Curriculum and Detailed Syllabi

For

B.E. Mechatronics
2022 Regulations

Thiagarajar College of Engineering

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

Madurai – 625 015, Tamil Nadu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

First Semester

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

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

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

B.E. Mechatronics 2022 - 2023

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Introduction to Mechatronic Systems ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT480 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Sensors and Instrumentation Project PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22MT630 Professional Communication HSMC 2	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22MT660 Mechanical Systems Project PW 3	23
VII	22MT710 Mechatronics System Design PCC 3	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 3	---	---	22MT730 Robotics and Automation Project PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT810 System Integration Project PW 3	9
									Total Credits	**160**

Passed in Board of Studies Meeting on 11.06.2022

Approved in 63rd Academic Council Meeting on 25.06.2022

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits	
			Regular Admission	Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**24 - 36**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	09 - 12
	b.	Basic Science Courses (BSC)	24 - 27	06 - 09
	c.	Engineering Science Courses (ESC)	21 - 27	12 - 15
B.	**Professional Core Courses (PCC)**		**55**	**45**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

I SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MA110	Calculus for Engineers	BSC	3	1	0	4
22PH120	Physics	BSC	3	0	0	3
22CH130	Chemistry	BSC	3	0	0	3
22EG140	Technical English	HSMC	2	0	0	2
22ES150	Engineering Exploration	ESC	1	1	0	2
22ME160	Engineering Graphics	ESC	3	0	2	4
PRACTICAL						
22EG170	English Laboratory	HSMC	0	0	2	1
22PH180	Physics Laboratory	BSC	0	0	2	1
22CH190	Chemistry Laboratory	BSC	0	0	2	1
		Total	**15**	**2**	**8**	**21**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

I SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22MA110	Calculus for Engineers	3	40	60	100	27	50
22PH120	Physics	3	40	60	100	27	50
22CH130	Chemistry	3	40	60	100	27	50
22EG140	Technical English	3	40	60	100	27	50
22ES150	Engineering Exploration	3	40	60	100	27	50
22ME160	Engineering Graphics	3	40	60	100	27	50
PRACTICAL							
22EG170	English Laboratory	3	60	40	100	18	50
22PH180	Physics lab	3	60	40	100	18	50
22CH190	Chemistry Laboratory	3	60	40	100	18	50

* CA – Continuous Assessment:

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.

TE - Terminal Examination

22MA110	CALCULUS FOR ENGINEERS	Category	L	T	P	Credit(s)
		BSC	3	1	0	4

Preamble

This course aims to provide technical competence of modeling engineering problems using calculus. In this course, the calculus concepts are taught geometrically, numerically, algebraically and verbally. Students will apply the main tools for analyzing and describing the behavior of functions of single and multi-variables: limits, derivatives, integrals of single and multi-variables to model and solve complex engineering problems using analytical methods and MATLAB.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Cognize the concept of functions, limits and continuity	TPS2	75	70
CO2	Compute derivatives and apply them in solving engineering problems	TPS3	70	65
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	TPS3	70	65
CO4	Demonstrate the techniques of integration to find the surface area of revolution of a curve.	TPS3	70	65
CO5	Utilize double integrals to evaluate area enclosed between two curves.	TPS3	70	65
CO6	Apply triple integrals to find volume enclosed between surfaces	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)			
	CAT 1			Assignment 1			CAT 1			Assignment 1						
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Total
CO1		20						-			-		-	10	-	10
CO2		32			50			-			-		-	-	16	16
CO3		36						-			-		-	-	18	18
CO4		12			-			39					-	-	25	25
CO5		-			-			35			50		-	-	17	17
CO6		-			-			26					-	-	14	14
MATLAB		-			50			-			50		-	-	-	-
TOTAL		100			100			100			100		-	10	90	100

***** Assignment 1: (i) Application Problems in CO1, CO2 and CO3 (50%)
(ii) MATLAB Onramp & Introduction to symbolic Math with MATLAB (50%).
**Assignment 2: (i) Application Problems in CO4, CO5 and CO6 (50%).
(ii) Application problems using MATLAB. (50%).
*******Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

DIFFERENTIAL CALCULUS
Functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Maxima and Minima of functions of one variable – Mean value theorem - Effect of derivatives on the shape of a graph- Application problems in engineering using MATLAB.

FUNCTIONS OF SEVERAL VARIABLES:
Function of several variables- Level curves and level surfaces - Partial derivatives – Chain rule - Maxima and minima of functions of two variables –Method of Lagrange's Multipliers - Application problems in engineering using MATLAB.

INTEGRAL CALCULUS:
The definite integral – Fundamental theorem of Calculus – Indefinite integrals and the Net Change Theorem – Improper integrals – Area of surface of revolution - Volume of solid of revolution -Application problems in engineering using MATLAB.

MULTIPLE INTEGRALS:
Iterated integrals-Double integrals over general regions-Double integrals in polar coordinates- Applications of double integrals (density, mass, moments & moments of inertia problems only)- triple integrals- triple integrals in cylindrical coordinates- triple integrals in spherical coordinates-change of variables in multiple integrals - Application problems in engineering using MATLAB.

Text Book(s)

1. James Stewart, "Calculus Early Transcendentals", 9th Edition, Cengage Learning, New Delhi, 2019.
    a. DIFFERENTIAL CALCULUS: [Sections: 1.3, 2.2, 2.5, 2,6,2.8, 4.1, 4.2 and 4.3.]
    b. FUNCTIONS OF SEVERAL VARIABLES: [Sections: 14.1,14.3,14.5,14.7 and 14.8.]
    c. INTEGRAL CALCULUS: [Sections: 5.2, 5.3, 5.4, 7.8, 8.2 and 6.2.]
    d. MULTIPLE INTEGRAL: [Sections: 15.1-15.4, 15.6-15.9]

2. Lecture Notes on Calculus Through Engineering Application Problems and Solutions, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books & Web Resources

1. George B. Thomas, "Thomas Calculus: early Transcendentals", 14thedition, Pearson, New Delhi, 2018.
2. Howard Anton, Irl Bivens and Stephen Davis, "Calculus: Early Transcendentals", 12the, John Wiley & Sons, 2021.
3. Kuldeep Singh, "Engineering Mathematics Through Applications", 2nd edition, Blooms berry publishing, 2019.
4. Kuldip S. Rattan, Nathan W. Klingbeil, Introductory Mathematics for Engineering Applications, 2nd e John Wiley& Sons, 2021

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**DIFFERENTIAL CALCULUS**	
1.1	Functions and New functions from old functions	2
1.2	Limit of a function &Continuity of a function	1
	Tutorial	**1**
1.3	Limits at infinity	1
1.4	Derivative as a function	2
	Tutorial	**1**
1.5	Maxima and Minima of functions of single variable	2
1.6	The Mean value theorem and effect of derivatives on the shape of a graph of a function	1
	Tutorial	**1**
1.7	Application problems in engineering using MATLAB	1
2	**FUNCTIONS OF SEVERAL VARIABLES**	
2.1	Level curves and level surfaces	2
2.2	Partial derivatives – Chain rule	1
	Tutorial	**1**
2.3	Maxima and minima of functions of two variables	2
2.4	Method of Lagrange's Multipliers	1
	Tutorial	**1**
2.5	Application problems in engineering using MATLAB	1
3	**INTEGRAL CALCULUS**	
3.1	The definite integral	1
3.2	Fundamental theorem of Calculus	2
	Tutorial	**1**
3.3	Indefinite integrals and the Net Change Theorem	1
3.4	Improper integrals	2
	Tutorial	**1**
3.5	Area of surface of revolution	1

Module No.	Topic	No. of Periods
3.6	Volume of solid of revolution.	2
3.7	Application problems in engineering using MATLAB	1
4	**MULTIPLE INTEGRALS**	
4.1	Iterated integrals	1
4.2	Double integrals over general regions	2
	Tutorial	**1**
4.3	Double integrals in polar coordinates	1
4.4	Applications of double integrals (density, mass, moments & moments of inertia problems only)	2
	Tutorial	**1**
4.5	Triple integrals	1
4.6	Triple integrals in cylindrical coordinates	1
4.7	Triple integrals in spherical coordinates	1
	Tutorial	**1**
4.8	Change of variables in multiple integrals	1
4.9	Application problems in engineering using MATLAB	1
	Total	**48**

Course Designers:

1. Dr. B. Vellaikannan, bvkmat@tce.edu
2. Dr. C.S. Senthilkumar, kumarstays@tce.edu
3. Dr. S.P. Suriya Prabha, suriyaprabha@tce.edu
4. Dr. S. Saravanakumar, sskmat@tce.edu
5. Dr. M. Sundar, msrmat@tce.edu

22PH120	PHYSICS	Category	L	T	P	Credit(s)
		BSC	3	0	0	3

Preamble

The course work aims in imparting fundamental knowledge of mechanics, oscillations and waves and optics, electromagnetism and quantum mechanics which are essential in understanding and explaining engineering devices.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Apply the vector calculus approach and Newton's law in polar coordinates to solve problems in mechanics	TPS3	85	80
CO2	Solve for the solutions and describe the behaviour of a damped harmonic oscillator and waves.	TPS3	85	80
CO3	Introduce Schrodinger equation to arrive at the energy values of particle in a box and linear harmonic oscillator	TPS3	85	80
CO4	Use the principle of quantum mechanics for quantum mechanical tunnelling, quantum confinement and quantum computation	TPS2	85	80
CO5	Use the laws of electrostatics and magnetostatics to explain electromagnetic wave propagation	TPS3	85	80
CO6	Explain the fundamentals of optical phenomena and its applications	TPS2	85	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)			
	CAT 1			Assignment 1			CAT 2			Assignment 2						
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Total**
CO1	8	15	22		100		-	-	-	-	-	-	6	6	10	22
CO2	8	10	15				-	-	-	-	-	-	4	3	10	17
CO3	4	5	13				-	-	15		100		-	2	15	17
CO4	-	-	-				4	15	-				4	6	-	10
CO5	-	-	-				-	-	35				-	3	15	18
CO6	-	-	-				16	15	-				6	10	-	16
Total	**20**	**30**	**50**		**100**		**20**	**30**	**50**		**100**		**20**	**30**	**50**	**100**

*Assignment I, II –Quiz/ Puzzle/ Case analysis/ Problem-solving/ Presentation/ Writing tasks
*****Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Mechanics of Particles:
Scalars and vectors under rotation transformation - Coordinate system - Cartesian, Polar, Spherical, Cylindrical - Newton's second law of motion - Forces in nature - Central forces - Conservative and non-conservative forces - Work - Energy theorem - Conservation of angular momentum - Satellite manoeuvres
Oscillations and Waves:
Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator - Q factor-Impedance matching- Wave groups and group velocity - Non dispersive Transverse and Longitudinal waves - Waves with dispersion - Water waves - Acoustic waves - Earthquake and Tsunami waves
Quantum Mechanics:
Wave nature of particles - wave function - probability current density and expectation values - Schrodinger wave equation - Uncertainty principle - Particle in a box in 1D - Linear harmonic oscillator - Quantum tunnelling – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope - Quantum Cascade lasers - Quantum computation (qubit) - Entanglement - Teleportation
Electromagnetic Fields and Waves:
Electric potential and Electric field of a charged disc - Magnetic Vector potential - Maxwell's equation - Equation of continuity – Poynting Vector - Energy and momentum of EM waves - CT/MRI scan
Optics:
Ray paths in inhomogeneous medium and its solutions – Applications - Fibre optics - Numerical Aperture& Acceptance angle - Fibre optic sensors - Liquid Level & Medical Applications - Interference in non-reflecting films - Fabry-Perot interferometer - Diffraction - Fraunhofer diffraction due to double slit.

Text Book(s)

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011
2. Paul A. Tipler and G. Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008

Reference Books & Web Resources

MECHANICS OF PARTICLES

1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 4, 9 & 10).
2. Manoj K. Harbola, Engineering Mechanics, 2nd Edition, Cengage, 2018.

OSCILLATIONS AND WAVES

3. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 14 & 15).
4. H. J. Pain, The Physics of Vibrations and Waves, 6th Edition, John Wiley, 2005 (Chapters 2, 5 & 6).

ELECTROMAGNETIC FIELDS AND WAVES

5. Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011 (Chapters - 23, 24, 32 & 33)
6. Paul M. Fishbane, Stephen G. Gasiorowicz and Stephen T. Thornton, Physics for Scientists and Engineers with Modern Physics, 3rd Edition, Pearson, 2005 (Chapters - 26, 28, 31 & 34).

OPTICS

7. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 31 & 33).
8. Ajoy Ghatak, Optics, 5th Edition, Tata McGraw Hill, 2012 (Chapters – 3, 18, 20)

QUANTUM MECHANICS

9. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 34 & 35).
10. Stephen T. Thornton and Andrew Rex, Modern Physics for Scientists and Engineers, 4th Edition, Cengage, 2013. (Chapters - 5 & 6).
11. R. Shankar, Fundamentals of Physics – I, II, Yale University Press, 2014, 2016.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Mechanics of Particles**	**8**
1.1	Scalars and vectors under rotation transformation	2
1.2	Coordinate system - Cartesian, Polar, Spherical, Cylindrical	2
1.3	Newton’s second law of motion - Forces in nature - Central forces	2
1.4	Conservative and non-conservative forces - Work - Energy theorem - Conservation of angular momentum - Satellite maneuvers	2
2	**Oscillations and Waves**	**6**
2.1	Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator	2
2.2	Q factor- Impedance matching – Wave groups and group velocity	2
2.3	Non-dispersive transverse and Longitudinal waves	1
2.4	Waves with dispersion- Water waves -Acoustic waves – Earthquake and Tsunami waves	1
3	**Quantum Mechanics**	**10**

3.1	Wave nature of particles - wave function -probability current density and expectation values - Schrodinger wave equation	3
	CAT-I after 18 contact hours	
3.2	Uncertainty principle - Particle in a box in 1D – Linear harmonic oscillator	3
3.3	Quantum tunnelling – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope – Quantum Cascade lasers – Quantum computation (qubit) – Entanglement - Teleportation	4
4	**Electromagnetic Fields and Waves**	**6**
4.1	Electric potential and Electric field of a charged disc	1
4.2	Magnetic Vector potential – Maxwell's Equations	2
4.3	Equation of continuity-Poynting Vector-Energy and momentum of EM waves	2
4.4	CT/MRI scan	1
5	**Optics**	**6**
5.1	Ray paths in inhomogeneous medium & its solutions–Applications – Fiber optics	2
5.2	Numerical Aperture& Acceptance angle - Fiber optic sensors - Liquid Level & Medical Applications	2
5.3	Interference in non-reflecting films - Fabry- Perot interferometer - Diffraction - Two slit Fraunhofer diffraction	2
	CAT-II after 18 contact hours	
	Total	**36**

Course Designers:

1. Dr. M. Mahendran, Professor, manickam-mahendran@tce.edu
2. Mr. V. Veeraganesh, Assistant Professor, vvgphy@tce.edu
3. Dr. A LSubramaniyan, Assistant Professor, alsphy@tce.edu
4. Dr. A. Karuppusamy, Assistant Professor, akphy@ce.edu

22CH130	CHEMISTRY	Category	L	T	P	Credit(s)
		BSC	3	0	0	3

Preamble

The objective of this course is to bestow basic concepts of chemistry and its applications in engineering domain. It imparts knowledge on properties and treatment methods of water, spectroscopic techniques and their applications. This course provides exposure on electrochemical techniques for corrosion control, surface coatings and energy storage devices and also emphasis the properties and applications of engineering materials.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the essential water quality parameters of water	TPS2	70	70
CO2	Determine hardness of water and identify suitable water treatment method	TPS3	70	70
CO3	Explain the electrochemical process involved in energy storage devices and corrosion of metals	TPS2	70	70
CO4	Interpret the electrochemical principles in modern energy storage devices and corrosion control methods	TPS3	70	70
CO5	Identify the appropriate spectroscopic technique for various applications	TPS3	70	70
CO6	Select the materials based on the properties for Engineering applications	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)			
	CAT 1			Assignment 1			CAT 2			Assignment 2						
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Total**
CO1	4	20	0	-	-	-	-	-	-	-	-	-	2	8	-	10
CO2	4	0	20	-	-	50	-	-	-	-	-	-	2	4	10	16
CO3	4	20	0	-	-	-	-	-	-	-	-	-	2	8	-	10
CO4	8	0	20	-	-	50	-	-	-	-	-	-	2	4	10	16
CO5	-	-	-	-	-	-	12	20	20	-	-	50	6	8	10	24
CO6	-	-	-	-	-	-	8	20	20	-	-	50	6	8	10	24
Total	**20**	**40**	**40**	**100**			**20**	**40**	**40**	**100**			**20**	**40**	**40**	**100**

*Assessment type of Assignments: Quiz / Test /Presentation
*****Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Water:
Water-sources- physical - characteristics - alkalinity - hardness of water – types -determination of hardness by EDTA method. Boiler trouble-Softening of water: internal and External treatment methods. Waste water treatment process.

Electrochemical technologies for energy storage and surface engineering:
Electrochemistry and Energy storage: Basics of electrochemistry. Batteries **-** Primary and Secondary batteries. Fuel cells. Hydrogen generation and storage. Corrosion and Surface Engineering–Basics –Corrosion - causes- factors- types - corrosion of metal and computer components- Corrosion control. Electroplating - Electroless process.

Spectroscopic technique and applications:
Principle, instrumentation, and applications: X-ray-diffraction - UV–Visible spectroscopy- Atomic Absorption Spectroscopy - Fluorescence spectroscopy - Inductively Coupled Plasma - Optical Emission Spectroscopy- Infra-red spectroscopy - Nuclear magnetic resonance spectroscopy**.**

Engineering materials:
Bonding and their influences on the property of materials - melting point - brittleness, ductility – thermal, electrical, and ionic conductivity - optical – magnetic properties, hydrophobic, hydrophilic. Polymer composites - structure and properties-applications. Ceramics and advanced ceramics - types-properties-applications Nano-materials – Synthesis, structure, and properties –applications.

Text Book(s)

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16thedition, 2015.

Reference Books & Web Resources

1. S.S. Dara and S.S. Umare, “A Textbook of Engineering Chemistry”, S.Chand& Company, 12thEdition, Reprint, 2013.
2. Shashi Chawla, “ A text book of Engineering Chemistry”, DhanpatRai& Co.(pvt) ltd, 3rd edition, reprint 2011.
3. C. N. Banwell and E.M. McCash, “Fundamentals of Molecular Spectroscopy”, Tata McGraw-Hill (India), 5thEdition, 2013.

4. W.F. Smith, Principles of Materials Science and Engineering: An Introduction; Tata Mc-Graw Hill, 2008.
5. V. Raghavan, Introduction to Materials Science and Engineering; PHI, Delhi, 2005.
6. M. Akay, 2015, An introduction to polymer matrix composites," from: https://www.academia.edu/37778336/An_introduction_to_polymer_matrix_composites

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Water**	
1.1	Importance of water, sources, standards for drinking water, (WHO, BIS & ICMR standards) physical, chemical & biological characteristics, Alkalinity (principle only)	1
1.2	Hardness of water - types, units. Determination of hardness by EDTA method and numerical problems	2
1.3	**boiler trouble:** Scale and sludge formation, boiler corrosion, priming and foaming, caustic embrittlement	1
1.4	**Internal treatment methods:** Carbonate, Phosphate, Colloidal, Calgon conditioning	1
1.5	**softening of water:** External treatment methods: Lime-soda process (concept only), zeolite process, ion exchange process	2
1.6	Desalination- reverse osmosis, electro dialysis, solar and multistage flash distillation, nano-filtration	1
1.7	Waste water treatment – primary, secondary, and tertiary treatment	1
2	**Electrochemical technologies for energy storage and surface engineering**	
2.1	**Electrochemistry and Energy storage**: Introduction**–** Basics of electrochemistry – Redox process, EMF	1
2.2	**Energy storage** – Batteries, Battery quality parameters	1
2.3	Primary battery – Dry cell and Alkaline cell	1
2.4	Secondary battery – Lead-acid battery, Lithium-ion battery	1
2.5	Fuel cells – Fundamentals, types and applications. Hydrogen generation and storage	1
2.6	**Corrosion and Surface Engineering**- Basics –Corrosion - causes- factors- types	1
2.7	chemical, electrochemical corrosion (galvanic, differential aeration), corrosion of metal and computer components-	1
2.8	Corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method	1
2.9	Electroplating –Introduction, Process, Applications (Gold and nickel plating). Electroless plating – Principle, process, Applications (PCB manufacturing)	1
3	**Spectroscopic technique and applications**	
3.1	Introduction to Electromagnetic Radiation, Types of atomic and molecular spectra	1
3.2	**Principle, Instrumentation and Applications:** X-ray-diffraction	1

Module No.	Topic	No. of Periods
3.3	UV–Visible spectroscopy, Atomic Absorption Spectroscopy	2
3.4	Fluorescence spectroscopy, Inductively Coupled Plasma - Optical Emission Spectroscopy	2
3.5	Infra-red spectroscopy	2
3.6	Nuclear magnetic resonance spectroscopy – Magnetic resonance imaging	1
4	**Engineering materials**	
4.1	Bonding and its influence on the property of materials	1
4.2	Properties of materials- melting point - brittleness, ductility - thermal, electrical and ionic conductivity	1
4.3	optical – magnetic properties, hydrophobic, hydrophilic	1
4.4	**Polymer composites** - structure and properties	1
4.5	applications -automotive, aerospace, marine, biomedical, and defense	1
4.6	**Ceramics and advanced ceramics** - types-properties	1
4.7	applications- medicine, electrical, electronics, space	1
4.8	**Nano-materials** – Synthesis, structure and properties	1
4.9	applications - sensors, drug delivery, photo and electro-catalysis, and pollution control	1
	Total	36

Course Designers:

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7. Dr. B. Shankar, Assistant Professor, Chemistry, bsrchem@tce.edu

22EG140	TECHNICAL ENGLISH	Category	L	T	P	Credit(s)
		HSMC	2	0	0	2

Preamble

The course aims at fostering the students ‘ability to communicate effectively in various academic, professional, and social settings through oral and written forms. Besides imparting the basic skills namely Listening, Speaking, Reading and Writing (LSRW), significant emphasis is placed on enriching their analytical, descriptive, and creative skills, enabling them to develop and demonstrate a holistic English language proficiency.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	**Relate** the fundamentals of language in terms of vocabulary, grammar and pronunciation in technical communication.	Understand	70%	80%
CO2	**Infer** ideas from technical and general contexts by identifying main ideas, specific details, predicting and note making	Understand	70%	80%
CO3	**Make use of** language in professional and social contexts with clarity and conciseness.	Apply	60%	70%
CO4	**Identify** specific contexts in technical writing, where appropriate lexical and grammatical functions are applied	Apply	60%	70%
CO5	**Develop** the skills such as understanding, evaluating, analysing and summarising the text and graphical representations.	Apply	60%	70%
CO6	**Organise** ideas with coherence, cohesion and precision in formal written communication	Apply	70%	80%

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1 (%)</th><th colspan="6">Assessment 2 (%)</th><th colspan="3" rowspan="2">Terminal (%)</th></tr>
<tr><th colspan="3">CAT 1</th><th colspan="3">Assignment 1</th><th colspan="3">CAT 2</th><th colspan="3">Assignment 2</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>CO1</td><td>-</td><td>24</td><td>-</td><td colspan="3" rowspan="3">100</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10</td><td>-</td></tr>
<tr><td>CO2</td><td>-</td><td>34</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>20</td><td>-</td></tr>
<tr><td>CO3</td><td>-</td><td>-</td><td>14</td><td>-</td><td>-</td><td>24</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>20</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>14</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>34</td><td colspan="3" rowspan="3">100</td><td>-</td><td>-</td><td>10</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>14</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>20</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>42</td><td>-</td><td>-</td><td>20</td></tr>
<tr><td>Total</td><td colspan="3">100</td><td colspan="3">100</td><td colspan="3">100</td><td colspan="3">100</td><td colspan="3">100</td></tr>
</table>

***** Assignment 1: Speaking activities in CO1, CO2, and CO3 (100%).
**Assignment 2: Writing activities in CO4, CO5, and CO6 (100%).
*******Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

MODULE- I - Basics of Language (CO1)
Vocabulary - Word Building, Prefix, Suffix and Root Words, Basics of Grammar – Parts of Speech, Tenses, Phonetics - Phonemes, Syllables and Stress.

MODULE- II– Reading (CO2)
Reading- Skimming and Scanning of Short Comprehension Passages and Answering Questions or Cloze exercises based on the text prescribed for extensive reading, Note-Making.

MODULE- III–Functional English (CO3)
Framing Questions (WH and Yes/No), Modals, Manual Writing, Recommendations Writing, Agenda and Minutes of Meeting.

MODULE-IV – Technical Notions (CO4)
Technical Notions - Subject-Verb Agreement, Relative Clause, Phrasal Verbs, Impersonal Passive Voice, Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives.

MODULE-V – Analytical Writing and Business Correspondence (CO5 & CO6)
Summary Writing, Interpretation of Graphics, Jumbled Sentences, Paragraph Writing, Formal Letters (Seeking Permission for Industrial Visit / internship / Bonafide), E-mail Writing (BEC Vantage Writing Task I)

Text Book(s)

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
3. Brook-Hart, Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,2013.
4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
5. Swan, Michael. Practical English Usage.4thEdn. OUP. 2017.
6. Elbow, Peter. Writing with Power: Techniques for Mastering the Writing Process. New York, Oxford University Press, 1998.

Reference Books & Web Resources

1. Anthology of Select Five Short Stories
2. Tagore, Rabindranath. Chitra, a Play in One Act. London, Macmillan and Co., 1914.
3. www.englishclub.com
4. owl.english.purdue.edu
5. www.oxfordonlineenglish.com
6. www.bbclearningenglish.com
7. tcesrenglish.blogspot.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	Word Building, Prefix, Suffix and Root Words	1
2.	Parts of Speech	1
3.	Tenses	1
4.	Skimming and Scanning of Short Comprehension Passages	1
5.	Manual Writing	1
6.	Recommendations	1
7.	Note-Making	1
8.	Subject-Verb Agreement	1
9.	Phonemes	1
10.	Syllables and Stress	1
11.	Answering Questions or Cloze exercises based on the text prescribed for extensive reading	1
12.	Noun Compounds, Classifications and Definitions	1
13.	Cause and Effect, Purpose and Function	1
14.	Summary Writing	1
15.	Interpretation of Graphics	1
16.	Jumbled Sentences	1
17.	Formal Letters (Seeking Permission for Industrial Visit / internship / Bonafide)	1
18.	Phrasal Verbs and Impersonal Passive Voice	1
19.	Numerical Adjectives	1
20.	Framing Questions (WH and Yes/No) and Modals	1
21.	Agenda and Minutes of Meeting	1
22.	Relative Clause	1
23.	E-mail Writing (BEC Vantage Writing Task I)	1
24.	Paragraph Writing	1
Total		**24**

Course Designers:

1. Dr. A. Tamilselvi, tamilselvi@tce.edu
2. Dr. S. Rajaram, sreng@tce.edu
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22ES150	ENGINEERING EXPLORATION	Category	L	T	P	Credit(s)
		ESC	1	1	0	2

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain technological & engineering development, change and impacts of engineering	TPS2	70	70
CO2	Draw a product in enough detail that others can accurately build it and write specification sheet for a given product	TPS3	70	70
CO3	Complete initial steps (Define a problem, list criteria and constraints, brainstorm potential solutions and document the ideas) in engineering design process	TPS3	70	70
CO4	Draw sketches to a design problem and provide a trade-off matrix	TPS3	70	70
CO5	Communicate possible solutions through drawings and prepare project report	TPS3	70	70
CO6	Apply the concept of engineering fundamentals in Civil and Mechanical, Engineering	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

TPS Scale	Assesment-1 (Theory)						Assesment-2 (Theory)						Terminal Examination (Theory)		
	Worksheet-1			CAT-1			Case study-1			CAT-2					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	-	30	-	-	-	-	-	-	-	-	20	-
CO2	-	-	30	-	-	30	-	-	-	-	-	-	-	-	15
CO3	-	-	40	-	-	40	-	-	-	-	-	-	-	-	15
CO4	-	-	-	-	-	-	-	30	-	-	30	-	-	-	20
CO5	-	-	-	-	-	-	-	-	30	-	-	30	-	-	15
CO6	-	-	-	-	-	-	-	-	40	-	-	40	-	-	15

***Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

What is Engineering: Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements

Engineering Design: Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement.

Defining problems and Brainstorming: Researching design, sketching problem solving

Communicating solution: Dimensioning orthographic drawing, perspective drawing

Modelling and testing final output: Product evaluation, reverse engineering, final project report.

Civil Engineering: Structural forces structural analysis, bridge design components, structural design

Mechanical Engineering: Types of motion, mechanical power system, mechanical power formula, mechanical design.

Reference Books

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

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**What is Engineering**	
1.1	Engineering Requirement	1
1.2	Knowledge within Engineering disciplines,	1
1.3	Engineering advancements	1
2	**Engineering Design**	
2.1	Problem definition,	1
2.2	idea generation through brainstorming and researching	1
2.3	solution creation through evaluating and communicating,	1
2.4	text/analysis	1
2.5	final solution and design improvement	1
3	**Defining problems and Brainstorming:**	
3.1	Researching design	1
3.2	sketching problem solving	2

No.	Topic	No. of Periods
4	**Communicating solution**	
4.1	Dimensioning orthographic drawing	1
4.2	perspective drawing	1
5	**Modelling and testing final output**	
5.1	Product evaluation	1
5.2	reverse engineering	1
5.3	final project report	1
6	**Civil Engineering**	
6.1	Structural forces structural analysis	1
6.2	bridge design components	2
6.3	structural design	1
7	**Mechanical Engineering**	
7.1	Types of motion	1
7.2	mechanical power system	1
7.3	mechanical power formula	1
7.4	mechanical design	1
	Total	24

Course Designers:

1. Dr.S.J. Thiruvengadam, sjtece@tce.edu
2. Dr. V.R.Venkatasubramani, venthiru@tce.edu

22ME160	ENGINEERING GRAPHICS	Category	L	T	P	Credit(s)
		HSMC	3	0	2	4

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Draw the orthographic views of objects from the given isometric views and draw the orthographic projections of points.	TPS 3	70	70
CO2	Draw the orthographic projections (Elevation and Plan) of straight lines inclined to both reference planes.	TPS 3	70	70
CO3	Draw the orthographic projections (Elevation and Plan) of plane surfaces inclined to both reference planes.	TPS 3	70	70
CO4	Draw the orthographic projections (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one-reference plane.	TPS 3	70	70
CO5	Draw the orthographic projections (Elevation and Plan) of sectioned solids (Prisms, Pyramids, Cylinder and Cone) and true shape of the sections.	TPS 3	70	70
CO6	Draw the development of surfaces (base and lateral) of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone).	TPS 3	70	70
CO7	Draw the isometric projections of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone and Sphere) and convert the orthographic projections into isometric views.	TPS 3	70	70
CO8	Create computer-aided 3D models for the given drawing (2D/3D) and draw orthographic views for the 3D model with appropriate dimensioning using CAD package (Continuous Assessment only).	TPS 3	Continuous Assessment Only	

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO2	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO3	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO4	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO5	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO6	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO7	S	M	S	M	M	-	-	-	M	M	-	-	-	-
CO8	S	M	S	M	S	-	-	-	M	M	-	-	-	-

S – Strong M – Medium L – Low

Assessment Pattern

Bloom's Category / TPS Scale	Continuous Assessment Test	Terminal Examination
Remember / 1	---	---
Understand / 2	---	---
Apply / 3	100	100
Analyze / 4	---	---
Evaluate / 5	---	---
Create / 6	---	---

Marks Allocation for Continuous Assessment:

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

Question Pattern for Terminal Examination:

Q. No.	Description	Type	Marks
1	Orthographic views from isometric view / Projection of Points	Either or type	10
2	Projection of lines	Either or type	15
3	Projection of planes	Either or type	15
4	Projection of solids	Either or type	15
5	Section of solids	Either or type	15
6	Development of surfaces	Either or type	15
7	Isometric projections of combined solids / Conversion of orthographic views into isometric view	Either or type	15
	Total		**100**

Note:

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

Syllabus

Introduction - Significance of engineering graphics, Use of drawing instruments, Standards, Lettering and dimensioning, Scales.

Orthographic Projection - Principles of orthographic projections, First angle projection, Orthographic projection of objects from pictorial views. Projection (Elevation and Plan) of points located in all quadrants.

Projection (Elevation and Plan) of straight lines in first quadrant, inclined to both reference planes by rotating line method.

Projection (Elevation and Plan) of plane surfaces in first quadrant, inclined to both reference planes by rotating object method.

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

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

Development of base and lateral surfaces of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone) with cutting plane inclined to HP only.

Isometric projection – Principle, isometric scale, Isometric views and Isometric projections of single simple solids. Combination of solids (Prisms, Pyramids, Cylinder, Cone and sphere - in simple vertical positions only). Conversion of orthographic projections (Elevation, Plan and Side view) of solid parts / engineering components into isometric views.

Computer Aided Drafting (For Continuous Assessment only):

Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Cross hairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), Command Line, Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems. Orthographic and isometric views.

Practice on drawing of 2 dimensional geometric patterns consisting of entities such as lines, arcs and circles. Practice on creation of 3 dimensional wire-frame and shaded models. Dimensioning in isometric and orthographic views.

Text Book

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

Reference Books

1. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2012.
2. Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2019.

3. Venugopal K. and Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited, 2011.
4. Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Publications, Bangalore, 2017.
5. Shah M.B, and Rana B.C (2009) “Engineering Drawing and Computer Graphics”, Pearson Education.
6. CAD Software Theory and User Manuals.

Course Contents and Lecture Schedule

Sl. No.	Topic	Lecture Hours	Practice Hours
1	**Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering and dimensioning, Scales	2	1
2	**Orthographic Projection-** Principles of orthographic projections, First angle projection, **Orthographic projection of objects from pictorial views.**	2	2
3	**Projection (Elevation and Plan) of points** located in all quadrants.	2	1
4	**Projection (Elevation and Plan) of straight lines** in first quadrant, inclined to both reference planes by rotating line method.	4	2
5	**Projection (Elevation and Plan) of plane surfaces** in first quadrant, inclined to both reference planes by rotating object method.	5	3
6	**Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) in first quadrant, by rotating object method when the axis is inclined to one of the reference planes.	5	3
7	**Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.	4	2
8	**Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone) with cutting plane inclined to HP only.	4	2
9	**Isometric projection –** Principle, isometric scale, Isometric views and Isometric projections of single simple solids. Combined solids (Prisms, Pyramids, Cylinder, Cone and sphere - in simple vertical positions only). **Conversion of orthographic projections** (Elevation, Plan and Side view) of solid parts / engineering components into isometric views.	4	2

Sl. No.	Topic	Lecture Hours	Practice Hours
10	**Computer Aided Drafting** (For Continuous Assessment only)**:** **10.1** Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Cross hairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line, The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems. Orthographic and isometric views.	1	1
	10.2 – Practice on drawing of 2 dimensional geometric patterns consisting of entities such as lines, arcs and circles. Practice on creation of 3 dimensional wire-frame and shaded models. Dimensioning in isometric and orthographic views.	3	5
	TOTAL	**36**	**24**

Course Designers:

1. Dr. B. Karthikeyan, Assistant Professor, Mechanical Engineering bkmech@tce.edu
2. Dr. M. Kannan, Assistant Professor, Mechanical Engineering mknmech@tce.edu

22EG170	**ENGLISH LABORATORY**	Category	L	T	P	Credit(s)
		HSMC	0	0	2	1

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale
CO1	Interpret words correctly through listening and watching general and technical online contents	Understand
CO2	Develop appropriate pronunciation skills through listening and speaking practices	Apply
CO3	Build and apply a wide range of lexicons in general and technical presentations	Apply
CO4	Identify and apply the key ideas and spoken English features learnt through auditory and visual listening tools	Apply
CO5	Experiment with inventiveness by creating a blog, vlog, or YouTube channel.	Apply
CO6	Prepare and deliver oral and written presentations using digital tools.	Apply

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Students' performance will be assessed in the language lab/ classroom as given below:

- Spoken Task - General / Technical Presentation / Picture Description : 20 Marks
- Listening Task – (MCQs, Gap Filling Exercises) : 10 Marks
- Written Test - Phonetics, Grammar, Vocabulary, Reading : 20 Marks

External:

- Online Exam- Phonetics, Grammar, Vocabulary, Reading (45 Minutes) : 50 Marks
- Listening Test : 20 Marks
- Submission of Students' Record on Practical Tasks in the Class and Lab : 10 Marks
- BEC Vantage Speaking Tasks I and II : 20 Marks

List of Experiments

Sl. No.	Topic	Hours
	LAB ACTIVITIES (12 Hours)	
1	Listening to TED Talks/ Podcasts/ Product Advertisements/ News Bulletins.	2
2	Phonetics – Tutorials through Online Repositories, English Movie Clips and Software in the Lab(S-net)	2
3	Vocabulary Development through Movies / Short Films/ Documentaries	2
4	Language Development through English software S-net and Online Content (Tenses, Voices, SV Agreement, Prepositions, Coherence Markers, Relative Clauses, Modals, Punctuation)	2
5	Reading Comprehension – I (General / Technical, BEC Vantage Reading Task III)	2
6	Creating a Blog/Vlog/YouTube Channel –Uploading MP3/MP4 – Practice (Movie/Book/ Gadget Review, General/Tech Talks, Interview with Celebrities)	1
7	Revision – Model Online Aptitude Test	1
	CLASSROOM ACTIVITIES (12 Hours)	
8	Introduction of Spoken English Features	1
9	Self-introduction and Introducing others	1
10	Video Comprehension – Brainstorming and Note-Taking	2
11	Role-Play, Picture/Movie Description	1
12	Reporting the events from Media / Newspapers – Discussion	1
13	Interactive Games for Language Development	1
14	Reading / Note Making (Extensive Reading – News Paper Reports)	1
15	Presentation – I (Book /Movie Review, Story Telling, General Presentations)	2
16	Presentation – II (Technical Presentations)	2
	Total	24

Software Used:

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

Teaching Resources and Websites:

1. Open Online Repositories from Oxford / Cambridge / British Council/ Voice of America
2. Free Video Downloads from YouTube
3. www.ted.com
4. tcesrenglish.blogspot.com

Course Designers:

1. Dr. A.Tamilselvi, tamilselvi@tce.edu
2. Dr. S. Rajaram, sreng@tce.edu
3. Dr. RS. Swarnalakshmi, rssleng@tce.edu
4. Mrs. M. Sarpparaje, mseeng@tce.edu

22PH180	PHYSICS LABORATORY	Category	L	T	P	Credit(s)
		BSC	0	0	2	1

Preamble

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

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Analyse the mechanical & electrical oscillations and determine their resonance frequency	TPS3	85	90
CO2	Analyse the interference and diffraction patterns for micron sized objects	TPS3	85	90
CO3	Investigate the V-I characteristics of photodiode, phototransistor under dark and bright illumination conditions	TPS3	85	90
CO4	Determine the Planck's constant using LEDs	TPS3	85	90
CO5	Plot the VI characteristics of solar cell and find the fill factor	TPS3	85	90
CO6	Determine the reversibility of classical and quantum logic gates	TPS3	85	90
CO7	Identify the variation of magnetic field with distance for circular coils	TPS3	85	90

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

1. Quantum Logic Gate-Toffoli gate
2. Study of Optoelectronic Devices- Photodiode, Phototransistor.
3. Solar cell VI characteristics, fill factor & Optical fibre-Determination of numerical aperture.
4. Torsional pendulum – Determination of rigidity modulus of wire and moment of inertia of regular objects.
5. Laser Diffraction - Determination of wave length of the laser using grating and determination of micro particle size. (Observing diffraction pattern due to single and double slit)
6. Air wedge – Determination of thickness of a thin sheet/wire.
7. Determination of Planck's constant through V-I characteristics of LED.
8. Determination of magnetic field-Stewart and Gees.
9. LCR Circuit – Determination of resonant frequency

Course Designers:

1. Dr. N. Sankarasubramanian, Professor, nssphy@tce.edu
2. Dr. A. L. Subramaniyan, Assistant Professor, alsphy@tce.edu
3. Dr. P.K. Kannan, Assistant Professor, akphy@ce.edu

22CH190	CHEMISTRY LABORATORY	Category	L	T	P	Credit(s)
		BSC	0	0	2	1

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale
CO1	Estimate the chemical water quality parameters of sample water / effluent	Apply
CO2	Demonstrate presence of calcium ions in milk sample	Apply
CO3	Determine the surface tension of solvent mixtures	Apply
CO4	Estimate pH and acid content of samples using pH metric and conductometric titrations	Apply
CO5	Illustrate the strength of oxidisable materials present in given sample by potentiometric method	Apply
CO6	Determine Fe2+ ion in effluent using colorimetric method	Apply
CO7	Calculate the efficiency of electroplating	Apply
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	Apply

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO2	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO3	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO4	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO5	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO6	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO7	S	M	L	-	M	-	-	-	L	-	-	-	-	-
CO8	S	M	L	-	M	-	-	-	L	-	-	-	-	-

S – Strong M – Medium L – Low

List of Experiments

Experimental List	CO
Quantitative Analysis	
Estimation of total hardness of water sample	CO1
Estimation of COD of industrial effluent	CO1
Determination of calcium ion in milk sample	CO2
Determination of surface tension of solvent mixture	CO3
Electrochemical and Photochemical Analysis	
Determination of the Phosphoric acid content in soft drinks using conductometric titration	CO4
Determination of pH of soil by pH metric titration	CO4
Potentiometric redox titration ($K_2Cr_2O_7$vs FAS, $KMnO_4$vs FAS)	CO5
Estimation of iron content in water sample using colorimeter	CO6
Estimation of current density of electroplating process using Hull cell	CO7
Determination of rate of corrosion of metal and alloy using potentio-dynamic polarisation technique (TAFEL)	CO8

Learning Resources:

1. Vogel's Textbook of Quantitative Chemical Analysis (8THedition, 2014)
2. Laboratory Manual – Department of Chemistry, Thiagarajar College of Engineering (2022)

Course Designers:

1. Dr. M. Kottaisamy, hodchem@tce.edu
2. Dr. V. Velkannan, velkannan@tce.edu
3. Dr. S. Sivailango, drssilango@tce.edu
4. Dr. M Velayudham, mvchem@tce.edu
5. Dr. R Kodi Pandyan, rkp@tce.edu
6. Dr. A Ramalinga Chandrasekar, arcchem@tce.edu
7. Dr. B. Shankar, bsrchem@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Second and Third Semester

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015
DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

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

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Mechatronic System Laboratory ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT480 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Sensors and Instrumentation Project PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22MT630 Professional Communication HSMC 2	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22MT660 Mechanical Systems Project PW 3	23
VII	22MT710 Mechatronics System Design PCC 3	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 3	---	---	22MT730 Robotics and Automation Project PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT810 System Integration Project PW 3	9
									Total Credits	**160**

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits: Regular Admission	Credits: Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**24 - 36**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	09 - 12
	b.	Basic Science Courses (BSC)	24 - 27	06 - 09
	c.	Engineering Science Courses (ESC)	21 - 27	12 - 15
B.	**Professional Core Courses (PCC)**		**55**	**45**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

II SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT210	Matrices and Ordinary Differential Equations	BSC	3	1	0	4
22MT220	Analog Electronics	PCC	3	0	0	3
22MT230	Free Body Mechanics	PCC	3	0	0	3
22MT250	Manufacturing Process	PCC	3	0	0	3
THEORY CUM PRACTICAL						
22MT240	Problem Solving using C	ESC	1	0	4	3
PRACTICAL						
22MT260	Mechatronic Workshop	ESC	0	0	2	1
22MT270	Manufacturing Laboratory	PCC	0	0	2	1
22MT280	Mechatronic System Laboratory	ESC	0	0	2	1
		Total	**13**	**1**	**10**	**19**

HSMC : Humanities and Social Sciences including Management Courses
BSC : Basic Science Courses
ESC : Engineering Science Courses
PCC : Program Core Courses
L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

II SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT210	Matrices and Ordinary Differential Equations	3	40	60	100	27	50
22MT220	Analog Electronics	3	40	60	100	27	50
22MT230	Free Body Mechanics	3	40	60	100	27	50
22MT250	Manufacturing Process	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22MT240	Problem Solving using C	3	50	50	100	25	50
PRACTICAL							
22MT260	Mechatronic Workshop	3	60	40	100	18	50
22MT270	Manufacturing Laboratory	3	60	40	100	18	50
22MT280	Mechatronic System Laboratory	3	60	40	100	18	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

III SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT310	Partial Differential Equations	BSC	3	1	0	4
22MT320	Digital Electronics	PCC	3	0	0	3
22MT330	Kinematics and Dynamics of Machinery	ESC	3	0	0	3
22MT340	Thermal Fluid Systems	PCC	3	0	0	3
22MT350	Electrical Machines	ESC	3	0	0	3
PRACTICAL						
22MT360	Thermal Engineering Laboratory	PCC	0	0	2	1
22MT370	Electrical Machines Laboratory	ESC	0	0	2	1
22MT380	Electronic Circuits and Digital Laboratory	PCC	0	0	2	1
22ES390	Design Thinking	ESC	2	0	2	3
		Total	**15**	**1**	**6**	**22**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

III SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT310	Partial Differential Equations	3	40	60	100	27	50
22MT320	Digital Electronics	3	40	60	100	27	50
22MT330	Kinematics and Dynamics of Machinery	3	40	60	100	27	50
22MT340	Thermal Fluid Systems	3	50	50	100	25	50
22MT350	Electrical Machines	3	40	60	100	27	50
PRACTICAL							
22MT360	Thermal Engineering Laboratory	3	60	40	100	18	50
22MT370	Electrical Machines Laboratory	3	60	40	100	18	50
22MT380	Electronic Circuits and Digital Laboratory	3	60	40	100	18	50
22ES390	Design Thinking	3	60	40	100	18	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

22MT210	MATRICES AND ORDINARY DIFFERENTIAL EQUATIONS	Category	L	T	P	C	TE
		BSC	3	1	0	4	Theory

Preamble

Several mathematical problems encountered in scientific or industrial applications involve solving a linear system at some stage and that are arise in applications to such areas as electronics, engineering and physics. In engineering, particularly Solid Mechanics, Fluid Flow, Heat Flow and Robotics have application that requires an understanding of Vector Calculus and Differential Equations. Moreover, Laplace Transform is essential to solve ordinary differential equations that occur in the above areas. This course designed to impart the knowledge and understanding of the above concepts to all Engineers and apply them in their areas of specialization.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Compute the unknowns of the system of linear equations.	TPS2	80	75
CO2	Apply various operations on matrices to solve traffic flow, electric networks and construct an orthonormal basis of an inner product space.	TPS3	75	70
CO3	Compute divergence and curl of vector functions.	TPS2	80	75
CO4	Apply the concepts of vector differentiation and vector integration to evaluate work done by the force and fluid flow problems.	TPS3	75	70
CO5	Apply Laplace transform to solve the initial value problems arise in engineering.	TPS3	75	70
CO6	Solve the homogeneous and non-homogeneous differential equations using appropriate methods.	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><td rowspan="3"></td><td colspan="6">Theory Assessment-1</td><td colspan="6">Theory Assessment-2</td><td colspan="3" rowspan="2">Theory Terminal Examination</td></tr>
<tr><td colspan="3">Assignment-1</td><td colspan="3">CAT-1</td><td colspan="3">Assignment-2</td><td colspan="3">CAT-2</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>TPS / COs</td><td colspan="15"></td></tr>
<tr><td>CO1</td><td colspan="3" rowspan="4">100%</td><td colspan="2">17%</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td colspan="2">8%</td><td>-</td></tr>
<tr><td>CO2</td><td colspan="3">33%</td><td colspan="3"></td><td>-</td><td>-</td><td>-</td><td colspan="3">17%</td></tr>
<tr><td>CO3</td><td>8%</td><td colspan="2"></td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td>4%</td><td colspan="2">-</td></tr>
<tr><td>CO4</td><td colspan="3">42%</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3">21%</td></tr>
<tr><td>CO5</td><td>-</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3" rowspan="2">100%</td><td colspan="3">50%</td><td colspan="3">25%</td></tr>
<tr><td>CO6</td><td>-</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3">50%</td><td colspan="3">25%</td></tr>
</table>

Syllabus

MATRICES AND SYSTEM OF EQUATIONS: Systems of Linear Equations- Equivalent Systems- Row Echelon Form- Overdetermined Systems- Underdetermined Systems- Reduced Row Echelon Form- Applications: Traffic Flow, Electric Networks - Kirchhoff's Laws – Vector Spaces – Basis and dimension – Eigen values and eigen vectors of a matrix. - Hermitian and Unitary matrices - Inner Product space – Orthonormal vectors - Gram Schmidt orthogonalization process.

VECTOR CALCULUS: Divergence of a Vector Field- Curl of a Vector Field- Line Integrals- Path independence of line integrals- Green's Theorem in the plane- Surface Integrals- Triple Integrals, Divergence Theorem of Gauss- Applications of the Divergence Theorem- Stoke's Theorem.

LAPLACE TRANSFORMS: Laplace transform, Linearity, First Shifting theorem – Transforms of derivatives and integrals, ODEs – Unit step function, Second shifting theorem – Short Impulses, Dirac's delta function, partial fractions – Convolution, Integral Equations – Differentiation and integration of transforms.

ORDINARY DIFFERENTIAL EQUATIONS: Homogeneous Linear ODEs of second order – Homogeneous Linear ODEs with constant coefficients – Euler Cauchy Equation – Existence and uniqueness of solutions, Wronskian – Non homogeneous ODE- Solution by Variation of Parameters.

Text and Reference Book(s)

1. Steven Leon, "Linear Algebra with Applications", 9th Edition, Pearson Education, 2015.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thedition, Wiley, New Delhi, 2017.
3. David C. Lay, "Linear Algebra and its Applications", 4th Edition, Pearson Education, 2014.
4. B.S. Grewal, "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers, New Delhi, 2014.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**MATRICES AND SYSTEM OF EQUATIONS**	
1.1	Systems of Linear Equations- Equivalent Systems	1
1.2	Row Echelon Form- Overdetermined Systems	1
1.3	Underdetermined Systems- Reduced Row Echelon Form-	1
	Tutorial	1
1.4	Applications: Traffic Flow, Electric Networks - Kirchhoff's Laws	2
1.5	Vector Spaces – Basis and dimension	1
1.6	Eigen values and eigen vectors of a matrix	1
	Tutorial	1
1.7	Inner Product space – Orthonormal vectors	1
1.8	Gram Schmidt orthogonalization process	1
	Tutorial	1
2.	**VECTOR CALCULUS**	
2.1	Gradient, divergence and curl of a scalar and vector field	2
2.2	Line Integrals	2
	Tutorial	1
2.3	Green's Theorem in the Plane, Surface Integrals	2
	Tutorial	1
2.4	Triple Integrals. Divergence Theorem of Gauss	1
2.5	Applications of the Divergence Theorem	1
2.6	Stoke's Theorem	1
	Tutorial	1
3.	**LAPLACE TRANSFORMS**	
3.1	Laplace Transform, Linearity, First Shifting Theorem (s-Shifting)	2
3.2	Transforms of Derivatives and Integrals: ODEs	2
	Tutorial	1
3.3	Unit Step Function, Second Shifting Theorem	1
3.4	Short Impulses, Dirac's Delta Function and Partial Fractions	1
	Tutorial	1
3.5	Convolution. Integral Equations	2
3.6	Differentiation and integration of transforms	1
	Tutorial	1
4	**ORDINARY DIFFERENTIAL EQUATIONS**	
4.1	Homogeneous Linear ODEs of Second Order	2
4.2	Homogeneous Linear ODEs with Constant Coefficients	1
	Tutorial	1
4.3	Euler–Cauchy Equations	1
4.4	Existence and Uniqueness of Solutions. Wronskian	1
	Tutorial	1
4.5	Nonhomogeneous ODEs	2
4.6	Solution by Variation of Parameters	2
	Tutorial	1
	Total	**48**

Course Designers:

1. Dr. S. Saravanakumar, sskmat@tce.edu
2. Dr. M. Sundar, msrmat@tce.edu

22MT220	ANALOG ELECTRONICS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

This course provides engineering students with basic understanding of analog electronic components and designs of circuits using them. The syllabus includes Construction of Transistor, MOSFET its construction and different circuit configurations. Then we have some of the Op-amp basics, its configurations and different configurations for different applications. Then we learn about the feedback mechanisms used in the circuits for the generation of sinusoidal oscillations in generating waveforms using different Devices and IC.
Then we discuss about the voltage convertors and Regulators for powering the analog electronics.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the different types of transistors for specific applications	TPS2	80	80
CO2	Construct a FET based transistor circuits for switching applications	TPS3	70	70
CO3	Interpret the working of an operational Amplifier	TPS2	80	70
CO4	Select operational amplifier circuits for applications like clipper, amplifier, switches etc	TPS3	70	70
CO5	Construct Tuned oscillator circuits for filter and frequency selection applications	TPS3	70	70
CO6	Identify the appropriate Voltage Regulators and Convertors for analog circuits	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	25	-	-	25	-	-	-	-	-	-	-	-	10	-
CO2	-	-	50	-	-	50	-	-	-	-	-	-	-	-	20
CO3	-	25	-	-	25	-	-	-	-	-	-	-	-	10	-
CO4	-	-	-	-	-	-	-	-	50	-	-	50	-	-	20
CO5	-	-	-	-	-	-	-	-	25	-	-	25	-	-	20
CO6	-	-	-	-	-	-	-	-	25	-	-	25	-	-	20

Syllabus

Introduction: Introduction to Electronic Devices – Circuit theorems, Review of BJT Working and its applications
Field Effect Transistors: Junction Field Effect Transistors (JFET) –Construction of N channel and P Channel Devices – Transfer Characteristics - Metal oxide semiconductor FET (MOSFET) – Types - P channel and N channel MOSFET – FET Biasing
Operational Amplifiers: Basic information about op-amps – Ideal Operational Amplifier – General operational amplifier stages. DC and AC performance characteristics, slew rate, Open and closed loop, Error analysis
Applications: Sign Changer, Scale Changer, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Comparators, Schmitt trigger, Precision rectifier, peak detector, Low-pass, high-pass and band-pass Butterworth filters. Special ICs-555 timer and applications
Feedback and Oscillator circuits: Feedback Concepts - Feedback Connection Types - Feedback Circuits - Feedback Amplifier - Phase and Frequency Considerations - Oscillator Operation - Phase-Shift Oscillator - Wien Bridge Oscillator - Tuned Oscillator Circuit - Crystal Oscillator.
Voltage Regulators: Introduction, General Filter Considerations, Capacitor Filter, RC Filter, Discrete Transistor Voltage Regulation, IC Voltage Regulators and Convertors

Text Book(s)

1. Electronic Devices and Circuits theory - Robert L. Boylestead, Louis Nashelsky, New International Edition, 2013, Pearson ISBN-13 978-1292025636
2. Introductory Circuit Analysis, Global Edition, (13th Edition) September 2015 by Robert Boylestad, ISBN-13 978-1292098951
3. Open Circuits: The Inner Beauty of Electronic Components, by Windell Oskay and Eric Schleper, September 2022, 304 pp. ISBN-13: 97817185023

Reference Books & Web Resources

1. Integrated Electronics, Jacob Milman,Christos C Halkias, Mcgraw Hill Education
2. Thomas L.Floyd, “Electronic devices” Conventional current version, Pearson prentice hall, 10th Edition, 2017
3. David A. Bell,” Electronic devices and circuits”, Oxford University higher education,5th edition 2008
4. Electronic Devices and Circuits, S Salivahanan, N Suresh Kumar, A Vallvaraj, 5th Edition, MCGRAW HILL EDUCTION
5. Electronics Circuits and Application, Md H Rashid, Cengage 2014

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods	Course Outcome
1	**Introduction:**	-	-
1.1	Induction to Electronic Devices - Review of BJT Working and its applications	1	CO1
1.2	Circuit theorems	2	CO1
2	**Field Effect Transistors:**	-	-
2.1	Junction Field Effect Transistors (JFET) – Construction of N channel and P Channel Devices –	2	CO1
2.2	Transfer Characteristics - Metal oxide semiconductor FET (MOSFET) – Types - P channel and N channel MOSFET –	2	CO2
2.3	FET Biasing	2	CO2
3	**Operational Amplifiers**	-	-
3.1	Ideal Operational Amplifier	1	CO3
3.2	General operational amplifier stages. DC and AC performance characteristics, slew rate	2	CO3
3.3	Open and closed loop, Error Analysis	1	CO3
3.4	Sign Changer, Scale Changer, Voltage Follower	1	CO4
3.5	V-to-I and I-to-V converters, adder, subtractor	2	CO4
3.6	Instrumentation amplifier, Integrator, Differentiator	2	CO4
3.7	Comparators, Schmitt trigger, Precision rectifier, peak detector	2	CO4
3.8	Low-pass, high-pass, and band-pass Butterworth filters. Special ICs-555 timer and applications	3	CO4
4	**Feedback and Oscillator circuits**	-	-
4.1	Feedback Concepts- Feedback Connection Types - Feedback Circuits	2	CO5
4.2	Feedback Amplifier—Phase and Frequency Considerations	1	CO5
4.3	Oscillator Operation	1	CO5
4.4	Operation Phase-Shift Oscillator Wien Bridge Oscillator	2	CO5
4.5	Tuned Oscillator Circuit Crystal Oscillator	1	CO5
5	**Voltage Regulators**	-	-
5.1	General Filter Considerations, Capacitor Filter	2	CO6
5.2	RC Filter	2	CO6
5.3	Discrete Transistor Voltage Regulation, IC Voltage Regulators	2	CO6
	Total	**36**	

Course Designers:

1. Mr. S Parthasarathi, parthasarathi_s@tce.edu
2. Mr. S.A.R. Sheik Masthan, sarsmech@tce.edu

22MT230	FREE BODY MECHANICS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Understand the laws and principles of mechanics	TPS2	70	80
CO2	Analyse and solve simple problems using the concept of static equilibrium	TPS3	70	80
CO3	Find the centroid and moment of inertia of a 2D and 3D components	TPS3	70	80
CO4	Solve problems involving frictional phenomena in machines	TPS3	70	80
CO5	Solve problems involving kinematics and kinetics of rigid bodies in plane motion	TPS3	70	80
CO6	Solve problems using D'Alembertz principles	TPS3	70	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	-	-	-	30	-	-	-	-	-	-	-	4	-
CO2	-	10	35	-	-	35	-	-	-	-	-	-	4	4	12
CO3	-	10	35	-	-	35	-	-	-	-	-	-	4	4	12
CO4	-	-	-	-	-	-	-	10	-	-	-	30	4	4	12
CO5	-	-	-	-	-	-	-	10	35	-	-	35	4	4	12
CO6	-	-	-	-	-	-	-	10	35	-	-	35	4	-	12

Syllabus

Static Equilibrium of Mechanical Systems: Equilibrium Conditions-Two force body-Three force body.
System of forces: Representation of Force, Moment and Couples-Reduction of system of forces to one force and couple.
Distributed forces: Centroid of lines and areas-Centre of gravity of mass-Moment of inertia of areas-Mass moment of inertia.
Objects with friction: Ladder friction-Wedge Friction-Screw Friction-Applications
Dynamic equilibrium: Particles in motion-Kinematics of particles-rectilinear motion-Curvilinear Motion-Kinetics of particles-Newton's Law of motion-Work-energy principle-Impulse-Momentum principle, D'Alembert's principle.
Rigid body motion: Kinematic Motion -Rotary motion of rigid bodies-Plane Motion-Kinetic motion.

Text Book(s)

1. Beer F.P. and Johnston Jr. E.R., Vector Mechanics for Engineers: Statics and Dynamics, Twelfth student Edition, Tata McGraw Hill College, 2018
2. Hibbeler R.C., Engineering Mechanics – Statics & Dynamics, Fourteenth Edition, Pearson Publisher, 2015

Reference Books & Web Resources

1. R.C Hibbeler, Irving H Shames, D.P Sharma., Engineering Mechanics, Pearson Education 2011
2. Tayal A.K., Engineering Mechanics, Fourteenth Edition, Umesh Publications, 2010
3. https://nptel.ac.in/courses/112103108/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1.	Introduction Static Equilibrium of mechanical systems	2
1.1	Fundamental laws, Free body diagram	1
1.2	Two force body, three force body	1
2.	**System of forces**	
2.1	Representation of Force,	1
2.2	Moment and Couples	1
2.3	Reduction of system of forces to one force and couple	1
3	**Distributed forces**	
3.1	Centroid of lines and areas	1
3.2	Centre of gravity of mass	2
3.3	Moment of inertia of areas	1
3.4	Tutorial Problems in Moment of Inertia	2
4.	**Objects with friction**	
4.1	Ladder friction	2
4.2	Wedge friction	1
4.3	Screw friction	2
5.	**Dynamic equilibrium**	
5.1	Particles in motion	1
5.2	Kinematics of particles	1
5.3	Rectilinear motion	1
5.4	Curvilinear motion	1
5.5	Kinetics of particles	1
5.6	Newton's Law of motion	2
5.7	Work-energy principle	2
5.8	Impulse-Momentum principle,	2
5.9	Tutorial Problems	1
6.	**Rigid body motion**	
6.1	General plane motion	1
6.2	Kinematic Motion –Rotary motion of Rigid bodies	1
6.3	Plane motion -D Alembert's principle	1
6.4	Kinetic motion	1
6.5	Tutorial Problems	2
	Total	**36**

Course Designer(s):

1. Dr. G Kanagaraj, gkmech@tce.edu

22MT240	PROBLEM SOLVING USING C (TCP)	Category	L	T	P	C	TE
		ESC	1	0	4	3	Practical

Preamble

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

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Develop algorithms for solving simple mathematical and engineering problems	TPS3	70	70
CO2	Explain the various programming concepts in C Language	TPS2	70	70
CO3	Translate algorithms to programs in C Language	TPS3	70	70
CO4	Examine the suitability of appropriate branching, selection, iteration, structures, data types for given problem and develop solution for the same	TPS3	70	70
CO5	Organize files, perform text operations like editing, pattern searching and string manipulation related problems	TPS3	70	70
CO6	Analyse and debug the programs written in C Language for syntax, run time and logical errors	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="2">Continuous Assessment Test (CAT)*</th><th rowspan="2">Terminal (Practical)</th></tr>
<tr><th>CAT 1 (Theory)</th><th>CAT 2 (Lab Model Exam)</th></tr>
<tr><td>CO1</td><td>30</td><td rowspan="6">100</td><td rowspan="6">100</td></tr>
<tr><td>CO2</td><td>20</td></tr>
<tr><td>CO3</td><td>10</td></tr>
<tr><td>CO4</td><td>-</td></tr>
<tr><td>CO5</td><td>40</td></tr>
<tr><td>CO6</td><td>-</td></tr>
</table>

Syllabus

Algorithms: Introduction to Computer, Program Design, Flowcharts, Developing an Algorithm, Fundamental Algorithms, Algorithms Using Selection and Repetition, exchanging values of variables, Counting

C Components: Program structure - Compilers – Assemblers – Linkers – Loaders - Integrated Development Environment - Project Creation

C Programming Concepts: Data Types – Operators - Control Structures – Format Specifiers – Arrays – 1D, 2D – Character and String handling - Functions – passing values – recursive functions - Scope and extent - Storage Classes - Pointers – pointer arithmetic – pointers and arrays – pointers as arguments - Structures – array of structures – union – dynamic memory allocation - File operations – I/O operations – error handling

Debugging Techniques: Error Types, identification – Debugging steps and tools – watch window – breakpoint – step in, out

Text Book(s) and Reference Materials

1. Herbert Schildt, C: The Complete Reference, 4th edition, McGraw Hill Education, 2017
2. Yashavant Kanetkar, Let Us C: Authentic guide to C programming language, 18th edition, BPB Publications, 2021

Reference Materials and Web Resources

1. E. Balagurusamy, “Programming in ANSI C”, 8th edition, McGraw Hill Education, 2019
2. NPTEL Course: https://onlinecourses.nptel.ac.in/noc17_cs43/preview
3. NPTEL Course: https://onlinecourses.nptel.ac.in/noc20_cs06/preview
4. https://www.tutorialspoint.com/cprogramming/index.htm
5. https://www.geeksforgeeks.org/c-programming-language/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	
		Theory	Practical
1	**Algorithms**	-	-
1.1	Introduction to Computer, Program Design, Flowcharts, Developing an Algorithm, Fundamental Algorithms,	2	-
1.2	Algorithms Using Selection and Repetition, exchanging values of variables, Counting	2	-
	Exercise involving algorithm development	-	2
2	**C Components**	-	-
2.1	Program structure - Compilers – Assemblers – Linkers – Loaders - Integrated Development Environment - Project Creation	2	-
3	**C Programming Concepts**	-	-
3.1	Data Types – Operators - Control Structures – Format Specifiers	2	-
	Algorithm to C Program Conversion	-	2
	Fundamentals Problem solving using Control Structures	-	6
3.2	Arrays – 1D, 2D – dynamic arrays	2	-
	Programs using Arrays	-	4
3.3	Character and String handling	2	-
	Programs involving character and string handling	-	2
3.4	Functions – passing values – recursive functions - Scope and extent - Storage Classes	4	-
3.5	Pointers – pointer arithmetic – pointers and arrays – pointers as arguments – Structures – array of structures – union – dynamic memory allocation	4	-
	Programs involving Functions and pointers	-	4
3.6	File operations – I/O operations – error handling	2	
	Programs involving files	-	2
4	**Debugging Techniques**	-	-
4.1	Error Types, identification – Debugging steps and tools – watch window – breakpoint – step in, out	2	-
	Programs predicting the output and debugging	-	2
	TOTAL	**24**	**24**

Course Designers:

1. S.A.R. Sheik Masthan, sarsmech@tce.edu

22MT250	MANUFACTURING PROCESS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

Primarily, the manufacturing processes are being carried out through casting, forming, machining, and joining processes. This course aims to provide knowledge on the working principles, basic operations and applications on the above stated processes

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the principle, process capabilities of metal casting, forming, joining and machining processes.	TPS2	75	80
CO2	Select the suitable metal casting and forming processes for the given product.	TPS3	75	80
CO3	Suggest the suitable joining methods for assembly of product.	TPS2	75	80
CO4	Select a suitable process for machining of a given part.	TPS3	75	80
CO5	Select a suitable process for the given manufacturing applications.	TPS3	75	80
CO6	Calculate the machining time for lathe and drilling operations	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 1			Assignment 1					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO2	4	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO3	2	20	30	-	-	100	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	35	4	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	35	2	5	10
CO6	-	-	-	-	-	-	2	10	20	-	-	30	2	5	10

Syllabus

Manufacturing Processes- Classification of Manufacturing Processes- Metal Casting-Metal Forming- Machining Processes- Metal Joining Processes- Metal Finishing Processes.
Metal Casting Processes: Expendable mould Casting Processes -Sand Casting – Shell moulding – Plaster Mould casting – Ceramic mould casting – Investment casting – Permanent Mold casting Processes – Pressure casting - Die casting - Centrifugal casting, Role of materials and chemistry in casting.
Plastic forming Processes: Plastics, general properties and applications of thermo plastics and thermosets, Extrusion, Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Transfer molding**.**
Metal Forming Processes: Flat Rolling – Flat Rolling Practice –Rolling Mills – Shape Rolling operations – Production of seamless tubing and pipe – Forging –Open die forging – Impression Die and Closed die forging – Extrusion - Hot extrusion – Cold extrusion – Impact extrusion – Hydrostatic extrusion.
Sheet metal forming Processes: Shearing – Sheet Metal characteristics – Bending sheet and plate.
Metal Joining Processes: Fusion Welding Processes- Oxy Acetylene welding - Arc welding processes: Consumable Electrode and Non-consumable Electrode – Electron Beam Welding – Laser Beam Welding. Solid State Welding Processes: **-** Ultrasonic welding – Friction welding – Resistance welding.
Brazing, Soldering: Introduction to Brazing and Soldering
Machining processes for producing round shapes: Centre Lathe, Horizontal Boring Machine – Radial Drilling Machine.
Machining processes for producing various shape: Vertical Milling machine – Horizontal Broaching machine, Surface treatment.
Abrasive machining and finishing processes: Abrasives – Bonded Abrasives (Grinding Wheels) – Cylindrical Grinding Machine – Surface Grinding Machine - Lapping – Honing - Super finishing.
Introduction to Additive Manufacturing and Unconventional Machining Process – Laser cutting, Chemical and Electro chemical Machining, Composite Manufacturing.

Text Book(s)

1. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Eighth Edition, Pearson, 2020.
2. Mikell P.Groover, "Fundamental of Modern Manufacturing", Wiley India Edition, Third Edition, Reprint, 2012.

Reference Books & Web Resources

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

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Manufacturing Processes**	
1.1	Classification of Manufacturing Processes- Metal Casting- Metal forming- Machining Processes- Metal Joining Processes- Metal Finishing Processes.	2
1.2	**Metal casting Processes** Expendable mould Casting Processes -Sand Casting Shell molding – Plaster Mould casting	2
1.3	Ceramic mould casting – Investment casting Permanent Mould casting Processes – Slush casting	2
1.4	Pressure casting – Die casting – Centrifugal casting	1
1.5	**Plastic forming Processes:** Plastics, general properties and applications of thermo plastics and thermosets, Extrusion	2
1.6	Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Transfer molding**.**	2
2	**Metal Forming Processes**	
2.1	Production of seamless tubing and pipe	1
2.2	Forging –Open die forging, Impression Die and Closed die forging and related forging operations	2
2.3	Extrusion- Hot extrusion – Cold extrusion, Impact extrusion – Hydrostatic extrusion	2
2.4	**Sheet metal forming Processes:** Shearing, Sheet Metal characteristics – Bending sheet and plate	2
3	**Metal Joining Processes**	
3.1	Fusion Welding Processes-Oxy Acetylene welding	1
3.2	Arc welding processes: Consumable Electrode and Non consumable Electrode	2
3.3	Electron Beam Welding – Laser Beam Welding.	1
3.4	Solid State Welding Processes: **-** Ultrasonic welding, Friction welding – Resistance welding	2
3.5	Introduction to Brazing and Soldering	1
4	**Machining processes for producing round shapes**	
4.1	Centre Lathe - Horizontal Boring Machine, Radial Drilling Machine	3
4.2	**Machining processes for producing various shape** Vertical Milling machine	1
4.3	Horizontal Broaching machine - surface treatment	1
4.3	**Abrasive machining and Finishing processes** Abrasives – Bonded Abrasives (Grinding Wheels)	1
4.4	Cylindrical Grinding Machine - Surface Grinding Machine	1
4.5	Lapping – Honing - Super finishing	1
4.6	Introduction to Additive Manufacturing	1
4.7	Unconventional Machining Process - LASER cutting, Chemical and Electro chemical Machining, Composite Manufacturing	2
	Total	**36**

Course Designers:

1. Dr. M. Palaninatharaja, pnatharaja@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu
3. Dr. K.J. Nagarajan, kjnmech@tce.edu

22MT260	MECHATRONIC WORKSHOP	Category	L	T	P	C	TE
		ESC	0	0	2	1	Practical

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Make different types of wooden joints and sheet metal components	TPS3	80	90
CO2	Construct protection circuits using Fuse, MCB, MCCB, ELCB	TPS3	80	90
CO3	Prepare and test an Ethernet cable for Local Area Network connection	TPS3	80	90
CO4	Construct Switching circuits using Transistor, MOSFET and Thyristors	TPS4	75	80
CO5	Design and fabricate a Printed Circuit Board	TPS3	80	90
CO6	Assemble components in PCB using Soldering Techniques	TPS4	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Name of the Experiment	No. of Periods
1	Preparation of wooden parts like Door frame / Office tray	4
2	Preparation of Sheet metals like Litre Cone/Dustpan (Straight, Taper)/Tray (Straight, Taper).	4
3	Electrical Wiring practices (One way switch and Two-way switch)	2
4	Electrical Wiring practices and testing with circuit breakers using Fuse, MCB, MCCB, ELCB	
5	Local Area Network Structure cabling	2
6	Verification of Transistor switching circuits using breadboard	2
7	Verification of MOSFET and Thyristor switching circuits using breadboard	2
8	Construction of timer circuits using 555 Timer IC	2
9	Identification of electronic components	2
10	Design a PCB layout for a given circuit	2
11	Fabricate a PCB using wet Etching	2
12	Assemble and dissemble of electronic components using soldering	2
	Total	**24**

Course Designers:

1. Mr. S. Parthasarathi, parthasarathi_s@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu

22MT270	MANUFACTURING LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

Manufacturing processes are the steps through which raw materials are transformed into a final product. Manufacturing processes can be classified as: 1. Casting Processes, 2. Forming Processes, 3. Machining Processes, 4. Joining Processes, 5. Finishing Processes.
Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify.
This course is aimed to provide practical experience on the working principles, process capabilities, process parameters, equipment advantages, limitations and applications of various casting, metal joining and Machining processes.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Prepare a mould using suitable casting process.	TPS3	80	90
CO2	Select a suitable material and process for a given product to perform welding.	TPS3	80	90
CO3	Perform tapering, turning and threading in lathe for the given component.	TPS3	80	90
CO4	Machine a given component using suitable milling process	TPS3	80	90

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Name of the Experiment	No. of Periods
1	Preparation of Mould for sand casting using single piece pattern	2
2	Preparation of Mould for sand casting using split pattern	2
3	Make a butt/lap/ corner/ Tee joint using the given metal strips in ARC welding	2
4	Make a butt/lap/ corner/ Tee joint using the given metal strips in MIG welding	2
5	Make a butt/lap/ corner/ Tee joint using the given metal strips in SPOT welding	2
6	Plain, Taper and Step turning in lathe	2
7	Grooving (UCD) and Thread (Left), and Thread (Right) in lathe	2
8	Spur / Helical Gear Cutting in Horizontal Milling Machine	2
9	Key Way Milling and Flat Milling in Vertical Milling Machine	2
10	Plain Grinding, Morse Taper Grinding in Grinding Machine	2
11	Drilling, Counter Boring and Tapping	2
12	Demonstration of 3D printing in RP Machine	2
	Total	**24**

Course Designers:

1. Dr. M. Palaninatharaja, pnatharaja@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu
3. Dr. K.J. Nagarajan, kjnmech@tce.edu

22MT280	MECHATRONIC SYSTEM LABORATORY	Category	L	T	P	C	TE
		ESC	0	0	2	1	Practical

Preamble

Mechatronics allows the engineer to integrate mechanical, electronics, control engineering and computer science into a product design process. Competing in a globalized market requires the adaptation of modern technology to yield flexible, multifunctional products that are better, cheaper, and more intelligent than those currently on the shelf. The importance of mechatronics is evidenced by the myriad of smart products that we take for granted in our daily lives, from the cruise control feature in our cars to advanced flight control systems and from washing machines to multifunctional precision machines.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Identify the components present in a Mechatronics system.	TPS3	80	80
CO2	Assemble and Disassemble a Mechatronics System	TPS3	70	70
CO3	Summarize the components present in a Mechatronics system.	TPS3	80	70
CO4	Develop a Toy Using the Electrical, Mechanical and Electronics components	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Name of the Experiment	No. of Periods
1	Identifying the Electrical, mechanical, and electronic Circuits available in an Automobile.	4
2	Assemble and disassemble a 3D Printer and Explain the working of its components.	2
3	Assemble and Disassemble a Washing Machine and Explain the working of its Components	2
4	Assemble and Disassemble a Microwave Oven and Explain the working of its Components	2
5	Assemble and Disassemble a Mobile Robot and Explain the working of its Components	2
6	Identify the Electrical, mechanical and Electronics Components for an Industrial Robot	2
7	Implementing the Electronic Circuits identified in the Electronics circuits.	4
8	Built a Creative Toy Using the Electrical, Mechanical and Electronics components Identified in the above experiments	6
	Total	**24**

Course Designers:

1. Dr. G. Kanagaraj, gkmech@tce.edu
2. Mr. S. Parthasarathi, parthasarathi_s@gmail.com

22MT310	PARTIAL DIFFERENTIAL EQUATIONS	Category	L	T	P	C	TE
		BSC	3	1	0	4	Theory

Preamble

Fourier series are infinite series that represent periodic functions in terms of cosines and sines that are of greatest importance to the engineer and applied mathematician. Integral theorems play a vital role to obtain Fourier transform from Fourier series. Fourier transform have wide applications in engineering especially in designing electrical circuits, solving differential equations, signal processing, signal analysis, image processing and filtering. The course also develops students' skills in the formulation, solution, understanding and interpretation of partial differential equation models, which helps to solve wave propagation and heat phenomena.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering applications.	TPS3	75	70
CO2	Understand Fourier integral theorems to transform of elementary functions.	TPS2	80	75
CO3	Apply Fourier transform to illustrate discrete/continuous functions arising in signals and systems.	TPS3	75	70
CO4	Solve the partial differential equations using various methods.	TPS3	75	70
CO5	Distinguish the partial differential equations of second order.	TPS2	80	75
CO6	Solve the boundary value problems involving wave phenomena and heat propagation using suitable methods.	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="3"></th><th colspan="6">Theory
Assessment-1</th><th colspan="6">Theory
Assessment-2</th><th colspan="3" rowspan="2">Theory
Terminal Examination</th></tr>
<tr><th colspan="3">Assignment-1</th><th colspan="3">CAT-1</th><th colspan="3">Assignment-2</th><th colspan="3">CAT-2</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th></tr>
<tr><th>TPS / COs</th><th colspan="15"></th></tr>
<tr><td>CO1</td><td colspan="3" rowspan="3">100%</td><td colspan="3">42%</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3">21%</td></tr>
<tr><td>CO2</td><td colspan="2">13%</td><td>-</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="2">6%</td><td>-</td></tr>
<tr><td>CO3</td><td colspan="3">45%</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3">23%</td></tr>
<tr><td>CO4</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3" rowspan="3">100%</td><td colspan="3">50%</td><td colspan="3">25%</td></tr>
<tr><td>CO5</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="2">13%</td><td></td><td colspan="2">6%</td><td>-</td></tr>
<tr><td>CO6</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3">37%</td><td colspan="3">19%</td></tr>
</table>

Syllabus

Fourier series: Conditions for Fourier expansion - Functions having points of discontinuity - Change of interval - Odd and even function- Periodic functions – Half range series – Fourier series of typical waveforms - Parseval's formula – Complex form of Fourier series – Harmonic analysis.

Fourier Transforms:
Fourier Integral theorem – Fourier sine and cosine integrals – Complex form of Fourier integrals – Fourier Transform – Fourier sine and cosine transforms – Finite Fourier sine and cosine transforms–Properties of Fourier transforms- Convolution theorem for Fourier transforms – Parseval's identity for Fourier transforms.

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

Applications of Partial Differential Equations:
Method of separation of variables – Classification of second order partial differential equations Vibrations of a stretched string: Wave equations – One dimensional heat flow – Two-dimensional heat flow: Solution of Laplace equation in Cartesian coordinates –Laplace equations in polar coordinates.

Text Book(s)

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 42nd Edition, 2012

Reference Books & Web Resources

1. Peter V.O. Neil, "Advanced Engineering Mathematics",7th edition, Cengage Learning, 2017.
2. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi,2016.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods	CO
1	**Fourier Series**		
1.1	Conditions for Fourier expansion, Euler's formula, Functions having points of discontinuity	1	**CO1 (10)**
1.2	Change of interval, Odd and even functions, Expansions of odd or even and periodic functions	2	
	Tutorial	1	
1.3	Half range series	2	
1.4	Fourier series of typical wave forms, Harmonic analysis	3	
	Tutorial	1	
2	**Fourier Transforms**		
2.1	Fourier Integral theorem – Fourier sine and cosine integrals	1	**CO2 (3)**
2.2	Complex form of Fourier integrals	1	
	Tutorial	1	
2.3	Fourier Transform, Fourier sine and cosine transforms	2	**CO3 (11)**
	Tutorial	1	
2.4	Finite Fourier sine and cosine transforms	2	
2.5	Properties of Fourier transforms	1	
	Tutorial	1	
2.6	Convolution theorem for Fourier transforms, Parseval's	3	
	Tutorial	1	
3.	**Partial Differential Equations**		
3.1	Formation and Solutions of PDE	1	**CO4 (12)**
3.2	Equations solvable by direct integration, Linear Equations of the first order	2	
	Tutorial	1	
3.3	Nonlinear equations of the first order	2	
3.4	Homogeneous linear equations with constant coefficients, Rules for finding the complementary functions	1	
	Tutorial	1	
3.5	Rules for finding the particular integral	1	
3.6	Working procedure to solve homogeneous and non-homogeneous linear equations	2	
	Tutorial	1	
4.	**Applications of Partial Differential Equations**		
4.1	Method of Separation of variables	1	**CO5 (3)**
4.2	Classification of second order partial differential equations	1	
	Tutorial	1	
4.2	Vibrations of a stretched string – Wave equations	2	**CO6 (9)**
	Tutorial	1	
4.3	One dimensional heat flow	2	
4.5	Solution of Laplace equation in Cartesian coordinates	2	
4.6	Laplace equations in polar coordinates	1	
	Tutorial	1	
	Total	**48**	

Course Designers:

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22MT320	DIGITAL ELECTRONICS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Interpret the different number systems and coding schemes and arithmetic operations on binary numbers	TPS2	80	80
CO2	Utilize K- Map for gate level minimization of the given Boolean function	TPS3	70	70
CO3	Construct combinational logic circuits for the given requirement	TPS3	80	70
CO4	Classify Different Latches and Flipflops used in memory-based circuit Design	TPS2	70	70
CO5	Construct synchronous and asynchronous counters for the Given requirement	TPS3	70	70
CO6	Experiment with programmable logic circuits for Desired application	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 1			Assignment 1					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-	-	20	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	-	-	40	-	-	-	-	-	-	-	-	20
CO3	-	20	-	-	20	-	-	-	-	-	-	-	-	10	-
CO4	-	-	-	-	-	-	-	-	30	-	-	30	-	-	10
CO5	-	-	-	-	-	-	-	-	30	-	-	30	-	-	20
CO6	-	-	-	-	-	-	-	-	40	-	-	40	-	-	20
CO7	-	20	-	-	20	-	-	-	-	-	-	-	-	10	-

Syllabus

Logic Gates and Minimization Techniques: Introduction to Analog and Digital Electronics, Need for digital, why digital, Number systems, Basic digital circuits: Characteristics of Digital IC's and Fan in -Fan out Logic circuits - universal building block construction using logic gates - Boolean Algebra- Simplification of Boolean functions - special forms of Boolean functions minterm (SOP) maxterm (POS) - K Map representation of logic functions - simplification of logic functions using K Map – Don't care conditions
Combinational Circuits: Half and Full Adders-Half and Full Subtractors - Code converters - Encoder-Decoder - Multiplexer- Demultiplexer - Binary/ BCD adders, subtractors - Carry look ahead adder- parity checker-parity generators- Magnitude comparator
Sequential Circuits: General model of sequential circuits - flip-flops - latches - level triggering, edge triggering - master slave configuration - Mealy/Moore models - state diagram - state table - State minimization State assignment Excitation table and maps
Synchronous and Asynchronous Sequential Circuits: Design of synchronous sequential circuits – Counter - parity checker - sequence detector - Asynchronous sequential logic: Race conditions and Cycles - Hazards in combinational circuits.
Sequential Memories: Shift registers, Recirculation shift registers Programmable Logic Devices (PLD) - Programmable Logic Array (PLA) - Programmable Array Logic (PAL) Field Programmable Gate Arrays (FPGA) - Implementation of combinational logic circuits using RAM, ROM, PLA, PAL, Applications in Automobile industries.

Text Book(s)

1. M. Morris Mano, Michel D. Ciletti, Digital Design with an Introduction to the Verilog HDL, VHDL, and System Verilog, Sixth Edition Global Edition Pearson Education, New Delhi, 2019. ISBN 10: 1-292-23116-5 ISBN 13: 978-1-292-23116-7
2. Ronald J. Tocci Neal S. Widmer and Gregory L. Moss, Digital Systems: Principles and Applications, Prentice Hall of India, New Delhi, 2010.

Reference Books & Web Resources

1. Anand Kumar, Fundamentals of Digital Circuits, PHI Learning Pvt. Ltd. 2014.
2. Thomas L. Floyd, Digital Fundamentals, Pearson Education Inc, New Delhi, 2003.
3. Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, Tata McGraw- Hill Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2003
4. Charles H.Roth. Fundamentals of Logic Design, Thomson
5. https://onlinecourses.nptel.ac.in/noc19_ee09/preview
6. https://nptel.ac.in/courses/117106086/.

Course Contents and Lecture Schedule

Module No	Topic	No. of. Lectures	Course Outcome
1	**LOGIC GATES AND MINIMIZATION TECHNIQUES**		
1.1	Introduction to Analog and Digital Electronics, Need for digital, why digital, Number systems	2	CO1
1.2	Characteristics of Digital IC's - Logic circuits - Universal building block construction using logic gates	2	CO1
1.3	Boolean Algebra- Simplification of Boolean functions - special forms of Boolean functions minterm (SOP) maxterm (POS)	2	CO2
1.4	K Map representation of logic functions - simplification of logic functions using K Map	2	CO2
1.5	Don't care conditions	1	CO2
2	**COMBINATIONAL CIRCUITS**		
2.1	Half and Full Adders-Half and Full Subtractors	1	CO3
2.2	Code converters -Encoder-Decoder	1	CO3
2.3	Multiplexer and Demultiplexer	1	CO3
2.4	Binary/ BCD adders, subtractors	1	CO3
2.5	Carry look ahead adder	1	CO3
2.6	Parity checker-parity generators	1	CO3
2.7	Magnitude comparator	1	CO3
3	**SEQUENTIAL CIRCUITS**		
3.1	General model of sequential circuits - flip-flops	1	CO4
3.2	Latches - level triggering, edge triggering	1	CO4
3.3	Master slave configuration - Mealy/Moore models	2	CO4
3.4	State diagram - state table - State minimization State assignment Excitation table and maps	2	CO4
4	**SYNCHRONOUS AND ASYNCHRONOUS SEQUENTIAL CIRCUITS**		
4.1	Design of synchronous sequential circuits - parity checker - sequence detector	2	CO5
4.2	Asynchronous sequential logic:	2	CO5
4.3	Race conditions and Cycles	2	CO5
4.4	Hazards in combinational circuits	2	CO5
5	**SEQUENTIAL MEMORIES**		
5.1	Shift registers, Recirculation shift registers	2	CO6
5.2	Programmable Logic Devices (PLD) - Programmable Logic Array (PLA) - Programmable Array Logic (PAL)	1	CO6
5.3	Field Programmable Gate Arrays (FPGA)	1	CO6
5.4	Implementation of combinational logic circuits using PAL, PLA	1	CO6
5.5	Applications in Automobile industries.	1	CO6
	Total	**36**	

Course Designers:

1. Mr. S Parthasarathi, parthasarathi_s@tce.edu
2. Mr. S.A.R. Sheik Masthan, sarsmech@tce.edu

22MT330	KINEMATICS AND DYNAMICS OF MACHINERY	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Develop skills for design and analyse the linkages, mechanism and its inversions	TPS1	70	80
CO2	Determine the velocity and acceleration for simple mechanism	TPS3	70	80
CO3	Construct the turning moment diagram for flywheel	TPS3	70	80
CO4	Develop the cam profile for three types of follower	TPS2	70	80
CO5	Design gear and gear trains for a given input/output motion or force relationship	TPS3	70	80
CO6	Determine the natural frequency of longitudinal, transverse and torsional vibrations	TPS3	70	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	-	-	-	30	-	-	-	-	-	-	-	4	-
CO2	-	10	35	-	-	35	-	-	-	-	-	-	4	4	12
CO3	-	10	35	-	-	35	-	-	-	-	-	-	4	4	12
CO4	-	-	-	-	-	-	-	10	-	-	-	30	4	4	12
CO5	-	-	-	-	-	-	-	10	35	-	-	35	4	4	12
CO6	-	-	-	-	-	-	-	10	35	-	-	35	4	-	12

Syllabus

Elements of machines and mechanism: Introduction, Links-types, Kinematics pairs-classification, Constraints-types, Degree of Freedom, Grubler's equation, linkage mechanisms, inversions of four bar linkage, slider crank chain and double slider crank chain.
Velocity in Mechanisms: Velocity diagram - Slider Crank and Four Bar mechanism, relative velocity method
Acceleration in Mechanisms: Acceleration diagram, Slider Crank and Four Bar mechanism Klein's construction for Slider Crank mechanism
Force Analysis: Static force analysis of linkages, Equivalent offset inertia force, Dynamic analysis of slider crank mechanism.
Turning moment diagrams: Fluctuation of energy and speed, coefficient of fluctuation of energy and speed, Energy stored in a Flywheel, Dimensions of the flywheel rim.
Cams and followers: classification of cam & follower, pressure angle evaluation, cam profile for constant velocity, SHM and constant acceleration and retardation motion with knife edge and roller followers.
Gears & Gear trains: Classification, law of gearing, forms of tooth, interference, under cutting, minimum number of teeth on gear and pinion to avoid interference, contact ratio, simple, compound Epicyclic gear trains and Differential gears.
Vibrations: Introduction - Types of Vibration – Free and forced vibration, longitudinal, transverse and torsional vibrations

Text Book(s)

1. Gordon R. Pennock & Joseph E. Shigley John J. Uicker "Theory of Machines and Mechanisms", Fourth Edition, Oxford University Press, 2014.
2. Cho W.S. To, "Introduction to Kinematics and Dynamics of Machinery (Synthesis Lectures on Mechanical Engineering)" Morgan & Claypool Publishers (30 December 2017)

Reference Books & Web Resources

1. Rattan.S.S, "Theory of Machines", Tata McGraw–Hill Publishing Co., New Delhi, Fourth edition, 2017
2. Thomas Bevan, "Theory of Machines", CBS – Third Edition, 2010.
3. Singh, V.P., "Theory of Machines", Dhanpat Rai & Co., (P) Ltd., New Delhi, 2011.
4. Sadhu Singh, "Theory of Machines". Pearson Education, New Delhi, 2009.
5. Ashok G.Ambekar," Mechanism and Machine theory",Prentice Hall of India , New Delhi,2011.
6. Ballaney, P.L., "Theory of Machines", Khanna Publishers, New Delhi, 2002.
7. Web resources :http://nptel.ac.in/courses/112104121/

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures	Course Outcome
1	**Elements of machines and mechanism**		
1.1	Kinematic link, Kinematic pairs	1	CO1
1.2	Kinematic chains – Mechanism	1	CO1
1.3	Mobility of mechanism, Inversions of Four bar chain	2	CO1
1.4	Inversions of Single slider crank chain mechanisms	2	CO1
1.5	Inversions of double slider crank chain mechanisms	2	CO1
2	**Velocity & Acceleration in Mechanisms:**		
2.1	Relative velocity method	1	CO2
2.1.1	Velocity and acceleration of four bar mechanisms and Single slider crank chain Mechanisms	2	CO2
2.2	**Klein's construction**		CO2
2.2.1	Velocity and acceleration of Single slider crank chain Mechanisms	1	CO2
3.1	**Force Analysis** Static force analysis of linkages, Equivalent offset inertia force	2	CO2
3.2	Dynamic analysis of slider crank chain mechanism. Piston and Crank effort, Inertia, Torque,	2	CO2
4.1	**Turning moment diagrams**	2	CO3
4.2	Fluctuation of energy and speed, coefficient of fluctuation of energy and speed	1	CO3
4.3	Energy stored in a Flywheel, Dimensions of the flywheel rim	1	CO3
5.1	**Cams** Types of cams and followers - Cam Nomenclature-Displacement, velocity and acceleration curves for various types of motions of follower- pressure angle evaluation in CAM profile	2	CO4
5.2	Construction of cam profiles- Knife edge followers - Roller follower - -Uniform Velocity Motion- Uniform Acceleration and Retardation Motion	2	CO4
6	**Gear and Gear trains**		CO5
6.1	General profiles of gears-Terminology of gears and types	1	CO5
6.2	law of gearing, forms of tooth, Interference, under cutting	2	CO5
6.3	Minimum number of teeth on gear and pinion to avoid interference, contact ratio	2	CO5
6.4	Simple, Compound Gear trains	1	CO5
6.5	Epicyclic gear trains- Differential gears	1	CO5
7.1	**Vibrations** Types of Vibration	1	CO6
7.2	Free Vibration, Forced Vibration	3	CO6
7.3	Longitudinal, transverse and torsional vibrations	1	CO6
	Total	**36 Hours**	

Course Designers:

1. Dr. G Kanagaraj, gkmech@tce.edu

22MT340	THERMAL FLUID SYSTEMS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Perform energy analyses of closed and open systems	TPS3	75	80
CO2	Determine efficiency of heat engines and COP of refrigerator & Heat pump	TPS3	75	80
CO3	Calculate entropy generation in heating with finite temperature difference	TPS3	75	80
CO4	Calculate fluid properties, static pressure variation in fluids and force required in Pascal devices	TPS3	75	80
CO5	Determine velocity and flow rate of fluid using Bernoulli equation	TPS3	75	80
CO6	Perform hydraulic circuit analysis taking into account energy loss due to friction	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 1			Assignment 1					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	10	20	-	-	35	-	-	-	-	-	-	2	5	8
CO2	4	10	20	-	-	35	-	-	-	-	-	-	2	5	10
CO3	2	10	20	-	-	40	-	-	-	-	-	-	2	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	35	2	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	35	2	5	10
CO6	-	-	-	-	-	-	2	10	20	-	-	30	2	5	10
CO7	4	10	20	-	-	35	-	-	-	-	-	-	2	5	8

Syllabus

Thermal Fluid Systems Applications: Introduction to air conditioning, Steam power plant, Domestic refrigerator and air conditioner, Power brake system in automobile, role of Mechatronics in thermal-fluid systems.
Basic Concepts: Thermodynamic system, properties, process, cycle – Zeroth law and temperature measurement-Energy interactions: Types of work transfer and heat transfer
First Law of thermodynamics: Closed system undergoing a process and cycle- Internal energy and specific heats. Open system - steady flow energy equation for nozzle, turbine, and compressor.
Second Law of thermodynamics: Kelvin Planck and Clausius Statement – Heat engine, refrigerator, Heat pump – Carnot and Reversed Carnot Engine – Efficiency and COP calculations, Thermal Treatment in devices.
Entropy: Concept of entropy, the increase of entropy principle, calculation of entropy generation in heating with finite temperature difference
Basic Concepts of Fluid Mechanics: Concept of fluid- Properties of Fluids: Pressure, Density, Specific Gravity, Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus.
Fluid Statics: Pressure at a Point: Pascal’s Law – hydrostatic law –U- tube manometer
Fluid Kinematics: Types of flow – Velocity and Acceleration of a fluid particle - Continuity Equation in Cartesian Co-ordinates.
Fluid Dynamics: Bernoulli’s Equation - Euler’s Equation for Motion - Applications of Bernoulli’s Equation, Venturimeter and Orifice meter.
Friction loss in hydraulic systems: laminar and turbulent flow, Reynolds number, friction factor for laminar and turbulent flow, head loss in a pipeline undergoing laminar or turbulent flow, frictional losses in valves and fittings, K factor, equivalent length, energy analysis of a complete hydraulic circuit.

Text Book(s)

1. Yunus A Cengel, John M Cimbala, Robert H Turner, Fundamentals of Thermal fluid Sciences, McGraw Hill Education, 2017
2. P. K. Nag, S. Pati, T. Jana, Engineering Thermodynamics and Fluid Mechanics,2nd edition, McGraw Hill Education, 2011

Reference Books & Web Resources

1. Anthony Esposito, Fluid Power With Applications, 7th Edition, Pearson New International Edition, 2014.
2. Merle Potter, Elaine P Scott, Thermal Sciences: An introduction to Thermodynamics, Fluid Mechanics and Heat Transfer, 1st Edition, Cengage Learning, 2007

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Thermal Fluid Systems Applications**	
1.1	Introduction to air conditioning, Steam power plant, Domestic refrigerator and air conditioner	1
1.2	Power brake system in automobile, role of Mechatronics in thermal-fluid systems.	2
1.3	**Basic Concepts:** Thermodynamic system, properties, process, cycle – Zeroth law and temperature measurement	2
1.4	Energy interactions: Types of work transfer and heat transfer	1
1.5	**First Law of thermodynamics:** Closed system undergoing a process and cycle- Internal energy and specific heats.	2
1.6	Open system - steady flow energy equation for nozzle, turbine, and compressor.	2
2	**Second Law of thermodynamics**	
2.1	Kelvin Planck and Clausius Statement	2
2.2	Heat engine, refrigerator	1
2.3	Heat pump – Carnot and Reversed Carnot Engine	1
2.4	Efficiency and COP calculations, Thermal Treatment in devices.	1
3	**Entropy**	
3.1	Concept of entropy, the increase of entropy principle	2
3.2	Calculation of entropy generation in heating with finite temperature difference	2
4	**Basic Concepts of Fluid Mechanics**	
4.1	Concept of fluid- Properties of Fluids: Pressure, Density, Specific Gravity	1
4.2	Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus.	2
4.3	**Fluid Statics**: Pressure at a Point: Pascal’s Law – hydrostatic law –U- tube manometer	2
4.4	**Fluid Kinematics:** Types of flow, Velocity and Acceleration of a fluid particle, Continuity Equation in Cartesian Coordinates.	2
5	**Fluid Dynamics**	
5.1	Bernoulli’s Equation	1
5.2	Euler’s Equation for Motion	1
5.3	Applications of Bernoulli’s Equation, Venturimeter and Orifice meter	2
6	**Friction loss in hydraulic systems**	
6.1	laminar and turbulent flow, Reynolds number, friction factor for laminar and turbulent flow	2
6.2	Head loss in a pipeline undergoing laminar or turbulent flow	1
6.3	frictional losses in valves and fittings, K factor	1
6.4	Equivalent length, energy analysis of a complete hydraulic circuit.	2
	Total	**36**

Course Designers:

1. Dr. G. Kumaraguruparan, gkgmech@tce.edu
2. Mr. M. M. Devarajan, mmdmech@tce.edu

22MT350	ELECTRICAL MACHINES	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Discuss about machines and its principles in real world application.	TPS2	80	70
CO2	Illustrate the various types of Machines, principle and operation.	TPS3	70	75
CO3	Explain the Construction principle and control of different types of Machines.	TPS2	80	70
CO4	Determine the characteristics, application of various types of Electrical Machines.	TPS3	70	75
CO5	Determine performance parameters of different machines to solve the problems related to its application.	TPS3	70	75
CO6	Select the suitable machine & working principle for a given situation and application.	TPS3	70	75

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)		Assessment 2 (%)		Terminal (%)
	CAT 1	Assignment 1	CAT 2	Assignment 1	
CO1	20	-	-	-	10
CO2	10	-	20	-	15
CO3	30	-	20	-	20
CO4	20	-	10	-	20
CO5	20	100	20	-	15
CO6	-	-	30	100	20

Syllabus

Introduction: Overview and Introduction about Electrical systems and Electrical machines.
Solenoids: Types - Construction – Working principle – circuit diagram- characteristics - Applications
DC Machines: Types - Constructional details – Principle & operation - Emf equation -Methods of excitation of D.C. generators - Characteristics of series, shunt generator - Principal operation of D.C. motor - Back emf and torque equation - Characteristics of series and shunt motors - Starting of D.C. motors - Speed control of D.C. motors – Applications.
Transformer: Types - Construction - Working principle - Emf equation – Losses - Voltage regulation - CT & PT - Applications.
AC Machines: Production of rotating magnetic field - Torque equation - Torque – Slip characteristics - Power stages and efficiency - Principle and operation of single phase and three phase Induction motors - methods of speed control – applications.
Special Machines: Stepper Motor: Constructional features – Step angle - Principle of operation -Variable reluctance motor – Single and multi-stack configurations.
Servo Motor: types - Construction and Working principle of Servomotor-Types-Position, speed control.
Switch Reluctance Motor: Construction and Working principle of SRM, Speed control characteristics.
Permanent magnet DC motor, BLDC motor - Construction and working Principle. Application: Application and case study of Special Machines in Mechatronics System.

Text Book(s)

1. Stephen J Chapman, “Electrical machines fundamentals” 4th edition. Tata McGraw hill, 2005.
2. A.E.Filtgerald & Charles Kingsley jr, “Electric Machinery “6th edition, McGrow science,2002.

Reference Books & Web Resources

1. J B Gupta, “Theory and Performances of Electrical Machines” 14th edition SK Kataria & Sons 2010.
2. D P Kothari and I J Nagrath,” Electric Machines” 4th Edition, McGraw Hill Education,2010.
3. Takashi Kenjo, “Stepper motor & their microprocessor control” 2nd edition, Oxford science publication 1995.
4. Vedam Subramanian, “Electric Drives", 2nd edition, Tata McGraw Hill, 2011
5. https://nptel.ac.in/courses/108106071/
6. https://nptel.ac.in/courses/108106072/
7. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/

Course Contents and Lecture Schedule

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

Course Designers:

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2. Mr. H. Ramesh, rameshh@tce.edu

22MT360	THERMAL ENGINEERING LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

The laboratory exercises are aimed at providing practical knowledge in thermal systems such as IC engines, compressors, and refrigerators. Some experiments are focussed on modelling and experimental verification of Hydraulic and Thermal Systems.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Determine the parameters like volumetric efficiency, friction power of internal combustion engine	TPS2	80	80
CO2	Determine fluid properties namely viscosity of incompressible fluids	TPS2	80	80
CO3	Calculate the Coefficient of performance of refrigerant	TPS2	85	85
CO4	Model, simulate and verify experimentally the flow rate of fluid in Hydraulic Suspension Systems	TPS2	90	85

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Experiments / Exercise	No. of Hours	Course Outcome
1.	Determination of friction power of diesel engine using retardation test	2	CO1
2.	Performance test on single-cylinder 4-stroke diesel engine at a constant speed	2	CO1
3.	Determination of mass flow rate of air through an orifice meter	2	CO2
4.	Determination of COP of vapour compression refrigerant system	2	CO3
5.	Determination of volumetric efficiency of a diesel engine	2	CO1
6.	Energy balance test on Diesel engine using exhaust	2	CO1

Expt. No.	Experiments / Exercise	No. of Hours	Course Outcome
	gas calorimeter measurement method		
7.	Determination of viscosity of an incompressible fluid	2	CO2
8.	Determine the volumetric efficiency of compressor	2	CO2
9.	Physical Network Modelling and Experimental verification of heat transfer in Insulated pipe	2	CO4
10.	Modelling and experimental verification of thermal effects in a battery	2	CO4
11.	Physical network modelling and verification of hydraulic system	2	CO4
12.	Experiment on air conditioning test rig	2	CO4

Reference Books & Web Resources

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

Course Designers:

1. Dr. G. Kumaraguruparan, gkmech@tce.edu
2. Mr. M.A. Ganesh, ganeshma2015@tce.edu

22MT370	ELECTRICAL MACHINES LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

Electric motors impact almost every aspect of modern living. Refrigerators, vacuum cleaners, air conditioners, fans, computer hard drives, automatic car windows, and multitudes of other appliances and devices all use electric motors to convert electrical energy into useful mechanical energy. In addition to running the common place appliances that we use every day; electric motors are also responsible for a very large portion of industrial processes. Electric motors are used at some point in the manufacturing process of nearly every conceivable product that is produced in modern factories.

The systems that controlled electric motors in the past suffered from very poor performance and were very inefficient and expensive. In recent decades, the demand for greater performance and precision in electric motors, combined with the development of better solid-state electronics and cheap microprocessors has led to the creation of modern Adjustable speed drives. The course is designed to provide the students a hands-on experience to understand the Characteristics of Electrical machines and its control which enables them to select the suitable motor for the given application.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Characteristics analysis of no load and load condition of various DC motors.	TPS4	80	80
CO2	Characteristics analysis of no load and load condition of various AC motors.	TPS4	80	80
CO3	no load and load characteristics analysis of transformers and study applications of CT and PT.	TPS4	80	80
CO4	Formulate performance parameters of Electrical machines in different conditions.	TPS3	80	80
CO5	Study and practice the function of different motor starters.	TPS2	80	80
CO6	Select the suitable special machines for given real time application.	TPS3	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Exercises / Experiments	No of Hours.	COs
1	Load test on DC Series Motors	2	CO1
2	Speed control of DC Shunt motor	2	CO1
3	Study of DOL and Star-Delta starting of Induction motor.	2	CO5
4	Load test on Single phase Transformer	2	CO3, CO5
5	OC/SC test on single phase Transformer	2	CO3, CO4
6	Characteristic study of CT and PT	2	CO3, CO4
7	Load test on Single phase Induction motor	2	CO2, CO5
8	Load test on Three phase Induction motor.	2	CO2, CO5
9	Speed control of Induction motor using VFD.	2	CO2
10	Position and Speed control of Stepper Motor.	2	CO6
11	Characteristics study of AC Servo motor	2	CO6
12	Speed control of BLDC motor.	2	CO5, CO6
13	Speed control of SRM motor.	2	CO6
14	Speed control of PMAC motor	2	CO6

Note:

1. **Any 12 experiments should be given as Laboratory experiment.**

Reference Books

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

Course Designers:

1. Dr. S. Julius Fusic, sjf@tce.edu
2. Mr. H. Ramesh, rameshh@tce.edu

22MT380	ELECTRONIC CIRCUITS AND DIGITAL LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

This laboratory course provides a hands-on experience on signal conditioning circuit on analog domain and combinational and sequential circuit design on digital domain

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Construct circuits for performing analog arithmetic operations.	TPS3	80	80
CO2	Use Analog to Digital convertors and digital to Analog Convertors for Interfacing applications	TPS3	80	80
CO3	Develop combinational circuits for Desired applications	TPS3	80	80
CO4	Develop synchronous and asynchronous sequential logic circuits for the given requirement	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Exercises / Experiments	No. of Periods
	Analog Experiments	
1.	Design of Signal Conditioning Circuits – 1 Adder and subtractor for AC and DC circuits	2
2.	Design of Signal Conditioning Circuits – 2 Comparator and instrumentation amplifier	2
3.	Design and Implementation of Analog to Digital Convertor using Operational Amplifier	2
4.	Design and Implementation of Digital to Analog using Operational Amplifier	2
5.	Design of active filters using operational amplifiers	2
	Digital experiments	
6.	Design and Implementation of Arithmetic operations using combinational circuit Design.	2
7.	Design and Implementation of Code Convertors using combinational circuit Design.	2
8.	Design and Implementation of Magnitude comparator and Selector Circuits	2
9.	Construction and Verification of 4 bit Ripple counter	2
10.	Implementation of SISO, SIPO, PISO and PIPO shift registers using Flip- flops	2
11.	An automobile alarm circuit is used to detect certain undesirable conditions. Three switches are used to indicate the status of the door by the driver’s seat, the ignition, and the headlights respectively. Design the logic circuit with these three switches as inputs so that the alarm will be activated whenever either of the following conditions exists: The headlights are on while the ignition is off •The door is open while ignition is on.	2
12.	A simple security system for two doors consists of a card reader and a keypad. A person may open a particular door if he or she has a card containing the corresponding code and enters an authorized code for that card. The output from the card reader are as follows.	2
	Total	**24**

Course Designers:

1. Mr. S. Parthasarathi, parthasarathi_s@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Fourth Semester (Lateral Entry)

For the students admitted from the
academic year 2023 - 2024 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015

22MTL10	PROBABILITY, STATISTICS AND FOURIER SERIES	Category	L	T	P	C	TE
		BSC	3	1	0	4	Theory

Preamble

This course introduces the various measures in statistics, which frequently applied in our daily life and basic level problems across all branches of engineering. It also helps to discuss the correlation between various kind of attributes and discuss the distributions will arise in engineering problems. Also, this course includes the idea about to obtain the Fourier series of a given periodic function. At the end of the course, former ideas are combined to solve boundary value problems for wave propagation and heat phenomena problems using Fourier series.

Prerequisite

- 22MA310 – Essentials of Matrices and Calculus

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Compute the measures of central tendency and interpret their significance in the relevant area of study	TPS2	80	75
CO2	Compute and interpret the correlation and regression coefficients that arise in engineering problems	TPS3	75	70
CO3	Apply the concept of probability through distributions and employ them in suitable situations	TPS3	75	70
CO4	Compute the Fourier series of functions occurs in various engineering applications.	TPS3	75	70
CO5	Employ the techniques of Fourier series to boundary value problems such as vibration of string and one-dimensional heat flow problems	TPS3	75	70
CO6	Adopt Fourier series techniques to solve two-dimensional heat flow problems in cartesian coordinates	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Assessment	CAT 1			Assignment 1			CAT 2			Assignment 2			Terminal Exam		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	5	20		-	-	-	-	-	-	-	-	-	-	12	-
CO2	-	-	25	-	-	40	-	-		-	-	-	-	-	12
CO3	5	10	35	-	-	60	-			-	-	-	-	6	20
CO4	-	-	-	-	-	-	5	20	25	-	-	50	-	6	18
CO5	-	-	-	-	-	-	5	10	20	-	-	30	-	6	12
CO6	-	-	-	-	-	-	-	-	15	-	-	20	-	-	8

Syllabus

Descriptive Statistics and Correlation: Mean, median, mode, Geometric mean, Harmonic mean- Measures of Dispersion: Range and standard deviation - Coefficient of variation - Correlation - Coefficient of correlation- Lines of Regression –Rank correlation- properties of regression coefficients.

Probability Distributions: Random experiment - Conditional probability - Baye's Theorem- Random variables – Discrete Probability distributions – Continuous Probability distributions – Expected values - Binomial and normal distributions.

Fourier Series: Introduction – Euler's formulae – Conditions for Fourier expansion –Odd and even function- Expansion of odd or even periodic functions–Half range series–Harmonic analysis.

Applications of Partial Differential Equations: Method of separation of variables - Vibrations of a stretched string – Wave equations – One dimensional heat flow problem – Two-dimensional heat flow–Solution of Laplace equation in Cartesian coordinates.

Text and Reference Book(s)

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 42nd Edition, 2012
2. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences" (English) Eighth Edition, Cengage Learning India Pvt Ltd, New Delhi, 2012.
3. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi,2016.
4. P. Kandasamy, K. Thilagavathy and K. Gunavathi, "Engineering Mathematics", Volume-III, S.Chand & Company Ltd, Fourth Edition,2008.
5. T. Veerarajan, "Engineering Mathematics",3rdEdition,Tata McGraw Hill ,New Delhi,2004.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Descriptive statistics and Correlation**	
1.1	Mean, median, mode	3
1.2	Geometric mean, Harmonic mean	1
1.3	Range and standard deviation and coefficient of variation	1
	Tutorial	1
1.4	Correlation - coefficient of correlation	1
	Tutorial	1
1.5	Lines of Regression	2
1.6	Rank correlation	1
	Tutorial	1
2.	**Probability Distributions**	
2.1	Random experiment-Conditional probability -	1
2.2	Baye's Theorem	2
	Tutorial	1
2.3	Random Variables, Discrete and Continuous Probability distributions	2
2.4	Expectation and variance	1
	Tutorial	1
2.5	Binomial and Normal Distributions	3
	Tutorial	1
3.	**Fourier Series**	
3.1	Introduction, Euler's formulae,	1
3.2	Conditions for Fourier expansion, Functions having points of discontinuity	1
3.3	Fourier Expansion in $(0,2\pi)$	2
	Tutorial	1
3.4	Odd and even functions, Expansions of odd or even periodic functions	1
3.5	Half range series	2
	Tutorial	1
3.6	Harmonic analysis	2
	Tutorial	1
4.	**Boundary value problems**	
4.1	Method of separation of variables	2
4.2	Vibrations of a stretched string - Wave equation	2
	Tutorial	1
4.3	One-dimensional heat flow	2
	Tutorial	1
4.4	Two-dimensional heat flow: Solution of Laplace's equation in Cartesian coordinates	3
	Tutorial	1
	Total	**48**

Course Designers:

1. Dr. S. Saravanakumar, sskmat@tce.edu
2. Dr. M. Sundar, msrmat@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Fourth and Fifth Semester

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

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

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Mechatronic System Laboratory ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT480 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Project I PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22MT630 Professional Communication HSMC 2	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22MT660 Project II PW 3	23
VII	22MT710 Mechatronics System Design PCC 3	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 3	---	---	22MT730 Project III PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT810 Project IV PW 3	9
									Total Credits	**160**

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits	
			Regular Admission	Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**22 - 35**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	08 - 11
	b.	Basic Science Courses (BSC)	24 - 27	06 - 09
	c.	Engineering Science Courses (ESC)	21 - 27	08 - 15
B.	**Professional Core Courses (PCC)**		**55**	**45**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

IV SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT410	Probability and Statistics	BSC	3	1	0	4
22MT420	Microcontroller based system design	PCC	3	0	0	3
22MT430	Power Electronics and Drives	ESC	3	0	0	3
22MT440	Sensors and Measurements	PCC	3	0	0	3
22MT460	Project Management	HSMC	3	0	0	3
THEORY CUM PRACTICAL						
22MT450	Digital Signal Processing	PCC	1	0	4	3
PRACTICAL						
22MT470	Microcontroller Laboratory	ESC	0	0	2	1
22MT480	Sensors and Measurements Laboratory	PCC	0	0	2	1
		Total	**16**	**1**	**8**	**21**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

IV SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT410	Probability and Statistics	3	40	60	100	27	50
22MT420	Microcontroller based system design	3	40	60	100	27	50
22MT430	Power Electronics and Drives	3	40	60	100	27	50
22MT440	Sensors and Measurements	3	40	60	100	27	50
22MT460	Project Management	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22MT450	Digital Signal Processing	3	50	50	100	25	50
PRACTICAL							
22MT470	Microcontroller Laboratory	3	60	40	100	18	50
22MT480	Sensors and Measurements Laboratory	3	60	40	100	18	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

V SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT510	Control Systems	PCC	3	1	0	4
22MT520	Design of Machine Elements	PCC	3	0	0	3
22MT530	Industrial Automation	PCC	3	0	0	3
22MT540	CNC Technology	PCC	3	0	0	3
22MTPx0	Program Elective I	PEC	3	0	0	3
22yyGx0	Inter disciplinary Elective	IE	3	0	0	3
PRACTICAL						
22MT550	CAD / CAM Laboratory	PCC	0	0	2	1
22MT560	Industrial Automation Laboratory	PCC	0	0	2	1
PROJECT						
22MT570	Project I	PW	0	0	6	3
		Total	**18**	**1**	**10**	**24**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

V SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT510	Control Systems	3	40	60	100	27	50
22MT520	Design of Machine Elements	3	40	60	100	27	50
22MT530	Industrial Automation	3	40	60	100	27	50
22MT540	CNC Technology	3	40	60	100	27	50
22MTPx0	Program Elective I	3	40	60	100	27	50
22yyGx0	Inter disciplinary Elective						
PRACTICAL							
22MT550	CAD / CAM Laboratory	3	60	40	100	18	50
22MT560	Industrial Automation Laboratory	3	60	40	100	18	50
PROJECT							
22MT570	Project I	-	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

22MT410	PROBABILITY AND STATISTICS	Category	L	T	P	C	TE
		BSC	3	1	0	4	Theory

Preamble

This course introduces the various measures of statistics, which are applied frequently in our daily life and basic level problems across all branches of engineering. It also helps to discuss the correlation between various kind of attributes and discuss the distributions involved in various engineering problems. Statistical methods are important tools that provide the engineers with both descriptive and analytical methods for dealing with the variability in observed data. Moreover, this course enables the students to cognitive learning in statistics and develops skills to analyse data's using various parametric and non-parametric tests.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Discover the measures of central tendency and interpret their significance in the relevant area of study.	TPS2	80	75
CO2	Compute and interpret the correlation and regression coefficients that arise in engineering problems.	TPS3	75	70
CO3	Illustrate the concepts of probability through distributions and employ them in suitable situations.	TPS3	75	70
CO4	Predict the hypotheses and test the inferences on a single sample.	TPS3	75	70
CO5	Predict the hypotheses and test the inferences based on two samples.	TPS3	75	70
CO6	Apply the appropriate non-parametric hypothesis testing procedure for various types and samples.	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

Assessment	CAT 1			Assignment 1			CAT 2			Assignment 2			Terminal Exam		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	5	20	-	-	-	-	-	-	-	-	-	-	-	12	-
CO2	-	-	25	-	-	33	-	-	-	-	-	-	-	-	12
CO3	5	10	35	-	-	67	-	-	-	-	-	-	-	6	19
CO4	-	-	-	-	-	-	4	-	17	-	-	21	-	-	10
CO5	-	-	-	-	-	-	4	10	15	-	-	29	-	6	10
CO6	-	-	-	-	-	-	-	20	30	-	-	50	-	6	19

Syllabus

Descriptive Statistics and Correlation: Mean, median, mode, Geometric mean, Harmonic mean- Measures of Dispersion: Range and standard deviation - Coefficient of variation - Correlation - Coefficient of correlation - Lines of Regression – Rank correlation- properties of regression coefficients.

Probability Distributions: Random experiment - Conditional probability - Baye's Theorem- Random variables – Discrete Probability distributions – Continuous Probability distributions – Expected values - Binomial and normal distributions.

Test of Hypothesis: Hypotheses and test procedures – Tests about a population mean – Tests concerning a population proportion – z tests and confidence intervals for a difference between two population means–The two-sample t Test and confidence interval – Inferences concerning a difference between population proportions.

Non-Parametric Statistics: Introduction- sign test - Signed rank test - Wilcoxon rank sum test - Kruskal's Wallis test- Runs test.

Text and Reference Book(s)

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 42nd Edition, 2012
2. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences" (English) Eighth Edition, Cengage Learning India Pvt Ltd, New Delhi, 2012.
3. Ronald E. Walpole, Sharon L. Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists", 9th Edition, Pearson Education, New Delhi, 2012.
4. Mendenhall William, "Introduction to Probability and Statistics", 14th Edition, Duxbury Press, New Delhi 2012.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Descriptive statistics and Correlation**	
1.1	Mean, median, mode	3
1.2	Geometric mean, Harmonic mean	1
1.3	Range and standard deviation and coefficient of variation	1
	Tutorial	1
1.4	Correlation - coefficient of correlation	1
	Tutorial	1
1.5	Lines of Regression	2
1.6	Rank correlation	1
	Tutorial	1
2.	**Probability Distributions**	
2.1	Random experiment-Conditional probability	1
2.2	Baye’s Theorem	2
	Tutorial	1
2.3	Random Variables, Discrete and Continuous Probability distributions	2
2.4	Expected values	1
	Tutorial	1
2.5	Binomial and Poisson Distributions	2
2.6	Normal Distribution	1
	Tutorial	1
3	**Testing of Hypothesis**	
3.1	Hypothesis and Test Procedures	1
3.2.	Tests about a population mean	2
3.3	Tests concerning a population proportion	1
	Tutorial	1
3.4	z tests and confidence intervals for a difference between two population means	2
	Tutorial	1
3.5	The two sample t Test and confidence interval	2
3.6	Inferences concerning a difference between population proportions.	1
	Tutorial	1
4	**Non-Parametric Statistics**	
4.1	Introduction- Sign test	2
4.2	Signed rank test	2
	Tutorial	1
4.3	Wilcoxon rank sum test	2
	Tutorial	1
4.4	Kruskal’s Wallis test - Runs test	3
	Tutorial	1
	Total	**48**

Course Designers:

1. Dr. S. Saravanakumar, sskmat@tce.edu
2. Dr. M. Sundar, msrmat@tce.edu

22MT420	MICROCONTROLLER BASED SYSTEM DESIGN	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- 22MT320 - Digital Electronics

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Describe the architecture and pin diagram of 8051 microcontroller, and evaluate its suitability for various applications.	TPS2	80	70
CO2	Develop programs using assembly language and C for the 8051 microcontrollers, and integrate them with peripherals, such as timers, interrupts, and UART.	TPS3	70	70
CO3	Design and implement systems using the 8051 microcontroller and its advanced features, such as analog-to-digital conversion and interfacing with LCD and keypad.	TPS3	70	70
CO4	Describe the architecture and pin diagram of the Cortex M0+ microcontroller, and evaluate the features of the Raspberry Pi Pico for IoT applications.	TPS2	80	70
CO5	Develop applications using the Raspberry Pi Pico and its I/O devices, such as GPIO, PWM, and ADC.	TPS3	70	70
CO6	Design and implement IoT systems using the Raspberry Pi Pico, and interface it with I2C and SPI sensors to acquire and process data.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	-	10	30	-	-	-	-	-	-	-	-	-	-	5	15
CO3	-	20	20	-	-	100	-	-	-	-	-	-	-	10	10
CO4	-	-	-	-	-	-	-	20	-	-	-	-	-	10	-
CO5	-	-	-	-	-	-	-	10	30	-	-	-	-	5	15
CO6	-	-	-	-	-	-	-	20	20	-	-	100	-	10	10

Syllabus

Introduction to 8051 Microcontroller and Architecture: Overview of microcontrollers and their applications, Architecture and pin diagram of 8051 microcontroller, Memory organization and addressing modes, Instruction set and programming in assembly language, Interfacing of I/O devices with 8051

Advanced 8051 Programming Techniques: Interrupts and their handling in 8051, Timers and counters in 8051, Serial communication, Analog-to-digital conversion using 8051, Interfacing of LCD and keypad with 8051

Programming 8051 using C Language: Introduction to C language and its programming principles, Configuring and programming the 8051-microcontroller using C, Interfacing of I/O devices with 8051 using C language, Debugging and testing microcontroller programs in C

Introduction to Raspberry Pi Pico and Cortex M0+ Architecture: Overview of Raspberry Pi Pico and its features, Architecture and pin diagram of Cortex M0+ microcontroller, Memory organization and addressing modes, Instruction set and programming in assembly language, Interfacing of I/O devices with Raspberry Pi Pico

Advanced Raspberry Pi Pico Programming Techniques: Interrupts and their handling in Raspberry Pi Pico, Timers and counters in Raspberry Pi Pico, Serial communication in Raspberry Pi Pico, Analog-to-digital conversion using Raspberry Pi Pico, Interfacing of LCD and keypad with Raspberry Pi Pico

GNU ARM Toolchain and Programming using VS Code: Introduction to GNU ARM toolchain and its features, Configuring and programming the Raspberry Pi Pico using VS Code, Interfacing of I/O devices with Raspberry Pi Pico using VS Code, Debugging and testing microcontroller programs using VS Code

Text Book(s)

1. "Programming and Customizing the 8051 Microcontroller" by Myke Predko (McGraw-Hill Education, 1999)
2. "The 8051 Microcontroller and Embedded Systems: Using Assembly and C" by Muhammad Ali Mazidi, Rolin D. McKinlay, and Janice Gillispie Mazidi (Pearson Education, 2016)
3. Ayala Kenneth J, "The 8051 Microcontroller, Third Edition: Architecture, Programming, and Applications", Cengage Learning, 2019

4. "Programming with Raspberry Pi Pico: Coding Tiny Embedded Systems in C and C++" by Simon Monk, 1st edition, McGraw-Hill Education TAB, 2021.
5. "Raspberry Pi Pico User Guide: Programming your Pico from Beginner to Expert" by Gareth Halfacree and Ben Everard, 1st edition, Raspberry Pi Press, 2021.
6. Harry fairhead, “Programming The Raspberry Pi Pico/W In C”, Second Edition, I/O press,2022
7. "Cortex-M0 and Cortex-M0+ Processors: The Definitive Guide" by Joseph Yiu, 2nd edition, Newnes, 2016.

Reference Books & Web Resources

1. Raspberry Pi Pico C/C++ SDK: https://datasheets.raspberrypi.com/pico/raspberry-pi-pico-c-sdk.pdf
2. Getting started with Raspberry Pi Pico: https://datasheets.raspberrypi.com/pico/getting-started-with-pico.pdf

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to 8051 Microcontroller and Architecture:**	
1.1	Overview of microcontrollers and their applications	1
1.2	Architecture and pin diagram of 8051 microcontroller	1
1.3	Memory organization and addressing modes	1
1.4	Instruction set and programming in assembly language	2
1.5	Interfacing of I/O devices with 8051	2
2	**Advanced 8051 Programming Techniques**	
2.1	Interrupts and their handling in 8051	1
2.2	Timers and counters in 8051	1
2.3	Serial communication	1
2.4	Analog-to-digital conversion using 8051	1
2.5	Interfacing of LCD and keypad with 8051	1
3	**Programming 8051 using C Language**	
3.1	Introduction to C language and its programming principles	2
3.2	Configuring and programming the 8051-microcontroller using C	2
3.3	Interfacing of I/O devices with 8051 using C language	2
3.4	Debugging and testing microcontroller programs in C	1
4	**Introduction to Raspberry Pi Pico and Cortex M0+ Architecture**	
4.1	Overview of Raspberry Pi Pico and its features	2
4.2	Architecture and pin diagram of Cortex M0+ microcontroller	1
4.3	Memory organization and addressing modes	1
4.4	Instruction set and programming in assembly language	1
4.5	Interfacing of I/O devices with Raspberry Pi Pico	2
5	**Advanced Raspberry Pi Pico Programming Techniques**	
5.1	Interrupts and their handling in Raspberry Pi Pico,	2
5.2	Timers and counters in Raspberry Pi Pico,	1
5.3	Serial communication in Raspberry Pi Pico,	1
5.4	Analog-to-digital conversion using Raspberry Pi Pico,	1
5.5	Interfacing of LCD and keypad with Raspberry Pi Pico	1
6	**GNU ARM Toolchain and Programming using VS Code**	
6.1	Introduction to GNU ARM toolchain and its features,	2

Module No.	Topic	No. of Periods
6.2	Configuring and programming the Raspberry Pi Pico using VS Code	1
6.3	Interfacing of I/O devices with Raspberry Pi Pico using VS Code	1
6.4	Debugging and testing microcontroller programs using VS Code	1
	Total	**37**

Course Designers:

1. Mr. S Parthasarathi, parthasarathi_s@tce.edu
2. Mr. M M Devarajan, mmdmech@tce.edu

22MT430	POWER ELECTRONICS AND DRIVES	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

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

Prerequisite

- 22MT220 - Analog Electronics
- 22MT350 - Electrical Machines

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the operations of controlled converters for different types of Loads.	TPS2	80	70
CO2	Differentiate the characteristics and performance parameters of different power electronic converters.	TPS3	70	70
CO3	Explain different power semiconductor switching circuits used in Electrical drives.	TPS2	80	70
CO4	Illustrate the frequency and phasor control of AC drives using AC converter circuits.	TPS3	70	70
CO5	Choose appropriate converter technique to control different drives in industrial applications.	TPS3	70	70
CO6	Select and integrate suitable electrical drives for motion control applications such as Machine tools and Industrial robotics.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)		Assessment 2 (%)		`Terminal (%)
	CAT 1	Assignment 1	CAT 2	Assignment 2	
CO1	20	-	-	-	10
CO2	20	-	20	-	15
CO3	20	-	20	-	15
CO4	-	-	20	-	15
CO5	40	100	20	-	30
CO6	-	-	20	100	15

Syllabus

Introduction: Power devices- SCR, Power MOSFET, IGBT- Electrical drive system-Types of Electric drives- selection of electrical drives- Modes of operation of electrical drives - types of power electronic converters- classification of controlled converters-Modes of operation of electrical drives- closed loop control of Drives.

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

Chopper Controlled DC Drives: Four Quadrant chopper- types- principle of operation of buck, boost, buck-boost Converter fed DC Drives.

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

Switching circuits for special machines and power supply applications: Synchronous Machines with PMs-Vector control of PMSM -Sensor less control BLDC motor- UPS configurations- online & offline UPS, SMPS

Text Book(s)

1. P. S. Bimbhra, “Power Electronics“ KHANNA PUBLISHSERS-DELHI, 2012
2. Mohammed H Rashid, “Power electronics” Pearson Education India, 2009.

Reference Books & Web Resources

1. R.Krishnan, “Electrical motor drives modelling, analysis and control” Pearson India, 2015.
2. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing house, 2017.
3. Bimal Bose, “Power electronics and driver circuits”, Elseveir, 2006.
4. Bogdan M. Wilamowski, J. David Irwin, ”Power Electronics and Motor Drives”, CRC Press, 2011
5. Bimal K Bose, “Modern Power electronics and AC drives”, Prentice Hall, 2002.
6. https://onlinecourses.nptel.ac.in/noc19_ee03
7. https://nptel.ac.in/downloads/108105066/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	**Introduction**		
1.1	Power devices- SCR, Power MOSFET, IGBT	2	CO3
1.2	Electrical drive system, types of Electric drives, Selection of electrical drives, Modes of operation of electrical drives.	1	CO2
1.3	Types of power electronic converters, classification of controlled converters- Modes of operation of electrical drives- -closed loop control of Drives.	1	CO2
2.0	**Controlled Rectifier (Converters) DC Drives**		
2.1	Single Phase and 3-phase Half wave and Full wave converter	1	CO1
2.2	Single phase Half controlled and fully controlled converters with R, RL and RLE loads, Continuous and discontinuous operations	2	CO1
2.3	Fully controlled converters with R, RL and RLE loads	2	CO2
2.4	Evaluation of performance parameters	2	CO2
2.5	Single & three phase controlled DC Drives	2	CO5
3.0	**Chopper controlled DC drives**		
3.1	Four quadrant chopper, Principle of operation of buck converter	2	CO2
3.2	Boost Converter	1	CO3
3.3	Buck-boost Converters	1	CO3
3.4	DC chopper Drives.	2	CO5
4.0	**Control of AC Drives**		
4.1	Dynamic Modelling of Induction machines- Single phase bridge inverters with R, RL and RLE loads	2	CO4
4.2	Frequency controlled Induction motor drives	1	CO4
4.3	Phase controlled Induction motor drive	1	CO4
4.4	Three phase 120 and 180 degree mode Inverter fed AC machine	3	CO4
4.5	Single phase and Three phase ac voltage controllers	2	CO4
4.6	Vector controlled Induction motor drives −Direct and Indirect vector control.	3	CO6
5.0	**Switching circuits for special machines and Power supply applications**		
5.1	Synchronous Machines with PMs.	1	CO5
5.2	Vector control of PMSM.	1	CO6
5.3	Sensor less control BLDC motor	1	CO6
5.4	UPS configurations- online & offline UPS, SMPS	2	CO5
	TOTAL	**36**	

Course Designer(s):

1. Dr. S Julius Fusic, sjf@tce.edu
2. Mr. H Ramesh, rameshh@tce.edu

22MT440	SENSORS AND MEASUREMENTS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

In today's world, there is a growing need for professionals who can integrate different fields of knowledge to solve complex problems. Mechatronics is a prime example of this trend, as it combines mechanical, electrical, and computer engineering principles to design and develop advanced systems. The use of sensors and PLC-based systems is essential in mechatronics, as these technologies allow for real-time monitoring and control of mechanical and electrical processes.

Moreover, the importance of measurement in scientific research and manufacturing cannot be overstated. Accurate measurement is critical to ensuring the reliability and validity of experimental results, and to ensuring consistency in product quality. With the globalization of research and manufacturing, there is a need for international standards of measurement to ensure that measurements made in one laboratory or facility can be compared to those made in another. This requires a thorough understanding of metrology, the science of measurement, and its principles and applications.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the basic principles and characteristics of sensors, including their operating principles, selection criteria, calibration, and signal conditioning techniques.	TPS2	80	70
CO2	Classify and explain the measurement principles of displacement, pressure, temperature, velocity, acceleration, and optical sensors, and their applications in mechatronics systems.	TPS3	70	70
CO3	Discuss the importance of signal conditioning circuits in achieving accurate and reliable sensor performance.	TPS2	70	70
CO4	Explain the various components of data acquisition systems and their functions, including sensors, signal conditioning circuits, analog-to-digital converters	TPS2	80	70
CO5	Discuss the advantages and limitations of different types of data acquisition systems, including PC-based systems and standalone systems	TPS3	70	70
CO6	Analyse real-world case studies of sensors and data acquisition systems in mechatronics applications, and assess their performance and limitations.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	25	-	-	25	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	-	-	40	-	-	-	-	-	-	-	-	20
CO3	-	-	35	-	-	35	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	25	-	-	25	-	-	10	-
CO5	-	-	-	-	-	-	-		40	-	-	40	-	-	20
CO6	-	-	-	-	-	-	-		35	-	-	35	-	-	20

Syllabus

Science of Measurement: Significance of Measurements and Methods, Characteristics of Measurement systems, Errors in Measurements, Calibration, Primary and secondary standards

Displacement, Pressure, Temperature sensors: Strain gauge, Gauge factor, sensing elements, configuration, and unbounded strain gage, Inductive and Magnetic Sensors, LVDT and RVDT, Hall Effect Sensors, Ultrasonic Sensors, Radar Sensors, Bellows, Membranes, and Thin Plates, Piezoresistive Sensors, Pirani Gauge, Thermosensitive Sensors, Resistance Temperature Detectors, Thermistors, Thermoelectric Contact Sensors

Velocity, Acceleration and optical sensor: Capacitive Accelerometers, Piezoresistive Accelerometers, Piezoelectric Accelerometers, Gyroscopes, Optical displacement sensors and optical encoders, Optoelectronic Motion Detectors, Sensor Structures, Visible and Near Infrared Light Motion Detectors, Far-Infrared Motion Detectors

Signal conditioning circuits: Functions of signal conditioning circuits, Preamplifiers, Concepts of passive filters, Impedance matching circuits, AC and DC Bridges, wheat stone bridge, Kelvin, Maxwell, Hay, Schering

Data acquisition systems: Components of an analog and digital data acquisition system, Use of data acquisition system, Use of recorders in digital systems, Input conditioning equipment.

Text Book(s)

1. A.K.Sawhney, ― Electrical & Electronics Measurement and Instrumentation‖,10th edition, Dhanpat Rai & Co, New Delhi, 19th Revised edition 2011, Reprint 2014.
2. John G. Webster, ― Medical Instrumentation Application and Design‖, 4th edition, Wiley India Pvt Ltd, New Delhi, 2015.

Reference Materials and Web Resources

1. Ernest O Doebelin and Dhanesh N Manik, Measurement systems, Application and design, 6th edition, McGraw-Hill, 2012.
2. Khandpur R.S, —Handbook of Biomedical Instrumentation, III edition, Tata Mc Graw Hill, New Delhi, 2014.
3. Leslie Cromwell, —Biomedical Instrumentation and measurement‖, 2nd edition, Prentice Hall of India, New Delhi, 2015.
4. Albert D. Helfrick and William D. Cooper. Modern Electronic Instrumentation and Measurement Techniques‖, Prentice Hall of India, I edition, 2016

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Science of Measurement**		
1.1	Significance of Measurements and Methods	1	CO1
1.2	Characteristics of Measurement systems	1	CO1
1.3	Errors in Measurements	1	CO1
1.4	Calibration	1	CO1
1.5	Primary and secondary standards	1	CO1
2	**Displacement, Pressure, Temperature sensors**		
2.1	Strain gauge		CO2
2.1.2	Gauge factor, sensing elements, configuration, and unbounded strain gage	1	CO2
2.2	Inductive and Magnetic Sensors		CO2
2.2.1	LVDT and RVDT	2	CO2
2.2.2	Hall Effect Sensors	1	CO2
2.3	Ultrasonic Sensors	1	CO2
2.4	Radar Sensors	1	CO2
2.5	Bellows, Membranes, and Thin Plates	1	CO2
2.6	Piezoresistive Sensors	1	CO2
2.7	Pirani Gauge	1	CO2
2.8	Thermosensitive Sensors		CO2
2.8.1	Resistance Temperature Detectors	1	CO2
2.8.2	Thermistors	1	CO2
2.9	Thermoelectric Contact Sensors	1	CO2
3	**Velocity, Acceleration and optical sensor**		
3.1	Capacitive Accelerometers	1	CO3
3.2	Piezoresistive Accelerometers	1	CO3
3.3	Piezoelectric Accelerometers	1	CO3
3.4	Gyroscopes	1	CO3
3.5	Optical displacement sensors and optical encoders	1	CO3
3.6	Optoelectronic Motion Detectors		CO3
3.6.1	Sensor Structures	1	CO3
3.6.2	Visible and Near-Infrared Light Motion Detectors	1	CO3
3.6.3	Far-Infrared Motion Detectors	1	CO3

Module No.	Topic	No. of Hours	Course Outcome
4	**Signal conditioning circuits**		
4.1	Functions of signal conditioning circuits	1	CO4
4.2	Preamplifiers	1	CO4
4.3	Concepts of passive filters	1	CO4
4.4	Impedance matching circuits	1	CO4
4.5	AC and DC Bridges	1	CO5
4.5.1	wheat stone bridge	1	CO5
4.5.2	Kelvin, Maxwell	1	CO5
5	**Data acquisition systems**		
5.1	Components of an analog & digital data acquisition system	1	CO5
5.2	Use of data acquisition system	1	CO6
5.3	Use of recorders in digital systems	1	CO6
5.4	Input conditioning equipment.	1	CO6
	Total	**36**	

Course Designers:

1. Dr. M PalaninathaRaja, pnatharaja@tce.edu
2. Mr. S Parthasarathi, parthasarathi_s@tce.edu

22MT450	DIGITAL SIGNAL PROCESSING (TCP)	Category	L	T	P	C	TE
		PCC	1	0	4	3	Practical

Preamble

This course on Digital Signal Processing (DSP) aims at providing the fundamentals of digital signal processing and its applications in various fields. DSP has become an essential tool in many areas of engineering, including telecommunications, audio processing, control systems, and many others. This course will cover topics such as digital signal analysis, LTI systems, Fourier analysis, filter design, and spectral analysis.
Students will gain an understanding of the principles and techniques used in DSP, and will learn how to apply them to solve practical problems. By the end of this course, students will have the skills and knowledge necessary to design and implement DSP systems for a wide range of applications.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Understand and explain the basic concepts of signals and systems, including the difference between analog and digital signals, sampling and quantization	TPS2	80	80
CO2	Implement the basic signal processing techniques such convolution, correlation using software tools	TPS3	70	70
CO3	Analyse the signals in both the time and frequency domains and extract information about the signal	TPS3	70	70
CO4	Design and implement digital filters for various applications, including low-pass, high-pass, band-pass, and notch filters, using techniques like windowing, FIR filter design, and IIR filter design	TPS3	70	70
CO5	Perform signal processing techniques such Gray Scale Transformations, Image Segmentation, Contour Tracing, Template matching and Edge Detection on 2D signal	TPS3	70	70
CO6	Apply DSP concepts and techniques to solve practical problems, including designing and implementing signal processing algorithms using software tools	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Continuous Assessment Test (CAT)			Terminal (Practical)
	CAT 1 (Theory)	CAT 2 (Theory)	Lab Model Exam	
CO1	40	-	100	100
CO2	40	-		
CO3	30	-		
CO4	-	30		
CO5	-	50		
CO6	-	20		

Syllabus

Signals and Systems: Analog and Digital signals – Conversion process – Sampling – Aliasing - Nyquist criteria – Quantization. Linear Time Invariant Systems

Signal Operations and Measurements: Signal generation - Convolution - Correlation – Windowing – Overlap Add and Save Methods - Padding – Delays - Peak Finding – Zero Crossing - Time Scope

Transforms: Fourier Transform – Fast Fourier Transform - Spectrum Analysis – Frequency Domain Analysis

Digital Filters: Low Pass – High Pass – Band Pass - Notch Filters – FIR and IIR Filter Design

2D Signal Processing: Image as a 2D signal. Gray Scale Transformations - Image Arithmetic. Image Segmentation - Regions of Interests (ROIs) - Binary Segmentation - Contour Tracing - Template matching - Edge Detection

Applications and Case Study:
1D Signals: Echo Cancellation – Noise removal from ECG Signal – Separation of Audio Signal from Music – Vibration Analysis
2D Signal: Bar Code Identification - Character Recognition - Print Quality Inspection - Gauging - Presence Verification

Text Book(s)

1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications”, 5th edition, Pearson, 2021
2. Christian Demant, Bernd Streicher-Abel, Carsten Garnica, “Industrial Image Processing”, Second Edition, Springer, 2013

Reference Books & Web Resources

1. Keonwook Kim, “Conceptual Digital Signal Processing with MATLAB”, Springer International Publishing, 2021
2. Samir I. Abood, “Digital Signal Processing: A Primer With MATLAB”, CRC Press, Inc., 2020
3. https://in.mathworks.com/solutions/signal-processing.html
4. R.C. Gonzalez, Richard E. Woods, “Digital Image Processing”, Fourth Edition, Prentice Hall India, 2018
5. https://swayam.gov.in/nd1_noc19_ee55/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	
		Theory	Practical
1	**Signals and Systems:**	-	-
1.1	Analog and Digital signals – Conversion process – Sampling	1	-
1.2	Aliasing - Nyquist criteria – Quantization. Linear Time Invariant Systems	2	-
2	**Signal Operations and Measurements:**	-	-
2.1	Signal generation - Convolution -	1	-
2.2	Correlation – Windowing – Overlap Add and Save Methods -	2	
2.3	Padding – Delays - Peak Finding – Zero Crossing - Time Scope	2	
	Experiments in signal generation, sampling and aliasing	-	4
3	**Transforms:**	-	-
3.1	Fourier Transform – Fast Fourier Transform - Spectrum Analysis – Frequency Domain Analysis	2	-
	Experiments involving FFT, finding the frequency in the given multi tone signal, frequency analysis	-	4
4	**Digital Filters:**	-	-
4.1	Low Pass – High Pass – Band Pass - Notch Filters – FIR and IIR Filter Design	2	-
	Experiments involving filter design	-	4
5	**2D Signal Processing:**	2	-
5.1	Image as a 2D signal. Gray Scale Transformations - Image Arithmetic.	2	-
5.2	Image Segmentation - Regions of Interests (ROIs) - Binary Segmentation -	2	-
3.5	Contour Tracing - Template matching - Edge Detection	2	-
	Experiments involving image pre-processing and post processing	-	4
6	**Applications and Case Study**	-	-
6.1	**1D Signals:** Echo Cancellation – Noise removal from ECG Signal – Separation of Audio Signal from Music – Vibration Analysis	2	
	Implementation of any two applications of 1D signal processing	-	4
6.2	**2D Signal:** Bar Code Identification - Character Recognition - Print Quality Inspection - Gauging - Presence Verification	2	-
	Implementation of any two applications of 2D signal processing	-	4
	TOTAL	**24**	**24**

Course Designers:

1. Mr. S A R Sheik Masthan, sarsmech@tce.edu

22MT460	PROJECT MANAGEMENT	Category	L	T	P	C	TE
		HSMC	3	0	0	3	Theory

Preamble

Management in business and human organization activity is simply the act of getting people together to accomplish desired goals. Qualified project managers are in high demand in this competitive world. This course focuses on project management methodology that will increase your ability to initiate and manage projects more efficiently and effectively. The Project Management course discusses activities of planning, organizing, motivating, controlling resources and leadership in theory and practice and the roles and responsibilities of the project manager. It deals with approaches to achieve the project goals and to optimize the allocation of necessary inputs and to integrate them.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the importance of project management and project initiation.	TPS2	80	80
CO2	Determine the project duration and time estimates by Gantt Chart, Bar chart and network diagram.	TPS3	70	70
CO3	Determine the project duration and time estimation using Network techniques - PERT and CPM	TPS3	70	70
CO4	Optimize resources of projects using resource smoothing or resource levelling techniques.	TPS3	70	70
CO5	Crash the project to its bare minimum value and obtain the optimum time – minimum cost relationships.	TPS3	70	70
CO6	Describe about risk assessment process, project closure and agile techniques.	TPS2	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)		Assessment 2 (%)		Terminal (%)
	CAT 1	Assignment 1	CAT 2	Assignment 2	
CO1	20	-	-	-	10
CO2	40	50	-	-	20
CO3	40	50	-	-	20
CO4	-	-	40	50	20
CO5	-	-	40	50	20
CO6	-	-	20	-	10

Syllabus

Overview of Project Management: Definition - Project Life Cycle - Objectives of Project management - Project knowledge areas - organization structure-roles of project management group-project management office and its role - Project Management Principles - ISO 21500:2012: Guidance on project management.

Project Initiation: Generation and Screening of PM ideas- Triple Constraint – Time, Cost and Scope – TOR / Project Charter / SOW (Statement of Work) - Project Presentation & Approval-Technology transfer: PPP – case study

Time Management: Work break down structure - Gantt Charts, Milestone chart - Project Network - Fulkerson’s rules – Activity-On-Arrow and Activity-On-Node networks – Network Techniques: Critical path method (CPM) - Project updating and monitoring - Program Evaluation & Review Technique (PERT) - case study

Resource Management: Types of resources - Balancing of resource - Resource Smoothing technique - Resource levelling technique - case study

Cost Management: Types of cost – Cost Slope - Variation of Cost with time - Crash time and crash cost - Optimize project cost for time and resource - case study

Risk Management and Agile: Risk Identification - Risk management process – Failure modes – NPD - FMEA - Project Closure - Project Report - Agile Project management - Enterprise project Management – Earned Value Management - software for PM - case study

Text Book(s) and Reference Materials

1. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Seventh Edition, Project Management Institute. 2021
2. Punmia B. C. and Khandelwal K.K., “Project Planning and Control with PERT/CPM”, Laxmi publications, New Delhi,
3. Erik W. Larson, Clifford F. Gray, “Project Management: The Managerial Process”, McGraw-Hill/Irwin, eighth Edition, 2017.
4. Construction Project Scheduling and Control, 4th Edition by Saleh A. Mubarak fourth edition 2019.

Reference Materials and Web Resources

1. NPTEL – Online course on Project Management
2. https://www.pmi.org
3. https://www.iso.org/standard

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Overview of Project Management**		
1.1	Definition - Project Life Cycle- Objectives of Project management	1	CO1
1.2	Project knowledge areas-	1	CO1
1.3	organization structure-roles of project management group-project management office and its role	1	CO1
1.4	Project Management Principles ISO 21500:2012: Guidance on project management	1	CO1
2.	**Project Initiation**		
2.1	Generation and Screening of PM ideas- Triple Constraint – Time, Cost and Scope -	1	CO1
2.2	TOR/ Project Charter/ SOW (Statement of Work)	1	CO1
2.3	Project Presentation & Approval –transfer: PPP, Case Study	1	CO1
3.	**Time Management**		
3.1	Work break down structure	2	CO2
3.2	Gantt Charts, Milestone chart	2	CO2
3.3	Project Network- Fulkerson’s rules	1	CO2
3.4	Activity-On-Arrow and Activity- On -Node networks	2	CO2
3.5	Critical path method (CPM)	3	CO3
3.6	Project updating and monitoring	1	CO3
3.7	Program Evaluation & Review Technique (PERT)	2	CO3
4.	**Resource Management**		
4.1	Types of resource- Balancing of resource-	2	CO4
4.2	Resource Smoothing technique	2	CO4
4.3	Resource levelling technique	2	CO4
5.	**Cost Optimization**		
5.1	Types of cost – Cost slope	1	CO5
5.2	Variation of Cost with time - Crash time and crash cost	1	CO5
5.3	Optimize project cost for time and resource	4	CO5
6.	**Risk Management, Agile**		
6.1	Risk Identification, Risk management process	1	CO6
6.2	Failure modes, NPD, FMEA	1	CO6
6.3	Project Closure, Project Report	1	CO6
6.4	Agile Project management, Enterprise project Management – Earned Value Management - software for Project Management - Case study	1	CO6
	Total	36	

Course Designers:

1. Mr. M M Devarajan, mmdmech@tce.edu
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22MT470	MICROCONTROLLER LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

This course covers the basics of 8051 microcontroller architecture, assembly language programming, and interfacing of I/O devices. It also includes advanced topics such as interrupt handling, timers, serial communication, and analog-to-digital conversion. Additionally, it introduces the Raspberry Pi Pico and its Cortex M0+ architecture, and covers programming techniques using C/C++ and the GNU ARM toolchain. The syllabus also includes a list of experiments to reinforce the concepts covered in the course. Overall, the course aims to provide students with a comprehensive understanding of microcontroller programming and interfacing, along with practical experience in designing and implementing microcontroller-based projects.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Analyze the architecture and pin diagram of 8051 microcontroller and apply different addressing modes and memory organization to solve programming problems.	TPS3	80	90
CO2	Evaluate the instruction set of 8051 microcontroller and apply assembly language programming techniques to interface I/O devices and handle interrupts.	TPS3	80	90
CO3	Synthesize C programming principles to configure and program 8051 microcontroller and design programs to interface I/O devices using C language.	TPS3	80	90
CO4	Evaluate the architecture and pin diagram of Cortex M0+ microcontroller and apply different addressing modes and memory organization to design programs using assembly language.	TPS4	75	80
CO5	Analyze the features of Raspberry Pi Pico and apply advanced programming techniques such as interrupt handling, serial communication, and interfacing with LCD and keypad.	TPS3	80	90
CO6	Create programs using C/C++ SDK for Raspberry Pi Pico to interface I/O devices, generate PWM signals, and communicate with peripheral devices using I2C and SPI protocols.	TPS4	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No of Periods.
1.	Write an assembly language program for single and double precision operations	4
2.	Write an assembly language program to read data from an input port and display it on an output port.	4
3.	Write a C program to generate a square wave on an output port using timers. Use timer 0 to generate a 1kHz square wave on Port 1 Pin 0.	2
4.	Write a C program to implement interrupt-based serial communication between two 8051 microcontrollers. Use timer 1 to generate the Baud rate, and interrupt when a byte is received.	
5.	Write a C program to implement timer interrupt to control the brightness of an LED connected to an output port. Use timer 0 interrupt to vary the duty cycle of a PWM signal.	2
6.	Write a C program to interface an LCD display with 8051 microcontrollers using the UART communication protocol. Use timer 1 to generate the Baud rate, and send data to the LCD display using UART.	2
7.	Configure GPIO pins of Raspberry Pi Pico and turn on/off an LED.	2
8.	Implement PWM signal generation using Raspberry Pi Pico and control the brightness of an LED.	2
9.	Interface a push button with Raspberry Pi Pico and detect its state change.	
10.	Interface a digital temperature sensor with Raspberry Pi Pico and read temperature values.	2
11.	Implement I2C communication protocol between Raspberry Pi Pico and a peripheral device.	2
12.	Implement SPI communication protocol between Raspberry Pi Pico and a peripheral device.	2
	Total	**24**
	Project Activity	
	Interfacing of any sensor with Raspberry Pi Pico and display text on LCD.	
	Interfacing of actuator and control with Raspberry Pi Pico.	
	Implementing a simple music synthesizer using Raspberry Pi Pico and a speaker. Use the DAC output to generate different frequencies of sine waves to produce musical notes, and play different melodies using C/C++ SDK.	

Course Designers:

1. Mr. S Parthasarathi, parthasarathi_s@tce.edu
2. Mr. M M Devarajan, mmdmech@tce.edu

22MT480	SENSORS AND MEASUREMENTS LABORATORY	Category	L	T	P	C	TE
		ESC	0	0	2	1	Practical

Preamble

Sensors are indeed becoming increasingly important in many fields and industries, as they allow us to measure and monitor a wide range of parameters with high accuracy and precision. Some of the key benefits of sensors include their ability to provide real-time data, automate processes, and improve safety and efficiency. As you mentioned, sensors can measure various physical and chemical properties, including temperature, pressure, flow, and viscosity, among others. They can also be used to detect motion, proximity, light, sound, and many other environmental factors. Overall, sensors are a critical component in many modern technologies, and their importance is only expected to increase in the coming years.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Select Appropriate Resolution ADC for Sensor Measurements	TPS3	80	90
CO2	Prepare Signal conditioning Circuits for the Active and Passive Sensors	TPS3	80	90
CO3	Measure change of capacitance using Touch and Proximity based Capacitance Sensors	TPS3	80	90
CO4	Measure luminescence, Temperature, Force and calibrate for Error	TPS3	75	80
CO5	Construct a Pressure and strain measurement system	TPS3	80	90
CO6	Collect Vibration measurement and AC Power Measurement for Real Time Monitoring	TPS3	75	80
CO7	Measure Linear, angular, thread elements, 2D & 3D profiles, surface roughness, flatness and straightness	TPS3	75	80
CO8	Check and calibrate different dimensions for given components	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	-	-	-	M	M	-	L	M	-
CO2	S	M	L	-	L	-	-	-	M	M	-	M	M	-
CO3	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO4	S	M	L	-	L	-	-	L	M	M	-	L	M	S
CO5	S	M	L	-	L	-	-	-	M	M	-	M	M	S
CO6	S	M	L		L				M	M		M	M	S
CO7	S	M	L		L				M	M		M	M	S
CO8	S	M	L		L				M	M		M	M	S

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No of Hrs	COs
1	Design of Signal Conditioning circuits -1 Adder and Subtractor for AC and DC Signals.	2	CO2
2	Design of Signal Conditioning circuits -2 Comparator and Instrumentation amplifier	2	CO2
3	Experimenting with Analog to Digital Conversion and Digital to Analog conversion	2	CO2
4	Measurement of Power and Energy of AC and DC source	2	CO1
case studies / mini project submission Design of Energy meters, Power factor meters, Metal Detector			
5	Experimenting with capacitive and Inductive Proximity Sensors	2	CO3
6	Characterisation and Calibration of Thermistor and Thermocouple		CO4
7	Characterisation and Calibration of Light Dependent Resistor, Photodiode		CO4
8	Characterisation and Calibration of Strain Gauge - Load cell	2	CO5
9	Measurement of Acceleration and Characterisation using Acceleration Sensors	2	CO6
10	Characterisation and Calibration Flow Sensor.	2	CO4
case studies: soil moisture measurement, fuel level, pH sensor, Oxygen sensors			
11	Characterisation and Calibration of Force Sensor using ANOVA	2	CO6
12	Profile measurement of linear, angular and thread elements using Profile Projector.	2	CO6
13	Straightness / Flatness Testing using Autocollimator	2	CO7
14	2D & 3D measurements using Coordinate Measuring Machine		CO7
15	Profile measurement of linear, angular and thread elements using Tool Makers Microscope	2	CO8
Case studies: Displacement Measurement sensor, Pressure Sensor, Torque Measurement			
	Total	**24**	

Course Designers:

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2. Mr. S. Parthasarathi, parthasarathi_s@gmail.com

22MT510	CONTROL SYSTEMS	Category	L	T	P	C	TE
		PCC	3	1	0	4	Theory

Preamble

Control system consists of interconnected components to achieve desired objective. The basis for analysis of a system is the foundation provided by linear system theory, which assumes a cause-effect relationship for the components of a system. The input-output relationship represents the cause-and-effect relationship of the process, which in turn represents a processing of the input signal to provide an output signal variable, often with a power amplification. A closed-loop control system utilizes an additional measure of the actual output to compare the actual output with the desired output response. The mathematical modelling, time and frequency response analysis, and controller design using transfer function and state space approaches of this course enable the students to design and analyse suitable control systems for mechatronics applications.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Develop a Mathematical model for physical Systems	TPS3	70	70
CO2	Investigate the Performance Specification of Control system using Time domain techniques	TPS3	70	70
CO3	Investigate the Performance Specification of Control system using Frequency domain techniques	TPS3	70	70
CO4	Select the suitable compensator to improve the performance of control systems	TPS3	70	70
CO5	Design a PID controller and predict optimal PID parameters using suitable technique.	TPS3	70	70
CO6	Determine the system Observability and controllability using state space approach	TPS2	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)		Assessment 2 (%)		Terminal (%)
	CAT 1	Assignment 1	CAT 2	Assignment 2	
CO1	30	40	-	-	20
CO2	40	40	-	-	15
CO3	30	20	-	-	15
CO4	-	-	40	30	20
CO5	-	-	30	40	15
CO6	-	-	30	30	15

Syllabus

Mathematical Modelling: Basic elements in control systems - open loop and closed loop systems – Introduction to mathematical modelling - Introduction to Nonlinear system – linear approximation through Taylor’s series- Transfer functions of mechanical, electrical and analogous systems-Modelling of Actuator Process Transducer system structure- Tutorials: Modelling Liquid level control process, manufacturing process component.

Time response analysis: Time response - Time domain specifications -Types of test inputs, First and Second order system response - Steady state error, error constants, generalized error coefficient - Stability concept and definition - Characteristic equation - Location of poles - Routh Hurwitz criterion - Root locus techniques: construction. Tutorials: Time response analysis of mechatronics systems.

Frequency domain analysis: Frequency response methods -Bode plots - Polar plot - Nyquist stability criterion. Tutorials: Frequency response analysis of mechatronics systems. Tutorials: Time response analysis of mechatronics systems.

Compensator and controller design: Design of lag, lead, lag lead series compensator (using Bode plot), PID Controller design-PID tuning Methods-Practical aspects of PID controller design. Tutorials: PID controller design for HVAC and Motor control.

State space analysis: State variable representation of systems, State space to transfer function conversion, transfer function to state space conversion, controllability and observability of control systems-poles, Eigen values and system stability-Introduction to model predictive and sliding mode control. Tutorials: MPC and sliding mode process control design.

Text Book(s)

1. Norman S. Nise, “Control System Engineering”, 6th Edition, John Wiley & Sons, 2018.
2. Jacqueline wilkie, Micheal Johnson and Reza Katebi, “Control Engineering”, Palgrave, macmillan, 2002.

Reference Books & Web Resources

1. Richard C. Dorf, Robert H. Bishop, “Modern control systems” 13th edition, Pearson Education, 2017.
2. M.Gopal, “Digital control and State variable methods”, Tata McGraw Hill, 2017.
3. J.Nagrath and M.Gopal, “Control System Engineering”, New age International Publisher, New Delhi,2018.
4. K.Ogata,”Modern Control Engineering”,Pearson,2015.
5. https://nptel.ac.in/courses/108107115/
6. https://nptel.ac.in/courses/108102043/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Mathematical Modelling**	
1.1	Basic elements and open loop and closed loop systems - introduction to nonlinear system	1
1.2	linear approximation through Taylor's series	1
1.3	Introduction to mathematical modelling - Transfer functions of mechanical and electrical systems	2
1.4	Transfer functions of analogous systems	1
1.5	Modelling of Actuator Process Transducer system structure	2
1.6	**Tutorials:** Mathematical Modelling Liquid level control process, manufacturing process component.	2
2	**Time response analysis**	
2.1	Time domain specifications	1
2.2	Types of Test input, First order system response	1
2.3	Second order system response	1
2.4	Steady state error, error constants, generalized error coefficient	1
2.5	Stability, Characteristic equation	1
2.6	Routh Hurwitz criterion	2
2.7	Root locus techniques	2
2.8	**Tutorials:** Time response analysis of mechatronics systems.	2
3	**Frequency domain analysis**:	
3.1	Bode plots	2
3.2	Polar plot	2
3.3	Nyquist stability criterion.	2
3.4	**Tutorials:** Frequency response analysis of mechatronics systems.	2
4	**Compensator and Controller design**	
4.1	Lag Compensator design	2
4.2	Lead Compensator design	2
4.3	Lag Lead Compensator Design	1
4.4	PID Controller Design and tuning methods	3
4.5	Practical aspects of PID controller design.	1
4.6	**Tutorials**: PID controller design for process and Motor control.	2
5	**State space analysis**	
5.1	State variable representation of systems	2
5.2	State space to transfer function conversion, transfer function to state space conversion,	1
5.3	Controllability and Observability of control systems	1
5.4	Poles, Eigen values and system stability	1
5.5	Introduction to model predictive and sliding mode control.	2
5.6	**Tutorials:** MPC and sliding mode process control design.	2
	Total	**48**

Course Designers:

1. Mr. H Ramesh, rameshh@tce.edu
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22MT520	DESIGN OF MACHINE ELEMENTS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

Design of machine elements is the process of deriving a system, component, or process to meet desired needs. It is a decision-making process, in which the basic sciences, mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment or objectives and criterion, synthesis, analysis, construction, testing and evaluation. Machine Elements Design deals with the creation of machine element that goes into the making of a machine as a product.

Prerequisite

- 22MT230 – Free Body Mechanics

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Compute the static and fatigue strength of mechanical components.	TPS2	70	80
CO2	Design the shafts for different loading conditions	TPS3	70	80
CO3	Design the flexible coupling for given power transmission.	TPS3	70	80
CO4	Select and Design suitable belt drive for given loading condition	TPS3	70	80
CO5	Select a suitable gear drive for given orientation of shaft and loading condition	TPS3	70	80
CO6	Select a rolling contact bearing and sliding contact bearing for given power transmission application	TPS3	70	80
CO7	Design Bolts and power screw.	TPS3	70	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	10	10	-	-	-	30	-	-	-	-	-	-	4	4	-
CO2	-	10	30	-	-	35	-	-	-	-	-	-	-	4	12
CO3	-	10	30	-	-	35	-	-	-	-	-	-	4	4	12
CO4	-	-	-	-	-	-	5	10	-	-	-	30	4	4	12
CO5	-	-	-	-	-	-	5	10	30	-	-	35	4	4	12
CO6	-	-	-	-	-	-	-	10	30	-	-	35	4	-	12

Syllabus

Machine Design Concepts: Machine Elements, Procedure for design of machine elements, Basic requirements of machine elements, Preferred Numbers, Engineering materials-its properties and selection, limits, fits, tolerance, Stress, Strain, Torsion, Bending, Factor of safety, Theories of failure, Variable stress.

Design of Rotating elements and Brakes: Shafts, Shafts subjected to twisting moment, combined Bending and twisting moment with axial loads. Design of Keys for shafts. Design of flexible coupling.

Design of power transmission drives: Drives classification, selection of Flat belt drive, selection of V belt Drive, Design of chain drive, design of timing belt drive, Design of Spur gear and bevel gear

Design of Bearings: Introduction, Classification, select of sliding contact bearing and rolling contact bearing.

Design of Linear motion elements: Introduction, Design of bolts and power screws, Design of guide ways.

Text Book(s)

1. V.B. Bhandari, “Design of machine elements”, Fourth edition, Tata McGraw Hill, 2017.
2. Joseph Edward Shigley and Charles R. Misucke, “Mechanical Engineering Design”, Tenth Edition, Tata McGraw Hill, 2015.
3. Robert L. Norton, “Machine Design: An integrated Approach”, Third edition, Prentice Hall, 2005.

Reference Books & Web Resources

1. Sundarajamoorthy T.V. and Shanmugam. N, “Machine Design”, Anuradha Publications, 2003.
2. K. Ganesh Babu, K.Srithar, “Design of machine Elements”, MCGraw Hill Education, 2009.
3. Hall, Holowenko and Laughin, “Theory and Problems of Machine Design”, Tata McGraw Hill Company, 2002.
4. Sharma P. C, and Agarwal D.K, “Machine design”, S.K. Kataria and Sons, New Delhi, 2000.
5. M. F. Spotts, T. E. Shoup, “Design of Machine Elements”, Eighth Edition, Pearson Education Asia, 2006.

6. Amit U Pawar, Apurav A Wagh and D U Patil," Design of Linear Motion Guideways", International journal of Engineering Research and Science & Technology, Vol.2, No. 4, 2015.
7. PSG, "Design Data Book", 2015
8. https://archive.nptel.ac.in/courses/112/105/112105124/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Machine design Concepts**	
1.1	Machine elements	1
1.2	Procedure for design of machine elements	1
1.3	Basic requirements of machine elements, Preferred numbers	1
1.4	Engineering materials- Its properties and selection	1
1.5	Stress, Strain, Torsion	1
1.6	Bending, variable stress, Factor of safety	1
1.7	Theories of failure	2
2	**Rotating Elements and Brakes**	
2.1	Shafts, Shafts subjected to Twisting moment and Combined Bending and Twisting moment	1
2.2	Shafts subjected to Combined Bending and Twisting moment with axial loads	2
2.3	Design of Keys for shafts	2
2.4	Design of Brake	2
3	**Design of power transmission drives**	
3.1	Drives introduction and its classification	1
3.2	Selection of Flat belt drive	2
3.3	Selection of V belt drive	2
3.4	Design of chain drive	2
3.5	Design of spur gear	2
3.6	Design of bevel gear	2
4	**Design of Bearings**	
4.1	Introduction and classification	2
4.2	select of sliding contact bearing and rolling contact bearing.	2
5	**Design of Linear motion elements**	
5.1	Introduction	1
5.2	Design of bolts	2
5.3	Design of power screws	2
5.4	Design of Guide ways	2
	Total	**36**

Course Designers:

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3. Dr. K J Nagarajan, kjnmech@tce.edu

22MT530	INDUSTRIAL AUTOMATION	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

Today's highly increasing competitiveness over the industry demands high quality and most consistent products with a competitive price. To address this challenge number of industries considering various new product designs and integrated manufacturing techniques in parallel with the use of automated devices. One of the remarkable and influential moves for getting the solutions of above-mentioned challenge is the industrial automation. Industrial automation facilitates to increase the product quality, reliability and production rate while reducing production and design cost by adopting new, innovative and integrated technologies and services. Industrial Automation is the replacement with computers and machines to that of human thinking. Industrial automation deals with the set of technologies and automatic control devices that results the automatic operation and control of industrial processes and machines without significant human intervention and achieving superior performance than manual control. These automation devices include PLCs, HMI, SCADA etc. and technologies include various industrial communication systems.

Prerequisite

- 22MT340 - Thermal Fluid Systems
- 22MT350 - Electrical Machines

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the selection and programming methods of different automation components like PLC, SCADA, DCS and communication buses.	TPS 2	80	70
CO2	Explain the construction, working and control strategies of different industrial drives and valves.	TPS 2	80	75
CO3	Design pneumatic and hydraulic circuits for industrial applications.	TPS 3	70	70
CO4	Construct a program using PLC to solve problems pertaining to Manufacturing industries.	TPS 3	70	70
CO5	Design an automation system by interconnecting work cell devices through an industrial network.	TPS 3	70	70
CO6	Select suitable automation system for given Industrial application.	TPS 3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

	Assessment 1 (%)		Assessment 2 (%)		Terminal (%)
	CAT 1	Assignment 1	CAT 2	Assignment 2	
CO1	20	-	10	-	15
CO2	20	-	-	-	10
CO3	-	-	30	-	20
CO4	-	-	30	-	20
CO5	20	-	20	100	15
CO6	40	100	10	-	20

Syllabus

PLC Basics: Basics of Electrical control-Parts of a PLC -Principles of Operation –Advantages and Disadvantages of PLC - PLC Size and Application- The I/O Section -Discrete I/O Modules-Analog I/O Modules-Special I/O Modules – I/O Specifications-Scanning cycle of PLC-The CPU-Memory Design-Memory Types- Processor Memory Organization-I/O Interfacing.

Programming PLC: PLC Programming Languages- PLC Modes of Operation - Relay-Type Instructions- Instruction Addressing-Branch Instructions Internal Relay Instructions Programming EXAMINE IF CLOSED and EXAMINE IF OPEN Instructions - Designing a Ladder Diagram for large process –Programming Timers-Programming Counters - High Speed Counter-Subroutine and Interrupt -programming Analog module - Developing a PLC program for Machine, Process and Motion control.

HMI and SCADA: HMI programming-Interfacing PLC with HMI. Basics of SCADA system-SCADA key features - Remote terminal units (RTUs)-Typical requirements for an RTU system - PLCs used as RTUs-Consideration and benefits of SCADA system-SCADA software package- Selection of Profibus, Profinet, Sercos, Ethernet and OPC/UA.

Fluidic Power Automation: Fundamentals of hydraulic and pneumatic drives-basic definitions and principles-benefits of fluidic drives-components of fluidic drive systems-Actuators-Control valves Classification- Directional, Pressure, Flow, Proportional and servo valves- Electro pneumatic circuit -Fluidic sequential circuit design using classical, cascade and step counter methods.

Industrial Applications: Role of PLC in Industry 4.0 application, Application of Wireless Networks for Industrial automation, Application of Pneumatic, Hydraulic circuits in Industrial automation.

Text Book(s)

1. Frank D Petruzella, **Programmable logic controllers,** Fourth edition, McGraw Hill higher education ,2016
2. Fluid power with applications by Antony Esposito ,Pearson publications,2017
3. Rajesh Mehra, Vikrant Vij, **PLCs & SCADA: Theory and Practice,** Laxmi Publications-2016

Reference Books & Web Resources

1. Steve Mackay ,Edwin Wright MIPENZ, Deon Reynders, John Park “**Practical Industrial Data Networks -Design, Installation, trouble shooting”** ,IDC Technologies, Australia.
2. Frank D petruzella, **Electrical Motor and control systems,** McGraw Hill higher education ,2010
3. Krishna Kant -**Computer Based Industrial Control**, EEE-PHI, 2nd edition, 2010.
4. Garry Dunning-**Introduction to Programmable Logic Controllers**, 2nd edition, Thomson, ISBN: 981-240-625-5.
5. W.Bolton- **Programmable Logic Controllers**, Sixth Edition (Paperback) ISBN-13: 978-0128029299, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.1	Basics of Electrical control-Parts of PLC, Principles of Operation, Advantages and Disadvantages of PLC.	1
1.2	PLC Size and Application- The I/O Section -Discrete I/O Modules	1
1.3	Analog I/O Modules-Special I/O Modules – I/O Specifications	1
1.4	Scanning cycle of PLC-The CPU-Memory Design-Memory Types- Processor Memory Organization, I/O interfacing.	1
2.0	**Programming PLC**	
2.1	Processor Memory Organization- PLC Programming Languages-PLC Modes of Operation	1
2.2	Relay-Type Instructions- Instruction Addressing-Branch Instructions Internal Relay Instructions	1
2.3	Programming EXAMINE IF CLOSED and EXAMINE IF OPEN Instructions	1
2.4	Designing a ladder diagram for Large Process	1
2.5	Programming Timers	1
2.6	Subroutine and Interrupt Concepts	1
2.6	Programming Counters-High speed counter.	1
2.7	Programming Analog module	1
2.9	Developing a PLC program for Machine, Process and Motion control.	2
3.0	**HMI and SCADA**	
3.1	HMI programming	1
3.2	Interfacing PLC with HMI	1
3.3	Basics of SCADA system-SCADA key features	1
3.4	Remote terminal units (RTUs)-Typical requirements for an RTU	1
3.5	PLCs used as RTUs-Consideration and benefits of SCADA system	1
3.6	SCADA software package	1
3.7	SCADA software package. Selection of Profibus, Profinet, Sercos, Ethernet and OPC/UA.	1
4.0	**Fluidic Power Automation**	
4.1	Fundamentals of hydraulic and pneumatic drives	1
4.2	Basic definitions and principles-benefits of fluidic drives	1

Module No.	Topic	No. of Periods
4.3	Components of fluidic drive systems	1
4.4	Control valves Classification-Pressure, Flow, Directional, Proportional and servo valves.	2
4.5	Fluidic actuators-Motors and Cylinders	1
4.6	Basic Fluidic Circuits	1
4.7	Electro pneumatic circuit	2
4.8	Fluidic speed control circuits –meter in and Meter out	1
4.9	Sequential circuit-manual, electro and proportional, Cascading circuit-manual and electrical control	2
5.0	**Industrial Applications**	
5.1	Role of PLC in Industry 4.0 application	1
5.2	Application of Wireless Networks for Industrial automation	1
5.3	Application of Pneumatic, Hydraulic circuits in Industrial automation.	1
	Total	**36**

Course Designers:

1. Mr. H. Ramesh, rameshh@tce.edu
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22MT540	CNC TECHNOLOGY	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Preamble

This course provides fundamental knowledge about the CNC system that are predominantly found in most manufacturing industries. CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. A CNC system is typically a traditional mechanical machine tool whose motion is controlled by electrical motors which depends on a computer program. CNC machines can produce components with good accuracy and precision along with very high production rate. The dependency on the skill of the worker can be eliminated when CNC machines are employed. In modern CNC systems, the design of a mechanical part and its manufacturing program is highly automated. The part's mechanical dimensions are defined using CAD software, and then translated into manufacturing directives by computer-aided manufacturing (CAM) software. The resulting directives are transformed into the specific commands necessary for a particular machine to produce the component, and then are loaded into the CNC machine

Prerequisite

- 22MT430 - Power Electronics and Drives

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Classify the CNC machine based on their specifications.	TPS2	70	70
CO2	Illustrate the construction features of mechanical components used in a CNC system.	TPS2	70	70
CO3	Design a 3 axis CNC System by selecting suitable controller, feed and spindle drives.	TPS3	70	70
CO4	Develop CNC part program for turning as per product geometry.	TPS3	70	70
CO5	Develop CNC part program for Milling Operations	TPS3	70	70
CO6	Develop a CNC system by selecting suitable components and Suggest methodologies for CNC system maintenance and troubleshooting.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	15	10	-	-	30	-	-	-	-	-	-	-	6	6	-
CO2	15	15	-	-	30	-	-	-	-	-	-	-	6	18	-
CO3	5	15	25	-	-	40	-	-	-	-	-	-	4	6	10
CO4	-	-	-	-	-	-	-	10	20	-	-	30	2	-	15
CO5	-	-	-	-	-	-	10	10	20	-	-	40	2	-	15
CO6	-	-	-	-	-	-	-	10	20	-	-	30	2	-	10

Syllabus

Introduction to CNC Systems: Fundamentals of NC, CNC and DNC technologies, Evolution of CNC Turning centre, Evolution of CNC Milling centre, Principles, specification, features, advantages and applications of CNC machines, Factors influencing the selection of CNC machines, Practical aspects of introducing CNC machines in manufacturing industry, Safety aspects of CNC machines.

Structure and Elements of CNC System: Machine physical architecture – Structural details, Types of loads on CNC machine, Types of guide ways – Friction guide ways, Antifriction guide ways, Elements for rotary motion to linear motion – Screw & nut, recirculating ball screw, , rack & pinion, Torque transmission elements – gears, timing belt, flexible coupling, bearing, Hydraulic and pneumatic systems in a CNC system – Industry 4.0 for Machine tools.

CNC Tooling: Cutting tool materials, types of cutting tool, tool selection, tool holder, tool probing and pre-setting, tool compensation, automatic turret changer, tool monitoring system

CNC Drives and Control: Spindle drive – Three phase induction motor – Construction, Characteristics, Speed control methods, VFD, Axis Drive – AC Servo motor, Construction Characteristics, Closed loop position control. Feedback devices – Rotary encoder, linear scale encoder, proximity sensor, synchronous resolver. Introduction to functioning and programming of CNC Controller, PLC, Man machine interface

CNC Programming: Machine axes identification NC Programming, Part programming terminology – G and M codes, Types of interpolation, Types of Programming – manual part programming: fixed cycle and canned cycle for turning and milling operations, Computer Assisted Part Programming (CAPP), CNC part programming using CAD/CAM tools. Introduction to Cloud computing for CNC programming.

Design, Verification and Maintenance of CNC Machines: Selection and Integration of CNC components-Case study 3 axis CNC turning and milling Machine, Verification of technical and functional aspects, Verification of CNC machine during idle running, Verification of CNC machine tool and work piece accuracy, Analysis of dynamic behaviour of CNC machines, Maintenance of CNC machines- Role of IOT in CNC maintenance sector, IOT based condition monitoring-Case study.

Text Book(s)

1. HMT, “Mechatronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi – 2018.
2. CNC Programming by Dr. S.K. Sinha, Galgotia publications Pvt. Ltd, 2016

Reference Books & Web Resources

1. Ken Evans, “Programming of Computer Numerically Controlled Machines”, Industrial Press Inc. – 2007.
2. Peter Smid, “CNC Programming Handbook”, Industrial Press Inc. 2007.
3. Yusuf Altintas, “Manufacturing Automation”, Cambridge University Press, 2012.
4. G. E. Thyer, “Computer Numerical Control of Machine Tools”, Second Edition, B/H Newnes, 1991.
5. Graham T. Smith, “CNC Machining Technology”, Springer-Verlag London Limited, 1993.
6. FANUC Series 0, Maintenance Manual

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to CNC Systems**	
1.1	Evolution of CNC Turning centre, Evolution of CNC Milling centre	1
1.2	Principles, specification, features, advantages and applications of CNC machines	1
1.3	Factors influencing the selection of CNC machines, Practical aspects of introducing CNC machines in manufacturing industry	1
1.4	Safety aspects of CNC machines	1
2	**Structure of CNC System**	
2.1	Machine physical architecture – Structural details	1
2.2	Types of loads on CNC machine	1
2.3	Types of guide ways – Friction guide ways, Antifriction guide ways	1
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	**Tooling for CNC Machines**	
3.1	Types of cutting tool, Tool selection	1
3.2	Tool holder, tool probing and pre-setting	1
3.3	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	2
4.2	VFD Axis Drive – AC Servo motor, Construction, Characteristics, Closed loop position control	2
4.3	Feedback devices – Rotary encoder, linear scale encoder, proximity sensor, synchronous resolver.	2
4.4	Introduction to functioning and programming of CNC Controller, PLC, Man machine interface.	2
4.5	Industry 4.0 for Machine tools	1
5	**CNC Part Programming**	
5.1	Part programming terminology – G and M codes	2

Module No.	Topic	No. of Periods
5.2	Types of interpolation, manual part programming: fixed cycle and canned cycle for turning and milling operations	2
5.3	Tool compensation	1
5.4	Computer assisted part programming	1
5.5	Introduction to CNC part programming using CAD/CAM tools.	1
6	**Design, Verification and Maintenance of CNC Machines**	
6.1	Selection and Integration of CNC components-Case study 3 axis CNC turning and milling Machine	1
6.2	Verification of technical and functional aspects, Verification of CNC machine during idle running	1
6.3	Verification of CNC machine tool and work piece accuracy	1
6.4	Analysis of dynamic behaviour of CNC machine	1
6.5	Maintenance requirements of CNC machine – Role of IOT in CNC maintenance sector, IOT based condition monitoring-Case study.	2
	Total	**36**

Course Designers:

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22MT550	CAD / CAM LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

Computer Aided Design (CAD) is the process of designing and developing computer assisted design tools in the design process. Computer Aided manufacturing (CAM) is concerned with use of computer to assist with manufacturing process through G codes and M codes.

Prerequisite

- 22ME160 - Engineering Graphics

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Develop the basics of CAD drawing of 2D models	TPS3	80	90
CO2	Develop the basics of CAD drawing of 3D models.	TPS3	80	90
CO3	Design part development drawing for given application.	TPS3	80	90
CO4	Develop and simulate the CNC program for mechanical operations like taper, turning, threading and curvature.	TPS3	80	90
CO5	Generate CNC code for milling and drilling operation	TPS3	80	90
CO6	Generate CNC program and interface with CNC machine/CNC simulator to draw the given pattern.	TPS3	80	90

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Experiments / Exercise	No. of Hours
1.	2D-drawings using sketcher options - 2 Exercises	2
2.	3D-modelling using form features - 2 Exercises	2
3.	Develop 3D model of plumber block.	2
4.	Develop 3D model of crankshaft	2
5.	Develop 3D model of IC engine piston.	2
6.	Obtain the drafting of the part developed.	2
7.	Write a manual CNC program for step and taper turning and simulate the operation	2
8.	Write a manual CNC program for step and taper turning and simulate the operation	2
9.	Complete the tool path simulation for drilling and pocket milling operations.	2
10.	Generate CNC program for profile milling, drilling and pocket operations using CAD/CAM package.	2
11.	Draw/Import the 2D diagram of the part using CAM package.	2
12.	Create a given sheet metal model (both unfold and finished) using 2D CAD and CAM software	2

Software required:

Siemens, Fusion 360, Denford FANUC offline software for Turning, MasterCAM software, AutoCAD

Course Designers:

1. Dr. G Kanagaraj, gkmech@tce.edu
2. Mr. H Ramesh, rameshh@tce.edu
3. Dr. K J Nagarajan, kjnmech@tce.edu

22MT560	INDUSTRIAL AUTOMATION LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

Industrial automation is the use of computer and machinery aided systems to operate the various industrial operations in a well-controlled manner. Depends on the operations involved, the industrial automation systems are majorly classified into two types, namely process plant automation and manufacturing automation. Earlier the purpose of automation was to increase productivity and to reduce the cost associated with human operators. However, today, the focus of automation has shifted to increasing quality and flexibility in a manufacturing process.

In industrial automation control, a wide number of process variables such as temperature, flow, pressure, distance, and liquid levels can be sensed simultaneously. All these variables are acquired, processed and controlled by complex microprocessor systems or PC based data processing controllers. The automated system needs special dedicated hardware and software products for implementing control and monitoring systems. In recent years, the number of such products has been developed from various vendors which providing their specializing software and hardware products. This course provides the practical skills on automation technologies which enable the students to design and develop the automated systems to meet out the requirements of digital manufacturing.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Design and verify the function of hydraulic and pneumatic circuits.	TPS3	80	80
CO2	Build programmable logic control for mechanical, hydraulic, pneumatic and electrical systems.	TPS3	80	80
CO3	Develop algorithm for Motion control applications	TPS3	80	80
CO4	Develop graphical user interface for industrial applications using HMI.	TPS3	80	80
CO5	Develop graphical user interface for industrial applications using SCADA.	TPS3	80	80
CO6	Program PLC for robot and Numerical Control.	TPS3	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Expt. No.	Exercises / Experiments	No of Hours.	COs
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)	4	CO1, CO2
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)	2	CO1, CO2
3	Exercises using PLC Bit logic Functions (2 Exercises)	2	CO2
4	Exercises using PLC Timer functions (2 Exercises)	2	CO2
5	Exercises using PLC Counter Functions (2 Exercises)	2	CO2
6	Exercises using PLC Move Function and arithmetic function (2 Exercises)	2	CO2
7	PLC Functions and Function blocks (1 Exercise)	2	CO2
8	Programming PLC Analog module	1	CO2
9	Programming with HMI and SCADA	2	CO4, CO5
10	Programming PLC-IOT module	1	CO2
11	Motion control programming for Industrial Robot applications	2	CO3, CO6
12	PLC program for Numerical control applications.	2	CO2, CO3, CO6
13	Industrial automation Mini Project.	-	CO1 to CO6
	TOTAL	**24**	

Reference Books

1. "**Indra Works 14VRS PLC Programming System Indra Logic 2G**" published by Bosch Rexroth Edition7- Application Description -R911343571.
2. "**Learn-/Training Document –S71200**", Siemens TIA Portal Module 011-001, Edition 09/2017 | Digital Factory, DF FA.
3. **S7-1500 Getting Started manual**, Siemens 05/2014, A5E03981761-AC.
4. KARL-HEINZ JOHN, **Programming Industrial automation systems**, Springer, 1995.

Course Designers:

1. Mr. H. Ramesh, rameshh@tce.edu
2. Dr. S. Julius Fusic, sjf@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

VI and VII Semester

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

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

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Mechatronic System Laboratory ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT480 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Project I PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22MT630 Professional Communication HSMC 2	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22MT660 Project II PW 3	23
VII	22MT710 Mechatronics System Design PCC 4	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 2	---	---	22MT730 Project III PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT810 Project IV PW 3	9
									Total Credits	**160**

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits	
			Regular Admission	Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**22 - 35**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	08 - 11
	b.	Basic Science Courses (BSC)	24 - 27	06 - 09
	c.	Engineering Science Courses (ESC)	21 - 27	08 - 15
B.	**Professional Core Courses (PCC)**		**55**	**45**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

VI SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT610	Accounting and Finance	HSMC	3	1	0	4
22MT620	Industrial Robotics	PCC	3	0	0	3
22MTPx0	Program Elective II	PEC	3	0	0	3
22MTPx0	Program Elective III	PEC	3	0	0	3
22MT630	Professional Communication	HSMC	0	1	2	2
22yyFx0	Basic Science Elective	BSE	3	0	0	3
PRACTICAL						
22MT640	Control and Dynamics Laboratory	PCC	0	0	2	1
22MT650	Robotics Laboratory	PCC	0	0	2	1
PROJECT						
22MT660	Project II	PW	0	0	6	3
		Total	**15**	**2**	**12**	**23**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

VI SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT610	Accounting and Finance	3	40	60	100	27	50
22MT620	Industrial Robotics	3	40	60	100	27	50
22MTPx0	Program Elective II	3	40	60	100	27	50
22MTPx0	Program Elective III	3	40	60	100	27	50
22MT630	Professional Communication	3	40	60	100	27	50
22yyFx0	Basic Science Elective	3	40	60	100	27	50
PRACTICAL							
22MT640	Control and Dynamics Laboratory	3	60	40	100	18	50
22MT650	Robotics Laboratory	3	60	40	100	18	50
PROJECT							
22MT660	Project II	-	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

VII SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MT710	Mechatronics System Design	PCC	3	1	0	4
22MTPx0	Program Elective IV	PEC	3	0	0	3
22MTPx0	Program Elective V	PEC	3	0	0	3
22MTPx0	Program Elective VI	PEC	3	0	0	3
22MTPx0	Program Elective VII	PEC	3	0	0	3
PRACTICAL						
22MT720	System Integration Laboratory	PCC	0	0	4	2
PROJECT						
22MT730	Project III	PW	0	0	6	3
		Total	**15**	**1**	**10**	**21**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

VII SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MT710	Mechatronics System Design	3	40	60	100	27	50
22MTPx0	Program Elective IV	3	40	60	100	27	50
22MTPx0	Program Elective V	3	40	60	100	27	50
22MTPx0	Program Elective VI	3	40	60	100	27	50
22MTPx0	Program Elective VII	3	40	60	100	27	50
PRACTICAL							
22MT720	System Integration Laboratory	3	60	40	100	18	50
PROJECT							
22MT730	Project III	-	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

VIII SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
THEORY						
22MTPx0	Program Elective VIII	PEC	3	0	0	3
22MTPx0	Program Elective IX	PEC	3	0	0	3
PROJECT						
22MT810	Project IV	PW	0	0	6	3
		Total	**6**	**0**	**6**	**9**

HSMC : Humanities and Social Sciences including Management Courses

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Program Core Courses

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

VII SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
THEORY							
22MTPx0	Program Elective VIII	3	40	60	100	27	50
22MTPx0	Program Elective IX	3	40	60	100	27	50
PROJECT							
22MT810	Project IV	-	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

22MT610	ACCOUNTING AND FINANCE	Category	L	T	P	C	TE
		HSMC	3	1	0	4	Theory

Preamble

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds an engineer needs among other things data about the organization's routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting, and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Prepare financial statements using common size statements, comparative statements and trend percentage methods	TPS 3	75	65
CO2	Prepare apportionment of overheads and cost sheet for the given direct and indirect costs.	TPS 3	75	65
CO3	Calculate material, labour and overhead cost variance by identify the reasons for the variances and deprecation for the assets.	TPS 3	75	65
CO4	Calculate various functional budgets, working capital and cash budget for manufacturing applications.	TPS 3	75	65
CO5	Compute the capital budgeting decisions by using pay back, accounting rate of return, net present value and internal rate of return methods.	TPS 4	60	65
CO6	Calculate the break-even points and margin of safety from the given statement.	TPS 3	75	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)								Terminal (%)			
	CAT 1			Assignment 1			CAT 2				Assignment 2							
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
CO1	-	-	30				-	-	-	-	-	-	-	-	4	5	8	-
CO2	-	-	30		100		-	-	-	-	-	-	-	-	4	5	8	-
CO3	-	-	40				-	-	-	-	-	-	-	-	4	5	8	-
CO4	-	-	-	-	-	-	-	-	30	-					2	5	8	-
CO5	-	-	-	-	-	-	-	-	-	40		100			4	-	-	15
CO6	-	-	-	-	-	-	-	-	30	-					2	5	8	-

Syllabus

Financial Accounting - Introduction and Definition -Functions of accounting -Concepts and conventions of accounting -Financial statements and their analysis

Finance - Introduction and Definition-Objectives of financing-Profit maximization vs wealth maximization - Functions of finance - Basics of Goods and Services Tax - Constitutional Framework of GST - GST Model – CGST / IGST / SGST / UTGST

Cost Accounting - Meaning and importance – Cost - Elements of cost - Cost classification - Overheads - Allocation and apportionment of overheads - Preparation of Cost sheet - Conventional Vs activity-based costing - Cost drivers and their impact on costs of production

Standard costing - Meaning and definition-Importance - Variance analysis - calculation of material, labour and overhead variances - Depreciation and its types

Budget and Budgetary control – Introduction - Meaning - objectives of budgetary control - Preliminaries for operation of budgetary control-Budget - Types of budgets and their preparation

Working capital - Meaning and definition-Importance-Factors influencing working capital-components of working capital -Estimation of working capital requirements

Capital Budgeting - Introduction-Meaning and Definition-Importance –process of capital budgeting - Appraisal of capital budgeting decisions

Profit Volume Analysis – Cost – Volume ratio analysis - Marginal cost, Marginal cost statement and total cost -Break Even Analysis - Margin of Safety - Applications of Break Even Analysis.

Accounting software for balance sheet, Budgeting, Break even Analysis

Text Book(s)

1. M.C. Shukla, T.S. Grewal, S.C. Gupta: "**Advanced Accounts-volume-I**", Reprint, S Chand & Company Ltd. 2017

Reference Books and Web Resources

1. S.N. Maheswari, "**Financial Management, principles and practices**", Sultan Chand & Company Ltd. 2013.
2. Prasanna Chandra, "**Financial Management-Theory and Practice**". Sixth Reprint, Tata McGraw-Hill publishing company Limited, 2015.
3. P.S. Boopathi Manickam, "**Financial and Management Accounting**" PSG Publications, 2009
4. Ramachandra Aryasri, A, Ramana Moorthy, V.V, "**Engineering Economics and financial Accounting**", Tata McGraw hill, 2007.
5. S.N. Maheswari, "**Advanced accountancy**" Vikas publishing, 2007.
6. https://nptel.ac.in/courses/110/101/110101132/
7. https://nptel.ac.in/courses/110/101/110101131/
8. https://nptel.ac.in/courses/110/107/110107127/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Financial Accounting**	
1.1	Introduction and Definition	1
1.2	Functions of accounting	1
1.3	Concepts and conventions of accounting	1
2	**Finance**	
2.1	Introduction and Definition	1
2.2	Objectives of financial management	1
2.3	Functions of finance	1
2.4	Basics of Goods and Services Tax - Constitutional Framework of GST - GST Model – CGST / IGST / SGST / UTGST	1
3	**Financial statements**	
3.1	Comparative statement	2
3.2	Common size statement	2
3.3	Trend percentage	1
4	**Cost Accounting**	
4.1	Meaning and importance	1
4.2	Cost-Elements of cost-Cost classification	1
4.3	Overheads – Allocation and apportionment of overheads	2
4.4	Preparation of Cost sheet	2
4.5	Conventional Vs Activity based costing	1
4.6	Cost drivers and their impact on costs of production	1
5	**Standard costing**	
5.1	Meaning and definition-Importance	1
5.2	Variance Analysis, Calculation of material, labour and overhead variances.	2
5.3	Depreciation and its types	2
6	**Budget and Budgetary control**	
6.1	Introduction-Meaning -objectives of budgetary control	1
6.2	Preliminaries for operation of budgetary control	1
6.3	Budget-Types of budgets and their preparation	2

Module No.	Topic	No. of Periods
7	**Working capital**	
7.1	Meaning and definition-Importance	1
7.2	Factors influencing working capital	1
7.3	components of working capital	1
7.4	Estimation of working capital requirements	2
8	**Capital Budgeting**	
8.1	Introduction-Meaning and Definition-Importance – process of capital budgeting	1
8.2	Appraisal of capital budgeting decisions	2
8.3	Payback Period, ARR	2
8.4	NPV, IRR and PI methods	2
9	**Profit Volume Analysis**	
9.1	Marginal cost, Marginal cost statement and total cost	1
9.2	Break Even Analysis	2
9.3	Margin of Safety	2
9.4	Applications of Break Even Analysis	2
	Total	48

Course Designers:

1. M.M. Devarajan, mmdmech@tce.edu
2. S. Rajkumar, srmech@tce.edu

22MT620	INDUSTRIAL ROBOTICS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

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. Industrial Robotics deals with the types of robots used in industries both industrial and mobile robots.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Review the Anatomy, types and applications of robots	TPS2	75	75
CO2	Compute the forward kinematic model (position and orientation) of multi DOF manipulator	TPS3	65	65
CO3	Compute the inverse kinematic model (joint angles) of 1 and 2 DOF manipulator	TPS3	65	65
CO4	Compute the forward and inverse dynamic model of two DOF manipulator (torque)	TPS3	65	65
CO5	Develop pendant program for palletizing and deburring application	TPS3	65	65
CO6	Implement Artificial Intelligence based robot picking	TPS2	75	75

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	60	-	-	-	-	-	-	-	-	-	-	-	20	-
CO2	-	-	20	-	100	-	-	-	-	-	-	-	-	-	25
CO3	-	-	20	-	-	-	-	-	-	-	-	-	-	-	25
CO4	-	-	-	-	-	-	-	-	40	-	-	50	-	-	10
CO5	-	-	-	-	-	-	-	-	40	-	-	50	-	-	10
CO6	-	-	-	-	-	-	-	-	20	-	-	-	-	-	10

Syllabus

Introduction to Industrial Robotics

Introduction – brief history, Robot – types – Industrial, Mobile; Classification and usage, configuration, Anatomy, Elements/subsystems of Robots, Point to point and continuous applications, Mobile manipulators, Grippers – Types; Application of robots in machining - Welding - Assembly - Material handling - Loading and unloading Inspection – Palletizing - Hostile and remote environments.

Representation and Transformation of joints, links

Mechanical Structure notations, Coordinate frames, Description of objects in space, Transformation and fundamental rotation matrices, Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, **Kinematics:** Forward kinematics of multi DOF manipulator - Inverse kinematics of 2DOF manipulator. **Dynamics:** Introduction – Manipulator dynamics – Lagrange - Euler formulation- Newton - Euler formulation. Examples of D-H parameters and link transforms. Introduction to Robo Analyser – Visualization of DH parameters. Introduction to Robot Operating System (ROS) – Demonstration.

Trajectory planning

Definitions and planning tasks, Joint techniques – Motion profiles- cubic polynomial motion, Cartesian Space techniques. Robot Controller – open, closed.

Robot Programming

Robot Programming: Manual programming – Teach Pendant, Online programming – Deburring, Palletizing and Inspection, Offline Programming – Welding.

Artificial Intelligence in Robotics

Artificial Intelligence – Types – Edge based; Cloud based, Security concerns - Consciousness, Scalability, Data Security. Case studies - Vision based robot picking, Collaborative Robots, Digital Twin Robots.

Text Book(s)

1. Dr Jisu Elsa Jacob, “Robotics Simplified: An Illustrative Guide to Learn Fundamentals of Robotics, Including Kinematics, Motion Control, and Trajectory Planning”, BPB Publications, 2022

Reference Books & Web Resources

1. Robotics, AI, and Humanity, Science, Ethics, and Policy, Springer, 2021
2. Shuai Li, Long Jin, Mohammed Aquil Mirza," Kinematic Control of Redundant Robot Arms Using Neural Networks", IEEE press, April 29, 2019.
3. John J Craig, "Introduction to Robotics, Mechanics and Control, third edition, Pearson education, 2005
4. K.S.Fu, R.C Gonzalez and C.S Lee, Robotics – Control, sensing Vision and Intelligence, Tata McGraw – Hill Editions, 2008.
5. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008.
6. Saeed B Niku, "Introduction to Robotics, Analysis, System, Applications," second edition, john Wiley, 2010.
7. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, "Industrial Robotics – Technology, Programming and Applications", Tata McGraw Hill Edition, 2008.
8. Robert J 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 Periods	Course Outcome
1.0	**Introduction to Industrial Robotics**		CO1
1.1	Introduction – brief history	1	CO1
1.2	Robot – types – Industrial, Mobile	1	CO1
1.3	Classification and usage, configuration	1	CO1
1.4	Anatomy, Elements/subsystems of Robots	1	CO1
1.5	Point to point and continuous applications	1	CO1
1.6	Mobile manipulators, Grippers, – Types	1	CO1
1.7	Application of robots in machining - Welding - Assembly	1	CO1
1.8	Material handling - Loading and unloading Inspection, Palletizing - Hostile and remote environments	1	CO1
2.0	**Representation and Transformation of joints, links**		
2.1	Mechanical Structure notations, Coordinate frames	1	CO2
2.2	Description of objects in space, Transformation and fundamental rotation matrices	1	CO2
2.3	Position and orientation of a rigid body, Homogeneous transformations	1	CO2
2.4	Representation of joints	1	CO2
2.5	Link representation using D-H parameters	1	CO2
2.6	Forward kinematics of multi DOF manipulator	1	CO2
2.7	Inverse kinematics of 2DOF manipulator	1	CO3
2.8	Introduction – Manipulator dynamics	1	CO4
2.9	Lagrange - Euler formulation	1	CO4
2.10	Newton - Euler formulation	1	CO4
2.11	Examples of D-H parameters and link transforms	1	CO4
2.12	Visualization of DH parameters	1	CO4
2.13	Introduction to Robo Analyser	1	CO4
2.14	Introduction to Robot Operating System (ROS)-Demonstration	1	CO4
3.0	**Trajectory planning**		
3.1	Definitions and planning tasks	1	CO4
3.2	Joint techniques – Motion profiles-	1	CO4

Module No.	Topic	No. of Periods	Course Outcome
3.3	Cubic polynomial motion	1	CO4
3.4	Cartesian Space techniques	1	CO4
3.5	Robot Controller – open, closed	1	CO4
4.0	**Robot Programming**		
4.1	Robot Programming types	1	CO5
4.2	Teach Pendant Commands	1	CO5
4.3	Manual programming	1	CO5
4.4	Online programming – Deburring, Palletizing and Inspection	1	CO5
4.5	Offline Programming – Welding	1	CO5
5.0	**Artificial Intelligence in Robotics**		
5.1	Artificial Intelligence – Types – Edge based; Cloud based	1	CO6
5.2	Security concerns - Consciousness, Scalability, Data Security	1	CO6
5.3	Case studies - Vision based robot picking,	1	CO6
5.4	Collaborative Robots, Digital Twin Robots.	1	CO6
	Total	**36 hours**	

Course Designers:

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22MT640	CONTROL AND DYNAMICS LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

Dynamic response of a system is often a key factor in system's overall performance. The design of modern, quiet and efficient engineering systems requires a good understanding of dynamic response. Dynamics is the field of engineering concerned with predicting, measuring and analyzing the behavior responses such as force, torque, speed, mass, velocity and acceleration.
Control engineering concerns the design of automatic systems to control the behavior of machines and processes. Effective control system design is critical in achieving optimal performance from machines and processes, and is dependent on a good understanding of the dynamics of the system that is to be controlled. Therefore, understanding the natural link between the fields of dynamics and control plays a vital role in modern engineering systems.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Infer the force, torque and gyroscope effect in rotatingmachinery	TPS3	75	80
CO2	Test and observe the longitudinal, transverse and torsionalvibrations so as to avoid resonance	TPS3	75	80
CO3	Interpret the effect of unbalanced reciprocating and rotatingmasses	TPS3	75	80
CO4	Compare the Responses of First order and second ordersystems	TPS3	75	80
CO5	Compare the effect of Compensation, addition of poles, addition of zeros to the closed loop transfer function	TPS3	75	80
CO6	Design a controller for mechatronics systems	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No of Periods.
1.	Governors - Determination of sensitivity, effort, etc. for watt, porter, proell, Hartnell governors	2
2.	Cam - Study of jump phenomenon and drawing profile of the cam.	2
3.	Motorized Gyroscope-Determination of Gyroscopic couple Verification of Laws	2
4.	Turn table-Determination of Moment of Inertia of Disc and Ring	2
5.	Balancing of rotating masses (Static and Dynamic Balancing)	2
6.	Balancing of reciprocating masses.	2
7.	Whirling of Shaft – Determination of Critical Speed	2
8.	Determination of a Step & Impulse response for a first order, second order, Type 0, Type 1 and Type 2 systems	2
9.	Design a suitable compensator to obtain the open loop specifications using root locus and bode plot techniques.	2
10.	Compare the effect of addition of poles, addition of zeros to the forward path transfer function of a closed loop system	2
11.	Derive the simulation model for Open loop and closed loop systems, plot the step response, Study the effect of P, Pi, PD, PID control, and tune the controller using ZN Tuning rule.	2
12.	Design a controller for DC Motor speed control and verify its performance	2
13.	Design a controller for Inverted pendulum and verify its performance	2
14.	Design a controller for process control application.	2
	Total	**24**

Reference Books & Web Resources

1. Norman S. Nise, “Control System Engineering”, Eigthth Edition, John Wiley & Sons,2019.
2. Rattan.S.S, “Theory of Machines”, Fifth Edition, Tata McGraw–Hill Publishing Co., New Delhi,2018.
3. J. Nagrath and M. Gopal, “Control System Engineering”, New Age International Publisher, Sixth Edition, New Delhi, 2018.
4. John Joseph Uicker, Gordon Pennock, Joselph E.Shigley, “Theory of Machines andMechanisms”, Fourth Edition, Oxford University Press, 2014.
5. Rao and Dukkipati, R.V, “Mechanism and Machine Theory”, Second edition NewAge International (P) Ltd., 2010.
6. K. Ogata, “Modern Control Engineering”, Fifth Edition, Pearson Edition, 2009.

Course Designers:

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3. Dr. G. Kanagaraj, gkmech@tce.edu

22MT650	ROBOTICS LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	2	1	Practical

Preamble

The fundamental concepts in robotics are its design, and control. An engineer should be able to model and control the robots through software and hardware.
This course provides in-depth knowledge on programming of robots, simulating them in a particular environment and designing them to perform a particular task. This course is useful for those students interested in control engineering, robotics and systems engineering.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Program and evaluate point-to-point motion for an industrial robot	TPS3	75	80
CO2	Program and evaluate continuous point motion for an industrial robot	TPS3	75	80
CO3	Simulate the function of a robotic cell for material handling application	TPS3	75	80
CO4	Simulate the function of a welding robotic cell	TPS3	75	80
CO5	Model, simulate and analyse the characteristics of a wheeled robot	TPS3	75	80
CO6	Develop path planning and navigation program for a mobile robot	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No. of Hours	Cos
1	To simulate and analyse the forward and inverse kinematics of industrial robot using Robo Analyser	2	CO1
2	To program and evaluate the point to point motion (pick and place) of an industrial robot using MH5LS robot	2	CO1
3	To program and perform the continuous motion (Deburring operation) using GP12 robot	2	CO2
4	To program the Kobuki robot to perform collision avoidance operation using bumper	2	CO6
5	To model, simulate and analyse the characteristics of a robot gripper using 20 SIM software	2	CO5
6	To simulate the function of a material handling robotic cell in using RoboDK software	2	CO3
7	To simulate the function of a welding robotic cell using MOTOSIM software	2	CO4
8	To model, simulate and analyse the characteristics of a wheeled robot using 20 SIM software	2	CO5
9	To program and perform the inspection operation using MH5LS robot	2	CO1
10	To program and perform the Assembly operation using GP12 and MH5LF robot (Cooperative operation)	2	CO2
11	To program and evaluate the Kinect based 2D mapping using Kobuki Platform	2	CO6
12	To program and evaluate path planning using Kobuki Platform	2	CO6
	TOTAL	**24**	

Reference Books & Web Resources

1. Lab operation manual
2. YASKAWA Operation Manual
3. Kobuki Quick Start Guide
4. 20 SIM Manual by Controllab products
5. SIEMENS TIA Portal Manual

Course Designers:

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22MT710	MECHATRONICS SYSTEM DESIGN	Category	L	T	P	C	TE
		PCC	3	1	0	4	Theory

Preamble

A Mechatronic system design is a design process that is characterized by synergistic integration of mechanisms, sensors, actuators and control to perform complex tasks in a metaphysical environment.
An important characteristic of mechatronic devices and systems is their built-in intelligence, which results through a combination of precision mechanical and electrical engineering and real-time programming integrated with the design process. Mechatronics system design makes possible to understand the basic design process involved in mechatronics, selection of sensors and actuators, the interface issues and communication problems. Design of a mechatronic systems is introduced in this subject to illustrate the concepts.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Review the Mechatronic design process	TPS2	65	65
CO2	Develop bond graph for the particular mechatronic system	TPS3	75	65
CO3	Select the sensor and Actuator for a Mechatronic application	TPS3	75	65
CO4	Interface the selected sensor, Actuator and Controller	TPS3	75	65
CO5	Analyse and improve conventional designs by using the mechatronic design approach	TPS3	75	65
CO6	Develop a Mechatronic product for the given problem	TPS3	75	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2 *			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	60	-	-	-	-	-	-	-	-	-	-	-	20	-
CO2	-	-	20	-	-	100	-	-	-	-	-	-	-	-	20
CO3	-	-	20	-	-	-	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	-	-	-	50	-	-	10
CO5	-	-	-	-	-	-	-	-	-	-	-	50	-	-	10
CO6	-	-	-	-	-	-	-	-	100	-	-	-	-	-	20

* CAT 2 Assessment: Mini project on development of a Mechatronics System

Syllabus

Introduction to Mechatronic System Design:
Key elements – Mechatronics Design process –Design Parameters – Traditional and Mechatronics designs – Advanced approaches in Mechatronics - Industrial design and ergonomics, safety.

Modelling of Mechatronic Systems by Bond Graphs:
Introduction-model categories-fields of application, generalized variables in bond graph-Power variables – Energy variables, Basic components in Bond graph-1 Port components- 1 Port Resistor- 1 Port Capacitor – 1 Port Inductor, 2 Port components- Transformer - Gyrator, 3 Port Components – 0 Junction, 1 Junction, Model Development - Design examples.

Generalized Mechatronics Design Process:
Recognition of the Need, Conceptual Design and Functional Specification, First principle Modular Mathematical Modeling, Sensor and Actuator Selection – Selection Parameters – Selection of motor & gear combination, Selection of pulley & belt combination, Interface of Sensor, Microcontroller and Actuator – Issues. Communication protocols – Transmission Control Protocol/Internet Protocol (TCP/IP), ProfiBus, DeviceNet, FieldBus, Modbus.

Control System Design, Design Optimization, Prototyping, Hardware-in-the-loop Simulation, Deployment of Embedded Software, Deployment/Life Cycle, and Life Cycle Optimization. Integration of machine learning to develop Intelligent Mechatronic systems.

Problems on advanced systems:
Active suspension system– 3D Printer - Anti lock braking system – Automatic Washing Machine – Auto-focusing in Digital Cameras – Dish washing system - Computer Numerically Control (CNC) machine – Industrial Robot.

Case Study on Intelligent Mechatronic systems:
Robotic Surgery Systems, Self-Driving Cars, Quadcopter – Activity based Humanoid Robots

Text Book(s)

1. Satya Bir Singh," Mechatronics System Design and Solid Materials methods and Practices", CRC press, 2023

Reference Books & Web Resources

1. Dobrivojie Popovich, "Mechatronics in Engineering Design and Product Development", CRC Press, First Edition, September 23, 2019.
2. Patrick O.J. Kaltjob "Mechatronic Systems and Process Automation: Model-Driven Approach and Practical Design Guidelines", CRC Press, First Edition, March 22, 2018.
3. Shuvra Das., "Mechatronic Modeling and Simulation Using Bond Graphs", CRC Press, 2009.
4. W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd., Second edition, 2011.
5. Shetty and Kolk, "Mechatronics System Design", CENGAGE Learning, India, second edition, 2011.
6. Amalendu Mukherjee, Ranjit Karmakar, Arun kumar samantaray, "Bond Graph in Modeling, Simulation and Fault Identification" I.K International Pvt Ltd, Jan 2006.
7. Jacqueline Wilkie., Michael Johnson., Reza Katebi., " Control Engineering an Introductory course " Palgrave Publication, 2003.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	**Introduction to Mechatronic System Design**		
1.1	Key elements – Mechatronics Design process	1	CO1
1.2	Design Parameters – Traditional and Mechatronics designs	1	CO1
1.3	Advanced approaches in Mechatronics	1	CO1
1.4	Industrial design and ergonomics	1	CO1
1.5	Safety	1	
2.0	**Modelling of Mechatronic Systems by Bond Graphs**		
2.1	Introduction-model categories-fields of application	1	CO2
2.2	Generalized variables in bond graph- Power variables – Energy variables	1	CO2
2.3	Basic components in Bond graph-1 Port components- 1 Port Resistor- 1 Port Capacitor – 1 Port Inductor	1	CO2
2.4	2 Port components- Transformer - Gyrator	1	CO2
2.5	3 Port Components – 0 Junction, 1 Junction	1	CO2
2.6	Model Development - Design examples	1	CO2
2.7	Tutorial Class: Problems on modelling Mechatronic Systems	2	CO2
3.0	**Generalized Mechatronics Design Process**		
3.1	Recognition of the Need, Conceptual Design and Functional Specification	1	CO3
3.2	First principle Modular Mathematical Modeling	1	CO3
3.3	Sensor and Actuator Selection	2	CO3
34	Selection Parameters – Selection of motor & gear combination	2	CO3
3.5	Selection of pulley & belt combination	1	CO3
3.6	Interface of Sensor, Microcontroller and Actuator	2	CO3
3.7	Issues	2	CO3

Module No.	Topic	No. of Hours	Course Outcome
3.8	Communication protocols – Transmission Control Protocol/Internet Protocol (TCP/IP)	1	CO4
3.9	ProfiBus, DeviceNet, FieldBus, Modbus	1	CO4
3.10	Control System Design	1	CO4
3.11	Design Optimization, Prototyping	1	CO4
3.12	Hardware-in-the-loop Simulation	1	CO4
3.13	Deployment of Embedded Software	1	CO4
3.14	Deployment/Life Cycle, and Life Cycle Optimization	1	CO4
3.15	Integration of machine learning to develop Intelligent Mechatronic systems.	2	CO4
4.0	**Problems on advanced systems**		
4.1	Active suspension system	1	CO5
4.2	3D Printer	1	CO5
4.3	Anti-lock braking system	1	CO5
4.4	Automatic Washing Machine	1	CO5
4.5	Auto-focusing in Digital Cameras	1	CO5
4.6	Dish washing system	1	CO5
4.7	Computer Numerically Control (CNC) machine	1	CO5
4.8	Industrial Robot	1	CO5
4.9	Tutorial Class: Discussion on Case study	2	CO5
5.0	**Case Study on Intelligent Mechatronic systems**		
5.1	Robotic Surgery Systems	1	CO6
5.2	Self-Driving Cars	1	CO6
5.3	Quadcopter	1	CO6
5.4	Activity based Humanoid Robots	2	CO6
	TOTAL	**48**	

Course Designers:

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22MT720	SYSTEM INTEGRATION LABORATORY	Category	L	T	P	C	TE
		PCC	0	0	4	2	Practical

Preamble

System integration is the process of bringing together the component sub-systems into one system and ensuring that the subsystems function together as a system. System integration involves integrating existing, often disparate systems in such a way “that focuses on increasing value to the customer such as improved product quality and performance, while at the same time providing value to the company by reducing operational costs and improving response time. In the modern world connected by Internet, the role of system integration engineers is important as more and more systems are designed to connect, both within the system under construction and to systems that are already deployed.

Cross-disciplinary integration of mechanical engineering, electrical and electronic engineering as well as recent advances in information engineering are becoming more and more crucial for future collaborative design, manufacture, and maintenance of a wide range of engineering products and processes. This course gives insight in to the integration of sensors and actuators with controller through communication networks in order to realize the new product and total automated system.

Prerequisite

- 22MT560 - Industrial Automation Laboratory

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Identify and select suitable sensors, actuators, controllers by their specifications.	TPS3	80	80
CO2	Integrate mechanisms with controller, sensor and actuator.	TPS3	80	80
CO3	Design a user interface to visualize and control the product and process.	TPS3	80	80
CO4	Configure electrical drives for mechatronics system integration	TPS3	80	80
CO5	Develop a software program to integrate all Mechatronics components using suitable communication protocol.	TPS3	80	80
CO6	Integrate sensor, actuator and controller with user interface through suitable communication protocol.	TPS3	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No. of Hours	Cos
I	**Mechanical System integration using Sensors, PLC, HMI and SCADA**	8	CO1-CO3
	Object sorting system		
	Industrial level control system		
	Conveyor system with pick and place robot control		
	Cooling fan control system		
	Hydraulic and pneumatic system integration		
	Mechanical System Integration - Project Module1	8	
II	**Electrical Drives configuration, programming and control**	8	CO4-CO5
	Variable Frequency drive (VFD)		
	Servo drive		
	Dc drive		
	PMSM-BLDC drive		
	Electrical Drives - Project Module 2	8	
III	**Sensor-Controller-Actuator integration using Communication protocols**	8	CO5-CO6
	Profibus		
	TCP/IP		
	Sercos		
	Profinet		
	Ethernet I/p		
	OPC/UA		
	Communication Protocol - Project Module 3	8	
	TOTAL	**48**	

Reference Books & Web Resources

1. Steve Mackay, Edwin Wright MIPENZ, Deon Reynders, John Park "**Practical Industrial Data Networks - Design, Installation, troubleshooting"**, IDC Technologies, Australia.
2. "**System development automation motion logic control**" published by Bosch Rexroth.
3. **S7-1500 Getting Started manual**, Siemens 05/2014, A5E03981761-AC
4. KARL-HEINZ JOHN, **Programming Industrial automation systems**, Springer,1995
5. Gary W. Johnson, Richard Jennings, **Labview Graphical Programming** , McGraw Hill education, fourth edition 2017.

Course Designers:

1. H Ramesh, rameshh@tce.edu
2. M A Ganesh, ganeshma2015@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Electives

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015
DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

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

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Mechatronic System Laboratory ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT480 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Project I PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22EG660 Professional Communication HSMC 2	22MT670 Project II PW 3	23
VII	22MT710 Mechatronics System Design PCC 4	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 2	---	---	22MT770 Project III PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT870 Project IV PW 3	9
									Total Credits	**160**

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits	
			Regular Admission	Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**22 - 35**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	08 - 11
	b.	Basic Science Courses (BSC)	24 - 27	06 - 09
	c.	Engineering Science Courses (ESC)	21 - 27	08 - 15
B.	**Professional Core Courses (PCC)**		**55**	**45**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
22MTGA0	Mechatronics	IE	3	0	0	3
22MTGB0	Value Engineering	IE	3	0	0	3
22MTPA0	Design and Analysis of Experiments	PSE	3	0	0	3
22MTPB0	Semiconductor Manufacturing	PSE	3	0	0	3
22MTPC0	Industry 4.0	PSE	3	0	0	3
22MTPD0	Electric Vehicle Technology	PSE	3	0	0	3
22MTPE0	Drone Technology	PSE	3	0	0	3
22MTPF0	OOP using C++ (TCP)	PSE	1	0	4	3
22MTRA0	Machine Vision using Machine Learning (TCP)	PEES	1	0	4	3

PSE : Programme Specific Elective

PEES : Programme Elective for Expanded Scope

IE : Interdisciplinary Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
22MTGA0	Mechatronics	3	40	60	100	27	50
22MTGB0	Value Engineering	3	40	60	100	27	50
22MTPA0	Design and Analysis of Experiments	3	40	60	100	27	50
22MTPB0	Semiconductor Manufacturing	3	40	60	100	27	50
22MTPC0	Industry 4.0	3	40	60	100	27	50
22MTPD0	Electric Vehicle Technology	3	40	60	100	27	50
22MTPE0	Drone Technology	3	40	60	100	27	50
22MTPF0	OOP using C++ (TCP)	3	50	50	100	22.5	50
22MTRA0	Machine Vision using Machine Learning (TCP)	3	50	50	100	22.5	50

* CA – Continuous Assessment:

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.

TE - Terminal Examination

22MTGA0	MECHATRONICS	Category	L	T	P	C	TE
		IE	3	0	0	3	Theory

Preamble

The synergistic fusion of computer science, information technology, mechanical and electrical engineering, and control systems using numerical approaches is known as mechatronics. Its goal is to build intelligent products. It entails researching common applications of mechatronics include sensors, actuators, regulating mechanisms and algorithms. Mechatronics may be used to build specific applications through the harmonious integration of several elements.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Identify the Elements of a Mechatronics system.	TPS 3	80	70
CO2	Explain the use of sensors in Mechatronics system.	TPS 2	80	70
CO3	Explain the Functions of electrical, mechanical, hydraulic and pneumatic actuator used in Mechatronics systems.	TPS 3	70	65
CO4	Describe the Function of controllers in Mechatronics system.	TPS 2	80	70
CO5	Develop a program using PLC to implement Bottle Filling Station.	TPS 3	70	65
CO6	Select the suitable actuator, sensors and controller system for Automatic Washing Machine.	TPS 3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	-	-	100	-	10	-	-	-	-	-	10	-
CO2	-	20	-	-	-	-	-	-	-	-	-	-	-	20	-
CO3	-	20	-	-	-	-	-	10	-	-	-	-	-	20	-
CO4	-	20	-	-	-	-	-	20	-	-	-	-	-	10	-
CO5	10	-	-	-	-	-	30	-	-	-	-	-	-	-	20
CO6	-	-	-	-	-	-	30	-	-	-	-	100	-	-	20

Syllabus

Introduction: Components used in mechatronics systems - Electrical, Mechanical, Electronics systems, Electro Mechanical systems, Intelligent Mechatronics Systems

Sensor System: Performance terminology – Selection of Sensors, Types of sensors, Position Sensors - Potentiometer, Strain Gauge, Proximity sensor, Hall effect sensors, Optical encoders, Infrared Sensors, Inertial Measurement unit (IMU), LIDAR; Tactile Sensors - Temperature Sensor - Thermistors, Thermocouples, Bimetallic strips, RTD, Optical sensors – RGB Camera, Thermal Camera.

Actuation System: Mechanical Actuating Systems - Cams, Gears, Ratchet and Pawl, Belt & Pulley; chain drives. Electrical Actuating Systems - Solenoids, DC Motors, Servomotors, Stepper motors - Pneumatic and Hydraulic systems – Single and double acting cylinders, rotational actuators. Hydraulic circuits, Selection of Actuators.

Control: Types - open loop and closed loop system, ON – OFF Control - PID controller. PLC - Principle of operation - input and outputs - programming language - ladder diagram – timer – counter.

Case Studies: Automatic Washing machine – Building Management Systems - Cruise control – Wiper motion control -IOT interfaced Mechatronics system– Vision based surveillance robot.

Text Book(s)

1. Devdas Shetty, Richard A Kolk, “Mechatronics System Design”, Cengage Learning, 2010.
2. Allie Weaver, “Mechatronics: Engineering Fundamentals”, Murphy & Moore Publishing, 2022.
3. W. Bolton, “Mechatronics – Electronic control systems in Mechanical & Electrical Engineering”, Pearson Education Ltd., 2015.

Reference Books and Web Resources

1. Frank D Petruzella, “Programmable logic controllers”, Fourth edition, McGraw Hill higher education ,2016.
2. Richard C. Dorf, Robert H. Bishop, “Modern Control Systems” Twelfth Edition, Pearson Education, 2014.
3. Mechatronics, IIT Roorkee, Prof. Pushparaj Mani Pathak, https://nptel.ac.in/courses/112107298

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
1.0	**Introduction**		
1.1	Components used in mechatronics systems	1	CO1
1.2	Mechanical	1	CO1
1.3	Electrical	1	CO1
1.4	Electronics systems	1	CO1
1.5	Electro Mechanical systems	1	CO1
1.6	Intelligent Mechatronics Systems.	2	CO1
2.0	**Sensor System**		

Module No.	Topic	No. of Lectures	CO
2.1	Performance terminology	1	CO2
2.2	Selection of Sensors	1	CO2
2.3	Types of sensors, Position Sensors - Potentiometer, Strain Gauge, Proximity sensor, Hall effect sensors, Optical encoders, Infrared Sensors	2	CO2
2.4	Inertial Measurement unit (IMU), LIDAR, Tactile Sensors	2	CO2
2.5	Temperature Sensor - Thermistors, Thermocouples, Bimetallic strips, RTD	2	CO2
2.6	Optical sensors – RGB Camera, Thermal Camera.	3	CO2
3.0	**Actuation System**		
3.1	Mechanical Actuating Systems - Cams, Gears	1	CO3
3.2	Ratchet and Pawl, Belt & Pulley	1	CO3
3.3	Chain drives	2	CO3
3.4	Electrical Actuating Systems - Solenoids, DC Motors	1	CO3
3.5	Servomotors, Stepper motors	1	CO3
3.6	Pneumatic and Hydraulic systems – Single and double acting cylinders	1	CO3
3.7	Rotational actuators	1	CO3
3.8	Hydraulic circuits	1	CO3
3.9	Selection of Actuators.	1	CO3
4.0	**Control**		
4.1	Types - open loop and closed loop system	1	CO4
4.2	ON – OFF Control - PID controller	1	CO4
4.3	PLC - Principle of operation	1	CO5
4.4	Input and outputs - programming language	1	CO5
4.5	Ladder diagram	1	CO5
4.6	Timer – counter	1	CO5
5.0	**Case Studies**		
5.1	Automated Washing machine – Building Management Systems	1	CO6
5.2	Cruise control – Wiper motion control	1	CO6
5.3	IOT interfaced mechatronics system	1	CO6
5.4	Vision based surveillance robot	1	CO6
Total		**36 Hours**	

Course Designers:

1. Mr. M A Ganesh, ganeshma2015@tce.edu
2. Dr. S Julius Fusic, sjf@tce.edu

22MTGB0	VALUE ENGINEERING	Category	L	T	P	C	TE
		IE	3	0	0	3	Theory

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 eliminate the unnecessary cost, while improving the product performance or otherwise quality. This course deals with improving the quality in terms of the requirements of customers at the same or reduced cost by ensuring adequate system performance. Value engineering is a systematic approach for value improvement and contains seven broader phases. Hence, for product development, both cost and quality related issues need to be tackled concurrently.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the Value engineering methodology	TPS2	75	65
CO2	Recognize the various phases of value engineering	TPS2	75	65
CO3	Perform functional cost worth analysis and Life cycle costing	TPS3	75	65
CO4	Create the ideas for New Product Development	TPS3	75	65
CO5	Analyse the functional importance and functional cost	TPS3	60	65
CO6	Recommend the present facts and present costs	TPS3	75	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	-	10
CO2	-	-	40	-	50	-	-	-	-	-	-	-	-	-	15
CO3	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	40	-	-	40	-	-	20
CO5	-	-	-	-	-	-	-	-	40	-	-	40	-	-	20
CO6	-	-	-	-	-	-	-	-	20	-	-	20	-	-	15

Syllabus

Introduction: Value Engineering (VE) and Value Analysis (VA) - Life Cycle of a product-Methodology of value engineering – Difference from the conventional methods of cost reduction.

Unnecessary costs reasons- Quantitative definition of value- Use value and Prestige value - Estimation of product Quality/performance-Types of functions- Relationship between Use functions and Esteem Functions in product design – Direct and indirect cost, Functional cost and Functional Worth –Effect of Value improvement on profitability-Test for poor value –Aims of Systematic Approach.

VE Job Plan: Functional approach to value improvement - various phases and techniques of Job Plan – Factors governing project selection – Types of Projects-Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC – Present value concept-Annuity concept- Net Present Value-Payback Period-Return on Investment (ROI)- Internal rate of return on Investment (IRR)-Examples and Illustrations. Creative thinking and creative judgment - positive or constructive discontent - Tangible and Intangible costs of implementation - False material - labour and overhead saving – Relationship between savings and probability of success - Reliability Estimation-System reliability- Reliability elements in series and parallel.

Various phases: General Phase-Information Phase – Type of costs- Function Phase – Evaluation of Functional Relationships- Checks for consistency-Function –cost-weight-matrix-Value Improvement Production (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 – Functional Analysis System Technique (FAST)

Mini Project presentation and Case Studies.

Text Book(s)

1. Value Engineering – A How to Manual by S S Iyer, 3rd edition, New Age Publishers, Chennai, 2019

Reference Books & Web Resources

1. Value engineering, Mukhopadhyaya, Anil Kumar, Response Books, New Delhi ,2009
2. Techniques of training in value Engineering- a trainer's manual, R.G. Chaudari, Notion press, Chennai, 2018
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 https://nptel.ac.in/courses/112107282

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1	**Introduction**	
1.1	Value Engineering and Value analysis	1
1.2	Life cycle of a product	1
1.3	Value Engineering methodology	2

1.4	Difference from the conventional methods of Cost reduction	1
2	**Reasons for unnecessary costs**	
2.1	Definition of value	1
2.2	Use value and Prestige value	1
2.3	Estimation of Quality /Performance	1
2.4	Types of functions	1
2.5	Relationship between Use functions and Esteem Functions in product design	2
2.6	Direct and indirect cost, Functional cost and Functional Worth	2
2.7	Effect of Value improvement on profitability	1
2.8	Test for poor value	1
2.9	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	2
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, Return on Investment (ROI) -Internal rate of return on Investment (IRR)-Examples and Illustrations	2
4	**Various phases**	
4.1	Creative thinking and creative judgment- positive or constructive discontent	2
4.2	Tangible and Intangible costs of implementation-False material-labour and overhead saving	1
4.3	Relationship between savings and probability of success-Reliability Estimation-System reliability- Reliability elements in series and parallel.	1
4.4	General Phase-Information Phase – Type of costs - Function Phase	1
4.5	Evaluation of Functional Relationships - Checks for consistency- Function – cost-weight-matrix - VIP Index – High cost and Poor value areas-	1
4.6	Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.	1
4.7	Functional Analysis System Technique (FAST)	2
4.7	Mini Project presentation and Case Studies	2
	Total	**36**

Course Designers:

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2. Mr. S Rajkumar, srmech@tce.edu

22MTPA0	DESIGN AND ANALYSIS OF EXPERIMENTS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course is an introduction to the statistical design of experiments and the role of random effects in data analysis. This course is created to provide an understanding of how experiments should be designed so that when the data are collected that can be used in a variety of experimental situations. A strategically planned and structured experiment may provide a great deal of information about the effect on a response variable due to one or more factors.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the process for experimental designs	TPS2	80	70
CO2	Perform ANOVA and Interpret results that influence the experiments	TPS3	70	65
CO3	Design the full factorial and fractional factorial experiments	TPS3	70	65
CO4	Optimize process parameters by applying experimental techniques.	TPS3	70	65
CO5	Perform robust design through Taguchi method.	TPS3	70	65
CO6	Interpret results using statistical packages.	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO3	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	40	-	-	-	-	-	20
CO5	-	-	-	-	-	-	-	-	30	-	-	-	-	-	15
CO6	-	-	-	-	-	-	-	-	30	-	-	100	-	-	15

Syllabus

Basic statistics: Mean - Standard Deviation - variance Variability – causes – Errors-hypothesis testing- statistical tests – t tests, z tests, chi-square tests

Introduction to experimental design: Basic techniques - Standard types of experimental design. Steps for Planning, Conducting and Analyzing an experiment – ANOVA – Model adequacy checking-Random effects model-attribute data analysis - Repetition and replication-Randomized complete block design-Latin square design.

Introduction to Factorial Design: The 2^k Factorial Design - Confounding and Aliasing in 2^k Factorial Design 3-level and Mixed-level full Factorials and Fractional Factorials- Simple Linear Regression - Response Surface Methods and Designs - Robust Parameter Designs - Experiments with Random Factors - Box Plot Designs.

Main and Interaction effects: Fixed effects and random effects model - Design of experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Taguchi Method, Robust design noise factors, Signal to noise ratios, Inner/outer Orthogonal Array design – experimental analysis using statistical packages

Text Book(s)

1. Douglas C Montgomery (2019), Design and Analysis of Experiments, 10th edition, John Wiley & Sons

Reference Books & Web Resources

1. Colin Hardwick (2019), Practical Design of Experiments - Doe Made Easy, Lulu.com
2. Angela Dean, Daniel Voss, Danel Draguljic (2017), Design and Analysis of Experiments, Second Edition, Springer Texts in Statistics, Springer.
3. John Lawson (2015), Design and Analysis of Experiments with R, Texts in Statistical Science, Chapman & Hall / CRC.
4. Roger Mead, S. G. Gilmour, A. Mead (2012), Statistical Principles for the Design of Experiments, Cambridge Series in Statistica l and Probabilistic Mathematics, Cambridge University Press.
5. Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook (2009), Response Surface Methodology, Third Edition, John Wiley & Sons

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1	**Basic statistics-Mean-Standard Deviation-variance Variability**	2
2	Hypothesis testing-statistical tests-t test, z test, chi-square tests	2
3	Causes – Errors	1
4	Introduction to experimental design - Basic techniques	2
5	Standard types of experimental design	1
6	**Steps for Planning, Conducting and Analyzing an experiment**	1
7	ANOVA	2
8	Model adequacy checking-Random effects model-attribute data analysis - Repetition and replication	2
9	Randomized complete block design-Latin square design-Graeco latin square design	1
10	Introduction to Factorial Design	1
11	The 2k Factorial Design	2
12	Confounding and Aliasing in 2k Factorial Design 3-level and Mixed-level Factorials	2
13	Fractional Factorials	1
14	Simple Linear Regression	1
15	Response Surface Methods	1
16	**Robust Parameter Designs**	1
17	Experiments with Random Factors-Nested and Split Plot Designs	1
18	Main and Interaction effects	1
19	Fixed effects and random effects model	1
20	Design of experiments using Orthogonal Arrays,	1
21	Data analysis from Orthogonal experiments	1
22	Taguchi Method	2
23	Robust design noise factors	1
24	**Signal to noise ratios**	1
25	Inner/outer OA design.	2
26	Performing experimental analysis using statistical packages	2
	Total	**36**

Course Designers:

1. Dr. M Palaninatharaja, pnatharaja@tce.edu
2. Dr. H Ramesh, rameshh@tce.edu

22MTPB0	SEMICONDUCTOR MANUFACTURING	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Semiconductor technology is the engine room of the New Economy. For 45 years there was a continuous improvement in IC functional capability with smaller size, increased reliability and lower cost. This course will teach the key fabrication technologies and the scientific foundations that carries fabrication of Transistors, ICs, Facilities required for Semiconductor Manufacturing, and microelectronics well into MEMS technology.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the silicon wafer manufacturing and IC fabrication techniques.	TPS2	70	75
CO2	Select suitable oxidation, doping and lithography processes for semiconductor manufacturing.	TPS3	65	75
CO3	Explain the etching, depositing, metallization and polishing processes for IC fabrication.	TPS3	65	75
CO4	Develop yield models of wafer production.	TPS3	65	75
CO5	Explain fabrication of IC and packaging	TPS2	70	75
CO6	Select appropriate process for MEMS fabrication.	TPS3	65	75

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		25					-	-	-	-	-	-	-	10	-
CO2		35			100		-	-	-	-	-	-	-	-	20
CO3		40					-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-		40					-	-	20
CO5	-	-	-	-	-	-		20			100		-	10	-
CO6	-	-	-	-	-	-		40					-	-	20

Syllabus

Development of ICs- Introduction, Integrated Circuits, Device Miniaturization, Challenges in IC Manufacturing, IC manufacturing stages.

Silicon Wafer Manufacturing - Wafer Specification, Polysilicon Manufacture, Single crystal Si Manufacturing – Czochralski crystal growth Technique, Float Zone Technique, Wafer Manufacturing.

Integrated Circuit Fabrication: Fabrication overview, Layering, Patterning, Doping, Heat treatment, MOSFET Fabrication.

Oxidation and Doping: Oxidation, Types of oxidation processes, oxide furnaces, doping techniques, thermal diffusion, ion implantation.

Lithography: Introduction, Process overview, photoresists, Mask Making, Photoresist Application, Alignment and Exposure, Developing, Lithography Advances

Etching and Doping: Etching Basics, Wet Etching, Dry Etching, Deposition – Chemical Vapour Deposition (CVD) - LPCVD, PECVD, APCVD, Molecular Beam Epitaxy, Deposited Si.

Metallization and Polishing: Basics, Materials, Techniques, Planarization, copper dual Damnascene process.

IC process Control: Process Evaluation, Electrical Measurements, Thickness measurement, Defect Detection, Fab Yield, Wafer sort yield, Yield Models and Fabrication costs.

IC Architecture and Packaging: IC components, Packaging, Clean room contamination, clean room design and Materials

MEMS fabrication: Introduction to bulk micromachining and surface micromachining, fabrication micro cantilever by bulk micromachining and surface micromachining, comparison between bulk and surface micromachining

Text Book(s)

1. Parasuraman Swaminathan, Semiconductor Materials, devices and Fabrication, 1st edition, Wiley, 2019
2. Peter Van Zant, Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6th edition, McGraw-Hill, 2013

Reference Books & Web Resources

1. Gary S May, Costas J Spanos, Fundamentals of semiconductor Manufacturing and process control, Wiley Interscience, 2006
2. Simon M. Sze, Gary S May, Fundamentals of semiconductor fabrication, Wiley student edition, 2012
3. James D Plummer, Michael D Deal, Peter B Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling, 1st edition, Pearson India, 2009
4. Vijay K Varadhan, K.J. Vinoy, S.Gopalakrishnan, Smart Material Systems and MEMS – Design and Development Methodologies, 1st edition, John Wiley and Sons, 2006
5. Julian W Gadner, Vijay K Varadhan, Osama O Awadelkarim, Microsensors, MEMS and Smart Devices, 1st edition, John Wiley & sons Ltd, 2001
6. Simon. M. Sze, Yiming Li, Kwok K. Ng, Physics of Semiconductor Devices, 4th Edition., Wiley India, 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Development of ICs**	
1.1	Introduction, Integrated Circuits, Device Miniaturization, Challenges in IC Manufacturing, IC manufacturing stages.	1
1.2	**Silicon Wafer Manufacturing -** Wafer Specification, Polysilicon Manufacture	1
1.3	Single crystal Si Manufacturing – Czochralski crystal growth Technique, Float Zone Technique, Wafer Manufacturing.	2
1.4	**Integrated Circuit Fabrication** - Fabrication overview, Layering, Patterning, Doping	1
1.5	Heat treatment, MOSFET Fabrication.	1
2	**Oxidation and Doping**	
2.1	Oxidation, Types of oxidation processes, oxide furnaces,	1
2.2	Doping techniques, thermal diffusion, and ion implantation.	2
2.3	**Lithography-**Introduction, Process overview, photoresists, Mask Making, Photoresist Application	1
2.4	Alignment and Exposure, Developing, Lithography Advances	2
3	**Etching and Doping**	
3.1	Etching Basics, Wet Etching, Dry Etching	1
3.2	Deposition – Chemical Vapour Deposition (CVD) - LPCVD, PECVD, APCVD, Molecular Beam Epitaxy, Deposited Si	2
3.3	**Metallization and Polishing-**Basics, Materials,	1
3.4	Planarization, copper dual Damnascene process	2
4	**IC process Control**	
4.1	Process Evaluation	1
4.2	Electrical Measurements	1
4.3	Thickness measurement	1
4.4	Defect Detection	1
4.5	Fab Yield, Wafer sort yield	1
4.6	Yield Models and Fabrication costs	2
5	**IC Architecture and Packaging**	
5.1	IC components	1
5.2	Packaging	1
5.3	Clean room contamination	2
5.4	Clean room design and Materials	2
6	**MEMS fabrication**	
6.1	Introduction to bulk micromachining and surface micromachining	1
6.2	Fabrication micro cantilever by bulk micromachining and surface micromachining	2
6.3	Comparison between bulk and surface micromachining.	2
	Total	**36**

Course Designers:

1. Dr. G Kumaraguruparan, gkgmech@tce.edu
2. Mr. M M Devarajan, mmdmech@tce.edu

22MTPC0	INDUSTRY 4.0	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Industry 4.0 refers to a new phase in the Industrial Revolution that places strong emphasis on interconnectivity, automation, machine learning, and real-time data. Industry 4.0, which includes Industrial internet of things(IIOT) and smart manufacturing, combines physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better-connected ecosystem for companies that focus on manufacturing and supply chain management. This course focusses on the components and applications of industry 4.0 for manufacturing sector.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain different technologies used in industry 4.0 and its applications.	TPS2	80	70
CO2	Perform AI and ML based analytics in Industry 4.0 frame work.	TPS3	70	65
CO3	Develop Cyber physical systems for industrial 4.0 applications	TPS3	70	65
CO4	Solve interoperable issues in connected factory using OPC, OPC-UA and TSN.	TPS3	70	65
CO5	Illustrate AR based operation and Maintenance sequence in Factory.	TPS3	70	65
CO6	Develop cloud-based database for Smart Manufacturing systems.	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO3	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	40	-	-	40	-	-	20
CO5	-	-	-	-	-	-	-	-	30	-	-	40	-	-	15
CO6	-	-	-	-	-	-	-	-	30	-	-	20	-	-	15

Syllabus

Introduction to Industry 4.0: The different Industrial revolutions-definition of Industry 4.0-comparision of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0-Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy- Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.

Basic principles and components of Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services (IOS)- Big Data- Cyber-Physical Systems-Smart Manufacturing- Smart Logistics- Customization of products- Digital Twins- Cloud applications in manufacturing.

Cyber physical systems (CPS): Core elements of CPS -control theory and real time requirements-self organization principles-communication in cyber physical systems-Modelling, programming and model-integrated development of CPS- AI and ML based analytics.

Interoperability: Communication standards for Industry 4.0: Industrial communication Networks- Reference Architecture Model Industry 4.0 (RAMI4.0) - Basics on Service oriented Architecture- Introduction into Open platform communications (OPC) - Classic OPC vs. OPC-Unified Architecture (UA) - OPC Services- System Architecture- OPC- UA and the Cloud-Time Sensitive Networking (TSN)-architecture-Standards-Benefits of adopting TSN. Case study on OPC-UA applications

Connected Factory: Virtualization-Augmented Reality (AR) in Manufacturing-integrating design and manufacturing-Data Visualization-Work piece traceability using QR codes, RFID and beacon tags -big data in production- Cloud-based Enterprise resource planning (ERP) and Manufacturing Execution system (MES) solutions.

Text Book(s)

1. Simon Introduction to industrial internet of things and industry 4.0 by Sudip Misra, Chandana Roy and Anandarup Mukherjee, CRC Press,2020.

Reference Books & Web Resources

1. “Industry 4.0: The Industrial Internet of Things”, by Alasdair Gilchrist (Apress), 2016.
2. “Industrial Internet of Things: Cyber manufacturing Systems “by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer),2017
3. Hands-on Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0 ,Giacomo veneri, Antonio capasso,Packt,2018.
4. Hand book of Industry 4.0 and SMART Systems, Diego Galar Pascual, Pasquuale Daponte, Uday Kumar, CRC Press, 2019.
5. https://nptel.ac.in/courses/106105195

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Introduction to Industry 4.0**	
1.1	The different Industrial revolutions-definition of Industry 4.0	1
1.2	comparison of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0	1
1.3	Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy	1
1.4	Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.	1
2.	**Basic principles and components of Industry 4.0**	
2.1	Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services	1
2.2	Big Data- Cyber-Physical Systems-	1
2.3	Smart Manufacturing- Smart Logistics	1
2.4	Customization of products- Digital Twins	1
2.5	Cloud applications in manufacturing	1
3.	**Cyber physical systems (CPS)**	
3.1	Core elements of CPS, Control theory and real time requirements	2
3.2	Self-organization principles-communication in cyber physical systems	1
3.3	Modelling, programming and model-integrated development of CPS, AI and ML based analytics	3
4.	**Interoperability: Communication standards for Industry 4.0**	
4.1	Industrial communication Networks-Ethernet I/P, Profinet, Profibus, Device net, Ethercat	2
4.2	Industry 4.0 Reference Architecture Model RAMI4.0	1
4.3	Basics on Service oriented Architecture	1
4.4	Introduction into OPC- Classic OPC vs. OPC-UA- OPC Services-System Architecture	2
4.5	OPC-UA and the Cloud	1
4.6	Time Sensitive Networking (TSN)-architecture-Standards-Benefits of adopting TSN	1
4.7	Case study on OPC-UA applications.	2
5.	**Connected factory**	
5.1	Virtualization-AR in Manufacturing	2
5.2	Integrating design and manufacturing, Data visualization	4
5.3	Work piece traceability using QR codes, RFID and beacon tags	2
5.4	Big data in production	1
5.5	Cloud-based ERP and MES solutions	2
	Total	**36**

Course Designers:

1. Dr. H Ramesh, rameshh@tce.edu
2. Dr. S Julius Fusic, sjf@tce.edu

22MTPD0	ELECTRIC VEHICLE TECHNOLOGY	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

High-efficiency, clean, and safe transportation has been the focus of transportation-related research and development efforts in recent decades. It has often been suggested that in the near future, fuel cell, hybrid, and electric cars would replace conventional automobiles. Details on vehicle system analysis, fuel cell applications in vehicles, ICE-based drive trains, EV design, HEV configurations, electric propulsion systems, energy storage systems, series/parallel/mild hybrid electric drive train design methodologies, regenerative braking, and fuel cell hybrid electric drive train design are covered in the course. It highlights the drive train system as a whole rather than simply individual parts.

Prerequisite

- 22MT430 - Power Electronics and Drives

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Illustrate the electric vehicle components	TPS 3	80	70
CO2	Explain the working of power converters in electric vehicles.	TPS 2	80	70
CO3	Calculate the power rating of e-vehicle.	TPS 3	80	70
CO4	Elaborate the electric train topology	TPS 2	80	70
CO5	Configure battery management system for e-vehicle	TPS 3	70	65
CO6	Select the appropriate components for electric car	TPS 3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	-	10
CO2	-	-	40	-	-	-	-	-	-	-	-	-	-	-	10
CO3	-	-	40	-	-	-	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	20	-	-	-	-	-	20
CO5	-	-	-	-	-	-	-	-	40	-	-	50	-	-	20
CO6	-	-	-	-	-	100	-	-	40	-	-	50	-	-	20

Syllabus

Introduction: Introduction – need for electric vehicle-Comparison of Electric Vehicle over conventional vehicle – Various types of Electric vehicle- Hybrid Electric Vehicles - Types of EVs, Hybrid Electric Drive-train - Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

Electric Vehicle Modelling: Tractive effort- Modelling vehicle acceleration- Modelling electric vehicle range- Rolling resistance- transmission efficiency- body mass consideration and vehicle chassis modelling.

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives - Induction Motor drives - Permanent Magnet Motor drives – d-q frame, Voltage equations-BLDC motor drives- Switch Reluctance Motor drives, drive system efficiency- Types of Braking System-Regenerative braking system-Servo braking system.

Vehicle motor drives & control: DC-DC converter- step up and step down – DC to AC Converter- Single phase and Three phase inverter- sliding mode control- PID based control.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis - Building mSnP battery pack, Building nPmS battery pack, Passive balancing, Active balancing, Cell equalisation, Failures in battery pack.

Case Studies: Design of Electric Bicycle- Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Book(s)

1. John G. Hayes and A. Goodarzi Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles, Wiley Publication,

Reference Books & Web Resources

1. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, John Wiley & Sons Inc 2017.
2. James Larminie, John Lowry- Electric Vehicle Technology Explained, 2nd Edition, John Wiley & Sons Inc 2012.
3. https://nptel.ac.in/courses/108/106/108106170/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Need for electric vehicle-Comparison of Electric Vehicle over conventional vehicle.	1
1.2	Various types of Electric vehicle	1
1.3	Hybrid Electric Vehicles	1
1.4	Types of EVs, Hybrid Electric Drive-train	1
1.5	Basic concept of electric traction	1
1.6	Introduction to various electric drive-train topologies	1
1.7	Self-diagnose in electric vehicles.	1
2	**Electric Vehicle Modelling**	
2.1	Tractive Effort, Modelling vehicle acceleration	2
2.2	Modelling electric vehicle range	1
2.3	Rolling resistance- transmission efficiency	1
2.4	Body mass consideration, Vehicle chassis modelling	2
3	**Electric Propulsion unit**	
3.1	Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives	2
3.2	Induction Motor drives	1
3.3	Permanent Magnet Motor drives – BLDC motor drives- Switch Reluctance Motor drives	1
3.4	Drive system efficiency	1
3.5	Types of Braking System-Regenerative braking system- Servo braking system	1
4	**Vehicle motor drives & control**	
4.1	DC-DC converter- four quadrant operation	1
4.2	step up and step-down chopper with RLE loads	1
4.3	DC to AC Converter	1
4.4	Single phase and Three phase inverter with RLE loads	1
4.5	Sliding mode control- PID based control.	1
5	**Energy Storage System**	
5.1	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, selection of battery and its electrical consideration	1
5.2	Battery based energy storage and its analysis	1
5.3	Fuel Cell based energy storage and its analysis	1
5.4	Super Capacitor based energy storage and its analysis	2
5.5	Building mSnP battery pack, Building nPmS battery pack.	1
5.6	Passive balancing, Active balancing, Cell equalisation, Failures in battery pack	1
6	**Case Studies**	
6.1	Design of Electric Bicycle	1
6.2	Design of a Hybrid Electric Vehicle (HEV)	2
6.3	Design of a Battery Electric Vehicle (BEV)	2
	Total	**36**

Course Designers:

1. Dr. S Julius Fusic, sjf@tce.edu
2. Dr. H Ramesh, rameshh@tce.edu

22MTPE0	DRONE TECHNOLOGY	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course covers the basics of drone technology, including its history, types, components, and regulations. Students will learn about drone design, assembly, and motor technology, as well as flight mechanics and controller selection. They'll also explore various drone applications such as GPS navigation, camera systems, agriculture, delivery services, and industry trends.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the dynamics involved with the development of drones	TPS2	75	75
CO2	Illustrate the function and terminology of drone components.	TPS2	75	75
CO3	Simulate the stability of the drone using simulation software.	TPS3	65	70
CO4	Measure the time of flight, stability and endurance of drone	TPS2	75	75
CO5	Select the components to build a drone for real world applications.	TPS3	65	70
CO6	Develop a drone for real world applications	TPS3	65	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	-	40	-	-	-	-	-	-	-	-	-	-	-	20	-
CO3	-	-	40	-	-	-	-	-	-	-	-	-	-	-	10
CO4	-	-	-	-	-	-	-	-	20	-	-	-	-	-	20
CO5	-	-	-	-	-	-	-	-	40	-	-	-	-	-	20
CO6	-	-	-	-	-	100	-	-	40	-	-	100	-	-	20

Syllabus

Introduction to Drones: Definition and history of drones, Types of drones and their applications, Drone components and terminology, Regulations and Guidelines for drone usage.

Flight Mechanics and Dynamics: Basic definitions: viscosity, Mach number and speed of sound, Bernoulli's equation, aerodynamics nomenclature, air foil, wind tunnel testing: air foil shape, flight simulator. Static stability, Dynamic stability, lateral stability, longitudinal stability, directional stability

Drone Design and Assembly: Design considerations for drone airframe and propulsion systems, Selecting and assembling drone components such as motors, batteries, flight controllers, and cameras, Basic wiring and soldering techniques.

Drone Motors and Electronic Speed Controller (ESC): Working, Types: Brush and Brushless Motors, motor sizing and identification, mounting patterns and thread size, Thrust to Weight ratio, KV ratings, advanced motor selection, ESC.

Applications of Drone: Overview of commercial and industrial drone applications, Case studies and examples of successful drone deployments, GPS based navigation system, Drone Camera Systems, Agro application, Drone Delivery, Future trends and developments in the drone industry.

Text Book(s)

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
2. Garvit Pandya, "Basics of Unmanned Aerial Vehicles: Time to Start Working on Drone Technology". (2021).

Reference Books & Web Resources

1. Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Drones**	
1.1	Definition and history of drones	2
1.2	Types of drones and their applications	2
1.3	Drone components and terminology	2
1.4	Regulations and Guidelines for drone usage	2
2	**Flight Mechanics and Dynamics**	
2.1	Basic definitions: viscosity, Mach number and speed of sound	2
2.2	Bernoulli’s equation, aerodynamics nomenclature, air foil	2
2.3	Wind tunnel testing: air foil shape, flight simulator	2
2.4	Static stability, Dynamic stability, lateral stability, longitudinal stability, directional stability.	2
3	**Drone Design and Assembly**	
3.1	Design considerations for drone airframe and propulsion systems	2
3.2	Selecting and assembling drone components (motors, batteries, flight controllers, cameras)	1
3.3	Basic wiring and soldering techniques	1
4	**Drone Motors and ESC**	
4.1	Working principles of drone motors and ESC	2
4.2	Types: Brush and Brushless Motors	2
4.3	Motor sizing and identification	2
4.4	Mounting patterns and thread size	1
4.5	Thrust to Weight ratio, KV ratings	1
4.6	Advanced motor selection, Electronic Speed Controller (ESC)	1
5	**Applications of Drone**	
5.1	Overview of commercial and industrial drone applications	1
5.2	Case studies and examples of successful drone deployments	1
5.3	GPS based navigation system, Drone Camera Systems	2
5.4	Agro application, Drone Delivery	2
5.5	Future trends and developments in the drone industry	1
	Total	**36**

Course Designers:

1. Dr. M Rajalakshmi, mrimect@tce.edu
2. Mr. M A Ganesh, ganeshma2015@tce.edu

22MTPF0	OOP USING C++	Category	L	T	P	C	TE
		PSE	1	0	4	3	Practical

Preamble

Object-Oriented Programming (OOP) have proved to be effective solutions in handling the inherent complexity of software design, development, testing and maintenance. Instead of viewing a program as a series of steps to be carried out, it views it as a group of objects that have certain properties and can take certain actions. Many object-oriented languages have become available and have been widely adopted. For an Engineer, solving any real time problem is not just about designing an algorithm and solving it, but also the ability to select appropriate data structures to solve the problem efficiently. This course introduces the concept of OOP using C++ along with ability to manipulate data using data structures.

Prerequisite

- 22MT240 - Problem Solving using C

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the programming concepts of C++	TPS2	80	80
CO2	Develop a C++ program for solving engineering problems	TPS3	70	70
CO3	Explain the various concepts in Object Oriented Programming	TPS2	80	80
CO4	Apply the concept Object Oriented Programming and develop program in C++ for solving engineering problems	TPS3	70	70
CO5	Analyze and debug the developed C++ program	TPS3	70	70
CO6	Implement linear and nonlinear data structures for a given application	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Continuous Assessment Test (CAT)								Terminal (%)
	CAT 1 (T)			CAT 2			Experiments	Model Exam	
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**3**	**3**	**3**
CO1	-	30	-	-	-	-	100	100	100
CO2	-	20	20	-	-	20			
CO3	-	30	-	-	30	30			
CO4	-	-	-	-	-	-			
CO5	-	-	-	-	-	20			
CO6	-	-	-	-	-	-			

Syllabus

Introduction to Object Oriented Programming (OOP): Procedural Languages - The Object-Oriented approach - Characteristics of Object-Oriented Languages – Objects - Classes - Inheritance – Reusability – Creating New Data Types - Polymorphism and Overloading

C++ Programming Basics: C++ programming basics – Pre-processor Directives – Header Files – Namespace – Manipulators – Loops – Structures – Functions – Inline Functions - Arrays – Strings – Pointers

OOP using C++: Objects and Classes - C++ Objects as Physical Objects - Objects as Data Types - Constructors - Destructors - Structures and Classes

Overloading: Operator Overloading - Overloaded Functions - Overloading Unary & binary operators - Data Conversion

Inheritance: Derived Class and Base Class - Class Hierarchies - Public and Private Inheritance - Levels of Inheritance - Multiple Inheritance - Classes within Classes Inheritance – UML Diagram

Memory Management – new, delete operators – Virtual Functions – Friend Functions – Static Functions – Function Templates – Exceptions

Data Structures: Linear Data structures – Stacks – Queues – Linked Lists; Non-Linear Data structures – Trees – Applications

Text Book(s)

1. E. Balagurusamy, Object-Oriented Programming with C++, 8^{th} edition, Mc Graw Hill, 2020

Reference Books & Web Resources

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 4^{th} edition, Pearson Education, 2014
2. Robert Lafore, Object-Oriented Programming in C++, Pearson Education, 2002
3. Programming in C++ in Swayam:
4. NPTEL Course https://swayam.gov.in/nd1_noc20_cs07/preview
5. C++ Programming in Tutorials Point: https://www.tutorialspoint.com/cplusplus/index.htm

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours		Course Outcome
		Theory	Practical	
1	**Introduction to Object Oriented Programming (OOP)**	2	-	CO1, CO3
2	**C++ Programming Basics:**	-	-	-
2.1	C++ programming basics – Pre-processor Directives – Header Files – Namespace – Manipulators	2	-	CO1
2.2	Loops – Structures – Functions – Inline Functions – Arrays – Strings – Pointers	2	-	CO1
2.3	Programs to apply the concept of C++ to solve engineering problems	-	4	CO2, CO5
3	**C++ OOP**	-	-	-
3.1	Objects and Classes – C++ Objects as Physical Objects – Objects as Data Types – Constructors – Destructors – Structures and Classes	3	-	CO3
3.2	Overloading	3	-	CO3
3.3	Inheritance	2	-	CO3
3.4	Memory Management – new, delete operators – Virtual Functions – Friend Functions – Static Functions –	2	-	CO1, CO3
3.5	Function Templates – Exceptions	2	-	CO1, CO3
3.6	C++ Programs using the various concepts of OOP to solve engineering problems	-	12	CO4, CO5
4	**Data Structures**	-	-	-
4.1	Linear Data structures – Stacks – Queues – Linked Lists	3	-	CO6
4.2	Non-Linear Data structures – Trees	3	-	CO6
4.3	C++ Programs to implement Linear and nonlinear data structures	-	8	CO6
	Total	**24**	**24**	

Course Designer(s):

1. Mr. S A R Sheik Masthan, sarsmech@tce.edu

22MTRA0	MACHINE VISION USING MACHINE LEARNING	Category	L	T	P	C	TE
		PEES	1	0	4	3	Practical

Preamble

Machine learning techniques, has revolutionized various industries, from healthcare to autonomous vehicles, and continues to drive innovation across diverse domains. This course is designed to provide the students with a comprehensive understanding of both the theoretical foundations and practical applications of machine vision using machine learning approaches. Through a blend of lectures, hands-on exercises, and projects, students will delve into the core concepts, algorithms, and tools essential for developing intelligent systems capable of understanding and extracting insights from visual data.

Prerequisite

- 22MT450 - Digital Signal Processing

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the components of a machine vision system and their functions	TPS 2	80	80
CO2	Develop machine vision system using image processing techniques	TPS 3	70	70
CO3	Enhance the image using machine learning and deep learning methods	TPS 3	70	70
CO4	Generate custom dataset for training and testing	TPS 3	70	70
CO5	Evaluate the machine learning models for quality inspection	TPS 3	70	70
CO6	Deploy the machine learning model in Raspberrypi and Jetson Nano boards	TPS 3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Continuous Assessment Test (CAT)								Terminal (%)
	CAT 1			CAT 2			Experiments	Model Exam	
TPS	1	2	3	1	2	3	3	3	3
CO1	-	30	-	-	-	-	100	100	100
CO2	-	30	-	-	-	-			
CO3	-	40	-	-	40	-			
CO4	-	-	-	-	-	-			
CO5	-	-	-	-	30	30			
CO6	-	-	-	-	-	-			

Syllabus

Machine Vision System: Components of Machine Vision System – Image Sensors – working principle – Optics foundation – laws of imaging – special lens types – Illumination techniques – light sources – front and back lighting

Image Processing Techniques: Point operation – local operation – Filtering – neighbourhood operation - space and frequency domain operations – Geometric transformations

Machine Learning Techniques: Supervised learning – Nearest neighbours – Support Vector Machines - Unsupervised learning – Clustering – K means

Deep Learning Techniques: Convolution Neural Network (CNN) - Single Stage detector - Two Stage detector

Dataset Preparation: Custom dataset preparation steps – preprocessing – image augmentation

Implementation: Introduction to OpenCV, TensorFlow and PyTorch. Training vision models in Google Colab, Loading vision models in Raspberrypi and Jetson Nano microcontroller boards.

Applications and case study: Quality Inspection - Parts Counting – Surface and Print Defect Identification – Measurement and Gauging - Presence Verification - Surveillance - Bar Code Identification - Character Recognition - Object classification - Face recognition

Text Book(s)

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, II edition, Springer, 2022
2. Christian Demant, Bernd Streicher-Abel, Carsten Garnica, “Industrial Image Processing”, II Edition, Springer, 2013

Reference Books & Web Resources

1. NPTEL Course: Deep Learning for Computer Vision - Prof. Vineeth N Balasubramanian - IIT Hyderabad https://onlinecourses.nptel.ac.in/noc21_cs93/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	
		Theory	Practical
1	**Machine Vision System**	-	-
1.1	Components of Machine Vision System – Image Sensors – working principle – Optics foundation – laws of imaging – special lens types	2	-
1.2	Illumination techniques – light sources – front and back lighting	1	-
2	**Image Processing Techniques**	-	-
2.1	Point operation – local operation – Filtering – neighbourhood operation	1	-
2.2	space and frequency domain operations – Geometric transformations	2	
	Experiments in space and frequency domain filtering	-	2
	Experiments in geometric transformation	-	2
	Experiments in surface and print defect identification	-	2
	Experiments in gauging and measurement	-	2
3	**Machine Learning Techniques**	-	-
3.1	Supervised learning – Nearest neighbours – Support Vector Machines	2	-
3.2	Unsupervised learning – Clustering – K means	2	-
4	**Deep Learning Techniques**	-	-
4.1	Convolution Neural Network (CNN)	2	-
4.2	Single Stage detector - Two Stage detector	2	-
5	**Dataset Preparation**	2	-
5.1	Custom dataset preparation steps – preprocessing – image augmentation	2	-
	Experiments in data set preparation, image labelling and annotation	-	2
	Experiments in character recognition, extraction	-	2
	Experiments in binary classification	-	2
	Experiments in multi class and multi label classification	-	4
6	**Implementation:**	-	-
6.1	Introduction to OpenCV, TensorFlow and PyTorch. Training vision models in Google Colab	2	-
6.2	Loading vision models in Raspberrypi and Jetson Nano microcontroller boards.	2	-
7	**Applications and case study:**	-	-
	Closed Loop Vision Systems – Quality Inspection - Gauging – Presence Verification – Surveillance – Bar Code Identification – Character Recognition – Image classification – Face recognition	2	-
	Implementation of trained models in Raspberrypi and Jetson Nano boards	-	6
	TOTAL	**24**	**24**

Course Designers:

1. Mr. S A R Sheik Masthan, sarsmech@tce.edu
2. Mr. M A Ganesh, ganeshma2015@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Program Elective Courses

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
22MTPG0	Sustainable Engineering	PSE	3	0	0	3
22MTPH0	Thermal Management of Electronic Systems	PSE	3	0	0	3
22MTPI0	Virtual Instrumentation	PSE	1	0	4	3
22MTPJ0	Autonomous Systems	PSE	3	0	0	3
22MTPK0	Non-Destructive Testing and Evaluation	PSE	3	0	0	3
22MTPL0	Building Management Systems	PSE	3	0	0	3
22MTPM0	Industrial Control of Motion Drives	PSE	3	0	0	3
22MTPN0	Industrial Communication Networks	PSE	3	0	0	3
22MTPO0	Machine Learning and Applications	PSE	3	0	0	3
22MTPP0	Quality Engineering	PSE	3	0	0	3
22MTPQ0	Micro Electro Mechanical Systems	PSE	3	0	0	3
22MTPR0	Smart HVAC Systems	PSE	3	0	0	3
22MTPS0	Edge Computing	PSE	3	0	0	3
22MTPT0	Wireless Sensor Networks	PSE	3	0	0	3
22MTRB0	Bio-Mechatronic Systems	PEES	1	0	4	3
22MTRC0	Additive Manufacturing	PEES	3	0	0	3
22MTSA0	Industrial Drives and Control	PSE	3	0	0	3

PSE : Programme Specific Elective

PEES : Programme Elective for Expanded Scope

IE : Interdisciplinary Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
22MTPG0	Sustainable Engineering	3	40	60	100	27	50
22MTPH0	Thermal Management of Electronic Systems	3	40	60	100	27	50
22MTPI0	Virtual Instrumentation	3	50	50	100	22.5	50
22MTPJ0	Autonomous Systems	3	40	60	100	27	50
22MTPK0	Non-Destructive Testing and Evaluation	3	40	60	100	27	50
22MTPL0	Building Management Systems	3	40	60	100	27	50
22MTPM0	Industrial Control of Motion Drives	3	40	60	100	27	50
22MTPN0	Industrial Communication Networks	3	40	60	100	27	50
22MTPO0	Machine Learning and Applications	3	40	60	100	27	50
22MTPP0	Quality Engineering	3	40	60	100	27	50
22MTPQ0	Micro Electro Mechanical Systems	3	40	60	100	27	50
22MTPR0	Smart HVAC Systems	3	40	60	100	27	50
22MTPS0	Edge Computing	3	40	60	100	27	50
22MTPT0	Wireless Sensor Networks	3	40	60	100	27	50
22MTRB0	Bio-Mechatronic Systems	3	50	50	100	22.5	50
22MTRC0	Additive Manufacturing	3	40	60	100	27	50
22MTSA0	Industrial Drives and Control	3	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

22MTPG0	SUSTAINABLE ENGINEERING	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course addresses the urgent need for sustainable development and the pivotal role engineers play in achieving it. Students will explore core concepts, including sustainability goals, systems thinking, life-cycle assessment, and circular economy principles.
Key frameworks and certifications, such as LEED and GRIHA, will be introduced, along with tools like environmental management systems, impact assessments, and auditing.
The course covers Environment, Social, and Governance (ESG) principles and introduces students to global reporting standards for sustainability. Through case studies and practical applications, students will learn to integrate sustainable practices into engineering, preparing them to lead in creating a resilient, sustainable future.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Articulate the importance of sustainable development and the role of engineers in achieving global sustainability objectives.	TPS2	60	70
CO2	Develop the ability to apply systems thinking and life-cycle assessment (LCA) methodologies.	TPS3	60	70
CO3	Explain the key sustainable engineering frameworks	TPS2	65	70
CO4	Integrate sustainable practices into engineering design	TPS3	60	70
CO5	Evaluate Environment, Social, and Governance (ESG) standards and reporting frameworks.	TPS3	60	70
CO6	Analyse real-world case studies to reinforce sustainable engineering practices in designing and implementing sustainable solutions in manufacturing	TPS4	60	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1 (%)</th><th colspan="7">Assessment 2 (%)</th><th rowspan="2" colspan="3">Terminal (%)</th></tr>
<tr><th colspan="3">CAT 1</th><th colspan="3">Assignment 1</th><th colspan="4">CAT 2</th><th colspan="3">Assignment 2</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>CO1</td><td>6</td><td>20</td><td>-</td><td rowspan="3" colspan="3">100</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>10</td><td>-</td></tr>
<tr><td>CO2</td><td>6</td><td>20</td><td>20</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>5</td><td>15</td></tr>
<tr><td>CO3</td><td>8</td><td>20</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>10</td><td>-</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6</td><td>10</td><td>20</td><td>-</td><td rowspan="3" colspan="3">100</td><td>4</td><td>5</td><td>15</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>8</td><td>10</td><td>20</td><td>-</td><td>4</td><td>5</td><td>15</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6</td><td>-</td><td>-</td><td>20</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Syllabus

SUSTAINABLE DEVELOPMENT AND ROLE OF ENGINEERS

Sustainable development- Need- various agreements and Role of Engineering- Sustainable Development and Engineering Profession. Sustainable Engineering concepts, Goals of Sustainability, System Thinking, Life cycle Thinking and circular economy, Carbon foot prints, lean waste.

SUSTAINABLE ENGINEERING AND CONCEPTS, PRINCIPLES AND FRAME WORK

Green Economy and Low Carbon Economy. Eco Efficiency, Triple bottom Line, Guiding principles of sustainable engineering, Frameworks for sustainable Engineering. LEED Certification, GRIHA certification, Tools for sustainability Assessment: Environmental Management System, Environmental Auditing, Cleaner Production Assessment, Environmental Impact Assessment, Strategic Environmental, Case Studies.

FUNDAMENTALS OF LIFE CYCLE ASSESSMENT

Goal and Scope, Life cycle inventory, Life Cycle Impact Assessment, Interpretation and presentation of Results, iterative Nature of LCA, Methodological Choices, LCA Software, Strength and Limitations of LCA. Introduction -Valuing the Environment, Market-based Incentives for Sustainability – Whole Life costing.

SUSTAINABILITY AND ENGINEERING DESIGN

Problems Solving in Engineering, conventional to Sustainable Engineering Design Process, Design for Life Guidelines and Strategies, Measuring Sustainability, Sustainable Design through sustainable procurement, Lightweight materials criteria, Case studies on sustainable Engineering Design Process ~Sustainable Process Design, Sustainable Production Design, Sustainable product design with Artificial Intelligence and Internet of Things. Carbon capture, utilization and storage in manufacturing

ENVIRONMENT SOCIAL AND GOVERNANCE

Concept, Scope, GRI standards, governance, ethical values, minimal wage, structure of a sustainability Report, Case Study: Net zero carbon, Sustainability Report Preparation.

Text Book(s)

1. James R. Mihelcic and Julie B. Zimmerman, Environmental Engineering: Fundamentals, Sustainability, Design, 2021
2. Rita Schenck, Environmental Life Cycle Assessment: Measuring the environmental performance of products, 2020
3. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall. 2015
4. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning, 2015

Reference Books and Web Resources

1. GRIHA Version 2019: The Sustainable Habitat Handbook (6 Volume Set), TERI Publications, ISBN 9788179936870,2019
2. Bakshi Bhavik R. Sustainable Engineering: Principles and Practice, ISBN: 9781108420457, 9781108420457, Cambridge University Press.2022

3. Ramesh C. Grover, Sachin Grover , Winning the Environmental Challenge with ISO 14001:2015 - Implementation of Environmental Management System ISBN: 9781947697324, 1947697323, Notion Press, 2017
4. IGBC New Green Buildng Rating system. https://igbc.in/igbc/html_pdfs/abridged/IGBC%20Green%20New%20Buildings%20Rating%20System%20(Version%203.0).pdf
5. The Manual of the Sustainability Report: ESG - Environment, Social, Governance
6. https://beeindia.gov.in/sites/default/files/BEE_ECBC%202017.pdf Energy Conservation Building Code (ECBC), 2017.
7. Environment Impact Assessment Guidelines, Notification of Government of India, 2006

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**SUSTAINABLE DEVELOPMENT AND ROLE OF ENGINEERS**	
1.1	Sustainable development- Need- various agreements and Role of Engineering	2
1.2	Sustainable Development and Engineering Profession. Sustainable Engineering concepts, Goals of Sustainability,	2
1.3	System Thinking, Life cycle Thinking and circular economy, Carbon foot prints, lean waste	1
2	**SUSTAINABLE ENGINEERING AND CONCEPTS, PRINCIPLES AND FRAME WORK**	
2.1	Green Economy and Low Carbon Economy. Eco Efficiency	2
2.2	Triple bottom Line, Guiding principles of sustainable engineering, Frameworks for sustainable Engineering.	2
2.3	LEED Certification, GRIHA certification, Tools for sustainability Assessment: Environmental Management System, Environmental Auditing, Cleaner Production Assessment, Environmental Impact Assessment, Strategic Environmental	4
2.4	Case Studies.	3
3	**FUNDAMENTALS OF LIFE CYCLE ASSESSMENT**	
3.1	Goal and Scope, Life cycle inventory, Life Cycle Impact Assessment, Interpretation and presentation of Results,	2
3.2	Iterative Nature of LCA, Methodological Choices, LCA Softwares, Strength and Limitations of LCA.Introduction -	3
3.3	Valuing the Environment, Market-based Incentives (or Economic Instruments) for Sustainability	2
3.4	Problems Solving in Engineering, conventional to Sustainable Engineering Design Process,	2
3.5	Design for Life Guidelines and Strategies, Measuring Sustainability,	1
3.6	Sustainable Design through sustainable procurement criteria,	1
3.7	Case studies on sustainable Engineering Design Process	2
3.8	Sustainable Process Design, Sustainable Production Design, Sustainable product design with Artificial Intelligence and IOT	2
4	**ENVIRONMENT SOCIAL AND GOVERNANCE**	
4.1	Concept, Scope, GRI standards, governance, ethical values, minimal wage, Structure of a sustainability Report	3
4.2	Case Study: Sustainability Report Preparation.	2
	Total	**36**

Course Designers:

1. Dr. M. Palaninatharaja, pnatharaja@tce.edu
2. Mr. M. M. Devarajan, mmdmech@tce.edu

22MTPH0	THERMAL MANAGEMENT OF ELECTRONIC SYSTEMS	Category	L	T	P	C	TE
		PE	3	0	0	3	Theory

Preamble

This course, Introduction to Thermal Management of Electronic Systems, addresses the critical challenge of managing heat in modern electronics, where increased power densities demand innovative thermal solutions. Covering foundational concepts of thermodynamics, entropy, and energy dissipation, the course prepares students to analyze and manage heat in electronic processors, PCB systems, and packaging. Advanced topics include the design and selection of heat sinks, vapor chambers, and heat pipes, alongside practical applications in high-power electronics and mobile devices. Through case studies, students will connect theory with real-world applications, gaining the skills to create efficient thermal management strategies essential for reliable electronic systems.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the basics of heat transfer	TPS2	65	70
CO2	Calculate the rate of heat transfer in components and PCB	TPS3	60	65
CO3	Determine the natural convection and radiation heat transfer from a sealed electronic box	TPS3	60	65
CO4	Select a fan for cooling an electronic enclosure	TPS3	60	65
CO5	Determine the Junction temperature of power transistors on a cold plate cooled by water	TPS3	60	65
CO6	Calculate the rate of heat transfer in immersion cooling of chips	TPS3	60	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	12	-				-	-	-	-	-	-	4	6	-
CO2	4	12	26		100		-	-	-	-	-	-	2	6	10
CO3	4	12	26				-	-	-	-	-	-	2	6	10
CO4	-	-	-	-	-	-	4	12	18				2	6	10
CO5	-	-	-	-	-	-	4	12	18		100		2	6	10
CO6	-	-	-	-	-	-	4	12	16				2	6	10

Syllabus

Basics of Heat transfer: Conduction, convection and radiation heat transfer, governing equations.

Heat transfer in components and PCB: Manufacturing of electronic equipment, The Chip Carrier, Printed Circuit Boards, The Enclosure, Cooling load of electronic equipment, thermal environment, electronics cooling in different applications, conduction cooling, Conduction in chip carriers, Conduction in Printed Circuit Boards, Heat Frames, The Thermal Conduction Module (TCM).

Air Cooling - Natural convection and radiation: Natural convection currents around a hot object in air, Natural convection cooling of electronic components in an enclosure with air vents, Simultaneous natural convection heat transfer to air and radiation heat transfer to the surrounding surfaces, A chassis with an array of vertically oriented PCBs cooled by natural convection, Simplified relations for natural convection heat transfer coefficients for various geometries in air at atmospheric pressure for laminar flow conditions, PCB orientation to maximize heat transfer.

Air Cooling - Forced convection: Forced convection of electronic components in an enclosure, Internal flow through a circular tube, Empirical correlations for the average Nusselt number for forced convection over a flat plate and circular and noncircular cylinders in cross flow, Nusselt number of fully developed laminar flow, Cooling Personal Computers, Forced-Air Cooling of a Hollow-Core PCB, Forced-Air Cooling of a Transistor Mounted on a PCB, choosing a Fan to Cool a computer.

Liquid cooling: Schematic of an indirect liquid cooling system, Liquid cooling of TO-3 packages placed on top of the coolant line, Cooling of Power Transistors on a Cold Plate by Water.

Immersion cooling: A simple open-loop immersion cooling system, schematics of two closed-loop immersion cooling systems, schematics of two all-liquid immersion cooling systems, Typical heat transfer coefficients for various dielectric fluids, Heat transfer from a chip immersed in the fluorocarbon fluid, Immersion Cooling of a Logic Chip, Cooling of a Chip by Boiling.

Text Book(s)

1. Lian-Tuu Yeh and R. C. Chu, Thermal Management of Microelectronic Equipment, ASME Press, 2016.
2. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S Lavine, Incropera's Principles of Heat and Mass Transfer, Global Edition, Wiley, 2017

Reference Books & Web Resources

1. Lian-Tuu Yeh and R. C. Chu, Thermal Management of telecommunication Equipment, second edition, ASME Press, 2023.
2. Y. Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press, 2009.
3. https://web.iitd.ac.in/~pmvs/course_mcl348.php
4. Yunus A. Çengel, Heat Transfer: A Practical Approach, McGraw-Hill, 2003
5. K. Azar, Thermal measurements in electronics cooling, CRC Press, 1997
6. S. Kakac, H. Yuncu, K. Hijikata, Cooling of Electronic Systems, Kluwer Academic Publishers.
7. D. Gilmore, Spacecraft Thermal Control Handbook, The Aerospace Corporation, 2002
8. Fethi Aloui, Edwin Geo Varuvel, Ankit Sonthalia, Handbook of Thermal Management Systems: e-Mobility and Other Energy Applications, Elsevier - Health Sciences Division, 2023.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Basics of Heat transfer:**	
1.1	Conduction, convection and radiation heat transfer,	2
	Governing Equations	1
2	**Heat transfer in components and PCB:**	
2.1	Manufacturing of electronic equipment, The Chip Carrier, Printed Circuit Boards,	1
2.2	The Enclosure, Cooling load of electronic equipment, thermal environment, electronics cooling in different applications, conduction cooling,	1
2.3	Conduction in chip carriers, Conduction in Printed Circuit Boards, Heat Frames, The Thermal Conduction Module (TCM)	2
3	**Air Cooling - Natural convection and radiation:**	
3.1	Natural convection currents around a hot object in air, Natural convection cooling of electronic components in an enclosure with air vents	1
3.2	Simultaneous natural convection heat transfer to air and radiation heat transfer to the surrounding surfaces, A chassis with an array of vertically oriented PCBs cooled by natural convection	2
3.3	Simplified relations for natural convection heat transfer coefficients for various geometries in air at atmospheric pressure for laminar flow conditions, PCB orientation to maximize heat transfer	1
4	**Air Cooling - Forced convection**	
4.1	Forced convection of electronic components in an enclosure, Internal flow through a circular tube	2
4.2	Empirical correlations for the average Nusselt number for forced convection over a flat plate and circular and noncircular cylinders in cross flow	2
4.3	Nusselt number of fully developed laminar flow, Cooling Personal Computers	2
4.4	Forced-Air Cooling of a Hollow-Core PCB	2
4.5	Forced-Air Cooling of a Transistor Mounted on a PCB	2
4.6	Choosing a Fan to Cool a Computer	1
5	**Liquid cooling**	
5.1	Schematic of an indirect liquid cooling system	2
5.2	Liquid cooling of TO-3 packages placed on top of the coolant line	2
5.3	Cooling of Power Transistors on a Cold Plate by Water	2
6	**Immersion cooling:**	2
6.1	A simple open-loop immersion cooling system, schematics of two closed-loop immersion cooling systems	2
6.2	schematics of two all-liquid immersion cooling systems, Typical heat transfer coefficients for various dielectric fluids	2
6.3	Heat transfer from a chip immersed in the fluorocarbon fluid, Immersion Cooling of a Logic Chip, Cooling of a Chip by Boiling	2
	Total	**36**

Course Designers:

1. Dr.G.Kumaraguruparan, gkgmech@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu

22MTPI0	VIRTUAL INSTRUMENTATION	Category	L	T	P	C	TE
		PSE	1	0	4	3	Practical

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-centred systems that exploit the computing power, productivity, display, and connectivity capabilities of popular desktop computers and workstations

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Summarize the need and advantages of virtual instruments over traditional instruments	TPS 2	80	70
CO2	Illustrate the software components needed to develop graphical programming using LabVIEW	TPS 2	80	70
CO3	Explain appropriate LabVIEW Architecture for realizing a given application	TPS 2	80	70
CO4	Develop Graphical Programming using LabVIEW	TPS 3	70	65
CO5	Acquire data from real world using various sensors and interpret the same	TPS 3	70	65
CO6	Develop LabVIEW based software application for realizing the given system	TPS 3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Continuous Assessment (%)								Terminal (%)		
	CAT 1			CAT 2			Experiments	Model Exam			
TPS	1	2	3	1	2	3	3	3	1	2	3
CO1	20	-	-	-	-	-	-	-	20*		-
CO2	-	60	-	20	-	-	-	-			-
CO3	-	-	-	-	40	-	-	-			-
CO4	-	-	20	-	-	40	100	100	-	-	80#
CO5	-	-	-	-	-	-			-	-	
CO6	-	-	-	-	-	-			-	-	

* - Viva; # - Practical

Syllabus

Virtual Instrumentation: Introduction to Virtual Instrumentation: Virtual Instrument and traditional instrument - Hardware and software in Virtual Instrumentation - Virtual Instrumentation in the Engineering Process - Graphical Programming and Textual Programming

Introduction to LabVIEW: Software Environment - Creating and Saving A VI - Front Panel Toolbar - Block Diagram Toolbar - Palettes - Property Dialog Boxes - Front Panel Controls and Indicators - Block Diagram - Data Types - Data Flow Program, Modular Programming

LabVIEW Programming: Loops: FOR, WHILE Loops - Tunnels – Shift Registers – Feedback Nodes – Control Timing – Communicating among Multiple Loops - Local and Global Variables. Structures: Case, Sequential, Timed, Formula, Event. Arrays – Clusters. Plotting Data: Waveform Graphs, Charts - XY Graphs. Strings - File I/O – Error Handling. Architectures: Functional Global Variable - State Machine - Event-Driven User Interface - Producer / Consumer

Data Acquisition: Introduction – Transducers - Signals - Principles of Data Acquisition – Sampling – Modes of communication - DAQ Assistant

Tools and Applications: Tools: Signal Processing and Analysis - Control Design and Simulation - Digital Filter Design - Report Generation - Data Logging - Embedded Module - Math Interface Toolkit. Applications: Machine Vision and Motion Control

Text Book(s)

1. Julio Cesar Rodriguez-Quinonez, Oscar Real-Moreno, Graphical Programming Using LabVIEW™: Fundamentals and advanced techniques, Institution of Engineering and Technology, 2022

Reference Books and Web Resources

1. LabVIEW Programming Reference Manual: https://www.ni.com/docs/en-US/bundle/labview-api-ref/page/intro.html, 2024, National Instruments.
2. Jovitha Jerome, Virtual Instrumentation Using LabVIEW, PHI Learning, New Delhi, 2011
3. Gary W.Johnson, Richard Jennings, LabVIEW Graphical Programming, Tata McGraw Hill Education Private Limited, 2017
4. Sanjay Gupta, Joseph John, Virtual Instrumentation Using LabVIEW, Tata McGraw Hill Education Private Limited, 2017

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	
		Theory	Practical
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	1	
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	1	
2.3	Data Types - Data Flow Program - Modular Programming	1	
	Introduction to LabVIEW components		2
3	**LabVIEW Programming**		

Module No.	Topic	No. of Hours	
		Theory	Practical
3.1	Loops: FOR, WHILE Loops - Tunnels – Shift Registers	1	
3.2	Feedback Nodes – Control Timing – Communicating among Multiple Loops - Local and Global Variables	1	
3.3	Structures: Case, Sequential, Timed, Formula, Event	2	
3.4	Arrays – Clusters	1	
3.5	Plotting Data: Waveform Graphs, Charts - XY Graphs	1	
3.6	Strings - File I/O - Error Handling	1	
3.7	Architectures: Functional Global Variable	1	
3.8	State Machine - Event-Driven User Interface	1	
3.9	Producer / Consumer	1	
	Programs using loops & structures		4
	Programs involving graphs & charts		4
	Programs using various architectures (Functional Global Variable - State Machine - Event-Driven User Interface - Producer / Consumer)		4
	Programs using files & data logging		2
4	**Data Acquisition**		
4.1	Introduction – Transducers - Signals - Principles of Data Acquisition – Sampling	2	
4.2	Modes of communication - DAQ Assistant	2	
5	**Tools and Applications**		
5.1	Tools: Signal Processing and Analysis - Digital Filter Design - Control Design and Simulation	1	
5.2	Tools: Report Generation - Data Logging	1	
5.3	Tools: Embedded Module - Math Interface Toolkit	1	
5.4	Applications: Machine Vision & Motion Control	2	
	Interfacing and measurements from various sensors (Ultrasonic, IR, Gyro, Proximity, temperature, Accelerometer)		4
	Interfacing and controlling using various devices (DC motor, Servo motor, LCD, Seven Segment display, Matrix Keyboard)		4
	Total	**24**	**24**

Course Designers:

1. Dr. M Rajalakshmi, mrimect@tce.edu
2. Mr. Sheik Masthan S A R, sarsmech@tce.edu

22MTPJ0	AUTONOMOUS SYSTEMS	Category	L	T	P	C	TE
		PE	3	0	0	3	Theory

Preamble

Autonomous vehicles are self-governing vehicles that can sense their surroundings and find their own way to their destination. A wide range of fields, including computer vision, control systems, and sensory networks that power electrical drives, are integrated into autonomous vehicles. At the moment, this field produces a wide range of tools for control and monitoring.

Prerequisite

- 22MT320 - Kinematics and Dynamics

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Derive the kinematics model and wheel kinematics model for different mobile robots	TPS2	70	65
CO2	Explain the operation of mobile robots' locomotion.	TPS2	70	65
CO3	Select appropriate sensors, actuators and controller for mobile robots in agricultural application.	TPS3	75	70
CO4	Develop autonomous map building for navigating structured and unstructured environments.	TPS3	70	65
CO5	Solve logistic application problems related to mobile robot mapping using Simultaneous Localization and Mapping (SLAM)	TPS3	70	65
CO6	Implement heuristic and meta heuristic techniques for obstacle avoidance in industrial application.	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	10	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO2	10	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO3	-	20	20	-	-	100	-	-	-	-	-	-	-	10	10
CO4	-	-	-	-	-	-	5	10	10	-	-	-	4	10	-
CO5	-	-	-	-	-	-	10	10	20	-	-	50	4	10	10
CO6	-	-	-	-	-	-	5	-	30	-	-	50	4	-	10

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 manoeuvrability- 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. **Controllers:** Control design basics, Cruise-Controllers, PID Controllers, Performance Objectives and control algorithms.

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 Graph SLAM, Visual SLAM - case study about mapping.

Motion Planning and Navigation: Introduction on Path and Motion Planning- Path Planning algorithms – Classical algorithm – Heuristic and Meta heuristic algorithm - Obstacle avoidance – bug algorithm, vector field histogram, velocity obstacle techniques. Navigation architecture, Case studies on navigation architecture

Assignment 1 & 2: Students will work on a semester long prototype consisting of design, fabrication, and programming a mobile robotic platform for selected application.

Text Book(s)

1. Nikolaus Correll And Bradley Hayes and Christoffer Heckman And Alessandro Roncone, “Introduction To Autonomous Robots”, MIT Press, 2022.
2. Igor Skrjanc and Andrej Zdesar and Saso Blazic and Gregor Klancar, “Wheeled Mobile Robotics”, Elsevier, 2017

Reference Books & Web Resources

1. Shaoshan Liu, “Engineering Autonomous Vehicles and Robots”, Wiley, 2020
2. https://www.edx.org/course/autonomous-mobile-robots
3. Ronald siegwart, Illah R.nourbakhsh, Davide scaramuzza,” Introduction to Autonomous Mobile Robots”,MIT Press Publication,2nd edition,2011.

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**	

Module No.	Topic	No. of Lectures
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**	
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	Basics of computer vision, Image processing techniques	1
3.7	Control design basics, Cruise-Controllers, PID Controllers	1
3.8	Performance Objectives and control algorithms	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	1
5	**Motion Planning and Navigation**	
5.1	Path Planning – Graph search technique	1
5.2	Classical algorithm	2
5.3	Heuristic and Meta heuristic Algorithm	2
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:

1. Dr. S Julius Fusic, sjf@tce.edu
2. Prof. M A Ganesh, ganeshma2015@tce.edu

22MTPK0	NON-DESTRUCTIVE TESTING AND EVALUATION	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Non-destructive testing and evaluation are a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage. The six most frequently used Non-Destructive testing and Evaluation methods are eddy- current, magnetic-particle, liquid penetrant, radiographic, ultrasonic, and visual testing.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain various non-destructive testing methods.	TPS2	60	70
CO2	Determine suitable techniques for fatigue crack detection	TPS3	60	70
CO3	Use the principles, procedures, and applications of MPT and thermography for weld	TPS3	65	70
CO4	Determine the Time-of-Flight Diffraction (TOFD) for flaw detection	TPS3	60	70
CO5	Use the radiographic imaging techniques for inspecting defective components.	TPS3	60	70
CO6	Choose suitable non-destructive technique to identify strength and weakness of materials used in automotive and aerospace applications.	TPS4	60	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1 (%)</th><th colspan="7">Assessment 2 (%)</th><th colspan="4" rowspan="2">Terminal (%)</th></tr>
<tr><th colspan="3">CAT 1</th><th colspan="3">Assignment 1</th><th colspan="4">CAT 2</th><th colspan="3">Assignment 2</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>CO1</td><td>6</td><td>20</td><td>-</td><td colspan="3" rowspan="3">100</td><td colspan="7" rowspan="3">-</td><td>4</td><td>10</td><td>-</td><td>-</td></tr>
<tr><td>CO2</td><td>6</td><td>10</td><td>20</td><td>4</td><td>5</td><td>10</td><td>-</td></tr>
<tr><td>CO3</td><td>8</td><td>10</td><td>20</td><td>4</td><td>5</td><td>10</td><td>-</td></tr>
<tr><td>CO4</td><td colspan="6" rowspan="3">-</td><td>6</td><td>10</td><td>20</td><td>-</td><td colspan="3" rowspan="3">100</td><td>4</td><td>5</td><td>10</td><td>-</td></tr>
<tr><td>CO5</td><td>8</td><td>10</td><td>20</td><td>-</td><td>4</td><td>5</td><td>10</td><td>-</td></tr>
<tr><td>CO6</td><td>6</td><td>-</td><td>-</td><td>20</td><td>-</td><td>-</td><td>-</td><td>10</td></tr>
</table>

Syllabus

Non-Destructive Testing: An Introduction, Visual Inspection and Liquid Penetrant Testing Types of non-destructive methods, Comparison of Destructive and Non-destructive Tests. Visual Inspection- Optical aids used for visual inspection, Applications. Penetrant Testing- Physical principles, procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods-water washable, Post – Emulsification methods, Applications.

Eddy Current Testing (ECT) & Acoustic Emission Test (AET): Principles, Instrumentation for ECT, Absolute, differential probes, Techniques – High sensitivity techniques, Multi frequency, Phased array ECT, Applications. Acoustic Emission Test -Principle of AET, Instrumentation, Applications - testing of metal pressure vessels, Fatigue crack detection in aerospace structures.

Magnetic Particle Testing (MPT) & Thermography: Principle of MPT, procedure used for testing a component, Equipment used for MPT, Magnetizing techniques, Applications.
Thermography- Principle, Infrared Radiometry, Active thermography measurements, Applications – Imaging entrapped water under an epoxy coating, Detection of carbon fiber contaminants.

Ultrasonic Testing: Principle, Ultrasonic transducers, Ultrasonic Flaw detection Equipment, Modes of display A- scan, B-Scan, C- Scan, D scan ,Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection, Normal Incident Through-transmission Testing, Angle Beam Pulse-Echo testing, Time of Flight Diffraction (TOFD) Technique, Applications of Normal Beam Inspection in detecting fatigue cracks, Inclusions, Slag, Porosity and Intergranular cracks - Codes, standards, specification and procedures and case studies in ultrasonic test, Piezo Electric Testing, non-invasive ultra sound equipment testing.

Radiography: Principle of Radiography, x-ray and gamma ray sources- safety procedures and standards, Effect of radiation on Film, Radiographic imaging, Inspection Techniques – Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography - Codes, standards, specification and procedures. Case studies on defects in cast, rolled, extruded, welded and heat-treated components - Comparison and selection of various NDT techniques.

Advanced Techniques: Image formation, Image quality, Digital Radiography, Image interpretation, Radiation Shielding, Prediction of Defects using data driven AI - ML models.

Text Book(s)

1. Johannes Vrana, Nathan Ida, Norbert Meyendorf, Ripi Singh, Ripudaman Singh, Handbook of Nondestructive Evaluation 4.0, Springer International Publishing, 2022

Reference Books & Web Resources

1. Charles, J. Hellier, "Handbook of Non-destructive evaluation", 3rd edition, McGraw Hill, New York, 2020
2. M. Thavasimuthu, T. Jayakumar, Baldev Raj "Practical Non Destructive Testing", Third Edition, Narosa Book Distributors Pvt Ltd, New Delhi, 2002
3. Peter J. Shull "Non Destructive Evaluation: Theory, Techniques and Applications", First Edition, Marcel Dekker, Inc., New York, 2002
4. Krautkramer. J., "Ultra Sonic Testing of Materials", Fourth Edition, Springer (India) Private Limited, New Delhi, 2003.
5. ASM Metals Handbook Vol 17: Non Destructive testing.
6. ASME Sec V - Non - Destructive Testing.
   ASTM Standards
   a. E 94, Standard Guide for Radiographic Examination.
   b. E 142, Standard Method for Controlling Quality of Radiographic Testing.
   c. E 164, Standard Practice for Ultrasonic Contact Examination of Weldments.
   d. E 165, Standard Test Method for Liquid Penetrant Examination.
   e. E 1444, Standard Practice for Magnetic Particle Examination.
7. https://nptel.ac.in/courses/113106070/ Dr. Ranjit Bauri, Associate Professor, Dept. of Metallurgical and Materials Engineering, IIT Madras.
8. https://nptel.ac.in/courses/114106035/35
   Prof. Dr. Srinivasan Chandrasekaran. Department of Ocean Engineering Indian Institute of Technology, Madras

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Non-Destructive Testing:**	
1.1	Introduction, Visual Inspection and Liquid Penetrant Testing Types of non-destructive methods	1
1.2	Comparison of Destructive and Non-destructive Tests. Visual Inspection- Optical aids used for visual inspection, Applications.	2
1.3	Penetrant Testing- Physical principles, procedure for penetrant testing, Penetrant testing materials	1
1.4	Penetrant testing methods-water washable, Post – Emulsification methods, Applications.	2
2	**Eddy Current Testing (ECT) & Acoustic Emission Test (AET):**	
2.1	Principles, Instrumentation for ECT, Absolute, differential probes	1
2.2	High sensitivity techniques, Multi frequency, Phased array ECT, Applications.	1
2.3	Acoustic Emission Test -Principle of AET, Instrumentation, Applications - testing of metal pressure vessels	2
2.4	Fatigue crack detection in aerospace structures	1
3	**Magnetic Particle Testing (MPT) & Thermography:**	

Module No.	Topic	No. of Periods
3.1	Principle of MPT, procedure used for testing a component	1
3.2	Equipment used for MPT, Magnetizing techniques, Applications	1
3.3	**Thermography**- Principle, Infrared Radiometry	1
3.4	Active thermography measurements	1
3.5	Applications – Imaging entrapped water under an epoxy coating	1
3.6	Detection of carbon fiber contaminants	1
4	**Ultrasonic Testing:**	
4.1	Principle, Ultrasonic transducers, Ultrasonic Flaw detection Equipment, Modes of display A- scan, B-Scan, C- Scan, D scan, Applications,	2
4.2	Inspection Methods - Normal Incident Pulse-Echo Inspection, Normal Incident Through-transmission Testing, Angle Beam Pulse-Echo testing, Time of Flight Diffraction (TOFD) Technique,	2
4.3	Applications of Normal Beam Inspection in detecting fatigue cracks, Inclusions, Slag, Porosity and Intergranular cracks - Codes, standards, specification and procedures and case studies in ultrasonic test. Piezo Electric Testing, non-invasive ultra sound equipment testing.	2
5	**Radiography:**	
5.1	Principle of Radiography	1
5.2	x-ray and gamma ray sources- safety procedures and standards	1
5.3	Effect of radiation on Film, Radiographic imaging, Inspection Techniques	1
5.4	Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography - Codes, standards, specification and procedures.	2
5.5	Case studies on defects in cast, rolled, extruded, welded and heat-treated components	2
5.6	Comparison and selection of various NDT techniques	
6	**Advanced Techniques:**	
6.1	Image formation, Image quality	1
6.2	Digital Radiography, Image interpretation	1
6.3	Radiation Shielding	1
6.4	Prediction of Defects using data driven AI - ML models.	3
	Total	**36**

Course Designers:

1. Mr. M.M. Devarajan, mmdmech@tce.edu
2. Mr. S. Rajkumar, srmech@tce.edu

22MTPL0	BUILDING MANAGEMENT SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Modern building Management systems leverage advanced sensors, actuators, and software to automate operations, reduce energy consumption, and improve the overall management of building resources. By using data-driven insights, these systems can monitor, adjust, and optimize conditions in real-time, making buildings more responsive, safe, and environmentally friendly. In the context of sustainable building design and operations, automation plays a critical role in achieving energy efficiency, reducing carbon footprints, and ensuring long-term cost savings.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the components and functions of BMS	TPS2	80	75
CO2	Develop BMS system using controllers, sensors and actuators	TPS3	80	75
CO3	Identify relevant communication protocols for integrating BMS devices	TPS3	75	70
CO4	Integrate HVAC system with BMS	TPS3	75	70
CO5	Implement integration of lighting, security using IOT concepts	TPS3	75	70
CO6	Utilize data analytics tool to monitor building performance	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	10	-	-	-	-	-	-	-	-	-	-	4	5	-
CO2	4	10	30	-	-	50	-	-	-	-	-	-	4	-	10
CO3	2	10	30	-	-	50	-	-	-	-	-	-	4	-	10
CO4	-	-	-	-	-	-	4	10	20	-	-	-	4	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	50	2	5	15
CO6	-	-	-	-	-	-	2	10	20	-	-	50	2	5	15

Syllabus

Introduction to BMS
Overview of BMS-History and evolution of BMS-BMS technology standards-Components and architecture of BMS -Importance of BMS in energy efficiency and sustainability.

Components of BMS
Sensors, actuators, controllers, user interfaces, communication protocols such as BAC net, Modbus, Lon works.

HVAC system Integration
Overview of HVAC systems-BMS control strategies for HVAC, Energy efficiency considerations in HVAC management.

Plumbing, Fire protection and Elevator systems
Water supply system-sanitary drainage system-plumbing system control devices-fire alarm systems-fire suppression systems-fire alarm control panel-fire protection system control devices-Elevator types-mechanical operation-safety features-operating modes-control devices

Lighting, Security and Access control systems
Types of lighting systems, Integration with BMS for energy savings-smart lighting technologies and its benefits-Overview of security systems-CCTV, alarms and access control-Integration of security with BMS for enhanced safety-monitoring and real time response strategies.

Energy Management and sustainability
Energy monitoring techniques and tools-Renewable energy sources: solar, wind, etc. -Sustainable building practices and certifications (LEED, BREEAM)-predictive building maintenance using data analytics-Data visualization and reporting tools-Integration of IOT technologies in BMS.

Text Book(s)

1. Building Automation: Control devices and applications, American technical publishers, 2008

Reference Books & Web Resources

1. Building automation: communicating systems with EIB/KNX, LON and BACnet, second edition, springer, 2018.
2. Intelligent buildings and building automation, Shengwei wang, Spon press, 2009

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to BMS**	
1.1	Overview of BMS-History and evolution of BMS	1
1.2	BMS technology standards-Components and architecture of BMS	2
1.3	Importance of BMS in energy efficiency and sustainability	2
2	**Components of BMS**	
2.1	Sensors, actuators, controllers, user interfaces	2
2.2	Communication protocols such as BAC net, Modbus, Lon works.	2
3	**HVAC system Integration**	
3.1	Overview of HVAC systems-BMS control strategies for HVAC	2
3.2	Energy efficiency considerations in HVAC management.	2
4	**Plumbing, Fire protection and Elevator systems**	

Module No.	Topic	No. of Periods
4.1	Water supply system-sanitary drainage system-plumbing system control devices	2
4.2	fire alarm systems-fire suppression systems-fire alarm control panel	2
4.3	fire protection system control devices	2
4.4	Elevator types-mechanical operation-safety features-operating modes-control devices	2
5.	**Lighting, Security and Access control systems**	
5.1	Types of lighting systems, Integration with BMS for energy savings	2
5.2	Smart lighting technologies and its benefits	2
5.3	Overview of security systems-CCTV, alarms and access control	2
5.4	Integration of security with BMS for enhanced safety-monitoring and real time response strategies.	1
6	**Energy Management and sustainability**	
6.1	Energy monitoring techniques and tools	2
6.2	Renewable energy sources: solar, wind, etc.	
6.3	Sustainable building practices and certifications (LEED, BREEAM)	2
6.4	predictive building maintenance using data analytics-Data visualization and reporting tools	2
6.5	Integration of IOT technologies in BMS.	2
	Total	**36**

Course Designers:

1. Dr. H Ramesh, rameshh@tce.edu
2. Mr. S Raj Kumar, srmech@tce.edu

22MTPM0	INDUSTRIAL CONTROL OF MOTION DRIVES	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

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 motion 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

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Describe the basic structure of the position, speed and torque control in drives.	TPS2	80	75
CO2	Experiment Position, Speed and Torque control in Motion control drives.	TPS3	75	70
CO3	Construct Field oriented control (FOC) for Induction, PMSM and BLDC drives.	TPS3	75	70
CO4	Develop the Vector control algorithm for AC servo drives.	TPS3	75	70
CO5	Develop Motion controller program for Motion applications.	TPS3	75	70
CO6	Select motor, gear and transmission system for motion control system.	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	20	-	-	-	-	-	-	-	-	-	-	4	5	-
CO2	4	15	20	-	-	50	-	-	-	-	-	-	4	5	10
CO3	2	15	20	-	-	50	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	20	4	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	40	2	5	10
CO6	-	-	-	-	-	-	2	10	20	-	-	40	2	5	10

Syllabus

Basics of Electrical Drives control –Modelling of Induction motor, Permanent Magnet Synchronous motor (PMSM), Brushless DC motor (BLDC), AC servo motor Model-block diagram, transfer function, state space modelling, Basic structure of position, speed and torque controller-structure of cascaded control-PI and PID controllers-Introduction to Field oriented control.

Control of Induction Motor Drives-Principle of vector control, direct control, indirect control, Tuning of vector controller, Cascaded Position/velocity/Torque controller with feed forward gain- case study on Sensored and Sensorless FOC control of induction motor.

Control of PMSM and BLDC Drives-Vector control of PMSM drives-control strategies-flux weakening operation-speed controller design-Trapezoidal control of BLDC drives-Case study on Sensored and Sensorless FOC control of PMSM and BLDC drives

Control of AC Servo Drives-Sinusoidal commutation –Torque generation with sinusoidal commutation-Motor phasing with encoders and hall sensors-Vector control of AC servo motor-Case study on control of Position, Velocity and Torque in servo drives

Motion Control Drives-Components of motion control system-Drive train design-Motor, gearbox and transmission mechanism selection-common motion profiles-single axis and multi axis motion-Move modes-motion programming- Interfacing Motion controllers and Drives -Case study on interfacing different motion controllers with Drives.

Text Book(s)

1. Hakan Gurocak, “Industrial Motion control”, John Wiley publications, 2018.
2. R. Krishnan, ”Electric motor drives-Modelling, analysis and control”, prentice hall publications, 2015

Reference Books & Web Resources

1. Ion Boldea, S.A Naser “Electric Drives” CRC Taylor & Francis group edition,2009
2. Texas instruments Motor Control Education https://training.ti.com/node/1139615
3. Frederick F. Ling, Servo motors and industrial control theory, springer, 2009.
4. Indra Motion Logic Drives ,Indra works Software User Manual Bosch Rexroth.
5. National instruments CRIO motion control manual.
6. Tarik Uzunovic, Asif Sabanovic, Motion control of functionality related systems, CRC press,2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Basics of Electrical Drives Control**	
1.1	Modelling of Induction, PMSM,BLDC and AC servo motors-block diagram, transfer function, state space modelling	2
1.2	Structure of position, speed and torque controller-PI,PID	1
1.3	Structure of cascaded control	1
1.4	Introduction to Field oriented control(FOC)	1
2	**Control of Induction Motor Drives**	
2.1	Principle of vector control, direct control, indirect control	2

Module No.	Topic	No. of Periods
2.2	Tuning of vector controller	1
2.3	Cascaded Position/velocity/Torque controller with feed forward gain	1
2.5	Case study on Texas instruments sensored and sensorless FOC control of induction motor	2
3	**Control of PMSM and BLDC Drives**	
3.1	Vector control of PMSM drives	1
3.2	Control strategies	2
3.3	Flux weakening operation	1
3.4	Speed controller design	1
3.5	Trapezoidal control of BLDC drives	2
3.6	Case study on Texas instruments Sensored and Sensorless control of PMSM and BLDC drives	2
4	**Control of AC Servo Drives**	
4.1	Sinusoidal commutation, Torque generation with sinusoidal commutation	2
4.2	Motor phasing with encoders and hall sensors	1
4.3	Vector control of AC servo motor	1
4.4	Case study on Bosch Rexroth and National Instruments servo drive control.	2
5	**Motion control drives**	
5.1	Components of motion control system	1
5.2	Drive train design-Motor, gearbox and transmission mechanism selection	2
5.3	common motion profiles, Move modes	1
5.4	Single axis and multi axis motion	1
5.5	Motion programming	2
5.6	Interfacing Motion controllers and Drives	1
5.7	Case study on Siemens and Bosch Rexroth Motion controllers	2
	Total	**36 Hours**

Course Designers:

1. Dr. H Ramesh, rameshh@tce.edu
2. Dr. S Julius Fusic, sjf@tce.edu

22MTPN0	INDUSTRIAL COMMUNICATION NETWORKS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Data communication is the transfer of information from one point to another. Modern instrumentation and automation systems are almost wholly concerned with the transfer of digital data. In the past decade many standards and protocols have been established which allow data communications technology to be used more effectively in industry. Protocols are the structures used within a communication system so that one device can talk to another device. Traditionally developers of software and hardware platforms have developed protocols, which only their products can use. In order to develop more integrated automation systems, standardisation of these communication protocols is required.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Identify the components required to build different types of networks.	TPS2	80	75
CO2	Describe functionality of OSI Layers of computer networks.	TPS2	80	75
CO3	Illustrate the concept of routing and addressing.	TPS3	75	70
CO4	Demonstrate industrial communication protocols such as field bus, Modbus, Ethernet I/P	TPS3	75	70
CO5	Program open communication interfaces such as OPC/UA, TSN.	TPS3	75	70
CO6	Choose the suitable protocol for interconnecting devices through an industrial network	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	20		-	-	-	-	-	-	-	-	-	4	10	-
CO2	4	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO3	2	20	30	-	-	100	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	20	4	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	40	2	5	10
CO6	-	-	-	-	-	-	2	10	20	-	-	40	2	5	10

Syllabus

Fundamentals of Networks

Overview of Data Communications - Data networks in Modern Instrumentation and automation systems- Types of network topologies (star, bus, ring, etc.) – Building Network and its types – Protocol Layering - OSI Model – Physical Layer – Overview of Data and Signals - Transmission Media - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction - Ethernet (802.3) - Wireless LANs – Connecting Devices.

Networking

Network layer services – Packet Switching – IPV4 Address - Routing - Unicast Routing - Multicast Routing and its basics – Overview of Intra domain and inter domain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6 - Introduction to Transport layer– Protocols- User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) – Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Application Layer

IT and IOT protocols

Introduction to communication protocols-Differences between IT and OT protocols- IT protocols-TCP/IP, HTTP/HTTPS, STP/SFTP, SNMP, DNS, DHCP, RDP IOT Protocols-MQTT, CoAP, LwM2M, AMQP, XMPP

OT Protocols Field bus technologies- Overview of Fieldbus systems -Profibus, DeviceNet, CAN.

Ethernet and wireless communication in Industrial Settings-Industrial Ethernet protocols -EtherCAT, Profinet, Modbus, EtherNet/IP – Comparison with traditional Ethernet-Wireless protocols -Wi-Fi, Zigbee, LoRaWAN-Advantages and challenges of wireless networks -Open communication protocols-OPCUA-TSN-BACnet

Text Book(s)

1. Industrial Communication Systems, Bogdan M. Wilamowski, J. David Irwin, CRC Press; 2018.

Reference Books & Web Resources

1. Industrial Network Basics: Practical Guides for the Industrial Technician, Gary D Anderson,2014, Kindle edition.
2. Industrial Communication technology hand book, Richard Zurawski, CRC press 2017.
3. Practical Industrial Data Communications: Best Practice Techniques, Deon Reynders, Butterworth-Heinemann publishers,2004

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Fundamentals of Networks**	
1.1	Overview of Data Communications - Data networks in Modern Instrumentation and automation systems	1
1.2	Types of network topologies (star, bus, ring, etc.) – Building Network and its types	1
1.3	Protocol Layering - OSI Model – Physical Layer – Overview of Data and Signals -	1
1.4	Transmission Media - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction	1
1.5	Ethernet (802.3) - Wireless LANs – Connecting Devices.	1

Module No.	Topic	No. of Periods
2	**Networking**	
2.1	Network layer services – Packet Switching	1
2.2	IPV4 Address - Routing	2
2.3	Unicast Routing - Multicast Routing and its basics	2
2.4	Overview of Intra domain and inter domain protocols – Overview of IPv6 Addressing	2
2.5	Transition from IPv4 to IPv6 - Introduction to Transport layer– Protocols	2
2.6	User Datagram Protocols (UDP) and Transmission Control Protocols (TCP) – Services – Features	2
2.7	TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Application Layer	2
3	**IT and IOT protocols**	
3.1	Introduction to communication protocols-Differences between IT and OT protocols	2
3.2	IT protocols-TCP/IP, HTTP/HTTPS, STP/SFTP, SNMP, DNS, DHCP, RDP	3
3.3	IOT Protocols-MQTT, CoAP, LwM2M, AMQP, XMPP	2
4	**OT Protocols**	
4.1	Field bus technologies- Overview of Fieldbus systems - Profibus, DeviceNet, CAN.	2
4.2	Industrial Ethernet protocols -EtherCAT, Profinet, Modbus, EtherNet/IP	3
4.3	Wireless protocols -Wi-Fi, Zigbee, LoRaWAN-Advantages and challenges of wireless networks	2
4.4	Open communication protocols-OPCUA-TSN-BACnet	2
	Total	**36**

Course Designers:

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2. Dr. S Julius Fusic, sjf@tce.edu

22MTPO0	MACHINE LEARNING AND APPLICATIONS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Machine Learning (ML) is a subfield of artificial intelligence (AI) that focuses on the development of algorithms and statistical models that allow computers to perform specific tasks without explicit programming. This course provides an introduction to the key principles and techniques in machine learning, with an emphasis on both theoretical foundations and practical implementation. Students will gain hands-on experience in using modern ML tools and libraries, as well as an understanding of the mathematical concepts behind popular algorithms.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Describe the mathematical concepts behind machine learning	TPS2	80	75
CO2	Pre-process the data for machine leaning model implementation.	TPS3	80	75
CO3	Use ML State vector machine techniques to real world data set.	TPS3	75	70
CO4	Evaluate the performance of ML Models	TPS3	75	70
CO5	Implement neural network architectures for machine vision applications	TPS3	75	70
CO6	Apply basic reinforcement learning to solve sequential decision-making problems.	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	20	-	-	-	-	-	-	-	-	-	-	4	5	-
CO2	4	15	20	-	-	50	-	-	-	-	-	-	4	5	10
CO3	2	15	20	-	-	50	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	20	4	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	40	2	5	15
CO6	-	-	-	-	-	-	2	10	20	-	-	40	2	5	15

Syllabus

Introduction to Machine learning

Types of Learning: Supervised, Unsupervised, and Reinforcement Learning-Overview of ML Workflow: Data Collection, Pre-processing, Data analysis, data post processing Model Training, Evaluation, Key challenges in ML: Overfitting, Under fitting, Bias-Variance Trade-off, Generative and discriminative models.

Supervised Learning

Simple and Multiple Linear Regression-Gradient Descent and Cost Function, Classification-Logistic Regression, Decision Trees and Random Forests, Support vector machine ,k-Nearest Neighbors (k-NN)-application of supervised learning in predictive maintenance analytics and quality systems- **Evaluation Metrics** Accuracy, Precision, Recall, F1-score, Confusion Matrix, ROC Curve, AUC (Area Under the Curve)

Unsupervised Learning

K-Means Clustering, Hierarchical Clustering, DBSCAN, **Dimensionality Reduction-**Principal Component Analysis (PCA), t-SNE (t-Distributed Stochastic Neighbor Embedding), Anomaly Detection

Neural Networks

Perceptron Model-Feedforward Neural Networks (FFNN)- Activation Functions: ReLU, Sigmoid, Tanh-Backpropagation and Gradient Descent-Convolutional Neural Networks (CNNs) for Image Processing-Recurrent Neural Networks (RNNs) for Sequence Data-Long Short-Term Memory (LSTM) Networks

Reinforcement Learning

Basic concepts**-**Agent, Environment, State, Action, Reward, Exploration vs. Exploitation-Markov Decision Processes (MDPs)- Q-Learning and Deep Q-Networks (DQN), Policy Gradient Methods

Text Book(s)

1. Peter Wlodarczak, Machine learning and its applications, CRC Press,2021
2. Bharti Motwani, Machine Learning for Text and Image Data Analysis: Practical Approach with Business Use Cases, Wiley,2023
3. Stephen Marsland, Machine learning: An algorithmic perspective, CRC press 2015

Reference Books & Web Resources

1. Henrik Brink, Real-world machine learning, Dreamtech press,2017.
2. Ethem Alpaydin, Introduction to machine learning, Second edition, MIT press,2014.
3. Christoper M. Bishop, Pattern recognition and machine learning springer 2011.
4. Ali Ismail Awad, Deep Learning in Computer Vision, Taylor & Francis Ltd,2021

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Machine learning**	
1.1	Types of Learning: Supervised, Unsupervised, and Reinforcement Learning	1
1.2	Overview of ML Workflow: Data Collection, Pre-processing, Data analysis, data post processing	1
1.3	Evaluation, Key challenges in ML: Overfitting, Under fitting, Bias-Variance Trade-off	2
1.4	Generative and discriminative models	2
2	**Supervised Learning**	
2.1	Simple and Multiple Linear Regression-Gradient Descent and Cost Function	2

Module No.	Topic	No. of Periods
2.2	Classification-Logistic Regression, Decision Trees and Random Forests	2
2.3	Support vector machine, k-Nearest Neighbors (k-NN)	2
2.4	application of supervised learning in predictive maintenance analytics and quality systems	2
2.5	Evaluation Metrics-Accuracy, Precision, Recall, F1-score, Confusion Matrix, ROC Curve, AUC (Area Under the Curve)	2
3	**Unsupervised Learning**	
3.1	K-Means Clustering, Hierarchical Clustering, DBSCAN	2
3.2	Dimensionality Reduction-Principal Component Analysis (PCA)	2
3.3	t-SNE (t-Distributed Stochastic Neighbor Embedding), Anomaly Detection	2
4	**Neural Networks**	
4.1	Perceptron Model-Feedforward Neural Networks (FFNN)- Activation Functions: ReLU, Sigmoid, Tanh	2
4.2	Backpropagation and Gradient Descent-Convolutional Neural Networks (CNNs) for Image Processing	2
4.3	Recurrent Neural Networks (RNNs) for Sequence Data-Long Short-Term Memory (LSTM) Networks	2
5	**Reinforcement Learning**	
5.1	Basic concepts-Agent, Environment, State, Action, Reward,	2
5.2	Exploration vs. Exploitation-Markov Decision Processes (MDPs)	2
5.3	Q-Learning and Deep Q-Networks (DQN),	2
5.4	Policy Gradient Methods	2
	Total	**36**

Course Designers:

1. Dr. G Kanagaraj, gkmech@tce.edu
2. Dr. H Ramesh, rameshh@tce.edu

22MTPP0	QUALITY ENGINEERING	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Quality engineering is the management, development, operation and maintenance of manufacturing systems and enterprise architectures with a high-quality standard. It focuses on quality control and quality assurance management through use of physical technology, standards information, and statistical tools.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the seven quality control tools	TPS2	75	70
CO2	Develop the process control charts – variables and attributes.	TPS3	65	65
CO3	Interpret the process control charts.	TPS4	65	60
CO4	Illustrate Multivariate quality control charts	TPS3	65	70
CO5	Develop the Sampling plans	TPS3	65	70
CO6	Compute the system Reliability of different system configuration with redundancy	TPS3	65	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)							Assessment 2 (%)						Terminal (%)		
	CAT 1				Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	4	1	2	3	1	2	3	1	2	3	1	2	3
CO1	8	10	-	-		100		-	-	-	-	-	-	4	5	-
CO2	8	10	20	-				-	-	-	-	-	-	4	5	10
CO3	4	10	20	10				-	-	-	-	-	-	2	5	10
CO4	-	-	-	-	-	-	-	8	-	20		100		4	5	10
CO5	-	-	-	-	-	-	-	8	10	20				4	5	10
CO6	-	-	-	-	-	-	-	4	10	20				2	5	10

Syllabus

Introduction: Quality – Definition, need- variation – causes-TQM - Seven Statistical Quality Control tools, Cost of Quality, DOE, QFD, FMCA, Cause and effect analysis, Roles of ISO and OSHA.
Control charts: Control charts for variables X bar, R and σ charts- control charts for attributes – p, np, c, u chart, CUSUM charts, Exponential Weighted Moving Average (EWMA) chart,
Analysis of process control: Shift in process mean – probability of shift, ARL, process capability analysis, Six Sigma.
Acceptance sampling: Sampling plans – need, types – single sampling plan – OC curve – construction, interpretation, AOQL, ATI- double sampling plan – probability of acceptance, ASN,ATI, AOQL- multiple sampling plans – design of sampling plans – use of Dodge Romig tables, IS2500 Part I and II.
Multivariate quality control: Quality control for two independent variables, two dependent variables- use of covariance matrix – Hoteling T^2 control chart – Monitoring process variability.
Reliability: Reliability- system reliability-series and parallel systems-system reliability in terms of probability of failure-MTBF- Reliability improvement-techniques-Redundancy-standby redundancy optimization in reliability - product Design-product Analysis-Product Development product life.

Text Book(s)

1. Dougles C. Montgomery, **“Introduction to Statistical Quality Control”**, John Wiley and Sons, Inc, Eighth Edition, 2020.

Reference Books & Web Resources

1. Amitava Mitra, **“Fundamentals of Quality Control and Improvement”**, Wily USA, Fourth Edition, 2016.
2. Grant, Eugene .L, **“Statistical Quality Control”**, McGraw-Hill, Tenth reprint, 2008
3. Monohar Mahajan, **“Statistical Quality Control**”, Dhanpat Rai and Co (P) Ltd, Third Edition, 2010.
4. NPTEL Video Lectures – Industrial Engineering, Prof. H.S. Shan, Prof. Pradeep Kumar, Prof. P. K. Jain, IIT-ROORKEE. URL: http://nptel.ac.in/courses/Webcourse-contents/IIT-ROORKEE/INDUSTRIAL-ENGINERRING/
5. L S Srinath, **“Reliability Engineering”,** East west Publishers, 2005.
6. Charles E. Ebeling, **“An Introduction to Reliability and Maintainability Engineering”,** Tata Mc-graw hill publication, eighth edition 2007.
7. Alessandro Birolini, **Reliability Engineering: Theory and Practice, Springer,** Eighth Edition, 2017.
8. Connor, P.D.T.O., **“Practical Reliability Engineering** “, John Wiley, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction:**	
1.1	Quality – Definition, need- variation – causes-TQM	2
1.2	Seven Statistical Quality Control tools, Cost of Quality	2
1.3	DOE, QFD, FMCA, Cause and effect analysis	3
	Roles of ISO and OSHA	1

Module No.	Topic	No. of Periods
2	**Control charts:**	
2.1	Control charts for variables X bar, R and σ charts	2
2.2	control charts for attributes – p, np, c, u chart	2
2.3	CUSUM charts, Exponential Weighted Moving Average (EWMA) chart	2
3	**Analysis of process control:**	
3.1	Shift in process mean – probability of shift, ARL	2
3.2	Process capability analysis, Six Sigma	2
4	**Acceptance sampling:**	
4.1	Sampling plans – need, types – single sampling plan	1
4.2	OC curve – construction, interpretation, AOQL, ATI	2
4.3	double sampling plan – probability of acceptance, ASN,ATI, AOQL- multiple sampling plans	2
4.4	design of sampling plans – use of Dodge Romig tables, IS2500 Part I and II.	2
5	**Multivariate quality control:**	
5.1	Quality control for two independent variables, two dependent variables- use of covariance matrix	3
5.2	Hoteling T^2 control chart – Monitoring process variability.	2
6	**Reliability:**	
6.1	Reliability- system reliability-series and parallel systems, system reliability in terms of probability of failure	2
6.2	MTBF- Reliability improvement-techniques-Redundancy-standby redundancy optimization in reliability -	2
6.3	Product Design-product Analysis-Product Development product life	2
	Total	**36**

Course Designers:

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2. Mr. M.M. Devarajan, mmdmech@tce.edu

22MTPQ0	MICRO ELECTRO MECHANICAL SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Micro Electro Mechanical System (MEMS) contains components of sizes less than 1 millimeter. MEMS achieve engineering functions by electro mechanical or electro Chemical means. In general sensor, an actuator and a signal transduction unit forms the MEMS device. Automobile, Aerospace, Health care are some of the areas where 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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Solve problems in scaling laws applicable to miniaturization.	TPS3	65	70
CO2	Identify the MEMS materials and their preparation	TPS3	60	65
CO3	Identify suitable micro-sensors and Micro-actuators for MEMS application.	TPS3	60	65
CO4	Select a suitable Micro-fabrication process for MEMS Application.	TPS3	60	65
CO5	Select a suitable Micro-manufacturing process for MEMS Application.	TPS3	60	65
CO6	Develop the flow process for fabrication of a silicon based micro pressure sensor, micro channel heat sink, Micro accelerometer	TPS3	60	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	8	20	100			-	-	-	-	-	-	2	4	10
CO2	4	10	20				-	-	-	-	-	-	2	5	10
CO3	4	10	20				-	-	-	-	-	-	2	5	10
CO4	-	-	-	-	-	-	4	8	20	100			2	4	10
CO5	-	-	-	-	-	-	4	10	20				2	5	10
CO6	-	-	-	-	-	-	4	10	20				2	5	10

Syllabus

Introduction: MEMS and Microsystems, products, Evolution of micro-fabrication, Micro system and Microelectronics, The multidisciplinary nature of MEMS, Miniaturization, applications of microsystems in automotive, healthcare, aerospace, and telecommunication fields.
Scaling law in miniaturization: Introduction to scaling, scaling in rigid body dynamics, electrostatic forces, electromagnetic forces, electricity, fluid mechanics and heat transfer.
MEMS Materials and their preparation: Metals, Semiconductors, Ceramics, Polymeric and Composite materials.
Micro Sensors: Acoustic wave sensors, Bio-medical sensors and Bio sensors, Chemical sensors, Pressure sensors, thermal sensors.
Micro Actuators: Actuation using Thermal forces, Shape memory alloys, Piezo-electric Crystals, Electrostatic Forces.
MEMS with Micro-actuators: Micro grippers, Micro motors, Micro valves, Micro Pumps, Micro accelerometers, Micro fluidics.
Micro-system fabrication process: Introduction, Photolithography, ion implantation, diffusion, oxidation, chemical vapour deposition, physical vapour deposition (sputtering), Deposition by epitaxy, wet and plasma etching.
Overview of Micro-manufacturing: Introduction, **Bulk micromachining:** Isotropic and Anisotropic Etching, Wet etchants, Etch Stop, Dry Etching, DRIE, Comparison of Wet versus Dry Etching, surface micromachining, the LIGA process.
Design of micro pressure sensor: Application of micro pressure sensor, process flow for silicon and packaging of micro pressure sensors.
Design of micro-channel heat sink: Application of micro-channel heat sink, silicon wafer preparation SiO_2 Deposition over silicon wafer, photoresist coating, Channel patterning, SiO_2 etching, Deep Reactive Ion Etching of silicon, photo resist removal, anodic bonding of glass and silicon micro-channel.

Text Book(s)

1. Julian W.Gardner, Vijay.K.Varadhan, Osama.O.Awadel karim, Microsensors, MEMS and Smart Devices", John Wiley & Sons, LTD, 2013.

Reference Books & Web Resources

1. Tai–RanHsu,"MEMS and Micro system: Design and Manufacture",Tata McGraw Hill, First Edition, 2002.
2. G.K. Anantha suresh, K. J. Vinoy, S. Gopalakrishnan, K.N.Bhatand, V.K.Athrae, "Micro and Smart System", Wiley India Pvt Ltd, First eition, 2010.
3. Chang Liu,"Foundation of MEMS", 2nd Edition, Pearson education,2012.
4. Marc J Madou, "Fundamentals of micro fabrication and Nano technology", Three volume set 3rdrevised Edition, Taylor and Francis, 2011
5. Gad El Hak (Editor), "The MEMS Hand Book", Three volume set, 2nd revised Edition. CRC press, 2005.
6. https://nptel.ac.in/courses/117/105/117105082/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1.0	**Introduction:** MEMS and Microsystems, products	1
1.1	Evolution of micro-fabrication	1
1.2	Micro system and Microelectronics	1
1.3	The multi-disciplinary nature of MEMS	1
1.4	Miniaturization	1

Module No.	Topic	No. of Hours
1.5	Applications of micro systems in automotive, health care, aerospace, and telecommunication fields.	1
1.6	**Scaling law in miniaturization**: Introduction to scaling, scaling in rigid body dynamics	2
1.6.1	Electro static forces, electromagnetic forces, electricity, fluid mechanics and heat transfer.	1
2.2	**MEMS Materials and their preparation:** Metals, Semiconductors, Ceramics	2
2.2.1	Polymeric and Composite materials	1
3.0	**Micro Sensors:** Acoustic wave sensors, Bio-medical sensors and Bio sensors	2
3.1	Chemical sensors, Pressure sensors, thermal sensors	1
3.2	**Micro Actuators:** Actuation using Thermal forces, Shape memory alloys	2
3.2.1	Piezo-electric Crystals, Electrostatic Forces	2
3.3	**MEMS with Micro-actuators:** Micro grippers, Micro motors, Micro valves	2
3.3.1	Micro Pumps, Micro accelerometers, Microfluidics	1
4.0	**Micro-system fabrication process:** Introduction, Photolithography, ion implantation	1
4.1	diffusion, oxidation, chemical vapour deposition	1
4.1.1	Physical vapor deposition (sputtering)	1
4.1,2	Deposition by epitaxy, wet and plasma etching	1
5.0	**Overview of Micro-manufacturing:** Introduction	1
5.1	**Bulk micro machining:** Isotropic and Anisotropic Etching	
5.1.1	Wet etchants, Etch Stop, Dry Etching, DRIE	1
5.2	Comparison of Wet versus Dry Etching, surface micro machining, the LIGA process.	1
6.0	**Design of micro pressure sensor:** Application of Micro pressure sensor, process flow for silicon and packaging of micro pressure sensors	2
6.1	**Design of micro-channel heat sink:** Application of micro-channel heat sink, silicon wafer preparation, SiO_2 Deposition over silicon wafer, photo-resist coating, Channel patterning, SiO_2 etching, Deep Reactive Ion Etching of silicon, photo resist removal, anodic bonding of glass and silicon micro-channel.	2
6.2	**Design of micro accelerometer:** Application of micro Accelerometer, flow process and packaging of micro accelerometers.	2
	Model Preparation using Simulation software	1
	TOTAL	**36**

Course Designers:

1. Dr. G. Kumaraguruparan, gkgmech@tce.edu
2. Mr. M.M. Devarajan, mmdmech@tce.edu

22MTPR0	SMART HVAC SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	0	Theory

Preamble

HVAC systems consume 50% of electric power in a building and contribute to global warming. Hence energy efficient smart HVAC system becomes inevitable in the mission of decarbonization. This subject deals with of application of control systems, Machine leaning and IoT to build energy efficient smart HVAC system

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Illustrate the principles of Smart HVAC system	TPS2	70%	60%
CO2	Estimate the heat load for given application.	TPS3	70%	60%
CO3	Explain the functioning of control systems pertinent to HVAC systems	TPS2	75%	70%
CO4	Design the control systems for single and multi-zone air handling units	TPS3	70%	60%
CO5	Build IoT hardware and software for Indoor Air quality.	TPS3	70%	60%
CO6	Use machine learning algorithms for Predictive maintenance for HVAC	TPS3	70%	60%

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	7	9	-	100			-	-	-	-	-	-	2	8	-
CO2	7	9	50				-	-	-	-	-	-	2	4	15
CO3	3	15	-				-	-	-	-	-	-	2	8	-
CO4	-	-	-	-	-	-	7	15	17	100			2	5	15
CO5	-	-	-	-	-	-	7	9	17				2	5	15
CO6	-	-	-	-	-	-	3	9	16				-	5	10

Syllabus

Introduction: Vapour compression refrigeration cycle working principle, Ph diagram. Calculation of COP of vapour compression cycle working of a conventional HVAC system, various components of Smart HVAC systems

Cooling load calculation: Psychrometric properties, Psychrometric processes, understanding psychrometric chart. Cooling load calculation of air conditioning systems, using psychrometric chart

HVAC controls: introduction, outside air controls, air stratification, heating, cooling coils, humidity controls, dehumidifiers, static pressure control, electric heat, Refrigeration equipment control systems: reciprocating compressors, centrifugal, positive-displacement compressors, air cooled condensers, water cooled condensers, ,

HVAC control system: single zone systems, multi zone air handling systems, dual duct systems, variable volume systems

IoT Hardware and software: Real time data collection using temperature, Humidity and pressure sensors, IOT based architecture for HVAC system, IOT based valves, dampers and heating elements, IOT controllers and protocols for HVAC system

Learning Algorithms for HVAC systems: Machine learning algorithms for predictive maintenance in cold storage and hospital

Text Book(s)

1. C.P Arora, Refrigeration and air conditioning 4th edition, McGraw Hill, 2021
2. Roger W. Haines and Douglas C Hittle, Control Systems for Heating, Ventilating, and Air Conditioning, 6th Edition, Springer,2006

Reference Books & Web Resources

1. Stephen L Herman and Bennie L Sparkman Electricity & Controls for HVAC/R, First Indian reprint, 2014
2. John D. Kelleher, Brian Mac Namee, Aoife D'Arcy - Fundamentals of Machine Learning for Predictive Data Analytics_ Algorithms, Worked Examples, and Case Studies-The MIT Press (2020)
3. Ross Montgomery and Robert McDowall, Fundamentals of HVAC Control Systems, SI Edition, ASHRAE, 2011

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Vapour compression refrigeration cycle working principle, Ph diagram.	2
1.2	Calculation of COP of vapour compression cycle working of a conventional HVAC system	2
1.3	various components of Smart HVAC systems	2
2	**Cooling load calculation**	
2.1	Psychrometric properties, Psychrometric processes,	3

Module No.	Topic	No. of Periods
	understanding psychrometric chart.	
2.2	Cooling load calculation of air conditioning systems, using psychrometric chart	4
3	**HVAC controls**:	
3.1	Introduction, outside air controls, air stratification, heating, cooling coils	2
3.2	humidity controls, dehumidifiers, static pressure control, electric heat	2
3.3	Refrigeration equipment control systems: reciprocating compressors, centrifugal	2
3.4	positive-displacement compressors, air cooled condensers, water cooled condensers	2
4	**HVAC control system**	
4.1	single zone systems, multi zone air handling systems	2
4.2	dual duct systems, variable volume systems	2
5	**IoT Hardware and software**	
5.1	Real time data collection using temperature, Humidity and pressure sensors,	2
5.2	IOT based architecture for HVAC system, IOT based valves, dampers and heating elements,	3
5.3	IOT controllers and protocols for HVAC system	2
6	**Learning Algorithms for HVAC systems**	
6.1	Machine learning algorithms for predictive maintenance in cold storage and hospital	4
	Total	**36**

Course Designers:

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22MTPS0	EDGE COMPUTING	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course introduces Mechatronics students to edge computing, focusing on its applications in real-time control, robotics, and smart manufacturing. Edge computing enables data processing near devices, allowing faster responses critical for autonomous systems and IoT in Mechatronics. Students will explore key concepts, architectures, and implementation strategies relevant to their field. The students will gain skills in deploying edge solutions that enhance efficiency and reduce latency. This course equips future engineers to harness edge computing for innovative, responsive, and connected mechatronic systems.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the benefits of edge computing in Mechatronic systems	TPS2	75	75
CO2	Explain major edge computing architectures	TPS2	75	75
CO3	Select sensors, microcontrollers which is feasible for edge computing	TPS3	65	65
CO4	Solve data processing and security challenges faced by edge devices	TPS3	65	65
CO5	Illustrate security challenges faced by edge devices	TPS3	65	65
CO6	Select suitable edge computing architectures for a given application	TPS3	65	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	10	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	10	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO3	-	-	40	-	100	-	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	10	10	15	-	-	-	-	-	20
CO5	-	-	-	-	-	-	10	5	15	-	-	-	-	-	20
CO6	-	-	-	-	-	-	10	5	20	-	-	100	-	-	20

Syllabus

Introduction:
Fundamentals of Edge Computing, Edge vs. Cloud Computing - Need for Edge and Cloud - Edge benefits for latency, data privacy, and real-time applications. Relevance to Mechatronics

Architecture:
Key Components- Edge devices-Sensors, actuators and IoT devices, AI Models, Edge Computing Frameworks, Connectivity modules, Gateways, fog nodes, Network, Cloud backend - Integration with Cloud. Case study - Edge Computing architecture for a search and rescue robot.

Edge Computing Hardware:
Microcontrollers and Communication Interfaces selection, protocols (MQTT, CoAP, HTTP, WebSocket, LoRaWAN, and cellular), and GPIO configuration. Optimization of AI models in terms size reduction – regularization – normalization – pruning - clipping. Effect of network latency. Developing gateways with microcontroller -Setting up edge-cloud interaction. Edge training and inference. Practical setup of edge hardware components.

Data storage and Security at the Edge:
Storage needs and limitations. Data Optimization and Reduction; Data compression, pre-processing, and efficient storage practices. Security Threats and Challenges at the Edge. Overview of common threats (e.g., data tampering, unauthorized access). Security Measures: Implementing encryption, device authentication, and secure boot processes. Privacy and Data Management: Privacy considerations, GDPR, and best practices in data anonymization.

Case Studies:
Integrating Edge AI for tasks like object detection and classification. Edge-based SLAM (Simultaneous Localization and Mapping) and motion planning. 5G-enabled Edge, AI at the Edge.

Text Book(s)

1. AI at the Edge by Daniel Situnayake, Jenny Plunkett · 2023 published by O'Reilly Media.

Reference Books & Web Resources

1. "Edge AI: Convergence of Edge Computing and Artificial Intelligence" by Xiaofei Wang, Yiwen Han, and Victor C.M. Leung (2020).
2. "Artificial Intelligence and Machine Learning for EDGE Computing" by Rajiv Pandey, Bhawana Rudra, and Jyotir Moy Chatterjee (2022).

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Fundamentals of Edge Computing,	1
1.2	Edge vs. Cloud Computing	1
1.3	Need for Edge and Cloud	1
1.4	Edge benefits for latency	1
1.5	Data privacy, and real-time applications	1
1.6	Relevance to Mechatronics	1
2	**Architecture**	
2.1	Key Components	1

Module No.	Topic	No. of Periods
2.2	Edge devices-Sensors, actuators and IoT devices	1
2.3	AI Models	1
2.4	Edge Computing Frameworks	1
2.5	Connectivity modules	1
2.6	Gateways, fog nodes	1
2.7	Network, Cloud backend, Integration with Cloud	1
2.8	Case study - Edge Computing architecture for a search and rescue robot.	1
3	**Edge Computing Hardware**	
3.1	Microcontrollers and Communication Interfaces selection	1
3.2	Protocols (MQTT, CoAP)	1
3.3	HTTP, WebSocket	1
3.4	LoRaWAN, and cellular and GPIO configuration	1
3.5	Optimization of AI models in terms size reduction - regularization – normalization – pruning - clipping	1
3.6	Effect of network latency	1
3.7	Developing gateways with microcontroller	1
3.8	Setting up edge-cloud interaction	1
3.9	Edge training and inference, Practical setup of edge hardware components.	1
4	**Data storage and Security at the Edge**	
4.1	Storage needs and limitations.	1
4.2	Data Optimization and Reduction	1
4.3	Data compression, pre-processing, and efficient storage practices	1
4.4	Security Threats and Challenges at the Edge	1
4.5	Overview of common threats (e.g., data tampering, unauthorized access).	1
4.6	Security Measures: Implementing encryption,	1
4.7	device authentication, and secure boot processes	1
4.8	Privacy and Data Management: Privacy considerations	1
4.9	GDPR, and best practices in data anonymization	1
5	**Case Studies**	
5.1	Integrating Edge AI for tasks like object detection and classification.	1
5.2	Edge-based SLAM (Simultaneous Localization and Mapping)	1
5.3	motion planning	1
5.4	5G-enabled Edge, AI at the Edge	1
	Total	**36**

Course Designers:

1. Mr. Ganesh M A, ganeshma2015@tce.edu
2. Mr. S Parthasarathi, parthasarathi_s@tce.edu

<table>
<tr><td rowspan="2">22MTPT0</td><td rowspan="2">WIRELESS SENSOR NETWORKS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td><td>TE</td></tr>
<tr><td>PSE</td><td>3</td><td>0</td><td>0</td><td>3</td><td>Theory</td></tr>
</table>

Preamble

This course provides an in-depth introduction to Wireless Sensor Networks (WSNs), focusing on the foundational principles of wireless communication, sensor network architecture, and energy harvesting techniques. It examines various wireless network types and standards, the core components of sensor nodes, and addresses critical challenges in scalability, reliability, and deployment. Topics include energy harvesting methods like solar, thermal, and RF, as well as energy storage and management strategies. Additionally, the course explores Medium Access Control (MAC) protocols, routing protocols, and Quality of Service (QoS) considerations. Security aspects specific to WSNs are also covered, encompassing cryptographic techniques and intrusion detection, along with relevant case studies.

Prerequisite

- Nil

Course Outcomes

Upon successful completion of this course, students will be able to:

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Interpret foundational principles of wireless networking to address network challenges.	TPS2	75	70
CO2	Analyse and evaluate the architecture of sensor networks.	TPS3	80	75
CO3	Construct sensor networks for specific real-world needs	TPS3	85	80
CO4	Demonstrate different energy harvesting techniques in WSNs.	TPS3	80	75
CO5	Implement and assess routing protocols for efficient network performance in WSNs	TPS3	85	80
CO6	Identify security challenges in WSNs and effective mitigation strategies.	TPS3	80	75

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><td rowspan="2">CO</td><td colspan="6">Assessment 1 (%)</td><td colspan="6">Assessment 2 (%)</td><td colspan="3" rowspan="2">Terminal (%)</td></tr>
<tr><td colspan="3">CAT 1</td><td colspan="3">Assignment 1</td><td colspan="3">CAT 2</td><td colspan="3">Assignment 2</td></tr>
<tr><td>TPS</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>CO1</td><td>10</td><td>10</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>20</td><td>-</td></tr>
<tr><td>CO2</td><td>-</td><td>20</td><td>20</td><td>-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10</td><td>10</td></tr>
<tr><td>CO3</td><td>-</td><td>20</td><td>20</td><td>-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>20</td><td>20</td><td colspan="3" rowspan="3">100</td><td>-</td><td>10</td><td>10</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>15</td><td>15</td><td>-</td><td>-</td><td>10</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>15</td><td>15</td><td>-</td><td>-</td><td>20</td></tr>
</table>

Syllabus

Introduction to Wireless Sensor Networks: Overview and definition of Wireless Sensor Networks (WSNs) – Significance of WSNs in modern applications – Roles and benefits of WSNs in data collection and analysis – Introduction to sensor nodes and wireless networking – Key concepts of frequency, wavelength, and bandwidth – Need for energy efficiency and robust design in WSN applications.

Wireless Communication Fundamentals: Basics of wireless communication principles – Frequency, modulation techniques, and signal propagation – Types of Wireless Networks (WPAN, WLAN, WMAN, WWAN) – Overview of IEEE wireless standards (IEEE 802.11, IEEE 802.15) – Challenges in wireless signal propagation: attenuation, interference, and fading – Key performance metrics for wireless networking.

Sensor Network Architecture and Applications: Introduction to sensor network architectures – Components of a sensor node (sensing, processing, communication, power) – Types of sensor networks (environmental, industrial, healthcare, etc.) – Real-world applications of WSNs in various industries – Challenges in sensor network design: scalability, deployment, and fault tolerance.

Energy Harvesting Techniques in WSNs: Introduction to energy harvesting and its importance in WSNs – Types of energy sources for WSNs (solar, thermal, vibration, RF) – Energy storage solutions (batteries, supercapacitors) – Energy management strategies and protocols – Energy-efficient hardware design and low-power communication techniques – Benefits and limitations of energy harvesting in WSNs.

Network Protocols and Data Management: Overview of Medium Access Control (MAC) protocols – MAC protocols used in WSNs: TDMA, CSMA/CA, etc. – Routing protocols in WSNs (data-centric, location-based, hierarchical) – Data aggregation techniques and methods to minimize energy consumption – Quality of Service (QoS) considerations for WSN applications – Performance evaluation of network protocols.

Security in Wireless Sensor Networks: Security challenges unique to WSNs due to resource constraints – Common security threats and vulnerabilities in WSNs – Cryptographic techniques and protocols for secure data transmission – Overview of Intrusion Detection Systems (IDS) in WSNs – Case studies of security breaches in WSNs – Security best practices and solutions for WSNs.

Applications and Case Studies: Role of WSNs in various fields: environmental monitoring, healthcare, industrial automation, smart cities – Case studies highlighting the applications of WSNs in real-world scenarios – Analysis of WSN performance in different applications – Evaluating the benefits, limitations, and future potential of WSN

Text Book(s)

1. Elhoseny, M., & Hassanien, A.E., "Wireless Sensor Networks: Principles, Design, and Applications", Springer, 1st edition, 2021.
2. Zheng, J., & Jamalipour, A., "Wireless Sensor Networks: A Networking Perspective", Wiley, 2nd edition, 2022.

Reference Books & Web Resources

1. Fontecha, J., & Islam, M.T., *"Energy Harvesting for Wireless Sensor Networks: Principles and Applications"*, Elsevier, 2020.
2. Sohraby, K., Minoli, D., & Znati, T., *"Wireless Sensor Networks: Technology, Protocols, and Applications"*, Wiley, Updated Edition, 2020.
3. NPTEL Course: Misra, Sudip. "Wireless Ad Hoc and Sensor Networks." NPTEL, Indian Institute of Technology Kharagpur. NOC | Wireless Ad Hoc and Sensor Networks

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Fundamentals of Wireless Networking**	
1.1	Introduction to wireless communication	2
1.2	Types of wireless networks	2
1.3	Wireless standards	3
1.4	Modulation and signal propagation	3
2	**Overview of Sensor Networks**	
2.1	Introduction and applications	3
2.2	Types of sensor networks	3
2.3	Sensor node architecture	2
2.4	Challenges in design	2
3	**Energy Harvesting Techniques**	
3.1	Introduction to energy harvesting	2
3.2	Types of energy sources	2
3.3	Energy storage solutions	1
3.4	Energy management strategies	1
4	**Network Protocols and Architectures**	
4.1	MAC protocols	2
4.2	Routing protocols	2
4.3	Data aggregation techniques	1
4.4	QoS considerations	1
5	**Security in Wireless Sensor Networks**	
5.1	Security challenges	1
5.2	Cryptographic techniques	1
5.3	Intrusion detection systems	1
5.4	Case studies	1
	Total	**36**

Course Designer(s):

1. Mr. S. Parthasarathi, parthasarathi_s@tce.edu
2. Mr. M.M.Devarajan, mmdmech@tce.edu

<table>
<tr><td rowspan="2">22MTRB0</td><td rowspan="2">BIO-MECHATRONIC SYSTEMS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td><td>TE</td></tr>
<tr><td>PEES</td><td>1</td><td>0</td><td>4</td><td>3</td><td>Practical</td></tr>
</table>

Preamble

This course introduces students to the interdisciplinary field of bio-mechatronics, combining elements of human anatomy, biomedical signal and image processing, and mechatronic system design. Students will gain foundational knowledge in human anatomy relevant to biomedical engineering applications, covering bio-sensors, actuators, and signal processing techniques. Software based experiments will be used for simulation, analysis, and real-time signal processing.

Prerequisite

- 22MT450 - Digital Signal Processing

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Describe the key anatomical structures of human body related to bio-signals	TPS 2	80	70
CO2	Explain the nature and characteristics of biomedical signals	TPS 2	80	70
CO3	Explain biomedical signal processing techniques	TPS 2	80	70
CO4	Describe the role of therapeutic and diagnostic biomedical instruments in measuring bio-signals	TPS 2	80	70
CO5	Interpret the bio-signal using simulation software	TPS 3	70	65
CO6	Design a bio-mechatronic systems using sensors and actuators for bio-medical applications.	TPS 3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><td rowspan="2">CO</td><td colspan="8">Continuous Assessment (%)</td><td colspan="3" rowspan="2">Terminal (%)</td></tr>
<tr><td colspan="3">CAT 1</td><td colspan="3">CAT 2</td><td>Experiments</td><td>Model Exam</td></tr>
<tr><td>TPS</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>3</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>CO1</td><td>10</td><td>20</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td colspan="2" rowspan="4">20*</td><td>-</td></tr>
<tr><td>CO2</td><td>10</td><td>30</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>CO3</td><td>10</td><td>20</td><td>-</td><td>10</td><td>40</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td>10</td><td>40</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2">100</td><td rowspan="2">100</td><td>-</td><td>-</td><td rowspan="2">80#</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

* - Viva; # - Practical

Syllabus

Fundamentals of Human Anatomy and Physiology
Overview of human anatomy - Key anatomical structures of the cardiovascular system – skeletal – muscular - nervous systems. Overview of bio-signals and their importance in biomedical applications.

Biomedical Signals
Types of biomedical signals such as ECG, EMG, EEG - Signal acquisition - Signal characteristics: amplitude, frequency, noise sources, and signal duration. Physiological and electrical characteristics of ECG, EMG, and EEG signals.

Bio-Signal Analysis
Introduction to simulation software for biomedical applications - Visualizing and analyzing ECG, EMG, and EEG signals - Steps in preprocessing, filtering, and segmenting bio-signals. Interpretation of signal data and extracting relevant features.

Biomedical Instruments
Overview of biomedical diagnostic instruments - Therapeutic devices: defibrillators, pacemakers, and ventilators. Role of sensors and transducers in bio-signal measurement. Safety standards and precautions in biomedical instrumentation.

Designing Bio-Mechatronic Systems
Components of a bio-mechatronic system: sensors, actuators, and controllers - Real-time processing and monitoring of bio-signals using sensors – Case Study

Text Book(s)

1. Ganesh R. Naik, Wellington Pinheiro dos Santos, “Biomedical Signal Processing. A Modern Approach”, CRC Press, 2024

Reference Books and Web Resources

1. Segil, Jacob, Handbook of biomechatronics, Academic Press, I Edition, 2019
   Khandpur, R.S., “Handbook of Biomedical Instrumentation”, Tata McGraw Hill, III Edition, 2014
2. NPTEL Course: Biomedical Instrumentation & Sensors - https://onlinecourses.swayam2.ac.in/nou25_bt02/course
3. NPTEL Course: Biomedical Signal Processing - By Prof. Sudipta Mukhopadhyay, IIT Kharagpur: https://onlinecourses.nptel.ac.in/noc20_ee41/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	
		Theory	Practical
1	**Fundamentals of Human Anatomy and Physiology**	-	-
1.1	Introduction	1	-
1.2	Overview of human anatomy	2	-
1.3	Key anatomical structures of the cardiovascular system – skeletal – muscular - nervous systems.	2	-
1.4	Overview of bio-signals and their importance in biomedical applications	2	-
2	**Biomedical Signals**		-

Module No.	Topic	No. of Hours	
		Theory	Practical
2.1	Types of biomedical signals such as ECG, EMG, EEG	1	-
2.2	Signal acquisition - Signal c*haracteristics: amplitude, frequency, noise sources, and signal duration.	1	-
2.3	Physiological and electrical characteristics of ECG, EMG, and EEG signals	2	-
	Generation of Bio Signals	-	6
3	**Bio-Signal Analysis**	-	-
3.1	Introduction to simulation software for biomedical applications	1	-
3.2	Visualizing and analyzing ECG, EMG, and EEG signals - Steps in preprocessing, filtering, and segmenting bio-signals.	2	-
3.3	Interpretation of signal data and extracting relevant features.	2	-
	Analysis and interpretation of bio-Signals	-	6
4	**Biomedical Instruments**	-	-
4.1	Overview of biomedical diagnostic instruments	1	-
4.2	Therapeutic devices: defibrillators, pacemakers, and ventilators.	1	-
4.3	Role of sensors and transducers in bio-signal measurement. Safety standards and precautions in biomedical instrumentation.	1	-
	Simulating Therapeutic devices	-	4
	Building a bio-feedback signal using DAQ	-	4
5	**Designing Bio-Mechatronic Systems**	-	-
	Components of a bio-mechatronic system: sensors, actuators, and controllers	2	-
	Real-time processing and monitoring of bio-signals using sensors	2	-
	Case Study	1	-
	Building a closed loop bio medical system for an application	-	4
	Total	**24**	**24**

Course Designers:

1. Dr. M Rajalakshmi, mrimect@tce.edu
2. Mr. Sheik Masthan S A R, sarsmech@tce.edu

22MTRC0	ADDITIVE MANUFACTURING	Category	L	T	P	C	TE
		PEES	3	0	0	3	Theory

Preamble

Additive Manufacturing is a technique used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology. Additive manufacturing improves product development by enabling better communication in a concurrent engineering environment and also reduces product development cycle time. This course aims to provide knowledge on the additive manufacturing and its application, advantages, limitations.

Prerequisite

- 22MT250 - Manufacturing Process

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Illustrate the concepts of prototypes and AM process chain	TPS2	65	70
CO2	Select the suitable Liquid based AM process for a given product/part drawing/Application	TPS3	65	65
CO3	Select the suitable solid based AM/Powder based AM process for a given product/part drawing/Application	TPS3	65	65
CO4	Select suitable Metal AM for a given product/part drawing/Application	TPS3	65	65
CO5	Choose the suitable AM process for rapid tooling application	TPS3	65	65
CO6	Build the steps involved in reverse engineering	TPS3	65	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	4	15	-				-	-	-	-	-	-	2	10	-
CO2	4	5	30		100		-	-	-	-	-	-	2	8	10
CO3	7	5	30				-	-	-	-	-	-	2	5	10
CO4	-	-	-	-	-	-	4	10	15				2	5	10
CO5	-	-	-	-	-	-	4	10	15		100		2	5	10
CO6	-	-	-	-	-	-	2	10	30				2	5	10

Syllabus

Introduction: Definition of Prototypes, Roles of Prototypes, Need for time compression in product development, History of AM Process, classification of AM Process - Fundamentals of AM Process – Process chain of AM Process – Data format – STL files. Benefits of AM.

Liquid Based AM: Stereo Lithography Apparatus (SLA) – Principle – Photo polymerization – Post processes – process parameters – Machine details – Advantages – Problems in computing time to build parts, Solid Ground Curing (SGC) – Principle – processes parameters – Process details - Machine details – Limitations.
Solid Based AM: Fusion Deposition Modelling (FDM) – Principle – Raw materials – BASS – Water soluble support system – Process parameters – Machine details – Advantages and limitations, Laminated Object Manufacturing (LOM) – Principle – Processes parameters – Process details – Advantages and limitations.

Metal Additive Manufacturing: Processes – Types – Friction stir AM - Direct Energy Deposition (DED) – Wire arc AM – Binder Jetting – Sheet Lamination, Post Processing
Powder based AM: Selective Laser Sintering (SLS) – Principle – process parameters – Process details –Machine details. Electron beam Melting (EBM) - Principle – process parameters – Process details –Machine details.

Rapid Tooling and Applications of AM: Classification of Rapid Tooling - Indirect rapid tooling - Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Direct rapid tooling - Direct ACES Injection Moulding. Soft tooling vs hard tooling, Applications of AM in product design, automotive industry, medical field – Case studies, Role of AM Process parameter on Part Quality, Growth of AM industry

Reverse Engineering: Introduction - Definition - Generic Process - Scanning – Point Processing – Geometric model development - Applications of reverse engineering.
Case Studies and demonstration of 3D model generation using additive manufacturing method.

Text Book(s)

1. Chua, C.K. Leong, K.F. and Lim, C.S. **"Rapid Prototyping: Principles and Applications",** World Scientific, New Jersey, 5th edition, 2017.
2. Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani**, "Additive Manufacturing Technologies"**, Springer, 2021.
3. Diegel, Olaf, Axel Nordin, and Damien Motte**, "A Practical Guide to Design for Additive Manufacturing"**, Springer, 2020.
4. Redwood, Ben, Filemon Schoffer, and Brian Garret, "**The 3D Printing Handbook: Technologies, Design and Applications"**, 3D Hubs, 2017.

5. Balasubramanian, K.R. and Senthilkumar, V., “Additive Manufacturing Applications for Metals and Composites”, IGI Global, 2020

Reference Books & Web Resources

1. Pham, D.T. and Dimov, S.S., **“Rapid manufacturing”,** Springer-Verlag, Londo, 2011.
2. Jacobs, P.F., **“Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography**”, McGraw-Hill, New York, 2011.
3. Hilton. P.D., **“Rapid Tooling”,** Marcel Dekker, New York, 2000.
4. **Rapid Prototyping Journal**, Emerald Group Publishing Limited.
5. www.utah.edu/~asn8200/rapid.html
6. http://www.cheshirehenbury,com/rapid/index.html
7. https://nptel.ac.in/courses/112104162/
8. https://nptel.ac.in/courses/112/104/112104265/
9. https://courses.gen3d.com/courses/enrolled/988400
10. https://all3dp.com/1/design-for-additive-manufacturing-dfam-simply-explained/#where-to-learn-dfam

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction:**	
1.1	Definition of Prototypes, Roles of Prototypes	1
1.2	History of AM Process, classification of AM Process, benefits of AM.	1
1.3	Need for time compression in product development	1
1.4	Fundamentals of AM Process – Process chain of AM Process – Data format – STL files	2
2	**Liquid Based AM:**	
2.1	Stereo Lithography Apparatus (SLA) – Principle	1
2.2	Photo polymerization – Post processes - process parameters	1
2.3	Machine details – Advantages, Problems in computing time to build parts	1
2.4	Solid Ground Curing (SGC) – Principle	2
2.5	Processes parameters	1
2.6	Process details - Machine details – Limitations	
3	**Solid Based AM:**	
3.1	Fusion Deposition Modelling (FDM) – Principle – Raw materials – BASS	1
3.2	Water soluble support system – Process parameters	1
3.3	Machine details – Advantages and limitations	1
3.4	Laminated Object Manufacturing – Principle – Processes parameters - Process details – Advantages and limitations	2
3.5	Metal Additive Manufacturing processes,	1
3.6	Processes, Types	1
3.7	Friction stir AM	1
3.8	Direct Energy Deposition (DED), Wire arc AM	1

Module No.	Topic	No. of Periods
3.9	Binder Jetting, Sheet Lamination	1
4	**Powder based AM:**	
4.1	Selective Laser Sintering (SLS) – Principle – process parameters - Process details –Machine details	2
4.2	Electron beam Melting (EBM) - Principle – process parameters – Process details - Machine details	2
5	**Rapid Tooling and Applications of AM:**	
5.1	Classification of Rapid Tooling - Indirect Rapid Tooling – Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling	1
5.2	Direct Rapid Tooling – Direct ACES Injection Moulding - soft tooling Vs hard tooling	1
5.3	Applications of AM in product design, automotive industry, medical field	1
5.4	Case studies	1
5.5	Role of AM Process parameter on Part Quality	1
5.6	Growth of AM industry	
6	**Reverse engineering**:	
6.1	Introduction – Definition	1
6.2	Generic Process – Scanning – Point Processing – Geometric model development	1
6.3	Applications of reverse engineering.	1
6.4	Demonstration of 3D model generation using additive manufacturing method	1
	Total	**36**

Course Designers:

1. Mr. M.M. Devarajan, mmdmech@tce.edu
2. Mr. S Parthasarathi, parthasarathi_s@tce.edu

22MTSA0	INDUSTRIAL DRIVES AND CONTROL	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

An Industrial Drives and Control syllabus typically focuses on the study of mechanical, fluidic and electrical drives and their control mechanisms, specifically in industrial applications. The syllabus covers the principles, design, operation, and control of electrical machines and drives used in various industries. The subject is highly interdisciplinary, combining elements of electrical engineering, electronics, control theory, and mechanical systems.

Prerequisite

- Nil

Course Outcomes

Upon successful completion of this course, students will be able to:

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Design a drive train for motion control applications	TPS3	75	70
CO2	Explain the function of valves and actuators in Fluidic drives	TPS2	80	75
CO3	Develop fluidic drive circuit for bottle filling station.	TPS3	75	70
CO4	Describe FOC control on PMSM motor.	TPS2	75	70
CO5	Write plc programming for material handling system	TPS3	75	70
CO6	Integrate and perform data visualization of fluidic, electric drives using SCADA	TPS3	75	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	10	20	-	-	-	-	-	-	-	-	-	4	5	-
CO2	4	20	-	-	-	50	-	-	-	-	-	-	4	5	10
CO3	2	20	20	-	-	50	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	4	20	-	-	-	-	4	5	-
CO5	-	-	-	-	-	-	4	15	20	-	-	50	2	5	15
CO6	-	-	-	-	-	-	2	15	20	-	-	50	2	5	15

Syllabus

Mechanical Drives

Drive train Design-Inertia and torque reflection, Inertia ratio, Transmission mechanisms- Load and Inertia Reflection through Transmission Mechanisms, Pulley-and-Belt, Lead Screw, Rack-and-Pinion Drive, Belt-Drive for Linear Motion, Torque Required for the Motion, Gearboxes, Motor, Gearbox, and Transmission Mechanism Selection–Case study on drive train design for Machine tools and conveyor systems.

Fluidic Drives

Importance of fluid power in modern machinery-Basic principles: Pascal's law, continuity equation, and Bernoulli's Principle-Components of Hydraulic Systems-Properties of hydraulic fluids: types and selection, Valves, actuators, Filters and accumulators-Hydraulics circuit Design. Pneumatic systems-Properties of compressed air and gases (Boyle's Law, Charles's Law), Valves, Actuators, Pneumatic circuit design.

Electric Drives

Induction motor drives-VFD control, direct torque control, vector control, FOC control –BLDC Motor drives and its control- PMSM Motor Drives-FOC control, Direct torque control, sensor less control –servo motor drives- position, speed, and torque control-PID control of servo motors.

Industrial Controllers

Programmable logic controllers (PLC)-basic components, I/O modules, execution cycle, architecture, programming and communication-Distributed Control systems (DCS)-Components, architecture and working, DCS control strategies, Integration with PLC and SCADA- SCADA Systems-components of scada, client-server architecture, communication protocols, HMI design and functionality.

Text Book(s)

1. Anthony Esposito, Fluid power with applications, Pearson,2023
2. M.T.White Mastering PLC programming, Packt Publishing,2023
3. Hakan Gurocak, Industrial Motion control, Wiley,2018

Reference Books & Web Resources

1. Frank Petruzella,Programmable logic controllers,Mc Graw Hill,2023

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Mechanical Drives**	
1.1	Drive train Design-Inertia and torque reflection, Inertia ratio	2
1.2	Transmission mechanisms- Load and Inertia Reflection through Transmission Mechanisms	2
1.3	Pulley-and-Belt, Lead Screw, Rack-and-Pinion Drive,	2
1.4	Belt-Drive for Linear Motion, Torque Required for the Motion	2
1.5	Gearboxes, Motor, Gearbox, and Transmission Mechanism Selection	1
1.6	Case study on drive train design for Machine tools and conveyor systems.	2
2	**Fluidic Drives**	

Module No.	Topic	No. of Periods
2.1	Importance of fluid power in modern machinery-Basic principles: Pascal's law, continuity equation, and Bernoulli's principle	2
2.2	Components of Hydraulic Systems-Properties of hydraulic fluids	2
2.3	Types and selection, Valves, actuators, Filters and accumulators-Hydraulics circuit Design.	2
2.4	Pneumatic systems-Properties of compressed air and gases (Boyle's Law, Charles's Law),	2
2.5	Valves, Actuators, Pneumatic circuit design.	2
3	**Electric Drives**	
3.1	Induction motor drives-VFD control, direct torque control	2
3.2	Vector control, FOC control	1
3.3	BLDC Motor drives and its control	1
3.4	PMSM Motor Drives-FOC control, Direct torque control, sensor less control	1
3.5	Servo motor drives- position, speed, and torque control-PID control of servo motors.	2
4	**Industrial Controllers**	
4.1	Programmable logic controllers (PLC)-basic components, I/O modules, execution cycle, architecture	2
4.2	Programming and communication	2
4.3	Distributed Control systems (DCS)-Components, architecture and working, Integration with PLC and SCADA	2
4.4	SCADA Systems-components of scada, client-server architecture, communication protocols,	2
4.5	HMI design and functionality, Data visualization	2
	Total	**36**

Course Designer(s):

1. Dr. H Ramesh, rameshh@tce.edu
2. Dr. S Julius Fusic, sjf@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Industry Supported Courses

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)
			L	T	P	
22MT1A0	IOT Based Cartridge Valves	PEES	1	0	0	1
22MT2B0	Reliability for Mechatronic Systems	PEES	2	0	0	2

PSE : Programme Specific Elective

PEES : Programme Elective for Expanded Scope

IE : Interdisciplinary Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE#	Max. Marks	TE#	Total
22MT1A0	IOT Based Cartridge Valves	3	40	60	100	27	50
22MT2B0	Reliability for Mechatronic Systems	3	40	60	100	27	50

***** CA – Continuous Assessment:

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.

TE - Terminal Examination

22MT1A0	IOT BASED CARTRIDGE VALVES	Category	L	T	P	C	TE
		PEES	1	0	0	1	Theory

Preamble

Hydraulics and Pneumatics are applied in a wide range of Industries: From construction machinery, automobiles, and air planes (outdoor) to machine tools and Press machines (Indoor). Hydraulic systems are extremely important to the operation of heavy equipment. Hydraulic principles are used when designing steering systems, brake systems, power train systems and automatic transmissions. Cartridge valves play a major role in mining, construction, agricultural and material handling equipment's and so on.

Prerequisite

- 22MT520 - Industrial Automation

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Identify different cartridge valve components used in pneumatics & Hydraulics	TPS2	80	70
CO2	Develop custom manifolds for Cartridge valves.	TPS3	80	70
CO3	Explain functioning of hydraulic cartridge electronics and control unit.	TPS2	80	70
CO4	Develop IOT Circuits for Different types cartridge valves used in Mobile vehicle applications.	TPS3	80	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment (%)						Terminal (%)		
	CAT 1			Assignment 1					
TPS	1	2	3	1	2	3	1	2	3
CO1	10	20	-	100			10	20	-
CO2	-	-	20				-	-	20
CO3	10	20	-				10	20	-
CO4	-	-	20				-	-	20

Syllabus

Pumps and Motors: Basics of pneumatics and hydraulics – Hydraulics Pumps and Motors -Gear pumps and gear motors- Pressure control valves, Flow control valves, Directional Control valves.

Cartridge Valves: 2 way and 3-way direction spool valve- 4-way 2-position solenoid operated directional spool valve- vented counter balance valve- soft shift directional spool valve- Needle control valves- Motor connect manifolds- BSPP and NPTF manifolds-Design of custom manifolds for cartridge valves- Electro-proportional direct-acting pressure reducing/relieving valve – Direct acting sequence valve - Electro-proportional flow control valve

Controls and Circuits of Cartridge valves: Design of control circuit for cartridge proportional valves - Basics of IOT circuits- Accumulator sense pump loading and unloading assembly- Timer connector- Twin leads connector- embedded proportional IR amplifier- CAN to USB communication protocol- configurable proportional solenoid driver- Cavity converter- Electro hydraulic hitch control for tractors- Applications of IOT based cartridge valves in mobile machines and its typical control circuits.

Reference Books and Web Resources

1. https://www.sunhydraulics.com/models/cartridges.
2. Ian C. Turner, Engineering Applications of Pneumatics and Hydraulics, Routledge,2020
3. Marian Muste, Experimental Hydraulics: Methods, Instrumentation, Data Processing and Management, CRC Press,2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Pumps and Motors**	
1.1	Hydraulic pumps and motors for Mobile Applications, Gear Pumps and Gear Motors	1
1.3	Electro hydraulic pumps, Pressure valves, Flow Control valves	1
1.5	Directional Control Valves	1
2	**Cartridge Valves**	
2.1	2 way and 3-way direction spool valve- Direct acting sequence valve - Electro-proportional flow control valve	1
2.2	4-way 2-position solenoid operated directional spool valve	1
2.3	Vented counter balance valve- Soft shift directional spool valve	1
2.4	Electro-proportional direct-acting pressure reducing/relieving valve	1
2.5	Needle control valves- Motor connect manifolds- BSPP and NPTF manifolds.	
2.6	Design of custom Manifolds for cartridge valves	1
3	**Controls and circuits of cartridge valves**	
3.1	Design of control circuit for cartridge proportional valves	1
3.2	Basics of IOT circuits	1
3.3	Accumulator sense pump loading and unloading assembly	1
3.4	Timer connector- Twin leads connector- embedded proportional IR amplifier	1
3.5	CAN to USB communication protocol- configurable proportional solenoid driver- Cavity converter	1
3.6	Electro hydraulic hitch control for tractors- Applications of IOT based cartridge valves in mobile machines and its typical control circuits.	1
	Total	**14 Hours**

Course Designers:

1. Mr. R Raghunathan, raghunathan@hydroquiphydraulics.com
2. Dr. H. Ramesh, rameshh@tce.edu
3. Dr. S. Julius Fusic, sjf@tce.edu

22MT2B0	RELIABILITY FOR MECHATRONIC SYSTEMS	Category	L	T	P	C	TE
		PEES	2	0	0	2	Theory

Preamble

Reliability engineering is one of the most important quality characteristics of a product and indeed, an integral part of the design, development, test and manufacture of any product. It is an engineering discipline, a combination of Physics, Statistics and Engineering for applying scientific know-how to a component, product, plant, or process in order to assure that it performs its intended function, without failure, for the required time duration in a specified environment, It is needless to say that customer focus is the key element of reliability engineering demonstrating how company develops products and production systems with clear advantage of customer satisfaction and hence stakeholders delight. As practicing engineer or a beginner, it is essential to understand the concepts, tools, methods, processes and apply some of the techniques used in the industry to develop reliable mechatronics systems and products and be an architect of such designs

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain the concepts of reliability engineering and practices in Mechatronic systems development in Industry	TPS2	75	70
CO2	Explain the statistical concepts related to reliability in Mechatronic systems development in Industry	TPS2	75	70
CO3	Demonstrate the relationship between the time to failure, reliability and the hazard rate	TPS3	70	65
CO4	Use design and quality tools necessary to ensure a reliable Mechatronic product	TPS3	70	65
CO5	Estimate reliability values from test data and set confidence limits on the results	TPS3	70	65
CO6	Demonstrate the reliability in repairable and non-repairable systems	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment (%)						Terminal (%)		
	CAT 1			Assignment 1					
TPS	1	2	3	1	2	3	1	2	3
CO1	4	10	-	100			4	10	-
CO2	4	10	-				4	10	-
CO3	2	6	10				2	6	10
CO4	2	6	10				2	6	10
CO5	2	6	10				2	6	10
CO6	2	6	10				2	6	10

Syllabus

Introduction – Primer for Beginner – Benefits of Reliability Engineering, Definition, interrelationships of safety, quality and Reliability, Elements of reliability management, program and function in product Development & Process

Statistics for Reliability Engineering - Basic Statistical concepts and probability distributions, SPC Techniques / control charts applied to reliability engineering, Advanced statistical concepts, Taguchi robust design concepts used in Reliability estimation, Mathematical Aspects of customer requirements

Reliability in Design and Development for mechanical and electrical systems - Reliabilitydesign concepts: Environmental and use Factor, Stress-Strength relationship, etc., Tools, methods (FMEA, FMECA, etc.), Reliability Allocation, parts, materials and system management, DFX : Design for X standards and techniques

Reliability Modeling and Prediction - Reliability Block Diagram and models and data for modeling, Physics of Failure approach and mechanisms in Mechanical and electrical systems, Reliability Prediction methods Parts count, Part Stress Analysis, thermal analysis, Industry data

Reliability Testing - Reliability test planning, Test strategies, types and applications of testing,Environmental Test Rationale and Mathematical formulation for demonstrating Reliability, Accelerated Life tests, Step-Stress testing, HALT, HASS, HAST, Environmental Stress Screening, Test Standards and procedures, Product Qualification, Acceptance andDemonstration testing

Reliability and Data Analysis - Data types, collection methods, field data, Warranty analysis,Root cause Analysis, FRACAS and problem-solving methods, Weibull analysis, Reliability Growth and Improvement

Reliability in Maintainable and Critical Systems - Maintainability, availability testability andServiceability consideration

Call For Action - Recap, Summary, Test Quiz, Back to Beginning: Understanding Customerrequirement, acceptance, Feedback, Data Analysis and Improvement

Text Book

1. Youchao Sun, Longbiao Li, Dmytro Tiniakov, “Reliability Engineering”, Springer publishers, 2023.

Reference Books and Web Resources

1. Massimo Lazzaromi and Loredana Cristaldi, “Reliability engineering Basic Conceptsand Application”, Springer Publications, 2011.
2. L S Srinath, **“Reliability Engineering”,** East west Publishers, 2005.
3. Dhillon, BS, “Reliability, Quality and Safety for Engineers”, CRC publications, 2005.
4. Murray R Spiegel, John J. Schiller and Alu Srinivasan, R, “Probability and Statistics”, Schaum Series, 2000.
5. “Handbook of Reliability Prediction procedures for Mechanical Equipment”, NavalSurface Warfare Center, 2011.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction – Primer for Beginner**	
1.1	Benefits of Reliability Engineering, Definition, interrelationships of safety, quality and Reliability, Elements of reliability management, program and function in product Development & Process	2
2	**Statistics for Reliability Engineering**	
2.1	Basic Statistical concepts and probability distributions, SPC Techniques / control charts applied to reliabilityengineering	2
2.2	Advanced statistical concepts, Taguchi robust design concepts used in Reliability estimation, MathematicalAspects of customer requirements	2
3	**Reliability in Design and Development for mechanical and electrical systems**	
3.1	Reliability design concepts: Environmental and use Factor, Stress-Strength relationship, etc.,	2
3.2	Tools, methods (FMEA, FMECA, etc.), Reliability Allocation, parts, materials and system management,DFX : Design for X standards and techniques	2
4	**Reliability Modeling and Prediction**	
4.1	Reliability Block Diagram and models and data for modeling, Physics of Failure approach and mechanisms in Mechanical and electrical systems, Reliability Prediction methods Parts count, Part Stress Analysis, thermal analysis, Industry data	2
5	**Reliability Testing**	
5.1	Reliability test planning, Test strategies, types andapplications of testing, Environmental Test Rationale and Mathematical formulation for demonstrating Reliability	2
5.2	Accelerated Life tests, Step-Stress testing, HALT, HASS, HAST, Environmental Stress Screening, Test Standards and procedures, Product Qualification, Acceptance and Demonstration testing	2
6	**Reliability and Data Analysis**	
6.1	Data types, collection methods, field data, Warrantyanalysis, Root cause Analysis	2
6.2	FRACAS and problem-solving methods, Weibull analysis, Reliability Growth and Improvement	2
7	**Reliability in Maintainable and Critical Systems**	
7.1	Maintainability, availability testability and Serviceabilityconsideration	2
8.	**Call For Action**	
8.1	Recap, Summary, Test Quiz, Back to Beginning: Understanding Customer requirement, acceptance, Feedback, Data Analysis and Improvement	2
	Total	**24**

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Laboratory Course Revision

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015

22MT481	SENSORS AND MESUREMENTS LABORATORY	Category	L	T	P	C	TE
		PC	0	0	2	1	Practical

Preamble

Sensors play a crucial role in modern technology, enabling precise measurement and monitoring of a wide range of parameters across various fields and industries. They provide essential real-time data, facilitate automation, and enhance both safety and efficiency in diverse applications. Sensors measure numerous physical and chemical properties, including temperature, pressure, flow, and viscosity, and are capable of detecting motion, proximity, light, and sound, among other environmental factors. As technological advancements continue, the role of sensors in data-driven decision-making and control systems will only grow, underscoring their importance in engineering and applied sciences. This course equips students with hands-on skills in sensor characterization, calibration, and data acquisition, preparing them to harness sensor technology for accurate and reliable measurements in real-world applications.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Determine unknown resistance using Wheatstone Bridge for precise resistance measurements.	TPS3	80	90
CO2	Characterize and calibrate Hall Effect sensors, LDRs, and photodiodes for reliable environmental sensing applications.	TPS3	80	90
CO3	Calibrate strain gauges and load cells and measure force for accurate mechanical force applications.	TPS3	80	90
CO4	Analyse and validate temperature sensors (thermistors, thermocouples) for accurate thermal measurements across varying conditions.	TPS3	75	80
CO5	Measure displacement using LVDT and apply ToF and laser sensors for accurate distance measurements in engineering applications.	TPS3	80	90
CO6	Assess acceleration, angular velocity, and directional data using IMU and implement IoT-based flow measurements for real-time data transmission.	TPS3	75	80
CO7	Evaluate linear, angular, and thread profiles using profile projectors and conduct 2D & 3D measurements using Coordinate Measuring Machines (CMM).	TPS3	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

List of Experiments

Sl. No.	Exercises / Experiments	No of Hrs
1	Measurement of Unknown Resistance using Wheatstone Bridge	2
2	Characterisation and Calibration of Hall Effect sensor	2
3	Characterisation and Calibration of Light Dependent Resistor, Photodiode.	2
4	Characterisation and Calibration of Strain Gauge - Load cell.	2
5	Characterisation and Calibration of Thermistor and Thermocouple.	2
6	Determination of Displacement using LVDT.	2
7	Measurement of Power and Energy of AC and DC source.	2
8	Measurement of Acceleration, angular velocity, Direction measurement using Inertial Measurement Unit.	2
9	Distance Measurement using ToF and Laser sensor.	2
10	Flow Measurement using Flow Sensor and IoT Implementation.	2
11	Measurement of Force using of Piezo Resistive Force Sensor.	2
12	Profile measurement of linear, angular and thread elements using Profile Projector.	2
13	2D & 3D measurements using Coordinate Measuring Machine.	
	Total	**24**

Course Designers:

1. Dr. M Palaninatharaja, pnatharaja@tce.edu
2. Mr. S Parthasarathi, parthasarathi_s@tce.edu

SYLLABI

FOR

AUDIT COURSES

23CHAD0 INDIAN CONSTITUTION AND KNOWLEDGE SYSTEMS

23CHAE0 UNIVERSAL HUMAN VALUES AND ETHICS

B.E. / B.Tech. DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2023-24 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU
Phone : 0452 – 2482240, 41
Fax : 0452 2483427
Web : www.tce.edu

23CHAD0	INDIAN CONSTITUTION AND KNOWLEDGE SYSTEMS

Category	L	T	P	Credit
AC	2	0	0	0

Preamble

This course offers a comprehensive exploration of India's constitutional framework and its rich traditional knowledge systems, fostering a universal approach to value-based education. It helps students develop a deeper understanding of reality through self-exploration and value-based learning. The course highlights how ancient Indian practices in areas like literature, arts, science, healthcare, and agriculture align with modern governance principles. Students will learn to appreciate the relevance of these traditions in solving today's challenges. By the end of the course, students will understand how India's knowledge heritage and constitutional values work together to support sustainable and inclusive development.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the core principles, features, and structure of the Indian Constitution, including its role in shaping modern democracy and governance.	TPS2	70	85
CO2	Interpret the fundamental rights, duties, and directive principles enshrined in the Constitution and their implications for individual and societal development.	TPS2	70	85
CO3	Assess the significance of the Constitution in addressing contemporary issues and promoting justice, equality, and sustainable development.	TPS2	70	85
CO4	Describe the key concepts, diversity, and significance of Indian traditional knowledge systems across various domains such as arts, sciences, and ecology.	TPS2	70	85
CO5	Compare Indian traditional knowledge with modern knowledge systems and identify their complementary roles in addressing societal challenges.	TPS2	70	85
CO6	Demonstrate the application of traditional knowledge in modern contexts, emphasizing sustainability, holistic living, and cultural reservation.	TPS2	70	85

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar
	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

Syllabus

Indian Constitution

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions: National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

Indian Knowledge Systems

Traditional and Modern Knowledge: Two Worlds of Knowledge

Phases of Exploration: Contributions of Sir Arthur Cotton in irrigation, smallpox vaccination advancements, and agricultural reforms by Voelcker and Howard.

Indian Art and Science: Havell's work in Indian art, Gaekwad of Baroda's push for technical education, and contributions to Ayurveda (Hakim Ajmal Khan) and indigenous drugs (R.N. Chopra).

Linking Science and Rural Development

Pioneering Models: Tagore's Sriniketan experiment, YMCA's Marthandam model, Gandhi's rural development ideas, and Nehru's perspectives on growth.

Post-Independence and Global Recognition

Modernization of Knowledge: Integration of traditional practices in modernization efforts and the rise of activism for traditional knowledge recognition.

Global Mechanisms: Efforts by UNESCO, WHO, UNEP, WIPO, and WTO for protecting and sharing traditional knowledge.

Intellectual Property Rights (IPR) and Traditional Knowledge

Theoretical Background: Strategies for safeguarding traditional knowledge through positive protections and defensive mechanisms.

Traditional Knowledge for Basic Needs

Cultural Practices: Midwifery traditions (Dai System), surface flow irrigation tanks, and community housing rights.

Biodiversity and Genetic Resources: Success stories like Jeevani (Kanis' herbal medicine) and AYUSH-based cosmetics.

Traditional Knowledge in Manufacturing and Industry

Notable Contributions: Channa Patna toys, Payyanur sacred rings, and innovations in drug discovery.

Cultural Expressions

Heritage and Modern Relevance: Banarasi sarees, classical music, yoga's evolution, and Sanskrit's role in artificial intelligence.

Text Book

- Durga Das Basu, 'Introduction to The Constitution of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
- Constitution of India, National Portal of India, Web link: https://www.india.gov.in/my-government/constitution-india
- Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.

Reference Books & web resources

- Amit Jha, "Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
- Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
- Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
- NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: https://nptel.ac.in/courses/121/106/121106003/#.
- YouTube video on "Introduction to Indian Knowledge Systems", Video link: https://www.youtube.com/watch?v=LZP1StpYEPM.
- YouTube video on "12 Great achievements of Indian Civilization", Video link: https://www.youtube.com/watch?v=xmogKGCmclE)

Course Designers

Adopted from AICTE MODEL CURRICULUM 2022

23CHAE0	UNIVERSAL HUMAN VALUES AND ETHICS

Category	L	T	P	Credit
AC	2	0	0	0

Preamble

This course presents a universal approach to value education by developing the right understanding of reality through the process of self-exploration. The course primarily focus es on affecting a qualitative transformation in the life of the student rather than just a transfer of information. The course introduces the holistic worldview and its implications, a critical appraisal of the prevailing notions is also made to enable the students discern the difference on their own right.

Prerequisite

Nil

Course Outcomes

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

COs	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the significance of value inputs in a classroom, distinguish between values and skills, understand the need, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society.	TPS2	70	85
CO2	Distinguish between the Self and the Body, understand the meaning of Harmony in the Self the Co-existence of Self and Body.	TPS2	70	85
CO3	Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships and explore their role in ensuring a harmonious society	TPS2	70	85
CO4	Understand the harmony in nature and existence and work out their mutually fulfilling participation in nature	TPS2	70	85
CO5	Distinguish between ethical and unethical practices.	TPS2	70	85
CO6	Prepare strategy to actualize a harmonious environment wherever they work and lead an ethical life Course	TPS2	70	85

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar
	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

Syllabus

INTRODUCTION TO VALUE EDUCATION

Value Education – Need, Basic Guidelines, Content and Process, Self-Exploration – meaning, importance and process, Continuous Happiness and Prosperity – A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities – The basic requirements, Understanding Happiness and Prosperity – A critical appraisal of the current scenario, Method to fulfil the above human aspirations – UNDERSTANDING and living in harmony at various levels.

HARMONY IN THE HUMAN BEING

An understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' – Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, the meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya.

HARMONY IN THE FAMILY AND SOCIETY

Understanding harmony in the family – The basic unit of human interaction, understanding values in a human-to-human relationship; Understanding Trust – The foundational value in relationship, Difference between intention and competence, Understanding Respect – as the right evaluation, Difference between respect and differentiation; the other salient values in a relationship, Understanding the harmony in the society – comprehensive Human Goals, Visualizing a universal harmonious order in society– Undivided Society, Universal Order – From family to world family!

HARMONY IN NATURE AND EXISTENCE

Understanding the harmony in Nature, Interconnectedness, self-regulation and mutual fulfilment among the four orders of nature – recyclability, Understanding Existence as Coexistence of mutually interacting units in all-pervasive space, Holistic perception of harmony at all levels of existence.

IMPLICATIONS OF THE ABOVE HOLISTIC UNDERSTANDING OF HARMONY ON PROFESSIONAL ETHICS

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in

Professional Ethics – augmenting universal human order, the scope and characteristics of people-friendly and eco-friendly, Holistic Technologies, production systems and management models – Case studies, Strategy for the transition from the present state to Universal Human Order – At the level of individual: as socially and ecologically responsible engineers, technologists and managers, At the level of society: as mutually enriching institutions and organizations.

Text Book

- R R Gaur, R Sangal, G P Bagaria, "A Foundation Course in Human Values and Professional Ethics", Excel Books, New Delhi, 2nd Revised Edition, 2019.

Reference Books & web resources

- A Nagaraj, "Jeevan Vidya: Ek Parichaya", Jeevan Vidya Prakashan, Amarkantak, 1999.
- A N Tripathi, "Human Values", New Age Intl Publishers, New Delhi, 2004.
- "The Story of Stuff" (Book).
- Mohandas Karamchand Gandhi, "The Story of My Experiments with Truth".
- E F Schumacher, "Small is Beautiful"
- Cecile Andrews, "Slow is Beautiful"
- J C Kumarappa, "The Economy of Permanence"
- Pandit Sunderlal, "Bharat Mein Angreji Raj"
- Dharampal, "Rediscovering India"
- Mohandas K Gandhi, "Hind Swaraj or Indian Home Rule"
- Maulana Abdul Kalam Azad, "India Wins Freedom"
- Romain Rolland, "Vivekananda" (English)
- Romain Rolland, "Gandhi" (English)

Course Designer(s):

Adopted from AICTE Model Curriculum 2022

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

Electives

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHATRONICS ENGINEERING

Vision:

"Be a globally renowned school of engineering in Mechatronics"

Mission:

As a department, we are committed to

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

Programme Outcomes (POs) of B.E.

PO1	**Engineering knowledge**	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3	**Design/ development of solutions**	Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4	**Conduct investigations of complex problems**	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
PO5	**Engineering tool usage**	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6	**The Engineer and the world**	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7	**Ethics**	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	**Individual and team work**	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication**	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10	**Project management and finance**	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-long learning**	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Programme Specific Outcomes (PSO) of B.E. Mechatronics Engineering

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

PSO1: Design, develop and retrofit conventional mechanical system into low-cost automated system using sensors and controllers

PSO2: Design, develop and analyse mechatronics system using hardware and software tools.

SCHEDULING OF COURSES

Sem	Theory / Theory cum Practical / Laboratory Courses								CDIO / Audit Courses	Total Credits
I	22MA110 Calculus for Engineers BSC 4	22PH120 Physics BSC 3	22CH130 Chemistry BSC 3	22EG140 Technical English HSMC 2	22ME160 Engineering Graphics ESC 4	22EG170 English Laboratory HSMC 1	22PH180 Physics Laboratory BSC 1	22CH190 Chemistry Laboratory BSC 1	22ES150 Engineering Exploration ESC 2	21
II	22MT210 Matrices and Ordinary Differential Equations BSC 4	22MT220 Analog Electronics PCC 3	22MT230 Free Body Mechanics PCC 3	22MT240 Problem Solving using C ESC 3	22MT250 Manufacturing Process PCC 3	22MT260 Mechatronic Workshop ESC 1	22MT270 Manufacturing Laboratory PCC 1	22MT280 Mechatronic System Laboratory ESC 1	Audit Course 1	19
III	22MT310 Partial Differential Equations BSC 4	22MT320 Digital Electronics PCC 3	22MT330 Kinematics and Dynamics of Machinery ESC 3	22MT340 Thermal Fluid Systems PCC 3	22MT350 Electrical Machines ESC 3	22MT360 Thermal Engineering Laboratory PCC 1	22MT370 Electrical Machines Laboratory ESC 1	22MT380 Electronic Circuits and Digital Laboratory PCC 1	22ES390 Design Thinking ESC 3	22
IV	22MT410 Probability and Statistics BSC 4	22MT420 Microcontroller based system design PCC 3	22MT430 Power Electronics and Drives ESC 3	22MT440 Sensors and Measurements PCC 3	22MT450 Digital Signal Processing PCC 3	22MT460 Project Management HSMC 3	22MT470 Microcontroller Laboratory PCC 1	22MT481 Sensors and Measurements Laboratory PCC 1	Audit Course 2	21
V	22MT510 Control Systems PCC 4	22MT520 Design of Machine Elements PCC 3	22MT530 Industrial Automation PCC 3	22MT540 CNC Technology PCC 3	22MTPx0 Program Elective I PEC 3	22yyGx0 Inter disciplinary Elective IE 3	22MT5500 CAD / CAM Laboratory PCC 1	22MT560 Industrial Automation Laboratory PCC 1	22MT570 Project I PW 3	24
VI	22MT610 Accounting and Finance HSMC 4	22MT620 Industrial Robotics PCC 3	22MTPx0 Program Elective II PEC 3	22MTPx0 Program Elective III PEC 3	22yyFx0 Basic Science Elective BSE 3	22MT640 Control and Dynamics Laboratory PCC 1	22MT650 Robotics Laboratory PCC 1	22EG660 Professional Communication HSMC 2	22MT670 Project II PW 3	23
VII	22MT710 Mechatronics System Design PCC 4	22MTPx0 Program Elective IV PEC 3	22MTPx0 Program Elective V PEC 3	22MTPx0 Program Elective VI PEC 3	22MTPx0 Program Elective VII PEC 3	22MT720 System Integration Laboratory PCC 2	---	---	22MT770 Project III PW 3	21
VIII	22MTPx0 Program Elective VIII PEC 3	22MTPx0 Program Elective IX PEC 3	---	---	---	---	---	---	22MT870 Project IV PW 3	9
									Total Credits	**160**

Passed in BoS Meeting on 09.05.2025

Approved in 69th Academic Council Meeting 28.06.2025

List of Electives (PSE & PEES)

	Vertical 1 **Sensors & Instrumentation**	Vertical 2 **Mechanical Systems**	Vertical 3 **Robotics & Automation**	Vertical 4 **System Integration**		**Minors**
PSE	22MTPN0 Industrial Communication Networks	22MTPA0 Design and Analysis of Experiments	22MTPE0 Drone Technology	22MTPC0 Industry 4.0		22MTQB0 Industry 4.0
	22MTPT0 Wireless Sensor Networks	22MTPB0 Semiconductor Manufacturing	22MTPF0 OOP using C++	22MTPD0 Electric Vehicle Technology		22MTQC0 Robotics
	22MTPI0 Virtual Instrumentation	22MTPK0 Non-Destructive Testing and Evaluation	22MTPJ0 Autonomous Systems	22MTPG0 Sustainable Engineering		22MTQD0 Sensors and Actutators
	22MTPS0 Edge Computing	22MTPL0 Building Management Systems	22MTPO0 Machine Learning and Applications	22MTPM0 Industrial Control of Motion Drives		22MTQE0 Drone Technology
	22MTPU0 Battery Management Systems	22MTPP0 Quality Engineering	22MTPV0 Cognitive Robotics	22MTPW0 Devices and System Packaging		22MTQF0 Embedded Systems
	22MTSB0 Real time Embedded Systems	22MTPQ0 Micro Electro Mechanical Systems	22MTPZ0 Flight Dynamics and Control	22MTSA0 Industry 5.0		
	22MTSC0 Sensor Fusion Technology	22MTPR0 Smart HVAC Systems	22MTSE0 Soft Computing	22MTSD0 Smart Supply Chain Management		
PSE MOOC				22MTPH0 Thermal Management of Electronic Systems		22MTQA0 Industrial Drives and Control
PEES	22MTRB0 Bio-Mechatronics	22MTRC0 Additive Manufacturing	22MTRA0 Machine Vision using Machine Learning	22MTRD0 Medical Digital Twin		

List of Interdisciplinary Electives (IE)

Course Code	Course Name
22MTGA0	Mechatronics
22MTGB0	Value Engineering

Industry Supported Courses (PEES)

Course Code	Course Name
22MT1A0	IOT Based Cartridge Valves
22MT2B0	Reliability for Mechatronic Systems

CREDIT DISTRIBUTION

Degree: B.E. **Program: Mechatronics**

Sl. No.	Category		Credits	
			Regular Admission	Lateral Entry Admission
A.	**Foundation Courses (FC)**		**54 - 66**	**22 - 36**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	06 - 09
	b.	Basic Science Courses (BSC)	24 - 27	08 - 12
	c.	Engineering Science Courses (ESC)	21 - 27	08 - 15
B.	**Professional Core Courses (PCC)**		**55**	**44-49**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 - 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 - 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 - 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 - 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 - 06
	b.	Basic Science Elective (BSE)	03 - 06	03 - 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

B.E. DEGREE (Mechatronics) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2022 - 2023 onwards)

Course Code	Name of the Course	Category	No. of Hours / Week			Credits (C)	Terminal Exam
			L	T	P		
22MTPU0	BATTERY MANAGEMENT SYSTEMS	PSE	3	0	0	3	Theory
22MTPV0	COGNITIVE ROBOTICS	PSE	3	0	0	3	Theory
22MTPW0	DEVICES AND SYSTEM PACKAGING	PSE	3	0	0	3	Theory
22MTPZ0	FLIGHT DYNAMICS AND CONTROL	PSE	3	0	0	3	Theory
22MTSA0	INDUSTRY 5.0	PSE	3	0	0	3	Theory
22MTSB0	REAL TIME EMBEDDED SYSTEMS	PSE	3	0	0	3	Theory
22MTSC0	SENSOR FUSION TECHNOLOGY	PSE	3	0	0	3	Theory
22MTSD0	SMART SUPPLY CHAIN MANAGEMENT	PSE	3	0	0	3	Theory
22MTSE0	SOFT COMPUTING	PSE	1	0	4	3	Practical
22MTRD0	MEDICAL DIGITAL TWIN	PEES	1	0	4	3	Practical
22MTQB0	INDUSTRY 4.0	PSE	3	0	0	3	Theory
22MTQC0	ROBOTICS	PSE	3	0	0	3	Theory
22MTQD0	SENSORS AND ACTUATORS	PSE	3	0	0	3	Theory
22MTQE0	DRONE TECHNOLOGY	PSE	3	0	0	3	Theory
22MTQF0	EMBEDDED SYSTEMS	PSE	3	0	0	3	Theory

PSE : Programme Specific Elective

PEES : Programme Elective for Expanded Scope

IE : Interdisciplinary Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

22MTPU0	BATTERY MANAGEMENT SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

With the increasing popularity of the green movement, more electric vehicles (EVs) ranging from scooters to freight trucks will appear on highways. Technology manufacturers must provide adaptable solutions for various battery styles and automobile efficiency specifications. This course covers crucial aspects such as battery capacity, lifespan, and protection in developing smart battery management and charging systems. EV battery packs contain several cell modules arranged in series and parallel. The battery management system (BMS) includes monitoring components near the cells, power conversion stages, and intelligent controllers.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the functions and importance of Battery Management Systems (BMS) in electric vehicles, energy storage, and portable devices	TPS2	80	70
CO2	Describe key electrical and thermal parameters, components, and interfaces essential to BMS operation.	TPS2	80	70
CO3	Compare passive and active cell balancing techniques and methods for estimating State of Charge (SOC).	TPS3	70	70
CO4	Illustrate and evaluate techniques for estimating State of Health (SOH) and fault detection using threshold and data-driven methods.	TPS3	70	70
CO5	Demonstrate the influence of temperature on battery performance and apply suitable thermal management strategies.	TPS3	70	70
CO6	Implement protection strategies and apply relevant industry standards to design safe, reliable BMS architectures.	TPS3	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT 1			Assignment1			CAT 2			Assignment 2					
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		30												10	
CO2		30			100									20	
CO3			40												10
CO4								20	20						20
CO5								10	20		100				20
CO6								10	20						20

Syllabus

Introduction to Battery Management Systems – Overview of BMS functions and relevance to battery safety; applications in EVs, energy storage, and portable electronics; common battery issues and BMS roles; basic battery terminology and electrochemical cell operation.
BMS Components and Operations – Critical pack-level parameters: voltage, current, temperature; measurable vs. unmeasurable parameters; BMS operating principles; introduction to BMS hardware including voltage, current, and temperature sensors; role of microcontrollers and communication protocols (CAN, SPI, I2C).
Cell Balancing and State Estimation – Causes and types of cell imbalance; passive vs. active cell balancing topologies; battery modeling techniques; SOC estimation methods such as coulomb counting and model-based algorithms (e.g., Kalman filtering).
Health Estimation and Fault Detection – Cycle-counting and impedance-based SOH estimation; data-driven methods for SOH; fault detection strategies: threshold-based and machine learning approaches.
Thermal Management, Safety, and Future Trends – Thermal effects on batteries and design of thermal management systems (active/passive cooling); safety mechanisms for overvoltage, under voltage, overcurrent, short circuits, and temperature control; industry standards - ISO 26262, UL, innovations including wireless BMS, and AI/ML integration for intelligent battery management.

Text Book

1. Plett, G. L. (2015). Battery management systems, Volume I: Battery modeling. Artech House Publishers. ISBN-13: 978-1630810238.
2. Plett, G. L. (2016). Battery management systems, Volume II: Equivalent-circuit methods. Artech House Publishers. ISBN-13: 978-1630810276.
3. Plett, G. L., & Trimboli, M. S. (2024). Battery management systems, Volume III: Physics-based methods. Artech House Publishers

Reference Books & web resources

1. Wang, S., Liu, K., Wang, Y., Stroe, D.-I., Fernandez, C., & Guerrero, J. M. (2023). State estimation strategies in lithium-ion battery management systems. Elsevier.
2. Balasingam, B. (2023). Robust battery management system design with MATLAB. Artech House Publishers.
3. González, M., & Anseán, D. (Eds.). (2021). Advanced battery technologies: New applications and management systems. MDPI.
4. University of Colorado, Colorado Springs. (n.d.). ECE4710/5710: Modeling, simulation, and identification of battery dynamics. Retrieved from http://mocha-java.uccs.edu/ECE5710/index.html

5. University of Colorado, Colorado Springs. (n.d.). ECE5720: Modeling, simulation, and identification of battery dynamics. Retrieved from http://mocha-java.uccs.edu/BMS2/index.html
6. Xion, R. (2019). Battery management algorithm for electric vehicle. Springer Nature. ISBN-13: 978-9811502484.
7. Dincer, I., Hamut, H. S., & Javani, N. (2017). Thermal management of electric vehicle battery systems. John Wiley & Sons. ISBN-13: 978-1118900222

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
	Introduction to BMS	
1.1	Overview of BMS and Applications (EVs, Storage, Electronics)	2
1.2	Battery Issues and Role of BMS	2
1.3	Battery Terminology and Electrochemical Cell Operation	2
	BMS Components & SOC Estimation	
2.1	Voltage, Current, Temperature Parameters and Measurement Techniques	2
2.2	BMS Hardware: Sensors and Interface Circuitry	2
2.3	Causes of Cell Imbalance and Classification of Balancing Methods	2
2.4	Passive vs. Active Balancing Topologies	2
2.5	Battery Modeling and Coulomb Counting for SOC Estimation	2
	SOH Estimation & Fault Detection	
3.1	Cycle-Counting and Impedance-Based SOH Estimation	2
3.2	Data-Driven SOH Estimation Techniques	2
3.3	Threshold-Based Fault Detection Methods	2
3.4	Data-Driven Approaches for Fault Detection	2
	Thermal Management & BMS Software	
4.1	Effect of Temperature on Battery Performance	2
4.2	Thermal Management System Design	2
4.3	Microcontrollers and Communication Interfaces (CAN,I2C,SPI)	2
4.4	SOC and SOH Algorithms (e.g., Kalman Filter)	2
4.5	Control Strategies for Charging and Discharging	2
	Safety, Standards & Emerging Trends	
5.1	Voltage, Current, and Thermal Protection Mechanisms	2
5.2	BMS Safety Standards (ISO 26262, UL Standards)	2
5.3	Wireless BMS and AI/ML Applications in BMS	2
	Total Hours	**36**

Course Designer(s):

1. Parthasarathi S Asisstant Professor parthasarathi_s@tce.edu
2. Devarajan M M, Assistant Professor mmdmech@tce.edu

22MTPV0	COGNITIVE ROBOTICS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Cognitive robotics combines robotics, AI, and cognitive science to develop intelligent machines capable of learning, reasoning, and adapting to dynamic environments. This course introduces key concepts and techniques that enable robots to perceive, decide, and interact intelligently, paving the way for advanced, human-like autonomy in machines.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamentals of cognitive processes in robots.	TPS2	80	75
CO2	Explore perception, reasoning, learning, and action in robotic systems.	TPS2	80	75
CO3	Describe Cognitive frameworks	TPS2	80	75
CO4	Discuss cognitive perception and integration with other sensors.	TPS2	80	75
CO5	Choose suitable cognitive framework, perception mechanism and knowledge representation for reasoning.	TPS3	70	65
CO6	Implement reinforcement learning for real-world robotic applications.	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT 2			Assignment 2*					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	20												10		
CO2	20	20											10		
CO3	20	20			100									20	
CO4							20	20						20	
CO5								10	20			100			20
CO6								10	20						20

***** Assignment 2 – Simulation of Robotic perception and knowledge representation.

Syllabus

Introduction

Cognitive robotics- History and Evolution- Difference between traditional and cognitive robots, Key components of cognitive robot - Human Robot Interaction. Applications: Assistive robots, Industrial cobots with adaptive learning, social companion robots (NAO, Pepper), Simulators, Man Made simulation and Experimentation

Foundations of Cognition

Human cognition – perception, attention, memory, learning and decision-making. Human cognitive models and robotic inspirations, Role of emotion in decision-making - Neurocognitive systems - Cognitive Architectures and Development Stages. Robotic ethics and consciousness.

Robotic Perception and Interpretation

Role of Robotic Perception in Robotics – Overview of Perception pipelines; Multisensory integration - Combining visual, auditory, tactile, and proprioceptive inputs; Cognitive Perception – Visual attention - Perceptual schemas and object recognition, Knowledge Representation and Reasoning; Ontologies for robotic understanding.

Adaptive and Learning-Based Control

Reinforcement Learning in cognitive robotics, Hierarchical learning systems (options, skills) Imitation learning (Learning from Demonstration).

Text Book

1. Angelo Cangelosi, Minoru Asada, “Cognitive Robotics”, Intelligent Robotics and Autonomous Agents series, MIT Press Direct, 2022.

Reference Books& web resources

1. Hooman Samani,” Cognitive Robotics, CRC Press, 2015
2. Rolf Pfeifer and Josh Bongard, “How the body shapes the way we think-A New View of Intelligence”, MIT Press, 2006
3. Prof. Bishakh Bhattacharya, “Foundations of Cognitive Robotics”, IIT Kanpur,

Link: https://onlinecourses.nptel.ac.in/noc24_me82/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Cognitive robotics- History and Evolution	1
1.2	Difference between traditional and cognitive robots	1
1.3	Key components of cognitive robot	1
1.4	Human Robot Interaction	1
1.5	Applications: Assistive robots, Industrial cobots with adaptive learning	3
1.6	Social companion robots (NAO, Pepper) Simulators, Man Made simulation and Experimentation	2
2	**Foundations of Cognition**	
2.1	Human cognition – perception, attention, memory, learning and decision-making	2
2.2	Human cognitive models and robotic inspirations	2

Module No.	Topic	No. of Periods
2.3	Role of emotion in decision-making	2
2.4	Neurocognitive systems	2
2.5	Cognitive Architectures and Development Stages	2
2.6	Robotic ethics and consciousness	1
3	**Robotic Perception and Interpretation**	
3.1	Role of Robotic Perception in Robotics	1
3.2	Overview of Perception pipelines	1
3.3	Multisensory integration	2
3.4	Combining visual, auditory, tactile, and proprioceptive inputs	2
3.5	Cognitive Perception – Visual attention	1
3.6	Perceptual schemas and object recognition	3
3.7	Knowledge Representation and Reasoning	2
3.8	Ontologies for robotic understanding.	1
4	**Adaptive and Learning-Based Control**	
4.1	Reinforcement Learning in cognitive robotics	1
4.2	Hierarchical learning systems (options, skills)	1
4.3	Imitation learning (Learning from Demonstration),	1
	Total Hours	**36**

Course Designer(s):

1. Ganesh M A, Assistant Professor ganeshma2015@tce.edu
2. Parthasarathi S, Assistant Professor parthasarathi_s@tce.edu

22MTPW0	DEVICES AND SYSTEM PACKAGING	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course provides a comprehensive introduction to device and system packaging, highlighting its role in modern electronic design. It covers core concepts including electrical signal integrity, thermal management, and thermo-mechanical reliability. Students will explore advanced packaging technologies, materials, and interconnection methods such as 3D integration. Emphasis is placed on designing for performance and reliability using real-world case studies. Applications span automotive electronics, bioelectronics, mobile devices, and communication systems. By the end, students will be equipped to design, analyze, and implement robust packaging solutions in diverse engineering contexts.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the fundamental concepts of device and systems packaging	TPS 2	65	70
CO2	Explain the electrical, thermal, and thermo-mechanical aspects of packaging	TPS 2	65	70
CO3	Design electronic systems using various packaging technologies	TPS 3	60	70
CO4	Solve thermal issues in electronic systems	TPS 3	60	70
CO5	Select suitable materials and interconnection for packaged systems	TPS 3	60	70
CO6	Select suitable packaging technology for electronic applications.	TPS 3	60	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal		
	CAT1			Assignment1			CAT2			Assignment2					
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	10	20											4	8	
CO2	10	20			100								4	8	
CO3		20	20										4	8	10
CO4							5	10	20				4	8	10
CO5							5	10	20		100		2	4	10
CO6								10	20				2	4	10

Syllabus

Introduction to Device and Systems Packaging: Overview of device and systems packaging technologies, Anatomy of an electronic packaged system, Devices and Moore's Law, Electronic technology waves: microelectronics, RF/wireless, photonics, MEMS, and quantum devices, EMI/EMC, Testing

Electrical Design for Signals, Power, and Electromagnetic Interference: Electrical package design and its need, Electrical study of a package, Signal distribution, Power distribution, Electromagnetic interference

Thermal Technologies: Thermal management and its necessity, Basics of a thermal package system, Chip-level thermal technologies, Module-level thermal technologies

Thermo-Mechanical Reliability: Thermo-mechanical reliability and its importance, System of a package with failures and failure mechanisms, Types of thermo-mechanical-induced failures

Advanced Packaging Technologies: Fundamentals of package materials at microscale and nanoscale, Ceramic, organic, glass, and silicon package substrates, Passive components and integration with active devices, Chip-to-package interconnections and assembly, 3D packaging with and without TSV

Applications of Packaging Technologies: Future car electronics, Bioelectronics, Communication systems, Computing systems, Flexible electronics, Smartphones

Text Book

1. Rao R. Tummala – Fundamentals of Devices and Systems Packaging, McGraw-Hill, 2019

Reference Books & web resources

1. Tummala, R.R. – Fundamentals of Microsystems Packaging, McGraw Hill text, 2001
2. John H. Lau – Semicondutor Advanced Packaging, Springer nature, 2021
3. Charles Harper. – Electronic Packaging and Interconnection Handbook, McGraw Hill Education, Edition 3, 2000
4. Research articles from IEEE, IMAPS, and JEDEC publications

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Device and Systems Packaging:**	
1.1	Overview of device and systems packaging technologies	1
1.2	Anatomy of an electronic packaged system	2
1.3	Devices and Moore's Law	1
1.4	Electronic technology waves: microelectronics, and quantum devices	2

Module No.	Topic	No. of Periods
1.5	Electronic technology waves: microelectronics, RF/wireless, photonics, EMI/EMC, Testing	2
2	**Electrical Design for Signals, Power, and Electromagnetic Interference:**	
2.1	Electrical package design and its need	1
2.2	Electrical study of a package	2
2.3	Signal distribution	1
2.4	Power distribution, Electromagnetic interference	2
3	**Thermal Technologies:**	
3.1	Thermal management and its necessity	1
3.2	Basics of a thermal package system	2
3.3	Chip-level thermal technologies	1
3.4	Module-level thermal technologies	2
4	**Thermo-Mechanical Reliability:**	
4.1	Thermo-mechanical reliability and its importance	1
4.2	System of a package with failures and failure mechanisms	2
4.3	Types of thermo-mechanical-induced failures	2
5	**Advanced Packaging Technologies:**	
5.1	Fundamentals of package materials at microscale and nanoscale	1
5.2	Ceramic, organic, glass, and silicon package substrates	1
5.3	Passive components and integration with active devices	1
5.4	Chip-to-package interconnections and assembly	2
5.5	3D packaging with and without TSV	1
6	**Applications of Packaging Technologies:**	
6.1	Future car electronics, Bioelectronics	1
6.2	Communication systems, Computing systems	2
6.3	Flexible electronics, Smartphones	2
	Total	36

Course Designer(s):

1	Dr.G.Kumaraguruparan	Professor, MECT	gkgmech@tce.edu
2	Dr.M.M.Devarajan	Assistant Professor, MECT	mmdmech@tce.edu

22MTPZ0	FLIGHT DYNAMICS AND CONTROL	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Flight Dynamics and Control is a foundational subject in aerospace engineering that explores the behaviour of aircraft in flight and the systems used to influence that behaviour. This course equips students with a deep understanding of the principles governing the motion of airborne vehicles, including stability, control, and response to various inputs. By integrating classical mechanics, aerodynamics, and control theory, learners gain the analytical and practical tools necessary to model, simulate, and design control systems for stable and efficient flight. Whether applied to fixed-wing aircraft, rotorcraft, or emerging UAV technologies, the knowledge acquired is vital for ensuring safe, reliable, and responsive flight performance.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamental forces, moments, and configurations involved in aircraft flight.	TPS2	80	75
CO2	Apply the equations of motion to describe aircraft translational and rotational dynamics.	TPS3	70	65
CO3	Identify the factors affecting the static and dynamic stability of an aircraft.	TPS2	80	75
CO4	Use basic control principles to explain aircraft attitude control and orientation	TPS3	70	65
CO5	Evaluate the aircraft's response to various control inputs under different flight conditions	TPS3	70	65
CO6	Assess the performance of flight control systems and their impact on aircraft stability and safety.	TPS2	80	75

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M
CO2	S	M	L	-	S	-	-	-	-	-	-	-	M
CO3	M	L	-	-	L	-	-	-	-	-	-	-	M
CO4	S	M	L	-	S	-	-	-	S	-	S	-	M
CO5	S	M	L	-	S	-	-	-	S	-	S	-	M
CO6	M	L	-	-	-	-	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT 2			Assignment 2					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	30												10		
CO2			20										10		
CO3	25	25			100									20	
CO4									20			100		20	
CO5							15	15	20						20
CO6							15	15							20

Syllabus

Basics of Flight and Aircraft Configurations

Fundamentals of aerodynamics: Lift, drag, thrust, weight -Aircraft components and configuration -Types of stability: Static and dynamic -Flight control surfaces and their functions - Trim conditions and equilibrium.

Aircraft Equations of Motion

Translational and rotational equations of motion -Body axes and inertial frames - Forces and moments acting on the aircraft - Linear and nonlinear motion equations - Longitudinal and lateral-directional dynamics.

Stability and Control

Static stability and control derivatives - Dynamic stability: Modes of motion (phugoid, short period, Dutch roll) - Aircraft response to control inputs - Linearization and small disturbance theory - Introduction to stability augmentation systems, Fixed wing, Rotary wing.

Flight Control Systems

Control system components: sensors, actuators, flight computers - Classical control techniques (PID, lead-lag) - Auto-pilot systems: longitudinal and lateral autopilot - Fly-by-wire systems and redundancy - Actuation technologies and feedback loops.

Modern Control and Applications

State-space representation of flight dynamics - Controllability and observability - LQR and optimal control strategies - UAV and drone flight dynamics - MATLAB/Simulink simulations of aircraft models.

Text Book

1. Flight Stability and Automatic Control by Robert C. Nelson, McGraw-Hill, 1998
2. Dynamics of Flight: Stability and Control by Bernard Etkin and Lloyd Duff Reid, Wiley, 1996

Reference Books & web resources

1. Aircraft Control and Simulation by Brian L. Stevens, Frank L. Lewis, and Eric N. Johnson, Wiley, 2015.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Basics of Flight and Aircraft Configurations**	
1.1	Fundamentals of aerodynamics: Lift, drag, thrust, weight	1
1.2	Aircraft components and configuration	2
1.3	Types of stability: Static and dynamic	2

Module No.	Topic	No. of Periods
1.4	Flight control surfaces and their functions	2
1.5	Trim conditions and equilibrium	2
2	**Aircraft Equations of Motion**	
2.1	Translational and rotational equations of motion	1
2.2	Body axes and inertial frames	1
2.3	Forces and moments acting on the aircraft	1
2.4	Linear and nonlinear motion equations	2
2.5	Longitudinal and lateral-directional dynamics	2
3	**Stability and Control**	
3.1	Static stability and control derivatives	1
3.2	Dynamic stability: Modes of motion (phugoid, short period, Dutch roll)	1
3.3	Aircraft response to control inputs	2
3.4	Linearization and small disturbance theory	2
3.5	Introduction to stability augmentation systems, Fixed wing, Rotary wing	2
4	**Flight Control Systems**	
4.1	Control system components: sensors, actuators, flight computers	1
4.2	Classical control techniques (PID, lead-lag)	1
4.3	Auto-pilot systems: longitudinal and lateral autopilot	1
4.4	Fly-by-wire systems and redundancy	1
4.5	Actuation technologies and feedback loops.	1
5	**Modern Control and Applications**	
5.1	State-space representation of flight dynamics	1
5.2	Controllability and observability	2
5.3	LQR and optimal control strategies	2
5.4	UAV and drone flight dynamics - MATLAB/Simulink simulations of aircraft models.	2
	Total Hours	36

Course Designer(s):

1. Dr M Rajalakshmi, Assistant Professor mrimect@tce.edu
2. Ganesh M A, Assistant Professor ganeshma2015@tce.edu

22MTSA0	INDUSTRY 5.0	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Industry 5.0 marks the next evolution in industrial development, emphasizing the collaboration between humans and intelligent machines. Unlike Industry 4.0, which focused on automation and connectivity, Industry 5.0 brings the human touch back into manufacturing, aiming for personalization, sustainability, and resilience. It combines advanced technologies like AI, IoT, and robotics with human creativity and problem-solving to create smarter, more adaptive, and people-centered industries.

Prerequisite

- Nil

Course Outcomes

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

COs	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Differentiate between the traditional factory models and the Industry 5.0 factory.	TPS2	80	70
CO2	Illustrate the concepts of human-centric, resilient, and sustainable manufacturing systems.	TPS2	80	70
CO3	Demonstrate the use of smart manufacturing approaches in designing human-centric production systems.	TPS3	70	65
CO4	Develop AI-based solutions for responsible and resilient manufacturing.	TPS3	70	65
CO5	Describe integrated manufacturing solutions using Industry 4.0 technologies to meet Industry 5.0 requirements.	TPS2	80	70
CO6	Explain how emerging technologies like IIoT and 5G contribute to next-generation manufacturing systems.	TPS2	80	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1 (%)</th><th colspan="6">Assessment 2 (%)</th><th colspan="3" rowspan="2">Terminal (%)</th></tr>
<tr><th colspan="3">CAT 1</th><th colspan="3">Assignment 1</th><th colspan="3">CAT 2</th><th colspan="3">Assignment 2</th></tr>
<tr><td>TPS</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>CO1</td><td>8</td><td>20</td><td>-</td><td colspan="3" rowspan="3">100</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>10</td><td>-</td></tr>
<tr><td>CO2</td><td>8</td><td>30</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>-</td><td>15</td></tr>
<tr><td>CO3</td><td>4</td><td>10</td><td>20</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>-</td><td>15</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>8</td><td>20</td><td>20</td><td colspan="3" rowspan="3">100</td><td>4</td><td>15</td><td>-</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>8</td><td>20</td><td>-</td><td>4</td><td>10</td><td>-</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>20</td><td>-</td><td>-</td><td>15</td><td>-</td></tr>
</table>

Syllabus

Introduction to Industry 5.0 -Introduction of Various Industrial Revolutions, Comparison of Industry 5.0 Factory and Today's Factory, Key enabling technologies and Industry 5.0 architecture, Challenges and opportunities of the transition from Industry 4.0 to Industry 5.0, Unmanned factory.

Human-centric, resilient, and sustainable manufacturing-Terminology and definition of human-centric systems, manufacturing paradigm of human-centric systems, Human-centric systems in smart manufacturing-Design of assembly lines for Industry 5.0: current trends and challenges- Workforce dimensioning and new methodology for dynamic workforce and task planning-Industry 5. 0 role in sustainable manufacturing.

Responsible manufacturing towards industry 5.0-Responsible artificial intelligence-Applicability of responsible artificial intelligence to smart manufacturing-Case study: application of responsible manufacturing in the automotive manufacturing industry-Resilience in Industry 5.0

Integration of Industry 4.0 technologies in modern production and manufacturing networks toward Industry 5.0-Operations management and information systems for smart manufacturing-Supply chain management in smart manufacturing- Quality control and traceability in smart manufacturing-Efficient data management for intelligent manufacturing-Data curation techniques

Industrial Internet of Things based advanced manufacturing toward Industry 5.0-Human-centric advanced manufacturing service collaboration-Challenges of advanced manufacturing service collaboration-Artificial intelligence for human–cyber-physical production systems-Cloud, fog, edge computing and 5G technologies for industrial automation-From data collection to advanced analytics and wisdom creation in manufacturing processes.

Text Book

1. Manufacturing from Industry 4.0 to Industry 5.0:Advances and Applications,Elsevier,2024, ISBN: 9780443139246
2. Uthayan Elangovan, Industry 5.0, “The Future of the Industrial Economy”, First Edition, Taylor & Francis, ISBN: 978-1-032-04127-8, 2022.
3. Alessandro Massaro, “Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances”, Wiley-IEEE Press, 2021, ISBN: 2021028944.

Reference Books & web resources

1. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress, 2016.
2. Lan Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.
3. Hans Bernhard Kief, Helmut Roschiwal, Karsten Schwarz, “The CNC Handbook: Digital Manufacturing and Automation from CNC to Industry 4.0”, Industrial Press Inc., U.S. ISBN 0831136367, Nov 2021.

4. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Industry 5.0**	
1.1	Introduction of Various Industrial Revolutions	1
1.2	Comparison of Industry 5.0 Factory and Today's Factory	1
1.3	Key enabling technologies and Industry 5.0 architecture	2
1.4	Challenges and opportunities of the transition from Industry 4.0 to Industry 5.0, Unmanned factory	2
2	**Human-centric, resilient, and sustainable manufacturing**	
2.1	Terminology and definition of human-centric systems	1
2.2	Manufacturing paradigm of human-centric systems, Human-centric systems in smart manufacturing	2
2.3	Design of assembly lines for Industry 5.0: current trends and challenges	2
2.4	Workforce dimensioning and new methodology for dynamic workforce and task planning-Industry 5.0 role in sustainable manufacturing.	2
3	**Responsible manufacturing towards industry 5.0**	
3.1	Responsible artificial intelligence	2
3.2	Applicability of responsible artificial intelligence to smart manufacturing	2
3.3	Case study: application of responsible manufacturing in the automotive manufacturing industry	2
3.4	Resilience in Industry 5.0	2
4	**Integration of Industry 4.0 technologies in modern production and manufacturing networks toward Industry 5.0**	
4.1	Operations management and information systems for smart manufacturing	2
4.2	Supply chain management in smart manufacturing	1
4.3	Quality control and traceability in smart manufacturing	2
4.4	Efficient data management for intelligent manufacturing-Data curation techniques	2
5	**Industrial Internet of Things based advanced manufacturing toward Industry 5.0**	
5.1	Human-centric advanced manufacturing service collaboration	1

Module No.	Topic	No. of Periods
5.2	Challenges of advanced manufacturing service collaboration	1
5.3	Artificial intelligence for human–cyber-physical production systems	2
5.4	Cloud, fog, edge computing and 5G technologies for industrial automation	2
5.5	From data collection to advanced analytics and wisdom creation in manufacturing processes.	2
	Total	36

Course Designer(s):

1. Dr. H Ramesh, Assistant Professor, rameshh@tce.edu
2. Dr. S Julius Fusic, Assistant Professor, sjf@tce.edu

22MTSB0	REAL TIME EMBEDDED SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course provides a comprehensive introduction to embedded systems, focusing on their architecture, functionality, and application in real-time and resource-constrained environments. It covers the fundamentals of microcontrollers, memory, and I/O interfaces, along with the principles of Real-Time Operating Systems (RTOS). Students will gain hands-on experience in designing and programming embedded systems using C and assembly language and develop practical skills in debugging and optimization. The course also integrates mechatronics concepts, enabling students to implement sensor-actuator-based embedded projects. Emphasis is placed on industry-relevant practices, reliability, and performance efficiency, preparing students for advanced work in embedded system development.

Prerequisite

- Nil

Course Outcomes

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

COS	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamental concepts and characteristics of embedded systems.	TPS2	80	70
CO2	Describe the architecture and functionality of Real-Time Operating Systems (RTOS).	TPS2	80	70
CO3	Design and develop a simple embedded system using RTOS.	TPS3	70	70
CO4	Implement a mechatronics project using embedded systems and sensors.	TPS3	70	70
CO5	Develop and debug embedded system code using a suitable programming language.	TPS3	70	70
CO6	Optimize embedded system performance by resolving power consumption and memory usage issues.	TPS3	70	70

Mapping with Programme Outcomes

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

S - Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT2			Assignment 2					
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		30			20									10	
CO2		30			30									20	
CO3			40			50									10
CO4								20	20			30			20
CO5								10	20			30			20
CO6								10	20			40			20

Syllabus

Introduction to Embedded Systems – Definition of embedded systems, characteristics, classification, applications in consumer, automotive, industrial, and medical domains, typical examples**. Embedded System Fundamentals** – Microcontroller architecture (Harvard, Von Neumann), types (8-bit, 16-bit, 32-bit), on-chip peripherals (timers, ADC, UART, SPI, I2C), memory types (ROM, RAM, Flash, EEPROM), memory organization and protection, input/output interfacing, communication protocols (UART, SPI, I2C, CAN), GPIO configuration, interrupt handling, design considerations (power consumption, reliability, fault tolerance). **Real-Time Operating Systems (RTOS**) – Introduction to RTOS, GPOS vs RTOS, types of scheduling (preemptive, cooperative), task states and management, kernel architecture, context switching, semaphores (binary, counting), mutexes, priority inversion, event flags, message queues, timers, device drivers, task synchronization and inter-process communication. **Embedded System Design and Development** – Embedded system design process, hardware-software partitioning, block diagram development, RTOS-based system design, task creation and communication, synchronization mechanisms, use of development tools (IDEs, compilers, debuggers, simulators), debugging techniques (breakpoints, trace tools, UART-based debugging), mini-projects using sensors and actuators. **Mechatronics Project Development** – Project lifecycle, requirement analysis, system design, sensor types (temperature, IR, ultrasonic, accelerometer), sensor interfacing, actuator types (DC motor, servo, relay), motor control (H-bridge, PWM), PID control and feedback systems, hardware integration, testing, documentation. **Embedded System Programming** – Embedded C and assembly programming basics, memory-mapped I/O, bit manipulation, ISR programming, modular code design, debugging tools (JTAG, SWD, serial monitor), best practices in coding (style, commenting, macros), performance optimization (loop unrolling, inlining, power-aware coding).

Text Book

1. Kamal, R. (2020). *Embedded systems* (4th ed.). McGraw Hill. ISBN-13: 978-9353168025.
2. White, E. (2024). *Making embedded systems: Design patterns for great software* (2nd ed.). O'Reilly Media. ISBN-10-1098151542
3. Zhu, Y. (2023). *Embedded systems with ARM Cortex-M microcontrollers in assembly language and C* (4th ed.). E-Man Press LLC. ISBN-10 - 0982692676

Reference Books & web resources

1. Gadre, D. V., & Subudhi, B. (2020). *Introduction to embedded system design* [Online course]. Netaji Subhas University of Technology, IIT Jammu. https://onlinecourses.nptel.ac.in/noc20_ee98/preview
2. Amos, B. (2020). Hands-on RTOS with microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools. Packt Publishing. ISBN-13: 978-1838826734.
3. Valvano, J. W. (2013). *Embedded systems: Introduction to ARM Cortex-M microcontrollers* (5th ed.). Jonathan Valvano. ISBN-13: 978-1477508992.

Course Contents and Lecture Schedule

Unit No.	Sub-topic	Periods
Introduction to Embedded Systems		
1.1	Definition of Embedded Systems and Applications (Consumer Electronics, Automotive, Medical, Industrial)	1
1.2	Characteristics of Embedded Systems (Real-time performance, Low power, Reliability)	
1.3	Embedded vs. General-Purpose Systems	1
Embedded System Fundamentals		
2.1	Microcontroller Architecture (Harvard vs. Von Neumann, CPU, ALU)	1
2.2	Types of Microcontrollers (8-bit, 16-bit, 32-bit, ARM)	
2.3	Memory Types and Organization (ROM, RAM, Flash, EEPROM)	1
2.4	I/O Systems and Communication Protocols (GPIO, UART, SPI,I2C,CAN)	
2.5	Power Consumption and Reliability Considerations in Embedded Systems	1
Real-Time Operating Systems (RTOS)		
3.1	Introduction to RTOS, Scheduling Policies (Preemptive, Cooperative)	1
3.2	Task Creation and Management in RTOS (Task States, Task Switching)	2
3.3	Semaphores and Mutexes for Task Synchronization	2
3.4	Inter-process Communication (Message Queues, Event Flags)	2
3.5	Device Drivers and Interrupt Handling in RTOS	2
Embedded System Design and Development		
4.1	Embedded System Design Process and Hardware-Software Partitioning	1
4.2	RTOS Programming: Task Creation, Synchronization, and Inter-task Communication	2
4.3	Development Tools: IDEs, Compilers, Debuggers, Emulators	2
4.4	Debugging Techniques and Performance Optimization in Embedded Systems	2
4.5	Hands-on Lab: Simple Embedded System Design (e.g., LED Blinking with RTOS)	2
Mechatronics and Embedded Systems		
5.1	Sensor Integration (Types: Temperature, IR, Ultrasonic)	1
5.2	Actuator Control (Types: DC Motor, Servo, Stepper, Motor Driver Circuits)	2
5.3	PID Control and Feedback Systems in Embedded Systems	2
5.4	Project Development and Testing (Hardware Integration and Validation)	2
Embedded System Programming		
6.1	C and Assembly Programming for Embedded Systems (Memory-Mapped I/O, Bit Manipulation)	2
6.2	Interrupt Service Routines (ISRs) and Modular Programming Techniques	2
6.3	Debugging Tools (JTAG, SWD, UART Debugging)	1
6.4	Code Optimization Techniques (Size, Speed, Power Consumption)	1
	Total Hours	**36**

Course Designer(s):

1. Mr.S.Parthasarathi Parthasarathi_s@tce.edu
2. Mr.S.A.R.SheikMasthan sarsmech@tce.edu

22MTSC0	SENSOR FUSION TECHNOLOGY	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Sensor fusion is the process of combining data from multiple sensors to produce more accurate, reliable, and comprehensive information than what a single sensor could provide. By leveraging the strengths and compensating for the weaknesses of individual sensors, sensor fusion enhances decision-making in systems like autonomous vehicles, robotics, and smart devices. It plays a key role in improving performance, reducing uncertainty, and enabling real-time awareness in complex environments.

Prerequisite

- Nil

Course Outcomes

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

Course outcomes	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the fundamental principles in sensor Fusion.	TPS2	80	70
CO2	Use algorithms for parameter estimation in linear and non-linear models.	TPS3	70	65
CO3	Implement algorithms for detection and estimation of the position of a target in a sensor network.	TPS3	70	65
CO4	Develop linear Kalman filter models for integrating autonomous vehicle sensors.	TPS3	70	65
CO5	Develop non-linear filter models for navigation and tracking applications	TPS3	70	65
CO6	Implement the motion models in target tracking and navigation applications	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	8	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO2	8	10	20	-	-	50	-	-	-	-	-	-	4	-	10
CO3	4	10	20	-	-	50	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	8	20	-	-	-	40	4	5	10
CO5	-	-	-	-	-	-	8	10	20	-	-	40	4	10	10
CO6	-	-	-	-	-	-	4	10	20	-	-	20	-	-	10

Syllabus

Introduction on estimation theories and sensor fusion- Statistical analysis: Gaussian distributions, expectation operator, means and variances, Dempster-Shafer Method - maximum likelihood- Least-squares method – Maximum Entropy methods – Bayesian-Recursive Bayesian methods

Sensors and Automated Driving Technologies: Basics of Camera, LIDAR, RADAR sensors – Sensor Positioning – Sensor Calibration – Sensing Algorithms – Automated Driving Systems – Mapping – Connectivity – Use of Artificial Intelligence for Autonomous Driving-Case study: Fusing an accelerometer, magnetometer gyroscope to estimate orientation

Observers: Principle of internal model matching, using outputs to match internal model, full state observer, reduced state observer Case study: Fusing a GPS and IMU to Estimate Pose

Estimators: Linear Kalman Filter, Extended Kalman Filter, Unscented Kalman Filter, Adaptive Filter (IMM Filter), Information Filter, Particle Filter. Tracking a Single Object With an IMM Filter

Sensor integration architectures: central, hierarchical, and decentralised fusion architectures-Multiple sensor fusion: Covariance intersection, State-vector fusion (track-to-track fusion), Information fusion-Tracking multiple objects using IMM filter.

Text Book

1. Jitendra R Raol, Data Fusion Mathematics: Theory and Practice, CRC Press, 2016.
2. David L. Hall, Sonya A.H. McMullen, Mathematical Techniques in Multisensor Data Fusion, Second Edition, Artech House, Boston, 2004.
3. R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.

Reference Books & web resources

1. Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer: Sensing and Control for Autonomous Vehicles: Applications to Land, Water and Air Vehicles, Springer, The Netherlands, 2017.
2. Tom Denton : Automated Driving And Driver Assistance Systems, IMI, NY, 2019.

Course Contents and Lecture Schedule

Module No.	Topic	Periods
1	**Introduction on estimation theories and sensor fusion**	
1.1	Statistical analysis: Gaussian distributions, expectation operator, means and variances	2

Module No.	Topic	Periods
1.2	Dempster-Shafer Method	1
1.3	Means and variances	1
1.4	Maximum likelihood- Least-squares method	1
1.5	Maximum Entropy methods – Bayesian- Recursive Bayesian methods	2
2	**Sensors and Automated Driving Technologies**	
2.1	Basics of Camera, LIDAR, RADAR sensors	2
2.2	Sensor Positioning ,Sensor Calibration	1
2.3	Sensing Algorithms, Automated Driving Systems, Mapping, Connectivity	2
2.4	Use of Artificial Intelligence for Autonomous Driving	2
2.5	Case study: Fusing an accelerometer, magnetometer gyroscope to estimate orientation	2
3	**Observers**	
3.1	Principle of internal model matching, using outputs to match internal model	2
3.2	full state observer, reduced state observer	2
3.3	Case study: Fusing a GPS and IMU to Estimate Pose	2
4	**Estimators**	
4.1	Linear Kalman Filter, Extended Kalman Filter, Unscented Kalman Filter	2
4.2	Adaptive Filter (IMM Filter), Information Filter, Particle Filter	2
4.3	Case study: Tracking a Single Object With an IMM Filter	2
5	**Sensor integration architectures**	
5.1	central, hierarchical, and decentralised fusion architectures	2
5.2	Multiple sensor fusion: Covariance intersection	2
5.3	State-vector fusion (track-to-track fusion), Information fusion	2
5.4	Case Study: Tracking multiple objects using IMM filter.	2
	Total	**36**

Course Designer(s):

1. Dr. H Ramesh, Assistant Professor rameshh@tce.edu
2. Prof.S Parthasarathi Assistant Professor parthasarathi_s@tce.edu

22MTSD0	SMART SUPPLY CHAIN MANAGEMENT	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

The Smart Supply Chain Management course introduces modern supply chain practices enhanced by digital technologies like AI, IoT, and Big Data. It focuses on building agile, data-driven, and efficient supply networks. Learners gain insights into optimizing operations, improving visibility, and enabling real-time decision-making in dynamic environments.

Prerequisite

- Nil

Course Outcomes

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

COs	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the evolution from traditional to smart supply chains	TPS2	80	70
CO2	Describe the role and integration of digital technologies in modern supply chain management.	TPS2	70	65
CO3	Apply descriptive, predictive, and prescriptive analytics to improve decision-making in supply chain operations.	TPS3	70	65
CO4	Implement smart logistics solutions to enhance warehousing and transportation efficiency.	TPS3	70	65
CO5	Develop the strategies for identifying and mitigating risks in digital supply chains, ensuring cyber security, and maintaining data privacy.	TPS3	70	65
CO6	Utilize digital tools to implement sustainable and ethical practices in supply chains, promoting environmental and social responsibility.	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO3	-	-	40	-	-	50	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	40	-	-	40	-	-	20
CO5	-	-	-	-	-	-	-	-	30	-	-	40	-	-	15
CO6	-	-	-	-	-	-	-	-	30	-	-	20	-	-	15

Syllabus

Foundations of Smart Supply Chains

Basics of supply chain management Understanding the evolution from traditional to smart supply chains -Key concepts: resilience, sustainability, visibility, and agility- Product Life cycle-Role of digital transformation in supply chain management- Explore the drivers and obstacles in digitizing supply chains.

Digital Technologies in Supply Chains

Integration of AI, IoT, Block chain, and Robotics -Application of digital twins in supply chain mapping - Reliability- Utilization of big data analytics for decision-making Examine practices for effective digital information exchange.-Utilize customer data to enhance supply chain decisions.

Supply Chain Analytics

Descriptive, predictive concepts , and prescriptive analytics - MTTF -Key performance indicators and metrics - Case studies on analytics-driven supply chain improvements -Apply digital initiatives to improve supply chain adaptability- Develop strategies for resilience in dynamic markets.

Smart Logistics and Fulfillment

Automation in warehousing and transportation- Vertical storage in large warehouse - Use of drones and autonomous vehicles - ASRS - Real-time tracking and inventory management-

Risk Management and Cyber security

Identifying and mitigating risks in digital supply chains -Ensuring data security and privacy -Developing contingency plans for disruptions- Formulate strategies aligning with digital competencies.- Assess organizational readiness for digital transformation.

Sustainability and Ethical Considerations

Implementing green logistics practices - Ethical sourcing and supplier compliance - Corporate social responsibility in supply chain decisions - Investigate how digital tools support sustainability goals - Implement technologies to promote environmental and social responsibility

Text Book

1. Chopra, S., Meindl, P., & Kalra, D.V, Supply Chain Management: Strategy, Planning, and Operation (8th ed.). Pearson, 2025
2. Amit Sinha.,Dr. Ednilson Bernardes.,Rafael Calderon& Dr. Thorsten Wuest, Digital Supply Networks: Transform Your Supply Chain and Gain Competitive Advantage with Disruptive Technology and Reimagined Processes , McGraw- Hill Education,2020.
3. Bart L. MacCarthy and Dimitry Ivanov, The Digital Supply Chain, Science direct, 2020

Reference Books & web resources

1. Muhammad Shujaat Mubarik & Sharfuddin Ahmed Khan, The Theory, Methods and Application of Managing Digital Supply Chains, Emerald Publishers, 2024

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Foundations of Smart Supply Chains**	
1.1	Basic of supply chain management concept Understanding the evolution from traditional to smart supply chains	2
1.2	Key concepts: resilience, sustainability, visibility, and agility	1
1.3	Product life cycle Role of digital transformation in supply chain management	2
1.4	Explore the drivers and obstacles in digitizing supply chains.	1
2.	**Digital Technologies in Supply Chains**	
2.1	Integration of AI, IoT, Block chain, and Robotics -Application of digital twins in supply chain mapping	2
2.2	Reliability, Utilization of big data analytics for decision-making Examine practices for effective digital information exchange	2
2.3	Utilize customer data to enhance supply chain decisions	1
2.4	Case studies on analytics-driven supply chain improvements	2
3.	**Supply Chain Analytics**	
3.1	Descriptive, predictive concepts , and prescriptive analytics -MTTF -Key performance indicators and metrics	2
3.2	Case studies on analytics-driven supply chain improvements Apply digital initiatives to improve supply chain adaptability	2
3.3	Develop strategies for resilience in dynamic markets	2
4.	**Smart Logistics and Fulfillment**	
4.1	Automation in warehousing and transportation -Vertical storage in large warehouse	2
4.2	Use of drones and autonomous vehicles	1
4.3	ASRS -Real-time tracking and inventory management	2
5.	**Risk Management and Cyber security**	
5.1	Identifying and mitigating risks in digital supply chains - Ensuring data security and privacy	2
5.2	Developing contingency plans for disruptions-	1
5.3	Formulate strategies aligning with digital competencies.- Assess organizational readiness for digital transformation.	2
6	**Sustainability and Ethical Considerations**	
6.1	Implementing green logistics practices - Ethical sourcing and supplier compliance	2
6.2	Corporate social responsibility in supply chain decisions	2
6.3	Investigate how digital tools support sustainability goals	2
	Total	**36**

Course Designer(s):

1. S. Rajkumar Assistant Professor srmech@tce.edu
2. Dr. M M. Devarajan Assistant Professor mmdmech@tce.edu

22MTSE0	SOFT COMPUTING	Category	L	T	P	C	TE
		PSE	1	0	4	3	Practical

Preamble

The field of Soft Computing provides powerful tools and techniques for addressing complex real-world problems that are difficult to solve using traditional computational methods. This course introduces students to foundational concepts in fuzzy logic, artificial neural networks, and bio-inspired algorithms, which form the pillars of Soft Computing. Students will explore fuzzy systems and controllers, gain insights into evolutionary and swarm intelligence algorithms, and learn to solve single and multi-objective optimization problems using these intelligent techniques. Through practical case studies students will bridge theory with engineering applications, preparing them to design robust and adaptive solutions in diverse domains.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Illustrate Fuzzy Logic operations and Defuzzification techniques	TPS 2	80	80
CO2	Solve real-world problems using Fuzzy Logic	TPS 3	70	70
CO3	Implement Genetic algorithm for solving optimization problems	TPS 3	70	70
CO4	Explain the working of Evolutionary and Swarm Intelligence algorithms	TPS 2	80	80
CO5	Use Swarm Intelligence algorithms for solving optimization problems	TPS 3	70	70
CO6	Implement Artificial Neural Networks for real world applications	TPS 3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="8">Continuous Assessment (%)</th><th rowspan="2">Terminal (%)</th></tr>
<tr><th colspan="3">CAT 1</th><th colspan="3">CAT 2</th><th>Experiments</th><th>Model Exam</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>3</th><th>3</th><th>3</th></tr>
<tr><td>CO1</td><td>10</td><td>20</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>CO2</td><td>10</td><td>-</td><td>20</td><td>-</td><td>-</td><td>-</td><td rowspan="2">50</td><td rowspan="2">50</td><td rowspan="2">50</td></tr>
<tr><td>CO3</td><td>-</td><td>20</td><td>20</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td>10</td><td>10</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td>10</td><td>10</td><td>20</td><td rowspan="2">50</td><td rowspan="2">50</td><td rowspan="2">50</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td>10</td><td>10</td><td>20</td></tr>
</table>

Syllabus

Introduction
Introduction to Soft Computing, Introduction to Fuzzy logic, Fuzzy membership functions, Operations on Fuzzy sets
Fuzzy Logic
Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences, Defuzzyfication Techniques, Fuzzy logic controller
Bio Inspired Algorithms
Introduction - Evolutionary Computing - Concept of Genetic Algorithm (GA), GA Operators: Encoding, Selection, Crossover, Mutation, Solving optimization problems
Swarm Intelligence Algorithms, Physics based Algorithms, Heuristic and Meta-Heuristics Algorithm, Hybrid Algorithms - Applications
Multi Objective Evolutionary Algorithms
Non-Pareto based approaches; Pareto based approaches
Artificial Neural Network
Introduction to ANN, ANN Architecture, ANN Training, Applications of ANN
Case Study:
Inverse Kinematics Approaches – Path Planning - Design Optimization - Welding path optimization – Engineering optimization

Text Book(s)

1. S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, 3ed, John Wiley & Sons, 2018

Reference Books and Web Resources

1. NPTEL Course: Introduction to Soft Computing - By Prof. Debasis Samanta, IIT Kharagpur - https://onlinecourses.nptel.ac.in/noc22_cs54/preview
2. Kuntal Barua, Prof. Prasun Chakrabarti, FUNDAMENTALS OF SOFT COMPUTING: Theory, Concepts and Methods of Artificial Intelligence, Neurocomputing, BPB Publications; First Edition, 2017

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1	**Introduction**	
1.1	Introduction to Soft Computing, Introduction to Fuzzy logic,	2
1.2	Fuzzy membership functions, Operations on Fuzzy sets	2
2	**Fuzzy Logic**	
2.1	Fuzzy relations, Fuzzy propositions, Fuzzy implications	1
2.2	Fuzzy inferences, Defuzzyfication Techniques, Fuzzy logic controller	2
3	**Bio Inspired Algorithms**	
3.1	Introduction - Evolutionary Computing - Concept of Genetic Algorithm (GA)	1
3.2	GA Operators: Encoding, Selection, Crossover, Mutation, Solving optimization problems	2
3.3	Swarm Intelligence Algorithms, Physics based Algorithms	2
3.4	Heuristic and Meta-Heuristics Algorithm, Hybrid Algorithms - Applications	2
4	**Multi Objective Evolutionary Algorithms**	
4.1	Non-Pareto based approaches	2
4.2	Pareto based approaches	2
5	**Artificial Neural Network**	

Module No.	Topic	No. of Hours
5.1	Introduction to ANN, ANN Architecture	2
5.2	ANN Training, Applications of ANN	2
6	**Case Study:**	
6.1	Inverse Kinematics Approaches – Path Planning	1
6.2	Design Optimization - Welding path optimization	1
	Total	**24**

List of Experiments

Expt. No.	Topic	COs	No. of Hours
1	Implementation of Fuzzy Membership Functions	CO3	2
2	Fuzzy Set Operations and Fuzzy Relations	CO3	2
3	Design of a Fuzzy Logic Controller	CO3	2
4	Implementation of Genetic Algorithm for Single-Objective Optimization	CO4	2
5	Tuning GA Parameters and Observing Convergence	CO4	2
6	Implementation of Particle Swarm Optimization (PSO)	CO5	2
7	Implementation of Physics based Algorithm	CO5	2
8	Implementation of Hybrid Algorithm	CO5	2
9	Multi-Objective Optimization Using NSGA-II	CO5	2
10	Implementation of a Feedforward ANN for Classification	CO4	2
11	ANN for Regression Tasks	CO4	2
12	Application of ANN in Control or Estimation	CO4	2
		Total Hours	**24**

Course Designers:

1. Dr. G Kanagaraj, gkmech@tce.edu
2. Mr. Sheik Masthan S A R, sarsmech@tce.edu
3. Dr. M Rajalakshmi, mrimect@tce.edu

22MTRD0	MEDICAL DIGITAL TWIN	Category	L	T	P	C	TE
		PEES	1	0	4	3	Practical

Preamble

The course "Medical Digital Twin" introduces students to the transformative concept of digital twins in the context of healthcare, where physical biological systems are mirrored with their digital counterparts. This multidisciplinary subject combines biomedical engineering, systems modelling, sensor integration, data analytics, and real-time simulation technologies to enable predictive, personalized, and preventive healthcare solutions. With increasing reliance on AI and virtual environments in modern medicine, this course prepares Mechatronics students to build and simulate real-time patient models, integrate sensor networks, and contribute to smart healthcare ecosystems.

Prerequisite

- NIL

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain digital twin concepts and architecture in medical systems	TPS 2	80	80
CO2	Interpret biomedical signals and sensor data for twin modelling	TPS 3	70	70
CO3	Model basic physiological systems using mathematical approaches	TPS 3	70	70
CO4	Develop systems using IoT for health data analysis	TPS 3	70	70
CO5	Develop a basic digital twin model for a healthcare scenario	TPS 3	70	70
CO6	Describe ethical and privacy aspects in medical digital twin systems	TPS 2	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Continuous Assessment (%)								Terminal (%)
	CAT 1			CAT 2			Experiments	Model Exam	
TPS	1	2	3	1	2	3	3	3	3
CO1	10	20	-	-	-	-	-	-	-
CO2	10	20	-	-	-	-	100	100	100
CO3	10	10	20	-	-	-			
CO4	-	-	-	10	10	20			
CO5	-	-	-	10	10	20			
CO6	-	-	-	10	10	-	-	-	-

Syllabus

Introduction to Digital Twins in Healthcare
Concept and evolution of digital twin - Digital twin vs simulation and modeling - Components: Physical entity, virtual entity, data, and services - Use cases in healthcare: preventive care, diagnostics, surgical planning - Overview of smart hospitals and digital healthcare ecosystems.

Biomedical Systems and Sensors
Human physiological systems relevant to DT (cardiac, respiratory, musculoskeletal) – Bio signal acquisition: ECG, EEG, EMG, temperature, SpO2 - Wearable devices, IoT health nodes - Signal pre-processing and noise removal

Mathematical Modeling and Simulation of Human Systems
System identification and modeling of dynamic biomedical systems - Lumped parameter and compartmental models - Case study: Cardiovascular and respiratory system models - Modeling in MATLAB/Simulink or similar environments - Role of real-time feedback loops

Digital Twin Platforms & Tools: Overview of DT development using Twin Builder, and cloud platforms.

Sensor Integration & AI: Linking real-time sensor data with virtual models; applying ML for anomaly detection and diagnostics; understanding healthcare data standards.

Healthcare Applications & Ethics: Use in chronic disease management, surgery simulation, and ICU monitoring; case studies; ethical considerations and future trends like VR/AR and Metaverse in healthcare.

Text Book(s)

1. A.K.M. Azad et al., Digital Twin Development and Deployment on the Cloud, Academic Press, 2021.

Reference Books and Web Resources

1. R.G. Carson & H.J. McKenna, Introduction to Modeling in Physiology and Medicine, Academic Press, 2012.
2. Deepak Gupta et al., Digital Twin Technology: Advances, Applications and Future Prospects, Springer, 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1	**Introduction to Digital Twins in Healthcare**	
1.1	Concept and evolution of digital twin - Digital twin vs simulation and modeling - Components: Physical entity, virtual entity, data, and services	2
1.2	Use cases in healthcare: preventive care, diagnostics, surgical planning - Overview of smart hospitals and digital healthcare ecosystems.	2
2	**Biomedical Systems and Sensors**	
2.1	Human physiological systems relevant to DT (cardiac, respiratory, musculoskeletal) – Bio signal acquisition: ECG, EEG, EMG, temperature, SpO2	2
2.2	Wearable devices, IoT health nodes	2
2.3	Signal pre-processing and noise removal	1
3	**Mathematical Modeling and Simulation of Human Systems**	
3.1	System identification and modeling of dynamic biomedical systems - Lumped parameter and compartmental models	2
3.2	Case study: Cardiovascular and respiratory system models	1
3.3	Modeling in MATLAB/Simulink or similar environments - Role of real-time feedback loops	2

Module No.	Topic	No. of Hours
4	**Digital Twin Platforms & Tools**	
4.1	Overview of DT development using Unity, Ansys Twin Builder, MATLAB Simscape	2
4.2	cloud platforms	1
5	**Sensor Integration & AI**:	
5.1	Linking real-time sensor data with virtual models; applying ML for anomaly detection and diagnostics;	2
5.2	understanding healthcare data standards.	1
6	**Healthcare Applications & Ethics**:	
6.1	Use in chronic disease management, surgery simulation, and ICU monitoring	2
6.2	case studies; ethical considerations and future trends like VR/AR and Metaverse in healthcare.	2
	Total	**24**

List of Experiments

Expt. No.	Topic	COs	No. of Hours
1.	Acquisition and Preprocessing of ECG Signals	CO2	2
2.	EMG Signal Pr ocessing for Muscle Monitoring	CO2	2
3.	EEG Feature Extraction for Brain Signal Interpretation	CO2	2
4.	A simple mathematical of the Cardiovascular System	CO3	2
5.	Compartmental Modelling of the Respiratory System	CO3	2
6.	Feedback Control for Heart Rate Regulation	CO3	2
7.	Simulated IoT Node for Body Temperature and SpO2 Monitoring	CO4	2
8.	Health Data Logging and Alert System using LabVIEW	CO4	2
9.	Machine Learning-Based Health Status Classification	CO4	2
10.	Digital Twin of a Beating Heart Using Ansys Twin Builder	CO5	2
11.	3D Visualization of ICU Patient Monitoring System	CO5	2
12.	Integration of Physiological Model with Unity Visualization	CO5	2
	Total Hours		**24**

Course Designers:

1. Dr. M Rajalakshmi, mrimect@tce.edu
2. Mr. Sheik Masthan S A R, sarsmech@tce.edu

22MTQB0	INDUSTRY 4.0	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Industry 4.0 refers to a new phase in the Industrial Revolution that places strong emphasis on interconnectivity, automation, machine learning, and real-time data. Industry 4.0, which includes Industrial internet of things (IIOT) and smart manufacturing, combines physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better-connected ecosystem for companies that focus on manufacturing and supply chain management. This course focusses on the components and applications of industry 4.0 for manufacturing sector.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency (in %)	Expected Attainment Level (in %)
CO1	Explain different technologies used in industry 4.0 and its applications.	TPS2	80	70
CO2	Perform AI based analytics in Industry 4.0 frame work.	TPS3	70	65
CO3	Develop Cyber physical systems for industrial 4.0 applications	TPS3	70	65
CO4	Solve interoperable issues in connected factory using OPC, OPC-UA and TSN.	TPS3	70	65
CO5	Illustrate AR based operation and Maintenance sequence in Factory.	TPS3	70	65
CO6	Develop cloud-based database for Smart Manufacturing systems.	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S – Strong M – Medium L – Low

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	8	20	-	-	-	-	-	-	-	-	-	-	4	10	-
CO2	8	10	20	-	-	50	-	-	-	-	-	-	4	-	10
CO3	4	10	20	-	-	50	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	8	20	-	-	-	40	4	5	10
CO5	-	-	-	-	-	-	8	10	20	-	-	40	4	10	10
CO6	-	-	-	-	-	-	4	10	20	-	-	20	-	-	10

Syllabus

Introduction to Industry 4.0: The different Industrial revolutions-definition of Industry 4.0-comparision of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0-Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy- Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.
Basic principles and components of Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services (IOS)- Big Data- Cyber-Physical Systems- Smart Manufacturing- Smart Logistics- Customization of products- Digital Twins- Cloud applications in manufacturing.
Cyber physical systems (CPS): Core elements of CPS -control theory and real time requirements-self organization principles-communication in cyber physical Systems-Modelling, programming and model-integrated development of CPS- AI and ML based analytics.
Interoperability: Communication standards for Industry 4.0: Industrial communication Networks- Reference Architecture Model Industry 4.0 (RAMI4.0) - Basics on Service oriented Architecture- Introduction into Open platform communications (OPC) - Classic OPC vs. OPC-Unified Architecture (UA) - OPC Services- System Architecture- OPC- UA and the Cloud-Time Sensitive Networking (TSN)-architecture-Standards-Benefits of adopting TSN. Case study on OPC-UA applications
Connected Factory: Virtualization-Augmented Reality (AR) in Manufacturing-integrating design and manufacturing-Data Visualization-Work piece traceability using QR codes, RFID and beacon tags -big data in production- Cloud-based Enterprise resource planning (ERP) and Manufacturing Execution system (MES) solutions, Case study on ERP and MES.

Text Book(s)

1. Introduction to industrial internet of things and industry 4.0 by Sudip Misra, Chandana Roy and Anandarup Mukherjee, CRC Press,2020.

Reference Books & Web Resources

1. “Industry 4.0: The Industrial Internet of Things”, by Alasdair Gilchrist (Apress), 2016.
2. “Industrial Internet of Things: Cyber manufacturing Systems “by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer),2017
3. Hands-on Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0 ,Giacomo veneri, Antonio capasso,Packt,2018.
4. Hand book of Industry 4.0 and SMART Systems, Diego Galar Pascual, Pasquuale Daponte, Uday Kumar, CRC Press, 2019.
5. https://nptel.ac.in/courses/106105195

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Introduction to Industry 4.0**	
1.1	The different Industrial revolutions-definition of Industry 4.0	1
1.2	comparison of industry 4.0 factory and existing factory-Difference between conventional automation and industry 4.0	1
1.3	Drivers, Enablers, compelling forces and challenges for Industry 4.0- Digitalization and the Networked Economy	1
1.4	Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation-Developments in industry 4.0.	1
2.	**Basic principles and components of Industry 4.0**	
2.1	Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services	1

2.2	Big Data- Cyber-Physical Systems-	1
2.3	Smart Manufacturing- Smart Logistics	1
2.4	Customization of products- Digital Twins	1
2.5	Cloud applications in manufacturing	1
3.	**Cyber physical systems (CPS)**	
3.1	Core elements of CPS, Control theory and real time requirements	2
3.2	Self-organization principles-communication in cyber physical systems	1
3.3	Modelling, programming and model-integrated development of CPS, AI and ML based analytics	3
4.	**Interoperability: Communication standards for Industry 4.0**	
4.1	Industrial communication Networks-Ethernet I/P, Profinet, Profibus, Device net, Ethercat	2
4.2	Industry 4.0 Reference Architecture Model RAMI4.0	1
4.3	Basics on Service oriented Architecture	1
4.4	Introduction into OPC- Classic OPC vs. OPC-UA- OPC Services- System Architecture	2
4.5	OPC-UA and the Cloud	1
4.6	Time Sensitive Networking (TSN)-architecture-Standards-Benefits of adopting TSN	1
4.7	Case study on OPC-UA applications.	2
5.	**Connected factory**	
5.1	Virtualization-AR in Manufacturing	2
5.2	Integrating design and manufacturing, Data visualization	4
5.3	Work piece traceability using QR codes, RFID and beacon tags	2
5.4	Big data in production	1
5.5	Cloud-based ERP and MES solutions, Case study	2
	Total Hours	**36**

Course Designers:

1. Dr. H Ramesh, rameshh@tce.edu
2. Dr. S Julius Fusic, sjf@tce.edu

22MTQC0	ROBOTICS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

Robotics is a multidisciplinary field that combines mechanical systems, electronics, control theory, and computer programming to design and develop intelligent machines capable of performing tasks. This course introduces the fundamental principles of robotics with a focus on basic robot structure, motion, sensing, and control. The syllabus is structured to provide both theoretical understanding and practical experience, helping students appreciate the role of robotics in automation, manufacturing, healthcare, and service industries. By the end of the course, students will gain foundational knowledge and get exposed to modern robotic technologies and systems.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the fundamental concepts of robots	TPS2	80	75
CO2	Apply kinematic principles to describe robot motion.	TPS3	70	65
CO3	Explain how actuators and sensors are used in robotic systems.	TPS2	80	75
CO4	Implement PID control for a mobile robot	TPS3	70	65
CO5	Execute basic robot pendant programs for task execution	TPS3	70	65
CO6	Discuss applications of robotics	TPS2	80	75

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT 2			Assignment 2					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	30												10		
CO2			20										10		
CO3	25	25			100									20	
CO4									20			100		20	
CO5							15	15	20						20
CO6							30								20

***** Assignment 02 – Simulation of Robot.

Syllabus

Introduction to Robotics
Definition - History of robotics, Types of robots – Industrial and Mobile Robots, Basic structure of a robot (mechanical, electrical, and software components), Grippers, Laws of Robotics, Applications.

Components
Basic sensors: Wheel encoders, IMU, Camera and LIDAR, Basic Actuators: DC motors -servo motors - stepper motors. Robot Chassis Construction.

Robot Kinematics
Degrees of Freedom (DOF), DH Parameters - Rotation Matrices - Forward and Inverse Kinematics for 2DOF industrial robots and mobile robots.

Robot Control
Trajectory Planning - PID control – Implementation. Basic robot pendant commands.

Applications
Industrial Robot, Maze robot, Surveillance Robot, Robot Vacuum Cleaner, Humanoid Robots.

Text Book

1. Dr Jisu Elsa Jacob, "Robotics Simplified: An Illustrative Guide to Learn Fundamentals of Robotics, Including Kinematics, Motion Control, and Trajectory Planning", BPB Publications, 2022

Reference Books & web resources

1. Robotics, AI, and Humanity, Science, Ethics, and Policy, Springer, 2021.
2. Shuai Li, Long Jin, Mohammed Aquil Mirza," Kinematic Control of Redundant Robot Arms Using Neural Networks", IEEE press, April 29, 2019.
3. John J Craig, "Introduction to Robotics, Mechanics and Control, third edition, Pearson education, 2005.
4. K.S.Fu, R.C Gonzalez and C.S Lee, Robotics – Control, sensing Vision and Intelligence, Tata McGraw – Hill Editions, 2008.
5. S.K. Saha, "Introduction to Robotics", second edition, Mc Graw Hill education India Private limited, New Delhi, 2008.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Robotics**	
1.1	Definition - History of robotics	1

Module No.	Topic	No. of Periods
1.2	Types of robots – Industrial and Mobile Robots	2
1.3	Basic structure of a robot (mechanical, electrical, and software components)	2
1.4	Grippers	1
1.5	Laws of Robotics	2
1.6	Applications	2
2	**Components**	
2.1	Basic sensors: Wheel encoders,	1
2.2	IMU, Camera	1
2.3	LIDAR	1
2.4	Basic Actuators: DC motors	1
2.5	Servo motors, Stepper Motors	2
2.6	Robot Chassis Construction	1
3	**Robot Kinematics**	
3.1	Degrees of Freedom (DOF)	1
3.2	DH Parameters	1
3.3	Rotation Matrices	2
3.4	Forward Kinematics for 2DOF industrial robots	2
3.5	Inverse Kinematics for 2DOF industrial robots	2
3.6	Mobile robots	1
4	**Robot Control**	
4.1	Trajectory Planning	1
4.2	PID control - Implementation	1
4.3	Basic robot pendant commands	1
5	**Applications**	
5.1	Industrial Robot	1
5.2	Maze robot, Surveillance Robot	2
5.3	Robot Vacuum Cleaner	2
5.4	Humanoid Robots	2
	Total Hours	**36**

Course Designer(s):

1. Ganesh M A, Assistant Professor ganeshma2015@tce.edu
2. Dr G Kanagaraj, Professor gkmech@tce.edu

22MTQD0	SENSORS AND ACUATORS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course on Sensors and Actuators introduces undergraduate students to the fundamental concepts, principles, and applications of sensors and actuators in modern engineering systems. These components are central to the operation of a wide range of devices and systems, including robotics, automotive technologies, Internet of Things (IoT), biomedical engineering, and industrial automation. The course covers the basic working principles of various sensors and actuators, their characteristics, and their performance criteria, with a focus on their real-world applications. Students will learn how to interface sensors and actuators with microcontrollers for data acquisition and control, and gain hands-on experience in signal conditioning, communication protocols, and practical implementation in embedded systems. The knowledge gained will equip students to contribute to the development of intelligent systems and automation solutions in their future careers

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the basic principles of operation and classification of sensors and actuators in various engineering applications.	TPS 2	80	70
CO2	Interpret characteristics of sensors, such as range, accuracy, sensitivity, and response time.	TPS 2	80	70
CO3	Classify different types of sensors like mechanical, thermal, optical, and chemical. Explain their working principles and areas of application.	TPS 3	70	70
CO4	Use appropriate sensors in practical applications based on their characteristics and functionalities.	TPS 3	70	70
CO5	Identify suitable actuators for specific engineering applications such as automation and control.	TPS 3	70	70
CO6	Demonstrate the application of actuators in real-time systems like automotive and industrial equipment.	TPS 3	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT2			Assignment 2					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		30			20									10	
CO2		30			30									10	
CO3			40			50									20
CO4								20	20			30			20
CO5								10	20			30			20
CO6								10	20			40			20

Syllabus

Introduction to Sensors and Actuators – Overview of transducers, sensors, and actuators; basic principles of operation; energy transformation and classifications; types of sensors and actuators used in various applications like automotive, robotics and biomedical systems.
Sensor Characteristics and Performance – Key characteristics of sensors including range, resolution, sensitivity, accuracy, precision, repeatability, response time, linearity, and dynamic range; comparison of different types of sensors based on their performance criteria.
Types of Sensors and Actuators – Mechanical and electromechanical sensors (e.g., resistive, capacitive, inductive, strain gauges); thermal sensors (e.g., thermocouples, thermistors, RTDs); radiation and optical sensors (e.g., photosensors, fiber optics); magnetic sensors (e.g., Hall effect, magneto resistive); chemical and gas sensors; inertial sensors (e.g., gyroscopes, accelerometers); and actuator types including electrical, pneumatic, hydraulic, piezoelectric, and piezoresistive.
Applications of Sensors and Actuators – Real-world applications of sensors and actuators in automotive, robotics, industrial automation and healthcare systems; integrating sensor and actuator solutions for system design and optimization.

Textbook

1. Ida, N. (2020). Sensors, Actuators, and Their Interfaces: A Multidisciplinary Introduction, 2nd ed. Springer.

Reference Books & web resources

1. de Silva, C. W. (2015). Sensors and Actuators: Engineering System Instrumentation 2nd ed., CRC Press.
2. Akande, O. (2023). Industrial Automation from Scratch: A Hands-on Guide to Using Sensors, Actuators, PLCs, HMIs, and SCADA to Automate Industrial Processes. Independently Published.
3. Brown, P. (2017). Sensors and Actuators: Technology and Applications. World Scientific Publishing
4. Pandya, H. J. (2025). Sensors and Actuators [Online course]. National Programme on Technology Enhanced Learning (NPTEL). https://onlinecourses.nptel.ac.in/noc25_ee76/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods (Hours)
	Introduction to Sensors and Actuators	
1.1	Introduction to transducers, sensors, actuators; principles of operation	2
1.2	Energy transformation and classification of sensors and actuators	2
1.3	Application domains: automotive, robotics and biomedical systems	2
1.4	Summary, examples, and case studies	1
	Sensor Characteristics and Performance	
2.1	Definitions: range, resolution, sensitivity, accuracy	2
2.2	Precision, repeatability, response time, linearity, and dynamic range	2
2.3	Comparison of different types of sensors based on performance criteria	2
2.4	Summary, examples, and case studies	1
	Types of Sensors and Actuators	
3.1	Mechanical and electromechanical sensors (resistive, capacitive, inductive, strain gauges)	1
3.2	Thermal sensors (thermocouples, thermistors, RTDs)	1
3.3	Radiation and optical sensors (photosensors, fiber optics)	2
3.4	Magnetic sensors (Hall effect, magnetoresistive)	2
3.5	Chemical and gas sensors	2
3.6	Inertial sensors (gyroscopes, accelerometers)	2
3.7	Actuator types (electrical, pneumatic, hydraulic, piezoelectric, piezoresistive)	2
	Applications of Sensors and Actuators	
4.1	Real-world applications in automotive systems	2
4.2	Robotics and industrial automation	2
4.3	healthcare systems	2
4.4	Integrating sensor and actuator solutions for system design and optimization	2
4.5	Summary, examples, and case studies	2
	Total Hours	**36**

Course Designer(s):

1. Mr.S.Parthasarathi Assistant Professor Parthasarathi_s@tce,edu
2. Dr. Devarajan M M Assistant Professor mmdmech@tce.edu

22MTQE0	DRONE TECHNOLOGY	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course provides a foundational understanding of drones (UAVs), their types, hardware components, principles of flight, assembly, and practical applications. It is aimed at equipping students with basic theoretical and practical knowledge in drone technology.

Prerequisite

- NIL

Course Outcomes

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

COs	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Illustrate the types, categories, and uses of drones.	TPS 2	80	80
CO2	Explain the fundamental forces and motions that affect drone flight.	TPS 2	80	80
CO3	Describe the functions of the main components used in drone assembly.	TPS 2	80	80
CO4	Demonstrate the steps to assemble and prepare a drone for flight.	TPS 3	70	70
CO5	Test and calibrate drone systems before flight.	TPS 3	70	70
CO6	Apply knowledge of drone applications to analyze simple case studies.	TPS 3	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT2			Assignment 2					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	20	20	-										4	5	
CO2	10	20	-		100								6	5	
CO3	10	20	-										6	10	
CO4							10	10	20				4	10	10
CO5								10	20			100		10	10
CO6								10	20					10	10

Syllabus

Introduction to Drone Technology (6 hours)
Definition and Types: UAV, Drone, RPA, Quadcopter - Categories: Nano, Micro, Mini, Tactical, Strategic - History and Evolution of Drones - Civil and Military Applications Overview of Drone Regulations and Safety Guidelines.

Basics of Flight Dynamics (6 hours)
Forces of Flight: Lift, Thrust, Drag, Weight - Stability and Control: Pitch, Roll, Yaw - Types of Drone Frames and Propulsion Systems - Introduction to Airframe Shapes and Their Effects - Basic Flight Maneuvers and Dynamics.

Drone Hardware and Assembly (8 hours)
Power System: Motors, Propellers, Battery, ESC -Control System: Flight Controller Board (FCB), IMU, GPS - Communication System: Transmitter, Receiver - Material Selection: Frame materials (carbon fiber, plastic, aluminum, composite), payload structure materials, Assembling Steps: Frame, Wiring, Propeller Mounting - Preflight Setup and Safety Precautions.

Drone Testing and Calibration (8 hours)
Safety rules before flying - Use a pre-flight checklist to prepare the drone - Check for simple problems after a crash - Understand how to balance the drone using sensors (IMU, compass, gyro) - Test if the motors are working properly - how to check battery level and return-to-home function.

Applications and Case Studies (8 hours)
Drone Applications: Aerial Photography, Agriculture (Crop Health Monitoring), Surveillance and Security, Disaster Management, Case Studies: Weed Detection, Structural Inspection, Future Trends in Drone Technology

Text Book

1. Reg Austin, Unmanned Aircraft Systems: UAV Design, Development, and Deployment, Wiley, 2010.

Reference Books & web resources

1. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, 1998
2. Paul G. Fahlstrom & Thomas J. Gleason, Introduction to UAV Systems, UAV Systems, Inc, 1998
3. Kimon P. Valavanis, Advances in Unmanned Aerial Vehicles, Springer, 2007

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Drone Technology**	
1.1	Definition and Types: UAV, Drone, RPA, Quadcopter	2
1.2	Categories: Nano, Micro, Mini, Tactical, Strategic	1
1.3	History and Evolution of Drones	1
1.4	Civil and Military Applications: Overview of Drone Regulations and Safety Guidelines.	2
2	**Basics of Flight Dynamics**	
2.1	Forces of Flight: Lift, Thrust, Drag, Weight	1
2.2	Stability and Control: Pitch, Roll, Yaw	1
2.3	Types of Drone Frames and Propulsion Systems	2

Module No.	Topic	No. of Periods
2.4	Introduction to Airframe Shapes and Their Effects - Basic Flight Maneuvers and Dynamics.	2
3	**Drone Hardware and Assembly**	
3.1	Power System: Motors, Propellers, Battery, ESC	2
3.2	Control System: Flight Controller Board (FCB), IMU, GPS	2
3.3	Communication System: Transmitter, Receiver	2
3.4	Assembling Steps: Frame, Wiring, Propeller Mounting - Preflight Setup and Safety Precautions.	2
4	**Drone Testing and Calibration**	
4.1	Safety rules before flying	2
4.2	Use a pre-flight checklist to prepare the drone - Check for simple problems after a crash	2
4.3	Understand how to balance the drone using sensors (IMU, compass, gyro)	2
4.4	Test if the motors are working properly - how to check battery level and return-to-home function.	2
5	**Applications and Case Studies**	
5.1	Drone Applications: Aerial Photography, Agriculture (Crop Health Monitoring), Surveillance and Security, Disaster Management.	4
5.2	Case Studies: Weed Detection, Structural Inspection, Future Trends in Drone Technology.	4
	Total	**36**

Course Designer(s):

1. Dr Rajalakshmi M, Assistant Professor, mrimect@tce.edu
2. Mr. Ganesh M A ganeshma2015@tce.edu

22MTQF0	EMBEDDED SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Preamble

This course provides a comprehensive introduction to embedded systems, focusing on their architecture, functionality, and application in real-time and resource-constrained environments. It covers the fundamentals of microcontrollers, memory, and I/O interfaces, along with the principles of Real-Time Operating Systems (RTOS). Students will gain hands-on experience in designing and programming embedded systems using C and assembly language and develop practical skills in debugging and optimization. The course also integrates mechatronics concepts, enabling students to implement sensor-actuator-based embedded projects. Emphasis is placed on industry-relevant practices, reliability, and performance efficiency, preparing students for advanced work in embedded system development.

Prerequisite

- Nil

Course Outcomes

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

COS	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamental concepts, characteristics, classification, and applications of embedded systems.	TPS2	80	70
CO2	Describe microcontroller architectures, on-chip peripherals, memory types, and communication protocols used in embedded systems.	TPS2	80	70
CO3	Develop input/output interfacing techniques and GPIO configurations in embedded system design.	TPS3	70	70
CO4	Implement real-time features such as task scheduling, semaphores, and inter-process communication using RTOS.	TPS3	70	70
CO5	Develop embedded systems by applying task management.	TPS3	70	70
CO6	Use development tools and debugging techniques to build embedded applications	TPS3	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment (%)												Terminal (%)		
	CAT1			Assignment 1			CAT2			Assignment 2					
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		30			20									10	
CO2		30			30									20	
CO3			40			50									10
CO4								20	20			30			20
CO5								10	20			30			20
CO6								10	20			40			20

Syllabus

Introduction to Embedded Systems – Definition of embedded systems, characteristics, classification, applications in consumer, automotive, industrial, and medical domains, typical examples**. Embedded System Fundamentals** – Microcontroller architecture (Harvard, Von Neumann), types (8-bit, 16-bit, 32-bit), on-chip peripherals (timers, ADC, UART, SPI, I2C), memory types (ROM, RAM, Flash, EEPROM), memory organization and protection, input/output interfacing, communication protocols (UART, SPI, I2C, CAN), GPIO configuration, interrupt handling, design considerations (power consumption, reliability, fault tolerance). **Real-Time Operating Systems (RTOS**) **–** Introduction to RTOS, GPOS vs RTOS, types of scheduling (preemptive, cooperative), task states and management, kernel architecture, context switching, semaphores (binary, counting), mutexes, priority inversion, event flags, message queues, timers, device drivers, task synchronization and inter-process communication. **Embedded System Design and Development** – Embedded system design process, hardware-software partitioning, block diagram development, RTOS-based system design, task creation and communication, synchronization mechanisms, use of development tools (IDEs, compilers, debuggers, simulators), debugging techniques (breakpoints, trace tools, UART-based debugging), mini-projects using sensors and actuators.

Text Book

1. Kamal, R. (2020). *Embedded systems* (4th ed.). McGraw Hill. ISBN-13: 978-9353168025.
2. White, E. (2024). *Making embedded systems: Design patterns for great software* (2nd ed.). O'Reilly Media. ISBN-10-1098151542
3. Zhu, Y. (2023). *Embedded systems with ARM Cortex-M microcontrollers in assembly language and C* (4th ed.). E-Man Press LLC. ISBN-10 - 0982692676

Reference Books & web resources

1. Gadre, D. V., & Subudhi, B. (2020). *Introduction to embedded system design* [Online course]. Netaji Subhas University of Technology, IIT Jammu. https://onlinecourses.nptel.ac.in/noc20_ee98/preview
2. Amos, B. (2020). Hands-on RTOS with microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools. Packt Publishing. ISBN-13: 978-1838826734.
3. Valvano, J. W. (2013). *Embedded systems: Introduction to ARM Cortex-M microcontrollers* (5th ed.). Jonathan Valvano. ISBN-13: 978-1477508992

Course Contents and Lecture Schedule

Module No	Sub-Topic	Periods
	1: Introduction to Embedded Systems	
1.1	Definition of Embedded Systems	1
1.2	Characteristics of Embedded Systems	1
1.3	Classification of Embedded Systems	1
1.4	Applications in Consumer, Automotive, Medical, and Industrial Domains	1
1.5	Typical Examples of Embedded Systems	1
	2: Embedded System Fundamentals	
2.1	Microcontroller Architecture (Harvard vs. Von Neumann, CPU, ALU)	1
2.2	Types of Microcontrollers (8-bit, 16-bit, 32-bit, ARM)	1
2.3	On-chip Peripherals (Timers, ADC, UART, SPI, I2C)	1
2.4	Memory Types and Organization (ROM, RAM, Flash, EEPROM), Memory Protection	1
2.5	Input/Output Interfacing	1
2.6	Communication Protocols (UART, SPI, I2C, CAN)	1
2.7	GPIO Configuration and Interrupt Handling	1
2.8	Design Considerations (Power Consumption, Reliability, Fault Tolerance)	1
	3: Real-Time Operating Systems (RTOS)	
3.1	Introduction to RTOS, GPOS vs RTOS	2
3.2	Scheduling Types (Preemptive, Cooperative)	2
3.3	Task States and Management	2
3.4	Kernel Architecture and Context Switching	2
3.5	Semaphores (Binary, Counting) and Mutexes	2
3.6	Priority Inversion, Event Flags, Message Queues	2
3.7	Timers, Device Drivers, Task Synchronization and IPC	2
	4: Embedded System Design and Development	
4.1	Embedded System Design Process, Hardware-Software Partitioning	
4.2	Block Diagram Development, RTOS-based System Design	1
4.3	Task Creation, Communication, and Synchronization Mechanisms	2
4.4	Use of Development Tools (IDEs, Compilers, Debuggers, Simulators)	1
4.5	Debugging Techniques (Breakpoints, Trace Tools, UART-based Debugging), Optimization	1
4.6	Mini-Project using Sensors and Actuators (Design and Implementation)	2
	Total Hours	36

Course Designer(s):

1. Mr.S.Parthasarathi Parthasarathi_s@tce.edu
2. Mr.S.A.R.SheikMasthan sarsmech@tce.edu

CURRICULUM AND DETAILED SYLLABI

for

B.E. Mechatronics Programme

22 Regulation Course title, Credit, Course code
assessment pattern mistake rectification

For the students admitted from the
academic year 2022 - 2023 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015

Assessment Pattern errors for the courses 22MT340, 22MT450 are modified

22MT340	THERMAL FLUID SYSTEMS	Category	L	T	P	C	TE
		PCC	3	0	0	3	Theory

Assessment Pattern

CO	Assessment 1 (%)						Assessment 2 (%)						Terminal (%)		
	CAT 1			Assignment 1			CAT 2			Assignment 2					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	10	20	-	-	35	-	-	-	-	-	-	2	5	8
CO2	4	10	20	-	-	35	-	-	-	-	-	-	2	5	10
CO3	2	10	20	-	-	40	-	-	-	-	-	-	2	5	10
CO4	-	-	-	-	-	-	4	10	20	-	-	35	2	5	10
CO5	-	-	-	-	-	-	4	10	20	-	-	35	2	5	10
CO6	-	-	-	-	-	-	2	10	20	-	-	40	2	5	10

22MT450	DIGITAL SIGNAL PROCESSING (TCP)	Category	L	T	P	C	TE
		PCC	1	0	4	3	Practical

Assessment Pattern

CO	Continuous Assessment Test (CAT)			Terminal (Practical)
	CAT 1 (Theory)	CAT 2 (Theory)	Lab Model Exam	
CO1	40	-	100	100
CO2	40	-		
CO3	30	-		
CO4	-	30		
CO5	-	50		
CO6	-	20		

Credit misspell errors are rectified for the course 22MTPR0

22MTPR0	SMART HVAC SYSTEMS	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory

Course Name misspell errors are rectified for the course 22MT481

22MT481	SENSORS AND MEASUREMENTS LABORATORY	Category	L	T	P	C	TE
		PC	0	0	2	1	Practical

Course code for minor course rectified as 22MTQA0

22MTQA0	INDUSTRIAL DRIVES AND CONTROL	Category	L	T	P	C	TE
		PSE	3	0	0	3	Theory