundamentals – Instruction set - Thumb Instruction Set - Efficient C Programming - ARM Assembly Code - Exception and Interrupt Handling- Firmware and Bootloader – Programming ARM processor.

RTOS BASED EMBEDDED SYSTEM DESIGN
Basic concepts of RTOS- Need,Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication-shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox,pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: VxWorks, µC/OS-II, RT Linux.
Case studies on Digital Camera, Adaptive Cruise control in a Car, Mobile Phone software for key inputs.

LIST OF EXPERIMENTS
Timer / Counter Operation - GPIO programming - UART programming - Interrupt programming - External peripherals interfacing - ADC, DAC, Keyboard, LED, 7 segment and LCD – Scheduling algorithms – Semaphores – Applications.
Arduino and Raspberry pi-based experiments.

Reference Book(s)

1. Andrew N. Sloss, Dominic Symes, Chris Wright "ARM System Developer's Guide", Elsevier, 2004
2. Trevor Martin, 'The Insider's Guide To The Philips ARM7-Based Microcontrollers, An Engineer's Introduction To The LPC2100 Series' Hitex (UK) Ltd
3. Rajkamal, 'Embedded system-Architecture, Programming, Design', TMH,2011.
4. Peckol, "Embedded system Design",JohnWiley&Sons,2010
5. Lyla B Das," Embedded Systems-An Integrated Approach",Pearson 2013

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**EMBEDDED SYSTEM**	
1.1	Embedded system architecture- classifications of embedded systems	1
1.2	Challenges and design issues in embedded systems -	1
1.3	Fundamentals of embedded processor and microcontrollers	2
1.4	CISC vs. RISC - fundamentals of Vonneuman/Harvard architectures	1
1.5	Types of microcontrollers - selection of microcontrollers.	1
2	**ARM PROCESSOR**	
2.1	ARM Processor Fundamentals	2

Module No.	Topic	No. of Lectures
2.2	Instruction set - Thumb Instruction Set	1
2.3	Efficient C Programming	2
2.4	Writing and Optimizing ARM Assembly Code	2
2.5	Exception and Interrupt Handling	1
2.6	Firmware and Bootloader	1
3	**RTOS BASED EMBEDDED SYSTEM DESIGN**	
3.1	Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling	2
3.2	Task communication-shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox,pipes,	3
3.3	priority inversion, priority inheritance	1
3.4	comparison of Real time Operating systems: VxWorks, µC/OS-II, RT Linux	1
3.5	Case studies on Digital Camera, Adaptive Cruise control in a Car, Mobile Phone software for key inputs	2
	Total	**24**

Course Designers:

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18MC170	AUTOMATION AND CONTROL LABORATORY	Category	L	T	P	Credit(s)
		PC	0	0	4	2

Preamble

The transition to digital manufacturing has become more popular with the rise in the quantity and quality of computer systems in manufacturing plants. The industry is right on the threshold of the fourth industrial revolution. Automation is being followed by the digitalization of production. Drive technology based on Integrated Drive Systems ensures maximum productivity, energy-efficiency and reliability in any automation environment and throughout the entire lifecycle. This course provides the practical skills on automation technologies so that students can 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

CO1	Design and verify the function of hydraulic and pneumatic circuits.	Apply
CO2	Built programmable logic control for mechanical, pneumatic, hydraulic and electrical systems.	Apply
CO3	Develop graphical user interface for industrial applications using HMI and SCADA.	Apply
CO4	Develop algorithm for motion control applications.	Apply
CO5	Design and Develop Numerical control systems.	Apply

Mapping with Program Outcomes

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

S - Strong M - Medium L - Low

Syllabus

List of experiments		
Ex. No	**Experiments/Exercise**	**Hours**
1	**Design, Simulation and Implementation of Hydraulic Circuits** 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)	8

2	**Design, Simulation and Implementation of Pneumatic Circuits** 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)	4
3	Exercises using PLC Bit logic Functions (2 Exercises)	4
4	Exercises using PLC Timer functions (2 Exercises)	4
5	Exercises using PLC Counter Functions (2 Exercises)	4
6	Exercises using PLC Move Function and arithmetic function (2 Exercises)	2
7	PLC Functions and Function blocks (1 Exercise)	2
8	Integration of PLC,HMI and SCADA (2 Exercises)	4
9	AC and DC Servo control system a. Position control b. Velocity control c. Torque control (2 Exercises)	4
10	VFD programming and Control (2 Exercises)	2
11	Industrial Communications-sercos, profinet, profibus (2 Exercises)	4
12	Motion Control Program. (1 Exercise)	2
13	Numerical control programming and interface (2 Exercises)	4
	Total	48

Course Designers:

Sl. No.	Name	E-mail Id
1	Mr. H. Ramesh	rameshh@tce.edu
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18MCPA0	PRINCIPLES OF MECHANICAL SYSTEMS	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

Mechanical Engineering is one of the major branches of the engineering practices and its principles are involved in the design, development and construction of physical devices and systems. It involves the production and usage of heat and mechanical power for the design, production, and operation of machines and tools. This course covers the mechanisms, transmission systems and machine tools to develop mechatronic systems.

Prerequisite

Nil

Course Outcomes

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

CO1	Solve the problems related to conservation laws of mass, momentum, and energy based on mechanics principles.	Apply
CO2	Select suitable mechanism for a given application and analyze velocity, acceleration.	Apply
CO3	Determine the frequency for free, forced and damped vibrations of machine parts.	Apply
CO4	Solve basic problems related to thermal engineering systems.	Apply
CO5	Solve basic problems related to fluid mechanics, and heat transfer	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L - Low

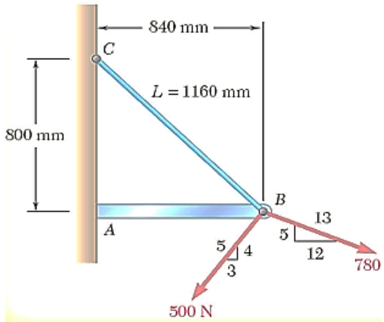
Assessment Pattern

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

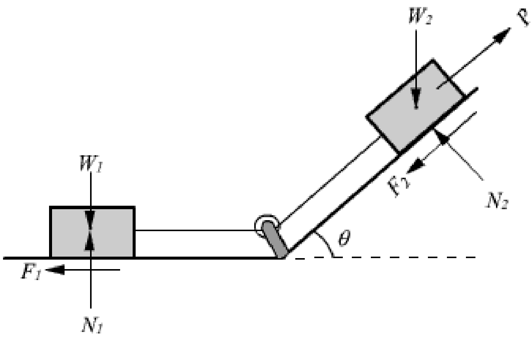
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Tension in cable BC is 725-N, determine the resultant of the three forces exerted at point B of beam AB

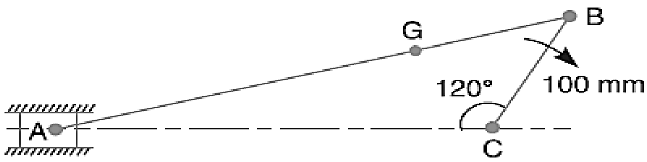


2. Two bodies of weight W1 and W2 have been connected by a string. The friction forces of the bodies during motion are indicated by F1 and F2. The bodies are pulled by applying a force P as shown in the figure. If the initial speed of bodies is u, find out the speed after the force P has moved a distance S.

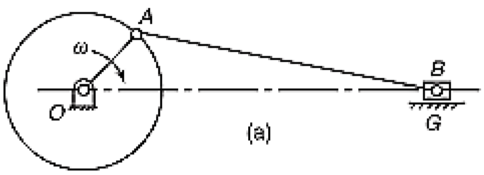


Course Outcome 2 (CO2):

1. An engine mechanism is shown in Fig. 1. The crank CB = 100 mm and the connecting rod BA = 300 mm with centre of gravity G, 100 mm from B. In the position shown, the crankshaft has a speed of 75 rad/s and an angular acceleration of 1200 rad/s^2. Find: 1. velocity of G and angular velocity of AB, and 2. acceleration of G and angular acceleration of AB 3. Velocity and acceleration of the slider A.



2. Draw the velocity and acceleration diagram for the slider crank mechanism shown in Fig.



Course Outcome 3 (CO3):

1. Derive the natural frequency of free longitudinal vibrations using energy method and equilibrium method.
2. Derive the expression for the length of the open belt drives.
3. A single cylinder vertical diesel engine has a mass of 400kg and is mounted on a steel chassis frame. The static deflection owing to their weight of the chassis is 2.4mm. the reciprocating masses of the engine amounts to 18kg and the stroke of the engine is 160mm. a dashpot with a damping coefficient of 2N/mm/s is also used to dampen the vibrations. In the steady state of the vibrations determine i) the amplitude of the vibrations if the driving shaft rotates at 500rpm ii) the speed of the driving shaft when the resonance occurs.

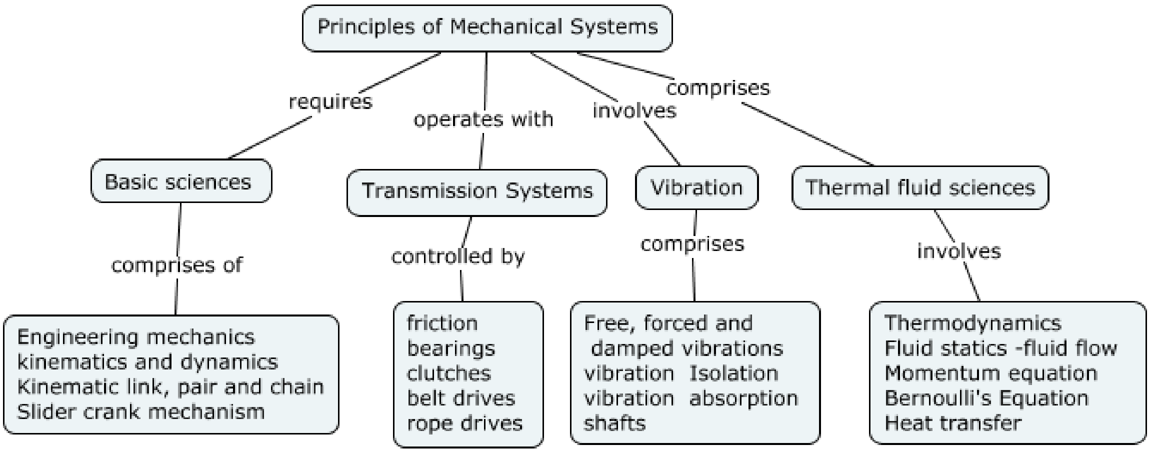
Course Outcome 4 (CO4):

1. A stationary mass of gas is compressed without friction from an initial state of 0.3 m3 and 0.105 MPa to a final state of 0.15 m3 and 0.105 MPa, the pressure remaining constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change?
2. A domestic food freezer maintains a temperature of -150C. The ambient air temperature is 300C. If heat leaks into the freezer at the continuous rate of 1.75 kJ/sec what is the least power necessary to pump this heat out continuously?
3. A reversible heat engine operates between two reservoirs at temperatures of 6000C and 400C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 400C and -200C. the heat transfer to the heat engine is 2000kJ and the net work output of the combined engine refrigerator plant is 360kJ. (a) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 400C. (b) Reconsider (a) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values.

Course Outcome 5 (CO5):

1. Determine the heat flow across a plane wall of 10cm thickness with a constant thermal conductivity of 8.5W/mK when the surface temperatures are steady at 1000C and 300C. The wall area is 3m2. Also find the temperature gradient in the flow direction.
2. Determine the heat transfer by convection over a surface of 0.5m2 area if the surface is at 1600C and fluid is at 400C. the value of convective heat transfer co-efficient is 25 W/m2K. Also estimate the temperature gradient at the surface given k=1 W/mK.
3. A surface is at 2000C and has an area 2m2. It exchanges heat with another surface B at 300C by radiation. The value of factor due to the geometric location and emissivity is 0.46. Determine the heat exchange. Also find the value of thermal resistance and equivalent convection coefficient.
4. The right limb of a U-tube manometer containing mercury is open to the atmosphere while the left limb is connected to a pipe in which a fluid of sp. gr. 0.9 is flowing. The centre of the pipe is 12 cm below the level of mercury in the right limb. Find the pressure of fluid in the pipe if the difference of mercury level in the limbs is 20cm.

Concept Map



Syllabus

Basic Sciences : Engineering mechanics -Free body diagram- kinematics and dynamics of particles- Work-energy principle- impulse momentum principle-Mechanisms : Definition – Machine and Structure – Kinematic link, pair and chain – classification of Kinematic pairs – Constraint motion - Degrees of freedom – Slider crank mechanism– Determination of velocity and acceleration of simple mechanisms.

Transmission Systems: Types of friction – friction in screw and nuts – pivot and collar – thrust bearings – collar bearing – plate and disc clutches – belt (flat & vee) and rope drives - Ratio of tensions – Effect of centrifugal and initial tension – condition for maximum power transmission.

Vibration: Free, forced and damped vibrations of single degree of freedom systems – force transmitted to supports – vibration Isolation – vibration absorption – torsional vibration of shafts – single and multi-rotor systems– critical speed of shafts.

Thermal fluid sciences: Thermodynamics concepts and definition-First law of thermodynamics - Second law of thermodynamics- Fluid statics -fluid flow - Momentum equation- Bernoulli's Equation- Heat transfer- conduction-convection- radiation.

Reference Book(s)

1. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, Vol II – Dynamics, 9th Ed, Tata McGraw Hill, 2011
2. RAO, "Mechanical Vibrations, 4E Pearson Education India; 4 editions (2003)
3. Yunus A Cengel; Michael A Boles, "Thermodynamics: An Engineering Approach" McGraw Hill Education; Eighth edition, 2017

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1	Basic sciences	
1.1	Engineering mechanics -Free body diagram- Force analysis	2
1.2	kinematics and dynamics of particles- Work-energy principle- impulse momentum principle	2
1.3	Mechanisms : Definition – Machine and Structure – Kinematic link, pair and chain – classification of Kinematic pairs	2
1.4	Constraint motion - Degrees of freedom – Slider crank mechanism	2
1.5	Determination of velocity and acceleration of simple mechanisms.	1
1.6	Problems to determine velocity and acceleration of simple mechanisms	2
2	**Transmission Systems**	
2.1	Types of friction	1
2.2	Friction in screw and nuts	2
2.3	Friction in pivot and collar – Friction in thrust and collar bearing	2
2.4	Friction in plate and disc clutches	1
2.5	Friction in Flat belt ,V-belt and rope drives	2
2.6	Open and crossed belt drives – Ratio of tensions	1
2.7	Effect of centrifugal and initial tension in belts – Condition for maximum power transmission	2
3	**Vibration**	
3.1	Free, forced and damped vibrations of single degree of freedom systems	2
3.2	Force transmitted to supports – vibration Isolation – vibration absorption	2
3.3	Torsional vibration of shafts – single and multi-rotor systems – geared shafts	2
3.4	critical speed of shafts	2
4	**Thermal fluid sciences**	
4.1	Thermodynamics concepts and definition-First law of thermodynamics	2
4.2	Second law of thermodynamics- Fluid statics -fluid flow - Momentum equation-	2
4.3	Bernoulli's Equation- Heat transfer- conduction-convection-radiation.	2
	Total Hours	**36**

Course Designers:

Sl. No.	Name	E-mail Id
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18MCPB0 PRINCIPLES OF ELECTRONIC SYSTEMS

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

Preamble

Analog and Digital Electronic devices and Systems used in Industries for the students migrated to study Mechatronics form other branches of engineering. Also covers the basics of communication principles which are essential in today ICT era in all industries.

Prerequisite

Nil

Course Outcomes

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

CO1	Explain the working and applications of electronic devices.	Understand
CO2	Summarize principle operation of power semi-conductor devices	Understand
CO3	Design circuit for simple applications using op-amps	Apply
CO4	Design the various Combinational and Sequential logic circuits	Apply
CO5	Explain the concept of modulation and demodulation techniques	Understand

Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	L	M	L	-	L	-	-	M	-	-
CO2	M	M	M	L	M	L	-	-	M	-	-
CO3	M	S	S	L	M	S	-	-	M	-	-
CO4	M	S	S	M	M	S	-	-	S	-	-
CO5	M	L	L	L	L	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	50	30	30	30
Apply	30	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define the static and dynamic resistance of a diode.
2. Give the applications of Zener diode.
3. What are the advantages of IC over discrete component circuits?

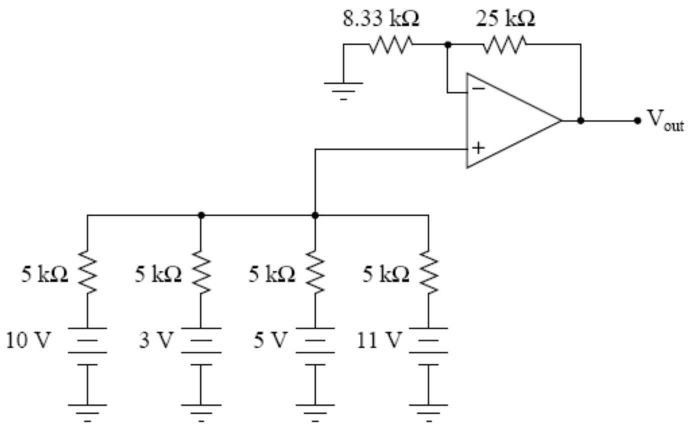
4. What is a scale changer?

Course Outcome 2 (CO2):

1. Define the reverse recovery time of a diode.
2. Define commutation.
3. List the type of power electronic converter.
4. Define firing angle.
5. Discuss the static V-I characteristics of a Thyristor.
6. Explain the single phase half wave rectifier.

Course Outcome 3 (CO3):

1. Define off-set current and virtual ground in an op-amp.
2. Mention the different types of DAC.
3. Explain the working of an instrumentation amplifier with neat sketch.
4. With neat sketch explain the 3 input inverting summing amplifier.
5. Determine the output voltage of the circuit shown below.



Course Outcome 4 (CO4):

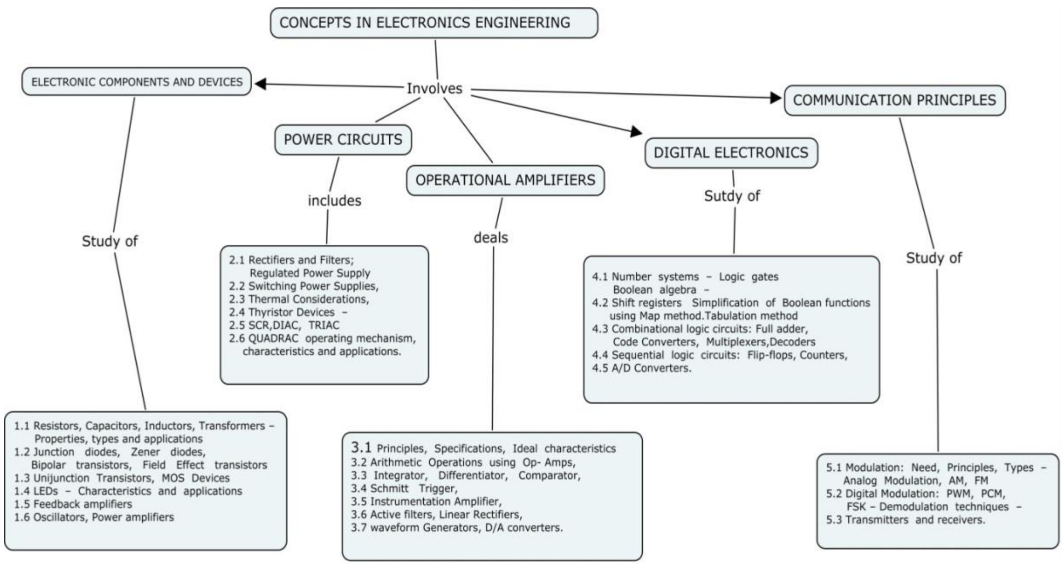
1. Draw the circuit diagram of 2 to 4 decoder.
2. Design a synchronous decade counter
3. Design a 3 input Multiplexer
4. Write excitation table of T flip flop.
5. Implement the following function using Mux

$$f(A,B,C,D) = 2(3,6,7,10,11)$$

Course Outcome 5 (CO5):

1. Define Communication.
2. Define Amplitude Modulation
3. Discuss the operation of a transmitter and receiver circuit.

Concept Map



Syllabus

Electronic Components And Devices: Resistors, Capacitors, Inductors, Transformers – Properties, types and applications; Junction diodes, Zener diodes, Bipolar transistors, Field Effect transistors, Unijunction Transistors, MOS Devices, LEDs – Characteristics and applications; Feedback amplifiers, Oscillators, Power amplifiers. Power Circuits: Rectifiers and Filters; Regulated Power Supply – Switching Power Supplies, Thermal Considerations, Thyristor Devices – SCR, DIAC, TRIAC, QUADRAC – operating mechanism, characteristics and applications.
Operational Amplifiers: Principles, Specifications, Ideal characteristics, Arithmetic Operations using Op- Amps, Integrator, Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Active filters, Linear Rectifiers, Waveform Generators, D/A converters.
Digital Electronics: Number systems – Logic gates – Boolean algebra – Simplification of Boolean functions using Map method. Tabulation method – Combinational logic circuits: Full adder, Code Converters, Multiplexers, Decoders – Sequential logic circuits: Flip-flops, Counters, Shift registers–A/D converters.
Communication Principles: Modulation: Need, Principles, Types – Analog Modulation, AM, FM – Digital Modulation: PWM, PCM, FSK – Demodulation techniques – Transmitters and receivers.

Reference Book(s)

1. Thomas L. Floyd, “Electronic Devices” – Pearson; 9 edition 2010.
2. Fanco, “Design with Operational amplifiers and Analog Integrated Circuits”, TMH,2014(new edition)
3. Taub and Schilling,” Principles of Communicating systems”, 4th edition TMH, 2013(new edition)
4. Ray & Chaudary, “Linear Integrated Circuits”, New Delhi 1991.
5. Thomas L. Floyd, “Digital Fundamentals,”, Pearson; 9 edition 2010

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1	**Electronic Components and Devices**	
1.1	Resistors, Capacitors, Inductors, Transformers – Properties, types and applications	1
1.2	Junction diodes, Zener diodes, Bipolar transistors, Field Effect transistors	1
1.3	Unijunction Transistors, MOS Devices	1
1.4	LEDs – Characteristics and applications	1
1.5	Feedback amplifiers	1
1.6	Oscillators, Power amplifiers	2
2	**Power Circuits**	
2.1	Rectifiers and Filters; Regulated Power Supply.	1
2.2	Switching Power Supplies,	1
2.3	Thermal Considerations, Thyristor Devices – SCR	2
2.4	DIAC, TRIAC	1
2.5	QUADRAC operating mechanism, characteristics and applications.	2
3	**Operational Amplifiers**	
3.1	Principles, Specifications, Ideal characteristics.	1
3.2	Arithmetic Operations using Op- Amps.	1
3.3	Integrator, Differentiator, Comparators.	1
3.4	Schmitt Trigger.	1
3.5	Instrumentation Amplifier.	1
3.6	Active filters, Linear Rectifiers.	2
3.7	Waveform Generators, D/A converters.	2
4	**Digital Electronics**	
4.1	Number systems – Logic gates – Boolean algebra – Shift registers	1
4.2	Simplification of Boolean functions using Map &Tabulation method	1
4.3	Combinational logic circuits: Full adder, Code Converters, Multiplexers, Decoders	2
4.4	Sequential logic circuits: Flip-flops, Counters,	2
4.5	A/D Converters.	2
5	**Communication Principles**	
5.1	Modulation: Principles, Types – Analog Modulation, AM, FM.	2
5.2	Digital Modulation: PWM, PCM, FSK – Démodulation	2
5.3	Transmitters and receivers.	1
	Total	36

Course Designers:

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1	Mr. Sheik Masthan S.A.R	sarsmech@tce.edu
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18MC210	**ROBOTICS CONCEPTS AND ANALYSIS**	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 20th 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. This course supports students to design and develop both multi DOF manipulators and wheeled mobile robots

Prerequisite

- 18MC110 - Linear Algebra

Course Outcomes

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

CO1	Describe the Anatomy , types and applications of robots	Understand
CO2	Develop the forward and inverse kinematic model of multi DOF manipulator	Apply
CO3	Develop forward and inverse dynamic model of two DOF manipulator	Apply
CO4	Elucidate kinematic analysis of wheeled mobile robot	Apply
CO5	Derive Wheel Constraint equations for a given wheeled robot	Apply
CO6	Develop offline robot program for a given application	Apply

Mapping with Program Outcomes

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

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	20	20	20	20
Apply	60	60	60	60
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

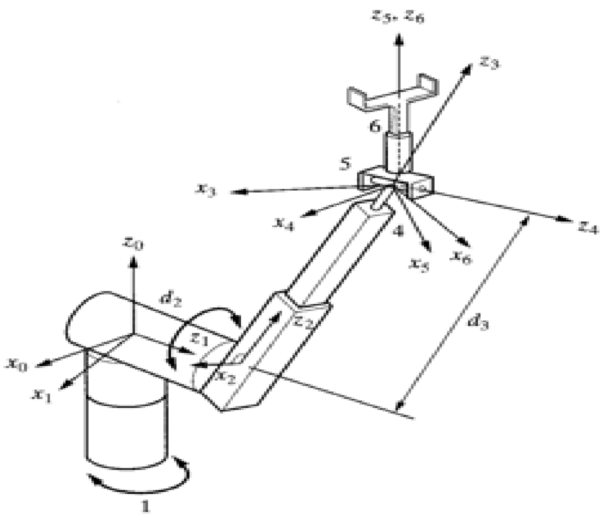
Course Outcome 1 (CO_1):

1. Define Robot
2. Explain the classification and the performance of Robots.
3. Describe the constructional features of a mobile robot.
4. Brief the applications of industrial and mobile robot.

Course Outcome 2(CO_2):

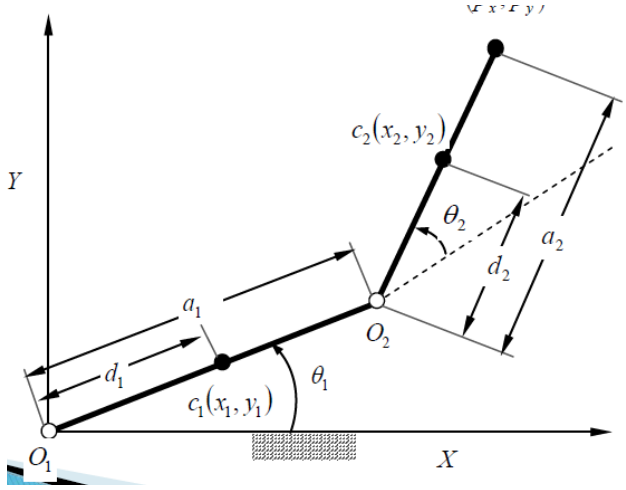
1. Write the coordinate transformation matrices for all PUMA joints as shown in the fig using DH parameters.

2. Find the DH parameters for the robot given in the following fig and derive the forward kinematics



Course Outcome 3 (CO_3):

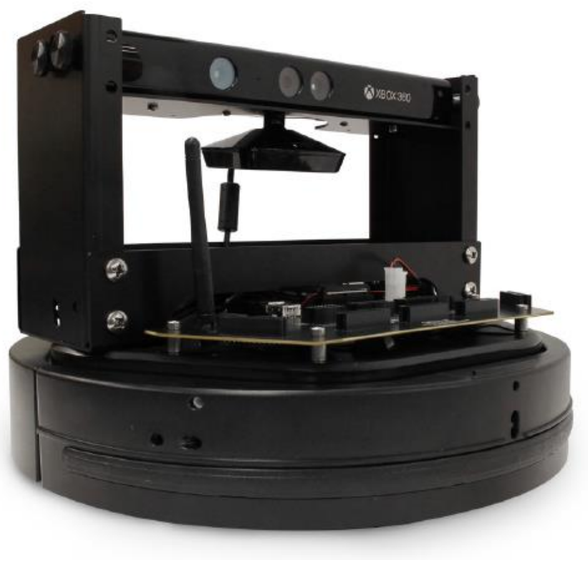
1. Derive the dynamic model of two link manipulator



2. Explain the lagrangian dynamic model. Compute the kinetic energy and potential energy and hence derive the torque.

Course Outcome 4 (CO_4):

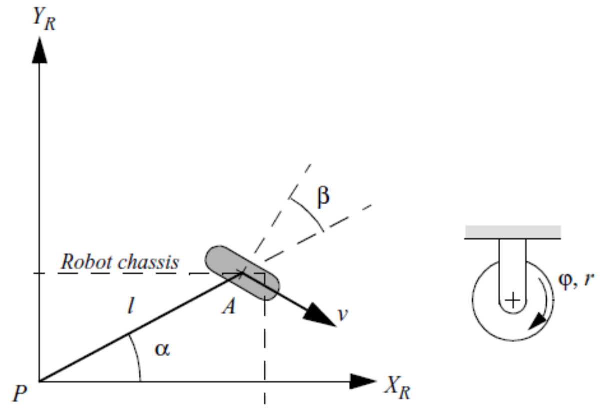
1. Derive the kinematic model of a two wheeled robot shown below. The diameter, distance between the left and right wheels, height, maximum speed mass of the QBot is 0.35 m, 0.235 m, 0.27 m, 0.7 m/s, 3.79 kg respectively. Consider flat surface, indoor environment, no frictional coefficient.



2. Assume the characteristics of a three wheeled robot and model the slip and analyze the static stability. Develop the equations of motion and verify whether the design is feasible or not.

Course Outcome 5 (CO_5):

1. Derive the kinematic equation for the standard wheel shown in the fig.

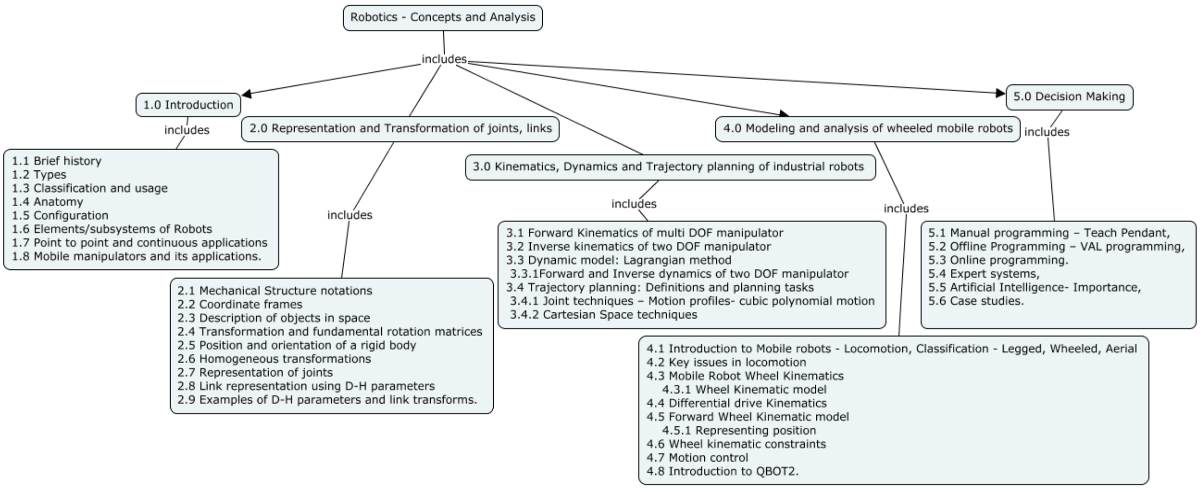


2. For the three wheeled robot shown in the following fig derive the rolling and sliding constraints if the distance between the wheels is 10 cm. The castor wheel is fixed at an angle of 40 degrees from the standard wheels.

Course Outcome 6 (CO_6):

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 are 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 and its applications.

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, Examples of D-H parameters and link transforms. Introduction to Robo Analyser.

Kinematics, Dynamics and Trajectory planning of industrial robots
Forward Kinematics of multi DOF manipulator, Inverse kinematics of two DOF manipulator, Dynamic model: Lagrangian method – Forward and Inverse dynamics of two DOF manipulator. Trajectory planning: Definitions and planning tasks, Joint techniques – Motion profiles- cubic polynomial motion, Cartesian Space techniques.

Modeling and analysis of wheeled mobile robots
Introduction to Mobile robots - Locomotion, Classification - Legged, Wheeled, Aerial - Key issues in locomotion. Mobile Robot Wheel Kinematics – Wheel Kinematic model- Differential drive Kinematics - Forward Wheel Kinematic model, Representing position, Wheel kinematic constraints. Motion control. Introduction to QBOT2.

Decision Making
Robot Programming: Manual programming – Teach Pendant, Offline Programming – VAL programming, Online programming. Expert systems, Artificial Intelligence- Importance, Case studies.

Reference Book(s)

1. John J Craig, "Introduction to Robotics, Mechanics and Control, third edition, Pearson education, 2005
2. K.S.Fu, R.C Gonzalez and C.S Lee, Robotics – Control, sensing Vision and Intelligence, Tata McGraw – Hill Editions, 2008.
3. Roland Seigwart and Illah R Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2004.
4. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008.

5. Saeed B Niku, “Introduction to Robotics, Analysis, System, Applications,” second edition, john Wiley, 2010.
6. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, “Industrial Robotics – Technology , Programming and Applications”, Tata McGraw Hill Edition, 2008.
7. 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 Lectures
1.0	**Introduction to Robotics**	
1.1	Introduction – brief history	1
1.2	Robot – types – Industrial and Mobile	1
1.3	Classification and usage	1
1.4	Configuration, Anatomy, Elements/subsystems of Robots	1
1.5	Point to point and continuous applications, Mobile manipulators and its applications.	1
2.0	**Representation and Transformation of joints, links**	
2.1	Mechanical Structure notations, Coordinate frames, Description of objects in space	1
2.2	Transformation and fundamental rotation matrices, Position and orientation of a rigid body	1
	Homogeneous transformations	1
2.3	Representation of joints, link representation using D-H parameters	1
2.4	Examples of D-H parameters and link transforms.	2
3.0	**Kinematics, Dynamics and Trajectory planning of industrial robots**	
3.1	Forward Kinematics of multi DOF manipulator	2
3.2	Inverse kinematics of two DOF manipulator	2
3.3	Lagrangian method – Forward dynamics of two DOF manipulator	2
	Inverse dynamics of two DOF manipulator	2
3.4	Trajectory planning: Definitions and planning tasks	1
3.5	Joint techniques – Motion profiles	1
	cubic polynomial motion	1
3.6	Cartesian Space techniques	1
4.0	**Modeling and analysis of wheeled mobile robots**	
4.1	Introduction to Mobile robots – Locomotion, Classification – Legged, Wheeled, Aerial – Key issues in locomotion	1
4.2	Mobile Robot Wheel Kinematics – Wheel Kinematic model	2
4.3	Differential drive Kinematics	1
4.3	Forward Wheel Kinematic model, Representing position	1

Module No.	Topic	No. of Lectures
4.4	Wheel kinematic constraints. Motion control	2
5.0	**Decision Making**	
5.1	Robot Programming: Manual programming, Teach Pendant	1
5.2	Offline Programming – VAL programming	2
5.3	Online programming	1
5.4	Expert systems	1
5.5	Artificial Intelligence- Importance	1
5.6	Case studies.	2
	Total Hours	**38**

Course Designers

Sl. No.	Name	E-mail Id
1	Dr G Kanagaraj	gkmech@tce.edu
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18PG250	**RESEARCH METHODOLOGY AND IPR**	Category	L	T	P	Credit(s)
		CC	2	0	0	2

Preamble

The course on the Research Methodology and IPR is offered as common Core course. The objective of this course is to understand and analyze Research Methodology and IPR protection

Prerequisite

NIL

Course Outcomes

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

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

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
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Syllabus

Module 1: Meaning of research problem, Sources of research problem, Criteria, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Module 2: Effective literature studies approaches, analysis Plagiarism, Research ethics

Module 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development.

International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Reference Book(s)

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’” 2nd Edition,
2. “Research Methodology: A Step by Step Guide for beginners”
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
4. Mayall, “Industrial Design”, McGraw Hill, 1992.
5. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov, “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

Course Designers

1. Adapted from AICTE Model Curriculum for Postgraduate Degree Courses in Engineering & Technology, Volume-I, January 2018.

18MC270 SENSORS AND ROBOTICS LABORATORY

Category	L	T	P	Credit(s)
PC	0	0	4	2

Preamble

This course provides engineering students with basic understanding of two of the main components of any modern electrical or electromechanical system; sensors as inputs and its interfacing. It also provides in-depth knowledge on modelling of robots, simulating them in a particular environment and programming them to perform a particular task. This course is useful for those students interested in control engineering, robotics and systems engineering.

Prerequisite

- 18MC120- Sensors and Actuators
- 18MC210 - Robotics Concepts and Analysis

Course Outcomes

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

CO1	Apply the knowledge gained in sensors and actuators to real time systems	Apply
CO2	Design and implement interfacing of Sensors and Actuators in practical/simulation computational environment	Apply
CO3	Simulate the industrial robot in a given environment	Apply
CO4	Program and execute assembly, deburring and inspection application using MH5LS and GP12 robots	Apply
CO5	Model, simulate and analyse mobile robots	Apply
CO6	Program and analyse the kinematics of a mobile robot	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

List of experiments

Ex.No	Name of Experiments	No of Hours
1	To perform and investigate the characteristics of LVDT	2
2	To perform and investigate the dynamic characteristics of piezo laminated cantilever beam	2
3	To perform and investigate the static characteristics of RTD	2
4	To perform and test the interfacing of switches and seven segments displays to computing systems.	2

5	To perform and test the loading effect of potential meter	2
6	To perform and measure the strain effect in strain gauges	2
7	To perform the interface of stepper motor, run forward, reverse and defined angle position.	2
8	To perform the interface of AD convertor to convert analog signal to digital using hardware kit	2
9	To perform the interface of DAC, predefined square wave and trapezoidal and sine wave	2
10	To analyze and detect the effect of modifying and interfering inputs	2
11	To perform the experimental determination of damping ratio	2
12	To test and analyze the characteristics of thermocouples	2
13	To simulate and analyse the forward and inverse kinematics of industrial robot using Robo Analyser	2
14	To simulate and evaluate the performance of the industrial robot using MOTO SIM software	2
15	To simulate and analyse point to point and continuous motion of an industrial robot	2
16	To program and evaluate the inspection operation using MH5LS robot	2
17	To program and perform the Deburring operation using GP12 robot	2
18	To program and perform the Assembly operation using GP12 robot	2
19	To model, simulate and analyse the characteristics of a biped robot using 20 SIM software	2
20	To model, simulate and analyse the characteristics of a wheeled robot using 20 SIM software	2
21	To program and evaluate the forward kinematics of a wheeled robot using QBOT2	2
22	To program and evaluate the inverse and differential drive kinematics of a wheeled robot using QBOT2	2
23	To program and evaluate the 2D mapping using QBOT2	2
24	To program and evaluate path planning using QBOT2	2
	Total	48

Course Designers

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2	Mr M.A.Ganesh	ganeshma2015@tce.edu

18MC360	MECHATRONICS SYSTEM DESIGN	Category	L	T	P	Credit(s)
		PC	2	0	2	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. The design process includes modelling and simulation. This course teaches the basic concepts of modelling and simulation of Electrical, Electronics, Mechanical and Hydraulic systems combining to Mechatronic Systems. Design of a mobile robot is introduced in this subject to illustrate the concepts.

Prerequisite

- 18MCPA0/18MCPB0 - Principles of Mechanical Systems/Principles of Electrical Systems
- 18MC120 – Sensors and Actuators
- 18MC130 – Digital Control System

Course Outcomes

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

CO1	Explain the Mechatronic Design Process	Understand
CO2	Describe the basics of modelling using bond graph	Understand
CO3	Model and Simulate Electrical and Mechanical systems	Apply
CO4	Model and Simulate Hydraulic and Electronic systems	Apply
CO5	Derive the system equation from the bond graphs	Apply
CO6	Examine the model developed for a Mechatronic System and analyze the simulated result	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Theory (70 marks)						Practical (30 marks)		
Bloom's Category	Continuous Assessment Tests (20)			Terminal Examination (50)		Valuation category	Continuous Assessment (10)	Continuous Assessment Test 3 (20)
	1	2						
Remember	20	20		20		Class work	90	90
Understand	20	20		20		Record	10	10
Apply	60	60		60				
Analyse	0	0		0				
Evaluate	0	0		0				
Create	0	0		0				

Theory cum Practical Courses:

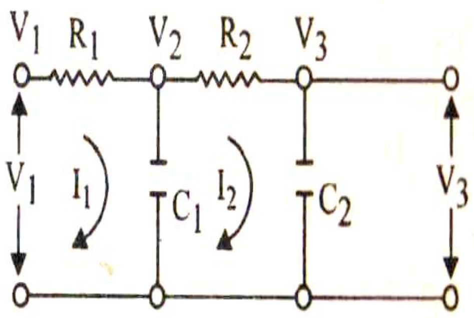
There shall be three tests: the first two tests (Maximum 50 marks for each test) will be from theory component and the third test (Maximum 50 Marks) will be for practical component. The sum of marks of first two tests shall be reduced to 20 Marks and the third test mark shall be reduced to 20 marks. 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.

Course Level Assessment Questions

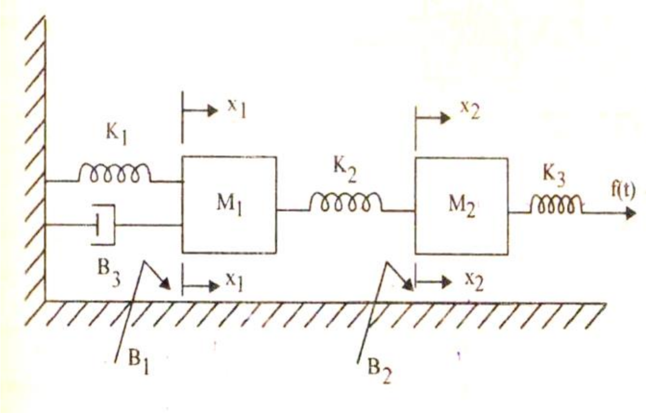
Course Outcome 1 (CO_1):
1. Define Transfer Function
2. Describe the Mechatronic Design process
3. List the interfacing issues in Mechatronic Design

Course Outcome 2 (CO_2):
1. Discuss about Power Variables used in bond graph
2. Define components in physical systems
3. Explain about Transformer Element and Gyrator Element
4. Differentiate the 1,2,3 port components in Electrical, Mechanical and Thermal systems.

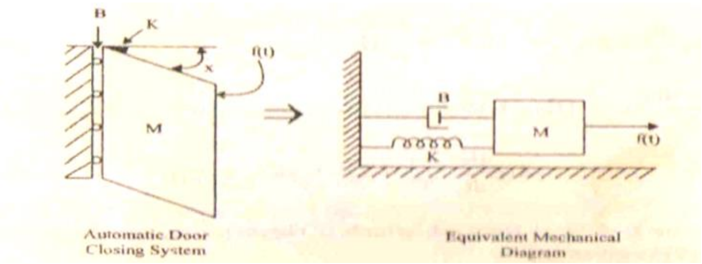
Course Outcome 3 (CO_3):
1. Develop a model for the physical system shown below using bond graph



2. Develop a model for the physical system shown below using bond graph

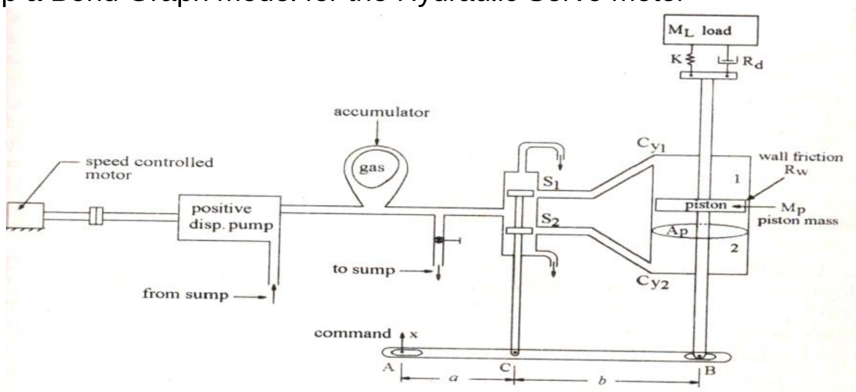


3. Develop a model for the physical system shown below using bond graph

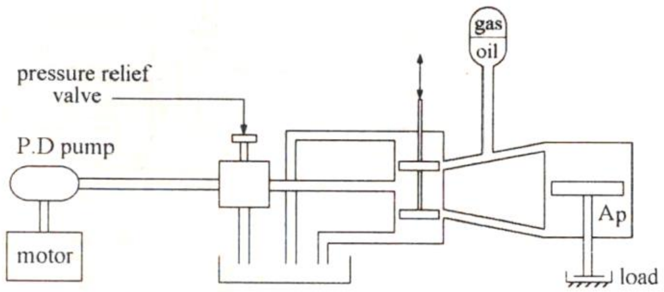


Course Outcome 4 (CO_4):

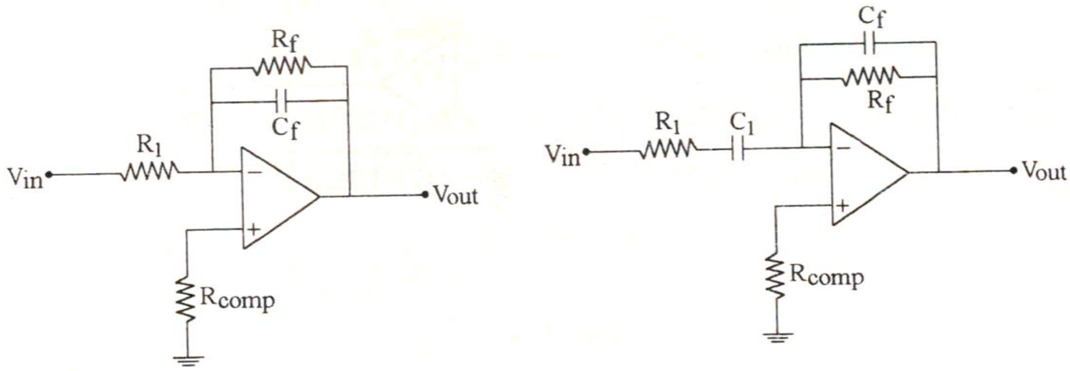
1. Develop a Bond Graph model for the Hydraulic Servo motor



2. Make a bond graph model of the hydraulic system used for metal forming operation

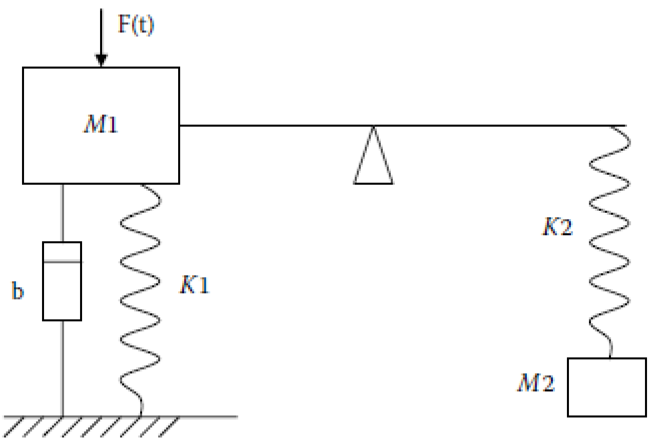


3. Draw a bond graph model for Practical integrator and differentiator circuit shown in below

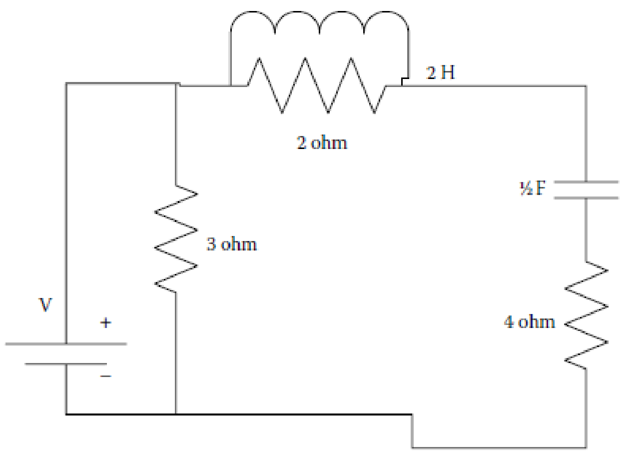


Course Outcome 5 (CO_5):

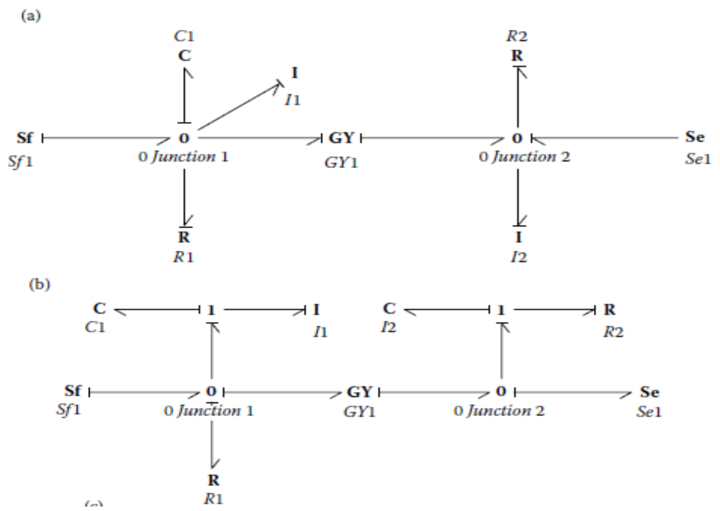
1. Derive the system equation for the following system. Follow the procedure and obtain the equations.



2. Consider the differential causality and derive the system equation for the following system.

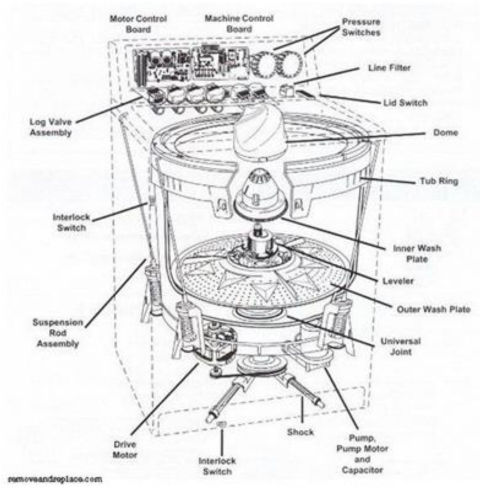


3. Derive the governing equations for the bond graphs below:

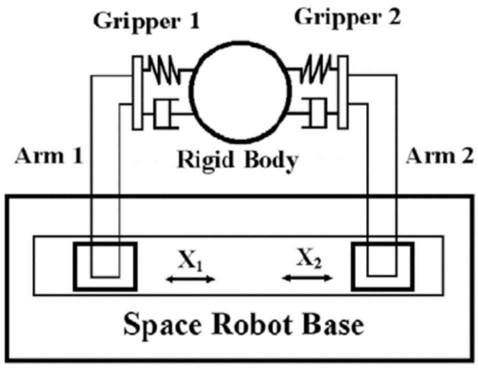


Course Outcome 6 (CO_6):

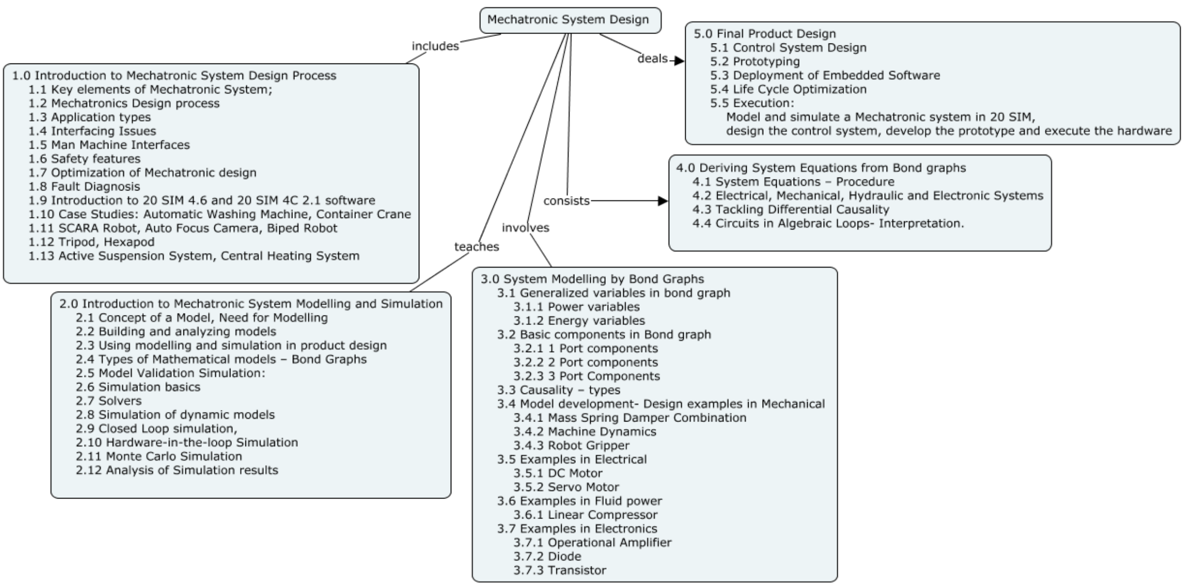
1. Model the automatic washing machine, analyze and interpret the simulation results if the maximum load is 6kg with the motor running torque at 20Nm.



2. Model the robot gripper, analyze and interpret the simulation results if the damping coefficient is 0.01, frictional coefficient is 0.01 and mass is 0.5 kg. Interpret the characteristics of the motion. Calculate the current needed to drive the motor of the robot base to move the gripper at 0.2m/sec.



Concept Map



Syllabus

Introduction to Mechatronic System Design Process:
Key elements of Mechatronic System; Mechatronics Design process - Application types – Interfacing
Issues – Introduction to 20 SIM 4.6 and 20 SIM 4C 2.1 software. **Case Studies:** Automatic Washing Machine, Container Crane, Biped Robot, Active Suspension System, Central Heating System.

Introduction to Mechatronic System Modelling and Simulation:
Concept of a Model, Need for Modelling, Building and analyzing models, Types of Mathematical models – Bond Graphs. Model Validation **Simulation:** Simulation basics – Solvers -Simulation of dynamic models, Closed Loop simulation, Hardware-in-the-loop Simulation, Analysis of Simulation results.

System Modelling by Bond Graphs:
Generalized variables in bond graph- Power variables – Energy variables, Basic components in Bond graph-1 Port components- 2 Port components- 3 Port Components, causality – types. Model development- Design examples in Mechanical, Electrical, Fluid power and Electronics Systems. **Case Studies:** Mass Spring Damper Combination, Machine Dynamics, DC Motor, Servo Motor, Robot Gripper, Operational Amplifier, Diode, Transistor, Linear Compressor.

Deriving System Equations from Bond graphs
System Equations – Procedure – Electrical, Mechanical, Hydraulic and Electronic Systems

Final Product Design
Control System Design - Prototyping

Reference Book(s)

1. Shuvra Das., “Mechatronic Modeling and Simulation Using Bond Graphs”, CRC Press, 2009.
2. W. Bolton, “Mechatronics – Electronic control systems in Mechanical & Electrical Engineering”, Pearson Education Ltd., 2003.
3. Shetty and Kolk , “Mechatronics System Design” , CENGAGE Learning, India, second edition, 2011.
4. Amalendu Mukherjee, Ranjit Karmakar, Arun kumar samantaray, “Bond Graph in Modeling, Simulation and Fault Identification” I.K International Pvt Ltd, Jan 2006.
5. Dean C Karnopp, Donal L Morgolis, Ronald C Rosenberg “System Dynamics; Modeling, Simulation and Control of Mechatronic systems”, John Wiley & Sons, Inc, 5th Edition, 2012.
6. Jacqueline Wilkie., Michael Johnson., Reza Katebi., “ Control Engineering an Introductory course “ Palgrave Publication, 2003.
7. Wayne Bequette. B., “Process Control: Modeling, Design and Simulation” ., Prentice Hall PTR, 2002.
8. Peter Fritzson., “Principles of object oriented modeling and Simulation with Modelica 2.1”., IEEE Press, 2004.
9. “Control design with Simulink” – The Math work tutorial – 2004

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.0	**Introduction to Mechatronic System Design Process**	
1.1	Key elements of Mechatronic System	1

Module No.	Topic	No. of Lectures
1.2	Mechatronics Design process	1
1.3	Application types , Interfacing Issues	1
1.4	Introduction to 20 SIM 4.6 and 20 SIM 4C 2.1 software.	1
1.5	**Case Studies:** Automatic Washing Machine, Container Crane, Biped Robot	1
1.6	Active Suspension System, Central Heating System	1
2.0	**Introduction to Mechatronic System Modelling and Simulation**	
2.1	Concept of a Model, Need for Modelling, Building and analyzing models	1
2.2	Types of Mathematical models – Bond Graphs	1
2.3	Model Validation	1
2.4	**Simulation:** Simulation basics	1
2.5	Solvers -Simulation of dynamic models	1
2.6	Closed Loop simulation, Hardware-in-the-loop Simulation	1
2.7	Analysis of Simulation results	1
3.0	**System Modelling by Bond Graphs**	
3.1	Generalized variables in bond graph- Power variables – Energy variables	1
3.2	Basic components in Bond graph -1 Port components- 2 Port components- 3 Port Components	1
3.3	Causality – types	1
3.4	Model development- Design examples in Mechanical - Mass Spring Damper Combination, Machine Dynamics, Robot Gripper	1
3.5	Electrical Examples - DC Motor, Servo Motor	1
3.6	Fluid power Examples – Linear Compressor	1
3.7	Electronics Systems - Operational Amplifier, Diode, Transistor	1
4.0	**Deriving System Equations from Bond graphs**	1
4.1	System Equations – Procedure – Electrical, Mechanical	1
4.2	Hydraulic and Electronic Systems	1
5.0	**Final Product Design**	
5.1	Control System Design	1
5.2	Prototyping	1
	Total	**25 Hours**

Laboratory Experiments

Sl No	Title	No of Hours
1	Modelling and Simulation of DC Motor control	2
2	Modelling and Simulation of a House heating system	2

3	Modelling and Simulation of a DC (i) Series (ii) Shunt Motor by P, PI,PD and PID controller	2
4	Modelling and Simulate the position of a Servo Motor by P, PI,PD and PID controller	2
5	Modelling and Simulation of Operational Amplifier	2
6	Modelling and Simulation of a Mass, Spring, Damper combination by P, PI,PD and PID controller	2
7	Modelling and Simulation of a Robot Grasping an object	2
8	Modelling and Simulation of a Linear compressor	2
9	Modelling and Simulation of a Hydraulic lift	2
10	Development and interface of an Active Suspension System	2
11	Interfacing and position control of a Servo motor	2
12	Interfacing and control of a DC Motor	2
	Total	**24 hours**

*The tools used are 20 SIM, Matlab and Lab view.

Course Designers

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18MCPC0	**INTERNET OF THINGS**	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

The IoT is receiving a large amount of interest on the part of researchers, with thousands of papers published on this topic in the recent past. While specific applications have existed for several years, perhaps supported on private enterprise networks, Internet-based systems along with system supporting a broader application scope are now beginning to be deployed. The capabilities offered by IP Version 6 (IPv6) are critical to the wide-spread deployment of the technology. This course aims at exploring these evolving trends and offering practical suggestions of how these technologies can be implemented in the service provider networks to support cost-effective applications, and how new revenue-generating services could be brought to the market. All the latest physical layer, MAC layer, and upper layer IoT and Machine to Machine (M2M) protocols are discussed.

Prerequisite

18MC120 – Sensors and Actuators

Course Outcomes

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

CO1	Developing knowledge on Fundamentals of internet of things	Understand
CO2	To ensure, develop different wireless technologies and to learn about the IPv6 over 6LoWPAN	Apply
CO3	Developing software packages using python for internet of things	Apply
CO4	Analysing most of IoT projects using open source hardware	Analyse

Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	L	M		L	L			L	M	S
CO2	L	L	M				L				
CO3	S	M	L	L	M			M		S	M
CO4	S	M	S			S	L		L		

S – Strong M – Medium L – Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	0	0	0	0
Understand	60	30	30	30
Apply	20	40	40	30
Analyse	20	30	30	40
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare IoT frameworks.
2. Describe the architecture of CoAP protocol
3. Define Scalability and Interoperability

Course Outcome 2 (CO2):

1. Explain about IEEE 802.15.6 protocol and architecture of Frames

2. Illustrate IPv6 tunnelling
3. Describe IPv6 over 6LoWPAN

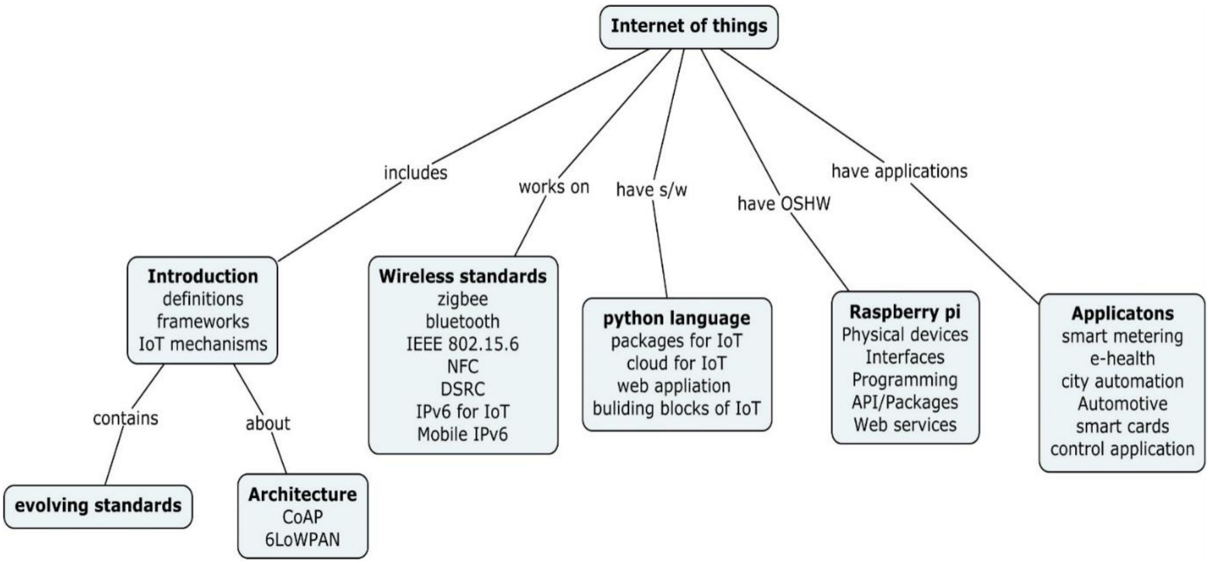
Course Outcome 3 (CO3):

1. What are the packages used in IoT frame work
2. Can machine learning theories and algorithms help explain human learning?
3. What are the basic building blocks of IoT device?
4. Write a simple python program for the Http request from Raspberry-pi to server

Course Outcome 4 (CO4):

1. Elaborate the design and working of city automation
2. Design an smart metering system for the IoT
3. Design a system to monitor your health using body area networks.
4. Write about an automotive IoT system

Concept Map



Syllabus

Introduction TO IoT: Overview, IPv6 role, Development and Standardization, IoT Definitions, IoT Frameworks.
Fundamental IoT Mechanisms: Characteristics, scalability, interoperability, Key IoT mechanisms, sensor technology, Evolving IoT standards, Architectural reference model, CoAP, 6LoWPAN.
Wireless Technologies for the IOT: ZIGBEE, BLUETOOTH, IEEE 802.15.6, NFC, DSRC, IPv6 FOR IoT, IPv6 address space, protocol, tunnelling, QoS.
Mobile IPV6 FOR IoT: New IPv6 protocol, requirements for IPv6 nodes, IPv6 over 6LoWPAN
Logical Design & Physical Devices: Python packages of interest for IoT, Cloud for IoT, python web application framework. Basic building blocks of a IoT Device.
Open Source Hardware: Raspberry PI physical devices, Raspberry Pi Interfaces, Programming, APIs / Packages. Web services, Open source Hardware – STM.
Applications: Smart Metering/Advanced Metering Infrastructure , e-Health/Body Area Networks ,City Automation , Automotive Applications ,Home Automation Smart Cards , Control Application

Reference Book(s)

1. ArshdeepBahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press,2015
2. Peter Waher “Learning Internet of Things”,PacktPublishing,UK, 2015.
3. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014
4. Adrian McEwen, Hakim Cassimally “Designing the Internet of Things”,WileyPublishing, 2015

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1	**INTRODUCTION TO IoT**	
1.1	Overview, IPv6 role	1
1.2	Development and Standardization	1
1.3	IoT Definitions	1
1.4	IoT Frameworks.	1
2	**FUNDAMENTAL IoT MECHANISMS**	
2.1	Characteristics	1
2.2	scalability, interoperability	1
2.3	Key IoT mechanisms	1
2.4	sensor technology	1
2.5	Evolving IoT standards	1
2.6	CoAP, 6LoWPAN	1
3	**WIRELESS TECHNOLOGIES FOR THE IOT**	
3.1	ZIGBEE	1
3.2	BLUETOOTH	1
3.3	IEEE 802.15.6	1
3.4	NFC, DSRC,	1
3.5	IPv6 FOR IoT	1
3.6	IPv6 address space, protocol, tunnelling, QoS	1
4	**MOBILE IPV6 FOR IoT**:	
4.1	New IPv6 protocol	1
4.2	requirements for IPv6 nodes	1
4.3	IPv6 over 6LoWPAN	1
5	**LOGICAL DESIGN& PHYSICAL Devices**	
5.1	Python packages of interest for IoT,	1
5.2	Cloud for IoT,	1
5.3	python web application framework..	1
5.4	Basic building blocks of a IoT Device	1
6	**OPEN SOURCE HARDWARE**	
6.1	Raspberry PI physical devices	1
6.2	Raspberry Pi Interfaces	1
6.3	Programming, APIs / Packages	2
6.4	Web services	2
7	**APPLICATIONS**	
7.1	Smart Metering/Advanced Metering Infrastructure	1
7.2	e-Health/Body Area Networks	2
7.3	City Automation	1
7.4	Automotive Applications	1
7.5	Home Automation Smart Cards	1
7.6	Control Application	1
	Total hours	36

Course Designers

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1	S. Parthasarathi	parthasarathi_s@tce.edu
2	M. Manimegalam	mmmech@tce.edu

18MCPD0	VIRTUAL INSTRUMENTATION	Category	L	T	P	Credit(s)
		PE	3	0	0	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

CO1	Explain the need and advantages of Virtual Instruments over Traditional Instruments	Understand
CO2	Develop Graphical Programming using LabVIEW	Apply
CO3	Choose appropriate LabVIEW Architecture for realizing a given application	Apply
CO4	Configure and acquire data from real world using DAQ	Apply
CO5	Develop LabVIEW based system for realizing a given application	Apply

Mapping with Program Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	L	L	L	-	-	-	-	L	M	-	-
CO2	M	S	S	M	S	S	-	M	M	-	L
CO3	M	S	S	M	S	S	-	M	M	-	L
CO4	M	S	S	M	S	S	-	M	M	-	L
CO5	M	S	S	M	S	S	-	M	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	30	30
Apply	40	40	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

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

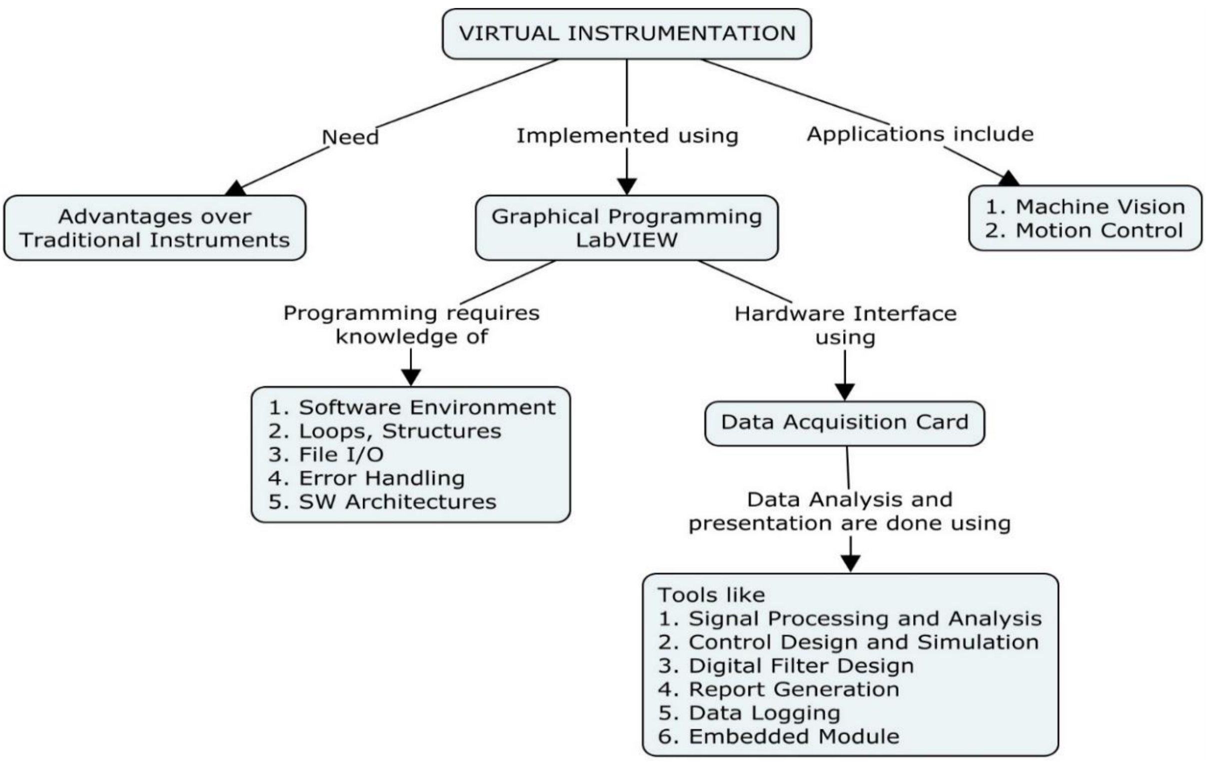
Course Outcome 2 (CO2):
1. Build a four-function calculator
2. Create a VI to find the factorial of the given number using For Loop and Shift Registers
3. Build a VI that generates 50 random numbers and plot it on a waveform chart using For and While Loops. Accumulate the random numbers into an array and display it on waveform graph.

Course Outcome 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. 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
2. Develop a Virtual Instrument to acquire temperature for every one minute and store the data in Excel sheet.

Course Outcome 5 (CO5):
1. Develop a LabVIEW based machine vision system for blister pack inspection in pharmaceuticals industry.
2. Develop a LabVIEW based motor control system for an in-line bottle filling plant.

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

LabVIEW: 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 – 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

Reference Book(s) / Learning Materials

1. Jovitha Jerome, **Virtual Instrumentation Using LabVIEW**, PHI Learning, New Delhi, 2010
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, 2011
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 Lectures
1	**Virtual Instrumentation**	
1.1	Introduction to Virtual Instrumentation: Virtual Instrument and traditional instrument - Hardware and software	1
1.2	Virtual Instrumentation in the Engineering Process - Graphical Programming and Textual Programming	2
2	**LabVIEW**	
2.1	Introduction to LabVIEW: Software Environment - Creating and Saving A VI - Front Panel - Block Diagram Toolbar	1
2.2	Palettes - Property Dialog Boxes - Front Panel Controls and Indicators - Block Diagram	2
2.3	Data Types - Data Flow Program - Modular Programming	2
3	**LabVIEW Programming**	
3.1	Loops: FOR, WHILE Loops - Tunnels – Shift Registers	2

Module No.	Topic	No. of Lectures
3.2	Feedback Nodes – Control Timing – Communicating among Multiple Loops - Local and Global Variables	2
3.3	Structures: Case, Sequential, Timed, Formula, Event	2
3.4	Arrays – Clusters	1
3.5	Plotting Data: Waveform Graphs, Charts - XY Graphs	2
3.6	Strings - File I/O - Error Handling	2
3.7	Architectures: Functional Global Variable	1
3.8	State Machine - Event-Driven User Interface	2
3.9	Producer / Consumer	1
4	**Data Acquisition**	
4.1	Introduction – Transducers - Signals - Principles of Data Acquisition	2
4.2	DAQ Assistant	2
5	**Tools and Applications**	
5.1	Tools: Signal Processing and Analysis - Digital Filter Design	2
5.2	Tools: Control Design and Simulation - Report Generation	2
5.3	Tools: Data Logging - Embedded Module - Math Interface Toolkit	2
5.4	Applications: Machine Vision	2
5.5	Applications: Motion Control	2
Total		**36**

Course Designers

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18MCPE0	MACHINE VISION SYSTEMS	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

CO1	Explain the components of a machine vision system and their functions	Understand
CO2	Select the appropriate sensor and illumination techniques of machine vision system for the given application	Apply
CO3	Explain the various image processing technique used to design a machine vision system	Understand
CO4	Choose a suitable image processing technique for the specified Requirement	Apply
CO5	Select suitable components of machine vision system for the given applications such as part identification, counting, measurement and gauging	Apply

Mapping with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	L	L	-	-	-	-	L	M	-	-
CO2	M	S	S	M	S	S	-	M	M	-	L
CO3	L	L	L	-	-	-	-	L	M	-	-
CO4	M	S	S	M	S	S	-	M	M	-	L
CO5	M	S	S	M	S	S	-	M	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	30	30	30
Apply	40	50	50	50
Analyse	---	---	---	---
Evaluate	---	---	---	---
Create	---	---	---	---

Course Level Assessment Questions

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):

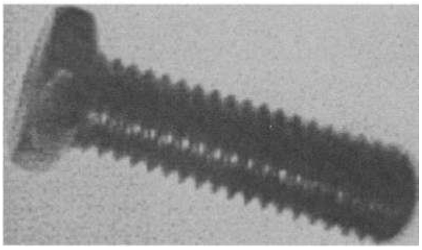
1. With suitable example, explain the use of binary morphology operations
2. Explain the various image arithmetic operations with suitable example

Course Outcome 4 (CO4):

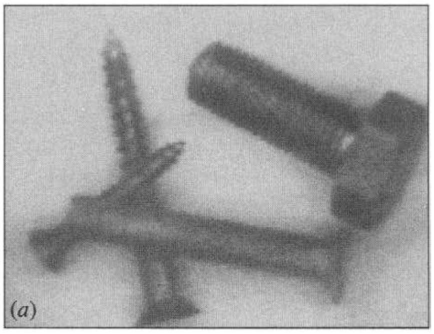
1. Select a suitable image processing technique to identify the missing component in a PCB board and explain the process involved
2. Select a suitable image processing technique to verify the hole shape and diameter of a punched panel

Course Outcome 5 (CO5):

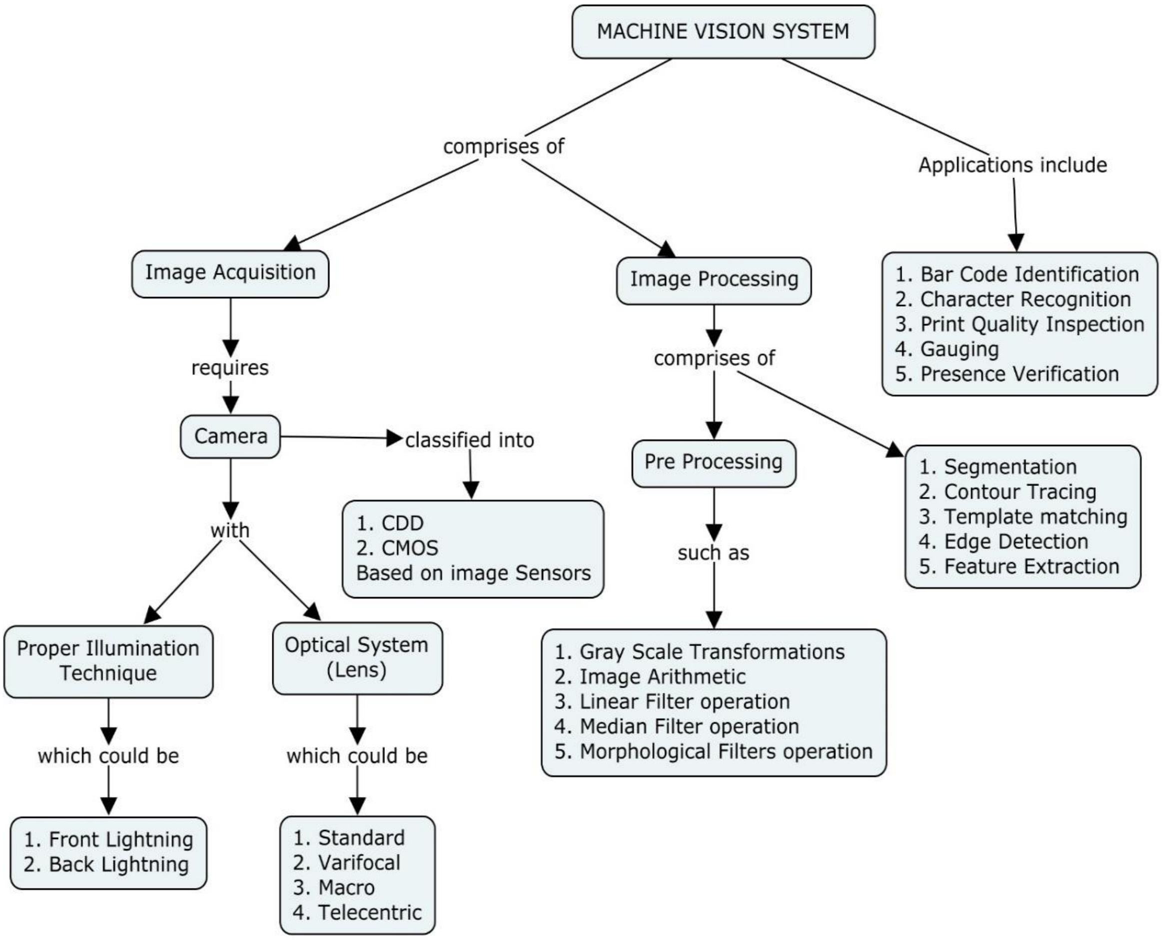
1. Design a machine vision system to measure the dimensions of the threaded part moving in a slow speed conveyor as shown in figure



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: Bar Code Identification - Character Recognition – Print Quality Inspection – Gauging – Presence Verification – Surveillance

Reference Book(s)

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,** Second Edition, Prentice Hall India, 2005
3. Alexander Hornberg, **Handbook of Machine Vision**, Wiley VCH, 2006

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Introduction – Structure of Image Processing Systems - Possibilities and Limitations	1
1.2	Types of Inspection Tasks – Examples	1
2	**Image Acquisition**	
2.1	Solid State Sensors: Operation of Charge Coupled Device (CCD)	2
2.2	Solid State Sensors: Operation of Complementary Metal Oxide Semiconductor (CMOS) Sensors	2
2.3	Color Sensors – Properties of Sensors	1
3	**Illumination Technology**	
3.1	Optical foundations: f number	1
3.2	Laws of Imaging	2
3.3	Depth of field - Typical Capturing Situations	1
3.4	Aberrations - Lens Determination – Special Lens Types	2
3.5	Illumination: Light Sources - Front Lighting	2
3.6	Illumination: Light Sources - Back Lighting	1
4	**Image Pre-processing**	
4.1	Gray Scale Transformations	2
4.2	Image Arithmetic	1
4.3	Linear Filters - Median Filter	2
4.4	Morphological Filters	1
5	**Image Processing**	
5.1	Segmentation: Regions of Interests (ROIs)	1
5.2	Binary Segmentation	2
5.3	Contour Tracing	2
5.4	Template matching	2
5.5	Edge Detection	1
5.6	Feature Extraction: Basic Geometric Features	1
6	**Applications**	
6.1	Bar Code Identification, Character Recognition	2
6.2	Print Quality Inspection, Gauging	2

Module No.	Topic	No. of Lectures
6.3	Presence Verification, Surveillance	1
Total		**36**

Course Designers

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18MCPF0 MICRO ELECTRO MECHANICAL SYSTEM

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

Preamble

Micro Electro Mechanical System (MEMS) contains components of sizes less than 1 millimeter. 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

Nil

Course Outcomes

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

CO1	Explain the characteristics and application of MEMS and Microsystems	Understand
CO2	Solve problems in scaling laws applicable to miniaturization.	Apply
CO3	Explain the working principle of MEMS sensors	Understand
CO4	Describe the working principle of MEMS actuators	Understand
CO5	Select appropriate micromachining process for fabricating MEMS devices and model MEMS device	Apply

Mapping with Program Outcomes

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

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	60	60	60	60
Apply	20	20	20	20
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define the term MEMS.
2. Define shape memory alloys.
3. Write note on the Characteristics of MEMS.
4. Explain in detail the application of MEMS in aerospace industry.
5. With neat diagram explain the functioning of micro pressure sensor.

Course Outcome 2 (CO2):

1. Write the scaling formula for a simple rectangular block.
2. Explain in detail, the Trimmer matrix to represent force scaling with related acceleration, time and power density required for scaling of systems in motion.
3. Give a report on scaling in heat conduction and heat convection.
4. 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.
5. Estimate the variation of the total heat flow and the time required to transmit heat in a solid with a reduction of size by factor of 10. What will happen if the solid is of sub micro meter level?

Course Outcome 3 (CO3):

1. Discuss how the Comb-drive accelerometer works.
2. Describe the working principle of resitive pressure sensor.
3. Explain Thermal Bimorph.
4. Illustrate the working principle of piezo electric force sensor.

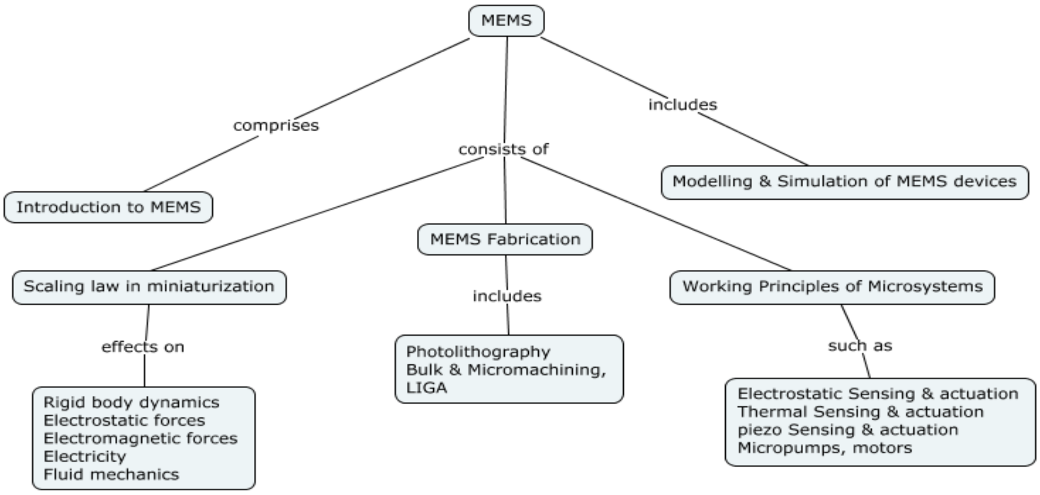
Course Outcome 4 (CO4):

1. Discuss how the piezoelectric actuator works.
2. Illustrate the working principle of micro motor.
3. Explain about microgripper.
4. Describe about the working of Magnetic actuators.

Course Outcome 5 (CO5):

1. Explain the general procedure of photolithography. Use neat diagrams.
2. Explain the LIGA process for MEMS fabrication.
3. Discuss about bulk-micromachining process.
4. Illustrate the fabrication process for Micro channel heat sink

Concept Map



Syllabus

Introduction to MEMS: Micro-Electro-Mechanical Systems (MEMS) and Microsystems, Intrinsic Characteristics of MEMS, Applications: Healthcare, Aerospace, Industrial & Consumer Products, Market for MEMS, Micro mechatronics, Overview of Micro fabrication, MEMS materials: Silicon, Silicon Dioxide, Silicon Nitride, Polysilicon, Silicon Carbide, Polymers, shape memory alloys - Clean rooms- Introduction to MOEMS & NEMS.

Scaling law in miniaturization: Introduction to scaling, scaling in rigid body dynamics, electrostatic forces, electromagnetic forces, electricity, fluid mechanics, heat transfer

Design Principles of Sensors and Actuators: Conductometric sensors, Capacitive sensors, Piezoelectric sensors, Magnetostrictive sensors, Piezoresistive sensors, Optical sensors, Acoustic sensors. Electrostatic comb-drive,Thermal bimorph, Magnetic actuators, micro gripper, micro motor, micro valves, micro pumps

MEMS Fabrication: Photolithography, bulk micromachining, surface micromachining, LIGA process **Modelling & simulation of MEMS Devices:** cantilever beam, Micro pressure sensor, Micro channel heat sink, and accelerometer

Reference Book(s)

1. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan “Smart Material Systems and MEMS: Design and Development Methodologies”,Wiley India, 2011
2. Tai –Ran Hsu, “MEMS and Microsystem: Design and Manufacture”, Tata McGraw Hill, First Edition, 2002.
3. Chang Liu , “Foundation of MEMS”, 2nd Edition, Pearson education, 2012.
4. Thomas M. Adams, Richard A. Layton “Introductory MEMS: Fabrication and Applications”, Springer, 2010
5. 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
6. Gad El Hak (Editor), “The MEMS Hand Book”, Three volume set, 2nd revised Edition, CRC press, 2005
7. Julian W. Gardner, Vijay K. Varadan, Osama O. Awadelkarim “Microsensors, MEMS, and smart devices”, 1st edition, John Wiley & Sons, Ltd, 2001

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction to MEMS**	
1.1	Micro-Electro-Mechanical Systems (MEMS) and Microsystems	1
1.2	Intrinsic Characteristics of MEMS, Applications: Healthcare, Aerospace, Industrial & Consumer Products	2
1.3	Market for MEMS,	1
1.4	Micro mechatronics	1
1.6	MEMS materials: Silicon, Silicon Dioxide, Silicon Nitride, Polysilicon, Silicon Carbide, Polymers, shape memory alloys- Clean rooms	3
1.7	Introduction to MOEMS & NEMS.	2
2	**Scaling law in miniaturization**	
2.1	Introduction to scaling,	1
2.2	Scaling in rigid body dynamics,	1
2.3	Electrostatic forces,	1
2.4	Electromagnetic forces, electricity	2
2.5	Fluid mechanics	2
2.6	Heat transfer	1
3	**Working Principles of Microsystems**	
3.1	Conductometric sensors, Capacitive sensors,	2
3.2	Piezoelectric sensors, Magnetostrictive sensors,	2
3.3	Piezoresistive sensors, Optical sensors, Acoustic sensors.	2
3.4	Electrostatic comb-drive,	1
3.5	Thermal bimorph	1
3.6	Magnetic actuators, Microgripper	1
3.7	micro motors- micro valves- micro pumps	2
4	**MEMS Fabrication**	
4.1	Photolithography**,** bulk micromachining, surface micromachining, LIGA process	3
4.2	**Modelling & simulation of MEMS Devices:** Cantilever beam	1
4.3	Micro pressure sensor	1
4.4	Micro channel heat sink	1
4.5	Accelerometer	1
	Total	36

Course Designers

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18MCPH0	**AUTOMOTIVE ELECTRONICS**	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

Automotive electronics is a discipline that involves multidisciplinary integration of automotive mechanical and electronic systems. It includes automotive-specific mechanics, electronics, and communication, advanced control and modelling. The course deals with all the aspects of automotive Mechatronics, especially in transmission, braking, steering, cruise, traction, suspension and stability. Some of the main applications of Mechatronics are introduced. The students would be able to understand the basic dynamics and develop the equations according to the vehicle conditions

Prerequisite

Nil

Course Outcomes

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

CO1	Explain the fundamental of automotive vehicle	Understand
CO2	Explain the fuel supply system of different vehicle.	Understand
CO3	Describe the working of sensors used in modern cars.	Understand
CO4	Select the suitable sensor for vehicle Safety system.	Apply
CO5	Illustrate the use of Engine Management and Control of Electric and hybrid vehicles	Understand
CO6	Choose the Intelligent Vehicle System for various environmental conditions	Apply

Mapping with Program Outcomes

Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	S	L	L	L	-	L	-	-	S	L	S
CO2	M	M	L	L	-	S	-	-	L	L	L
CO3	S	M	L	L	L	-	-	-	M	-	L
CO4	S	S	M	S	M	-	-	-	L	-	L
CO5	M	L	L	L	L	L	-	-	M	-	L
CO6	M	S	M	S	M	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	20
Understand	50	50	50	50
Apply	30	30	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the various types of suspension
2. Describe the purpose of ABS system. How is it different from conventional braking.
3. Review the function of Four-Wheel Steering Systems
4. List the four methods of Four-wheel steering system.

Course Outcome 2 (CO2):

1. Define lambda sensor
2. State five advantages of fuel injection.
3. Describe briefly the purpose of each component of fuel injection system.

Course Outcome 3 (CO3):

1. Explain the working of crankshaft angular position sensor with neat sketch.
2. Write short note on brake fluid level sensor.
3. Discuss about strain gauge MAP sensor.

Course Outcome 4 (CO4):

1. Define impact sensing.
2. Illustrate the rain sensing and wiper activation system.
3. State what is meant by active and passive Safety

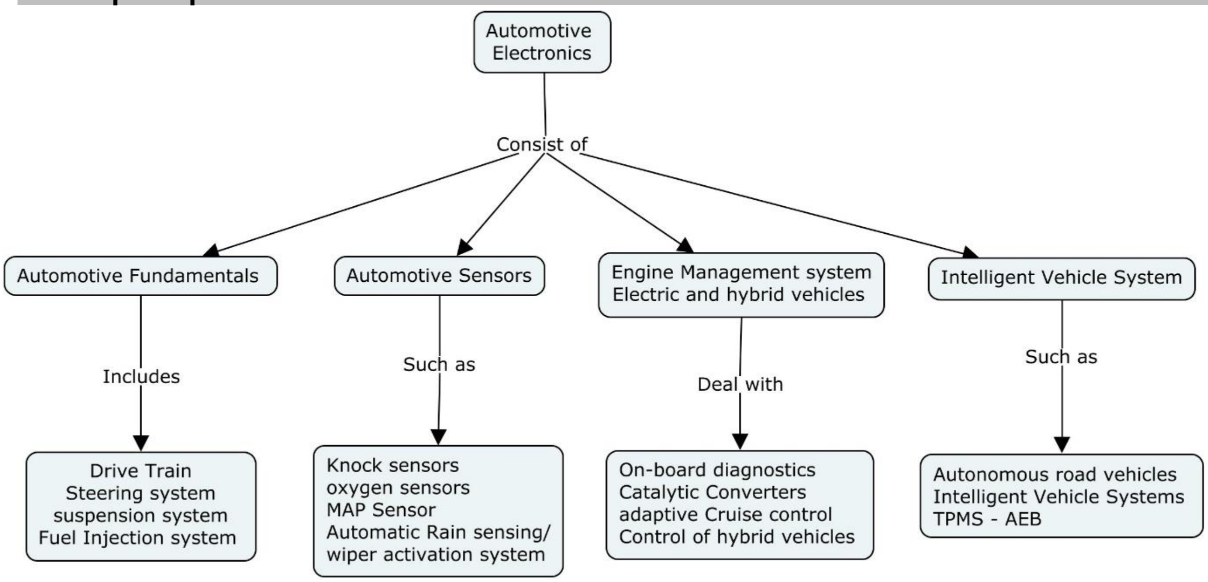
Course Outcome 5 (CO5):

1. Describe the purpose of on-board diagnostics (OBD).
2. Describe about emission management in engine control system.
3. State four methods of reducing diesel engine emissions.
4. Describe briefly the term ‘Hybrid’.
5. List five types of EV batteries.

Course Outcome 6 (CO6):

1. Define AEB.
2. Discuss in detail about adaptive Cruise Control.
3. Discuss about the working of tire pressure monitoring system.

Concept Map



Syllabus

Automotive Fundamentals

Engine Components – Drive train – suspension system, ABS, Steering System - Fuel Injection system - components, electronic fuel injection –Throttle body versus Port Injection - MPFI-CRDI. Fuel Ignition System – Electronic ignition system – operation – types – Battery, magneto ignition systems – Electronic spark timing control

Automotive Sensors

Knock sensors, oxygen sensors, crankshaft angular position sensor, temperature sensor, speed sensor, Pressure sensor, Mass air flow sensor, Manifold Absolute Pressure Sensors, crash sensor, Coolant level sensors, Brake fluid level sensors – operation, types, characteristics, advantage and their applications - Automatic Rain sensing/wiper activation system, drowsy-driver sensing system, Active Safety Sensor systems, Passive Sensor Safety system - Side Impact sensing, front impact sensing system.

Engine Management system

On-board diagnostics, Exhaust emission control, Catalytic Converters, New Developments in engine management, adaptive Cruise control

Control of Electric and hybrid vehicles

Electric Vehicle - batteries electric motor and controller, regenerative braking – Control of hybrid vehicles – CNG electric hybrid vehicle – Hybrid Vehicle case studies – Battery Management.

Intelligent Vehicle System

Vision based autonomous road vehicles, Object detection, Collision warning and avoidance system – Tyre pressure warning system, security systems, Emergency Electronic braking. Intelligent Vehicle Systems – Unmanned ground vehicles, Vehicle Platooning- infotainment system - Communication networks-CAN, LIN, MOST, V2X .

Reference Book(s)

1. William B.Ribben, Understanding Automotive Electronic: An Engineering Perspective (2012), Elsevier Science.
2. Tom Denton, Automobile Electrical and Electronic systems (2013), Rouletedge, Taylor & Francis Group.
3. Gianfranco Pistoia, Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market (2010), Elsevier.
4. Ronald K.Jurgen, Electric and Hybrid-electric vehicles (2011), SAE International.
5. Ronald K Jurgen, “Automotive Electronics”, by McGraw Hill, second edition. (Original edition- 1999).

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Automotive Fundamentals**	
1.1	Engine Components – Drive train	2

1.2	suspension system, ABS, Steering System	1
1.3	Fuel Injection system – components F	1
1.4	electronic fuel injection - Throttle body versus Port Injection-	1
1.5	MPFI- CRDI. Fuel Ignition System	1
1.6	Electronic ignition system – operation – types – Battery,	1
1.7	magneto ignition systems – Electronic spark timing control	1
2	**Automotive Sensors**	
2.1	Knock sensors, oxygen sensors, crankshaft angular position sensor	2
2.2	temperature sensor, speed sensor, Pressure sensor	2
2.3	Mass air flow sensor, Manifold Absolute Pressure Sensors	2
2.4	crash sensor, Coolant level sensors, Brake fluid level sensors	2
2.5	Automatic Rain sensing/wiper activation system, drowsy-driver sensing system	2
2.6	Active Safety Sensor systems	1
2.7	Passive Sensor Safety system	1
2.8	Side Impact sensing, front impact sensing system.	1
3	**Engine Management system**	
3.1	On-board diagnostics, Exhaust emission control,	2
3.2	Catalytic Converters - New Developments in engine management,	2
3.3	adaptive Cruise control	1
4	**Control of Electric and hybrid vehicles**	
4.1	Electric Vehicle - batteries electric motor and controller, regenerative braking	2
4.2	Control of hybrid vehicles – CNG electric hybrid vehicle	1
4.3	Hybrid Vehicle case studies - Battery Management.	1
5	**Intelligent Vehicle System**	
5.1	Vision based autonomous road vehicles, Object detection, Collision warning and avoidance system	2
5.2	Tyre pressure warning system, security systems	1
5.3	Emergency Electronic braking, Intelligent Vehicle Systems	1
5.4	Unmanned ground vehicles, Vehicle Platooning.	1
5.5	Infotainment system - Communication networks-CAN, LIN, MOST, V2X	1
	Total	36

Course Designers

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18MCPI0	AUTONOMOUS MOBILE ROBOTS	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

Autonomous Vehicles are self-governing vehicle, capable of sensing and navigate its own path for destination. Autonomous vehicles are broad scope of area which integrate computer vision, control system and sensory networks that driven the electrical drivers. Currently this field create a broad resources for surveillance and oppression.

Prerequisite

Nil

Course Outcomes

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

CO1	Derive the kinematics model and wheel kinematics model for different mobile robots.	Understand
CO2	Explain the classifications and operation of mobile robots locomotion.	Understand
CO3	Select appropriate sensors and implementation in mobile robots for given application.	Apply
CO4	Illustrate various localization and mapping techniques for mobile robots.	Apply
CO5	Implement path planning and navigation techniques for various case study conditions.	Apply

Mapping with Programme Outcomes

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

S - Strong M – Medium L - Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	-	20
Understand	40	40	-	40
Apply	40	40	100	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Note: CAT 3 will conduct as Product based assessment pattern technique where students individually submit application prototype and defend the application through presentation.

Course Level Assessment Questions.

Course Outcome 1(CO1):

1. Describe robot motion on terms of component motion by mapping motion along the axes of the global reference frame to motion along the axes of the robot's local reference frame.
2. Explain forward kinematic models.
3. Consider the situation shown in figure 1, with an arbitrary position and orientation of the robot and a predefined goal position and orientation. The actual pose error vector given in the robot reference frame is with, and being the goal coordinates of the robot.

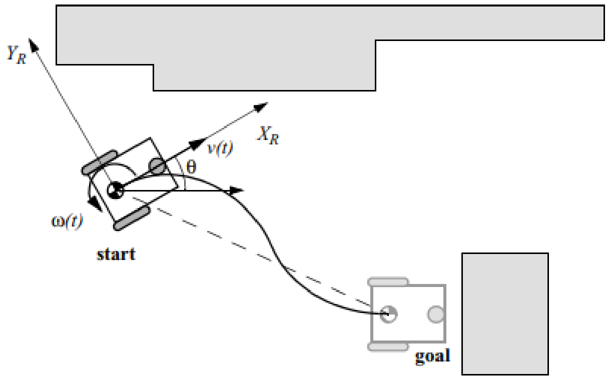


Fig-1

Course Outcome 2 (CO2):

1. With use of simple sketches, explain the working of castor wheel for steering a mobile robot.
2. Explain the classification of the sensors used in robotic applications.
3. List some Key issues of locomotion.

Course Outcome 3 (CO3):

1. Select suitable sensors to identify the obstacles and overcome the obstacles by controlling the robot actuators for following environment shown in Fig-2. Also every 1m distance the robot will generate signal to the remote area operator.

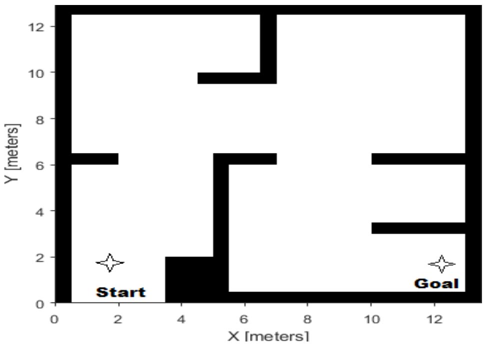


Fig-2

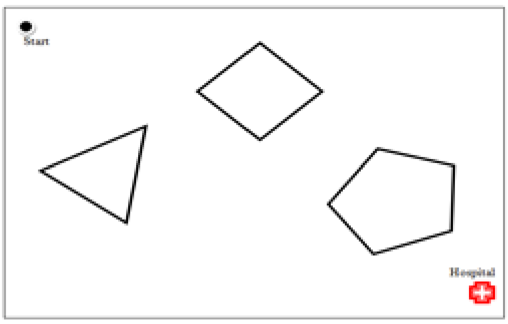


Fig-3

2. Calculate the dynamic range of current sensor which measures motor current and register values from a minimum of 1mA to 20Amps.
3. Select suitable sensor to measure the internal state and dynamics of a mobile robot.

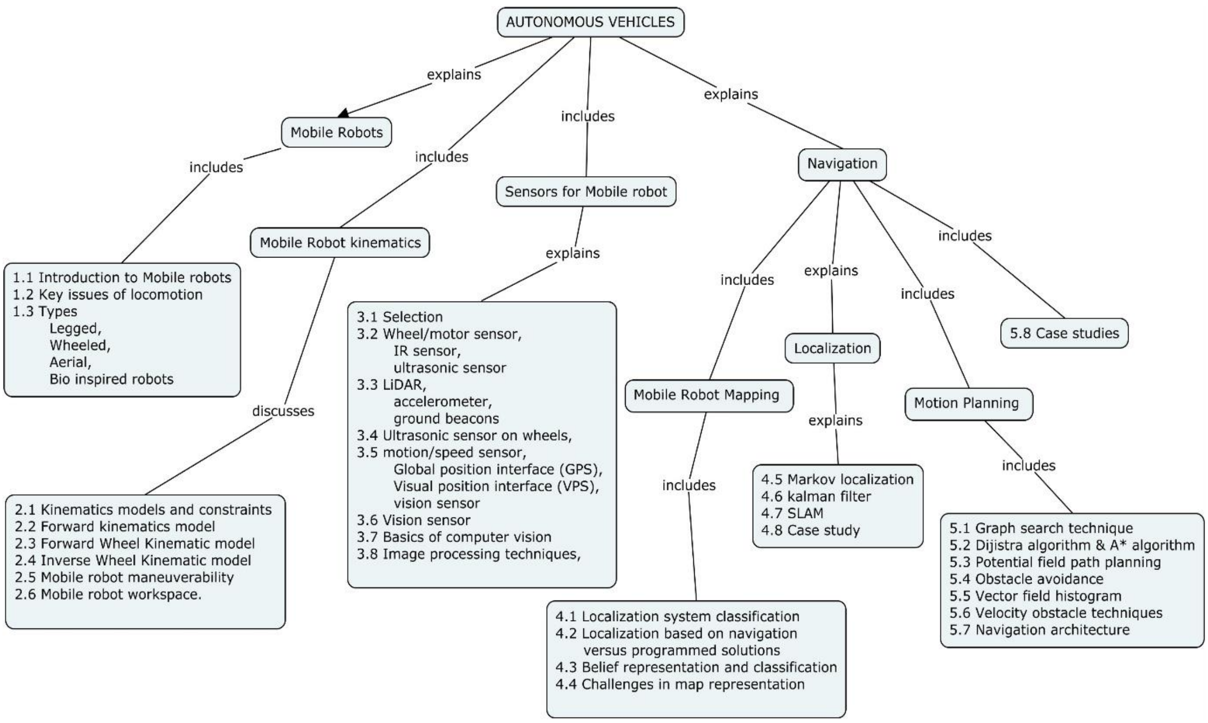
Course Outcome 4 (CO4):

1. A two axis robot is to be used to carry the patient from home location to hospital as shown in the below figure 3. Select a suitable graph search and Cell decomposition technique along with algorithm to overcome the obstacles and find the best path to reach the hospital at short time.
2. Select the suitable mapping technique for map building and maintenance into the standard localization loop using kalman filter localization.
3. Choose the appropriate technique used to correct the error produced in global map because of significant local error.

Course Outcome 5 (CO5):

1. A robot has three IR range sensor, four controlled front and rear wheel motors. Develop a pseudo code of algorithm for keep moving the robot to reach destination. Also explain the control of motors using flow chart. (Select your own environment with static and dynamic obstacles)
2. Illustrate the working for bug algorithm.
3. Apply potential field path planning for the given environment in fig-3.

Concept Map



Syllabus

Introduction: Introduction to Mobile robots – key issues of locomotion – Types- Legged, Wheeled, Aerial, Bio inspired robots. **Mobile Robot kinematics:** Kinematics models and constraints – Forward kinematics model- Wheel Kinematic model- Classification- Forward Wheel Kinematic model, Inverse Wheel Kinematic- Mobile robot maneuverability- Mobile robot workspace.

Sensors for Mobile robot: Sensor classification on perception- wheel/motor sensor, IR sensor, ultrasonic sensor, LiDAR, accelerometer, ground beacons, motion/speed sensor, Global position interface (GPS), Visual position interface (VPS), vision sensor- Fundamentals of computer vision-Image processing.

Mobile Robot Mapping and Localization: localization system –Localization based on navigation versus programmed solutions-Belief representation and classification- challenges in map representation- classifications of probabilistic map-based localization-Markov localization, kalman filter localization-Autonomous Map building SLAM and classifications-case study about mapping.

Motion Planning and Navigation: Path and Motion Planning- Path Planning – graph search, A* algorithm, Dijistra algorithm, Potential field path planning. Obstacle avoidance – bug algorithm, vector field histogram, velocity obstacle techniques. Navigation architecture, Case studies on navigation architecture

Reference Books

1. Ronald siegwart, Illah R.nourbakhsh, Davide scaramuzza," Introduction to Autonomous Mobile Robots",MIT Press Publication,2nd edition,2011.
2. S. M. LaValle. "Planning Algorithms". Cambridge University Press, Cambridge, UK, 2004.
3. Andon Venelinov Topalov, "Recent Advances in Mobile Robotics", published by InTech, Chapters published December 14, 2011
4. https://www.edx.org/course/autonomous-mobile-robots

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction to Mobile Robots**	
1.1	Introduction to Mobile robots	1
1.2	Key issues of locomotion –	1
1.3	Types- Legged, Wheeled, Aerial, Bio inspired robots.	1
2	**Mobile Robot kinematics**	
2.1	Kinematics models and constraints	1
2.2	Forward kinematics model	1
2.3	Forward Wheel Kinematic model	1
2.4	Inverse Wheel Kinematic model	1
2.5	Mobile robot maneuverability- Mobile robot workspace.	1
3	**Sensors for Mobile robot**	

Module No.	Topic	No. of Lectures
3.1	Selection of sensors for mobile robots – Classification, performance	1
3.2	Wheel/motor sensor, IR sensor, ultrasonic sensor	1
3.3	LiDAR, accelerometer, ground beacons	1
3.4	Ultrasonic sensor on wheels,	1
3.5	motion/speed sensor, Global position interface (GPS), Visual position interface (VPS), vision sensor	1
3.6	Vision sensor	1
3.7	Basics of computer vision	1
3.8	Image processing techniques,	2
4	**Mobile Robot Mapping and Localization**.	
4.1	Localization system classification	1
4.2	Localization based on navigation versus programmed solutions	1
4.3	Belief representation and classification	1
4.4	Challenges in map representation	1
4.5	Markov localization	1
4.6	kalman filter localization	1
4.7	Autonomous Map building SLAM and classifications	1
4.8	Case study about localization systems	2
5	**Motion Planning and Navigation**	
5.1	Path Planning – Graph search technique	2
5.2	Dijistra algorithm & A* algorithm	1
5.3	Potential field path planning	1
5.4	Obstacle avoidance – bug algorithm	1
5.5	Vector field histogram	1
5.6	Velocity obstacle techniques	1
5.7	Navigation architecture	1
5.8	Case studies on navigation architecture.	2
	Total Hours	**36**

Course Designers:

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18MCPJ0 INTELLIGENT MOTION CONTROL 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

- 18MCPA0 - Principles of Mechanical systems
- 18MC120 - Sensors and actuators
- 18MC170 - Automation and Control Lab

Course Outcomes

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

CO1	Explain the basic structure of the position, speed and torque control in drives.	Understand
CO2	Design and evaluate the digital position control of drives.	Apply
CO3	Design and evaluate the digital speed control of drives	Apply
CO4	Develop the Torque control algorithms for the given application	Apply
CO5	Develop the trajectory generation and tracking algorithms.	Apply
CO6	Illustrate the effect of Torsional oscillations in drives and methods to suppress.	Understand

Mapping with Program Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	S	S	S	L	M	M	S	S	M	L
CO2	S	S	S	S	M	S	M	S	S	M	L
CO3	S	S	S	S	M	S	M	S	S	M	L
CO4	S	S	S	S	M	S	M	S	S	M	L
CO5	S	S	S	S	M	M	M	S	S	M	L
CO6	M	M	M	S	S	M	M	M	M	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	20
Understand	20	20	20	20
Apply	60	60	60	60

Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

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 kgm2 and B=0.01 Nm/(rad/s). The torque actuator gain is KM=1.Assuming the sampling time of 10 ms, obtain the pulse transfer function WP(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.

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. Brief the components of Sliding mode motion control system

Course Outcome 5 (CO5):

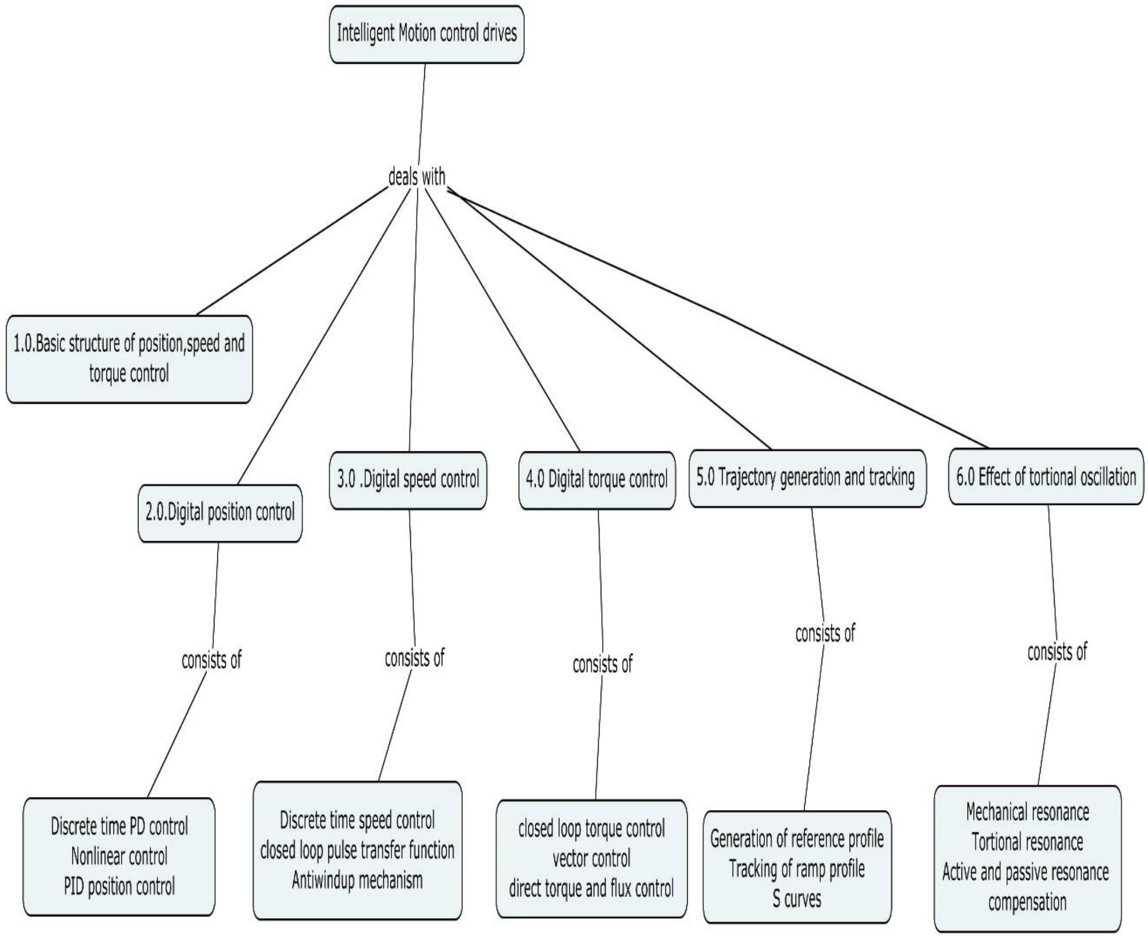
1. Develop a experimental setup for the ramp tracking of PID controller.
2. Discuss the coordinated motion in multiaxis systems
3. Explain the spline interpolation of course reference profiles.
4. Consider the linear PID position controller with proportional and derivative actions replaced in to the 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.

Course Outcome 6 (CO6):

1. Discuss the importance of anti resonant compensators.
2. Explain the closed loop response of a system with tortional oscillation.

3. Discuss the difference between active and passive resonance compensation methods.
4. A mechanical resonator consists of two rigid bodies ,each one having inertia $J=0.0001kgm^2$.They are coupled by means of a flexible shaft,with stiffness K_k=500Nm/(rad/s).The internal friction of the shaft is K_v=0.01 Nm/(rad/s).Calculate the resonant and antiresonant natural frequency and relevant damping factors.

Concept Map



Syllabus

Structure of Motion control drives-Basic structure of position controllers-structure of speed controller-structure of torque controller-structure of cascaded control.-overview of Fuzzy, neural and genetic algorithms.

Digital position control-Performance of a single axis positioners -pulse transfer function-discrete time PD position controller-Evaluation of a system with PD controller-Operation in linear and pulse transfer functions-Non linear position controller-Simulation of a system with non linear position controller-step response and band width of PD and PID controller-parameter setting of PID position controllers-simulation of input step and load step response-non linear PID position controller

Digital speed control: Discrete time implementation of speed controllers-analysis of the system with a PI discrete time speed controller-high frequency disturbances and sampling processes-closed loop system pulse transfer function-parameter setting of discrete time speed

controller-performance evaluation-response to large disturbances and the wind up phenomenon-anti windup mechanism.
Digital torque control: closed loop torque control-torque perturbation observer-vector control-direct torque and flux control methods-multivariable force control.

Motion control Algorithms: sliding mode motion control system for robot arm- -state space motion control-motion control by fuzzy systems, neural networks.

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-abrupt torque changes and mechanical resonance problems.

Torsional oscillations and its compensation: control object with mechanical resonance-closed loop response of the system with torsional oscillation-ratio between motor and load inertia-Active and passive resonance compensation methods-sustained torsional oscillations-antiresonant compensators.

Reference Book(s)

1. Ion Boldea, S.A Naser “Electric Drives” CRC Taylor & Francis group edition,2009
2. Slobodan N.Vukosavic “Digital control of electric drives” Springer international edition,2012.
3. M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, “Neural and fuzzy logic control of drives and power systems” newness publications,2002
4. Frederick F. Ling, Servo motors and industrial control theory, springer,2009.
5. Gopal k.dubey, “Power semiconductor controlled drives”, prentice hall,1988.
6. Fundamenals of Servo motion control ,Parker Hannifin – Electromechanical Automation Div.
7. Indra Motion Logic Drives ,Indra works Software User Manual Bosch Rexroth.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Structure of Motion control drives**	
1.1	Structure of position controller	1
1.2	Structure of speed controller	1
1.3	Structure of torque controller	1
1.4	Structure of cascaded control	1
1.5	Introduction to Fuzzy and neural networks	1
2	**Digital position control**	
2.1	Performance of a single axis positioners , pulse transfer function	1
2.2	Discrete time PD position controller-Evaluation of a system with PD controller	1
2.3	Operation in linear and pulse transfer functions	1
2.4	Non linear position controller-Simulation of a system with non linear position controller	1

Module No.	Topic	No. of Lectures
2.5	Step response and band width of PD and PID controller	1
2.6	Parameter setting of PID position controllers	1
2.7	Simulation of input step and load step response-non linear PID position controller	1
3	**Digital speed control**	
3.1	Discrete time implementation of speed controllers	1
3.2	Analysis of the system with a PI discrete time speed controller	1
3.3	High frequency disturbances and sampling processes	1
3.4	Closed loop system pulse transfer function-	1
3.5	Parameter setting of discrete time speed controller-performance evaluation	1
3.6	Response to large disturbances and the wind up phenomenon-anti windup mechanism.	2
4	**Digital torque control**:	
4.1	Closed loop torque control-torque perturbation observer	1
4.2	Vector control-direct torque and flux control methods	1
4.3	multivariable force control	1
4.4	Sliding mode motion control system for robot arm-	1
4.5	State space motion control-motion control by fuzzy systems, neural networks.	2
5	**Trajectory generation and tracking**	
5.1	Tracking of ramp profiles with the PID position controller	1
5.2	Steady state error in ramp profile tracking	1
5.3	Generation of reference profiles-coordinated motion in multi axis systems-	2
5.4	Trajectories with trapezoidal speed change	1
5.5	Abrupt torque changes and mechanical resonance problems.	1
6	**Torsional oscillations and its compensation**	
6.1	Control object with mechanical resonance	1
6.2	Closed loop response of the system with torsional oscillation	1
6.3	Ratio between motor and load inertia-	1
6.4	Active and passive resonance compensation methods	1
6.5	Sustained torsional oscillations-antiresonant compensators.	1
	Total	**36**

Course Designers

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18MCPK0	SOFT COMPUTING	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

Soft computing is a discipline that deals with the design of intelligent systems, which is in contrast to classical hard computing technique. A consortium of computing methodologies that provides a foundation for the conception, design, and deployment of intelligent systems and aims to formalize the human ability to make rational decisions in an environment of uncertainty, imprecision, partial truth, and approximation. The main constituents of soft computing involve fuzzy logic, neuro computing, and genetic algorithms and its applications.
Students acquire knowledge of soft computing theories, fundamentals and so they will be able to design program systems using approaches of these theories for solving various real-world problems. Students also awake the importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent machines.

Prerequisite

NIL

Course Outcomes

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

CO1	Explain the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience	Understand
CO2	Explain the basics of neural networks	Understand
CO3	Derive the mathematical background for carrying out the optimization and control associated with neural network learning	Apply
CO4	Explain the use genetic algorithm to obtain global optimum solution	Understand
CO5	Illustrate the intelligent behaviour of programs based on soft computing for various case studies	Apply

Mapping with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	L	L	L	-	-	-	-	L	M	-	-
CO2	L	L	L	-	-	-	-	L	M	-	-
CO3	M	S	S	M	S	S	-	M	M	-	L
CO4	L	L	L	-	-	-	-	L	M	-	-
CO5	M	S	S	M	S	S	-	M	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	30	30	30
Apply	40	50	50	50
Analyse	---	---	---	---

Evaluate	---	---	---	---
Create	---	---	---	---

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Give some common applications of fuzzy logic.
2. What are the parameters to be considered for the design of membership function?
3. Let $A = \{(x1, 0.2), (x2, 0.7), (x3, 0.4)\}$ and $B = \{(y1, 0.5), (y2, 0.6)\}$ be two fuzzy sets defined on the universe of discourse $X = \{x1, x2, x3\}$ and $Y = \{y1, y2, y3\}$ respectively. Find the Cartesian product of the A and B and fuzzy relation R.

Course Outcome 2 (CO2):

1. Explain multilayer perceptron with its architecture. How is it used to solve XOR Problem?
2. Explain feed forward networks with proper example

Course Outcome 3 (CO3):

1. Describe the structure and operation of continuous Hopfield network. & Construct an auto associative BAM using the following training vectors. $x1 = (1, -1, -1, 1, -1, 1)^T$ $x2 = (1, 1, 1, -1, -1, -1)^T$. Determine the output using $xo = (1, 1, 1, 1, -1, 1)^T$

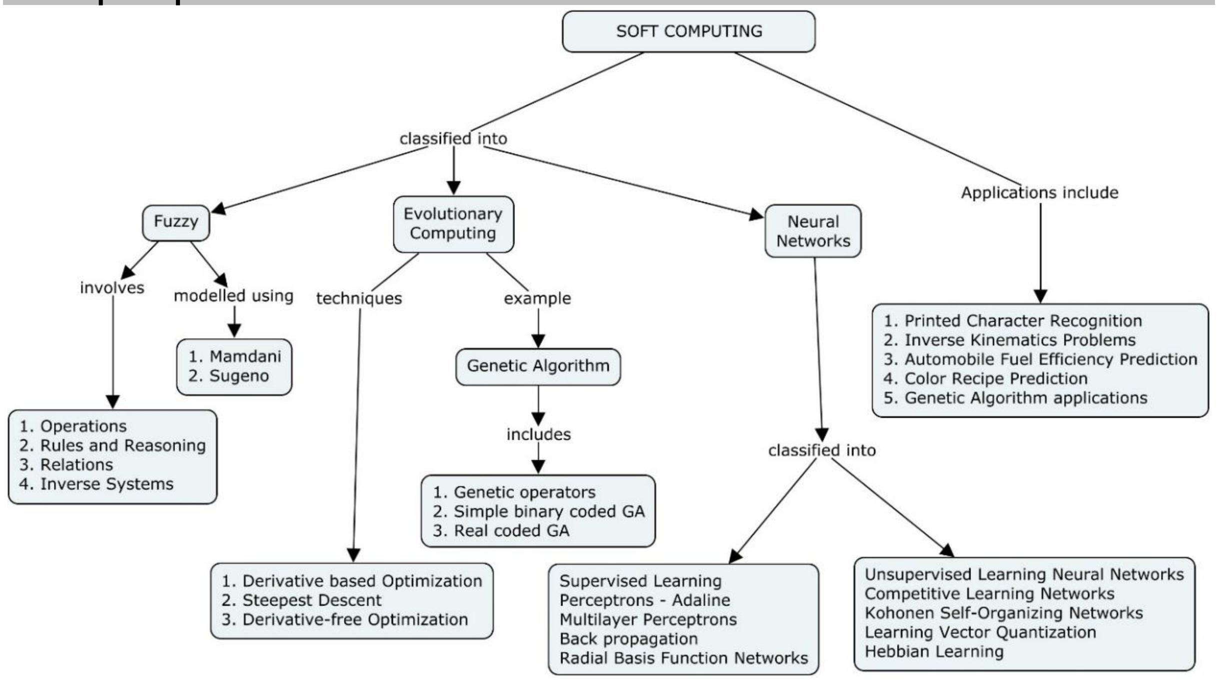
Course Outcome 4 (CO4):

1. Explain the various steps involved in GA in detail
2. Perform two generations of simple binary coded genetic algorithm to maximize the function $f(x) = x^2;\ 0 \leq x \leq 31,\ x$ is an integer

Course Outcome 5 (CO5):

1. Explain the use of soft computing in colour recipe prediction
2. Predict automobile fuel efficiency using suitable soft computing technique

Concept Map



Syllabus

Introduction: Soft Computing and Conventional Artificial Intelligence – Neural Networks – Fuzzy Set Theory – Evolutionary Computation

Fuzzy Set Theory: Fuzzy Sets – Basic Definition and Terminology – Fuzzy set operators – Fuzzy Rules and Fuzzy Reasoning – Extension Principle and Fuzzy Relations – Fuzzy Inference Systems – Mamdani Fuzzy Models – Sugeno Fuzzy Models – Fuzzy Modelling

Genetic Algorithm (GA): Introduction to optimization techniques – Derivative based Optimization – Steepest Descent – Derivative-free Optimization – Genetic Algorithms - Genetic operators: Selection, Crossover and Mutation –Simple binary coded GA - Real coded GA

Neural Networks: Introduction - Supervised Learning Neural Networks – Perceptrons - Adaline – Multilayer Perceptrons – Back propagation - Radial Basis Function Networks – Unsupervised Learning Neural Networks – Competitive Learning Networks – Kohonen Self-Organizing Networks – Learning Vector Quantization – Hebbian Learning – Support vector Machines

Applications & Case Study: Printed Character Recognition – Inverse Kinematics Problems – Automobile Fuel Efficiency Prediction – Soft Computing for Color Recipe Prediction - Genetic Algorithm application to nonlinear optimization problems

Reference Book(s)

1. J.S.R.Jang, C.T.Sun and E.Mizutani, **Neuro-Fuzzy and Soft Computing**, PHI, 2004, Pearson Education 2004
2. Melanie Mitchell Santa Fe Institute, Santa Fe, NM, **An Introduction to Genetic Algorithm**, MIT Press Cambridge, MA, USA, 1996
3. Davis E.Goldberg, **Genetic Algorithms: Search, Optimization and Machine Learning**, Addison Wesley, N.Y.
4. Timothy J. Ross, **Fuzzy Logic with Engineering Applications**, Wiley, III Edition
5. Simon Haykin, **Neural Networks A comprehensive foundation**, PHI, III Edition
6. NPTEL Link: https://nptel.ac.in/courses/106105173/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Soft Computing and Conventional Artificial Intelligence – Neural Networks	1
1.2	Fuzzy Set Theory – Evolutionary Computation	1
2	**Fuzzy Set Theory**	
2.1	Fuzzy Sets – Basic Definition and Terminology	1
2.2	Fuzzy set operators – Fuzzy Rules and Fuzzy Reasoning	2
2.3	Extension Principle and Fuzzy Relations – Fuzzy Inference Systems	1

Module No.	Topic	No. of Lectures
2.4	Mamdani Fuzzy Models – Sugeno Fuzzy Models – Fuzzy Modelling	2
3	**Genetic Algorithm (GA)**	
3.1	Introduction to optimization techniques	1
3.2	Derivative based Optimization	1
3.3	Steepest Descent – Derivative-free Optimization	1
3.4	Genetic Algorithms	1
3.5	Genetic operators: Selection, Crossover and Mutation	2
3.6	Simple binary coded GA	2
3.7	Real coded GA	2
4	**Neural Networks**	
4.1	Introduction - Supervised Learning Neural Networks	1
4.2	Perceptrons - Adaline – Multilayer Perceptrons	2
4.3	Back propagation	2
4.4	Radial Basis Function Networks	1
4.5	Unsupervised Learning Neural Networks – Competitive Learning Networks	1
4.6	Kohonen Self-Organizing Networks	1
4.7	Learning Vector Quantization	1
4.8	Hebbian Learning	1
4.9	Support vector Machines	2
5	**Applications & Case Study**	
5.1	Printed Character Recognition	1
5.2	Inverse Kinematics Problems	1
5.3	Automobile Fuel Efficiency Prediction	1
5.4	Soft Computing for Color Recipe Prediction	1
5.5	Genetic Algorithm application to nonlinear optimization problems	2
Total		**36**

Course Designers:

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18MCPL0	THERMAL PACKAGING FOR ELECTRONICS	Category	L	T	P	Credit(s)
		PE	3	0	0	3

Preamble

Appropriate thermal design has become one of the enabling factors for the realization of high-power density electronic equipment. In addition to preventing failures that may result from high temperature, smart and innovative thermal designs will increase the life expectancy. In addition, design and manufacture of microelectronic devices and systems are multidisciplinary engineering activities. With the continuous trend toward miniaturization and high-power density systems, the dependency between different design disciplines becomes more pronounced. Mechatronics being interdisciplinary branch, thermal packaging becomes more suitable subject.

Prerequisite

Nil

Course Outcomes

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

CO1	Determine Conduction heat transfer rate	Apply
CO2	Calculate convection heat transfer rate	Apply
CO3	Determine conduction and convection heat transfer from electronics components	Apply
CO4	Estimate the heat transfer from heat sinks	Apply
CO5	Determine flow and heat transfer parameters in microchannel heat sinks	Apply
CO6	Design microchannel heat sink for given application	Analyze

Mapping with Program Outcomes

Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	S	S	M	M	M	M	L	L	L	L	L
CO2	S	S	M	M	M	M	L	L	L	L	L
CO3	S	S	M	M	M	S	L	L	L	L	L
CO4	S	S	M	M	M	S	L	L	L	L	L
CO5	S	S	M	M	M	S	L	L	L	L	L
CO6	S	S	S	S	S	S	L	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	20
Understand	30	30	30	30
Apply	50	50	30	30
Analyse	-	-	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

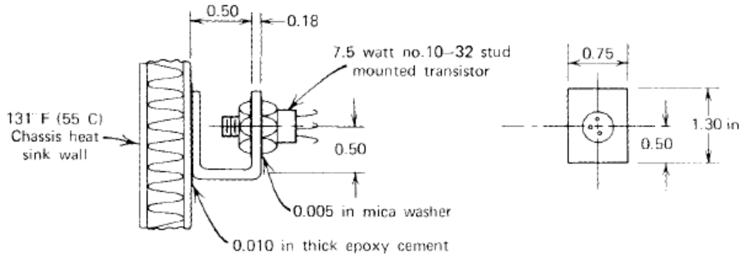
Course Level Assessment Questions

Course Outcome 1 (CO1):

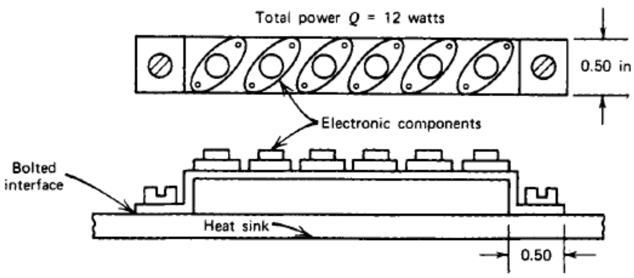
1. Explain the cooling requirements of electronic equipment for Airplanes, Missiles, Satellites, and Spacecraft, Ships, Submarines.
2. Explain the Cooling Specifications for Electronics
3. Explain the Humidity Considerations in Electronic Boxes.
4. What are popular types of Conformal Coatings?
5. Explain the Sealed Electronic Boxes.

Course Outcome 2 (CO2)

1. Determine the mounting surface temperature on the case of a transistor that is bolted to an aluminum bracket (5052 aluminum) as shown in Fig. The bracket is cemented to a heat sink wall, which is maintained at a temperature of 55°C. The transistor has a mica insulator at the mounting interface, and the power dissipation is 7.5 watts. Radiation and convection heat transfer from the assembly are small and can be ignored.

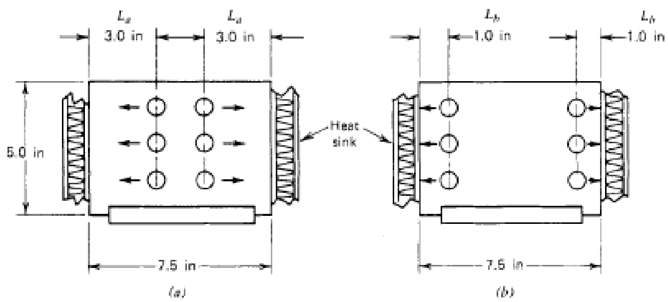


2. A series of flat pack integrated circuits are to be mounted on a multilayer printed circuit board (PCB) as shown in Figure 3.2. Each flat pack dissipates 100 milliwatts of power. Heat from the components is to be removed by conduction through the printed circuit copper pads, which have *2* ounces of copper [thickness is 0.0028 in (0.0071 cm)]. The heat must be conducted to the edges of the PCB, where it flows into a heat sink. Determine the temperature rise from the center of the PCB to the edge to see if the design will be satisfactory.
3. Determine the temperature rise across the bolted interfaces of an aluminum bracket that is bolted to a chassis side wall. The bolts will produce an interface pressure of 200 lb/in2 (14,074 g/cm2), as shown in Fig. The total power dissipation of the components on the bracket is 12 watts. The surface roughness at the bolted interfaces is about 65 pin rms. The bracket is in a confined area where very little heat will be lost by convection or radiation**.**

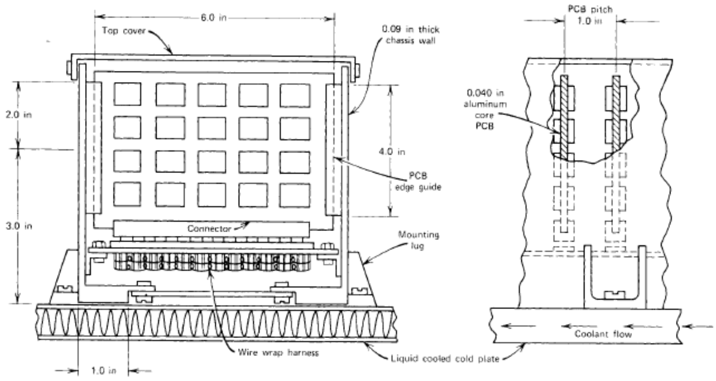


Course Outcome 3 (CO3)

1. Several power transistors. which dissipate *5* watts each, are mounted on a power supply circuit board that has a 0.093 in (0.236 cm) thick 5052 aluminum heat sink plate, as shown in Figure 4.9. Determine how much lower the case temperatures will be when these components are mounted close to the edge of the PCB, as shown in Fig, instead of the center, as shown in Fig.

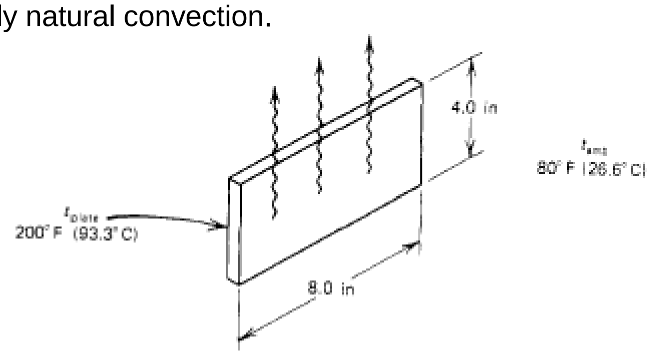


2. An electronic chassis, with many plug-in types of PCBs, is to be bolted to a liquid cooled cold plate because the system must be capable of operating at an altitude of 100,000 ft (30,480 m). Conduction cooling is the only reliable method of cooling, because natural convection is sharply reduced at high altitudes. In addition. there are other warm electronic boxes in the same equipment bay, which will prevent effective cooling by radiation. The PCBs will be populated with flat pack integrated circuits. These will be uniformly distributed, with a total power dissipation of 8 watts for each board, as shown in Fig. Components are mounted on both sides of a PCB which has an aluminum heat sink core at the center. The maximum allowable component case temperature is 212°F (100°C). Determine if the proposed design is satisfactory.

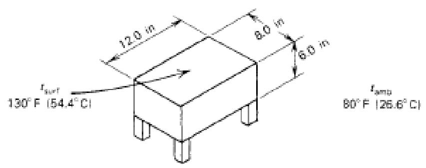


Course Outcome 4 (CO4)

1. Determine the amount of heat that can be camed away from the vertical plate shown in Fig. considering only natural convection.

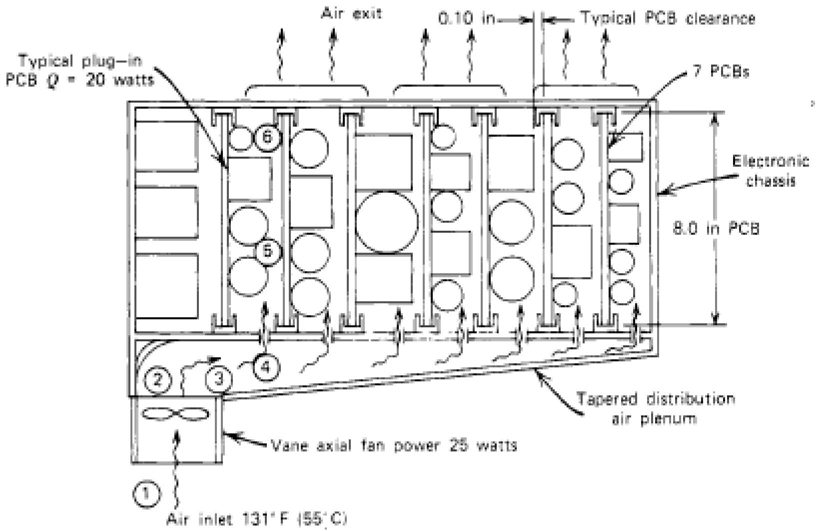


2. Determine the amount of heat that is lost by natural convection from the external surfaces of the box shown in Fig. The surface temperature is relatively uniform at 130°F and the ambient temperature is 80°F at sea level conditions. The box is aluminum with an iridited (or chromate) finish that has a low emissivity. So that heat lost by radiation is small and is ignored here.

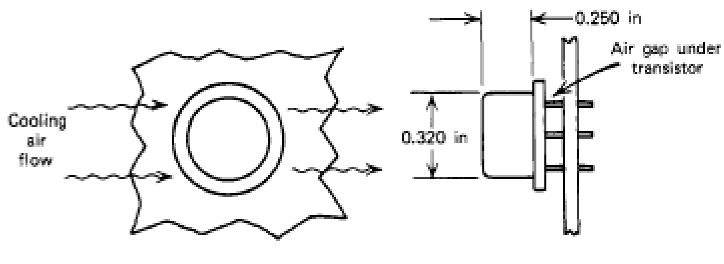


Course Outcome 5 (CO5)

1. The axial flow fan shown in Figure 6.1 has an air inlet velocity of 3500 ft/min (1778 cm/sec). It is estimated that the turbulence and contraction in the air at the entrance to the fan will result in a static loss of about 1.5 velocity heads. Determine the static head loss in terms of the height of a column of water.
2. Determine the pressure drop characteristics of the electronic box in Fig. and determine a fan size for the system. The system must be capable of continuous operation in a 131°F (55°C) ambient at sea level conditions. The maximum allowable hot spot component surface temperature is limited to 212°F (100°C). The system contains seven PCBs, each dissipating 20 watts, for a total power dissipation of 140 watts. This does not include the fan power dissipation.



3. A 2N2905 transistor (TO-5 case size) dissipates 0.25 watt under steady state power conditions in **a** 160°F (71°C) ambient environment. The transistor is mounted above the circuit board as shown in Fig. Determine the case temperature when the air velocity over the transistor is 250 ft/min.

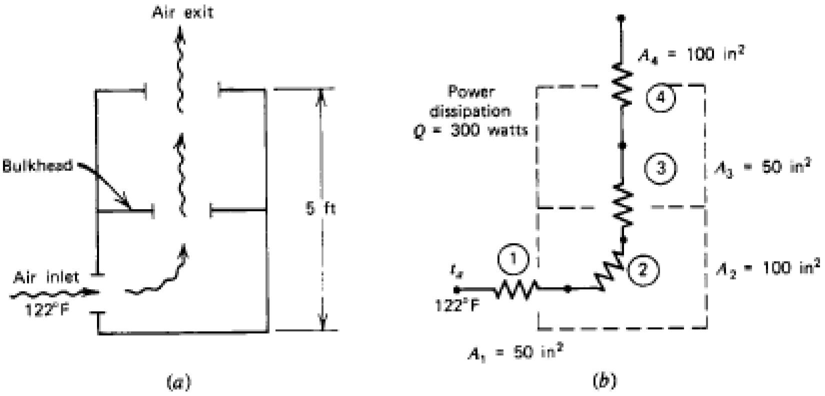


Course Outcome 6 (CO6)

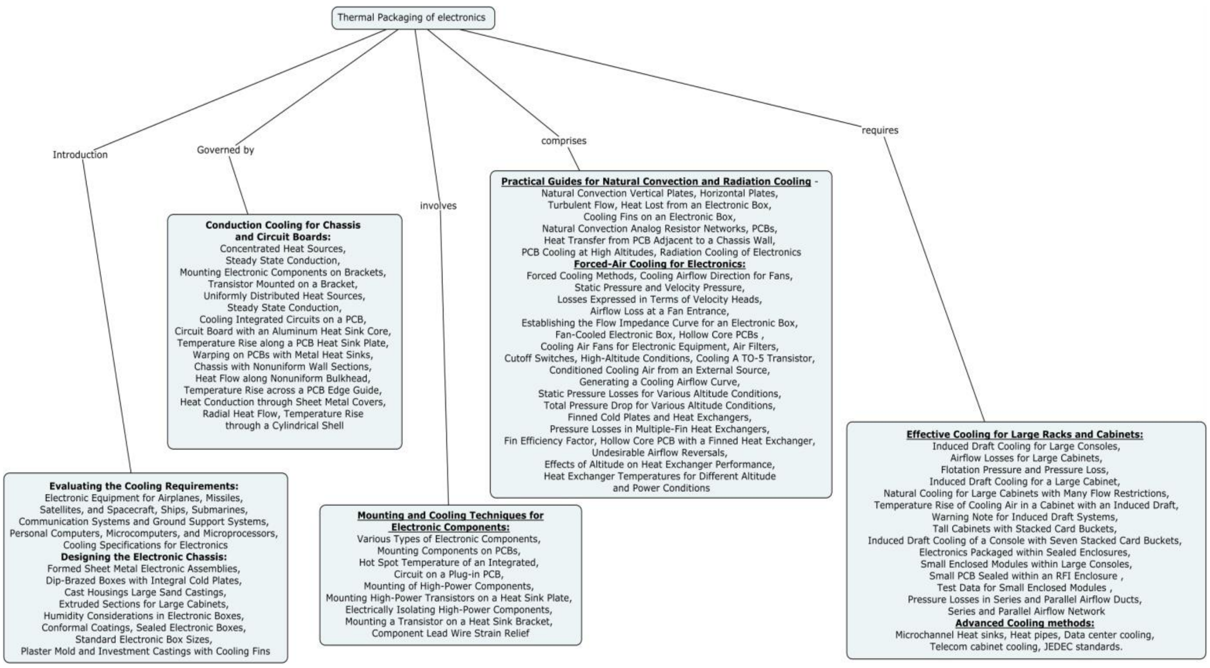
1. A 6 ft tall (182.9 cm) cabinet must operate in a 100°F (37.8"C) ambient temperature, with a uniformly distributed heat load of 500 watts along its height. The cabinet is 19 in (48.2 cm) wide, with a free flow path of 100 in2 (645.2 cm2) area through the center of the cabinet, as shown in Figure 11.2. Determine the temperature rise of the cooling air and the cooling airflow rate through the cabinet.
2. A PCB is mounted within a sealed enclosure to provide protection against radio frequency interference (RFI). The small sealed enclosure is mounted within a large console that is cooled by forced convection. The average velocity of the cooling air through the console is about 150 ft/min. The modules are spaced 0.10 in (0.254 cm) apart. Each module measures 5.0 in (12.7 cm) high x 5.5 in (13.97 cm) deep x 1.5 in (3.81 cm) thick and dissipates about 4.0 watts, as shown in Figure 11.14. The maximum cooling air temperature expected at sea level conditions is 122°F (5O^{O}C). The inside surface of the PCB enclosure is painted black to improve its radiation heat transfer. Determine the

approximate hot spot temperature of the PCB surface and the enclosure surface when the cooling air temperature is 122°F.

3. A 5.0 ft tall console with a 300 watt uniformly distributed power dissipation must operate in a 122°F ambient. There are three flow restrictions, one at the inlet, one at a center bulkhead, and one at the exit, as shown in Fig. The flow restrictions are shown as flow resistors for the mathematical model in Fig. Using induced draft cooling, determine the temperature rise of the cooling air as it rises through the cabinet. Also determine the cfm flow and the pressure drop through the cabinet.



Concept Map



Syllabus

Evaluating the Cooling Requirements: Electronic Equipment for Airplanes, Missiles, Satellites, and Spacecraft, Ships, Submarines, Communication Systems and Ground Support Systems, Personal Computers, Microcomputers, and Microprocessors, Cooling Specifications for Electronics

Designing the Electronic Chassis: Formed Sheet Metal Electronic Assemblies, Dip-Brazed Boxes with Integral Cold Plates, Die Cast Housings Large Sand Castings, Extruded Sections for Large Cabinets, Humidity Considerations in Electronic Boxes, Conformal Coatings, Sealed Electronic Boxes, Standard Electronic Box Sizes, Plaster Mold and Investment Castings with Cooling Fins

Conduction Cooling for Chassis and Circuit Boards: Concentrated Heat Sources, Steady State Conduction, Mounting Electronic Components on Brackets, Transistor Mounted on a Bracket, Uniformly Distributed Heat Sources, Steady State Conduction, Cooling Integrated Circuits on a PCB, Circuit Board with an Aluminum Heat Sink Core, Temperature Rise along a PCB Heat Sink Plate, Warping on PCBs with Metal Heat Sinks, Chassis with Nonuniform Wall Sections, Heat Flow along Nonuniform Bulkhead, Temperature Rise across a PCB Edge Guide, Heat Conduction through Sheet Metal Covers, Radial Heat Flow, Temperature Rise through a Cylindrical Shell

Mounting and Cooling Techniques for Electronic Components: Various Types of Electronic Components, Mounting Components on PCBs, Hot Spot Temperature of an Integrated, Circuit on a Plug-in PCB, Mounting of High-Power Components, Mounting High-Power Transistors on a Heat Sink Plate, Electrically Isolating High-Power Components, Mounting a Transistor on a Heat Sink Bracket, Component Lead Wire Strain Relief

Practical Guides for Natural Convection and Radiation Cooling - Natural Convection Vertical Plates, Horizontal Plates, Turbulent Flow, Heat Lost from an Electronic Box, Cooling Fins on an Electronic Box, Natural Convection Analog Resistor Networks, PCBs, Heat Transfer from PCB Adjacent to a Chassis Wall, PCB Cooling at High Altitudes, Radiation Cooling of Electronics

Forced-Air Cooling for Electronics: Forced Cooling Methods**,** Cooling Airflow Direction for Fans**,** Static Pressure and Velocity Pressure**,** Losses Expressed in Terms of Velocity Heads**,** Airflow Loss at a Fan Entrance**,** Establishing the Flow Impedance Curve for an Electronic Box**,** Fan-Cooled Electronic Box**,** Hollow Core PCBs **,** Cooling Air Fans for Electronic Equipment**,** Air Filters**,** Cutoff Switches**,** High-Altitude Conditions, Cooling A TO-5 Transistor, Conditioned Cooling Air from an External Source, Generating a Cooling Airflow Curve, Static Pressure Losses for Various Altitude Conditions, Total Pressure Drop for Various Altitude Conditions, Finned Cold Plates and Heat Exchangers, Pressure Losses in Multiple-Fin Heat Exchangers, Fin Efficiency Factor, Hollow Core PCB with a Finned Heat Exchanger, Undesirable Airflow Reversals, Effects of Altitude on Heat Exchanger Performance, Heat Exchanger Temperatures for Different Altitude and Power Conditions

Effective Cooling for Large Racks and Cabinets: Induced Draft Cooling for Large Consoles**,** Airflow Losses for Large Cabinets**,** Flotation Pressure and Pressure Loss**,** Induced Draft Cooling for a Large Cabinet**,** Natural Cooling for Large Cabinets with Many Flow Restrictions**,** Temperature Rise of Cooling Air in a Cabinet with an Induced Draft**,** Warning Note for Induced Draft Systems**,** Tall Cabinets with Stacked Card Buckets**,** Induced Draft Cooling of a Console with Seven Stacked Card Buckets**,** Electronics Packaged within Sealed Enclosures**,** Small Enclosed Modules within Large Consoles**,** Small PCB Sealed within an RFI Enclosure **,** Test Data for Small Enclosed Modules **,** Pressure Losses in Series and Parallel Airflow Ducts**,** Series and Parallel Airflow Network

Advanced Cooling methods: Microchannel Heat sinks, Heat pipes, Data center cooling, Telecom cabinet cooling, JEDEC standards.

Reference Book(s)

1. Yunus A. Çengel and Afshin J. Ghajar, "Heat and Mass Transfer – Fundamental & Applications", McGraw-Hill Education, Fifth Edition, 2015.
2. Incropera, F. P., D. P. DeWitt, T. L. Bergman, and A. S. Lavine, "Fundamentals of heat and mass transfer", Hoboken, NJ: John Wiley & Sons, Inc., Sixth Edition, 2007.
3. PK Nag, "Fundamentals of Heat and Mass Transfer", 2011.
4. HoSung Lee, "Thermal Design-Heat Sinks, Thermoelectrics, Heat Pipes, Compact Heat Exchangers, and Solar Cells", John Wiley & Sons, Inc., 2010.
5. Sathis Kandlikar, Srinivas Garimella, Dongqing Li, Stephen Colin and Michael King, "Heat transfer and fluid flow in minichannels and microchannels" Butterworth-Heinemann, 2nd Edition, 2014.

6. C. B. Sobhan and G. P. Peterson, “Microscale and Nanoscale Heat Transfer Fundamentals and Engineering Applications”, CRS Press- New York, 2008

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	Evaluating the Cooling Requirements	
1.1	Electronic Equipment for Airplanes, Missiles, Satellites, and Spacecraft, Ships, Submarines, Communication Systems and Ground Support Systems	1
1.2	Personal Computers, Microcomputers, and Microprocessors, Cooling Specifications for Electronics	1
	Designing the Electronic Chassis	
1.3	Formed Sheet Metal Electronic Assemblies, Dip-Brazed Boxes with Integral Cold Plates, Die Cast Housings Large Sand Castings	1
1.4	Extruded Sections for Large Cabinets, Humidity Considerations in Electronic Boxes, Conformal Coatings, Sealed Electronic Boxes	1
1.5	Standard Electronic Box Sizes, Plaster Mold and Investment Castings with Cooling Fins	1
2	Conduction Cooling for Chassis and Circuit Boards	
2.1	Concentrated Heat Sources, Steady State Conduction, Mounting Electronic Components on Brackets	1
2.2	Transistor Mounted on a Bracket, Uniformly Distributed Heat Sources, Steady State Conduction	1
2.3	Cooling Integrated Circuits on a PCB, Circuit Board with an Aluminum Heat Sink Core,	2
2.4	Temperature Rise along a PCB Heat Sink Plate, Warping on PCBs with Metal Heat Sinks	1
2.5	Chassis with Nonuniform Wall Sections, Heat Flow along Nonuniform Bulkhead	1
2.6	Temperature Rise across a PCB Edge Guide, Heat Conduction through Sheet Metal Covers, Radial Heat Flow, Temperature Rise through a Cylindrical Shell	1
3	Mounting and Cooling Techniques for Electronic Components	
3.1	Various Types of Electronic Components, Mounting Components on PCBs	1
3.2	Hot Spot Temperature of an Integrated, Circuit on a Plug-in PCB	1
3.3	Mounting of High-Power Components, Mounting High-Power Transistors on a Heat Sink Plate	1
3.4	Electrically Isolating High-Power Components, Mounting a Transistor on a Heat Sink Bracket, Component Lead Wire Strain Relief	1
4	Practical Guides for Natural Convection and Radiation Cooling	

Module No.	Topic	No. of Lectures
4.1	Natural Convection Vertical Plates, Horizontal Plates	1
4.2	Turbulent Flow, Heat Lost from an Electronic Box, Cooling Fins on an Electronic Box	1
4.3	Natural Convection Analog Resistor Networks, PCBs	1
4.4	Heat Transfer from PCB Adjacent to a Chassis Wall, PCB Cooling at High Altitudes, Radiation Cooling of Electronics	1
5	Forced-Air Cooling for Electronics	
5.1	Forced Cooling Methods, Cooling Airflow Direction for Fans, Static Pressure and Velocity Pressure	1
5.2	Losses Expressed in Terms of Velocity Heads, Airflow Loss at a Fan Entrance, Establishing the Flow Impedance Curve for an Electronic Box	1
5.3	Fan-Cooled Electronic Box, Hollow Core PCBs , Cooling Air Fans for Electronic Equipment, Air Filters, Cutoff Switches	1
5.4	High-Altitude Conditions, Cooling A TO-5 Transistor, Conditioned Cooling Air from an External Source, Generating a Cooling Airflow Curve	1
5.5	Static Pressure Losses for Various Altitude Conditions, Total Pressure Drop for Various Altitude Conditions	1
5.6	Finned Cold Plates and Heat Exchangers, Pressure Losses in Multiple-Fin Heat Exchangers, Fin Efficiency Factor, Hollow Core PCB with a Finned Heat Exchanger, Undesirable Airflow Reversals	1
5.7	Effects of Altitude on Heat Exchanger Performance, Heat Exchanger Temperatures for Different Altitude and Power Conditions	1
6	Effective Cooling for Large Racks and Cabinets	
6.1	Induced Draft Cooling for Large Consoles, Airflow Losses for Large Cabinets	1
6.2	Flotation Pressure and Pressure Loss, Induced Draft Cooling for a Large Cabinet	1
6.3	Natural Cooling for Large Cabinets with Many Flow Restrictions, Temperature Rise of Cooling Air in a Cabinet with an Induced Draft	1
6.4	Warning Note for Induced Draft Systems, Tall Cabinets with Stacked Card Buckets	1
6.5	Induced Draft Cooling of a Console with Seven Stacked Card Buckets, Electronics Packaged within Sealed Enclosures	1
6.6	Small Enclosed Modules within Large Consoles, Small PCB Sealed within an RFI Enclosure	1
6.7	Test Data for Small Enclosed Modules , Pressure Losses in Series and Parallel Airflow Ducts, Series and Parallel Airflow Network	1
	Advanced Cooling methods	
6.8	Microchannel Heat sinks, Heat pipes	1

Module No.	Topic	No. of Lectures
6.9	Data center cooling, Telecom cabinet cooling, JEDEC standards	1
	Total	36

Course Designers

Sl. No.	Name	E-mail Id
1	Dr.G.Kumaraguruparan	gkgmech@tce.edu

18MCPM0	PROFESSIONAL PRACTICE	Category	L	T	P	Credit(s)
		PE	0	0	6	3

Preamble

This course will aim to achieve a professional development of the student in the context of the overall goal of his/her programme. Depending upon his professional interest, this course will be conducted in terms of actual participation in professional activities such as teaching, laboratory organization, course development, organizational development, R&D work, design, production, data organization, data preparation or management of institution etc. The course will also deal with communication aspects such as teaching a course, presenting a paper in the seminar/conference, articulating ideas and concepts to professional audience/customers, etc. This course will also deal with the laws and ethics concerned with the profession of an individual

Prerequisite

Nil

Course Outcomes

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

CO1	Participate in the professional activities	Understand
CO2	Teach the interested subjects of Mechatronics engineering	Understand
CO3	Handle the laboratory experiments for Under Graduate Students	Understand
CO4	Develop the learning materials in the form of lecture notes and laboratory manuals	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Valuation category	Assessment (100)
Class work and Lab classes	30
Online Courses	20
Assignments and Quiz	10
Industrial visit and Report	30
Viva-voce	10

Note:

Each student will get assigned /attached to the faculty member of the Department. The student will be assisting on Professional activities assigned by the concerned faculty. A technical report will be prepared by the individual student on a relevant industry visit made during the semester of study. All the assessments will be carried out by the assigned faculty and submit the marks at the end of the semester. Viva-voce will be conducted by a team of 4 faculty members constituted by the Head of the Department.

Course Designers

Sl. No.	Name	E-mail Id
1	Dr. M. Palaninatha Raja	pnatharaja@tce.edu

18MCPN0 **CNC TECHNOLOGY**

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

Preamble

This course provides fundamental knowledge about the CNC system that are predominantly found in most manufacturing industries. 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.

Prerequisite

- 18MCPA0 - Principles of Mechanical systems
- 18MC120 - Sensors and actuators

Course Outcomes

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

CO1	Explain the evolution and importance of CNC technology in manufacturing industry.	Understand
CO2	Describe the construction features and specification of various mechanical components used in a CNC system.	Understand
CO3	Design a 3 axis CNC System by selecting suitable controller, feed and spindle drives.	Apply
CO4	Develop CNC part program for basic turning and milling operations as per product geometry.	Apply
CO5	Suggest methodologies for CNC system maintenance and troubleshooting.	Understand

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	20	20	20
Understand	50	40	40	40
Apply	20	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

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):

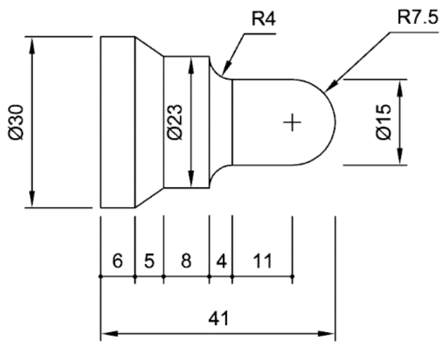
1. List the various types of loads acting in a CNC machine and elaborate how it influences the selection of various mechanical components.
2. Describe the ball screw and nut assembly with suitable sketches.
3. Explain the various tool monitoring system present in a CNC Turning centre.

Course Outcome 3 (CO3):

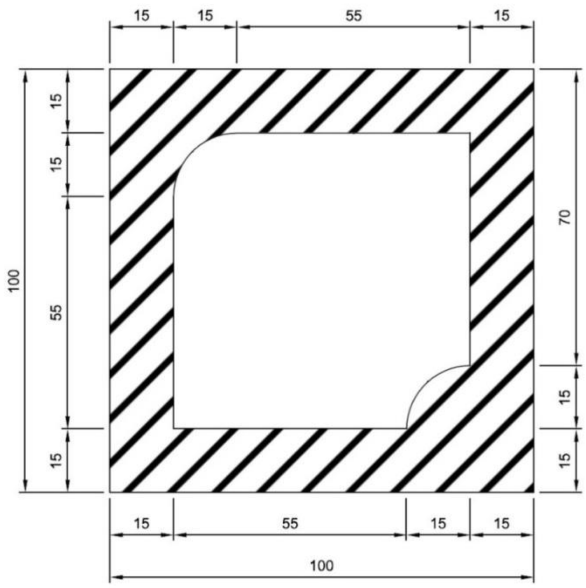
1. Design a spindle drive using VFD for varying the speed between a range of 500 to 1500 rpm for CNC Milling Machine.
2. Explain the interface between controller and Axis drive with neat block diagram.
3. Design a CNC control system using PLC and 3 Axis Servo Drive System.
4. Design a 3-axis Servo drive 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.



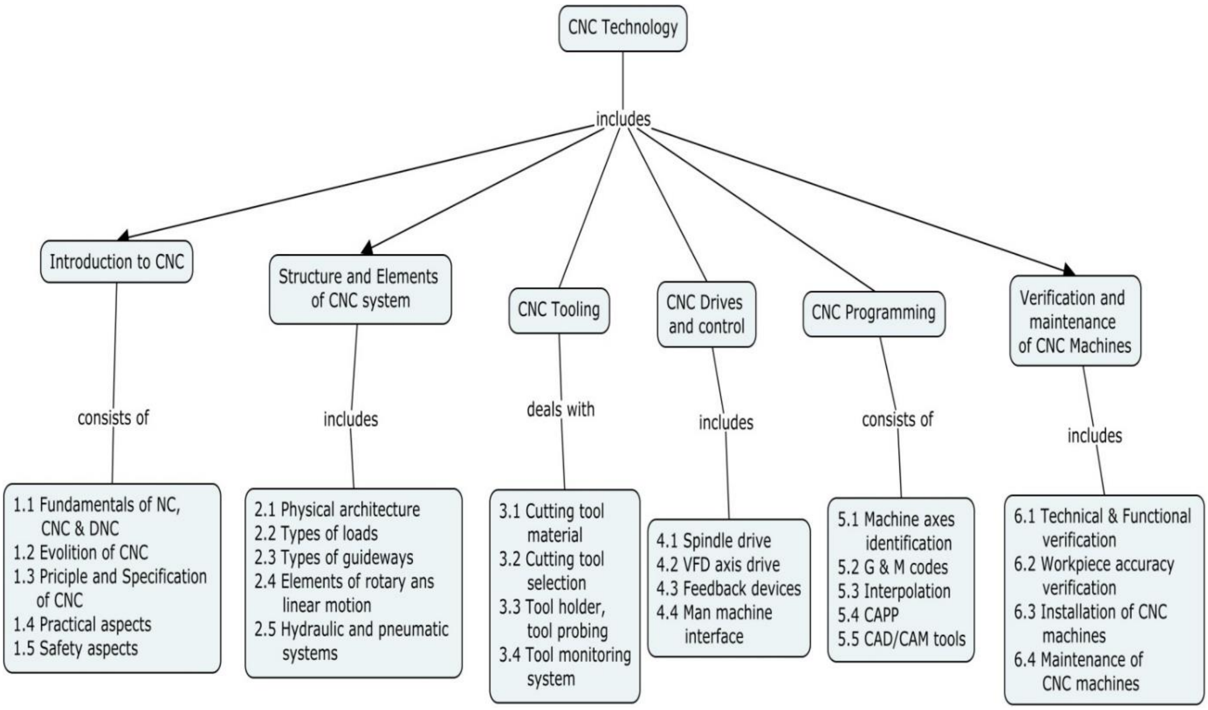
2. Develop part program for the given component shown in figure below that is to be manufactured in a CNC Machining centre.



Course Outcome 5 (CO5):

1. Prepare scheduled maintenance chart for conducting maintenance activities in a CNC Turning centre.
2. Explain methods of verification to ensure the accuracy of the produced component.
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, recirculating ball screw, rack & pinion, Torque transmission elements – gears, timing belt, flexible coupling, bearing, Hydraulic and pneumatic systems in a CNC system.

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.

Verification and Maintenance of CNC Machines: Verification of technical and functional aspects, Verification of CNC machine during idle running, Verification of CNC machine tool and work piece accuracy, Installation of CNC machines-Maintenance of CNC machines.

Reference Book(s)

1. HMT, "Mechatronics", Tata McGraw-Hill Publishing Company Limited, New Delhi – 2005.
2. Dr.S.K.Sinha, "CNC Programming" Galgotia Publications Pvt Ltd,2011.
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 Lectures
1	**Introduction to CNC Systems**	
1.1	Fundamentals of NC, CNC and DNC	1
1.2	Evolution of CNC Turning centre, Evolution of CNC Milling centre	1
1.3	Principles, specification, features, advantages and applications of CNC machines	1
1.4	Practical aspects of introducing CNC machines in manufacturing industry	1
1.5	Safety aspects of CNC machines	1
2	**Structure and Elements of CNC System**	
2.1	Machine physical architecture – Structural details	2
2.2	Types of loads on CNC machine	1
2.3	Types of guide ways – Friction guide ways, Antifriction guide ways	2
2.4	Elements for rotary motion to linear motion – Screw & nut, recirculating ball screw, recirculating ball screw, rack & pinion	2
2.5	Torque transmission elements – gears, timing belt, flexible coupling, bearing	1
2.6	Hydraulic and pneumatic systems in a CNC system	1
3	**CNC Tooling**	
3.1	Cutting tool materials ant types of tools	1
3.2	Cutting tool selection, tool holder	1
3.3	Tool holder, tool probing and pre-setting	1
3.4	Tool Compensation	1
3.5	Automatic turret changer, Tool monitoring system	1
4	**CNC Drives and Control**	

4.1	Spindle drive – Three phase induction motor – Construction, Characteristics, Speed control methods	1
4.2	VFD Axis Drive – AC Servo motor, Construction, Characteristics, Closed loop position control	1
4.3	Feedback devices – Rotary encoder, linear scale encoder, proximity sensor, synchronous resolver.	1
4.4	Introduction to functioning and programming of CNC Controller, PLC, Man machine interface.	1
5	**CNC Programming**	
5.1	Machine axes identification	1
5.1	Part programming terminology – G and M codes	1
5.2	Types of interpolation, manual part programming: fixed cycle and canned cycle for turning and milling operations	1
5.3	Tool compensation	1
5.4	Computer assisted part programming(CAPP)	1
5.5	Introduction to CNC part programming using CAD/CAM tools.	1
5.6	Case study on Sinumerik turning cycle programming	1
5.7	Case study on sinumerik Milling cycle programming	1
6	**Verification and Maintenance of CNC Machines**	
6.1	Verification of technical and functional aspects, Verification of CNC machine during idle running	1
6.2	Verification of CNC machine tool and work piece accuracy	1
6.3	Installation of CNC machines	1
6.4	Maintenance of CNC machines.	1
	Total	**36**

Course Designers

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18PGAA0	PROFESSIONAL AUTHORING	Category	L	T	P	Credit(s)
		AC	2	0	0	2

Preamble

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

1. Explain how to improve your writing skills and level of readability
2. Write each section of research paper
3. Write good quality technical paper

Syllabus

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Key skills for writing a Title, writing an Abstract, writing an Introduction, writing a Review of the Literature,

Skills for Writing the Methods, Results, Discussion and Conclusions
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Assessment Pattern

Abstract	:	10
Introduction	:	10
Literature Review	:	10
Research Question	:	10
Methods	:	10
Results and Discussion	:	10
Conclusions	:	10
Appropriateness of Title	:	05
Quality of the Paper and Plagiarism	:	25

References

1. Goldbort R, ‘Writing for Science’, Yale University Press, 2006
2. Day R, ‘How to Write and Publish a Scientific Paper’, Cambridge University Press, 2006
3. Highman N, ‘Handbook of Writing for the Mathematical Sciences, SIAM Highman’s book, 1998
4. Adrian Wallwork, ‘English for Writing Research Papers’, Springer New York Dordrecht Heidelberg London, 2011

18PGAB0	**VALUE EDUCATION**	Category L T P Credit(s) AC 2 0 0 2

Preamble

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

1. Experience self-development
2. Explain the importance of Human values
3. Develop the overall personality

Syllabus

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles, Value judgements

Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National Unity, Patriotism, Love for nature, Discipline

Personality and Behavior Development, Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth.

Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence , Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

Assessment Pattern

Bloom's Category	Continuous Assessment Test	Terminal Examination
Remember	20	20
Understand	40	40
Apply	40	40
Analyse	0	0
Evaluate	0	0
Create	0	0

References

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, OxforUniversity Press, New Delhi

18MCGA0	VALUE ENGINEERING	Category	L	T	P	Credit(s)
		OE	2	0	0	2

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

CO1	Establish the Value engineering methodology	Remember
CO2	Recognize the various phases of value engineering	Understand
CO3	Perform function cost worth analysis	Apply
CO4	Create the ideas for solving the problems	Create
CO5	Analyse the functional importance and functional cost	Analyse
CO6	Recommend the present facts and present costs	Apply

Mapping with Program Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	0	10
Understand	80	40	0	20
Apply	0	40	40	30
Analyse	0	0	40	30
Evaluate	0	0	0	0
Create	0	0	20	10

CAT3: MINI PROJECT **(50 MARKS)**

Course Level Assessment Questions

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 mean 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

	A (RS.)	**B(RS.)**
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	**ALT B**	**ALT C**
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

The machines can be used for 5 years or they can be retained for use after the 5th 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):

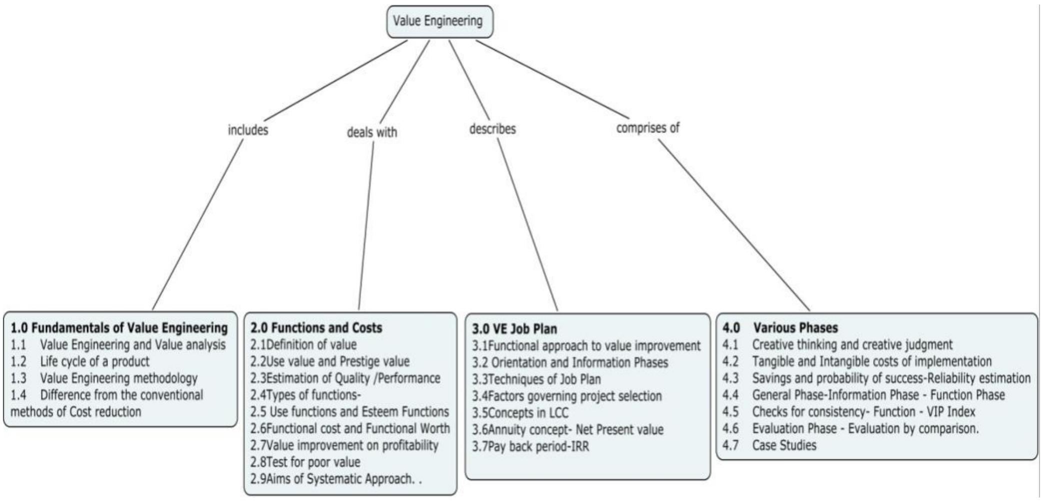
1. A company proposes to invest Rs.40000 in a new machine. The service life of machine is 10 years.
   a) What should be the annual savings if the minimum acceptable rate of return is 20%?
   b) If the actual savings over this period are Rs.8000/- per year. What is the actual rate of return (internal) on investment?

2. A man needs Rs.300000immediately for the purchase of a house. He will be required to repay the loan in equal six-monthly instalments 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

Value Engineering (VE) and Value Analysis (VA) - Life Cycle of a product-Methodology of value engineering - 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- Aims of Systematic Approach. 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 – 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

Reference Book(s)

1. Value engineering, Mukhopadhyaya, Anil Kumar, Response Books, New Delhi ,2009, ISBN: 0-7619-9788-1
2. Value Engineering – A How to Manual by S S Iyer, 3rd edition, New Age Publishers, Chennai, 2009, ISBN: 978-81-224-2405-8
3. Richard J Park, “Value Engineering – A Plan for Inventions”, St.Lucie Press, London, 1999.
4. Profit Improvement through Value Analysis, value Engineering and Purchase Price Analysis, A.D.Raven, (1971),Cassell and Co. London.
5. Arthur E Mudge, “Value Engineering”, McGraw Hill Book Company, 1989.
6. NPTEL Value Engineering course videos

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Value Engineering and Value analysis	1
1.2	Life cycle of a product	1
1.3	Value Engineering methodology	1
2	**Reasons for unnecessary costs**	
2.1	Definition of value -Use value and Prestige value	1
2.2	Types of functions	1
2.3	Relationship between Use functions and Esteem Functions in product design	1
2.4	Functional cost and Functional Worth	1
2.5	Effect of Value improvement on profitability	1
2.6	Aims of Systematic Approach. Functional approach to value improvement	1
3	**VE Job Plan**	
3.1	Functional approach to value improvement	1
3.2	Orientation and Information Phases	1
3.3	Techniques of Job Plan	1
3.4	Factors governing project selection – Types of Projects	1
3.5	Life Cycle Costing (LCC) for managing the Total Value-Concepts in LCC –	1
3.6	Present value concept-Annuity concept- Net Present value	1
3.7	Payback period-Internal rate of return on Investment (IRR)-Examples and Illustrations	1
4	**Various phases**	
4.1	Creative thinking and creative judgment- positive or constructive discontent	1
4.2	Tangible and Intangible costs of implementation-False material-labour and overhead saving	1
4.3	General Phase-Information Phase – Type of costs - Function Phase	1
4.4	Evaluation of Functional Relationships - Checks for consistency- Function – cost-weight-matrix - VIP Index – High cost and Poor value areas-	1
4.5	Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.	1
4.6	FAST Diagram	1
4.7	Mini Project presentation and Case Studies	3
	Total	25

Course Designers

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