B.E. MECHANICAL ENGINEERING
DEGREE PROGRAMME

SCHEDULING OF COURSES
&
CURRICULUM AND DETAILED SYLLABI

FOR THE STUDENTS ADMITTED IN THEACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

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

Vision:

"Be a globally renowned school of engineering in mechanical sciences"

Mission:

As a department, we are committed to

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

Programme Educational Objectives (PEOs) of B.E. (Mechanical Engineering)

PEO1: The programme will prepare graduates for successful careers in design, manufacturing, service and process industries, research and development organizations and academic institutions

PEO2: The programme will prepare graduates with aspiration for higher studies and research

PEO3: The programme will prepare graduates with entrepreneurial and self-learning capabilities to excel in their profession

PEO4: The programme will prepare graduates to work with ethical values in diverse teams

Programme Outcomes (POs) of B.E. (Mechanical Engineering)

Graduating Students of B.E. Mechanical Engineering programme will have

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **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.
4. **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.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **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.
7. **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.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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.
12. **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 (PSOs) of B.E. (Mechanical Engineering)

Graduating students of B.E.(Mechanical Engineering) programme will be able to:

PSO1: Design mechanical components/subsystem(s), prepare production drawings using CAD tools and select suitable manufacturing processes.

PSO2: Formulate and analyze energy and mass flow in thermal devices.

PSO3: Design, analyze, optimize and realize mechanical processes/systems to meet industrial competitiveness.

PEO – PO Matrix

POs PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1	S	S	S	S	S	M	L	M	M	M	M	M
PEO2	S	S	S	S	S	M	M	S	L	S	M	S
PEO3	S	M	M	M	M	M	L	M	S	S	S	S
PEO4	M	M	M	M	M	M	M	S	S	M	M	M

Correlation: S – Strong; M-Medium; L-Low

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

CREDIT DISTRIBUTION
(For the students admitted in the Academic Year 2022-23 onwards)

Degree: B.E. **Programme: Mechanical Engineering**

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 (HSSMC)	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**	**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	

SCHEDULING OF COURSES

B.E. Degree (Mechanical Engineering)

Semester	Theory				Theory / Theory cum Practical / Practical		Practical		CDIO	Mandatory Audit Courses	Credits
	1	2	3	4	5	6	7	8	9	10	
I	22MA110 Calculus for Engineers (BSC-4)	22PH120 Physics (BSC-3)	22CH130 Chemistry (BSC-3)	22EG140 Technical English (HSSMC-2)	22ME160 Engineering Graphics (ESC-4)	22EG170 English Laboratory (HSSMC-1)	22PH180 Physics Laboratory (BSC-1)	22CH190 Chemistry Laboratory (BSC-1)	22ES150 Engineering Exploration (ESC-2)		21
II	22ME210 Vector Calculus and Ordinary Differential Equations (BSC-4)	22ME220 Engineering Mechanics (ESC - 3)	22ME230 Metal Casting and Forming (PCC-3)	22ME240 Engineering Thermodynamics (PCC-3)	22ME250 Programming using C and Python (ESC-3)	22ME260 Materials Science and Metallurgy (ESC -4)	22ME270 Workshop (ESC-1)			Audit Course 1	21
III	22ME310 Partial Differential Equations and Numerical Methods (BSC-4)	22ME320 Mechanics of Materials (PCC-3)	22ME330 Metal Joining and Sheet Metal Working (PCC-3)	22ME340 Thermal Engineering (PCC-3)	22ME350 Production Drawing (ESC 4)		22ME370 Thermal Engineering Lab (PCC-1)	22ME380 Manufacturing Processes Lab (PCC-1)	22ES390 Design Thinking (ESC-3)		22
IV	22ME410 Operations Research (BSC-4)	22ME420 Design of Machine Elements (PCC-3)	22ME430 Machining Processes (PCC-3)	22ME440 Fluid Mechanics (PCC-3)	22ME450 Manufacturing Automation (PCC-3)		22ME470 Strength of Materials and Material Science Lab (ESC -1)	22ME480 Machining Practices Lab (PCC-1)	22ME490 Project Management (HSSMC-3)	Audit Course 2	21
V	22MEPXX PEC -1 (PEC-3)	22ME520 Kinematics and Dynamics of Machinery (PCC-3)	22ME530 Metrology and Quality Control (PCC-4)	22ME540 Heat and Mass Transfer (PCC-3)	22YYGX0 Interdisciplinary Elective (OEC-3)	22ME560 Dynamics and Measurement Lab (PCC-1)	22ME570 Fluid Mechanics and CFD Lab (PCC-1)	22ME580 CAM and Metrology Lab (PCC-1)	22ME590 Project 1 (P-3)		22
VI	22ME610 Accounting and Finance (HSSMC-3)	22ME620 Design of Transmission Systems (PCC-3)	22MEPXX PEC-2 (PEC-3)	22MEPXX PEC-3 (PEC-3)	22YYGX0 Science and Humanities Elective (OEC-3)	22EG660 Professional Communication (HSSMC-2)	22ME670 Heat Transfer Lab (PCC-1)	22ME680 CAD Lab (PCC-1)	22ME690 Project -2 (P-3)		22
VII	22ME710 Operations Management (PCC-3)	22ME720 Finite Element Analysis (PCC-3)	22MEPXX PEC-4 (PEC-3)	22MEPXX PEC-5 (PEC-3)	22MEPXX PEC-6 (PEC-3)	22MEPXX PEC-7 (PEC-3)	22ME770 Simulation and Analysis Lab (PCC-1)		22ME790 Project -3 (P-3)		22
VIII	22MEPXX PEC-8 (PEC-3)	22MEPXX PEC-9 (PEC-3)							22ME890 Project - 4 (P-3)		9

Total Credits: 160

Basic Science Courses (BSC) 24	Humanities and Social Sciences including Management Courses (HSSMC) 11	Engineering Science Courses (ESC) 25	Professional Core Courses (PCC) 55	Electives (PEC/OEC) 33	Project (P) 12

Credit Distribution

S.No	Category	Credits	Total	I	II	III	IV	V	VI	VII	VIII
A	**Foundation Courses (FC)**	**54-66**	**60**	**21**	**15**	**11**	**8**	**-**	**5**	**-**	**-**
	Humanities and Social Sciences including Management Courses (HSSMC)	09-12	11	3	-	-	3	-	5	-	-
	Basic Science Courses (BSC)	24- 27	24	12	4	4	4	-	-	-	-
	Engineering Science Courses (ESC)	21 -27	25	6	11	7	1	-	-	-	-
B	**Professional Core Courses (PCC)**	**55**	**55**	**-**	**6**	**11**	**13**	**13**	**5**	**7**	**-**
C	**Professional Elective Courses (PEC)**	**24 - 39**	**27**	**-**	**-**	**-**	**-**	**3**	**6**	**12**	**6**
	Programme Specific Elective (PSE)	15 - 24	27	-	-	-	-	3	6	12	6
	Programme Elective for Expanded Scope (PEES)	09-15									
D	**Open Elective Courses (OEC)**	**06-12**	**6**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**-**
	Interdisciplinary Elective	03-06	6	-	-	-	-	3	3	-	-
	Science and Humanities Elective	03-06									
E	**Project, Seminar, Internship in Industry or at Higher Learning Institutions**	**12**	**12**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**3**
	Minimum Credits to be earned for the awardof the Degree	**160** (from A to E) and the successful completion of Mandatory Courses	**160**	**21**	**21**	**22**	**21**	**22**	**22**	**22**	**9**

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

COURSES OF STUDY
(For the candidates admitted from 2022-23 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MA110	Calculus For Engineers	BSC	3	1	-	4
22PH120	Physics	BSC	3	-	-	3
22CH130	Chemistry	BSC	3	-	-	3
22EG140	Technical English	HSSMC	2	-	-	2
22ES150	Engineering Exploration	ESC	2	-	-	2
THEORY CUM PRACTICAL						
22ME160	Engineering Graphics	ESC	3	-	2	4
PRACTICAL						
22EG170	English Laboratory	HSSMC	-	-	2	1
22PH180	Physics Laboratory	BSC	-	-	2	1
22CH190	Chemistry Laboratory	BSC	-	-	2	1
Total			**16**	**1**	**8**	**21**

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

L : Lecture
T : Tutorial
P : Practical

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

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

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-23 onwards)

FIRST SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22MA110	Calculus for Engineers	3	40	60	100	27	50
2	22PH120	Physics	3	40	60	100	27	50
3	22CH130	Chemistry	3	40	60	100	27	50
4	22EG140	Technical English	3	40	60	100	27	50
5	22ES150	Engineering Exploration	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	22ME160	Engineering Graphics	3	50	50	100	25	50
PRACTICAL								
7	22EG170	English Laboratory	3	60	40	100	18	50
8	22PH180	Physics Laboratory	3	60	40	100	18	50
9	22CH190	Chemistry Laboratory	3	60	40	100	18	50

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

22MA110	CALCULUS FOR ENGINEERS

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

This course aims to provide technical competence of modeling engineering problems using calculus. This course is implements the calculus concepts 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's	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
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

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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 (%)			
	Written Test 1 (%)			Assignment 1 (%)			Written Test 2 (%)			Assignment 2 (%)						
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.[9 hours]

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 Books

1) James Stewart, "Calculus Early Transcendentals", 9e, Cengage Learning, New Delhi, 2019.
DIFFERENTIAL CALCULUS: [Sections: 1.3, 2.2, 2.5, 2,6,2.8, 4.1, 4.2 and 4.3.]
FUNCTIONS OF SEVERAL VARIABLES: [Sections: 14.1,14.3,14.5,14.7 and 14.8.]
INTEGRAL CALCULUS: [Sections: 5.2, 5.3, 5.4, 7.8, 8.2 and 6.2.]
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 and web resources

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

Module No.	Topic	No. of Periods
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 Designer(s):

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22PH120	**PHYSICS (Common to all branches)**

Category	L	T	P	Credit
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

None

Course Outcomes

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

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
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

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
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**										

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	8	15	22										6	6	10
CO2	8	10	15		100								4	3	10
CO3	4	5	13				-	-	15				-	2	15
CO4							4	15	-		100		4	6	-
CO5							-	-	35				-	3	15
CO6							16	15	-				6	10	-
Total	**20**	**30**	**50**		**100**		**20**	**30**	**50**		**100**		**20**	**30**	**50**

*Assignment I, II –Quiz/ Puzzle/ Case analysis/ Problem-solving/ Presentation/ Writing tasks

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 Books

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9thEdition, Wiley, 2011.
2. PaulA.TiplerandG.Mosca,PhysicsforScientistsandEngineers,6thEdition,Freeman,2008.

Reference Books

MECHANICS OF PARTICLES

1. Paul A.Tipler and GeneMosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 4, 9 & 10).
2. Manoj K. Harbola, Engineering Mechanics, 2ndEdition, Cengage, 2018.

OSCILLATIONS AND WAVES

1. Paul ATipler, Gene Mosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 14 & 15).
2. HJ Pain, The Physics of Vibrations&Waves,6^{th}Ed., John Wiley 2005 (Ch. 2, 5, 6).

ELECTROMAGNETIC FIELDS AND WAVES

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9thEdition, Wiley, 2011 (Chapters - 23, 24, 32 & 33)
2. PMFishbane,Stephen G.Gasiorowicz, Stephen T Thornton, Physics for Scientists & Engineers with Modern Physics,3rdEdition,Pearson,2005(Chapters-26, 28, 31, 34).

OPTICS

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

QUANTUM MECHANICS

1. Paul A.Tipler and GeneMosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 34 & 35).
2. 2.StephenT.Thorntonand Andrew Rex, Modern Physics for Scientists and Engineers, 4th Edition, Cengage, 2013. (Chapters- 5 & 6).
3. 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 manoeuvres	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 -Uncertainty principle - Schrodinger wave equation	4
	CAT-I after 18 contact hours	
3.2	Applications - Particle in a box in 1D – Linear harmonic oscillator	2
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 Fraunhoffer diffraction	2
	CAT-II after 18 contact hours	
	Total	**36**

Course Designers:

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22CH130	CHEMISTRY

Category	L	T	P	Credit
BSC	3		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	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
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 techniquefor various applications	TPS3	70	70
CO6	Select the materials based on the properties for Engineering applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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	CAT1						CAT2						Terminal					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	4	20	-										2	8				
CO2	4	-	20										2	4	10			
CO3	4	20	-										2	8				
CO4	8	-	20										2	4	10			
CO5							12	20	20				6	8	10			
CO6							8	20	20				6	8	10			

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

CO	Assignment 1*						Assignment 2*					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1												
CO2			20									
CO3												
CO4			20									
CO5									20			
CO6									20			

*Assessment type: Quiz / Test /Presentation

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

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. ShashiChawla, " 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 ionicconductivity	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 Designer(s):

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22EG140	TECHNICAL ENGLISH

Category	L	T	P	Credit
HSSMC	2		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 such as 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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	**Relate** the fundamentals of language in terms of vocabulary, grammar and pronunciation in technical communication.	Understand	60%	70%
CO2	**Infer** ideas from technical and general contexts by identifying main ideas, specific details, predicting and note-making.	Understand	60%	70%
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

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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

CO	Assessment 1						Assessment 2						Terminal (%)		
	Written Test 1 (%)			Assignment 1 (%)			Written Test 2 (%)			Assignment 2 (%)					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		24%									-		-	10%	-
CO2		34%			100%						-		-	20%	
CO3			14%						24%		-		-	-	20%
CO4			14%		-				34%				-	-	10%
CO5			14%		-						100%		-	-	20%
CO6					-				42%				-	-	20%
TOTAL		**100%**			**100%**			**100%**			**100%**			**100%**	

* 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)

Suggested Reading:

Books:

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
3. Brook-Hart,Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,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.

Extensive Reading:

1. Anthology of Select Five Short Stories
2. Tagore, Rabindranath. *Chitra, a Play in One Act.* London, Macmillan and Co., 1914

Websites:

1. www.englishclub.com
2. owl.english.purdue.edu
3. www.oxfordonlineenglish.com
4. www.bbclearningenglish.com
5. tcesrenglish.blogspot.com

Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
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.	Summary Writing	1
14.	Interpretation of Graphics	1
15.	Cause and Effect, Purpose and Function	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:

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22ES150	ENGINEERING EXPLORATION

Category	L	T	P	C	Terminal Exam Type
ESC	1	-	2	2	Theory

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	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
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

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2						Terminal Examination		
	Theory						Theory						Theory		
	Worksheet-1			CAT-1			Case study-1			CAT-2					
TPS Scale	**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

Syllabus

What is Engineering: Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements **Engineering Design:** Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. **Defining problems and Brainstorming:** Researching design, sketching problem solving **Communicating solution**: Dimensioning orthographic drawing, perspective drawing **Modeling and Testing final output:** Product evaluation, reverse engineering, final project report. **Civil Engineering:** Structural forces structural analysis, bridge design components, structural design **Mechanical Engineering:** Types of motion, mechanical power system, mechanical power formula, mechanical design.

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
4	**Communicating solution**	
4.1	Dimensioning orthographic drawing	1
4.2	perspective drawing	1
5	**Modeling 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

No.	Topic	No. of Periods
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:

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22ME160	ENGINEERING GRAPHICS

Category	L	T	P	Credit
ESC	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

- Basic knowledge about geometry of objects.

Course Outcomes

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

CO Number	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
C01	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

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO2.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO3.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO4.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO5.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO6.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO7.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
C08.	S	M	S	M	S	_	_	_	M	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
Analyse / 4		
Evaluate / 5		
Create / 6		

Marks Allocation for Continuous Assessment:

Sl. No	Description	Marks
1	Submission of Plates (Drawing sheets) and Computer Aided Drafting (CAD) Exercises	60
2	Continuous Assessment Test (CAT)	40
Total		**100**

Question Pattern for Terminal Examination:

Question Number	Description	Type	Marks
1	Orthographic views from isometric view Or 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 Or 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

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
		HSSMC	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

COs	Course Outcomes	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 presentation using digital tools.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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

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

S.No	Topic	Hours
	LAB ACTIVITIES (12 Hours)	
1	Listening to TED Talks/ Podcasts/ Product Advertisements/ NewsBulletins.	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 softwareS-net and Online Content (Tens Voices, SV Agreement, Prepositions, Coherence Markers, Relative Clauses, Mod 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 (Common to all branches)

Category	L	T	P	Credit
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

- None

Course Outcomes

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

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Analyze 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

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	M	L	-	M	-	-	-	S	-	-	L
CO2.	S	M	L	-	M	-	-	-	S	-	-	L
CO3	S	M	L	-	M	-	-	-	S	-	-	L
CO4	S	M	L	-	M	-	-	-	S	-	-	L
CO5	S	M	L	-	M	-	-	-	S	-	-	L
CO6	S	M	L	-	M	-	-	-	S	-	-	L
CO7	S	M	L	-	M	-	-	-	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 Designer(s):

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 (Common to all branches)

Category	L	T	P	Credit
BSC	0	0	1	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	TCE Proficiency Scale
CO1	Estimate the chemical water quality parameters of sample water / effluent	TPS Apply
CO2	Demonstrate presence of calcium ions in milk sample	TPS Apply
CO3	Determine the surface tension of solvent mixtures	TPS Apply
CO4	Estimate pH and acid content of samples using pH metric and conductometric titrations	TPS Apply
CO5	Illustrate the strength of oxidisable materials present in given sample by potentiometric method	TPS Apply
CO6	Determine Fe^{2+} ion in effluent using colorimetric method	TPS Apply
CO7	Calculate the efficiency of electroplating	TPS Apply
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	TPS Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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/Activities with CO Mapping

Experimental List	CO
Quantitative Analysis	
Estimation of total hardness of water sample	CO1
Estimation of COD of industrial effluent	CO1

Determination of calciumion inmilk 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 potentiodynamic 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.S.Balaji sbalaji@tce.edu
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4. Dr. S. Sivailango drssilango@tce.edu
5. Dr.M.Velayudham mvchem@tce.edu
6. Dr.R.Kodi Pandyan rkp@tce.edu
7. Dr.A.Ramalinga chandrasekar arcchem@tce.edu
8. Dr. B. Shankar bsrchem@tce.edu

B.E. MECHANICAL ENGINEERING

SCHEDULING OF COURSES
&
DETAILED SYLLABI

FOR

SECOND TO EIGHTH SEMESTERS

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Web: www.tce.edu

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

SECOND SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ME210	Vector Calculus and Ordinary Differential Equations	BSC	3	1	-	4
22ME220	Engineering Mechanics	ESC	3	-	-	3
22ME230	Metal Casting and Forming	PCC	3	-	-	3
22ME240	Engineering Thermodynamics	PCC	3	-	-	3
22ME260	Materials Science and Metallurgy	ESC	4	-	-	4
THEORY CUM PRACTICAL						
22ME250	Programming using C and Python	ESC	1	-	4	3
PRACTICAL						
22ME270	Workshop	ESC	-	-	2	1
AUDIT COURSE						
22AAPX0	Audit Course -1	AUD	2	-	-	-
	Total		**19**	**1**	**6**	**21**

BSC : Basic Science Course
HSSMC : Humanities and Social Sciences including Management Course
ESC : Engineering Science Course
PCC : Programme Core Course
AUD : Audit Course

L : Lecture
T : Tutorial
P : Practical

Note:

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

THIRD SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ME310	Partial Differential Equations and Numerical Methods	BSC	3	1	-	4
22ME320	Mechanics of Materials	PCC	3	-	-	3
22ME330	Metal Joining and Sheet Metal Working	PCC	3	-	-	3
22ME340	Thermal Engineering	PCC	3	-	-	3
THEORY CUM PRACTICAL						
22ME350	Production Drawing	ESC	2	-	4	4
PRACTICAL						
22ME370	Thermal Engineering Lab	PCC	-	-	2	1
22ME380	Manufacturing Processes Lab	PCC	-	-	2	1
22ES390	Design Thinking	ESC	1	0	4	3
Total			**15**	**1**	**12**	**22**

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

MATHEMATICS COURSES OF STUDY
FOR LATERAL ENTRY STUDENTS

(For the candidates admitted from 2023-24 onwards)

THIRD SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MA310	Essentials of Matrices and Calculus	BSC	3	1	-	4

FOURTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MEL10	Numerical Methods and Operations Research	BSC	3	1	-	4

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

FOURTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ME410	Operations Research	BSC	3	1	-	4
22ME420	Design of Machine Elements	PCC	2	1	-	3
22ME430	Machining Processes	PCC	3	-	-	3
22ME440	Fluid Mechanics	PCC	3	-	-	3
22ME450	Manufacturing Automation	PCC	3	-	-	3
PRACTICAL						
22ME470	Strength of Materials and Material Science Lab	ESC	-	-	2	1
22ME480	Machining Practices Lab	PCC	-	-	2	1
22ME490	Project Management	HSSMC	3	-	-	3
AUDIT COURSE						
22AAPX0	Audit Course -2	AUD	2	-	-	-
Total			**15**	**2**	**4**	**21**

BSC : Basic Science Course
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ESC : Engineering Science Course
PCC : Programme Core Course
AUD : Audit Course

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P : Practical

Note:

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY
(For the candidates admitted from 2022-23 onwards)

FIFTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MEPXX	Programme Elective Course – 1	PEC	3	-	-	3
22ME520	Kinematics and Dynamics of Machinery	PCC	3	-	-	3
22ME530	Metrology and Quality Control	PCC	4	-	-	4
22ME540	Heat and Mass Transfer	PCC	3	-	-	3
22YYGX0	Interdisciplinary Elective	IEC	3	-	-	3
PRACTICAL						
22ME560	Dynamics and Measurements Lab	PCC	-	-	2	1
22ME570	Fluid Mechanics and CFD Lab	PCC	-	-	2	1
22ME580	CAM and Metrology Lab	PCC	-	-	2	1
PROJECT						
22ME590	Project-1	P	-	-	6	3
Total			**16**	**-**	**12**	**22**

PCC : Programme Core Course
IEC : Interdisciplinary Elective Course
PEC : Programme Elective Course
P : Project

L : Lecture
T : Tutorial
P : Practical

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

SIXTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ME610	Accounting and Finance	HSSMC	3	-	-	3
22ME620	Design of Transmission Systems	PCC	3	-	-	3
22MEPXX	Programme Elective Course – 2	PEC	3	-	-	3
22MEPXX	Programme Elective Course – 3	PEC	3	-	-	3
22YYGX0	Interdisciplinary Elective	OEC	3	-	-	3
THEORY CUM PRACTICAL						
22EG660	Professional Communication	HSSMC	0	1	2	2
PRACTICAL						
22ME670	Heat Transfer Lab	PCC	-	-	2	1
22ME680	CAD Lab	PCC	-	-	2	1
PROJECT						
22ME690	Project-2	P	-	-	6	3
	Total		**15**	**1**	**12**	**22**

BSC : Basic Science Course
HSSMC : Humanities and Social Sciences including Management Course
ESC : Engineering Science Course
PCC : Programme Core Course
OEC : Open Elective Course
PEC : Programme Elective Course
P : Project

L : Lecture
T : Tutorial
P : Practical

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

SEVENTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ME710	Operations Management	PCC	3	-	-	3
22ME720	Finite Element Analysis	PCC	3	-	-	3
22MEPXX	Programme Elective Course – 4	PEC	3	-	-	3
22MEPXX	Programme Elective Course – 5	PEC	3	-	-	3
22MEPXX	Programme Elective Course – 6	PEC	3	-	-	3
22MEPXX	Programme Elective Course – 7	PEC	3	-	-	3
PRACTICAL						
22ME770	Simulation and Analysis Lab	PCC	-	-	2	1
PROJECT						
22ME790	Project-3	P	-	-	6	3
	Total		**18**	**-**	**8**	**22**

BSC : Basic Science Course
HSSMC : Humanities and Social Sciences including Management Course
ESC : Engineering Science Course
PCC : Programme Core Course
OEC : Open Elective Course
PEC : Programme Elective Course
P : Project

L : Lecture
T : Tutorial
P : Practical

Note:

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

EIGHTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22MEPXX	Programme Elective Course – 8	PEC	3	-	-	3
22MEPXX	Programme Elective Course – 9	PEC	3	-	-	3
PROJECT						
22ME890	Project-4	P	-	-	6	3
	Total		**6**	**-**	**6**	**9**

PEC : Programme Elective Course
P : Project

L : Lecture
T : Tutorial
P : Practical

Note:

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

SECOND SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22ME210	Vector Calculus and Ordinary Differential Equations	3	40	60	100	27	50
2	22ME220	Engineering Mechanics	3	40	60	100	27	50
3	22ME230	Metal Casting and Forming	3	40	60	100	27	50
4	22ME240	Engineering Thermodynamics	3	40	60	100	27	50
5	22ME260	Materials Science and Metallurgy	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	22ME250	Programming using C and Python	3	50	50	100	25	50
PRACTICAL								
7	22ME270	Workshop	3	60	40	100	18	50

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

THIRD SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22ME310	Partial Differential Equations and Numerical Methods	3	40	60	100	27	50
2	22ME320	Mechanics of Materials	3	40	60	100	27	50
3	22ME330	Metal Joining and Sheet Metal Working	3	40	60	100	27	50
4	22ME340	Thermal Engineering	3	40	60	100	27	50
5	22ME260	Materials Science and Metallurgy	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	22ME350	Production Drawing	3	50	50	100	25	50
7	22ES390	Design Thinking	-	50	50	100	25	50
PRACTICAL								
8	22ME370	Thermal Engineering Lab	3	60	40	100	18	50
9	22ME380	Manufacturing Processes Lab	3	60	40	100	18	50

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS
for
LATERAL ENTRY MATHEMATICS COURSES

(For the candidates admitted from 2023-24 onwards)

THIRD SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22MA310	Essentials of Matrices and Calculus	3	40	60	100	27	50

FOURTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22MEL10	Numerical Methods and Operations Research	3	40	60	100	27	50

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

FOURTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22ME410	Operations Research	3	40	60	100	27	50
2	22ME420	Design of Machine Elements	3	40	60	100	27	50
3	22ME430	Machining Processes	3	40	60	100	27	50
4	22ME440	Fluid Mechanics	3	40	60	100	27	50
5	22ME450	Manufacturing Automation	3	40	60	100	27	50
PRACTICAL								
7	22ME470	Strength of Materials and Material Science Lab	3	60	40	100	18	50
8	22ME480	Machining Practices Lab	3	60	40	100	18	50
9	22ME490	Project Management	3	60	40	100	18	50

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

FIFTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22MEPXX	Programme Elective Course -1	3	40	60	100	27	50
2	22ME520	Kinematics and Dynamics of Machinery	3	40	60	100	27	50
3	22ME530	Metrology and Quality Control	3	40	60	100	27	50
4	22ME540	Heat and Mass Transfer	3	40	60	100	27	50
5	22YYGX0	Interdisciplinary Elective	3	40	60	100	27	50
PRACTICAL								
6	22ME560	Measurement and Dynamics Lab	3	60	40	100	18	50
7	22ME570	Fluid Mechanics and CFD Lab	3	60	40	100	18	50
8	22ME580	CAM and Metrology Lab	3	60	40	100	18	50
PROJECT								
9	22ME590	Project-1	-	60	40	100	18	50

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

SIXTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22ME610	Accounting and Finance	3	40	60	100	27	50
2	22ME620	Design of Transmission Systems	3	40	60	100	27	50
3	22MEPXX	Programme Elective Course – 2	3	40	60	100	27	50
4	22MEPXX	Programme Elective Course – 3	3	40	60	100	27	50
5	22YYGX0	Interdisciplinary Elective	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	22EG660	Professional Communication	3	50	50	100	25	50
PRACTICAL								
7	22ME670	Heat Transfer Lab	3	60	40	100	18	50
8	22ME680	CAD Lab	3	60	40	100	18	50
PROJECT								
9	22ME690	Project-2	-	60	40	100	18	50

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

SEVENTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22ME710	Operations Management	3	40	60	100	27	50
2	22ME720	Finite Element Analysis	3	40	60	100	27	50
3	22MEPXX	Programme Elective Course – 4	3	40	60	100	27	50
4	22MEPXX	Programme Elective Course – 5	3	40	60	100	27	50
5	22MEPXX	Programme Elective Course – 6	3	40	60	100	27	50
6	22MEPXX	Programme Elective Course – 7	3	40	60	100	27	50
PRACTICAL								
7	22ME770	Simulation and Analysis Lab	3	60	40	100	18	50
PROJECT								
8	22ME790	Project-3	-	60	40	100	18	50

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E. (MECHANICAL ENGINEERING)

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2022-23 onwards)

EIGHTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY								
1	22MEPXX	Programme Elective Course – 8	3	40	60	100	27	50
2	22MEPXX	Programme Elective Course – 9	3	40	60	100	27	50
PROJECT								
3	22ME890	Project-4	-	60	40	100	18	50

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

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHANICAL ENGINEERING

Honours and Minor Specialization for the students those who joined in 2022

Honours				Minor
Vertical 1	**Vertical 2**	**Vertical 3**	**Vertical 4**	**Mechanical Engineering**
Thermal Systems	**Materials and Design**	**Manufacturing Automation**	**Product and Process Management**	
Programme Specific Electives (PSE)				
22MEPA0 - Energy Conversion Systems	**22MEPF0 - Design of Hydraulic and Pneumatic Circuits**	**22MEPL0 - Design for Sheet Metal Processing**	22MEPS0 - Process Planning and Cost Estimation	22MEQA0 - Automobile Engineering
22MEPB0 - Refrigeration and Air Conditioning	22MEPG0 -Machine Tool Design	**22MEPM0 -Non-Traditional Machining Processes**	22MEPT0 - Supply Chain Management	22MEQB0 - 3D Printing
22MEPC0 - Computational Fluid Dynamics	22MEPH0 -Experimental Methods for Engineering	22MEPN0 -Material Handling Systems Engineering	22MEPU0 - Work study and Ergonomics	22MEQC0 -Composite Materials
22MEPD0 - Turbomachines	22MEPJ0 -Non-Destructive Testing Techniques	22MEPQ0 – Geometric Dimensioning and Tolerancing	22MEPV0 - Organizational Behaviour	22MEQD0 -Systems Approach for Engineers
22MEPE0 - Design of Thermal Systems (MOOC)	**22MEPK0 - Manufacturing of Composite Materials (MOOC)**	**22MEPR0 - Geometric Modeling (MOOC)**	**22MEPW0 – Total Quality Management (MOOC)**	22MEQE0 -Thermal Management Systems
Programme Electives for Expanded Scope (PEES)				
22MERA0 - Energy Management in Thermal Systems	**22MERE0 - Mechanical Vibrations**	**22MERJ0 - Industry 4.0**	**22MERN0 - Decision Support System**	22MEQF0 -Design of Mechanical Systems
22MERB0 - Solar Energy Systems	**22MERF0 - Biomaterials**	22MERK0 - Robotics	**22MERS0 - Product Design and Development**	22MEQG0 -Integrated Product Development
22MERC0 - Gas Turbines and Propulsion Systems	22MERG0 - Mechanics of Composite Materials	22MERL0 - Additive Manufacturing	**22MERT0 - Design for Welding**	22MEQH0 -Lean Six Sigma
22MERD0 - Vehicle Technologies	22MERH0 -Tribology in Machine Design	22MERM0 - AI for Mechanical Engineers	22MERU0 - Design for Manufacture and Assembly	22MEQJ0 -Safety Engineering

VLCI Courses	
Programme Specific Electives (PSE)	**Programme Electives for Expanded Scope (PEES)**
22MEPX0 - Observation Skills	22MERY0 - Material Flow Mapping
22MEPY0 - Evolution of Modern Manufacturing	22MERZ0 - Flow Management Concepts
22MEPZ0 - Modern Manufacturing Basic Knowledge and Skills	

22ME210	VECTOR CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS

Category	L	T	P	C	Terminal Exam Type
BSC	3	1	-	4	Theory

Preamble

Eigenvalues and eigenvectors are often introduced to students in the context of linear algebra courses focused on matrices. Furthermore, linear transformations over a finite-dimensional vector space can be represented using matrices. Matrix eigenvalue problems are extremely important while creating engineering models in control systems, designing bridges, communication systems and searching algorithms. Moreover, this course introduces the concepts and applications of differentiation and integration of vector valued functions and ordinary differential equations in a broader approach to mechanical engineers in particularly Solid Mechanics, Aerodynamics, Fluid Flow, Heat Flow and Robotics.

Prerequisite

- Calculus for Engineers

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Apply matrix algebra techniques for transformations to model real world problems.	TPS3	75	70
CO2	Characterize a set of vectors and linear systems using the concept of linear independence.	TPS2	80	75
CO3	Compute the orthogonal projection of a vector onto a subspace, given a basis for the subspace.	TPS3	75	70
CO4	Apply the concept of linear ordinary differential equations solutions to mechanics.	TPS3	75	70
CO5	Compute the divergence and curl of vector functions.	TPS2	80	75
CO6	Apply the concepts of vector differentiation and vector integration to evaluate work done by the force and fluid flow problems.	TPS3	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	L	-	-	-	-	-	L	-	M	L
CO2	S	M	L	-	L	L	-	-	-	-	-	L	-	M	L
CO3	M	M	L	-	L	L	-	-	-	-	-	L	-	M	L
CO4	S	M	L	-	L	L	-	-	-	-	-	L	-	M	L
CO5	M	M	L	-	L	L	-	-	-	-	-	L	-	M	L
CO6	S	M	L	-	L	L	-	-	-	-	-	L	-	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	50	-	16	26	-	-	-	-	-	-	-	5	16
CO2	-	-	-	4	16		-	-	-	-	-	-	-	10	-
CO3	-	-	50	4	-	34	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	50	4	16	26	-	5	18
CO5	-	-	-	-	-	-	-	-		4	8		-	5	-
CO6	-	-	-	-	-	-	-	-	50	-	8	34	-	5	16
												Total	**-**	**30**	**70**

Syllabus

MATRIX EIGEN VALUEPROBLEM: The Matrix eigen value Problem - Determining eigen values and eigenvectors— Some Applications of eigen value problems– Symmetric- Skew symmetric and orthogonal matrices –Eigen bases- Diagonalization- Quadratic forms.

LINEAR ALGEBRA: Vector Spaces: Definition and examples – Subspaces - Linear independence - Basis and Dimension - Row space and Column space - Orthogonal spaces - Inner product spaces - Orthonormal sets - The Gram-Schmidt orthogonalization process.

ORDINARY DIFFERENTIAL EQUATION: Homogeneous Linear ODEs of second order– Homogeneous Linear ODEs with constant coefficients–Euler Cauchy Equation – Non-homogeneous ODE – Solution by Variation of Parameters.

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

Text Books

1. Erwin Kreyszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
2. Steven J.Leon, Lisette G.de Pillis, "Linear Algebra with Applications", 10th edition, Pearson Education limited 2021.

Learning Resources

3. Peter V.O'Neil, "Advanced Engineering Mathematics",7th edition, Cengage Learning, 2017.
4. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi,2016.
5. David C.lay, "Linear Algebra and its Applications", 3rd edition, Pearson Education, New Delhi,2019.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**MATRIX EIGEN VALUEPROBLEM**	
1.1	The Matrix Eigenvalue Problem. Determining Eigenvalues and Eigenvectors	2
	Tutorial	1
1.3	Symmetric, Skew-Symmetric, and Orthogonal Matrices	2
	Tutorial	1
1.4	Eigenbases. Diagonalization.	1
1.5	Quadratic Forms	2
	Tutorial	1
2	**LINEAR ALGEBRA**	
2.1	Vector Spaces: Definition and examples	1

No.	Topic	No. of Periods
1.	**MATRIX EIGEN VALUEPROBLEM**	
2.2	Subspaces	2
2.3	Linear independence	1
	Tutorial	1
2.4	Basis and Dimension	1
2.5	Row space and Column space	1
2.6	Orthogonal spaces	1
	Tutorial	1
2.7	Inner product spaces	1
2.8	Orthonormal sets	1
2.9	The Gram-Schmidt orthogonalization process	2
	Tutorial	1
3	**ORDINARY DIFFERENTIAL EQUATION**	
3.1	Homogeneous Linear ODEs of Second Order	2
3.2	Homogeneous Linear ODEs with Constant Coefficients	1
	Tutorial	1
3.3	Modeling of Free Oscillations of a Mass–Spring System	2
	Tutorial	1
3.4	Non homogeneous ODEs	2
3.5	Solution by Variation of Parameters	1
	Tutorial	1
4	**VECTOR CALCULUS**	
4.1	Gradient of a scalar filed. Directional derivative	1
4.2	Divergence and Curl of a Vector Field	1
	Tutorial	1
4.3	Line Integrals, Path independence	2
4.4	Green's Theorem in the Plane	2
	Tutorial	1
4.6	Triple Integrals. Divergence Theorem of Gauss	2
4.7	Stoke's Theorem	2
	Tutorial	1
	Total	48

Course Designers:

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22ME220	ENGINEERING MECHANICS

Category	L	T	P	C	Terminal Exam Type
ESC	3	-	-	3	Theory

Preamble

Mechanics can be defined as that science which describes and predicts the conditions of rest or motion of bodies under the action of forces. The discipline has its roots in several ancient civilizations. Scientists such as Galileo, Kepler and especially Newton, during the early modern period, laid the foundation for what is now known as classical mechanics. The often-used term **'body'** in the field of mechanics stands for a wide assortment of objects, including particles, projectiles, spacecraft, stars, parts of machinery, parts of solid, parts of fluids (gases and liquids) etc. The branch of mechanics is divided into three parts: Mechanics of Rigid Bodies, Mechanics of Deformable Bodies, and Mechanics of Fluids. The mechanics of rigid bodies is subdivided into **Statics** and **Dynamics (Kinematics & Kinetics)**, the former dealing with bodies at rest, the latter with bodies in motion. In the current part of the study, bodies are assumed to be perfectly rigid. Actual structures and machines, however, are never absolutely rigid and deform under the loads to which they are subjected. But these deformations are usually small and do not appreciably affect the conditions of equilibrium or motion of the structure under consideration. This course covers the fundamentals of statics and dynamics of particles and rigid bodies.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Solve problems on particles and rigid bodies using the concept of static equilibrium.	TPS3	70	65
CO2	Compute the frictional forces for mechanical components.	TPS3	70	65
CO3	Determine the centre of gravity and moment of inertia of the given geometry.	TPS3	70	65
CO4	Select suitable method for solving problems on kinematics of particles	TPS3	70	65
CO5	Select suitable method for solving problems on kinetics of particles by applying the principles of Newton's law of motion, Conservation of energy, work energy and Impulse momentum.	TPS3	70	65
CO6	Solve problems in kinematics and kinetics of rigid bodies subjected to general planar motion using various principles.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	L	-	-	-	S	-	M
CO2	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO3	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO4	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO5	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO6	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	-	6	40	-	-	-	-	-	-	-	2	10
CO2	-	-	30	-	7	20	-	-	-	-	-	-	-	2	10
CO3	-	-	30	-	7	20	-	-		-	-	-	-	4	15
CO4	-	-	-	-	-	-	-	-	30		6	20	-	4	15
CO5	-	-	-	-	-	-	-	-	35		7	40	-	4	15
CO6	-	-	-	-	-	-	-	-	35		7	20	-	4	15
												Total	-	**20**	**80**

Syllabus

Statics of Particles: Fundamental principles and concepts – Laws of mechanics – Principle of Transmissibility – Parallelogram, Triangle and Polygon law of forces – Resultant of concurrent and non-concurrent coplanar forces. Static Equilibrium – Conditions of equilibrium in statics – Lami's Theorem – Free body Diagram – Reactions. 3D Statics – Forces in space; **Statics of Rigid Bodies:** Moment of a force – Varignon's theorem – Force Couple System – Reduction of system of forces into one force and couple – Equilibrium of rigid bodies in 2D and 3D.

Friction: Role of frictional force – Types of friction – Limiting friction – Coefficient of friction and angle of friction – Coulomb's law of friction – Angle of Repose – Wedge friction – Belt friction.

Distributed Forces: Centroid and Centre of Gravity – Simple and Composite plane figures and solid bodies – Pappus and Guldinus Theorem. Area Moment of Inertia – Parallel and Perpendicular Axis Theorem – Polar Moment of Inertia – Radius of gyration – Mass Moment of Inertia – Simple and Composite plane figures and solid bodies;

Dynamics of Particles: **Kinematics of Particles:** Rectilinear Motion – Uniform and Variation acceleration – Motion of particle under gravity – Relative motion. Curvilinear motion

Kinetics of Particles: Newton's Second Law of motion – D'Alembertz Principle. Work energy principle – Conservation of energy. Impulse-Momentum principle – Conservation of linear momentum – Motion of singular body and connected bodies.

Kinematics and Kinetics of Rigid Bodies: Relationship between angular motion and linear motion. Uniformly accelerated rotation- Kinematics of General plane motion - Instantaneous Axis of rotation- Kinetics of rolling bodies- Kinetics of General Plane motion.

Text Books

1. Beer F.P. and Johnston Jr. E.R., '**Vector Mechanics for Engineers: Statics and Dynamics**', Twelfth Edition, Tata McGraw Hill, 2019.
2. Meriam J.L and Kraig L.G, '**Engineering Mechanics-Statics and Dynamics**', John Wiley & sons, New York, Eighth Edition, 2016.
3. Timoshenko, S, Young, D, Rao. J, '**Engineering Mechanics**', Fourth Edition, Tata McGraw Hill, Fifth Edition, 2017.

Reference Books & Web Resources

1. R.C. Hibbeller, **'Engineering Mechanics: Statics & Dynamics'**, Prentice Hall, , Thirteen Edition, 2013.
2. Irving H. Shames, **'Engineering Mechanics - Statics and Dynamics'**, Pearson Education Asia Pvt. Ltd., 2006.
3. Palanichamy and Nagan S., '**Engineering Mechanics – Statics and Dynamics**', Third Edition, Tata McGraw Hill, 2005.
4. . Rajasekaran and G. Sankara subramanian, '**Fundamentals of Engineering Mechanics**', Vikas Publishing House Pvt. Ltd., New Delhi, Third Edition, 2005.
5. Anthony M. Bedford and Wallace Fowler, '**Engineering Mechanics: Statics and Dynamics'**, Prentice Hall, Fifth Edition, 2007.
6. Lakshmana Rao, '**Engineering Mechanics – Statics and Dynamics**', Prentice Hall of India, New Delhi, 2009.
7. N.H.Dubey, '**Engineering Mechanics – Statics and Dynamics**', Tata McGraw-Hill Publishing Company, New Delhi, 2017.
8. Boresi A.P. and Schmidt R.J., '**Engineering Mechanics: Statics and Dynamics**', Thomson Asia Press, Singapore, 2008.
9. Andrew Pytel and Jaan Kiusalaans, **'Engineering Mechanics – Statics and Dynamics',** Cengage Publications, USA, Third Edition, 2011.
10. Sadhu Singh, '**Engineering Mechanics; Statics and Dynamics',** Khanna publishers, New Delhi, Second Edition, 2004.
11. https://nptel.ac.in/courses/112103108/ - Engineering Mechanics - Prof. U. S. Dixit- Indian Institute of Technology, Guwahati
12. https://nptel.ac.in/courses/112106180/ - Statics and Dynamics- Dr. Mahesh V. Panchagnula, Indian Institute of Technology, Madras
13. https://www.edx.org/course/engineering-mechanics
14. https://www.coursera.org/learn/engineering-mechanics-statics

Course Contents and Lecture Schedule

Module No.	Topics	No. of hours	Course outcome
1	**Statics of Particles**		
1.1	Fundamental principles and concepts		
1.1.1	Laws of Mechanics	1	CO1
1.2	Resultant of concurrent and non-concurrent	1	CO1
1.3	Conditions of Static Equilibrium	1	CO1
1.3.1	Lami's theorem & its application in 2D	1	CO1
1.4	Forces in space	2	CO1
1.2	**Statics of Rigid bodies**		
1.2.1	Moment of a force & Varignon's theorem	1	CO1
1.2.2	Force couple system	1	CO1
1.2.3	Equilibrium of rigid bodies in 2D	1	CO1
1.2.4	Equilibrium of rigid bodies in 3D	2	CO1
2.	**Friction**		
2.1	Fundamentals of friction	1	CO2
2.2	Angle of repose and wedge friction	1	CO2
2.3	Belt friction	2	CO2
3.	**Distributed Forces**		
3.1	Centroid of simple and composite plane figures	1	CO3
3.2	Centre of gravity of simple and composite solid	1	CO3
3.3	Pappus and Guldinus theorem Centroid of line	1	CO3
3.4	Moment of Inertia – Theorems	1	CO3
3.5	Area Moment of Inertia of plane figures	2	CO3

3.6	Mass Moment of Inertia of solid bodies	1	CO3
4.	**Kinematics of Particles**		
4.1	Kinematics of Particles		
4.1.1	Rectilinear motion	1	CO4
4.1.2	Curvilinear motion	1	CO4
5.	**Kinematics of Particles**		
5.1	Newton's second law of motion	1	CO5
5.2	Conservation of Energy	1	CO5
5.3	Work Energy Principle	2	CO5
5.4	Impulse Momentum Principle	2	CO5
6.	**Kinematics and Kinetics of Rigid Bodies**		
6.1	Relationship between angular motion and linear motion	1	CO6
6.2	Uniformly accelerated rotation	1	CO6
6.3	Kinematics of General plane motion	1	CO6
6.4	Instantaneous Axis of rotation	1	CO6
6.5	Kinetics of rolling bodies	1	CO6
6.6	Kinetics of General Plane motion	1	CO6
Total No. of Hours		**36**	

Course Designers:

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2. Mr. C. Vignesh Assistant Professor Mechanical Engineering cvmech@tce.edu

22ME230	METAL CASTING AND FORMING

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Manufacturing is the process by which raw materials are transformed into finished products. There are five basic types of manufacturing processes: casting, forming, machining, joining, and finishing. Through the use of these processes, objects of all shapes and sizes can be created with great flexibility. Casting is the process of pouring liquid material into a mold that contains a hollow cavity in the desired shape and allowing it to solidify. Metal forming is the process of deforming metal parts and objects mechanically so that they can be shaped without adding or subtracting material. By using three-dimensional computer-aided design (CAD) data, rapid prototyping is a method for fabricating scale models of physical parts or assemblies in a short period of time. In this course, the learners will gain knowledge of the working principles, capabilities, process parameters, advantages, limitations, and applications of different metal casting, metal forming, plastic moulding, and additive processes.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe process parameters and equipment of metal casting, forming, plastic moulding and additive processes	TPS2	70	70
CO2	Select a suitable casting process with its process parameters for the stated requirements	TPS3	70	65
CO3	Determine the forming forces for metal-forming processes such as forging, rolling, and extrusion.	TPS3	70	65
CO4	Select a suitable forming process with its process parameters for the stated requirements	TPS3	70	65
CO5	Propose the remedial measures for various defects in the cast and formed products	TPS3	70	65
CO6*	Perform a comparative study of various methods of casting or forming process(es) for a given product or component.	TPS3	70	65

*CO6 is assessed through conduct of study, and report preparation as an assignment in continuous assessment and are not evaluated in terminal examination

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-		6	10	20	-	-	-	-	-	-	2	10	-
CO2	-	-	100		10	20	-	-	-	-	-	-	2	5	15
CO3	-	-		4	10	20	-	-	-	-	-	-	2	5	15
CO4	-	-	-	-	-	-	-	-	-	10	10	30	2	5	15
CO5	-	-	-	-	-	-	-	-	-	10	10	30	2	5	15
CO6	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-
												Total	**10**	**30**	**60**

Syllabus

Metal casting:

Expendable mould Casting Processes: Pattern - materials, types, and allowances. Moulding sand- types, ingredients, properties Core- Types, functions, chaplets, Types of sand moulds. Steps involved in making a green sand mould. Moulding machines - Squeeze type, Jolt type, and Sand slinger. Procedural steps and applications of Shell mould casting, Investment mould casting, Plaster and Ceramic mould casting.

Permanent mould casting processes: Procedural steps and applications of Permanent mould casting processes such as Gravity die casting, Slush casting, Centrifugal casting- True, Semi and Centrifuging, Pressure die casting – hot chamber and cold chamber.

Casting Quality: Defects in casting and remedies - Non-destructive testing techniques – Liquid penetrant test – Radio graphic testing.

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

Metal forming Processes:

Fundamental of Metal forming, Elastic and plastic deformation, Hot and cold working processes.

Rolling Process: Hot and cold rolling process, process parameters involved, Type of rolling mills, Flat rolling practice, Shape rolling operations, Production of seamless pipe and tubing, Defects in rolled plates and sheets, Calculation of Rolling Force.

Forging: Outline of forging and related operations, process parameters involved, Various Forging Processes such as open die, closed die, Forging Operations such as Heading, Piercing, coining, Forging presses and dies and defects in forging, Calculation of Forging Force.

Drawing Process: Wire and tube drawing, process parameter involved, Wire Drawing equipment and dies and defects in drawing, Calculation of Drawing Force.

Extrusion Process: hot, cold, impact and hydro static extrusion, process parameter involved, Extrusion Machines-Horizontal, Vertical hydraulic presses and dies and defects in extrusion, Calculation of Extrusion Force.

Metal additive processes: Introduction to Rapid Prototyping – fusion deposition modelling - Stereolithography– Selective laser sintering – applications.

Textbook (s)

1. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Eighth Edition, Pearson Education , 2019.

Reference Books & Web Sources

1. Mikell P.Groover "Fundamental of Modern Manufacturing: Materials. Processes and Systems", Wiley Publisher, Seventh Edition, 2020.
2. P.L.Jain, "Principles Of Foundry Technology", Tata McGraw Hill, Fifth Edition, 2009.
3. Prabodh C. Bolur, "A Guide to Injection Moulding of Plastics", Third edition, Sri Prema Sai Printers & Publishers, Mangalore, 2007.
4. P. N. Rao, "Manufacturing Technology", Volume-1, 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.
6. E.Paul Degarmo, J.T.Black, and Ronald A. Konser, "Materials and Processes in Manufacturing", 5th Edition, Prentice Hall India Ltd., 1997.
7. Philip F. Oswald, and Jairo Munoz, "Manufacturing Process and systems", John Wiley and Sons, 1992.
8. https://nptel.ac.in/courses/112107144/13- COURSE CO-ORDINATED BY : IIT ROORKEE
9. https://nptel.ac.in/courses/112107145/17-Dr. D. B. Karunakar Mechanical and Industrial Engineering Department Indian Institute of Technology, Roorkee
10. https://nptel.ac.in/courses/112107083/-Dr. D. B. Karunakar Department of Mechanical and Industrial Engineering Indian Institute of Technology, Roorkee
11. https://www.class-central.com/course/nptel-principles-of-casting-technology-7899-Prof. Pradeep K. Jha, Department of Mechanical and Industrial Engineering, IIT Roorkee.
12. https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x-0-A. John Hart, Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology
13. https://www.afsinc.org/courses/introduction-metalcasting- CourseCoordinated by American Foundry Society, 1695 North Penny Lane, Schaumburg, IL 60173
14. https://www.coursera.org/lecture/high-throughput/additive-manufacturing-metals-Dxsjj- Dr. Richard W. Neu, Professor, The George W. Woodruff School of Mechanical Engineering
15. https://www.mooc-list.com/course/fundamentals-manufacturing-processes-edx- A. John Hart, MIT.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1	**Metal casting Processes**	
1.1	**Expendable mould Casting Processes:** Pattern - materials, types, and allowances. Moulding sand- types, ingredients, properties	2
1.1.1	Core- Types, functions, chaplets, Steps involved in making a green sand mould.	1
1.1.2	Moulding machines - Squeeze type, Jolt type, and Sand slinger.	1
1.1.3	Procedural steps and applications of Shell mould casting, Investment mould casting, Plaster and Ceramic mould casting	3
1.2	**Permanent mould casting processes:** Procedural steps and applications of Permanent mould casting processes such as Gravity die casting, Slush casting	2
1.2.1	Centrifugal casting- True, Semi and Centrifuging, Pressure die casting – hot chamber and cold chamber	2
1.3	**Casting Quality:** Defects in casting and remedies and summary of Non-destructive testing techniques - Liquid penetrant test – Radio graphic testing.	2
2	**Plastic forming processes:** Plastics, general properties and applications of thermo plastics and thermosets.	2
2.1	Forming/shaping and applications of plastics: Extrusion, Injection Molding, Blow Molding, Rotational Molding	2
2.1.1	Thermoforming, Compression Molding, Transfer molding, Casting.	2

Module No.	Topic	No. of Hours
3.	**Metal Forming Process**	
3.1	Fundamental of Metal forming, Elastic and plastic deformation, Hot and cold working processes.	2
3.2	Rolling Process: Hot and cold rolling process, process parameters involved, Type of rolling mills, Flat rolling practice, Shape rolling operations, Production of seamless pipe and tubing.	2
3.2.1	Calculation of Rolling Force	1
3.2.2	Defects in rolled plates and sheets.	1
3.3	Forging Processes: Outline of forging and related operations, process parameters involved, Various Forging Processes such as open die, closed die, Forging Operations such as Heading, Piercing, coining.	3
3.3.1	Forging presses and dies and defects in forging.	1
3.3.2	Calculation of Forging Force	1
3.4	Extrusion Process: hot, cold, impact and hydro static extrusion, process parameter involved	2
3.4.1	Extrusion Machines-Horizontal, Vertical hydraulic presses and dies and defects in extrusion	1
3.4.2	Calculation of Extrusion Force	1
3.5	Drawing Process: Wire and tube drawing, process parameter involved, Wire Drawing equipment and dies and defects in drawing.	2
3.5.1	Calculation of Drawing Force	1
4	**Metal additive processes**	
4.1	Introduction to Rapid Prototyping, Fusion deposition modelling.	2
4.2	Stereolithography, Selective laser sintering and applications.	2

Course Designers:

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22ME240	ENGINEERING THERMODYNAMICS

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

All activities in nature involve some interaction between energy and matter. Thermodynamics is a branch of science that deals with the concepts and laws governing the energy and its transfer. Engineering thermodynamics plays a major part in the design and analysis of engineering systems including automotive engines, rockets, jet engines, power plants, and refrigeration and air-conditioning systems. A better understanding of the basic laws of engineering thermodynamics and applying them to the design of engineering systems is essential for mechanical engineers. This course deals with the concepts and laws of thermodynamics to determine the energy and entropy of ideal gas, water, mixture of gases and air and water vapour mixture.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the change of properties and energy transfer during different thermodynamic processes in closed system using ideal gas, water or steam.	TPS3	70	65
CO2	Determine the energy transfer and change inproperties of ideal gas, steam in thermodynamically open systems during different thermodynamic processes.	TPS3	70	65
CO3	Determine the efficiency of heat engine and COP of heat pump and refrigerator	TPS3	70	65
CO4	Determine the entropy change and availability of openand closed system for different thermodynamic processes and Second law efficiency	TPS3	70	65
CO5	Calculate the change of properties of ideal gas mixture	TPS3	70	65
CO6	Determine the psychrometric properties of air for various psychrometric processes using thermodynamic relations and psychrometric chart.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	L	-	M	-
CO2	S	M	L	-	-	-	-	-	-	-	-	L	-	S	-
CO3	S	M	L	-	-	-	-	-	-	-	-	L	-	S	-
CO4	S	M	L	-	-	-	-	-	-	-	-	L	-	M	-
CO5	S	M	L	-	-	-	-	-	-	-	-	L	-	L	-
CO6	S	M	L	-	-	-	-	-	-	-	-	L	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	5	10	20	-	-	-	-	-	-	4	5	10
CO2	-	-	30	5	10	20	-	-	-	-	-	-	4	5	8
CO3	-	-	30	5	10	15	-	-	-	-	-	-	4	5	8
CO4	-	-	-	-	-	-	-	-	40	5	10	20	4	5	8
CO5	-	-	-	-	-	-	-	-	20	5	10	20	2	5	8
CO6	-	-	-	-	-	-	-	-	40	5	10	15	2	5	8
												Total	20	30	50

Syllabus

Basic Concepts: Definition and applications **-** Open, closed and isolated systems – System and control volume approach - Thermodynamic properties, State and Equilibrium, Processes and cycles, - Zeroth Law of thermodynamics

Gases and water/steam: Ideal gas and real gas – compressible and incompressible fluid - Sensible heat and latent – phase diagrams of water/steam(p-v, p-T, T-v, T-s, h-s) - Tables and charts of physical properties.

First law of Thermodynamics: Forms of energy, energy transfer by heat and work, sign convention, path and point functions. pdv work for closed system using air and water/steam in thermodynamic processes - First law for process and cycle. Open systems, steady flow and unsteady flow- flow work, -v dp work using steam and air in thermodynamic processes - Steady flow energy equation (SFEE) for nozzle, diffuser, compressor, turbine, heat exchanger.

Second Law of Thermodynamics: Second law statements and its equivalence - Heat engine, refrigerator and heat pump - Carnot Cycle, Efficiency and COP - Carnot theorem - Absolute thermodynamic temperature scale.

Entropy: Concept and causes - Clausius inequality - change of entropy for solids, liquids and gases in different thermodynamic processes- T-ds relation, Principle of increase of entropy - Thermodynamic relations-Maxwell's relations, Clausius-Clapeyron equation, The Joule-Thomson co-efficient - Third law of thermodynamics.

Exergy and Anergy: Available (Exergy) and Unavailable energy (Anergy) – Availability for flow and non-flow processes, Irreversibility.

Gas mixture: Avogadro's law, Dalton's law of partial pressure, property equations and change of properties of gas mixture.

Psychrometric properties, processes and air conditioners: Psychrometric properties, Psychrometric processes- heating, cooling, humidification dehumidification, Applications in air-conditioning, Types of Air conditioners- components and working of Window, Split, Packaged Air conditioners

Textbook (s)

1. Cengel, Y and M. Boles, **Thermodynamics - An Engineering Approach**, Tata McGraw Hill,9th Edition, 2019.
2. Nag, P.K., '**Engineering Thermodynamics**', 5thedition, Tata McGraw Hill, 2017.

Reference Books &Web Resources

1. Venkatesh, A., '**Basic Engineering Thermodynamics**', University Press, 2007.
2. Rajput, R.K., '**Engineering Thermodynamics**', Fifth Edition, Laxmi Publications, 2016
3. ValanArasu, A., '**Engineering Thermodynamics**', 2ndedition,Vijay Nicole Imprints Pvt. Ltd., Chennai, 2014.
4. https://nptel.ac.in/courses/112105123/
5. https://www.youtube.com/watch?v=Sn_TSa7AkMU
6. https://www.youtube.com/watch?v=4RX_lpoGRBg
7. https://www.youtube.com/watch?v=SQEkhVUM_Kw

Tables and Charts

1. R.S Khurmi and J.K. Gupta,**"Steam Tables with Mollier diagram"**, S.Chand publication 8th edition, 2008.
2. M.L.Mathur and F.S. Metha -Psychrometric chart, Jain brothers, 2018

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Basic Concepts and First law of thermodynamics applied to closed system**	
1.1	Definition and applications **-** Open, closed and isolated systems – System and control volume approach	1
1.2	Thermodynamic properties, State and Equilibrium, Processes, cycles and Zeroth Law of thermodynamics	1
1.3	Ideal gas and real gas, Incompressible and compressible fluid	1
	sensible heat and latent heat ,Phase diagrams – water/steam Tables and charts for physical properties.	1
1.4	Energy transfer (work and Heat), path and point functions	2
	pdV work for closed system using water/steam and air in thermodynamic processes	2
	First law for process and cycle	2
2.	**First law of thermodynamics applied to Open system**	
2.1	Open system, steady flow and unsteady flow	1
2.2	Flow work,–vdp work using air, steam in thermodynamic processes, SFEE	1
2.3	SFEE for nozzle, diffuser, compressor, turbine, heat exchanger.	4
3	**Second Law of Thermodynamics**	
3.1	Statements and its equivalence, reversible and irreversible processes	2
3.2	Heat engine, Refrigerator and Heat Pump	2
3.3	Carnot cycle, Efficiency and COP	1

No.	Topic	No. of Periods
3.4	Carnot theorem, Absolute thermodynamic temperature scale	1
4.	**Entropy, Exergy and Anergy**	
4.1.	Concept and causes, Clausius inequality	1
4.2	Change of entropy for solids, liquids and gases in different thermodynamic processes- T-ds relation	2
4.3	Principle of increase of entropy, Maxwell's relations.	1
4.4	Clausius-Clapeyron equation, The Joule-Thomson co-efficient, Third Law of thermodynamics	1
4.5	Available energy (Exergy) and Unavailable energy (Anergy) and Second law efficiency.	1
4.6	Availability for flow and non-flow processes and Irreversibility	2
5	**Gas mixture**	
5.1	Avogadro's law, Dalton's law of partial pressure, property equations	2
5.2	change of properties of gas mixture	2
6	**Psychrometric properties, processes and air conditioners**	
6.1	Psychrometric properties, Psychrometric processes- heating, cooling, humidification dehumidification	3
6.2	Applications in air-conditioning.	1
6.3	Types of Air conditioners- components and working of Window, Split, Packaged Air conditioners	2
	Total	38

Course Designers

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2. Dr. M.S.Govardhanan Assistant Professor Mechanical Engineering govardhanans@tce.edu

22ME250	PROGRAMMING USING C AND PYTHON

Category	L	T	P	C	Terminal Exam Type
ESC	1	-	4	3	Practical

Preamble

This course on Programming Using C and Python is intended to introduce the students to computational thinking, the methodology of programming with emphasis on modularity. Upon completion of the course, the students would be able to master the principles of structured programming and demonstrate significant experience in solving Mechanical Engineering problems using C and Python.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Develop algorithm and flowchart for the given problem specification.	TPS3	70	65
CO2	Write simple programs involving input and output statements, expressions, arrays, control and iterative statements by appropriate choice of data types, expressions and control structures.	TPS3	70	65
CO3	Deploy the concept of dynamic memory allocation and pointers for memory management in C programming	TPS3	70	65
CO4	Utilize functions, scoping and abstraction to develop modular programs in Python	TPS3	70	65
CO5	Utilize Python libraries for file management, basic plotting and data visualization	TPS3	70	65
CO6	Practice software engineering principles like analysis, design, coding and testing and maintenance in development of engineering applications.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	-	L	-	-	-	-	M	-	L
CO2	S	M	L	-	M	-	-	L	-	-	-	-	M	-	L
CO3	S	M	L	-	M	-	-	L	-	-	-	-	L	-	-
CO4	S	M	L	-	S	-	-	L	-	-	-	-	L	-	-
CO5	S	M	L	-	S	-	-	L	-	-	-	L	L	-	-
CO6	S	M	L	-	S	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Continuous Assessment						Terminal Examination (Practical: 3 Hours)
	CAT 1 (Theory)			CAT 2 (Practical)			
	1	2	3	1	2	3	
CO1	-	10	10	-	-	-	20
CO2	-	10	30	-	-	-	40
CO3	-	10	30	-	-	-	
CO4	-	-	-	-	-	100	40
CO5	-	-	-	-	-		
CO6	-	-	-	-	-		

Syllabus

Introduction to Problem Solving: Problem Specification, input-output analysis, Algorithms -Design and Analysis, Flowcharts, Program Execution.

C Programming

Basics: Character set, Keywords, Constants and variables, Data types, Input and Output statements, Operators and Expressions, Operator Precedence, Type Conversion, Type casting. Control Statements, Branching and Looping, Functions, Arrays

User Defined Data types and Memory Management: Structures, Unions and Bit fields, Pointers to variables, arrays and structures, Dynamic Memory allocation, Storage classes

Python Programming

Basics: Character set and data types, looping and branching constructs – break and continue.

Functions, scoping and Abstraction: Function definition – keyword arguments and default values – scoping – specifications – recursion

Structured types, Mutability and Higher order functions: Tuples – sequences and multiple assignments – list and mutability – mutable sequence – list comprehension – functions as objects – sets – dictionaries – file I/O – exceptions

Basic Plotting and Applied visualizations: Line plot - Bar plot - Pie Chart - Scatter Plot - Histogram - Stacked Bar Charts - Sub Plots - Matplotlib, Searborn, Plotly - Seaborn Styles.

Textbooks

1. Byron S. Gottfried, "Programming with C", McGraw Hill Education, Fourth Edition, 2018
2. John V. Guttag, "Introduction to Computation and Programming Using Python: With Application Computational Modeling and Understanding Data", Prentice-Hall International publishers, Third Edition, 2021

Reference Books & Web Resources

1. Brian W. Kernighan and Dennis Ritchie, "The C Programming Language", Second Edition, Pearson Education India, 2015
2. Yashavant Kanetkar, "Let Us C: Authentic guide to C programming language", 18th Edition, BPB Publications, 2021
3. Reema Thareja, "Python Programming using problem solving Approach", Oxford University, Higher Education Oxford University Press, First edition, 2017.
4. E. Balagurusamy, "Introduction to Computing and Problem Solving using Python", McGraw Higher Education, First Edition, 2016.
5. NPTEL Course on Introduction to Programming in C, Prof. Satyadev Nandakumar, IIT Kanpur, https://nptel.ac.in/courses/106104128
6. NPTEL course on The Joy of Computing using Python by Prof. Sudarshan Iyengar, IIT Ropar https://onlinecourses.nptel.ac.in/noc21_cs32/preview
7. Coursera - Programming for Everybody (Getting Started with Python) By Charles Russell Severance

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to Problem Solving**	
1.1	Problem Specification, input-output analysis	1
1.2	Algorithms -Design and Analysis	
1.3	Flowcharts	
1.4	Program Execution	
2	**C Programming**	
2.1	Character set, Keywords, Constants and variables, Data types, Input and Output statements, Operators and Expressions, Operator Precedence, Type Conversion, Type casting	1
2.2	Branching Constructs and Looping Constructs	1
2.3	Arrays and Functions	1
2.4	User Defined Datatypes – Structures, Unions and Bit fields	1
2.5	Memory Management - Pointers to variables, arrays and structures, Dynamic Memory allocation, Storage classes	1
3	**Python Programming**	
3.1	**Basics** -Character set and data types, looping and branching constructs, break and continue	1
3.2	**Functions, scoping and Abstraction** – Function definition – keyword arguments and default values – scoping – specifications – recursion	1
3.3	**Structured types, Mutability and Higher order functions** – tuples – sequences and multiple assignments – list and mutability – mutable sequence – list comprehension – functions as objects – sets – dictionaries – file I/O – exceptions	2
3.4	**Basic Plotting and Applied visualizations** - Line plot - Bar plot - Pie Chart - Scatter Plot - Histogram - Stacked Bar Charts - Sub Plots - Matplotlib, Searborn, Plotly - Seaborn Styles	2
	Total	12

Program No.	List of Programs	No. of Periods
C Programming		
1.	Simple programs with branching and looping	2
2.	Arrays	4
3.	String Manipulations	2
4.	Functions	4
5.	User Defined Data types -Structures & Unions	4
6.	Memory Management - Pointers	4
7.	Dynamic Memory allocation	4
Python Programming		
8.	Simple Programs	2
9.	Lists and Tuples	4
10.	Sets and Dictionaries	4
11.	Functions	4
12.	File handling with exceptions	4

Program No.	List of Programs	No. of Periods
13.	Exploring Numpy Library	4
14.	Programs related to Mechanical Engineering	4
	Total Hours	**48**

List of Programs (Not Limited to)

C Programming

1. Simple programs like
    a. To check whether the given number is
        i. prime or not
        ii. perfect or abundant or deficient
    b. Electricity bill tacking for different categories of users, different slabs in each category. (Using Nested If Else Statement).
    c. To evaluate the following using loops
        i. $1 + x^2 / 2! + x^4 / 4! + \ldots$ up to n terms
        ii. $x + x^3 / 3! + x^5 / 5! + \ldots$ up to n terms
    d. To generate the first 'n' terms of the Fibonacci sequence. A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence.
2. Use of Arrays
    a. To find the mean, mode, median, and variance of list of values by using one dimensional array.
    b. To sort the given set of numbers.
    c. To add, subtract, multiply the two given matrices.
3. String Manipulations
    a. To insert a sub-string in to a given main string from a given position.
    b. To delete n characters from a given position in a given string.
    c. To determine if the given string is a palindrome or not
    d. To count the lines, words and characters in a given text.
4. Functions
    a. Do recursive and non-recursive functions for towers of Hanoi, GCD, LCM
    b. Perform calculator operations using call by reference
    c. To read a list of numbers and search for given number using binary search algorithm and if found display its index otherwise display the message "element not found in the list" using functions
5. User Defined Datatypes -Structures & Unions
    a. Medical shop automation
    b. Book shop automation
    c. Library management system
    d. Ticket management system
6. Pointers
    a. Number conversions (Decimal to binary)
    b. Compare, concatenate, reverse, copy with strings using pointers
    c. Find the transpose of a given matrix
7. Dynamic Memory allocation
    a. Matrix Multiplication
    b. Implementation of Stack

Python Programming

8. Simple Programs
    a. Find those numbers which are divisible by 7 and multiple of 5, between 1500 and 2700
    b. Convert temperatures to and from Celsius, Fahrenheit.

c. Construct the following pattern, using a nested for loop.

```
*
* *
* * *
* * * *
```

d. Iterate the integers from 1 to 50. For multiples of three print "Fizz" instead of the number and for the multiples of five print "Buzz". For numbers which are multiples of both three and five print "FizzBuzz".

e. Accept a sequence of comma separated 4-digit binary numbers as its input and print the numbers that are divisible by 5 in a comma separated sequence.

9. List and Tuples
   f. Write a Python program to get the 4th element and 4th element from last of a tuple.
   g. Write a Python program to create the colon of a tuple.
   h. Write a Python program to find the repeated items of a tuple.
   i. Write a Python program to check whether an element exists within a tuple.
   j. Write a Python program to remove an item from a tuple.

10. Sets and Dictionaries
    k. Write a menu driven program to perform the following operations:
       i. Add an item into the set
       ii. Union of two sets {A} U {B}
       iii. Intersection of two sets
       iv. Difference of two sets {A} -{B}
       v. Superset of a set
       vi. Subset of a set
       vii. Check if two sets are disjoint
       viii. Remove an item from the set
       ix. Remove duplicates from the set

12. Functions
    a. Write a Python program that accepts a hyphen-separated sequence of words as input and prints the words in a hyphen-separated sequence after sorting them alphabetically.
    b. Write a Python function to create and print a list where the values are square of numbers between 1 and 30 (both included
    c. Write a Python program to make a chain of function decorators (bold, italic, underline etc.) in Python.
    d. Write a Python program to execute a string containing Python code.
    e. Write a Python program to detect the number of local variables declared in a function.

13. File handling with exceptions
    a. Write a Python program that takes a text file as input and returns the number of words of a given text file.
    b. Write a Python program to extract characters from various text files and puts them into a list.
    c. Write a Python program to generate 26 text files named A.txt, B.txt, and so on up to Z.txt.
    d. Write a Python program to create a file where all letters of English alphabet are listed by specified number of letters on each line.

14. Exploring Numpy Library
    a. Write a program to multiply a matrix by another matrix of complex numbers and create a new matrix of complex numbers.
    b. Write a program to generate inner, outer, and cross products of matrices and vectors.
    c. Write a program to add one polynomial to another, subtract one polynomial from another, multiply one polynomial by another and divide one polynomial by another.
    d. Write a program to create a random array with 1000 elements and compute the average, variance, standard deviation of the array elements.

15. Programs related to Mechanical Engineering
    a. Write a program to determine the resultant force in a concurrent force system.
    b. Write a program to plot the displacement, velocity and acceleration of a particle moving in 1D with respect to time.
    c. Write a program to calculate the centre of gravity and moment of inertia of a given area.
    d. Write a program to plot p-v diagram and T-s diagram for a given thermodynamic cycle.
    e. Write a program to represent the position and orientation of an object with a homogeneous transformation matrix.

Course Designers

1.	Dr. C. Jeyamala	Associate Professor	Information Technology	jeyamala@tce.edu
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22ME260	MATERIALS SCIENCE AND METALLURGY

Category	L	T	P	C	Terminal Exam Type
ESC	4	-	-	4	Theory

Preamble

The course aims at imparting the fundamental knowledge on classification, properties, selection criteria imperfections, strengthening mechanism, and testing of materials. It also provides knowledge on phase diagram for ferrous, heat treatment, surface treatment of steel, Alloy steel, Tool Steels and Cast iron. This course covers fundamentals of powder metallurgy which is being practiced in variety of industries for decades

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Select suitable material on the basis of its structure and properties for specific engineering application	TPS3	70	65
CO2	Select suitable strengthening mechanism and list its effects for a crystalline material.	TPS3	70	65
CO3	Calculate the stress, strain, hardness, percentage elongation and reduction in area and tensile strength of materials.	TPS3	70	65
CO4	Illustrate various phases, phase percentage, invariant reactions, micro structure development of ferrous systems using phase diagrams.	TPS2	70	70
CO5	Select appropriate heat treatment and surface hardening process for steel.	TPS3	70	65
CO6	Select suitable material for the stated machine tool fabrication and cutting operations.	TPS3	70	65
CO7	Illustrate Powder metallurgy process for production of PM parts	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	S	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO7	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	25	-	2	10	20	-	-	-	-	-	-	4	5	10
CO2	-	25	-	4	10	20	-	-	-	-	-	-	4	5	10
CO3	-	50	-	4	10	20	-	-	-	-	-	-	2	-	10
CO4	-	-	-	-	-	-	-	25	-	2	15	-	2	10	-
CO5	-	-	-	-	-	-	-	25	-	2	10	20	2	-	10
CO6	-	-	-	-	-	-	-	25	-	4	10	20	2	-	10
CO7	-	-	-	-	-	-	-	25	-	2	15	-	4	10	-
												Total	**20**	**30**	**50**

For Continuous assessment,

- CAT 1 and Assignment 1: Materials science topics will be handled by physics dept. faculty
- CAT 2 and Assignment 2: Metallurgy topics will be handled by mechanical engineering dept. faculty

For Terminal Examination,

- Students are examined for 50 marks in Materials science and 50 marks in Metallurgy through two separate answer sheets.
- Duration:3 Hours

Syllabus

Materials Science

Structure, properties and selection of engineering materials: Introduction to crystals, Unit cells, Metallic crystal structures, Classification and properties of Materials, Metals and Alloys, Polymers, Ceramics, Composites, Biomaterials and Semiconductors. Selection of Engineering Materials: Material selection approach, selection process.

Imperfection in solids and strengthening mechanism: Point, Line, Surface and Volume defects, Dislocations and plastic deformation, slip systems, slip in single crystals, Deformation by twinning, Mechanisms of strengthening: solid solution strengthening, Strengthening by Grain Size Reduction, Recovery, Recrystallization, and Grain Growth, Strain Hardening and Precipitation Hardening.

Mechanical Property characterization: Tensile, Compression and Torsion tests, young's modulus, Shear modulus, True stress and strain, Engineering stress and strain, Stress-strain curves, Generalized Hooke's law, Yielding and yield strength, Ductility, Resilience, Toughness and Elastic recovery, Hardness: Rockwell, Brinell and Vickers and their relation to strength.

Metallurgy

Phase diagrams: Alloys, Substitutional and Interstitial solid solutions, Phase diagram fundamentals, Eutectic, Peritectic, Peritectoid and Monotectic reactions, Iron-carbide phase diagram and Microstructural aspects of Ledeburite, Austenite, Ferrite and Cementite. Applications of Copper alloys; Brass, Bronze, Aluminum alloys, Al-Cu, Nickel and Titanium alloys.

Alloy Steels: Purpose of alloying, Effect of alloying elements. Tool Steels: Classification and selections of tool steels.

Cast irons: Types and mechanical properties of gray cast iron, chilled cast iron, nodular cast iron and alloy cast iron.

Heat Treatment and Surface treatment of Steel: Annealing, Stress relieving, Process annealing, Spheroidising, Full annealing, Normalising, Hardening, Tempering, TTT diagram, Continuous cooling curves, Austenitizing temperature, Martempering, Austempering and Ausforming, Mechanism of heat removal during quenching, Quenching medium, Surface Hardening of steel: Carburising, Nitriding, Cyaniding, Carbonitriding, Flame hardening, Induction hardening.

Powder Metallurgy: Powder Metallurgy processes, Preparation of metal powders, Mixing, compacting, sintering, hot pressing and applications of PM.

Textbook (s)

1. Callister W.D, "**Materials Science and Engineering",** John Wiley & Sons, 9th Edition, 2014.
2. Sidney H. Avner, "**Introduction to Physical Metallurgy**", Tata McGraw Hill, New Delhi, 2nd Edition, 5th reprint, 2009.

Reference Books & Web Resources

1. William F Smith, Javad Hashemi, Ravi Prakash, "**Materials Science and Engineering**", Tata McGraw Hill Private Limited, 5th Edition, 2013.
2. George Dieter, "**Mechanical Metallurgy**", Tata McGraw-Hill, 3rd Edition, New Delhi, 2013.
3. Van Vlack L.H., "**Elements of Materials Science and Engineering**", 6th Edition, Pearson India, 2002.
4. Rajan.T.V., Sharma C.P., Ashok Sharma., "**Heat Treatment Principles and Techniques**", Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. https://nptel.ac.in/courses/112104203/
6. https://nptel.ac.in/couses/113107078/
7. https://nptel.ac.in/courses/113105023/
8. https://nptel.ac.in/courses/113106032/
9. https://nptel.ac.in/courses/113105024/
10. http://web.utk.edu/~prack/MSE%20300/surface%20treatments.pdf

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Structure, properties and selection of engineering materials**	
1.1	Introduction to crystals, Unit cells, Metallic crystal structures.	2
1.2	Classification and properties of Materials, Metals and alloys, Polymers, Ceramics, Composites, Biomaterials and semiconductors.	3
1.3	Selection of engineering materials: Material selection approach, selection process.	2
2.	**Imperfection in solids and strengthening mechanism**	
2.1	Point, Line, Surface and volume defects.	2
2.2	Dislocations and plastic deformation, Slip systems, Slip in single crystals, Deformation by twinning.	2
2.3	Mechanisms of strengthening: Solid solution strengthening, Strengthening by grain size reduction, Recovery, Recrystallization and grain growth, Strain hardening and precipitation hardening.	4
3.	**Mechanical Property measurement**	
3.1	Tensile, Compression and Torsion tests, Young's modulus, Shear modulus.	2
3.2	True stress and strain, Engineering stress and strain, Stress-strain curves, Generalized Hooke's law, Yielding and yield strength,	3
3.3	Ductility, Resilience, Toughness and Elastic recovery.	2
3.4	Hardness: Rockwell, Brinell and Vickers and their relation to strength.	2
4.	**Phase diagrams**	
4.1	Alloys, Substitutional and Interstitial solid solutions, Phase diagram fundamentals.	1
4.2	Eutectic, Peritectic, Peritectoid and Monotectic reactions.	2
4.3	Iron-carbide phase diagram and Microstrctural aspects of Ledeburite, Austenite, Ferrite and Cementite,	2
4.4	Applications of Copper alloys; Brass, Bronze, Aluminium alloys, Al-Cu, Nickel and Titanium alloys.	2
5	**Alloy Steels**	
5.1	Purpose of alloying, Effect of alloying elements on steel .	2
5.2	Tool Steels: Classification and selections of tool steels.	2
6	**Cast irons**	
6.1	Types and mechanical properties of gray cast iron, chilled cast iron, nodular cast iron and alloy cast iron	2

No.	Topic	No. of Periods
7.	**Heat Treatment and Surface treatment of Steel**	
7.1	Annealing, Stress relieving, Process annealing, Spheroidising, Full annealing, Normalising, Hardening, Tempering.	2
7.2	TTT diagram, Continuous cooling curves, Austenitizing temperature.	1
7.3	Martempering, Austempering and Ausforming, Mechanism of heat removal during quenching, Quenching medium,	2
7.4	Surface Hardening of steel: Carburising, Nitriding, Cyaniding, Carbonitriding, Flame hardening, Induction hardening.	2
8	**Powder Metallurgy**	
8.1	Powder Metallurgy processes, Preparation of metal powders	1
8.2	Mixing, compacting, sintering, hot pressing of metal powders	2
8.3	Applications of Powder Metallurgy	1
	Total	**48**

Course Designers

1.	Dr. N. Sankara Subramanian	Professor	Physics	nssphy@tce.edu
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22ME270	WORKSHOP

Category	L	T	P	C	Terminal Exam Type
ESC	-	-	2	1	Practical

Preamble

The workshop is a hands-on training practice for Mechanical engineering students. It deals with fitting, carpentry, sheet metal, welding, and plumbing-related exercises. The course is designed to train the students to identify and manage the tools, materials, and methods required to execute an engineering project. Students will be introduced to a team working environment where they develop the necessary skills for planning, preparing, and executing an engineering project. To enable the student to familiarize various tools, measuring devices, practices, and different methods of manufacturing processes employed in industry for fabricating components. This course is a response to the growing demand for a broad knowledge base for those who undertake a specialized career in science, especially those who take up a research career.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Assemble the pipes and joints for the given plumbing pipeline circuit	TPS3	70	65
CO2	Prepare different types of joints using fitting operations for the given metal plates	TPS3	70	65
CO3	Fabricate sheet metal components.	TPS3	70	65
CO4	Fabricate different types of wooden joints.	TPS3	70	65
CO5	Perform Lap joint / Butt Joint using an arc welding process	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	_	_	_	S	_	_	_	L	_	L
CO2	S	M	L	L	L	_	_	_	S	_	_	_	L	_	L
CO3	S	M	L	L	L	_	_	_	S	_	_	_	L	_	L
CO4	S	M	L	L	L	_	_	_	S	_	_	_	L	_	L
CO5	S	M	L	L	L	_	_	_	S	_	_	_	L	_	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Trade	Observation/Viva	Record	Model Test	Total Marks
CO1	10	2	25	100
CO2	10	2		
CO3	15	2		
CO4	20	2		
CO5	10	2		
* Internal assessment marks shall be converted into 60 marks				

- Terminal Examination will be conducted for a Maximum of 100 Marks and it will be converted to 40 marks
- Students will be evaluated in any two trades. Each trade of 1 hour and 30 minutes duration

List of Experiments

No.	Experiment	CO
1.	**Plumbing Exercise:** Assemble of plumbing pipeline circuit for domestic application (Any one Plumbing Exercise) – **4 hours**	CO1
2.	**Fitting Exercises:** Preparation of Square/V/L/Gauge/Taper Fitting (Any one Fitting Exercises) – **4 hours**	CO2
3.	**Sheet Metal Exercises:** Preparation of Dustpan/Tray/ Liter Cone - (Any one sheet metal Exercise) **– 6 hours**	CO3
4.	**Carpentry Exercises**: Preparation of wooden parts like Photo frame/Office tray (Any one Carpentry Exercise) **– 6 hours**	CO4
5.	**Arc welding Exercises**: Preparation of lap/butt joint using arc welding process (Any one Welding Exercise) **– 4 hours**	CO5

Learning Resources

1. Lab Manual, Department of Mechanical Engineering, TCE (2022)
2. John K.C "Mechanical Workshop", Practice by Prentice Hall India Learning Private Limited, Second edition, 2010.

Course Designers

1.	Dr.R.Sivasankaran	Assistant Professor	Mechanical	rssmech@tce.edu
2.	Mr. M. Karthic	Assistant Professor	Mechanical	mkmect@tce.edu

22CHAA0	ENVIRONMENTAL SCIENCE

Category	L	T	P	Credit
BS	1		1	0

(Common to all branches)

Preamble

The objective of this course is to make the students learn the basic concepts of environment, ecology, and to create awareness on current environmental issues, and develop
a sustainable environment by participating in various activities on conserving natural resources and protecting the environment.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment Level %
CO1	Describe the importance and progression of ecological system	TPS2	A	80
CO2	Explain the significance of natural resources	TPS2	A	80
CO3	Examine the effects of pollution on environment and human beings	TPS3	A	80
CO4	Practice the suitable solid waste management for segregation and reuse of waste	TPS3	A	80
CO5	Explain renewable energy resources for sustainable environment	TPS2	A	80
CO6	Perform Environment oriented group activities	TPS4	A	80

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT						Assignment#						Terminal***					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1		20																
CO2		20																
CO3			20				NA						Presentation on case study report					
CO4			20															
CO5		20																
CO6																		

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

*** Case study presentation and evaluation

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

Method of Evaluation

a)Internal assessment

S.No	Description	Max.marks	Final conversion
1	CAT	60	30
2	Assignment marks (from Review I&II)	2×20 =40	20
Total			50

b) End semester examination – Case study presentation

Performance Index	Marks per Individual
Originalityof the work	20
Data collected	20
Suggestion to overcomefor the identified issues	20
FinalPresentation	40
Total	100

Model Titles for Case Study:

1. Environmental impacts of rubber industry in Virudhunagar district
2. Solid waste and waste water management in TCE hostel.
3. Status of workers in fireworks industry in Sivakasi region
4. A study on impacts of tanneries on ground water and soil quality in Dindigul district.
5. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, AlagarKovil.
6. Environmental impacts of quarry industries in MelurTaluk.
7. Environmental effect of Kudankulam atomic power plant.
8. Effect on ground water and soil quality by dyeing industries in Tiruppur.
9. Effect of textile wastes in Karur District.
10. Segregation of waste and its recycling by Madurai Municipality at Vellakkal

Syllabus

Environment and Ecosystem - Multidisciplinary nature of environment- Ecosystem-Structure and Functions, Energy flow in ecosystem-Ecological succession- Natural resources -Over exploitation, Conservation. **Environmental pollution and control -** Environmental pollution – Types (Air, Water, Soil)and Effects–Control measures, Solid waste management, Environmental Impact Assessment.**Sustainable Environment–**Carbon footprint, Carbon and water neutrality, Sustainable development goals, Renewable energy resources (Solar, Wind, Tidal, Biomass), Atom economy,Carbon vs Hydrogen economy, Linear economy vs Circular economy, Environmental ethics – issues, solution

Awareness and activities:

- ✓ Lectures by Environmentalist
- ✓ Group meeting on water management
- ✓ Awareness on modern pollution control measures
- ✓ Drive on e-waste segregation and disposal
- ✓ Field visit to treatment systems
- ✓ Preparation of seed ball and plantation
- ✓ Slogan, Poster, Essay writing, Role play events

Text Book

1. Kaushik, A &Kaushik, C.P, Environmental Science and Engineering, 6thEdition, New Age International, 2018.
2. ErachBharucha, Text book of Environmental studies for Undergraduate courses, 2ndEdtion, UGC, 2013.

Reference Books& web resources

1. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
2. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.
3. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
4. www.indiaenvironmentportal.org.in
5. www.teriin.org
6. www.cpcp.nic.in
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Environment and Ecosystem**	
1.1	Multidisciplinary nature of environment	1
1.2	Structure and Function of Ecosystem. Energy flow in ecosystem – Universal energy flow model	2
1.3	Ecological succession	1
1.4	Natural resources - Over exploitation, Conservation	1

Module No.	Topic	No. of Periods
2	**Environmental pollution and control**	
2.1	Environmental pollution – Types(Air, Water, Soil) and Effects	2
2.2	Control measures: Air pollution (Bag filter, Cyclone separator, Electrostatic Precipitator)	1
2.3	Industrial waste water treatment – Primary, Secondary, Tertiary	1
2.4	Solid waste management	1
2.5	Environmental Impact Assessment – Components, Processes and methods	1
3	**Sustainable Environment**	
3.1	Concept of carbon credit and carbon foot print, Carbon and water neutrality	1
3.2	Sustainable development goals – An overview	1
3.3	Renewable energy resources – Solar, Wind, Tidal, Biomass	2
3.4	Sustainable environment: Atom economy, Carbon vs Hydrogen economy, Linear economy vs Circular economy,	1
3.5	Environmental ethics: Issues and solution	1
4	**Awareness and activities**	
4.1	Lectures by environmentalist	1
4.2	Awareness on modern pollution control measures	1
4.3	Group activity on waste management	1
4.4	Drive on e-waste segregation and disposal	1
4.5	Field visit to treatment systems	1
4.6	Plantation using seed ball	1
4.7	Slogan, Poster, Essay writing, Role play events	1
	Total	24

Course Designer(s):

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22ME310	PARTIAL DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS

Category	L	T	P	C	Terminal Exam Type
BSC	3	1	-	4	Theory

Preamble

Many physical processes fundamental to science and engineering governed by partial differential equations(PDE)that are equations involving partial derivatives. The most familiar of these processes are heat conduction and wave propagation. The equations of fluid flow are PDE's, and are widely used in aeronautical engineering, acoustics, study of ground water flows in civil engineering, development of fluid handling devices in mechanical engineering and investigating flame and combustion processes in chemical engineering. Stress analysis is important in large area of civil and mechanical engineering that requires a complicate set of PDE's. This course aims to provide the ability to form a PDE and giving the adequate exposure in the theory and applications of Fourier series, PDE and Numerical methods.

Prerequisite

- Calculus for Engineers
- Linear Algebra and Ordinary Differential Equations

Course Outcomes

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

CO#	Course Outcomes	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe and formulate a Partial differential equation.	TPS2	80	75
CO2	Solve homogeneous and non-homogeneous linear partial differential equations.	TPS3	75	70
CO3	Solve the system of linear and nonlinear algebraic equations and compute the solution of boundary value problems in PDE using various numerical methods.	TPS3	75	70
CO4	Compute the existence of Fourier expansion and points of discontinuity of functions.	TPS2	80	75
CO5	Obtaintheperiodicfunctions arisinginthestudyof engineering problems in terms of Sine and Cosine byusing Fourierseries.	TPS3	75	70
CO6	Solvetheboundaryvalueproblems arisinginengineering problems involving one-dimensional vibration, heatflow and two dimensional heat and wave problemsbyFourierseries.	TPS3	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO2	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO3	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO4	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO5	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO6	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	-	8	-	-	-	-	-	-	-	-	-	5	-
CO2	-	-	50	-	17	25	-	-	-	-	-	-	-	5	15
CO3	-	-	50	-	17	33	-	-	-	-	-	-	-	5	20
CO4	-	-	-	-	-	-	-	-		8	-	-	-	5	-
CO5	-	-	-	-	-	-	-	-	50	-	17	25	-	5	15
CO6	-	-	-	-	-	-	-	-	50	-	17	33	-	5	20
												Total	-	30	70

Syllabus

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

Numerical Methods:
Numerical solutions of linearsimultaneous equations-Gauss Elimination, Gauss Jordan methods – Gauss Jacobi, Gauss Seidal methods-Classification of PDE of second order-– Elliptic equations – Solution of Laplace equation by Liebmann Process – Parabolic equations – solution of Heat Equations by Bendre-Schmidt methods – Hyperbolic equations – Solution of wave equation by Explicit scheme method.

Fourier Series:
Conditions for Fourier expansion – Functions having points ofdiscontinuity- Change of interval-Odd and even function- Periodic functions–Halfrangeseries–Fourierseriesoftypicalwaveforms-Parseval's formula–Harmonic analysis.

Applications of Partial Differential Equations:
Method of separation of variables – 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

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

Reference Books

1. PeterV.O. Neil,"AdvancedEngineeringMathematics",7thedition,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
1.	**Partial Differential Equations**	
1.1	Formationof a partial differential equation	2
1.2	Equations solvable by direct integration, Linear equations of the first order	2
	Tutorial	1
1.3	Non linear equations of the first order	2
1.4	Homogeneous linear equations with constant coefficients, Rules for finding the complementary functions	1
	Tutorial	1

1.5	Working procedure to solve homogeneous and non homogeneous linear equations	2
	Tutorial	1
2.	**Numerical Methods**	
2.1.	Solution of Linear simultaneous equations: Gauss Elimination and Jordan methods	2
2.2.	Gauss Jacobi and Gauss-Seidal iteration methods	2
	Tutorial	1
2.3.	Classification of Second order partial Differential equations	1
	Tutorial	1
2.4	Solution of Laplace equation: Liebmann Iteration Process	2
2.5	Solution of Heat equation: Bender Schmidt	1
2.6	Solution of wave equation: Explicit Scheme	1
	Tutorial	1
3.	**Fourier Series**	
3.1	ConditionsforFourierexpansion,Euler'sformula,Functionshaving pointsofdiscontinuity	2
3.2	Changeofinterval	2
	Tutorial	1
3.3	Oddandevenfunctions, Expansions ofodd or even and periodic functions	2
	Tutorial	1
3.4	Halfrangeseries and Fourierseriesoftypicalwave forms	1
3.5	Parseval'sformula and Harmonic Analysis	2
	Tutorial	1
4.	**Applications of Partial Differential Equations**	
4.1	Method of Separation of variables	1
4.2	Vibrations of a stretchedstring – Wave equations	2
	Tutorial	1
4.3	One dimensional heat flow	2
4.4	Two dimensional heat flow	2
	Tutorial	1
4.5	Laplaceequationsinpolar coordinates	2
	Tutorial	1
	Total	48

Course Designers:

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22MA310	ESSENTIALS OF MATRICES AND CALCULUS

Category	L	T	P	C	Terminal Exam Type
BSC	3	1	-	4	Theory

Preamble

This course aims to convey the process of finding the Eigen values and Eigen vectors of a matrix and hence the process of diagonalization of a matrix. It also demonstrates the techniques and sense of the utility of calculus using differentiation and integration of functions of single and several variables, enabling to solve complex engineering problems.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Utilize Eigen values and Eigen vectors of a matrix to diagonalize it.	TPS3	65	60
CO2	Model and solve extreme value problems of functions of single variable using their derivatives.	TPS3	65	60
CO3	Make use of partial derivative to model and solve extreme value problems of functions of several variables.	TPS3	65	60
CO4	Apply vector derivative to compute directional derivative and to identify solenoidal and irrotational vector fields.	TPS3	65	60
CO5	Demonstrate techniques of definite integrations of single variable functions.	TPS2	70	65
CO6	Compute mass and moments of given lamina using double integration in Cartesian coordinates.	TPS3	65	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	50	5	15	30	-	-	-	-	-	-	-	6	19
CO2	-	-	50	5	15	30	-	-	-	-	-	-	-	6	19
CO3	-	-	-	-	-	-	-	-	30	-	5	20	-	3	12
CO4	-	-	-	-	-	-	-	-	30	3	5	17	-	3	7
CO5	-	-	-	-	-	-	-	-	-	4	10	-	-	6	-
CO6	-	-	-	-	-	-	-	-	40	3	10	23	-	6	13

Syllabus

MATRIX EIGEN VALUE PROBLEMS [12Hrs]

The Matrix Eigen value Problem –Determination of Eigen values and Eigenvectors – Symmetric, Skew Symmetric and Orthogonal matrices – Eigen Bases – Diagonalization – Quadratic forms.

DIFFERENTIAL CALCULUS AND ITS APPLICATIONS [12Hrs]

The Limit of a function – Continuity of a function– The derivative as a function – Maximum and Minimum values – The Mean value theorem.

PARTIAL DIFFERENTIATION AND ITS APPLICATIONS [12Hrs]

Partial derivatives – The Chain rule – Maximum and Minimum Values – Directional derivatives and the Gradient vector – Curl and Divergence.

TECHNIQUES OF INTEGRATION AND ITS APPLICATIONS [12Hrs]

Definite Integrals – Properties of Definite integrals – Fundamental Theorem of Calculus – Double integrals over rectangles - Double integrals over general regions - Applications of double integrals in Cartesian coordinates (Density, Mass, Moments & Moments of Inertia problems only).

Textbook (s)

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2017.
2. James Stewart, Daniel Clegg and Saleem Watson "Calculus Early Transcendentals", 9e, Cengage Learning, New Delhi, 2019.
3. Lecture Notes on Calculus Through Engineering Application Problems and Solutions, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books & Web Resources

1. Kuldeep Singh, "Engineering Mathematics Through Applications",2e, Palgrave Macmillan, 2011, Great Britan.
2. KuldeepS.Rattan, Nathan W.Klingbeil, “Introductory Mathematics for Engineering Applications”,Wiley, 2015.
3. 3) George B. Thomas, "Thomas Calculus: Early transcendentals ", Pearson, New Delhi, 2013.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**MATRIX EIGEN VALUE PROBLEMS**	
1.1	The Matrix Eigen value Problem	1
1.2	Determination of Eigenvalues and Eigenvectors	2
	Tutorial	1
1.3	Symmetric, Skew Symmetric and Orthogonal matrices	2
	Tutorial	1
1.4	Eigen Bases, Diagonalization	2
1.5	Quadratic forms.	2

No.	Topic	No. of Periods
	Tutorial	1
2	**DIFFERENTIAL CALCULUS AND ITS APPLICATIONS**	
2.1	The Limit of a function	2
2.2	Continuity of a function	1
	Tutorial	1
2.3	The derivative as a function	2
2.4	Maximum and Minimum values of a function of single variable.	2
	Tutorial	1
2.5	The Mean value theorem	2
	Tutorial	1
3	**PARTIAL DIFFERENTIATION AND ITS APPLICATIONS**	
3.1	Partial derivatives	1
3.2	The Chain rule	2
	Tutorial	1
3.3	Maximum and Minimum Values of a function of two variables	2
	Tutorial	1
3.4	Directional derivative and the Gradient vector	2
3.5	Curl and Divergence	2
	Tutorial	1
4	**TECHNIQUES OF INTEGRATION AND ITS APPLICATIONS**	
4.1	Definite Integrals- Properties of Definite integrals.	1
4.2	Fundamental Theorem of Calculus	2
	Tutorial	1
4.3	Double integrals over rectangles	2
4.4	Double integrals over general regions	2
	Tutorial	1
4.5	Applications of double integrals in Cartesian coordinates(Density, Mass, Moments &Moments of Inertia problems only).	2
	Tutorial	1
	Total No. of Hours	48

Course Designers

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5.	Dr. S. Suriyakala	Assistant Professor	Mathematics	ssamat@tce.edu

22ME320	MECHANICS OF MATERIALS

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Mechanics of materials deals with the mechanical behaviour of mechanical components which have been made with different materials, subjected to different types of loading. This course covers for determination of stresses and strains for stepped bars, Composite bars, beams, columns, pressure vessels and shafts. This course is concerned with the stability of mechanical components under different static loading conditions.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concepts of deformation, stress, strain in structural member	TPS2	70	70
CO2	Compute the stresses, strains, principal stresses, elastic constantsand their relations of a structural member.	TPS3	70	65
CO3	Determine the shear force and bending moment, slope, deflection on different types of beams	TPS3	70	65
CO4	Calculate the bending and shear stresses of different beams	TPS3	70	65
CO5	Compute the torsional shear stresses in circular shafts	TPS3	70	65
CO6	Determine the crippling load on columns of different end conditions and the stresses in cylindrical and spherical vessels	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	L	-	-	-	**S**	-	**M**
CO2	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO3	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO4	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO5	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO6	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	30	5	5	20	-	-	-	-	-	-	2	10	-
CO2	-	-	30	5	5	20	-	-	-	-	-	-	2	-	10
CO3	-	-	40	5	5	30	-	-	-	-	-	-	-	10	15
CO4	-	-	-	-	-	-	-	-	40	5	5	30	2	-	15
CO5	-	-	-	-	-	-	-	-	30	5	5	20	2	-	15
CO6	-	-	-	-	-	-	-	-	30	5	5	20	2	-	15
												Total	**10**	**20**	**70**

Syllabus

Stress and Strain: Concept of stress and strain, tension, compression, shearing stress and strain, stress-strain relationship, Hooke's law, Poisson's ratio, elastic constants and their relations, thermal stresses, stresses in composite bars, strain energy due to axial loading. Principal stresses and planes, Major and Minor principal stresses- Stress strain transformation- Mohr's circle of stress.

Members Subjected to Flexural Loads: Relation between load, shear force and bending moment. Construction of Shear force diagrams and bending moment diagrams for different types of static loading - Cantilever, simply supported and overhanging beams. Slope and deflection of beams (Cantilever, simply supported and overhanging beams) under static loading.

Bending and Shear stresses in Beams: Theory of simple bending - section modulus — Determination and distribution of bending and shear stress in different beams.

Torsion of shafts: Torsional shear stress in solid and hollow circular shafts, torsional rigidity of shafts - Power transmission.

Columns, Cylinders and Spherical shells: Long and short columns, Euler's formula for crippling load with different end conditions, eccentric loading, Rankine formulae. Stresses in thin, thick cylinders and spherical shells.

Textbook (s)

1. Ferdinand P. Beer and E. Russell Johnston Jr., "**Mechanics of Materials**", McGraw Hill BookCompany, 2022.
2. Egor P. Popov, "**Engineering Mechanics of Solids**", Second Edition, Pearson Education Ltd,2020.

Reference Books

1. R.C.Hibbeler , Mechanics of materials , (SI Edition) , Pearson Education Ltd, 2020.
2. James M. Gere and Stephen P. Timoshenko, **"Mechanics of Materials",** 3rd edition, McGraw HillBook Company, 2020.
3. Timoshenko, S.P. and D.H. Young, "**Elements of Strength of Materials**", 5th edition. East-West Press, 2020.
4. Bansal, R.K., "**A Text Book of Strength of Materials**", Laxmi Publications (P) Ltd. New Delhi,2020.
5. Rajput, R.K., "**Strength of Materials**", S. Chand Publications, 2020.
6. MIT Open Courseware — Mechanics of Materials — Prof. Carol Livermore URL:http://ocw.mit.edu/courses/mechanical-engineering/2-001-mechanics-materials-i-fall-2006/syllabus

Course Contents and Lecture Schedule

Module Number	Topic	No of Lectures
1.0	**Stress and Strain:**	
1.1	Elementary definition of stress and strain, tension, compression, shearing stress and strain	1
1.2	Stress-strain relationship, Hooke"s law, Poisson"s ratio	1
1.3	Elastic constants and their relations	1
1.4	Thermal stresses	
1.5	Composite bars	2
1.6	Strain energy due to axial loading	1
1.7	Principal planes, stresses and strains	2
1.8	Stress strain transformation	1
1.9	Mohr's circle of stress and strain	2
2.0	**Members Subjected to Flexural Loads:**	
2.1	Shear force and bending moment. Relation between load, shear force and bending moment.	2
2.2	Shear force and bending moment diagram	
2.2.1	Shear force and bending moment diagrams for cantilever subjected to various types of loading	2
2.2.2	Shear force and bending moment diagrams for simply supportedbeam subjected to various types of loading	2
2.2.3	Shear force and bending moment diagrams for overhanging beam subjected to various types of loading	2
3.0	**Bending and Transverse Deflection of Beams:**	
3.1	Theory of simple bending,	2
3.2	Bending stresses, section modulus,	1
3.3	Bending stress and Shear stress distribution	1
3.4	Transverse deflection of beams under static loading	1
4.0	**Torsion:**	
4.1	Torsional shear stress in solid and hollow circular shafts	2
4.2	Angular deflection and power transmission capacity	1
4.3	Torsional Shear stress distribution in shafts	1
5.0	**Columns, Cylinders and Spherical shells**	
5.1	Long and short columns, ideal strut,	1
5.2	Euler's formula for crippling load for columns of different ends, concept of equivalent length, eccentric loading	2
5.3	Rankine formulae and other empirical relations	2
5.4	Stresses in thin cylindrical vessels	2
5.5	Stresses in thin spherical vessels.	1
	Total	**36**

Course Designers:

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2. Mr. C. Vignesh Assistant Professor Mechanical Engineering cvmech@tce.edu

22ME330	METAL JOINING AND SHEET METAL WORKING

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Metal joining is a crucial process in most manufacturing industries. This course is intended to lay strong foundation on metal joining processes by introducing the various principles and concepts. Topics related to weld defects and sheet metal fabrication processes are included to add in-depth.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the working principles, processes, capabilities, process parameters and equipment of metal joining processes.	TPS2	70	70
CO2	Select a suitable metal joining process for the given scenario.	TPS3	70	65
CO3	Determine weld parameters of in terms of heat flow and strength.	TPS3	70	65
CO4	Interpret the weld symbols and dimensioning of various welded joints and joining processes.	TPS2	70	70
CO5	Suggest remedial actions for the defects identified by suitable testing techniques in welded components.	TPS3	70	65
CO6	Determine the operating forces required, by selecting a suitable process to fabricate / assemble a given sheet metal component.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	L	-	M	-	-
CO2	S	M	L	-	-	-	M	-	-	-	M	-	S	-	M
CO3	S	M	L	-	-	-	-	-	-	-	M	-	S	M	-
CO4	S	M	L	-	-	-	-	-	-	-	L	-	S	-	-
CO5	S	M	L	-	-	-	-	-	-	-	M	-	M	-	M
CO6	S	M	L	-	-	-	M	-	-	-	M	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	15	25	-	-	-	-	-	-	-	6	10	-
CO2	-	-	50	-	-	40	-	-	-	-	-	-	-	-	20
CO3	-	-	30	5	-	15	-	-	-	-	-	-	2	-	10
CO4	-	-	-	-	-	-	-	20	-	5	15	-	2	10	-
CO5	-	-	-	-	-	-	-	-	40	5	10	20	6	-	10
CO6	-	-	-	-	-	-	-	-	40	10	15	20	4	10	10
												Total	**20**	**30**	**50**

Syllabus

Introduction: Solidification of the weld metal, base metal, heat affected zone, weld metal, shielding gases, filler metal, fluxes, types of weld joints.
Fusion welding: Oxy-fuel gas welding, thermit welding, Arc welding - shielded metal arc welding, flux core arc welding, submerged arc welding, MIG welding, TIG welding, CO_2 welding, plasma arc welding. Electron beam welding, laser beam welding.
Solid state welding: Resistance projection welding, friction welding, friction stir welding, diffusion bonding, ultra-sonic welding, explosion welding.
Semi-permanent joints: Brazing and soldering
Numerical Problems: Problems related to heat flow, heat generated, power density, strength and weld size.
Weld symbols: Symbols and conventional representation of welded joints, welding processes and its dimensioning.
Defects in joints: Crack, distortion, incomplete penetration, inclusions, porosity, blow holes, poor fusion, poor weld bead appearance, spatter, under-cutting and over lapping - causes and remedies of defects.
Testing and inspection: Destructive testing of welds – Acid Etch Test, Fillet Weld break test, Transverse Tension Test, Guided Bend Test and Free Bend Test. Non-destructive testing of welds - Visual inspection, Magnetic Particle Test, Ultrasonic Test and Eddy Current Test.
Sheet metal operations: Cutting operations - blanking, piercing, slitting, lancing, shaving, trimming, cut off. Non-cutting operations - forming, embossing, coining, curling, bulging, edge bending, V-bending, U–bending, tube bending, shallow drawing, deep drawing. Formability and drawability. Determination of operating forces - cutting force, bending force and drawing force. Joining operations – hemming, resistance spot welding, resistance seam welding, riveting, defects in sheet metal operations.

Textbooks

1. Serope Kalpakjian and Steven R. Schmid, “Manufacturing Engineering and Technology”, Eighth Edition, Pearson, 2018.
2. Parmer R.S, “Welding Engineering and Technology”, Second Edition, Khanna publishers, Delhi, 2013.
3. K. R. Gopalakrishna, “Machine Drawing”, Eighteenth Edition, Subhas Stores, Bangalore, 2017.

Reference Books & Web Resources

1. Mikell P Groover, “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, Seventh Edition, Wiley India, 2019.
2. Richard L Little, “Welding and Welding Technology” – McGraw Hill Education (India) Private Limited, New Delhi, 2017.
3. NPTEL course titled “Welding Processes” by Prof. Murugaiyan Amirthalingam, IIT Madras. Link: https://nptel.ac.in/courses/113106087
4. NPTEL course titled “Fundamental of Welding Science and Technology” by Prof. Pankaj Biswas, IIT Guwahati. Link: https://nptel.ac.in/courses/112103263

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction**	
1.1	Solidification of the weld metal, base metal, heat affected zone, weld metal.	1
1.2	Shielding gases, filler metal, fluxes, types of weld joints	1
2	**Fusion welding**	
2.1	Oxy-fuel gas welding, thermit welding	2
2.2	Arc welding – shielded metal arc welding, flux core arc welding, submerged arc welding, CO_2 welding	3
2.3	MIG welding, TIG welding, plasma arc welding	2
2.4	Electron beam welding, laser beam welding	1
3	**Solid state welding**	
3.1	Resistance projection welding, friction welding, friction stir welding	2
3.2	Diffusion bonding, ultra-sonic welding, explosion welding	2
4	**Semi-permanent joints**	
4.1	Brazing and soldering	1
5	**Numerical Problems**	
5.1	Problems related to heat flow, heat generated, power density, strength and weld size	3
6	**Weld symbols**	
6.1	Symbols and conventional representation of welded joints, welding processes and its dimensioning	2
7	**Defects in joints**	
7.1	Crack, distortion, incomplete penetration, inclusions, porosity, blow holes, poor fusion, spatter	1
7.2	Poor weld bead appearance, under-cutting and over lapping – causes and remedies of defects	1
8	**Testing and inspection**	
8.1	Destructive testing of welds – Acid Etch Test, Fillet Weld break test, Transverse Tension Test, Guided Bend Test and Free Bend Test.	2
8.2	Non-destructive testing of welds – Visual inspection, Magnetic Particle Test, Ultrasonic Test and Eddy Current Test	3
9	**Sheet metal operations**	
9.1	Cutting operations – blanking, piercing, slitting, lancing, shaving, trimming, cut off.	2
9.2	Non-cutting operations – forming, embossing, coining, curling, bulging, edge bending, V-bending, U–bending, tube bending, shallow drawing, deep drawing. Formability and drawability.	2
9.3	Determination of operating forces - cutting force, bending force and drawing force.	2
9.4	Joining operations - hemming, resistance spot welding, resistance seam welding, riveting.	2
9.5	Defects in sheet metal operations	1
	Total	**36**

Course Designers

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22ME340	THERMAL ENGINEERING

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Thermal Engineering is the branch of mechanical engineering which deals with the applications of engineering thermodynamics in power cycles, refrigeration cycles, and engineering devices such as steam turbines, compressors, refrigerators and air conditioners. A mechanical engineer needs to know the basic construction, working principle and performance analysis of power and refrigeration cycles and thermal systems

Prerequisite

- Engineering Thermodynamics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the performance of various gas power cycles using P-V and T-s diagrams	TPS3	70	65
CO2	Compute the performance of vapour power cycles using steam tables and Mollier chart.	TPS3	70	65
CO3	Determine the coefficient of performance of vapour compression refrigeration systems using refrigeration tables and charts	TPS3	70	65
CO4	Determine the workout put and diagram efficiency of steam turbines using velocity triangles, steam tables and Mollier chart and.	TPS3	70	65
CO5	Calculate the isothermal efficiency, volumetric efficiency and free air delivery of reciprocating air compressors.	TPS3	70	65
CO6	Determine the amount of air required for complete combustion of fuel, air-fuel ratio and calorific values of fuels.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	M	-	-	-	S	-
CO2	S	M	L	-	-	-	-	M	M	M	-	-	-	S	-
CO3	S	M	L	-	-	-	-	M	M	M	-	-	-	M	-
CO4	S	M	L	-	-	-	-	M	M	M	-	-	-	M	-
CO5	S	M	L	-	-	-	-	M	M	M	-	-	-	M	-
CO6	S	M	L	-	-	-	-	M	M	M	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	5	10	25	-	-	-	-	-	-	2	6	10
CO2	-	-	30	5	10	15	-	-	-	-	-	-	2	6	10
CO3	-	-	30	5	10	15	-	-	-	-	-	-	2	6	10
CO4	-	-	-	-	-	-	-	-	40	5	10	25	-	6	10
CO5	-	-	-	-	-	-	-	-	30	5	10	15	2	6	10
CO6	-	-	-	-	-	-	-	-	30	5	10	15	2	-	10
												Total	10	30	60

Syllabus

Gas power cycles: Carnot cycle, Otto cycle, Diesel cycle, Air standard efficiency and mean effective pressure calculations, Comparison of Otto and Diesel cycles, Dual cycle- Air standard efficiency and mean effective pressure calculations, Brayton (Joule) cycle- Air standard efficiency and mean effective pressure calculations. Internal combustion engines construction and terminologies.

Vapour power cycles: Carnot cycle, Rankine cycle, Reheat Rankine cycle, – Performance calculations, Regenerative Rankine Cycle with one open or closed feed water heater (Qualitative treatment), Concept of cogeneration.

Refrigeration cycles: Reversed Carnot cycle, Vapour Compression Refrigeration cycle with superheating and sub-cooling, Performance calculations and applications. Working principle of Vapour Absorption Refrigeration System.

Steam turbines: Impulse and Reaction Types, Components – steam nozzle, Working principle, Velocity diagrams and Performance calculations for single stage turbine, Compounding (Qualitative treatment).

Reciprocating air compressors: Working principle, Work of compression in single stage with and without clearance volume, Free Air Delivery, Isothermal efficiency, volumetric efficiency, Multi stage compression, Intercooling, Condition for minimum work, Performance calculations

Fuels and Combustion: Fuel types, Characteristics of an ideal fuel, Calorific value, Combustion equations of solid, liquid and gaseous fuels, Stoichiometric air fuel ratio, conversion of volumetric analysis to gravimetric analysis, conversion of gravimetric analysis to volumetric analysis, mass of carbon in flue gases, excess air supplied.

Text Books

1. Yunus A.Cengel and Michael A.Boles, "**Thermodynamics: An Engineering Approach**", Ninth edition, McGraw-Hill, 2019.
2. P.K. Nag, "**Basic and Applied Thermodynamics**", McGraw Hill Education (India) Private Limited; 2nd edition, 2017.
3. A. Valan Arasu, "**Thermal Engineering**"- second edition, McGraw Hill Education (India) Private Limited, 2017.

Reference Books & Web Resources

1. Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner P, Margaret B. Bailey, "**Fundamentals of Engineering Thermodynamics**", Seventh Edition, John Wiley & Sons Inc., 2011.
2. T.D.Eastop and McConkey, "**Applied Thermodynamics for Engineering Technologists**" Fifth Edition, Pearson Education Ltd, 2009.

3. Gordon Rogers and Yon Mayhew "**Engineering Thermodynamics: Work and Heat Transfer**", 4th edition, Pearson Education Ltd, 2009.
4. R.K. Rajput, "**Thermal Engineering**", Laxmi Publications, Ninth Edition, 2013.
5. http://nptel.ac.in/courses/IIT-MADRAS/Applied_Thermodynamics/
6. http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-050-thermal-energy-fall-2002/lecture-notes/

Tables and Charts

1. R.S. Khurmi, "**Steam Tables with Mollier Diagram**", S.Chand Publishers, 2008.
2. C.P. Kothandaraman, "**Refrigerant tables and charts including air conditioning data**", 4th edition, New Age International Publishers, 2014.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Gas power cycles**	
1.1	Carnot cycle - Air standard efficiency and mean effective pressure calculations, Internal combustion engine construction and terminologies	1
1.2	Otto cycle - Air standard efficiency and mean effective pressure calculations	1
1.3	Diesel cycle- Air standard efficiency and mean effective pressure calculations	1
1.4	Comparison of Otto and Diesel cycles	1
1.5	Dual cycle- Air standard efficiency and mean effective pressure calculations.	1
1.6	Brayton (Joule) cycle- Air standard efficiency and mean effective pressure calculations.	2
2	**Vapour power cycles**	
2.1	Carnot cycle	1
2.2	Rankine cycle- Performance calculations	2
2.3	Reheat Rankine cycle - Performance calculations	2
2.4	Regenerative Rankine cycle	1
2.5	Cogeneration- Definition and Types	1
3	**Refrigeration cycles**	
3.1	Reversed Carnot cycle	1
3.2	Vapour Compression Refrigeration cycle with super heating and sub-cooling, Performance calculations and applications.	2
3.3	Working principle of Vapour Absorption Refrigeration System	1
4	**Steam turbines**	
4.1	Impulse and reaction types- Components- steam nozzle	1
4.2	Working principle, Velocity diagrams	1
4.3	Performance calculations for single stage turbine	2
4.4	Compounding - Types	1
5	**Reciprocating air compressors**	
5.1	Working principle, Work of compression in single stage with and without clearance volume, Free Air Delivery	2
5.2	Isothermal efficiency, Volumetric efficiency	1
5.3	Multi stage compression, Intercooling	1
5.4	Condition for minimum work, Performance calculations	2
6	**Fuels and Combustion**	
6.1	Fuel types, Characteristics of an ideal fuel, Calorific value, Combustion equations of solid, liquid and gaseous fuels,	1

No.	Topic	No. of Periods
6.2	Stoichiometric air fuel ratio, conversion of volumetric analysis to gravimetric analysis,	2
6.3	conversion of gravimetric analysis to volumetric analysis,	2
6.4	Mass of carbon in flue gases, excess air supplied.	2
	Total	**36**

Course Designers

1. Prof.A. Valan Arasu Professor Mechanical Engineering avamech@tce.edu
2. Dr. B. Karthikeyan Assistant Professor Mechanical Engineering bkmech@tce.edu

22ME350	PRODUCTION DRAWING

Category	L	T	P	C	Terminal Exam Type
ESC	2	-	4	4	TCP

Preamble

Production Drawing is an indispensable communicating medium employed in industries to furnish all information required to manufacture and assembly of the components of a machine. It deals with the blue print reading and the preparation of orthographic projections of various machine parts and assemblies with all details of products regarding material, surface finish and tolerances along with fits as per ISO/BIS drawing standards for drawing practices through manual method.

Prerequisite

- Engineering Graphics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the ISO/BIS standards of production drawing	TPS2	70	70
CO2	Interpret the blue print drawing as per drawing standards	TPS2	70	70
CO3	Explain the tolerances, limits and fits used in production drawing	TPS2	70	70
CO4	Draw manual assembly drawing from the given part drawings	TPS3	70	65
CO5	Draw manual part drawing from the given assembly drawing	TPS3	70	65
CO6	Draw the manual detailed/production drawing from the given assembly/part drawing	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	L	-	S	-	-
CO2	S	M	L	-	-	-	-	-	-	-	L	-	S	-	-
CO3	S	M	L	-	-	-	-	-	-	-	L	-	S	-	-
CO4	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-
CO5	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-
CO6	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Internal Evaluation												*Terminal Examination		
	CAT- 1			CAT- 2			Plates/OCR			Model Exam			Theory		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	40	-	-	-	-	-	-	-	-	6	-	-	6	-
CO2	-	20	-	-	-	-	-	-	-	-	12	-	-	12	-
CO3	-	40	-	-	-	-	-	-	-	-	12	-	-	12	-
CO4	-	-	-	-	-	30	-	-	30	-	-	20	-	-	20
CO5	-	-	-	-	-	30	-	-	30	-	-	20	-	-	20
CO6	-	-	-	-	-	40	-	-	40	-	-	30	-	-	30

Question pattern for Terminal Examination*

PART-A

Understand type 5 x 6 Mark = 30 Marks

PART – B

Apply type [either / or Type]

B1. Part to Assembly 1 x 20 Mark = 20 Marks
B2. Assembly to Part 1 x 20 Mark = 20 Marks
B3. Detailed/Production Drawing 1 x 30 Mark = 30 Marks

Total = 100 Marks

Syllabus

ISO/BIS Drawing standards for practice - Sizes of drawing sheet, lettering, terminologies of drawing layout, title block, scale, types of line & its application, methods of dimensioning, uses of different grades of pencils, drawing sheet folding method, **Sections** – hatching, cutting planes, revolved, removed, half and local sections. Classification of drawings, Difference between machine drawing over production drawing. **Conventional representation** – Materials, springs, gears, surface roughness, weld dimensioning, internal & external thread, bolts, nuts, screws and keys. **Blueprint Reading** – Interpretation of information from the given production/detailed drawing. **Limits and Tolerances** - Elements, system and arrangement of dimensioning, Indication of dimensional and geometrical tolerances, Indication of lay, Tolerance grade number of different manufacturing process, selection of tolerance grade, standard tolerance grade, computation of IT tolerance, positioning of tolerance, computation of fundamental deviations. **Fits** - Hole and Shaft basis system of fits, classifications, and calculation.

Assembly Drawing: Preparation of assembly drawing from the given part drawing like Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.

Part Drawing: Preparation of part drawing from the given assembly drawing like Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.

Production/Detailed drawings: Preparation of production/detailed drawing of part/assembly drawing like Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.

Textbook (s)

1. K.R.Gopalakrishna, "**Machine Drawing**", Eighteenth Edition, Subhas Stores, Bangalore, 2013.
2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, "**Machine Drawing**", Third Edition, New Age International Publishers, New Delhi, 2019.

Learning Resources

1. BIS-SP46:2003 standard recommendations for school practices.

2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, “**Production Drawing**”, Third Edition, New Age International Ltd., New Delhi, 2014.
3. Thamos P.Olivo and Dr.C.Thamos Olivo, “**Basic Blueprint Reading and Sketching**”, 9th edition, Industrial Press Inc, New York, 2011.
4. Walter W Sturtevant, “Practical Problems in Mechanical Drawing and Blue-Print Reading”, Wentworth Press, 2016.
5. PS. Gill, “**A Text Book of Machine Drawing**”, Seventh edition Reprint, S.K. Kataria & Sons. New Delhi. 2004.
6. RK. Dhawan, “**A Text book of Machine Drawing**”, First Edition, Sultan Chand and Sons, New Delhi, 2015.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**ISO/BIS Drawing standards for practice**	
1.1	Sizes of drawing sheet, lettering, terminologies of drawing layout, title block, scale, types of line & its application, methods of dimensioning, uses of different grades of pencils, drawing sheet folding method,	2
1.2	Sections – hatching, cutting planes, revolved, removed, half and local sections. Classification of drawings, Difference between machine drawing over production drawing.	2
1.3	**Blue Print Reading** – Interpretation of information from the given production/detailed drawing.	2
1.4	**Conventional representation** – Materials, springs, gears, surface roughness, weld dimensioning, internal & external thread, bolts, nuts, screws and keys.	2
1.5	**Limits and Tolerances** - Elements, system and arrangement of dimensioning, Indication of dimensional and geometrical tolerances, Indication of lay, Tolerance grade number of different manufacturing process. selection of tolerance grade, standard tolerance grade, computation of IT tolerance, positioning of tolerance, computation of fundamental deviations.	6
1.6	**Fits** - Hole and Shaft basis system of fits, classifications, and calculation.	4
2	**Assembly Drawing**	
2.1	Preparation of assembly drawing from the given part drawing-1 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
2.2	Preparation of assembly drawing from the given part drawing-2 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
2.3	Preparation of assembly drawing from the given part drawing-3 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
3	**Part Drawing**	
3.1	Preparation of part drawing from the given assembly drawing-1 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
3.2	Preparation of part drawing from the given assembly drawing-2 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
3.3	Preparation of part drawing from the given assembly drawing-3 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
4	**Production/Detailed drawing**	
4.1	Preparation of production/detailed drawing-1 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6

No.	Topic	No. of Periods
4.2	Preparation of production/detailed drawing-2 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6
4.3	Preparation of production/detailed drawing-3 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6
	Total	60

List of Exercises

No.	Exercises	CO
	Assembly Drawing with respect to Lecture Schedule	
1.	Preparation of assembly drawing from the given part drawing-1	CO4
2.	Preparation of assembly drawing from the given part drawing-2	CO4
3.	Preparation of assembly drawing from the given part drawing-3	CO4
	Part Drawing with respect to Lecture Schedule	
4.	Preparation of part drawing from the given assembly drawing-1	CO5
5.	Preparation of part drawing from the given assembly drawing-2	CO5
6.	Preparation of part drawing from the given assembly drawing-3	CO5
	Production/Detailed drawing with respect to Lecture Schedule	
7.	Preparation of production/detailed drawing-1	CO6
8.	Preparation of production/detailed drawing-2	CO6
9.	Preparation of production/detailed drawing-3	CO6

Course Designers

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22ME370	THERMAL ENGINEERING LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

Mechanical engineering students are required to understand the construction, working andperformance of thermal systems. This course enables the students to determine experimentally, theperformance characteristics of I.C.Engines, gas turbine, steam boiler and turbine, air compressor,
refrigerator and air conditioner.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine various performance characteristics of I.C. and Gas turbine Engines and air compressor	TPS3	70	65
CO2	Determine the performance of Refrigerator and Air-conditioning units	TPS3	70	65
CO3	Determine dryness fraction of steam and thermal efficiency of steam generator and steam turbine	TPS3	70	65
CO4	Draw valve timing of 4-stroke engine and port timing of 2-stroke engine and determine the properties of fuel	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	S	M	-	-	-	S	S	S	M	-	-	M	-
CO2	S	M	S	M	-	-	-	S	S	S	M	-	-	M	-
CO3	S	M	S	M	-	-	-	S	S	S	M	-	-	M	-
CO4	M	L	M	L	-	-	-	S	S	S	M	-	-	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Continuous Assessment	
Laboratory Observation and Record	75 %
Test	25 %
Terminal Examination (Duration:3 Hours)	
Test and Viva Voce	100%

List of Experiments

No.	Experiment	CO
1.	Performance test on 4-stroke Petrol / Diesel / Gas turbine engine	CO1
2.	Energy balance test on Diesel engine by calorimeter method / air flow measurement	CO1

No.	Experiment	CO
3.	Retardation test on Diesel engine	CO1
4.	Volumetric efficiency test on Diesel engine / Reciprocating air compressor	CO1
5.	Performance test on vapour compression /absorption Refrigeration test rig	CO2
6.	Performance test on Air conditioning test rig	CO2
7.	Performance test on steam Boiler and Turbine	CO3
8.	Steam dryness fraction test using separating and throttling calorimeter	CO3
9.	Determination of valve timing of 4-stroke and port timing of 2-stroke engines	CO4
10.	Evaluation of physical properties such as flash point, fire point and viscosity of fuel	CO4

Learning Resources

1. Lab Manual, Department of Mechanical Engineering, TCE (2022)
2. https://nptel.ac.in/courses/112103262/1 byDr. Pranab K. Mondal and Dr. Vinayak N. Kulkarni, IITG.

Course Designers

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22ME380	MANUFACTURING PROCESSES LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

It is essential for a mechanical engineering student to have hands on practice of the different fundamental manufacturing processes This practical course aims to develop psychomotor skills on the various processes such as metal casting, injection moulding, metal joining, metal forming and Inspection through Non - Destructive Testing techniques.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Prepare Green Sand Mould using Single Piece and Split Patterns for metal casting.	TPS3	70	65
CO2	Prepare a component using plastic injection moulding machine.	TPS3	70	65
CO3	Make simple components by hand smith forging method.	TPS3	70	65
CO4	Perform simulation on Gas welding.	TPS3	70	65
CO5	Make joints using Fusion Welding – Gas and MIG/TIG Welding.	TPS3	70	65
CO6	Make joints using Solid State Spot Welding.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L
CO2	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L
CO3	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L
CO4	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L
CO5	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L
CO6	S	M	L	L	L	-	-	-	S	-	-	-	L	-	L

S - Strong; M - Medium; L – Low

Assessment Pattern - Continuous Assessment

Trade	Exercises	Record	Model Test	Total Marks
CO1	15	4	25	100
CO2	5	1		
CO3	20	5		
CO4	5	1		
CO5	10	2		
CO6	5	2		
Continuous Assessment Marks shall be converted into 60 marks.				

Assessment Pattern – Terminal Examination

Trade	Trade - 1	Trade -2	Total
Students will be evaluated in any two trades from Foundry, Smithy and Welding, with 1 ½ hours duration each.			
Any Two from Foundry, Smithy and Welding	50	50	100
Terminal Examination will be conducted for a Maximum of 100 Marks and it will be converted to 40 marks.			

List of Exercises

No.	Exercises	CO
	Foundry:	
1.	Preparation of green sand mould using single piece pattern (Anvil/Pulley Block/Spur Gear).	CO1
2.	Preparation of green sand mould using split pattern (Dumbbell).	CO1
3.	Metal Melting and pouring.	CO1
4.	Preparation of component using plastic injection moulding machine.	CO2
	Smithy:	
5.	Conversion of Round rod into Square rod by hand forging.	CO3
6.	Preparation of Tool for shaping machine/Chisel.	CO3
7.	Preparation of S – Hook / Z – Clamp.	CO3
8.	Preparation of square headed bolt.	CO3
	Welding:	
9.	Practice Exercise on Simulation of Gas Welding.	CO4
10.	Preparation of Lap/Butt/Corner/T Joint using Gas Welding with appropriate flame settings.	CO5
11.	Preparation of Lap/Butt/Corner /T Joint using MIG Welding/TIG Welding with appropriate current and voltage settings.	CO5
12.	Preparation of Lap joint on metal sheets using Spot Welding.	CO6
	Testing - Demonstration Exercises:	
13.	Demonstration on Inspection of castings and weldments (surface cracks) using liquid penetrant test method.	---
14.	Demonstration of inspection of castings and weldments (Internal cracks) using ultrasonic flaw detector.	---

Learning Resources

1. Lab Manual, Department of Mechanical Engineering, TCE (2022)
2. S. K. Hajra Choudhury, Nirjhar Roy, A. K. Hajra Choudhury, “Elements of Work shop Technology, Vol – I Manufacturing Processes”, Media Promoters and Publishers Pvt. Ltd, 2017.

Course Designers

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2. Dr. R. Sivasankaran — Assistant Professor — Mechanical Engineering — rssmech@tce.edu

22ME410	OPERATIONS RESEARCH

Category	L	T	P	C	Terminal Exam Type
BSC	3	1	-	4	Theory

Preamble

Optimization is a scientific approach to decision making that seeks the best design and operate a system usually under conditions requiring the allocation of scarce resources. Operations research helps in solving problems in different environments that needs decisions. Because of the complexity of most real world optimization problems, it has been necessary to reduce the complexity of the problem by either simplifying the problem or constrains it by making reasonable assumptions. This course will enable the students to understand the basic ideas of formulate a real world problem with constraints in order to produce decisions effectively. In addition, the course will make the students to have an idea of distribution and its applications in the field of queuing theory.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Formulate the Linear Programming Problem and estimate it by Graphical method and simplex method	TPS3	75	70
CO2	Estimate the characteristics such as time and cost in solving transportation and assignment problems with an appropriate model	TPS3	75	70
CO3	Compute the expectations of discrete and continuous random variables	TPS2	80	75
CO4	Apply the concept of discrete and continuous distributions and compute the probable values of a random experiments	TPS3	75	70
CO5	Calculate the solutions of single and multi-channel Queuing problems	TPS3	75	70
CO6	Solve deterministic inventory problems	TPS3	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO2	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO3	M	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO4	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO5	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L
CO6	S	M	L	-	L	L	-	-	-	-	-	L	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	35	-	8	25	-	-	-	-	-	-	-	5	12
CO2	-	-	45	-	8	35	-	-	-	-	-	-	-	5	16
CO3	-	-	-	4	8	-	-	-	-	-	-	-	-	5	-
CO4	-	-	20	4	8	-	-	-	20			16	-	5	10
CO5	-	-	-	-	-	-	-	-	40	4	16	22	-	5	16
CO6	-	-	-	-	-	-	-	-	40	4	16	22	-	5	16
												Total	**-**	**30**	**70**

Syllabus

Linear Programming: Introduction - Linear Programming Problem formulation – Graphical method - Simplex method- Basics of Duality

Transportation and Assignment Problems: Transportation problems -Initial Basic Feasible solutions by North west corner rule - Least Cost Method - Vogel's approximation method - optimal solution for a Transportation problem using Modified distribution method -Formulation of an Assignment Problem –Hungarian method for solving an assignment problem.

Probability Distributions: Random Variable - Discrete Random Variable - Continuous Random Variable - Expected Values - Binomial distribution - Poisson distribution - Exponential Distribution - Normal distribution.

Queuing Models: Single channel Queuing theory – Single channel Poisson arrival with exponential service times - infinite population (M/M/1)/(FCFS/∞/∞) – Generalization of model (M/M/1)/(FCFS/∞/∞) (Birth death process) - Single channel Poisson arrival with exponential service times - infinite population - service in random order model (M/M/1)/(SIRO/∞/∞) – Finite Queue length model (M/M/1)/(FCFS/N/∞) – Multi channel Queueing model (M/M/C)/(FCFS/∞/∞).

Inventory Models: Inventory model with deterministic demand -Classical EOQ model - Demand rate uniform replenishment rate infinite - Demand rate non-uniform replenishment rate infinite - Demand rate uniform, replenishment or production rate finite - Demand rate uniform, replenishment rate infinite with shortages - Demand rate uniform, replenishment rate finite withshortages - Inventory model with price breaks.

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Text Books

1. Hira.DGupta.P.K "Operations Research",S.Chand Publications, Revised seventh Edition, Reprint 2014.
2. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences" Eighth Edition, CengageLearning India Pvt Ltd., New Delhi, 2012.

Reference Books

1. KantiSwarup,Gupta. P.K, Man Mohan "Operations Research" Sultan Chand & Sons India Ltd.,TwelfthEdition,NewDelhi, 2014.
2. Frederick Hillier, Gerald Lieberman, "Introduction to Operations Research"Tenth Edition, Tata McGraw Hill, 2015.
3. J K Sharma,"Operations Research, Theory and Applications", Sixth Edition, , Trinity Press, Laxmi Publications Pvt. Ltd., 2016.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Linear Programming**	
1.1	Introduction and formulation of Linear Programming Problem	1
1.2	Graphical method	2
	Tutorial	1
1.3	Simplex method	2
1.4	Basics in Duality	1
	Tutorial	1
2	**Transportation and Assignment Problem**	
2.1	Transportation problem	1
2.2	Initial basic solution by Northwest Corner Rule, Least cost method, Vogel's approximation method	2
	Tutorial	1
2.3	Optimal solution of a transportation problem by MODI method	2
2.4	Formulation of assignment problem	1
2.5	Hungarian method for assignment problem	2
	Tutorial	1
3	**Probability Distributions**	
3.1	Random Variables, Discrete and Continuous Random Variables, Expected Values	2
	Tutorial	1
3.2	The Binomial distribution	1
3.3	The Poisson distribution	1
	Tutorial	1
3.4	The Exponential distribution	1
3.5	The Normal distribution	2
	Tutorial	1
4	**Queuing Models**	
4.1	Single channel Poisson arrival with exponential service times, infinite population (M/M/1)/(FCFS/∞/∞)	2
4.2	Generalization of model (M/M/1)/(FCFS/∞/∞) (Birth death process)	1
	Tutorial	1
4.3	Single channel Poisson arrival with exponential service times, infinite population, service in random order model (M/M/1)/(SIRO/∞/∞)	2
	Tutorial	1
4.4	Finite Queue length model (M/M/1)/(FCFS/N/∞)	1
4.5	Multi-channelQueuing model (M/M/C)/(FCFS/∞/∞)	1
	Tutorial	1
5	**Inventory Models**	
5.1	Classical EOQ model: Demand rate uniform, replenishment rate infinite	2
5.2	Demand rate non-uniform replenishment rate infinite	1
	Tutorial	1
5.3	Demand rate uniform, replenishment or production rate finite	1
5.4	Demand rate uniform, replenishment rate infinite with shortages	1
	Tutorial	1
5.5	Demand rate uniform, replenishment rate finite with shortages	1
5.6	Inventory model with price breaks	1
	Tutorial	1
	Total	48

Course Designers:

1. Dr.A.Anitha Assistant Professor Department of Mathematics anithavalli@tce.edu
2. Dr.S.Saravanakumar Assistant Professor Department of Mathematics sskmat@tce.edu
3. Dr.M.Sundar Assistant Professor Department of Mathematics msrmat@tce.edu

22MEL10	NUMERICAL METHODS AND OPERATIONS RESEARCH

Category	L	T	P	C	Terminal Exam Type
BSC	3	1	-	4	Theory

Preamble

An engineering student needs to have some basic mathematical tools, numerical tools and techniques. This assures the development of rigorous logical thinking and analytical skills of the student and develops him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving the adequate exposure in the theory of numerical methods for solving algebraic equations, system of equations and particularly the numerical solution of partial differential equations along with the basics and applications of linear programming problem.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcomes	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Estimate the solutions of algebraic and transcendental equations numerically.	TPS2	80	75
CO2	Solve the system of linear algebraic equations using appropriate numerical techniques.	TPS3	75	70
CO3	Compute the solution of boundary value problems using suitable numerical methods.	TPS3	75	70
CO4	Formulate the linear programming problem and solve it by appropriate techniques.	TPS3	75	70
CO5	Model the transportation problem and solve it for optimality.	TPS3	75	70
CO6	Model the assignment problem and solve it using Hungarian method.	TPS3	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L		L	L						L			L
CO2	S	M	L		L	L						L			L
CO3	S	M	L		L	L						L			L
CO4	S	M	L		L	L						L			L
CO5	S	M	L		L	L						L			L
CO6	S	M	L		L	L						L			L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	-	-	20	-	-	-	-	-	-	-	-	10	-
CO2	-	-	40	4	10	16	-	-	-	-	-	-	-	5	10
CO3	-	-	60	6	-	44	-	-	-	-	-	-	-	10	15
CO4	-	-	-	-	-	-	-	-	50	6	20	24	-	5	20
CO5	-	-	-	-	-	-	-	-	30	4	10	16	-	-	15
CO6	-	-	-	-	-	-	-	-	20	-	-	20	-	-	10

Syllabus

Solution of algebraic and transcendental equations: Bisection method – Regula-Falsi method - Newton – Raphson method. Solution of simultaneous algebraic equations: Direct methods: Gauss Elimination method – Gauss Jordan method– Iterative methods of solution: Jacobi's iteration method – Gauss-Seidel iteration methods.

Numerical solution of Partial Differential Equations: Classification of second order equations – Elliptic equations: Solution of Laplace's equations – Solution of Poisson's equations Parabolic equations: Solution of one-dimensional heat equation by Bendre-Schmidt method – Hyperbolic equations: Solution of wave equation.

Linear Programming: Formulation of Linear Programming Problems – Graphical method of solution – The general Linear Programming Problem – Canonical and Standard forms of Linear Programming Problem – Simplex method- Basics of duality

Transportation and Assignment Models: Definition of the transportation model – North West Corner rule and Least cost method - Vogel's approximation methods – The Modified Distribution Method – Definition of the assignment model – Mathematical representation of the assignment model – Formulation of Assignment Problem – The Hungarian method for solution of the Assignment problems.

Text Books

1. B.S. Grewal, "Numerical methods in Engineering Science", Khanna publishers, 43/E, 2014.
2. Hira. D Gupta. P. K "Operations Research", S. Chand Publications, Revised seventh Edition, Reprint 2014.

Reference Books

1. Steven C.Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", Tata McGraw Hill publishers, 3rd edition, 2012.
2. P. Kandasamy, K. Thilagavathy, K. Gunavathi, "Numerical methods", S. Chand & Company Ltd, New Delhi, 8th Edition, 2013.
3. Kanti Swarup, Gupta. P.K, Man Mohan, "Operations Research", Sultan Chand & Sons India Ltd., 12th Edition, New Delhi, 2014.
4. J K Sharma, "Operations Research, Theory and Applications", 6th Edition, Trinity Press, Laxmi Publications Pvt. Ltd., 2016.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
	1. Solution of Algebraic and transcendental Equations	
1.1.	Bisection method and Regula – Falsi method	2
1.2.	Newton – Raphson method	2
	Tutorial	1
1.3	Gauss Elimination method	1
1.4	Gauss Jordan method – Inverse of a matrix by Gauss Jordan method	2
	Tutorial	1
1.5	Jacobi's iteration method – Gauss-Seidel iteration methods	2
	Tutorial	1
	2. Numerical solution of Partial Differential Equations	
2.1	Classification of second order equations	1
2.2	Elliptic equations: Solution of Laplace's equations	2
	Tutorial	1
2.3	Solution of Poisson's equations	2
	Tutorial	1
2.4	Parabolic equations: Solution of one dimensional heat equation by Bendre-Schmidt method	2
2.5	Hyperbolic equations: Solution of wave equation.	2
	Tutorial	1
	3. Linear Programming	
3.1	Linear Programming Problem - Introduction	1
3.2	Formulation of LPP	1
	Tutorial	1
3.3	Graphical method	2
3.4	Canonical and Standard forms of Linear Programming Problem	1
	Tutorial	1
3.5	Simplex method	3
3.6	Basics of Duality	1
	Tutorial	1
	4. Transportation and Assignment Models	
4.1	Definition of the transportation model and solution of Transportation models	1
4.2	Mathematical formulation of Transportation problems	1
4.3	Vogel's approximation method	2
	Tutorial	1
4.4	The Modified Distribution Method	2
	Tutorial	1
4.5	Definition of the assignment model, Mathematical representation of the assignment model	1
4.6	The Hungarian method for solution of the Assignment problems	2
	Tutorial	1
	Total	48

Course Designers

1.	Dr.A.Anitha	Assistant Professor	Department of Mathematics	anithavalli@tce.edu
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22ME420	DESIGN OF MACHINE ELEMENTS

Category	L	T	P	C	Terminal Exam Type
PCC	2	1	0	3	Theory

Preamble

Machine Design is the creation of new and better machines that works safely, reliably and well. Mechanical design is a complex process, requiring many skills. Extensive relationships need to be subdivided into a series of simple tasks. The complexity of the process requires a sequence in which ideas are introduced and iterated. Design is an iterative process with many interactive phases. Many resources exist to support the designer, including many sources of information about the materials, loading conditions and computational design equations and tools. The survival of a mechanical machine element is often related through their stress and strength. Thus, Machine Design is defined as the use of scientific principles, technical information and imagination in the description of a machine or a mechanical system to perform specific functions with maximum economy and efficiency.

Prerequisite

- Engineering Mechanics
- Mechanics of Materials

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Design of simple machine elements subjected to static and fatigue loading.	TPS3	70	65
CO2	Design of shafts, keys and couplings under different loading conditionsfor mechanical applications.	TPS3	70	65
CO3	Design of welded joints subjected to different loading conditions	TPS3	70	65
CO4	Design of riveted joints and threaded joints subjected to different loading conditions	TPS3	70	65
CO5	Design of helical coil springs, leaf springs and flywheels for mechanical components	TPS3	70	65
CO6	Design of piston, connecting rod and crank shaft for an automobile engine.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	L	-	-	-	S	-	M
CO2	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO3	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO4	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO5	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO6	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1			Theory Assessment-2			Design Project	Theory Terminal Examination		
TPS / COs	1	2	3	1	2	3	3	1	2	3
CO1	-	6	20	-	-	-	100	-	10	10
CO2	-	8	30	-	-	-		-	-	15
CO3	-	6	30	-	-	-		-	-	15
CO4	-	-	-	-	3	30		-	-	15
CO5	-	-	-	-	4	30		-	-	15
CO6	-	-	-	-	3	30		-	-	20
							Total	**-**	**10**	**90**

Design Project: The students will do a Design project in which the students should identify the real-life application of the machine element and gather the input information for loads, materials etc., from the identified real-life application. The student has to follow the procedure for designing that machine element and compare it with that of the actual value. A final technical report has to be submitted.

Syllabus

Machine Design Concepts: Introduction to Machine Design – General Considerations in Machine elements Design – Machine Design Process/Procedure. Engineering Materials & its properties – Selection of Materials – Standardization – Preferred Numbers. Determination of Loads, Types of Stresses, Strain & Deflection in simple machine parts – Factor of safety. Design for Static Load – Theories of Failure. Design for Fluctuating loads – Fatigue failure theories – Goodman equation – Soderberg equation.

Shafts and Couplings: Design of Shafts — combined twisting moment and bending moment - combined twisting moment, bending moment and axial loads. Design of Keys. Design of Couplings – Rigid and Flexible Couplings.

Design of Joints: Design of Welded joints — Lap and Butt joints — Welded joints subjected to transverse and eccentric loads. Riveted Joints — Design of different types of riveted joints — Pressure vessels — Structural Joints — Riveted joints subjected to eccentric loads. Design of Threaded Joints – Bolted Joints in simple Tension and Shear – Eccentrically Loaded Bolted Joints.

Energy Storing Elements: Design of Helical Coil Springs — Tension and Compression springs subjected to axial loads and eccentric loads. Design of parallel and concentric springs subjected toaxial loads - Design of Leaf Springs. Design of Flywheels for IC engines and Punching presses.

IC Engine Components: Design of Piston, Connecting Rod & Crank shafts — Sideand Centre Crank.

Textbooks

1. V.B. Bhandari, **"Design of Machine Elements"**, Fourth Edition, McGraw Hill Education IndiaPvt. Ltd., 2017.
2. Richard G Budynas and J Keith Nisbett **"Shigley's Mechanical Engineering Design"**, Tenth Edition, Tata McGraw Hill, 2015.

Reference Books

1. Robert L. Norton, **"Machine Design: An Integrated Approach"**, Fifth Edition, Pearson,2018.
2. Alfred Hall, Alfred Holowenko, Herman Laughlin and S Somani, **"Schaum's Outline -Machine Design"**, McGraw Hill Education India Pvt. Ltd., 2017
3. Robert C. Juvinall and Kurt M. Marshek, **"Machine Component Design"**, Wiley India Edition,2016.
4. Ansel C. Ugural, **"Mechanical Design of Machine Components"**, Second Edition, CRCPress, 2015
5. Anup Goel, "**Design of Machine Elements",** First Edition, Technical Publications, 2016.
6. PSG College, **"Design Data: Data Book of Engineers"**, Kalaikathir Achchagam, 2019

7. Joseph E Shigley and Charles R Mischke, **“Standard Handbook of Machine Design”,** Third Edition, McGraw Hill Pvt. Ltd., 2004
8. K. Lingaiah, **“Machine Design Data Handbook”**, Second Edition, McGraw Hill Pvt. Ltd., 2010.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Machine Design Concepts**	
1.1	Introduction to Machine Design	1
1.2	General Considerations in Machine Elements Design	
1.3	Machine Design Process/Procedure	
1.4	Engineering Materials & its Properties	1
1.5	Selection of Materials	
1.2	Standardization	
1.6	Preferred Numbers	
1.7	Determination of Loads, Types of Stresses, Strain & Deflection in Simple Machine Parts	1
1.8	Factor of Safety	
1.9	Design for Static Loads	1
1.10	Theories of Failure	
1.11	Design for Variable or Fluctuating Loads	1
1.12	Fatigue Failure Theories – Goodman & Soderberg Equation	2
2	**Shafts and Couplings**	
2.1	Design of Shafts subjected to combined twisting & bending	1
2.2	Design of Shafts subjected to combined twisting, bending & axialloads	2
2.3	Design of Keys	1
2.4	Design of Couplings – Rigid Couplings	2
2.5	Design of Couplings – Flexible Couplings	1
3	**Design of Welded Joints**	
3.1	Design of Welded Joints – Lap and Butt Joints	2
3.2	Welded Joints subjected to axial loads, Bending and torsion	2
3.3	Eccentrically Loaded welded Joints	2
4	**Design of Riveted Joints and Threaded Joints**	
4.1	Design of Riveted Joints and its Types	1
4.2	Design of Riveted Joints for Pressure Vessels & Structural Joints	2
4.3	Design of Threaded Joints in Tension & Shear	1
4.4	Bolted Joints subjected to Eccentrical Loading	1
5	**Energy Storing Elements**	
5.1	Design of Helical Coil Springs – Axial Loads & Eccentric Loads	2
5.2	Springs in Parallel and Concentric or Composite Springs	1
5.3	Design of Leaf Springs	1
5.4	Design of Flywheels	2
6	**Automobile Components**	
6.1	Design of Connecting Rod	2
6.2	Design of Crankshafts	4
6.3	Design of Piston	2
	Total	36

Course Designer:

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2. Mr.M.Sermaraj — Assistant Professor — Mechanical Engineering — msjmech@tce.edu

22ME430	MACHINING PROCESSES

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Machining is a process in which a material is cut to a desired final shape and size by a controlled material-removal process. The processes that have this common theme are collectively called subtractive manufacturing, which utilizes machine tools. This course aims to provide knowledge on the working, advantages, limitations andapplications of various machining processes.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the fundamentals of metal removal process	TPS2	70	70
CO2	Determine the cutting forces and temperature for orthogonal metal cutting process	TPS3	70	65
CO3	Determine the machinability rating and tool life of cutting tools	TPS3	70	65
CO4	Determine the cutting parameters for turning, drilling, boring, shaping, milling, grinding and broaching operations	TPS3	70	65
CO5	Determine the cutting parameters for USM, ECM, EDM, LBM process	TPS3	70	65
CO6	Prepare a process plan for the given part drawing	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20		10	10	-	-	-	-	-	-	-	4	6	-
CO2	-	-	40		10	30	-	-	-	-	-	-	2	6	10
CO3	-	-	40		10	30	-	-	-	-	-	-	2	6	10
CO4	-	-	-	-	-	-	-	-	30	5	10	20	2	6	10
CO5	-	-	-	-	-	-	-	-	30	5	10	20	2	6	10
CO6	-	-	-	-	-	-	-	-	40	-	10	20	2	6	10
												Total	**14**	**36**	**50**

Syllabus

Fundamentals of Metal Removal Process

Purpose, principle and requirements of machining process. Definition, classification, principle of machine tool operations, configuration and specifications of machine tool. Geometry of single point cutting tools. Mechanism of chip formation. Types of chips and formation chips. Orthogonal and oblique cutting, causes & amount of chip flow deviation, effects of oblique cutting. Use of chip breaker in machining.

Cutting forces and temperature in the orthogonal cutting operation

Components of cutting force, significance Merchant's Circle diagram, development of equation for the estimation of cutting forces. Cutting temperature - causes, effects, assessment and control. Sources and types forces developed during machining. Effects of various forces on machine tool, and analysis of forces acting on machine tool. Sources and causes of heat generation in machining, effects of high cutting temperature on tool and workpiece, determination and control of cutting temperature, types of cutting fluid and its application.

Machinability rating and tool life

Machinability - Concept, definition, factors influencing machinability rating, failure of cutting tools and tool life, mechanism & geometry of cutting tool wear and properties for cutting tool materials. Chronological development of cutting tool materials, characteristics and applications of cutting tool materials. Taylor's tool life equation and Modified Taylor's tool life equation of cutting tool.

Cutting parameters of conventional machining tools

Lathe: Centre lathe, Capstan & Turret Lathe, single spindle, multi spindle automats, specifications, description. Nomenclature of single point cutting tool, operations performed on lathe, lathe accessories & attachments, Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time.

Radial Drilling machine: Specification, description, nomenclature of drill, operations performed, Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time.

Horizontal Boring machine: Specification, description, nomenclature of boring tool, operations performed, Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time.

Milling Machine: Working principle of column & knee type milling machine, specification, attachments, milling cutters, nomenclature of plain milling cutter and operations performed, Work & tool holding methods/devices, process parameters - cutting speed, feed, DOC & machining time.

Shaper: Types, specifications, quick return mechanism, p rocess parameters - cutting speed, feed, DOC and machining time.

Broaching Machine: Types, specifications, types of broaches, operations and advantages.

Grinding Machines: Classification, working principle of grinding machines. Grinding wheel - Selection, mounting, glazing & loading, dressing and balancing. Work & tool holding methods/devices. Process parameters - cutting speed, feed, DOC & machining time.

Finishing processes: Lapping, Honing, Super finishing, Polishing and Buffing.

Principle operation & Cutting parameters of non-conventional machining

Principle operation and material removal rate for Ultra Sonic Machining (USM), Electro Chemical Machining (ECM), Electric Discharge Machining (EDM) and Laser Beam Machining (LBM) process.

Process Plan: Significance of process plan, general format and preparation of process plan for the given part drawing.

Textbook (s)

1. S. K. Hajra Choudhury, Nirjhar Roy, A. K. Hajra Choudhury, "Elements of Work shop Technology, Vol – II Machine Tools", Fifteenth Edition Media Promoters and Publishers Pvt. Ltd, 2010.

Reference Books & Web Resources

1. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Seventh Edition, PHI, 2018.
2. Mikell P.Groover, "Fundamental of Modern Manufacturing", Third Edition, Wiley India Edition Reprint, 2012.
3. https://archive.nptel.ac.in/courses/112/105/112105127/ (NPTEL Courses - IIT Kharagpur)

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Fundamentals of Metal Removal Process**	
1.1	Purpose, principle and requirements of machining process. Definition, classification, principle of machine tool operations, configuration and specifications of machine tool	1
1.2	Geometry of single point cutting tools. Mechanism of chip formation. Types of chips and formation chips	1
1.3	Orthogonal and oblique cutting, causes & amount of chip flow deviation, effects of oblique cutting, Use of chip breaker in machining	1
2.	**Cutting forces and temperature in the orthogonal cutting operation**	
2.1	Components of cutting force, significance Merchant's Circle diagram, development of equation for the estimation of cutting forces	2
2.2	Cutting temperature - causes, effects, assessment and control. Sources and types forces developed during machining	1
2.3	Effects of various forces on machine tool, and analysis of forces acting on machine tool	1
2.4	Sources and causes of heat generation in machining, effects of high cutting temperature on tool and workpiece, determination and control of cutting temperature, types of cutting fluid and its application	1
3.	**Machinability rating and tool life**	
3.1	Machinability - Concept, definition, factors influencing machinability rating, failure of cutting tools and tool life, mechanism & geometry of cutting tool wear and properties for cutting tool materials	1
3.2	Chronological development of cutting tool materials, characteristics and applications of cutting tool materials	1
3.3	Taylor's tool life equation and Modified Taylor's tool life equation of cutting tools	1
4.	**Cutting parameters of conventional machining tools**	
4.1	**Lathe**: Centre lathe, Capstan & Turret Lathe, single spindle, multi spindle automats, specifications, description.	2
	Nomenclature of single point cutting tool, operations performed on lathe, lathe accessories & attachments	2
	Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time	1
4.2	**Radial Drilling machine**: Specification, description, nomenclature of drill, operations performed	1
	Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time.	1
4.3	**Horizontal Boring machine**: Specification, description, nomenclature of boring tool, operations performed	1
	Work & tool holding methods/devices, Process parameters - cutting speed, feed, DOC & machining time	1
4.4	**Milling Machine**: Working principle of column & knee type milling machine, specification, attachments, milling cutters, nomenclature of plain milling cutter and operations performed	2
	Work & tool holding methods/devices, process parameters - cutting speed, feed, DOC & machining time	1
4.5	**Shaper:** Types, specifications, quick return mechanism, process parameters - cutting speed, feed, DOC and machining time	2
4.6	**Broaching Machine:** Types, specifications, types of broaches, operations and advantages	1
4.7	**Grinding Machines**: Classification, working principle of grinding machines	1
	Grinding wheel - Selection, mounting, glazing & loading, dressing and balancing	1
	Work & tool holding methods/devices. Process parameters - cutting speed, feed,	1

No.	Topic	No. of Periods
	DOC & machining time	
5.	**Finishing processes**	
5.1	Lapping, Honing, Super finishing, Polishing and Buffing	1
6.	**Principle operation & Cutting parameters of non-conventional machining**	
6.1	Principle operation of Ultra-Sonic Machining (USM), Electro Chemical Machining (ECM), Electric Discharge Machining (EDM) and Laser Beam Machining (LBM) process	2
6.2	Cutting parameters for Ultra-Sonic Machining (USM), Electro Chemical Machining (ECM), Electric Discharge Machining (EDM) and Laser Beam Machining (LBM) process	2
7.	**Process Plan**	
7.1	Significance of process plan, general format	1
7.2	Preparation of process plan for the given part drawing	1
	Total	**36**

Course Designers

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22ME440	FLUID MECHANICS

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Fluid mechanics is defined as the science that deals with the behavior of fluids at rest (fluid statics) or in motion (fluid dynamics) and the interaction of fluids with solids or other fluids at the boundaries. Fluid mechanics itself is also divided in to several categories. The study of the motion of fluids that are practically incompressible (such as liquids, especially water and gases at low speeds) is usually referred to as hydrodynamics. Gas dynamics deals with the flow of fluids that undergo significant density changes such as the flow of gases through the nozzle at high speeds. The occurrence of normal shocks and constant area flow with friction (Fanno flow) and constant area flow with heat transfer (Rayleigh flow) are the branches of gas dynamics used to acquire knowledge in compressible flow.

Prerequisite

Nil

Course Outcomes

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

CO #	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the effect of fluid properties on a flow system and concept of fluid statics.	TPS3	70	65
CO2	Apply the kinematic concepts and dynamic concepts which relates to the conservation principles of mass and energy.	TPS3	70	65
CO3	Determine the major and minor losses associated with pipes.	TPS3	70	65
CO4	Compute the compressible flow properties and its application.	TPS3	70	65
CO5	Determine the property variation in variable area duct.	TPS3	70	65
CO6	Determine the property variation across the normal shock in isentropic flow	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO2	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO3	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO4	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO5	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO6	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	5	10	25	-	-	-	-	-	-	6	5	10
CO2	-	-	30	5	10	15	-	-	-	-	-	-	2	5	10
CO3	-	-	30	5	10	15	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	-	-	40	5	10	25	4	5	10
CO5	-	-	-	-	-	-	-	-	30	10	-	20	2	-	10
CO6	-	-	-	-	-	-	-	-	30	10	-	20	2	-	10
												Total	**20**	**20**	**60**

Syllabus

Basic Concepts: Concept of fluid: Liquid and gases, Ideal and real fluids, Newtonian and non-Newtonian fluid - Thermodynamic properties of Fluids: Pressure, Density, Specific Gravity, Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus.
Fluid Statics: Pressure at a Point: Pascal's Law - Pressure force on a fluid element: Hydrostatic law and aerostatic law – Manometry.
Fluid Kinematics: Velocity and Acceleration of a fluid particle-Stream line, stream tubes and path line-Continuity Equation in Cartesian Co-ordinates – Vorticity and irrotationality- Velocity Potential and Stream Function.
Fluid Dynamics: Different types of fluid forces- non-dimensional number: Reynolds number, Froude number, Euler number, Weber number and Mach number- Euler's Equation for Motion - Bernoulli's Equation - Applications of Bernoulli's Equation, Venturimeter and Orifice meter - Navier Stokes Equation – Boundary layer separation.
Pipe Flow: Laminar and turbulent flow - Reynolds Experiment - Significance of Reynolds Number - Laminar Flow in Pipes: Hagen Poiseuille's flow, Turbulent Flow in Pipes: Darcy-Weisbach equation, losses due sudden enlargement and contraction.
Gas Dynamics: Definition - Basic laws and Governing equations - Stagnation state and properties - Velocity of sound - Mach number –Various regimes of flow- Critical Mach number - Crocco number-Applications gas flow dynamics: Rayleigh and Fanno flow.
Isentropic Flow with variable area: Nozzle and Diffuser -relation between area and mach number-
Normal Shock – Governing equations, property ratio in terms of Mach number across the shock-Prandtl- Mayer relation, Impossibility of rarefaction shock.

Textbook (s)

1. Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Rothmayer, "**Fluid Mechanics**", Seventh Edition, Wiley India Pvt. Ltd, 2013.
2. S.M. Yahya, "**Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion**", Sixth Edition, New Age International (P) Ltd, 2018.

Reference Books

1. S. K. Som, G. Biswas, Suman Chakraborty, "**Introduction to Fluid Mechanics and Fluid Machines**", Third Edition, Tata McGraw - Hill Publishing Company Limited - New Delhi, 2017.
2. Yunus A. Cengel, John M. Cimbala, **"Fluid Mechanics: Fundamental and Applications"**, Third Edition, McGraw-Hill Education (India) Pvt. Ltd, 2014.
3. Frank White, "**Fluid Mechanics**", Eighth Edition, McGraw Hill Education (India) Pvt. Ltd, 2017.
4. R.K. Bansal, "**A Text Book of Fluid Mechanics and Hydraulic Machines**", Tenth Edition, Laxmi Publications (P) Ltd., 2018.
5. R.K. Rajput, "**Fluid Mechanics and Hydraulic Machines**", S.Chand & Company Ltd, 2016.

Data Book

1. S.M. Yahya, "**Gas tables for Compressible Flow Calculations**", Eighth Edition, New Age International (P) Ltd, 2018.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Basic Concepts**	
1.1	Concept of fluid: Liquid and gases, Ideal and real fluids, Newtonian and non-Newtonian fluid.	1
1.2	Properties of Fluids, Pressure, Density, Specific Gravity, Viscosity, Surface Tension and Capillarity, Compressibility and Bulk Modulus	1
	Tutorials	2
	Fluid Statics	
1.3	Pressure at a Point: Pascal's Law - Pressure force on a fluid element: Hydrostatic law and aerostatic law	1
1.4	Manometry	1
	Tutorials	2
2.	**Fluid Kinematics**	
2.1	Velocity and Acceleration of a fluid particle	1
2.2	Stream line, stream tubes and path line, Continuity Equation in Cartesian Co-ordinates	1
2.3	Vorticity and irrotationality	1
2.4	Velocity Potential and Stream Function	1
	Tutorials	2
	Fluid Dynamics	
2.5	Different types of fluid forces- non-dimensional number, Reynolds number, Froude number, Euler number, Weber number and Mach number - Euler's equation of motion, Bernoulli's equation	1
2.6	Applications of Bernoulli's Equation, Venturi meter and Orifice meter -Navier Stokes Equation, Boundary Layer separation	1
	Tutorials	2
3.	**Pipe Flow**	
3.1	Laminar and turbulent flow, Reynolds Experiment and Significance of Reynolds Number	1
3.2	Laminar Flow in Pipes: Hagen Poiseuille's flow,	2
3.3	Turbulent Flow in Pipes: Darcy-Weisbach equation	1
3.4	Losses due sudden enlargement and contraction.	1
	Tutorials	2
4.	**Gas Dynamics**	
4.1	Definition - Basic laws and Governing equations	1
4.2	Stagnation state and properties - Velocity of sound	1
4.3	Mach number –Various Regimes of flow- Critical Mach number – Crocco number	1
4.4	Applications gas flow dynamics: Rayleigh and Fanno flow.	1
	Tutorials	2
5	**Isentropic Flow with variable area**	
5.1	Nozzle and Diffuser -Relation between area and Mach number	2
5.2	Nozzle Off-design performance	1
	Tutorials	2
6	**Normal Shock**	
6.1	Governing equations, property ratio in terms of Mach number across the shock.	1
6.2	Prandtl- Mayer relation, Impossibility of rarefaction shock.	1
	Total	36

Course Designers:

1.	Dr.K.Srithar	Professor	Mechanical Engineering	ksrithar@tce.edu
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22ME450	MANUFACTURING AUTOMATION

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

This course provides knowledge of different manufacturing systems such as group technology, Flexible Manufacturing system, and programming methods practiced in industries. It also highlights the fundamentals and balancing of the assembly line, the methodologies related to Plant layout, automated material handling system, and inspection system along with its system of controls.

Prerequisite

- Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the components and types of the production system and automation.	TPS2	70	70
CO2	Identify the part family and arrange the machines in group technology cells.	TPS3	70	65
CO3	Construct the CNC part program for the given drawing and ladder logic diagram for the given manufacturing process	TPS3	70	65
CO4	Balance of assembly line using appropriate line balancing algorithms	TPS3	70	65
CO5	Design the layouts of manufacturing systems and service organizations	TPS3	70	65
CO6	Select suitable Material Handling, Storage, Identification, and Inspection Systems for the given scenario.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	L	-	-	-	-	-	-	-	-	-	-	M	-	M
CO2	S	M	L	-	M	-	-	-	-	-	M	-	S	-	S
CO3	S	M	L	-	S	-	-	-	-	-	-	-	S	-	S
CO4	S	M	L	-	M	-	-	-	-	-	S	-	S	-	S
CO5	S	M	L	-	-	-	-	-	-	-	S	-	S	-	S
CO6	S	M	L	-	-	-	-	-	-	-	S	-	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	10	10	-	-	-	-	-	-	-	4	5	-
CO2	-	-	40	5	20	20	-	-	-	-	-	-	4	5	10
CO3	-	-	40	5	10	20	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	-	-	35	-	15	25	2	-	15
CO5	-	-	-	-	-	-	-	-	35	-	15	25	2	-	15
CO6	-	-	-	-	-	-	-	-	30	-	10	10	4	5	10
												Total	**20**	**20**	**60**

Syllabus

Introduction of Production system and automation

Production Systems: Introduction, Components, and Categories. **Automation in Production Systems:** Opportunities, Reasons, and roles of labor in Factory automation. **Manufacturing Operations:** Activities, Limitations, and Capabilities of a Manufacturing Plant. **Manufacturing Support System:** Activities.

Manufacturing system, Group technology and FMS

Manufacturing system: Classification, Single-Station Manufacturing Manned, and Automated Cells, Applications. **Group technology**: Part classification, coding, and production flow analysis. **Flexible Manufacturing System (FMS)**: Types, Functions, FMS layout, computer control, and planning of FMS.

CNC, Robotics, and Programmable Logic Controllers

Computer Numerical Control: Fundamentals, Applications, CNC G code, M code, Part programming for CNC turning such as step, tapper turning, curvature, and threading operation. Part programming for CNC milling such as profile milling, circular, rectangular pocketing, and drilling operation. **Industrial Robotics**: Introduction, Robot Anatomy, and Related Attributes, Robot Control Systems, End Effectors, Applications of Industrial Robots. **Programmable Logic Controllers**: Architecture, Basic operations such as input, output, Special instruction, internal relay, timers and counters, Ladder symbols, Ladder diagram for logic function, and cylinder sequence.

Assembly Line and Line balancing algorithms

Assembly Line: Fundamentals, Analysis of Single-Model Assembly Lines. **Line balancing algorithms**: Objective, Types such as Largest Candidate Rule, Kilbridge and Wester, Ranked Positional Weights Method.

Facility Planning

Plant layout: Introduction, Principles, Objectives, Influential factors

Layout design Procedures: Manual Methods such as Systematic Layout planning (SLP) and Computerized Method such as Automated Layout Design Program (ALDEP), Computerized Relationship Layout Planning (CORELAP), Computerized Relative Allocation of Facilities Technique (CRAFT)

Material Transport, Storage, Identification, and Inspection Systems:

Material handling: Introduction, Classification, Design Considerations. **Material Transport Equipment**: Industrial trucks, Automated guided vehicles, Rail-guided vehicles, Conveyors, Cranes, and hoists. **Material Storage Systems**: Introduction, Application Characteristics of the types of Storage Equipment and Methods, Automated Storage Systems such as ASRS and Carousel storage system. **Automatic Identification**: Types, Bar code technique, RF identification system, Magnetic stripes, and Optical character recognition. **Automatic Inspection system:** Contact Vs Non-Contact Inspection techniques, coordinate measuring machine, and machine vision.

Text Books

1. Mikell P. Groover, “**Automation, Production systems and Computer Integrated Manufacturing**” PHI Learning Pvt. Ltd., 3rd Edition, 2009.
2. P.M. Agarwal and V.J. Patel, "**CNC Fundamentals and Programming**", Charotar Publishing House Pvt. Ltd., Second Edition, 2014.
3. Tompkins, J.A. and White J.A., “**Facilities planning**”, Fourth Edition, John Wiley, 2010.

Reference Books

1. Vajpayee S. Kant, “**Principles of Computer Integrated Manufacturing**”, Prentice Hall of India Learning, 2009.
2. Hindustan Machine Tool Ltd., “**Mechatronics**”, Tata McGraw Hill, 2000.
3. Jerry Banks and Barry L. Nelson, “**Discrete Event System Stimulation**”, Pearson Education, Fifth edition 2006.
4. H.K.Shivanand and M.M. Bengal, “**Flexible Manufacturing System**”, New Age International Pvt Ltd Publishers, 2006.
5. Richard Francis.L. and John A. White, “Facilities Layout and location - an analytical approach”, Prentice Hall of India, 2012.
6. James Apple, M, ”Plant layout and “Material Handling”, John Wiley, 1991. (No Reprint)
7. Pannerselvam, R, “Production and Operations Management”, Third Edition, Prentice Hall of India,2012.
8. Krajewski, J. and Ritzman, “Operations Management – Strategy and Analysis”, Addison – Wesley publishing company, 5th Edition, 1999
9. https://nptel.ac.in/courses/112/104/112104288/
10. https://nptel.ac.in/courses/112102011/
11. htps://nptel.ac.in/courses/112102106

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction of Production system and automation**	
1.1	**Production Systems**: Introduction, Components, and Categories.	1
1.2	**Automation in Production Systems:** Opportunities, Reasons, and roles of labor in Factory automation.	1
1.3	**Manufacturing Operations:** Activities, Limitations, and Capabilities of a Manufacturing Plant.	1
1.4	**Manufacturing Support System:** Activities.	1
2	**Manufacturing system, Group technology, and FMS**	
2.1	**Manufacturing system**: Classification, Single-Station Manufacturing Manned, and Automated Cells, Applications.	2
2.2	**Group technology**: Part classification, coding, and production flow analysis.	2
2.3	**Flexible Manufacturing System (FMS)**: Types, Functions, FMS layout, computer control, and planning of FMS	1
3	**CNC, Robotics, and Programmable Logic Controllers**	
3.1	**Computer Numerical Control**: Fundamentals, Applications, CNC G code, M code	1
3.2	Part programming for CNC turning such as step, tapper turning, curvature, and threading operation.	2
3.3	Part programming for CNC milling such as profile milling, circular, rectangular pocketing, and drilling operation.	2
3.4	**Industrial Robotics**: Introduction, Robot Anatomy, and Related Attributes, Robot Control Systems, End Effectors, Applications of Industrial Robots.	2
3.5	**Programmable Logic Controllers**: Architecture, Basic operations such as input, output, Special instruction, internal relay, timers and counters, Ladder symbols, Ladder diagram for logic function, and cylinder sequence	2
4	**Assembly Line and Line balancing algorithms**	
4.1	**Assembly Line**: Fundamentals, Analysis of Single-Model Assembly Lines.	2

No.	Topic	No. of Periods
4.2	**Line balancing algorithms**: Objective, Types such as Largest Candidate Rule, Kilbridge and Wester, Ranked Positional Weights Method.	3
5	**Facility Planning**	
5.1	**Plant layout:** Introduction, Principles, Objectives, Influential factors **Layout design Procedures**: Manual Methods such as Systematic Layout planning (SLP)	2
5.2	**Layout design Procedures**: Computerized Methods such as Automated Layout Design Program (ALDEP), Computerized Relationship Layout Planning (CORELAP), Computerized Relative Allocation of Facilities Technique (CRAFT)	3
6	**Material Transport, Storage, Identification, and Inspection Systems**	
6.1	**Material handling**: Introduction, Classification, Design Considerations.	1
6.2	**Material Transport Equipment**: Industrial trucks, Automated guided vehicles, Rail-guided vehicles, Conveyors, Cranes, and hoists.	2
6.3	**Material Storage Systems**: Introduction, Application Characteristics of the types of Storage Equipment and Methods, Automated Storage Systems such as ASRS and Carousel storage system.	2
6.4	**Automatic Identification**: Types, Bar code technique, RF identification system, Magnetic stripes, and Optical character recognition.	1
6.5	**Automatic Inspection system:** Contact Vs Non-Contact Inspection techniques, coordinate measuring machine, and machine vision	2
	Total	**36**

Course Designers:

1	Dr. R. Sivasankaran	Assistant Professor	Mechanical Engineering	rssmech@tce.edu
2	Mr. T. Prakash	Assistant Professor	Mechanical Engineering	tpmech@tce.edu

22ME470	STRENGTH OF MATERIALS AND MATERIAL SCIENCE LAB

Category	L	T	P	C	Terminal Exam Type
ESC	-	-	2	1	Practical

Preamble

Students of Mechanical engineering would get exposure in the properties of engineering materials and molding sand and also able to identify the microstructure of the given material.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the Young's modulus and rigidity modulus of Engineering materials.	TPS3	70	65
CO2	Determine the mechanical properties of materials	TPS3	70	65
CO3	Identify the microstructure of the given ferrous material.	TPS3	70	65
CO4	Determine physical properties of the moulding sand	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	L	L	-	-	-	-	-	-	-	-	M	-	-
CO2	M	L	L	L	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	S	L	-	-	-	-	-	-	-	-	M	-	M
CO4	S	M	S	L	-	-	-	-	-	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

1. Students are examined for 50 marks in strength of materials lab and 50 marks in composite materials lab for terminal examination.
2. Duration:3 Hours (1 Hour 30 minutes for strength of materials lab and 1 Hour 30 minutes for Material Science lab)

Syllabus

Part A: Strength of Materials Lab. (Any six experiments are to be conducted)

1. Determination of the Young's Modulus of Steel by conducting tension test in UTM.
2. Determination of the Young's Modulus of the beam (Steel, Wood, Aluminum etc.) by conducting the bending test.
3. Determination of the Young's Modulus of the beam (Steel, Wood, Aluminum etc.) by conducting the bending test using Huggen Berger Tensometer.
4. Determination of the rigidity modulus of the material by conducting torsion test.
5. Determination of the rigidity modulus of the compression and tension spring by conducting spring test.
6. Determination of the Young's Modulus of the beam (Steel, wood, Aluminum etc.) by conducting the deflection test in UTM

7. Determination of Brinell hardness and Rockwell hardness for Steel, Copper, Aluminum and Brass

Part B: Material Science Lab (Any six experiments are to be conducted)

1. Preparation of composite laminate by Hand layup technique.
2. Determination of tensile properties of a composite material by conducting tensile test
3. Determination of flexural properties of a composite material using three point bending test.
4. Determination of shear strength of a composite material by conducing shear test.
5. Determination of Impact properties of a composite material by conducting the Impact test.
6. Determination of fatigue properties of a steel using fatigue testing machine.
7. Identification of the microstructure of the given steel and iron specimens
8. Sieve analysis of the moulding sand
9. Determination of strength of the moulding sand
10. Determination of the hardenability of steel by conducting Jominy end quench test.
11. Determination of hardness of the steel under different heat treatment techniques.

Course Designers:

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2.	Dr. M .Elango	Associate Professor	Mechanical Engineering	memech@tce.edu

22ME480	MACHINING PRACTICES LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

To impart knowledge and skill in the field of machine tools used in the industries. To increase the level of confidence of students by working individually in various machine tools. This would supplement the understanding of the theory course on Machining Processes.

Prerequisite

- Production Drawing

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Prepare the process plan for the given part drawing	TPS3	70	65
CO2	Perform various operations like facing, turning, taper turning, threading etc. using Conventional/CNC Lathe.	TPS3	70	65
CO3	Conduct various operations like face milling, plain milling, key way milling, form milling etc. in Universal/Vertical Milling machine.	TPS3	70	65
CO4	Produce hole and tapping operation in Radial/Pillar drilling machine.	TPS3	70	65
CO5	Make horizontal, vertical, angular surfaces using shaping machine.	TPS3	70	65
CO6	Assemble the various parts already produced for completing the final assembly using appropriate tools.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-
CO2	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-
CO3	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-
CO4	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-
CO5	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-
CO6	S	-	-	-	-	-	-	-	S	M	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Internal assessment for 100 marks calculated based on Observation, Record & Test using details shown in following table and it will be **converted into 60 marks:**

CO#	Observation	Record	Total for Observation & Record	Test
CO1	15	5	75	25
CO2	10			
CO3	10			
CO4	10	5		
CO5	10			
CO6	10			

- **Terminal practical examination will be conducted for 100 Marks** as per the COE norms, to evaluate any 2 machine tool trades like turning, milling, drilling, grinding, shaping etc. with 1½ hours duration each & it will be **converted in to 40 Marks.**
- If he/she got less than 50 marks in terminal examination, he/she has to undergo this examination as arrear during subsequent supplementary examination schedule.

Syllabus

The following sample parts/assemblies and the possible machine tools shall be used for machining the parts are given in the following table for reference purpose:

S.No.	Assembly	Machine tools shall be used
1.	Single Way Tool Post	Lathe, Vertical Milling, Horizontal milling, Shaping, Tapping and Drilling machine tools
2.	Machine vice	Lathe, Vertical Milling, Horizontal milling, Shaping, Tapping and Drilling machine tools
3.	Universal Joint	Lathe, Vertical Milling, Shaping, Tapping and Drilling machine tools
4.	Tail Stock Spindle Binding Lever	Lathe and horizontal injection molding machine
5.	Quick Change Tool Post	Lathe, Milling ad Drilling machine
6.	Catch Plate	Lathe, Milling and Surface Grinding machine
7.	Face Plate	Lathe, Milling and Surface Grinding machine
8.	Drilling vice	Lathe, Milling and Drilling machine
9.	Four Way Tool Post	Lathe, Milling, shaping Tapping and Drilling machine
10.	Flange Coupling	Lathe, Milling and Drilling machine

List of Experiments

No.	Experiment	CO
1.	Preparation of Process Plan for the given part drawing	CO1
2.	Conducting facing, step & taper turning using Conventional/CNC Lathe.	CO2
3.	Conducting facing, step turning, undercut and Thread operations using Conventional/CNC Lathe.	CO2
4.	Conducting face plain & form milling using Universal/Vertical Milling machine.	CO3
5.	Conducting slot & key way milling in Universal/Vertical Milling machine.	CO3
6.	Perform simple and step hole using radial/Pillar drilling machine.	CO4
7.	Perform hole & tapping operation in Radial/Pillar drilling machine.	CO4
8.	Making of horizontal & vertical surfaces using shaping machine.	CO5
9.	Making of angular & dovetail surfaces using shaping machine.	CO5
10.	Assembly of different parts produced to complete the final assembly	CO6

Learning Resources

1. Manufacturing Practices Lab Manual, Department of Mechanical Engineering, TCE (2022)
2. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Seventh Edition, PHI, 2018.
3. S. K. Hajra Choudhury, Nirjhar Roy, A. K. Hajra Choudhury, "Elements of Work shop Technology, Vol – II Machine Tools", Fifteenth Edition Media Promoters and Publishers Pvt. Ltd, 2010.

Course Designers

1.	Dr.C. Paramasivam	Professor	Mechanical Engineering	cpmech@tce.edu
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22ME490	PROJECT MANAGEMENT

Category	L	T	P	C	Terminal Exam Type
HSSMC	2	1	-	3	Theory

Preamble

Project Management (PM) is increasingly important in today's world. This course covers the fundamental concepts and applied techniques for cost effective management of both long-term development programs and short-term projects. The content deals with planning, scheduling, organizing, and controlling projects. The course uses cases from a wide variety of industries, including construction, information systems, non-profit organizations, the government and the military. This course gives an exposure to the basic concepts involved in the formulation of a project, project management principles, importance and need for network techniques and its applications to a project.

Prerequisite

- Design Thinking

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Identify the elements of the Project Management life cycle, including: Plan, Control, and Organize and Allocate Resources	TPS2	75	70
CO2	Explain the Project Management processes	TPS2	75	70
CO3	Comprehend basic tools and techniques to plan, organize and manage a project	TPS3	70	65
CO4	Optimize results while managing the triple constraints - using Network diagrams and resource smoothing and levelling techniques	TPS4	70	60
CO5	Carry out an Earned Value Analysis using real world data.	TPS4	70	60
CO6	Perform a Qualitative risk Analysis for a given Project.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	M	-	-	-	S	S	S	S	M	S	-	-	-	M
CO2	-	M	-	-	-	L	L	M	M	L	M	-	-	-	L
CO3	S	M	-	-	S	S	S	S	S	S	S	-	-	-	M
CO4	S	S	-	-	-	S	S	S	S	S	S	-	-	-	S
CO5	S	S	-	-	-	S	S	S	S	S	S	-	-	-	S
CO6	S	M	-	-	-	S	S	S	S	S	S	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination			
	Assignment-1			CAT-1			Assignment-2			CAT-2						
TPS / COs	1	2	3	1	2	3	2	3	4	2	3	4	1	2	3	4
CO1	-	20	-	10	20	-	-	-	-	-	-	-	2	4	-	-
CO2	-	20	-	10	20	-	-	-	-	-	-	-	2	4	-	-
CO3	-	-	60		10	30	-	-	-	-	-	-	2	4	12	-
CO4	-	-	-	-	-	-	-	-	40	10	-	30	2	4	-	20
CO5	-	-	-	-	-	-	-	-	30	10	-	30	2	4	-	20
CO6	-	-	-	-	-	-	-	30	-	-	20	-	2	4	12	-
												Total	**12**	**24**	**24**	**40**

Syllabus

Projects and the Project Manager: Definitions, The project manager's role, Internal and external environment - Project structures. Project and product life cycles - PM processes. **Project environment**: The Project Management Office - Rationale and business case - Mission, goals and Strategy - Portfolio management - financial analysis. **Charter**: PM Plan - Charter - Triple constraints. **Scope:** Project justification - The specification Constraints, limits, assumptions, and technical requirements - Statement of Work (SOW) - Priority Matrix. **Work Breakdown Structure and Cost estimation:** WBS structure - WBS Dictionary - Graphical vs. outline format - Activity/ Task- Events- Case study. Project planning tools- Rolling wave planning. Gantt Charts, Milestone chart, Program Progress chart- Creating milestone plan. Project Network- Fulkerson"s rules – Activity-On-Arrow and Activity- On -Node networks. Cost estimation: Top down and bottom up - Types of estimates and accuracies - Parametric estimates - Budget and contingencies. **Stakeholder engagement and communications:** Identify stakeholders - Manage stakeholder expectations - Communications tools. **The network and the critical path:** Forward and backward passes - Slack and critical path - Assigning resources Milestones - Lags, leads and loops. Resource Smoothing technique- Time constraint. Resource leveling technique- Resource constraint - Schedule Compression Techniques- Crashing, Fast Tracking & Re-estimation- Crash time and crash cost. Optimize project cost for time and resource. **Earned Value Management:** Planned value, earned value and actual cost - Cost and Schedule. Performance Indices - Cost and schedule analyses – Case Study. **Risk analysis**: Positive and negative risks - Risk strategies - Qualitative risk analyses - Program Evaluation and Review Technique - Contingencies and reserves - FMEA and SWOT analysis – Case Study.

Textbook (s)

V E Rama Moorthy and P Gopalakrishnan, "Text Book of Project Management", Laxmi Publications Pvt Ltd, First Edition, 2021.

Reference Books & Web Resources

1. Joshep Heagney, "Fundamentals of Project Management:" Fifth Edition, AMAcom Publications, American Management Association, E book, 2021
2. Punmia B. C. and Khandelwal K.K., "Project Planning and Control with PERT/CPM", Laxmi publications, New Delhi, 1989.
3. "A Guide to the Project Management Body of Knowledge (PMBOK Guide)" - Fifth Edition, An American National Standard, ANSI/PMI 990001-2008.
4. Jerome D. Wiest and Ferdinand K. Levy, "A Management Guide to PERT/CPM", Prentice Hall of India Publishers Ltd., New Delhi, 1994.
5. Srinath L.S., "PERT & CPM- Principles and Applications", Affiliated East West Press Pvt., Ltd., New Delhi, 2008
6. A Risk Management Standard, AIRMIC Publishers, ALARM, IRM: 2002
7. Gene Dixon, "Service Learning and Integrated Collaborative Project Management", Project Management Journal, DOI:10.1002/pmi, February 2011, pp.42-58
8. NPTEL videos at https://nptel.ac.in/courses/112102107/ by Prof. Arun Kanda, Dept of Mechanical Engineering, IIT, Delhi.

9. NPTEL videos at https://nptel.ac.in/courses/105106149/ by Dr. Koshy Varghese, Dept of Civil Engineering, IIT, Madras.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Projects and the Project Manager:**	
1.1	Definitions, The project manager's role, Internal and external environment.	**1**
1.2	Project structures - Project and product life cycles	**2**
1.3	PM processes.	**2**
1.4	Project environment: The Project Management Office - Rationale and business case - Mission, goals and Strategy.	**1**
1.5	Portfolio management - financial analysis.	**1**
1.6	Charter: PM Plan - Charter - Triple constraints.	**1**
1.7	Scope: Project justification - The specification Constraints, limits, assumptions, and technical requirements - Statement of Work (SOW) - Priority Matrix.	**2**
2	**Work Breakdown Structure and Cost Estimation:**	
2.1	WBS structure - WBS Dictionary - Graphical vs. outline format - Activity/ Task- Events - Case study.	**1**
2.2	Project planning tools- Rolling wave planning. Gantt Charts, Milestone chart,	**1**
2.3	Program Progress chart- Creating milestone plan.	**1**
2.4	Project Network- Fulkerson‟s rules – Activity-On-Arrow and Activity- On - Node networks.	**1**
2.5	Cost estimation: Top down and bottom up - Types of estimates and accuracies.	**1**
2.6	Parametric estimates - Budget and contingencies.	**2**
2.7	Stakeholder engagement and communications:	**1**
2.8	Identify stakeholders - Manage stakeholder expectations - Communications tools.	**1**
3.0	**The network and the critical path:**	
3.1	Forward and backward passes - Slack and critical path	**1**
3.2	Assigning resources Milestones - Lags, leads and loops.	**1**
3.3	Resource Smoothing technique- Time constraint. Resource leveling technique.	**2**
3.4	Resource constraint - Schedule Compression Techniques- Crashing, Fast Tracking & Re-estimation	**2**
3.5	Crash time and crash cost. Optimize project cost for time and resource.	**2**
4	**Earned Value Management:**	
4.1	Planned value, earned value and actual cost - Cost and Schedule	**2**
4.2	Performance Indices - Cost and schedule analyses.	**2**
5	**Risk analysis:**	
5.1	Positive and negative risks - Risk strategies - Qualitative risk analyses	**2**
5.2	Program Evaluation and Review Technique	**2**
5.3	Contingencies and reserves	**1**
	Total	**36**

Course Designers

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2. Dr. S. Karthikeyan Professor Mechanical Engineering skarthikeyanlme@tce.edu

22ME520	KINEMATICS AND DYNAMICS OF MACHINERY

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

The movement and interaction of machine components are covered in kinematics and dynamics. The determination of the motion and interaction of machine components, as well as forces operating on machines and mechanisms, will be based on the application of fundamental statics, kinematics, and dynamics ideas. Applications will focus on rotating equipment, cams, gears, flywheels, and balancing devices.

Prerequisite

- Engineering Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the working of different mechanism and their inversions	TPS2	70	70
CO2	Determine the velocity and acceleration of simple mechanisms	TPS3	70	65
CO3	Develop the cam profile for various type of motion.	TPS3	70	65
CO4	Determine the contact ratio of gear pair and speed ratio of gear trains.	TPS3	70	65
CO5	Perform balancing of rotating and reciprocating components.	TPS3	70	65
CO6	Determine the gyroscopic couple on the two-wheeler, four-wheeler, ship and airplane.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	L	L	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	S	L	-	-	-	-	-	-	-	-	M	-	M
CO3	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO4	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO5	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO6	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	*20	10	10		-	-	-	-	-	-	5	5	-
CO2	-	-	*80	10	10	20	-	-	-	-	-	-	-	-	15
CO3	-	-		10	10	20	-	-	30	-	-	-	2	2	15
CO4	-	-	-	-	-	-	-	-	20	10	10	20	2	2	15
CO5	-	-	-	-	-	-	-	-	30	10	10	20	2	2	15
CO6	-	-	-	-	-	-	-	-	20	5	5	10	4	4	10
												Total	**15**	**15**	**70**

*Assignment 1: Making of mechanism prototype and Simulation of mechanism to determine the velocity and acceleration in mechanism.

Syllabus

Mechanisms: Kinematics, Mechanisms and machines **–**Kinematic link, Kinematic pairs, Kinematic chains – Mechanism –Mobility of mechanism. Planar Mechanisms: Simple mechanisms -Four bar, Single slider crank chain and Double slider crank chain mechanism, Steering gear mechanism, Mechanism with lower pairs -Intermittent Motion Mechanisms, compound Mechanisms. Inversions of Four bar, Single slider crank chain and Double slider crank chain mechanism**.**

Velocity and acceleration of simple mechanisms: Instantaneous centre method - Velocity calculation of four bar and Single slider crank chain Mechanisms. Relative velocity method: Vector Position Analysis -Velocity and acceleration of different mechanisms -Coriolis component of acceleration in Quick return motion mechanisms. Analytical Method: Angular velocity and angular acceleration of connecting rod in Single slider crank chain & four bar Mechanisms.

Cams: Types of cams and followers - Cam Nomenclature-Displacement, velocity and acceleration curves for various types of motions of follower -Construction of cam profiles for radial cams with reciprocating followers-Knife edge followers - Roller follower - flat faced follower – spherical faced follower - Uniform Velocity Motion- simple harmonic motion- Cycloidal Motion- Uniform Acceleration and Retardation Motion.

Gears and Gear trains: General profiles of gears- Theory of involute gearing -Contact ratio – Interference and undercutting Gear trains: speed ratio - Simple, Compound, Reverted and Epicyclic gear trains.

Balancing- need of balancing, concept of static and dynamic balancing, Balancing of rotating mass by another mass in the same plane, Forces due to revolving masses. Concept of reference plane, balancing of several rotating masses in same plane and different planes. Balancing of reciprocating masses. Primary and Secondary Unbalanced Forces of Reciprocating Masses- Partial Balancing of Unbalanced Primary Force in a Reciprocating engine - Effect of partial balancing of reciprocating parts of two-cylinder locomotives. Introduction to Linear vibrations

Gyroscope – Introduction –gyroscope couple – applications – airplane, ship, two wheelers, four wheelers.

Textbook (s)

1. John Joseph Uicker, Gordon Pennock, JoselphE.Shigley, "Theory of Machines and Mechanisms", Third Edition, Oxford University Press,2010.

Reference Books &Web Resources

1. Rao and Dukkipati, R.V, **"Mechanism and Machine Theory",** New Age International (P) Ltd.,2010.
2. Rattan.S.S**, "Theory of Machines",** Tata McGraw–Hill Publishing Co., New Delhi,2014.
3. Thomas Bevan, **"Theory of Machines",** CBS – Third Edition,2010.
4. Singh, V.P., **"Theory of Machines",** Dhanpat Rai & Co., (P) Ltd., New Delhi,2011.
5. Sadhu Singh, "**Theory of Machines**". Pearson Education, New Delhi,2009.
6. Ashok G.Ambekar," **Mechanism and Machine theory**",Prentice Hall of India, New Delhi,2011.

7. **Kinematics of Mechanisms and Machines** https://nptel.ac.in/courses/112/105/112105268/ Prof. Anirvan Das Gupta,Indian Institute of Technology, Kharagpur
8. **Kinematics of Machines**https://nptel.ac.in/courses/112/104/112104121/#Prof. A. K. Malik,Indian Institute of Technology, Kanpur
9. **Dynamics of Machines**, https://nptel.ac.in/courses/112/104/112104114/ Prof. Amithbha Ghosh Indian Institute of Technology, Kanpur

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1	**Mechanisms**	
1.1	Kinematic link	1
1.2	Kinematic pairs	
1.3	Kinematic chains – Mechanism	
1.4	Mobility of mechanism	
1.5	Planar Mechanisms	
1.6	Four bar Mechanisms	1
1.7	Single slider crank chain Mechanism	
1.8	Double slider crank chain mechanisms	
1.9	Steering gear mechanism	
1.10	Ackermann's steering gear mechanism	2
1.11	Davis steering gear mechanism	
1.12	Mechanism with lower pairs	1
1.13	Intermittent Motion Mechanisms	
1.14	Inversions of mechanism	1
1.15	Inversions of Single slider crank chain mechanisms	
1.16	Inversions of double slider crank chain mechanisms	
1.17	Inversions of four bar chain mechanisms	
2	**Velocity and acceleration of simple mechanisms**	
2.1	Instantaneous centre method	
2.1.1	Properties of Instantaneous Centre and Arnold-Kennedy's theorem	3
2.1.2	Velocity calculation of four bar mechanisms and Single slider crank chain Mechanisms	
2.2	Relative velocity method	
2.2.1	Vector Position Analysis -Velocity and acceleration of different mechanisms	3
2.2.2	Coriolis component of acceleration in Quick return motion mechanisms.	2
2.2.3	Velocity and acceleration of Single slide crank chain Mechanisms	
2.3	Analytical Method:	
2.3.1	Angular velocity and angular acceleration of connecting rod in Single slider crank chain	2
2.3.2	Angular velocity and angular acceleration of four bar chain	
3	**Cams**	
3.1	Types of cams and followers - Cam nomenclature - Displacement, velocity and acceleration curves for various types of motions.	2
3.2	Construction of cam profiles	3
4	**Gears and Gear trains**	
4.1	General profiles of gears-Terminology of gears and types	1
4.2	Theory involute gearing	2
4.3	Construction of Involute profile and its Characteristics	

S.No	Topic	No. of Lectures
4.4	Gear trains	
4.5	Simple, Compound and Reverted gear trains	1
4.6	Epicyclic gear trains	1
5	**Balancing**	
5.1	Need of balancing, concept of static and dynamic balancing	1
5.2	Balancing of rotating masses	2
5.3	Balancing of reciprocating masses	4
6	**Gyroscope**	
6.1	Gyroscope couple Introduction	1
6.2	Applications – Airplane, ship	1
6.3	Applications- two wheelers, four wheelers	3
	Total number of hours	**38**

Course Designers

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22ME530	METROLOGY AND QUALITY CONTROL

Category	L	T	P	C	Terminal Exam Type
PCC	4	-	-	4	Theory

Preamble

Engineered products have to be accurately measured, so that assurance of quality can be guaranteed. This course deals with the principles and techniques involved in metrology instruments that are widely utilized in industries and R&D organizations. Further in order to make useful inferences from the measured data, this course emphasizes on various statistical quality control tools, control charts, and sampling techniques.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Identify methods and devices for measurement of length, angle, gear parameters, thread parameters, surface roughness and geometric features of parts.	TPS3	70	65
CO2	Design GO-NOGO gauges for the given specification.	TPS3	70	65
CO3	Discuss the significance and working of various types of comparators and advanced metrological machines.	TPS2	70	70
CO4	Explain the basic concepts of quality and its tools.	TPS2	70	70
CO5	Construct control chart from the given variable and attribute data.	TPS3	70	65
CO6	Design and measure the performance of sampling plans.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	L	-	-	-	-	-	M	-	S
CO2	S	M	S	L	-	-	-	-	-	-	-	-	S	-	S
CO3	M	L	L	-	-	-	-	-	-	-	-	-	L	-	M
CO4	M	L	L	-	-	-	-	-	-	-	-	-	-	-	L
CO5	S	M	M	L	S	-	-	L	-	-	L	-	M	-	M
CO6	S	M	S	L	-	-	-	L	-	-	L	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	8	20	20	-	-	-	-	-	-	4	10	10
CO2	-	-	40	4	-	20	-	-	-	-	-	-	2	-	10
CO3	-	20	-	8	20	-	-	-	-	-	-	-	4	10	-
CO4	-	-	-	-	-	-	-	20	-	8	20	-	4	10	-
CO5	-	-	-	-	-	-	-	-	40	4	20	20	2	-	10
CO6	-	-	-	-	-	-	-	-	40	8	-	20	4	10	10
												Total	20	40	40

Syllabus

Fundamentals of Metrology: The process of measurement, significance, generalized measuring system. Data types: continuous data, discrete data. Characteristics of measuring instruments: Static characteristics - Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity. Errors in measurement: Systematic and Random, Uncertainty of Measurement. Standards: National, Reference, Secondary, and Working Standards, interchangeability, Calibration, Traceability, Confidence level.

Linear and Angular Measurements: internal/ external calipers, vernier caliper, vernier height gauge, depth gauge, gear tooth vernier, plunger dials, slip gauges, inside / outside micrometer, sine bar, bevel protractor, sprit level.

Form Measurement: Straightness measurement, flatness measurement – N.P.L flatness interferometer, roundness measurement, measurement of screw thread elements – major diameter, minor diameter, effective diameter, pitch, use of thread gauges, measurement of gear elements – runout, pitch, profile, lead, backlash

Surface Finish Measurement: Concepts, terminology and methods of measuring surface finish, Principle and operation of stylus probe instruments.

Inspection using gauges: types- limit gauges, snap gauge, plain plug gauge, ring gauges, radius gauges, and feeler gauges, design of GO – NOGO gauges.

Comparator - Mechanical comparator, electrical comparator, optical comparators, pneumatic air gauge.

Advanced Metrological Machines: Auto collimator, laser interferometer, Coordinate Measuring Machine (CMM), machine vision for metrology.

Introduction to Quality Control: Definition of quality, basic concept of quality, consequences of lack of quality. Quality control, quality assurance, quality cost, variation in process, causes of variation. Seven QC tools: Histogram, check sheet, cause and effect diagram, pareto chart, scatter diagram, stratification diagram, control chart.

Process Control: Theory of control chart, uses of control chart. Control chart for variables: X bar chart, R chart and sigma chart, pattern study, process capability, process capability studies, Six Sigma concept. Control chart for attributes, control chart for nonconforming: p chart and np chart, control chart for nonconformities: c and u chart.

Introduction about statistical software – (One assignment will be based on statistical software).

Acceptance Sampling: Types of sampling plan, probability of acceptance in single, double, multiple sampling techniques and sequential Sampling plan, Operating Characteristic (OC) curve, producer's risk and consumer's risk– Average Quality Level (AQL), Lot Tolerance Percent Defective (LTPD), Average Total Inspection (ATI), Average Sample Number (ASN), Average Outgoing Quality Limit (AOQL), concepts.

Text Books

1. N.V. Raghavendra and L. Krishnamurthy, "Engineering Metrology and Measurements", Oxford University Press, 2013
2. Amitava Mitra, "Fundamentals of Quality Control and Improvement", Pearson Education Asia, Fifth Edition, 2021.

Reference Books & Web Resources

1. R. K. Jain, "Engineering Metrology", Khanna Publishers, Twenty Second Edition 2022
2. Anand K Bewoor and Vinay A Kulkarni, "Metrology and Measurement", Tata McGraw Hill, 2017.
3. Douglas C. Montgomery, "Introduction to Statistical Quality Control", John Wiley and Sons Inc, Eighth Edition, 2019
4. NPTEL course titled "Metrology" by Dr. K. Sadashivappa, IIT Madras.
   Link: https://nptel.ac.in/courses/112106179/
5. NPTEL course titled "Engineering Metrology" by Prof. J. Ramkumar, IIT Kanpur.
   Link: https://nptel.ac.in/courses/112104250/
6. NPTEL course titled "Quality Design and Control" by Prof. Pradip Kumar Ray, IIT Kharagpur
   Link: https://nptel.ac.in/courses/110105088

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Fundamentals of Metrology:**	
1.1	The process of measurement, significance, generalized measuring system, Data types: continuous data, discrete data	1
1.2	Characteristics of measuring instruments: Static characteristics - Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity.	1
1.3	Errors in measurement: Systematic and Random, Uncertainty of Measurement.	1
1.4	Standards: National, Reference, Secondary, and Working Standards, interchangeability, Calibration, Traceability, Confidence level.	1
2	**Linear and Angular Measurements:**	
2.1	Internal/ external calipers, vernier caliper, vernier height gauge, depth gauge	1
2.2	Gear tooth vernier, plunger dials, slip gauges	1
2.3	Inside / outside micrometer, sine bar, bevel protractor, sprit level.	1
3	**Form Measurement:**	
3.1	Straightness measurement, flatness measurement – N.P.L flatness interferometer, roundness measurement	1
3.2	Measurement of screw thread elements – major diameter, minor diameter, effective diameter, pitch, use of thread gauges	1
3.3	Measurement of gear elements – runout, pitch, profile, lead, backlash	1
4	**Surface Finish Measurement:**	
4.1	Concepts, terminology and methods of measuring surface finish	2
4.2	Principle and operation of stylus probe instruments	2
5	**Inspection using gauges:**	
5.1	Types- limit gauges, snap gauge, plain plug gauge	1
5.2	Ring gauges, radius gauges, and feeler gauges	1
5.3	Design of GO – NOGO gauges	2
6	**Comparator:**	
6.1	Mechanical comparator, electrical comparator	1

No.	Topic	No. of Periods
6.2	Optical comparators, pneumatic air gauge	2
7	**Advanced Metrological Machines:**	
7.1	Auto collimator, laser interferometer	1
7.2	Coordinate Measuring Machine (CMM)	1
7.3	Machine vision for metrology	1
8	**Introduction to Quality Control:**	
8.1	Definition of quality, basic concept of quality, consequences of lack of quality	2
8.2	Quality control, quality assurance, quality control, quality cost, variation in process, causes of variation.	2
8.3	Seven QC tools: Histogram, check sheet, cause and effect diagram, pareto chart, scatter diagram, stratification diagram, control chart.	2
9	**Process Control:**	
9.1	Theory of control chart, uses of control chart.	1
9.2	Control chart for variables: X bar chart, R chart and sigma chart	2
9.3	Pattern study, process capability, process capability studies	2
9.4	Six Sigma concept.	1
9.5	Control chart for attributes, control chart for nonconforming: p chart and np chart, control chart for nonconformities: c and u chart	2
9.6	Introduction about statistical software	1
10	**Acceptance Sampling:**	
10.1	Types of sampling plan, probability of acceptance in single sampling technique	2
10.2	Probability of acceptance in double and multiple sampling technique	1
10.3	Sequential Sampling plan	1
10.4	Operating Characteristic (OC) curve	1
10.5	Producer's risk and consumer's risk– Average Quality Level (AQL), Lot Tolerance Percent Defective (LTPD)	1
10.6	Average Total Inspection (ATI)	1
10.7	Average Sample Number (ASN)	1
10.8	Average Outgoing Quality Limit (AOQL)	1
	Total	48

Course Designers:

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22ME540	HEAT AND MASS TRANSFER

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Heat and mass are two different forms of energy. As a branch of science, heat and mass transfer deals with the determination of the rates at which heat and mass are transferred. The study of heat and mass transfer mechanisms has become increasingly important in engineering practice as heat transfer plays a crucial role in the design of vehicles, power plants, refrigerators, electronic devices, buildings, and bridges, among others. In this course, students will develop a fundamental understanding of heat transfer principles, develop an intuitive understanding of the heat transfer mechanisms, and apply the knowledge to analyze heat transfer systems in real-world engineering applications. Using the knowledge of heat transfer, one can gain a basic understanding of the principle and mechanisms of mass transfer.

Prerequisite

- Thermal Engineering
- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Calculate the conduction heat and mass transfer rates under steady state.	TPS3	70	65
CO2	Compute the conduction heat transfer rate under transient state.	TPS3	70	65
CO3	Determine the convection heat and mass transfer rates under natural mode.	TPS3	70	65
CO4	Determine the convection heat and mass transfer rates under forced mode.	TPS3	70	65
CO5	Compute the radiation heat transfer rate between surfaces.	TPS3	70	65
CO6	Determine the heat transfer rate and size of heat exchangers.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO2	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO3	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO4	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO5	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO6	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	40	5	10	25	-	-	-	-	-	-	6	5	10
CO2	-	-	20	5	-	15	-	-	-	-	-	-	2	-	10
CO3	-	-	40	5	10	25	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	-	-	40	5	10	25	4	5	10
CO5	-	-	-	-	-	-	-	-	40	5	10	25	2	5	10
CO6	-	-	-	-	-	-	-	-	20	5	-	15	2	-	10
												Total	**20**	**20**	**60**

Syllabus

Steady State Conduction

Introduction, Modes of heat transfer, Fourier law of conduction, General heat conduction equation in Cartesian co-ordinates. One dimensional steady state heat conduction -plane wall, hollow cylinder and sphere, numerical problems. Conductive mass transfer- Fick's law of diffusion- Analogy between heat, and mass transfer, Composite systems with combined mechanism, electrical analogy, critical thickness of insulation, numerical problems. Conduction with inner heat sources - plane wall and solid cylinders, numerical problems. Heat transfer through extended surfaces-Heat transfer through long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip- longitudinal and circumferential and triangular fins - efficiency and effectiveness, numerical problems.

Conductive mass transfer- Fick's law of diffusion-Analogy between heat, and mass transfer numerical problems.

Transient Conduction

Introduction, Lumped heat capacity systems, numerical problems. Heat flow in a semi - infinite body-initial temperature with suddenly immersed in liquid and convection boundary conditions, numerical problems- Heat flow in an infinite body-Plane wall, Cylindrical wall and Spherical wall - Heisler and Grober charts, numerical problems.

Forced convection

Introduction-Hydrodynamic, thermal boundary and concentration layers- Flow over flat plates- Laminar boundary layer thickness in terms of Reynolds number, Nusselt equation, Flow through tubes - Nusselt equation, Flow across cylinder- Nusselt equation, Forced convection mass transfer – Similarity, Sherwood equation.

Free convection

Introduction-Hydrodynamic, thermal boundary and concentration layers, Horizontal and vertical plates, Horizontal and vertical cylinders – Nusselt and Sherwood equations- Analogy between heat and mass transfer, numerical problems.

Radiation

Introduction, Wave theory and quantum theory- concepts of black body and gray body - Stefan - Boltzman law - emissive power – monochromatic emissive power - Weins law - Kirchoff's law- numerical problems. Radiative properties, Emissivity, absorptivity, reflectivity, transmissivity, radiosity - Radiation shape factor - Reciprocity theorem. Heat exchange between black and gray surfaces, numerical problems - Reradiating surfaces.

Heat exchangers

Classification- overall heat transfer co-efficient- fouling factor- LMTD method, numerical problems -NTU method, numerical problems.

Textbooks

1. Sachdeva, R.C., **"Fundamentals of Engineering Heat and Mass Transfer"**, New Age International Publishers, 2017.
2. Yunus A.Cengel and Afshin Ghajar, "**Heat and Mass Transfer: Fundamentals and Applications**", 6th Edition, Mc Graw Hill Education, 2020.

Reference Books &Web Resources

1. Holman, J.P., **"Heat Transfer"**, 10th Edition, McGraw Hill Education, 2017.
2. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, and Adrienne S. Lavine, "**Principles of Heat and Mass Transfer**", Wiley, 2013.
3. Nag P.K., **"Heat and Mass Transfer"**, 3rd Edition, Mc Graw Hill Education, 2011.
4. Mahesh M. Rathore, "**Engineering Heat and Mass Transfer**", LaxmiPublication , 4th Edition, 2023.
5. Necati Ozisik, "**Heat Transfer – a Basic Approach**", McGraw Hill, 1994.
6. Rajput, R.K., "**A Text Book of Heat and Mass Transfer**", 7th Edition, S.Chand& Company Ltd, 2018.
7. Som, S.K. "**Introduction to Heat Transfer**", PHI Learing Private Ltd, 2008.
8. Frank Kreith, Mark S. Bohn, "**Principles of Heat Transfer"**, Sixth Edition, Brooks/cole, Thomson Asia Private Ltd., Singapore, 2001.
9. Kothandaraman, C.P., **"Fundamentals of Heat and Mass Transfer",** 4th Edition, New Age International, 2012.
10. https://nptel.ac.in/courses/112108149/ - Lecture Notes
11. https://nptel.ac.in/courses/112101097/ - Video Lectures by Prof.S.P.Sukhatme, Mechanical Engineering, IIT Bombay.

Data Book

1. Kothandaraman, C.P., **"Heat And Mass Transfer Data Book",** 9th Edition, New Age International, 2018.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**Steady State Conduction**	
1.1	Introduction, Modes of heat transfer	1
1.2	Fourier law of conduction, general heat conduction equation in Cartesian co-ordinates	1
1.3	One dimensional steady state conduction- plane wall, hollow cylinder and sphere, numerical problems.	2
1.4	Composite systems with combined mechanism – electrical analogy, Critical thickness of insulation, numerical problems.	1
1.5	Conduction with inner heat sources – plane wall and solid cylinders, numerical problems.	2
1.6	Heat transfer through long fins, short fins with negligible heat loss from the fin tip (insulated fin tip).	2
1.7	Heat transfer through extended surfaces-Heat transfer through long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip- longitudinal and circumferential and triangular fins - efficiency and effectiveness, numerical problems.	2

No.	Topic	No. of Periods
1.8	Conductive mass transfer- Fick's law of diffusion-Analogy between heat, and mass transfer, numerical problems.	2
2	**Transient Conduction**	
2.1	Introduction, Lumped heat capacity systems, numerical problems.	1
2.2	Heat flow in a semi - infinite body- initial temperature with suddenly immersed in liquid and convection boundary conditions, numerical problems	1
2.3	Heat flow in an infinite body- Plane wall, Cylindrical wall and Spherical wall.	1
2.3.1	Heisler and Grober charts, numerical problems.	1
3	**Forced convection**	
3.1	Introduction, Hydrodynamic, thermal and concentration boundary layers	1
3.2	Flow over flat plates: Laminar boundary layer thickness in terms of Reynolds number, Nusselt equationnumerical problems.	1
3.3	Flow through tubes - Nusselt equation, numerical problems.	1
3.4	Flow across cylinder- Nusselt equation, numerical problems.	1
3.5	Forced convection mass transfer – Similarity, Sherwood equation, numerical problems.	1
4	**Free convection**	
4.1	Introduction, Hydrodynamic, thermal boundary and concentration layers	1
4.2	Horizontal and vertical plates – horizontal and vertical cylinders – Nusselt equation, numerical problems.	1
4.3	Horizontal and vertical cylinders – Nusselt equation, numerical problems.	1
4.4	Free convection mass transfer – Similarity, Sherwood equation	1
5	**Radiation**	
5.1	Introduction, Wave theory and quantum theory	1
5.2	Concepts of black body and gray body	1
5.3	Stefan – Boltzman law – emissive power – monochromatic emissive power – Weins law –Kirchoff's law, numerical problems.	1
5.4	Radiative properties, emissivity, absorptivity, reflectivity,transmissivity, radiosity	1
5.5	Radiation shape factor – Reciprocity theorem	1
5.6	Heat exchange between black surfaces, numerical problems.	1
5.7	Reradiating surfaces, Heat exchange between gray surfaces, numerical problems.	1
6	**Heat exchangers**	
6.1	Classification- overall heat transfer co-efficient- fouling factor	1
6.2	LMTD method, numerical problems	1
6.3	NTU method, numerical problems	1
	Total	**36**

Course Designers

1.	Dr. A.Valan Arasu	Professor	Mechanical Engineering	avamech@tce.edu
2.	Dr.K.Srithar	Professor	Mechanical Engineering	ksrithar@tce.edu
3.	Dr. M.S. Govardhanan	Assistant Professor	Mechanical Engineering	govardhanans@tce.edu

22ME560	DYNAMICS AND MEASUREMENTS LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

Students are exposed to the practical knowledge of physical measurement techniques in this course, including force, torque, strain, displacement, and measurement of dynamics parameters, including gyroscopic couple, balancing masses, whirling of speed, governor lift, moment of inertia, Cam profile, and vibrations.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the Rotating and reciprocating balancing masses, governor lift	TPS3	70	65
CO2	Determine of whirling speed of shaft, Gyroscopic couple, cam lift, cam profile, moment of inertia,	TPS3	70	65
CO3	Determine the natural frequency of spring mass system, single and two rotor system , and damping coefficient	TPS3	70	65
CO4	Determination of error in torque, strain and Displacement measuring device	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	M	M	-	-	-	M	-	-	-	M		S
CO2	S	S	M	M	M				M				M		S
CO3	S	S	M	M	M				M				M		S
CO4	S	S	M	M	M				M				M		S

S- Strong; M-Medium; L-Low

Assessment Pattern

- Students are examined for 100 marks in instrumentation and dynamics lab for terminal examination.
- Duration of terminal examination :3 Hours

List of Experiments

No.	Experiment	CO
1.	Determination of balancing masses in rotating systems	CO1
2.	Determination of balancing masses in reciprocating systems	CO1
3.	Determination of governor lift for the given speed range	CO1
4.	Determination of whirling speed of the given shaft	CO2
5.	Determination of Gyroscopic couple	CO2
6.	Determination of displacement, velocity, acceleration of the given cam and follower system	CO2
7.	Determination of moment of inertial of the given object	CO2
8.	Determination of natural frequency of undamped spring-mass systems	CO3

No.	Experiment	CO
9.	Determination of natural frequency a single rotor shaft system	CO3
10.	Determination of natural frequency a Two rotor shaft system	CO3
11.	Determination of damping coefficient of the damper	CO3
12.	Determination of error of torque transducer measurement	CO4
13.	Determination of error of Strain gauge measurement	CO4
14.	Determination of error of LVDT measurement	CO4

Learning Resources

1. **Dynamics of Machines**, https://nptel.ac.in/courses/112/104/112104114/ Prof. Amithbha Ghosh Indian Institute of Technology, Kanpur

Course Designers

1. Dr M.Elango Associate Professor Mechanical Engineering memech@tce.edu

22ME570	FLUID MECHANICS AND CFD LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

This practical course provides hands on experiment and the numerical simulation of different fluid systems flowing internally and externally in different engineering systems using experimental set up in Fluid Mechanics Laboratory and simulation software based on finite volume method in Computational Fluid Dynamics (CFD) Laboratory.

Prerequisite

- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine experimentally the rate of flow of liquids and its losses in closed conduits.	TPS3	70	65
CO2	Determine experimentally the diameter of pipe carrying fluid using Bernoulli's theorem.	TPS3	70	65
CO3	Determine experimentally the performance of hydraulic machines such as turbines and pumps.	TPS3	70	65
CO4	Compute numerically the properties of fluid flowing through a pipe / venturi / between two parallel plates using finite volume based simulation software.	TPS3	70	65
CO5	Compute numerically the properties of fluid flowing over a streamlined / bluff body using finite volume based simulation software	TPS3	70	65
CO6	Determine numerically the temperature distribution in a fluid flowing through a nozzle / in a solid block at steady state / transient condition using finite volume based simulation software	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	L	-	S	-	M	-	-	-	M	-
CO2	S	M	L	-	-	L	-	S	-	M	-	-	-	M	-
CO3	S	M	L	-	-	L	-	S	-	M	-	-	-	M	-
CO4	S	M	L	-	S	L	-	S	-	M	-	-	-	M	-
CO5	S	M	L	-	S	L	-	S	-	M	-	-	-	M	-
CO6	S	M	L	-	S	L	-	S	-	M	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Fluid Mechanics Lab (50%)		CFD Lab (50%)	
Continuous Assessment		Continuous Assessment	
Laboratory Observation and Record	75 %	Laboratory Observation and Record	75 %
Test	25 %	Test	25 %
Terminal Examination (Duration:1 ½ Hours)		Terminal Examination (Duration: 1 ½Hours)	
Test and Viva Voce	100%	Test and Viva Voce	100%

List of Experiments

No.	Experiment	CO
	FLUID MECHANICS LAB	
1.	Determination of flow rate of fluid in a pipe using Venturi meter.	CO1
2.	Determination of flow rate of fluid in a pipe using Orifice meter.	CO1
3.	Determination of frictional loss in pipes.	CO1
4.	Determination of diameter of pipe carrying water using Bernoulli's theorem.	CO2
5.	Performance test on turbines (Pelton wheel/Francis turbine).	CO3
6.	Performance test on pumps (Centrifugal pump/Reciprocating pump).	CO3
	CFD LAB	
7.	Determination of pressure, velocity distribution and losses in laminar/turbulent flow of fluid through a circular pipe using numerical simulation software.	CO4
8.	Determination of pressure, velocity distribution and losses in laminar flow over a flat plate or between two parallel plates using numerical simulation software	CO4
9.	Determination of pressure, velocity distribution, and losses in incompressible fluid flow through a venturi meter using numerical simulation software.	CO4
10	Determination of flow behaviour of fluid flowing over a flat plate/ cylinder / air foil blade using numerical simulation software.	CO5
11	Determination of pressure, velocity, temperature and Mach number distribution in a compressible fluid flow through a convergent-divergent nozzle using numerical simulation software.	CO6
12	Determine temperature distribution in a solid wall under steady state / transient condition using numerical simulation software.	CO6

Learning Resources

1. Lab Manual, Department of Mechanical Engineering, TCE 2022
2. https://nptel.ac.in/courses/112105045/ -Computational Fluid Dynamics by Professor Suman Chakravarty, IIT Kharagpur
3. https://nptel.ac.in/courses/112107079/ - Computational Fluid Dynamics by Professor Krishna M. Singh, IIT Madras

Course Designers

1.	Mr. M. Ramasamy	Assistant Professor	Civil Engineering	mrciv@tce.edu
2.	Dr. T. Baskaran	Professor	Civil Engineering	tbciv@tce.edu
3.	Dr. P. Maran	Professor	Mechanical Engineering	pmmech@tce.edu
4.	Dr. M.S. Govardhanan	Assistant Professor	Mechanical Engineering	govardhanans@tce.edu

22ME580	CAM AND METROLOGY LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

This course aims to provide development/generation and execution of NC Codes using computer aided manufacturing packages. It also exposes the students to the practical knowledge on dimensional measurement techniques such as linear and angular measurement of part, surface finish measurements and inspection methods using calipers, comparators, gauges and measuring machines.

Prerequisite

- Manufacturing Automation

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Simulate the tool path by writing the CNC Turning and Milling program and execute the CNC codes for the given component/drawing using CAM software	TPS3	70	70
CO2	Simulate the tool path by developing the milling profile drawing and generating the milling program from the given component/drawing using CAM software	TPS3	70	70
CO3	Develop a part program and execute the process for the given component for CNC Turning and Milling process	TPS3	70	70
CO4	Measure the various linear, angular and form measurements of the given component.	TPS3	70	70
CO5	Determine the surface roughness of the given components.	TPS3	70	70
CO6	Calibrate linear measurement devices using slip gauges.	TPS3	70	70
CO7*	Extract 3D cloud point data for a given component.	TPS3	70	70

* CO7 – Assessment through continuous assessment only

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	L	S	-	-	-	M	L	-	M	S	-	S
CO2	S	S	M	L	S	-	-	-	M	L	-	M	S	-	S
CO3	S	S	M	L	S	-	-	-	M	L	-	M	S	-	S
CO4	S	S	M	L	-	-	-	-	M	L	-	M	M	-	S
CO5	S	S	M	L	-	-	-	-	M	L	-	M	M	-	S
CO6	S	S	M	L	-	-	-	-	M	L	-	M	M	-	S
CO7	S	S	M	L	S	-	-	-	M	L	-	M	M	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

- **Internal assessment marks will be converted into 60 marks** based on Observation, Record & Test details shown in following table:

Lab	CO#	Observation	Record	Total for Observation & Record	Test
CAM LAB	CO1	10	5	75	25
	CO2	10			
	CO3	10			
METROLOGY LAB	CO4	10	5		
	CO5	10			
	CO6	10			
	CO7	5			

- Students shall be examined in both CAM and Metrology exercises during Terminal examination.
- **Terminal Examination will be conducted for 100 Marks and it will be converted to 40 marks**
- Duration: 3 Hours (1½ hours for CAM Lab and 1½ hours for Metrology lab)

List of Experiments

S. No.	CAM LAB - Experiments	CO#
1.	Develop and simulate the tool path of CNC Turning programme with step, tapper turning, curvature and threading operation for the given component/drawing using CAM software.	CO1
2.	Develop and simulate the tool path of CNC Milling programme with profile milling, circular/rectangular pocketing and drilling operation for the given component/drawing using CAM software.	CO1
3.	Generate the NC Code and simulate the tool path of CNC milling programme for the given component/drawing using CAM software	CO2
4.	Develop a CNC Turning part program for the given component and execute the program	CO3
5.	Develop a CNC Milling part program for the given component and execute the program	CO3
S. No.	**METROLOGY LAB - Experiments**	**CO#**
1.	Profile measurement of linear, angular and thread elements using Tool Makers Microscope	CO 4
2.	Profile measurement of linear, angular and thread elements using Profile Projector	CO 4
3.	Measurement of Surface Roughness using portable surface roughness tester.	CO 5
4.	Checking of OD and ID using comparators– Pneumatic, electronic and mechanical.	CO 6
5.	Calibration of micrometer / Vernier caliper using Standard slip gauge.	CO 6
6.	Straightness / Flatness Testing using Autocollimator	CO 4
7.	2D & 3D measurements using Coordinate Measuring Machine	CO 7

Learning Resources

1. NPTEL Course: Computer Aided Design and Manufacturing.
   URL: https://nptel.ac.in/courses/112102102/#
2. NPTEL Course: Computer Aided Design and Manufacturing II
   URL: https://nptel.ac.in/courses/112102103/
3. NPTEL Course: Computer Numerical Control (CNC) of Machine tools and processes
   URL: https://nptel.ac.in/courses/112105211/
4. NPTEL Course: Mechanical measurement and metrology.
   URL: https://nptel.ac.in/courses/112106138/46
5. NPTEL Course: Engineering Metrology
   URL: https://nptel.ac.in/courses/112104250/

Course Designers:

1.	Mr. T. Prakash	Assistant Professor	Mechanical Engineering	tpmech@tce.edu
2.	Mr. C. Selva Kumar	Assistant Professor	Mechanical Engineering	cskmech@tce.edu

22ME610	ACCOUNTING AND FINANCE

Category	L	T	P	C	Terminal Exam Type
HSSMC	3	-	-	3	Theory

Preamble

The engineering profession involves lots of decision-making. The decisions may range from operation to non-operation. To taking decisions of these kinds an engineer needs routine operations. Accounting is a science that provides all the data by recording, classifying, summarizing, and interpreting the various transactions taking place in an organization and thereby helps an engineer in effectively taking vital decisions. Finance is an allied but separate field relying on accounting, and enables engineers to take 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	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the basic concepts and process of accounting	TPS2	70	70
CO2	Prepare financial statements, Analyse the financial statements.	TPS4	70	70
CO3	Prepare cost sheet and various types of budgets.	TPS3	70	70
CO4	Analyse the reasons for cost variances.	TPS4	70	70
CO5	Calculate the working capital requirement and Capital budgeting.	TPS3	70	70
CO6	Suggest the appropriate sources of finance.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	M	-	M	S	S	-	-	L
CO2	M	M	L	-	-	-	-	M	S	M	S	S	-	-	M
CO3	S	L	L	-	-	-	-	M	S	S	S	S	-	-	S
CO4	S	M	L	L	L	M	M	M	S	M	S	M	-	-	M
CO5	S	M	L	-	S	M	M	M	S	M	M	M	-	-	S
CO6	M	M	L	-	-	M	M	M	M	M	M	S	-	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory								Theory							Theory			
	Assessment-1								Assessment-2							Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2							
TPS / COs	1	2	3	4	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4
CO1	-	20			10	15	-	-	-	-	-	-	-	-	-	6	5	-	-
CO2	-	-	20	20	10	10	-	20	-	-	-	-	-	-	-	2	5		10
CO3	-	-	40		5	10	20	-	-	-	-	-	-	-	-	2	5	10	-
CO4	-	-	-	-	-	-	-	-	-	-	35	5	20	-	10	2	5	-	10
CO5	-	-	-	-	-	-	-	-	-	-	35	5	15	10	-	4	5	10	-
CO6	-	-	-	-	-	-	-	-	-	-	30	10	15	10	-	4	5	10	-
															Total	**20**	**30**	**30**	**20**

Syllabus

Accounting –Introduction, Definition, and principle -Functions of accounting - Preparation of Financial statements and analyze them by the comparative statement, common size statement, and trend analysis.
Cost Accounting - Meaning and importance -Elements of cost- classification of cost- Cost centre, cost unit-Preparation of cost sheet-Overheads and its classification-Cost drivers and their impact on costs of production.
Budget and Budgetary control- Introduction-Meaning -objectives of budgetary control -Budget-Types of budgets and their preparation.
Standard costing-Meaning and definition-Importance -Variance analysis-calculation of material cost, labour cost variances, Overhead variances.
Capital budgeting- Meaning and features, capital budgeting decisions, depreciation – meaning and causes of depreciation. Methods of evaluating investment proposals- Pay Back Period Method, ARR, NPV, IRR, PI..
Working capital management -concept, classification, Estimation of working capital requirements. **Finance:** objective, Source of finance and financial institutions, and Venture capital.

Textbook (s)

1. M.C.Shukla,T.S.Grewal,"AdvancedAccounts-Volume-I,2010 Reprint, S. Chand & Company Ltd.,2010.
2. P.S.BoopathiManickam "Financial and Management Accounting" PSG publications 2009.

Reference Books & Web Resources

1. Prasanna Chandra, "Financial Management-Theory and practice" seventh Reprint, Tata McGraw-Hill publishing company Limited,2010.
2. Michael C . Ehrhardt and Eugene F . Brigham, "Financial Management: Theory and Practice - thirteenth edition" South-Western Cengage learning, 2011
3. Paramasivan.C, Subramanian.T, "Financial management" New Age international Publishers, 2014.
4. Ittelson, Thomas R., "Financial Statements: A Step-by-step Guide to Understanding and Creating Financial Reports" The career press, 1998.
5. https://nptel.ac.in/courses/110101003/
6. https://swayam.gov.in/nd1_noc19_mg38/preview
7. https://www.youtube.com/watch?v=P9JIBbZas3w
8. Finance for everyone – Coursera

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1.	**Accounting**	
1.1	Introduction, Definition	1
1.2	principle	1
1.3	Functions of Accounting	1
2.1	Preparation of Financial statements	2
2.2.	Analyse by comparative statements	1
2.3	common size statement	1
2.4	trend analysis	1
3	**Cost Accounting**	
3.1	Meaning and importance -Elements of cost	1
3.2	classification of cost- Cost centre, cost unit	1
3.3	Preparation of cost sheet	2
3.4	Overheads and their classification- Cost drivers and their impact on costs of production.	2
3.5	Introduction- Meaning -objectives of budgetary control	1
3.6	Budget-Types of budgets	1
3.7	Budget preparation	3
4	**Standard costing**	
4.1	Meaning and definition-Importance	1
4.2	Variance analysis	1
4.3	calculation of material cost variances	2
4.4	labour cost, Overheads variances.	2
5	**Capital budgeting**	
5.1	Meaning and features, capital budgeting decisions	1
5.2	depreciation – meaning and causes of depreciation	1
5.3	Methods of evaluating investment proposals- Pay Back Period Method, ARR	1
5.4	NPV	1
5.5	IRR, PI	1
5.6	Working capital management - concept, classification	1
5.7	Estimation of working capital requirements	1
6	**Finance**	
6.1	Meaning and objective of finance	1
6.2	Source of finance and financial institutions	2
6.3	Venture capital.	1
	Total	**36 hrs**

Course Designers

1. Dr.R.Sivasankaran Assistant Professor Mechanical Engineering rssmech@tce.edu

22ME620	DESIGN OF TRANSMISSION SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PCC	3	0	0	3	Theory

Preamble

A transmission is a machine in a power transmission system, which provides controlled application of the power. Transmissions are also used in agricultural, industrial, construction, mining and automotive equipment. The transmission system used in motor vehicles used, to transfer the power from an engine to the drive wheels. The transmission system in engines reduces the higher speed to the lower speed, increasing torque in the process. Transmission systems are also used on various industrial applications where different rotational speeds and torques are required. A transmission has multiple gear ratioswith the ability to switch between them as speed varies. This course is concerned with designing the basic mechanical power transmission elements such as flexible drives, Gears, Gear boxes, Clutches and Brakes for varied applications.

Prerequisite

- Mechanics of Materials
- Design of Machine Elements

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Design Flat Belts, V- Belts and Chain drives for given engineering application.	TPS3	70	65
CO2	Design Parallel axis gears such as Spur gears and Helical Gears based on strength and wear considerations.	TPS3	70	65
CO3	Design Inclined axis gears such as Bevel gears, Worm Gears and Crossed Helical Gears under static loading conditions.	TPS3	70	65
CO4	Design a Gear box for machine tool and automotive applications.	TPS3	70	65
CO5	Design a Clutch for automotive applications and material handling equipment.	TPS3	70	65
CO6	Design of Radial Brakes and bearings for given engineering applications.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	L	L	-	-	-	-	-	-	-	-	M	-	M
CO2	S	M	S	L	-	-	-	-	-	-	-	-	M	-	M
CO3	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO4	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO5	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M
CO6	S	M	M	L	-	-	-	-	-	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1			Theory Assessment-2			Integrated System Design Project	Theory Terminal Examination		
TPS / COs	1	2	3	1	2	3	3	1	2	3
CO1	-	4	30	-	-	-	100	2	-	15
CO2	-	3	30	-	-	-		2	-	15
CO3	-	3	30	-	-	-		2	-	15
CO4	-	-	-	-	3	30		-	-	15
CO5	-	-	-	-	3	30		2	-	15
CO6	-	-	-	-	4	30		2	-	15
							Total	**10**	**-**	**90**

Integrated System Design Project: This is a team project and each team may consist of 3 or 4 students. The students will do an Integrated System Design project wherein the students are expected to,

- Identify an application which consists of various machine elements and transmission systems and gather the input information for load, power etc.
- Design the various machine elements and transmission systems for their applicationby following the design procedure.
- Create a Part & Assembly model of the various designed components and draft themusing any of the computer aided parametric modelling software packages.
- A final technical report has to be submitted summarizing all the work done. The totalmark for evaluation is 100 and has to be converted to 30.

Syllabus

Introduction: Review on Friction, Metallurgy and Materials — Need for Power Transmission – Requirements of a Transmission System – Types and Classification of Transmission Systems – Loading Conditions – Working Conditions – Specifications of a Transmission Element.
Flexible Drives: Belt Drives –Types, Materials and Construction – Design of Flat Belts and Pulleys – Design of V Belt drives - Types of Chain drives – Design of TransmissionChain and Sprockets.
Parallel Axis Gears: Tooth terminology – Speed ratios and number of teeth- Factor of safety – Gear materials – Design of spur and helical gears based on strength and wear considerations – Pressure angle in the normal and transverse plane – Equivalent numberof teeth for helical gears.
Inclined Axis Gears: Design of Straight/Spiral bevel gear: Tooth terminology– equivalent number of teeth – Estimating the dimensions of pair of straight bevel gears. Worm Gear–Terminology – Thermal capacity, materials – Efficiency – Design of Worm Gear drives.
Gear box: Geometric progression – Standard step ratio – Ray diagram – Kinematics layout — Design of gear box — Design of multi speed gear box for machine tool & automobile applications – Gear Shifting mechanism.
Clutches: Design of Plate clutches: Single plate and Multi Plate clutches
Brakes & Bearings: Design of Brakes: Block or Shoe brakes – Single, Pivoted and Double Block or Shoe brakes – Band Brakes – Simple and Differential Band Brakes. Design of Sliding Contact and Rolling Contact Bearings.

Textbook (s)

1. Richard G Budynas and J Keith Nisbett **"Shigley's Mechanical Engineering Design"**,Tenth Edition, Tata McGraw Hill, 2015.

Reference Books

1. Richard G Budynas and J Keith Nisbett **"Shigley's Mechanical Engineering Design"**,Tenth

Edition, Tata McGraw Hill, 2015.

2. Robert L. Norton, **“Machine Design: An Integrated Approach”**, Fifth Edition, Pearson, 2018.
3. Alfred Hall, Alfred Holowenko, Herman Laughlin and S Somani, **“Schaum's Outline - Machine Design”**, McGraw Hill Education India Pvt. Ltd., 2017
4. Robert C. Juvinall and Kurt M. Marshek, **“Machine Component Design”**, WileyIndia Edition, 2016.,
5. Ansel C. Ugural, **“Mechanical Design of Machine Components”**, Second Edition, CRC Press, 2015
6. B. J. Hamrock, B. Jacobson and S. R. Schmid, **“Fundamentals of Machine Elements”**, Third Edition, Tata McGraw Hill Publishing Company Pvt. Ltd., NewDelhi, 2014.
7. Orthwein W, “**Machine Component Design**”, Jaico Publishing Co, 2010.
8. PSG College, **“Design Data: Data Book of Engineers”**, KalaikathirAchchagam,2019
9. Joseph E Shigley and Charles R Mischke, **“Standard Handbook of Machine Design”,** Third Edition, McGraw Hill Pvt. Ltd., 2004
10. K. Lingaiah, **“Machine Design Data Handbook”**, Second Edition, McGraw Hill Pvt.Ltd., 2010.

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures	Course Outcome
1.	**Introduction**		
1.1	Review on Friction, Metallurgy & Materials.	1	CO1
1.2	Need for Power Transmission		CO1
1.3	Types and Classification of Transmission Systems		CO1
1.4	Requirement of a Transmission Systems		CO1
1.5	Loading & Working Conditions	1	CO1
1.6	Specifications of a Transmission Element.		CO1
2.	**Flexible Elements**		
2.1	Design of Belt Drives	2	CO1
2.1.1	Types, Material and Construction		CO1
2.2	Design of Flat Belts and Pulleys		CO1
2.3	Selection of V Belts and Pulleys	2	CO1
2.4	Types of Chain Drives	2	CO1
2.5	Design of Transmission Chain and Sprockets		CO1
3.	**Parallel Axis Transmission Elements**		
3.1	Speed ratios and Number of teeth - Dynamic Effects – Fatigue Strength & Factor of Safety - Gear Materials	1	CO2
3.2	Design of Straight tooth spur gears	2	CO2
3.3	Design of Helical Gears Pressure angle in the normal and transverse plane - Equivalent number of teeth for helical gears	1	CO2
4.	**Inclined Axis Transmission Elements**		
4.1	Bevel Gears -Tooth terminology & equivalent number of teeth	1	CO3
4.2	Design of straight/spiral bevel gears	2	CO3
4.3	Worm Gears - Terminology, Thermal capacity, Materials & Efficiency	2	CO3
4.4	Design of worm gears	1	CO3
5.	**Gear Box**		

Module No.	Topics	No. of Lectures	Course Outcome
5.1	Gear Shifting Mechanism & Geometric progression	1	CO4
5.2	Standard step ratio		CO4
5.3	Ray diagram	1	CO4
5.4	Kinematics layout		CO4
5.5	Design of gear box	2	CO4
5.6	Design of Multi speed gear box for machine tool & automobile applications	2	CO4
6.	**Clutches**		
6.1	Design of Single Plate Clutch	2	CO5
6.2	Design of Multi-Plate Clutch	2	CO5
7.	**Brakes**		
7.1	Design of Block or Shoe Brakes – Single, Pivoted & Double	2	CO6
7.2	Design of Band Brakes – Simple & Differential	2	CO6
7.3	Design of Sliding Contact Bearings	2	CO6
7.4	Design of Rolling Contact Bearings	2	CO6
	Total No. of Hours	**36**	

Course Designers:

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22ME670	HEAT TRANSFER LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

The purpose of the practical course is to supplement theoretical knowledge of the mechanisms of heat transfer gained from the theory course on heat and mass transfer by conducting experiments, calculating heat transfer parameters and verifying the experimental results with the corresponding theoretical values.

Prerequisite

- Heat and Mass Transfer

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the thermal conductivity of metal rod and insulating material and specific heat capacity of air	TPS3	70	65
CO2	Compute heat transfer rate through fins and its efficiency under natural and forced convection modes	TPS3	70	65
CO3	Calculate the Biot number and heat transfer coefficient under transient heat transfer mode	TPS3	70	65
CO4	Determine the natural and forced convection heat transfer coefficients	TPS3	70	65
CO5	Determine the Stefan-Boltzmann constant and emissivity of a test surface.	TPS3	70	65
CO6	Calculate the overall heat transfer coefficient and effectiveness of a heat exchanger	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO2	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO3	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO4	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO5	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L
CO6	S	M	L	-	-	-	-	S	M	M	-	-	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Continuous Assessment	
Laboratory Observation and Record	75 %
Test	25 %
Terminal Examination (Duration:3 Hours)	
Test and Viva Voce	100%

List of Experiments

No.	Experiment	CO
1.	Conduction heat transfer test on metal bar apparatus	**CO1**
2.	Heat transfer analysis in a lagged pipe	**CO1**
3.	Determination of specific heat capacity of air	**CO1**
4.	Heat transfer performance of pin-fin in natural convection	**CO2**
5.	Heat transfer performance of pin-fin in forced convection	**CO2**
6.	Determination of Biot number for a lumped thermal capacity system	**CO3**
7.	Experiment on Transient heat transfer analysis	**CO3**
8.	Experimental study of heat transfer in fluidized bed	**CO3**
9.	Determination of heat transfer co-efficient in natural convection	**CO4**
10.	Determination of heat transfer co-efficient in forced convection	**CO4**
11.	Determination of Stefan - Boltzmann constant	**CO5**
12.	Determination of Emissivity of the given gray surface	**CO5**
13.	Determination LMTD and effectiveness of heat exchanger	**CO6**

Learning Resources

1. Lab Manual, Department of Mechanical Engineering, TCE (2022)
2. https://nptel.ac.in/courses/103/101/103101137/ by Prof. Ganesh A. Viswanathan, Chemical Engineering, IIT Bombay

Course Designers

1.	Dr. A.Valan Arasu	Professor	Mechanical Engineering	avamech@tce.edu
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3.	Dr. M.S. Govardhanan	Assistant Professor	Mechanical Engineering	govardhanans@tce.edu

22ME680	CAD LAB

Category	L	T	P	C	Terminal Exam Type
PCC	0	0	2	1	Practical

Preamble

Computer Aided Design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. This course provides the knowledge on development, manipulation and assembly of the 3D models using CAD.

Prerequisite

Production Drawing

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Develop 3D part model of the given component drawing using CAD packages.	TPS3	70	65
CO2	Assemble the 3D parts with assembly constraints using CAD software.	TPS3	70	65
CO3	Prepare detailed drawing of components comprising of orthographic views and tolerances.	TPS3	70	65
CO4	Prepare detailed drawing of assembly comprising of exploded view and bill of materials.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	L	-	-	-	S	-	M
CO2	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO3	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M
CO4	S	M	L	-	-	-	-	M	L	L	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Practical Model			Practical Terminal		
TPS / COs	1	2	3	1	2	3
CO1	-	-	100	-	-	100
CO2	-	-		-	-	
CO3	-	-		-	-	
CO4	-	-		-	-	

List of Experiments/Activities with CO Mapping

Module No.	List of Experiments	No. of Hours	Course Outcome
1	**Computer Aided Design**		
1.1	Demonstration on part modelling features such as extrude, revolve, sweep, blend, swept blend, helical sweep and assembly technique followed by detailed drawing.	4	CO1 CO2 CO3 and CO4
1.2	Develop 3D part model, assemble and prepare detailed drawing (orthographic views, exploded view, bill of materials and tolerances) of the given machine drawing (any 2 assembly - considered as 4 experiments) i. Engine Parts – Connecting rod/Piston, etc., ii. Machine Tool Parts — Square tool post/Machine vice/Lathe tail stock, etc., iii. Miscellaneous Parts – Coupling/Screw Jack/knuckle joint/ Plummer block/foot step bearing/Universal Joint/Plummer block, etc.,	16	CO1 CO2 CO3 and CO4
1.3	Develop 3D part model, assemble and preparedetailed drawing (orthographic views, exploded view, bill of materials and tolerances) of the given real time product.(1 real time model - considered as 2 experiments) i. Writing pen ii. Pet bottle iii. Computer monitor iv. Tool post. v. Sitting stool vi. Computer mouse. etc.	4	CO1 CO2 CO3 and CO4
	Total	**24**	

Reference Books

1. K.R.Gopalakrishna, “Machine Drawing”, Eighteenth Edition, Subhas Stores,Bangalore, 2004.
2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, “Production Drawing”, ThirdEdition, New Age International Ltd., New Delhi, 2014.
3. Peter Smid, “CNC Programming Handbook”, Industrial Press Inc., 2008.

Course Designers:

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2.	Mr.M.Sermaraj	Assistant Professor	Mechanical Engineering	msjmech@tce.edu

22ME710	OPERATIONS MANAGEMENT

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Gain knowledge of current trends and practice-able skills in the areas of operations management. Learn to analyze and improve business processes in services or in manufacturing by learning how to increase productivity and attain higher quality standards.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the components of production management and productivity measurement	TPS2	75	70
CO2	Choose appropriate forecasting model to forecast the future demand.	TPS4	70	60
CO3	Design the Inventory management system for given manufacturing environment	TPS3	70	65
CO4	Choose appropriate strategies for production planning	TPS4	70	60
CO5	Prepare schedule for single machine, flow shop and Job shops.	TPS3	70	65
CO6	Explain ToC based methods for manufacturing control	TPS2	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	S
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	-	S
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO6	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination			
	Assignment-1			CAT-1			Assignment-2			CAT-2						
TPS / COs	1	2	3	2	3	4	1	2	3	2	3	4	1	2	3	4
CO1	-	20	-	5	20	-	-	-	-	-	-	-	4	10	-	-
CO2	-	-	40	10	-	25	-	-	-	-	-	-	4	5	-	10
CO3	-	-	40	15	25		-	-	-	-	-	-	-	10	10	-
CO4	-	-	-	-	-	-	-	-	40	10	-	25	2	5	-	10
CO5	-	-	-	-	-	-	-	-	40	20	25	-	-	5	10	-
CO6	-	-	-	-	-	-	-	20	-	20	-	-	-	15	-	-
												Total	**10**	**50**	**20**	**20**

Syllabus

PRODUCTION MANAGEMENT – objectives, Trends and challenges, operations strategy, Operations Competitive Dimensions, Corporate strategy, Strategic fit- fitting operational activities to strategy, Technological Innovations in Manufacturing. Productivity – types of measures – enhancement strategies. **FORECASTING**: Need for forecasting, the process, methods- qualitative methods, Quantitative models-Time series forecasting models, moving averages, exponential smoothing with trend and seasonal adjustment, multi-item forecasting, Simple and multiple linear regression models, monitoring and controlling forecasts. **INVENTORY MANAGEMENT**: Types of inventory, Inventory costs. Inventory models - deterministic models (with and without shortage) - EOQ, EBQ- safety stock and reorder points – Inventory control systems - ABC, VED, Vendor Managed Inventory (VMI) system.
PLANNING ACTIVITIES: Aggregate planning - strategies, planning methods, Master Production Plan - cut and fit methods. Material Requirement Planning(MRP) - Bill of materials, MRP calculation, Lot sizing- EOQ, LUC, POQ,PPB. MRP II and CRP. **PRODUCTION CONTROL ACTIVITIES**: Strategic decisions, operational and tactical decisions, Scheduling: Single Machine scheduling - Minimizing mean flow time, tardiness, and makespan. Flow shop scheduling - Johnson's algorithm and extension rule, Palmer and CDS heuristics, Job shop scheduling - 2 jobs and M machines by graphical method. **THEORY OF CONSTRAINTS (ToC)**: Toc performance measurements, Unbalanced capacity, Bottlenecks and Capacity constrained resources, and Methods for control.

Text Books

1. Panneerselvam, R, “Production and operations management”, 12th Edition, PHI, 2012
2. Chase, Jacobs, Nicholas J. Aquilano, Operations management for competitive advantage", TMH, 11th Edition 2008.

Reference Books

1. Lee J.Krajewski, Larry P.Ritzman, “Operations Management”, Pearson Education, 2019.
2. Mahadevan, B, “Operations Management - Theory & Practice”, Pearson Education, 2015.
3. Seetharama L.Narasimhan, Dennis W.Mc Leavey, Peter J.Billington, “Production Planning and Inventory Control” , PHI, 2007.
4. Edward A. Silver, David F. Pyke, Douglas J. Thomas, “Inventory and Production Management in Supply Chains”, CRC Press, Taylor & Francis Group, 2021.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**PRODUCTION MANAGEMENT**	
1.1	Objectives, Trends and challenges	1
1.2	Operations strategy, Operations Competitive Dimensions	1
1.3	Technological Innovations in Manufacturing	1
1.4	Corporate strategy, Strategic fit- fitting operational activities to strategy, Technological Innovations in Manufacturing	1

No.	Topic	No. of Periods
1.5	Productivity – types of measures – enhancement strategies	1
2	**FORECASTING**	
2.1	Need for forecasting, the process, methods- qualitative methods	1
2.2	Quantitative models-Time series forecasting models, moving averages	1
2.3	Exponential smoothing with trend and seasonal adjustment	1
2.4	Multi-item forecasting, Simple and multiple linear regression models	2
2.5	Monitoring and controlling forecasts.	1
3	**INVENTORY MANAGEMENT**	
3.1	Types of inventory, Inventory costs.	1
3.2	Inventory models - deterministic models (with and without shortage) - EOQ	2
3.3	Deterministic models (with and without shortage) - EBQ	1
3.4	Safety stock and reorder points	1
3.5	Inventory control systems - ABC, VED, Vendor Managed Inventory (VMI) system.	1
4	**PLANNING ACTIVITIES**	
4.1	Aggregate planning - strategies, planning methods	1
4.2	Master Production Plan - cut and fit methods.	2
4.3	Material Requirement Planning(MRP) - Bill of materials, MRP calculation	2
4.4	Lot sizing- EOQ, LUC, POQ,PPB.	2
4.5	MRP II and CRP.	1
5	**Production Scheduling**	
5.1	Strategic decisions, operational and tactical decisions	1
5.2	Scheduling: Single Machine scheduling - Minimizing mean flow time, tardiness, and makespan	3
5.3	Flow shop scheduling - Johnson's algorithm and extension rule, Palmer and CDS heuristics	2
5.4	Job shop scheduling - 2 jobs and M machines by graphical method.	1
6	**THEORY OF CONSTRAINTS**	
6.1	Toc performance measurements, Unbalanced capacity	1
6.2	Bottlenecks and Capacity constrained resources	2
6.3	Methods for control.	2
	Total	37

Course Designers:

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22ME720	FINITE ELEMENT ANALYSIS

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

Preamble

Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers have used FEA to reduce the number of physical prototypes and experiments and optimize components in theirdesign phase to develop better products. FEA gives an approximate solution of the problem and it is a numerical method used for the prediction of how a part or assembly behaves under given conditions. FEA can produce accurate, reliable approximate solutions, at a smallfraction of the cost of more rigorous, closed-form analyses. This course provides the basic theoretical knowledge to competently perform finite element analysis for structural and thermal analyses. It also provides an introduction to the finite element analysis from engineering point of view.

Prerequisite

- Mechanics of Materials
- Numerical Methods

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Solve the physical problem using functional approximation method like weighted residual method & Variational methods.	TPS3	70	65
CO2	Explain the fundamental concepts of theory of Elasticity.	TPS2	70	70
CO3	Solve for one dimensional structural and thermal problems using FEM.	TPS3	70	65
CO4	Solve the two dimensional structural and thermal problems usingFEM.	TPS3	70	65
CO5	Formulate the shape function and stiffness matrix for two dimensional Iso Parametric Elements and Higher Order Elements	TPS3	70	65
CO6	Solve the three-dimensional structural problems using FEM	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	S	M	M	M	L	L	-	-	M	-	S
CO2	M	L	M	L	S	M	M	M	L	L	-	-	M	-	S
CO3	S	M	L	L	S	M	M	M	L	L	-	-	M	-	S
CO4	S	S	M	L	S	M	M	M	L	L	-	-	M	-	S
CO5	S	M	L	L	S	M	M	M	L	L	-	-	M	-	S
CO6	S	S	M	L	S	M	M	M	L	L	-	-	M	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	50	-	10	20	-	-	-	-	-	-	-	-	10
CO2	-	-	-	-	20		-	-	-	-	-	-	-	10	-
CO3	-	-	50	-	10	40	-	-	-	-	-	-	-	-	20
CO4	-	-	-	-	-	-	-	-	40		10	30	-	-	20
CO5	-	-	-	-	-	-	-	-	30		10	20	-	-	20
CO6	-	-	-	-	-	-	-	-	30		10	20	-	-	20
												Total	**-**	**10**	**90**

Syllabus

Functional Approximation Method: Historical Background – Methods for Engineering Analysis – Introduction to Numerical Methods — Mathematical Modelling of field problems in Engineering — Governing Equations — Boundary, Initial and Eigen Value problems — Functional Approximation methods Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Rayleigh Ritz Technique – Procedure involved in FiniteElement Method – Types – Coordinate Systems – Meshing – Error Estimates – Adaptive Refinement – Advantages & Applications of FEM.

Theory of Elasticity: Degrees of Freedom — Rigid Body Motion — Discrete and Continuum structures – Material Properties – Linear and Non-linear Analysis – Stiffness &Flexibility — Principle of Minimum Potential Energy — Stress & Strain — Notation & Components – Strain Displacement Relation – Stress Strain Relation – Plane Stress – Plane Strain - Axisymmetric — Compatibility Equations — Equilibrium Equations — Governing Differential Equations for Thermal problem.

One Dimensional Problems: One Dimensional Second Order Equations – Discretization-Element types – Derivation of Shape functions and Stiffness matrices and force vectors using FEM – Assembly of Matrices – Solution of problems from solid mechanics, heat transfer and fluid mechanics in one dimension.

Two Dimensional Problems: Second Order 2D Equations – Variational formulation – Finite Element formulation for Triangular elements (CST & LST) – Shape functions andelement matrices and vectors – Plane stress, plane strain and axisymmetric problems –Body forces and temperature effects – Stress calculations – Application to Field Problems in Structural and Thermal domain using 2D triangular elements.

Iso Parametric & Higher Order Elements: Rectangular Elements – Quadrilateral Elements – Natural co-ordinate systems – Isoparametric elements – Shape functions for Iso parametric elements – Formulation of stress strain & strain displacement relation forIso parametric Elements – Jacobian Matrix – Numerical integration using Gaussian Quadrature.- Six noded triangular Element- Eight noded Rectangular Element- Formulation of Shape functions in Natural coordinate system.

Textbook (s)

1. M.Asghar Bhatti, "Fundamental finite Element Analysis and Applications", John Wiley & Sons Inc, 2019
2. Singuresu S. Rao, "**Finite Element method in Engineering**", Fourth edition,Elsevier Science & Technology Books, Reprint 2021.
3. Daryl L. Logan A, **"First Course in the Finite Element Method**", Fourth Edition, Cengage Learning, 2020.

Reference Books

1. J.N.Reddy, "**An Introduction to the Finite Element Method"** Third Edition, McGraw- Hill Mechanical Engineering, Reprint, 2020.

2. Tirupathi R. Chandrupatla, Ashok D. Belagundu, "**Introduction to Finite Elements in Engineering**", Third Edition, Reprint, Prentice Hall, 2020.
3. R. D. Cook, D. S. Malkus, and M. E. Plesha, "**Concepts and Applications of FiniteElement Analysis**", Third Edition, John Wiley and Sons, New York, Reprint 2020.
4. O. C. Zienkiewicz and R. L. Taylor, "**The Finite Element Method: Volume 1 TheBasis**", 5th Edition, Butterworth-Heinemann, Oxford. Reprint 2019.
5. K. J. Bathe, "**Finite Element Procedures**", Second Edition, Prentice-Hall Inc.,Englewood Cliffs, New Jersey, Reprint 2019.
6. A J Davies, **"The Finite Element Method: An Introduction with Partial DifferentialEquations"**, Oxford Press, Second Edition, 2020
7. George R Buchanan, **"Schaum's outline on Finite Element Analysis",** Schaum"soutline series, 2020
8. G Lakshmi Narasaiah, **"Finite Element Analysis"**, BS Publications, 2008
9. David V Hutton, **"Fundamentals of Finite Element Analysis",** McGraw HillPublications, 2004
10. Zhuming Bi, **"Finite Element Analysis, Applications: A Systematic & PracticalApproach",** Elsevier Academic Press, 2020

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Functional Approximation Method:**	
1.1	Historical Background -Methods of Engineering Analysis- Numerical Methods	1
1.2	Mathematical modelling of field problems in Engineering - Governing Equations - Boundary, Initial and Eigen Value Problems	1
1.3	Weighted Residual Methods -Variational Formulation of BVP.	1
1.4	Rayleigh Ritz Technique	2
1.5	Procedure Involved in FEM – Types, Coordinate Systems,Meshing	1
1.6	Error Estimates, Adaptive Refinement, Advantages & Applications of FEM	1
2	**Theory of Elasticity**	
2.1	Degree of freedom, Rigid body motion, Discrete and Continuum Structures- Material Properties, Linear and Nonlinear Analysis - Stiffness & Flexibility	1
2.2	Principle of Minimum potential energy - Stress & Strain in 1D – Notation and Components - Strain Displacement relation - Stress Strain Relation for Plane Stress, Plane Strain and Axisymmetric category	1
2.3	Compatibility and Equilibrium Equations for Structural Problems, Governing Differential Equations of Thermal Problem	1
3	**One Dimensional Problems:**	
3.1	1D Second Order Equations - Discretization, Element Types	1
3.2	Derivation of shape functions and stiffness matrices and force vectors using FEM - Assembly of element Matrices	2
3.3	Solution of Problems from Solid Mechanics	3
3.4	Solution of problems from heat transfer in One Dimension	1
3.5	Solution of fluid mechanics problems in One Dimension	1
4	**Two Dimensional structural Problems**	
4.1	2D Second Order Equations - Variational Formulation -Constant triangle Triangular elements Shape function, element matrices – Linear strain triangle elements	2
4.2	Linear strain triangle elements - Shape function, element matrices	2
4.3	Plane stress, plane strain and axisymmetric problems - D matrix	1

No.	Topic	No. of Periods
4.4	Application to Field Problems in Structural domain using 2D triangular elements.	2
5	**Two Dimensional Problems**	
5.1	Plane stress, plane strain and axisymmetric problems - D matrix	1
5.2	Application to Field Problems in Structural domain using 2D triangular elements.	2
5.3	Application to Field Problems in Thermal domain using 2D triangular elements.	2
6	**Iso Parametric & Higher Order Elements**	
6.1	Rectangular Elements -Quadrilateral Elements - Natural co-ordinate systems - Isoparametric elements	1
6.2	Shape functions for Iso parametric elements	1
6.3	Formulation of stress strain & strain displacement relation for Iso parametric Elements	1
6.4	Numerical integration using Gaussian Quadrature	1
6.5	Six noded triangular Element- Eight noded Rectangular Element- Formulation of Shape functions in Natural coordinate system	2
	Total	**36**

Course Designers:

1. Dr. V. Balasubramani Associate Professor Mechanical Engineering vbmech@tce.edu
2. Mr. C.Vignesh Assistant Professor Mechanical Engineering cvmech@tce.edu

22ME770	SIMULATION AND ANALYSIS LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

Preamble

Finite element analysis (FEA) is the modeling of products and systems in a virtual environment, for the purpose of finding and solving potential (or existing) structural or performance issues.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Perform Structural analysis of beams, plane trusses, rectangular plate, corner bracket, and pressure vessels etc..	TPS3	70	65
CO2	Perform Thermal analysis of composite walls, composite cylinders. and pin fins	TPS3	70	65
CO3	Perform Dynamic analysis of mechanical components like beams and spring-mass damper system	TPS3	70	65
CO4	Perform Structural analysis of mechanical system like couplings and temporary joints.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	S	-	-	-	S	-	-	-	M	-	S
CO2	S	M	L	L	S	-	-	-	S	-	-	-	M	-	S
CO3	S	M	L	L	S	-	-	-	S	-	-	-	M	-	S
CO4	S	M	L	L	S	-	-	-	S	-	-	-	M	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

- Students are examined for 100 marks in simulation and analysis lab for terminal examination.
- Duration of terminal examination :3 Hours

Reference Books

1. Xiaolin Chen, Yijun Liu, "Finite Element Modeling and Simulation with ANSYS Workbench", Second edition, CRC press, 2014
2. Mary. Kathryn Thompson, John M. Thompson, "ANSYS Mechanical APDL for Finite Element Analysis", Butterworth-Heinemann, 2017
3. A. J. M Ferreira, "Matlab codes for Finite Element Analysis Solis and Structures", Springer, 2008

Course Contents and Lecture Schedule

Ex. No	List of Exercises	COs
1	**One dimensional structural Problems**	
1.1	Determination of the nodal deflections, reaction forces, stress and member forces in simple truss system	CO1
1.2	Determination of deflection, Shear force and bending moment for beams	
1.3	Stress analysis of rectangular plate with hole and without hole	
1.4	Stress analysis of corner bracket.	
1.5	Stress analysis of pressure vessels (Axi symmetric elements)	
2	**One dimensional thermal Problems**	
2.1	Determine the temperature distribution and thermal gradient distribution of Fin	CO2
2.2	Determine the temperature distribution and hear flux of a composite wall- one dimensional element	
2.3	Determine the temperature distribution and heat flux of a composite wall and composite cylinder	
3	**Dynamic analysis**	
3.1	Determine the natural frequency of loaded beams	CO5
3.2	Harmonic analysis of loaded beams.	
4	**Mechanical system**	
4.1	Stress analysis of couplings (Universal coupling, flange coupling, Muff coupling)	CO6
4.2	Stress analysis of temporary joints (Knuckle joint and screw joint)	
	TOTAL HOURS	

List of softwares to be used: ANSYS, ANSYS Workbench, FEAST, MATLAB

Course Designers:

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2. Mr. C.Vignesh Assistant Professor Mechanical Engineering cvmech@tce.edu

B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
ELECTIVE COURSES

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

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22MEPA0	ENERGY CONVERSION SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

The development of energy conversion systems is constrained by the depletion of fossil fuel, local environmental impacts, the problem of global warming and associated climate change and search for alternative fuels to reduce the dependence on imported oil. The energy sector is in transition and needs engineering, design, research and development inputs in building efficient conventional energy systems, cost effective renewable sources and conversion devices. This course is designed to enable the students to understand, demonstrate, and calculate the performance of various energy conversion systems and their applications. The course also focuses on combined use of fossil fuels and renewable energy for power generation.

Prerequisite

- Thermal Engineering

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain with a layout, the working of steam power plant with fuel handling and ash handling systems.	TPS2	70	70
CO2	Determine the performance parameters of Diesel enginepower plants.	TPS3	70	65
CO3	Determine the power developed and cycle efficiency of gas turbine power plants with reheating and regeneration.	TPS3	70	65
CO4	Determine the amount of heat transfer in solar thermal energy system and explain the working of various solar energydevices.	TPS3	70	65
CO5	Describe the working of non-renewable energy conversion systems such as nuclear power plants, wind mill and biofuelsystems.	TPS2	70	70
CO6	Calculate load factor, capacity factor, utilization factor andcost of power generation of power plants.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						S		M		L		S	
CO2	S	M	L					S		M		L		S	
CO3	S	M	L					S		M		L		S	
CO4	S	M	L					S		M		L		S	
CO5	M	L						S		M		L		S	
CO6	S	M	L					S		M		L		S	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20				-							2	7	-
CO2			40	10	40	25							2	7	12
CO3			40			25							2	7	12
CO4									40			25	2	7	12
CO5								20		10	40	-	1	7	-
CO6									40			25	1	7	12

Syllabus

Energy source: Review of energy sources.
Steam power plant: Layout, Working, coal handling, fuel firing, grate firing and pulverized fuel firing, Ash handling, dust collection draught and cooling systems Boilers-types - High pressure boilers: Working of La-Mont and Benson - accessories - Simple Fluidized bed boiler - advantages and Applications- cogeneration.
Diesel engine power plant: Layout Working principle, Components and sub systems- Supercharging - Applications, advantages and disadvantages, Performance analysis.
Gas turbine power plant: Layout of open and closed cycle plants- working, components and accessories Fuels and combustion chamber Performance analysis with reheating and regeneration- working of combined gas turbine and steam power plants.
Solar Energy: Solar Radiations and solar angles - latitude angle, declination angle, hour angle, zenith angle - Solar flat plate and concentrating type collectors performance analysis. Solar pond, Solar Still. Solar Thermal Power Plant, Photo Voltaic Cell.
Nuclear power plant: Principles of Nuclear reactions- Nuclear reactor types and working of reactors - Boiling water reactor (B.W.R.), Pressurized water reactor (P.W.R.) and Fast Breeder Reactor (FBR), CANDU type reactor- types of nuclear fuels and waste disposal.
Wind energy: Basic principle - Power in the wind- site selection- working of Horizontal and vertical axis wind mill.
Bio fuel Energy and Fuel Cell: Bio mass and vegetable oil for power generation Gasification- Biodiesel and its blends-fuel cell.
Power Plant Economics: Load curve - Average and Peak load Plant capacity factor and utilization factor - Cost of power generation - Selection of peak and base load power plant - Emission Regulations.

Textbook (s)

1. M.M. El-Wakil, **"**Power Plant Technology**"**, McGraw Hill, 2002.
2. A.K.Raja, Amit Prakash,Srivastava, ManishDwivedi,**"**Power Plant Engineering", New Age International Publishers, 2006.
3. Aldo V. Da Rosa **"**Fundamentals of Renewable Energy Process", Elsevier Academic Press, 2005.
4. Volker Quaschning, "Understanding Renewable Energy Systems", Earth scan, 2005.
5. Rajput R.K., "A Text Book of Power Plant Engineering", Laxmi Publications (P) Ltd., 2001.
6. Nag P.K., "Power Plant Engineering"- second edition, Tata McGraw Hill, New Delhi, 2001.
7. Rai G.D., Non- Conventional Energy Sources, Khanna Publishers, New Delhi, 1995.

Reference Books & Web Resources

1. John R Fanchi, "Energy in the 21st Century", World Scientific Publishing Co. Pvt Ltd, 2005.
2. John R Fanchi, "Energy – Technology and directions for future", Elsevier Academic Press, 2004.
3. David Pimentel, "Bio Fuels, Solar and Wind as Renewable Energy Systems", Springer, 2008.
4. Bent Sorensen, "Renewable Energy", Elsevier Academic Press, 2004.
5. https://www.youtube.com/watch?v=PCv4S9EtHxE - Thermal Power Plant and Coal/Ash Handling
6. https://nptel.ac.in/courses/112103262/ - IC Engines and Gas Turbine Dr. Pranab K. Mondal, IIT Guwahati
7. https://www.youtube.com/watch?v=uulD0KVkmWg – CET, IIT Kharagpur
8. https://nptel.ac.in/courses/121106014/ Non conventional Energy resources, Prof. Pratap Haridoss,

9. https://www.youtube.com/watch?v=mpHZWYpKDJg, Energy resources and Technology Prof.S.Banerjee ,
10. https://nptel.ac.in/courses/112105221/Energy conservation and waste heat recovery, prof, Anatharoop bhattachararya, IIT Kharagpur

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**Steam Power Plant:**	
1.1	Review of Energy Sources	1
1.2	Layout – Working, coal handling, fuel firing – grate firing and pulverised fuel firing, Ash handling, dust collection, draught and cooling systems	3
1.3	Boilers – types - High pressure boilers: Working of La-Mont and Benson - accessories	1
1.4	Simple Fluidized bed boilers, advantages and Applications. cogeneration	1
2.	**Diesel engine power plant:**	
2.1	Layout – Working principle, Components and sub systems	1
2.2	Supercharging - Applications, advantages and disadvantages	1
2.3	Performance analysis	3
3.	**Gas turbine power plant:**	
3.1	Layout of Open and closed cycle plants- working, components and accessories	1
3.2	Fuels and combustion chamber	1
3.3	Performance analysis with reheating and regeneration	3
3.4	Working of combined gas turbine and steam power plant	1
4.0	**Solar Energy:**	
4.1	Solar Radiations and solar angles - latitude angle, declination angle, hour angle, zenith angle	1
4.2	Solar Collectors - working of flat plate and concentrating type- performance analysis	3
4.3	Solar pond, Solar Still	1
4.4	Solar Thermal Power Plant, Photo Voltaic Cell-working	1
5.	**Nuclear power plant:**	
5.1	Principles of Nuclear reactions- Nuclear reactor types	1
5.2	Working of Reactors - Boiling water reactor (B.W.R.), Pressurised water reactor (P.W.R.) Fast Breeder Reactor (FBR) and CANDU type reactor	1
5.3	Types of nuclear fuels and waste disposal.	1
	Wind energy:	
5.4	Basic principle- Power in the wind- Site selection	1
5.5	Working of Horizontal and vertical axis wind mill.	1
	Biofuel Energy and Fuel Cell:	
5.6	Bio mass and Vegetable oil for power generation	1
5.7	Gasification	1
5.8	Biodiesel and its blends, Fuel Cell	1
6	**Power Plant Economics:**	
6.1	Load curve - Average and Peak load – Plant capacity factor and utilization factor	1
6.2	Cost of power generation	3
6.3	Selection of peak and base load power plant	1
6.4	Emission Regulations	
	Total	**36**

Course Designers

1.	Prof.K.Srithar	Professor	Mechanical Engineering	ksrithar@tce.edu
2.	Prof.P.Maran	Professor	Mechanical Engineering	pmmech@tce.edu

22MEPB0	REFRIGERATION AND AIR CONDITIONING

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Refrigeration deals with cooling of bodies (or) fluids to temperatures lower than surroundings temperature. Air conditioning involves control of temperature, humidity, cleanliness of air and its distribution to meet the comfort requirements of human beings and/or some industrial requirements. Air conditioning has made the living conditions more comfortable, hygienic and healthy in offices, work places and homes. The objectives of this course are to understand the functioning of various components of refrigeration and air-conditioning systems, to analyse the performance of air and vapour compression refrigeration cycles and various psychrometric processes and to estimate the cooling load of air conditioned space.

Prerequisite

- Thermodynamics
- Thermal Engineering

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the COP of air refrigeration cycle.	TPS3	70	65
CO2	Determine the COP of the Vapour Compression Refrigeration cycle and explain the working of various refrigeration systems	TPS3	70	65
CO3	Explain the working of components of Vapour Compression Refrigeration system and select environmentally benign refrigerants	TPS2	70	70
CO4	Determine the mass and energy transfer of various Psychrometric Process.	TPS3	70	65
CO5	Explain the functioning of air conditioning systems and understand the requirements of comfort air conditioning.	TPS2	70	70
CO6	Calculate the cooling load of an airconditioned space	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L					M		M				S	
CO2	S	M	L					M		M				S	
CO3	S	M	L					M		M				S	
CO4	S	M	L					M		M				S	
CO5	S	M	L					M		M				S	
CO6	M	M	L					M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40			30							2	5	10
CO2			40	10	30	30							2	5	10
CO3		20											6	5	-
CO4									40			30	2	5	10
CO5								20		10	30		6	5	-
CO6									40			30	2	5	20

Syllabus

Review of thermodynamic principles of refrigeration.

Air cycle refrigeration

Bell-Coleman cycle - ideal and actual, numerical problems. Aircraft cooling system simple and bootstrap systems.

Vapour compression refrigeration:

Working, p-h and T-s diagrams, Vapour compression refrigeration cycle: ideal and actual- Innovative VCR systems- cascade, Multistage compression - Vapour absorption refrigeration: Ammonia Water system, Lithium-Bromide Water system, Electrolux system- Solar refrigeration system-Thermoelectric and Vortex tube refrigeration. Liquefaction of gases- Linde and Claude system.

Vapour compression Refrigeration components and refrigerants:

Compressors: Types based on operation and based on arrangement - Condensers: Types- air cooled, water cooled and evaporative condensers- Evaporators: Flooded and dry expansion types - Expansion valves: Capillary type, Automatic expansion valve, Thermostatic expansion valve- Refrigerants: Properties and Selection, Eco friendly refrigerants- Ozone Depletion Potential (ODP) and Global Warming Potential (GWP).

Psychrometric process:

Review of fundamental properties of psychrometry, Psychrometric chart, Psychrometric processes, Bypass factor, Apparatus Dew Point (ADP) temperature, numerical problems.

Air Conditioning Systems:

Air conditioning definition, standards of temperature, humidity and air motion, components of air conditioning system - types and function. Summer, winter and year-round air conditioners, Window, Split air conditioners, Cassette type Air Conditioners.Central air conditioner systems-VRF air conditioners, Packaged air conditioner.

Requirements of comfort air conditioning: oxygen supply, body heat and body moisture removal, sufficient air movement, purity of air. Selection of design inside condition thermal comfort, factors affecting thermal comfort, indices for thermal comfort, comfort chart. Selection of design outside condition.

Cooling Load Estimation:

Sensible and latent heat loads: Internal heat sources, heat transmission through building, load from occupants, Equipment load, load due to food storage, load due to solar radiation, infiltration, fresh air load, estimation of total load. Room and Grand sensible heat factors and Effective sensible factor. Cooling load calculations: return air mixing before conditioner and mixing after conditioner.

Application of refrigeration cold storage and process industries, Application of air-conditioning comfort, automobile and industrial.

Textbook (s)

1. C.P. Arora, “Refrigeration and Air Conditioning”, Fourth Edition,Tata Mc-Graw Hill, 2021.
2. W.F. Stoecker, J.W. Jones “ Refrigeration and Air Conditioning”, Mc-Graw Hill, 1984.
3. Ibrahim Dincer, “Fundamentals of Geometric Dimensioning and Tolerancing”, Third Edition, Cengage Learning, 2012.
4. R.K. Rajput, “Refrigeration and Air Conditioning”, Third Edition, S.K. Kataria and Sons, 2013.
5. Arora and Domkundwar, “A Course in Refrigeration and Air Conditioning”, Dhanpat Rai & Co Pvt. Ltd., 2018.

Data book

1. Domkundwar and Domkundwar, “Refrigeration and Air Conditioning Data book”, Dhanpat Rai & Co Pvt. Ltd., 2016.
2. Manohar Prasad, “Refrigeration and Air Conditioning Data book”, New Age International Pvt. Ltd., Third Edition, 2020.

Reference Books & Web Resources

1. Manohar Prasad, “Refrigeration and Air Conditioning”, Third Edition, New Age International Pvt. Ltd., Third Edition, 2020.
2. S.N. Sapali, “Refrigeration and Air Conditioning”, Second Edition, Prentice Hall India Learning Private Limited, 2013.
3. https://nptel.ac.in/courses/112105129/ - NPTEL Lecture Material
4. https://nptel.ac.in/courses/112105128/ - NPTEL Lecture Material
5.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Air cycle refrigeration:**	
1.1	Refrigeration Systems- Review of thermodynamic principles of refrigeration.	1
1.2	Bell-Coleman cycle - ideal and actual, numerical problems.	3
1.3	Aircraft coolingsystem simple and bootstrap systems.	2
2	**Vapour compression refrigeration:**	
2.1	Working, p-h and T-s diagrams, Vapour compression refrigeration cycle: ideal and actual	2
2.2	Innovative VCR systems - Cascade, Multistage compression refrigeration system.	1
2.3	Vapour absorption refrigeration: Ammonia Water system, Lithium-Bromide Water system, Electrolux system	1
2.4	Solar refrigeration system-Thermoelectric and Vortex tube refrigeration	1
2.5	Liquefaction of gases- Linde and Claude system.	1
3	**Vapour compression Refrigeration components and refrigerants:**	
3.1	Compressors: Types based on operation and based on arrangement - Condensers: Types- air cooled, water cooled and evaporative condensers	2
3.2	Evaporators: Flooded and dry expansion types -Expansion valves: Capillary type, Automatic expansion valve, Thermostatic expansion valve	2
3.3	Refrigerants: Properties and Selection, Eco friendly refrigerants	1
3.4	Ozone Depletion Potential (ODP) and Global Warming Potential (GWP).	1
4	**Psychrometric process:**	
4.1	Review of fundamental properties of psychrometry, Psychrometric chart	1
4.1.1	Psychrometric processes	2
4.2	Bypass factor, Apparatus Dew Point (ADP) temperature	1
4.3	numerical problems.	2
5	**Air Conditioning Systems:**	
5.1	Air conditioning definition, standards of temperature, humidity and air motion, components of air conditioning system-types and function.	1
5.2	Summer, winter and year-round air conditioners, Window,Split air	2

No.	Topic	No. of Periods
	conditioners, Cassette type Air Conditioners. systems	
5.3	Central air-conditioner, VRF air conditioners, Packaged air conditioner	1
5.4	Requirements of comfort air conditioning: oxygen supply, body heat and body moisture removal, sufficient air movement, purity of air. Selection of design inside condition thermal comfort, factors affecting thermal comfort, indices for thermal comfort, comfort chart. Selection of design outside condition.	2
6	**Cooling Load Estimation:**	
6.1	Sensible and latent heat loads: Internal heat sources, heat transmission through building, load from occupants, Equipment load, load due to food storage, load due to solar radiation, infiltration, fresh air load, estimation of total load. Room and Grand sensible heat factors and Effective sensible factor	1
6.2	Cooling load calculations: return air mixing before conditioner and mixing after conditioner.	4
6.3	Application of refrigeration cold storage and process industries, Application of air-conditioning comfort, automobile and industrial.	1
	Total	36

Course Designers

1.	Prof. A. Valan Arasu	Professor	Mechanical Engineering	avamech@tce.edu
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22MEPC0	COMPUTATIONAL FLUID DYNAMICS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Computational Fluid Dynamics (CFD) course provides an introduction to the use of computational techniques to analyze the fluid flow and heat transfer in engineering problems of practical interest. The conservative laws are applied as governing equations to model and simulate problems involving diffusion, convection and convection-diffusion with different boundary conditions using finite difference method and finite volume method. The course also gives the opportunity to learn and compare various numerical models and simulation techniques for turbulent flow and combustion process.

Prerequisite

- Partial Differential Equations and Numerical Methods
- Thermal Engineering
- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the different computational techniques and solutionprocedures for various heat and fluid flow problems.	TPS2	70	70
CO2	Determine the numerical solution for steady diffusionproblem using finite difference method.	TPS3	70	65
CO3	Analyse one dimensional unsteady diffusion using finitedifference method.	TPS4	70	60
CO4	Determine the numerical solution for one-, two- and three-dimensional diffusion problems using finite volume method.	TPS3	70	65
CO5	Analyse one dimensional convection-diffusion using finitevolume method.	TPS4	70	65
CO6	Explain the concepts, advantages and limitations of various turbulence models and combustion models.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L		M			S		M				L	
CO2	S	M	L		M			S		M				M	
CO3	S	M	L	L	M			S		M				S	
CO4	S	M	L		M			S		M				M	
CO5	S	M	L	L	M			S		M				S	
CO6	S	M	L		M			S		M				L	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1								Theory Assessment-2								Theory Terminal Examination			
	Assignment-1				CAT-1				Assignment-2				CAT-2							
TPS / COs	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
CO1		20															6	5	-	-
CO2			40		10	30	30										4	5	10	
CO3				40			20	10									2	5	10	5
CO4											40				30		4	5	10	
CO5												40	10	30	20	10	2	5	10	5
CO6										20							2	5	-	-

Syllabus

Basics of CFD:
Overview of CFD Definition, stages, applications. Fluid Flow -Continuum hypothesis, Lagarangian and Eulerian formulation, continuity and momentum equations for fluid flow in differential and integral forms. Energy equation for work and heat flow. Partial Differential Equations Initial and Boundary conditions. Computational Techniques: Definition and advantages Finite difference, Finite volume and Finite element.
Finite Difference Method for Steady State Diffusion Problem: Finite difference, schemes-forward, central and backward difference, properties of discretization schemes. FDM for steady state diffusion - one-dimensional(1-D), two dimensional (2-D) and three dimensional (3-D) steady state conduction problems,
Finite Difference Method for Unsteady State Diffusion Problem : Explicit and Implicit method, FDM for 1-D transient heat conduction problems, Numerical errors - solution criteria stability and convergence, grid independent test, types of grid.
Finite Volume Method for Steady State Diffusion Problem: Basics of Finite volume schemes Control volume, Fluxes, Gauss-Divergence Theorem, Finite Volume formulation for 1-D, 2-D and 3-DDiffusion problems.
Finite Volume Method for Steady Convection-Diffusion Problem: 1-D and 2-D steady convection diffusion Peclet number - SIMPLE Algorithm, pressure correction equation, Staggered gird.
CFD Applications:
Introduction, Turbulence models Concepts, Applications, advantages, limitations - One equation, two equations models of RSM, DNS, LES. Combustion models - Applications, advantages, limitations - Simple chemical reacting system model, Eddy break up model and probability distribution function model.

Textbook (s)

1. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat transfer ”, 2nd Edition, Narosa Publishing house, New Delhi, 2009
2. Versteeg H K “An Introduction to Computational Fluid Dynamics, The Finite Volume Method” 2nd edition Pearson, 2008.
3. Anderson, Jr., John D “Computational fluid Mechanics the Basics with Applications”, McGraw Hill Education, 2012.
4. Gautam Biswas and Somenath Mukherjee, “Computational Fluid Dynamics” Narosa Publishing House, 2013.

Reference Books & Web Resources

1. John F Wendt, “Computational Fluid Dynamics ”,Springer 2012.
2. https://nptel.ac.in/courses/112105045/ -Computational Fluid Dynamics by Professor Suman Chakravarty, IIT Kharagpur
3. https://nptel.ac.in/courses/112107079/ - Computational Fluid Dynamics by Professor Krishna M. Singh, IIT Madras
4. https://nptel.ac.in/courses/112104272/ - Turbulent Combustion Theory and Modeling by Professor Asok De, IIT Kharagpur

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.0	**Basics of CFD**	
1.1	Overview of CFD	1
1.2	Definition and stages	
1.3	Applications	1
1.4	Fluid Flow	
1.4.1	Continuum hypothesis	1
1.4.2	Lagarangian and Eulerian formulation	1
1.4.3	Continuity and momentum equations for fluid flow indifferential and integral forms	2
1.5	Energy equation for work and heat flow	1
1.6	Partial Differential Equations	1
1.7	Initial and Boundary conditions	
1.8	Computational Techniques Definition and advantages -finite difference, finite volume, finite element Methods	1
2.0	**Finite Difference Method for Steady State Diffusion Problem**	
2.1	Finite difference schemes: forward, central and backward difference	2
2.2	Properties of discretization schemes	1
2.3	FDM for Steady state diffusion one-dimensional (1- D), Two dimensional (2-D), Three dimensional (3-D) conductionProblems	3
3.0	**Finite Difference Method for Un-Steady State Diffusion Problem**	
3.1	Explicit and Implicit method	1
3.2	FDM for One dimensional transient state heat conduction problem	2
3.3	Numerical errors	1
3.4	solution criteria stability and convergence, grid independent test, types of grid	2
4.0	**Finite Volume Method for Steady State DiffusionProblem**	
4.1	Basics of Finite volume schemes control volume, fluxes,	1
4.2	Gauss Divergence Theorem	1
4.3	Finite Volume formulation: 1-D steady,2-D and 3-D steadystate heat transfer	3
5.0	**Finite Volume Method for Steady State Convection-Diffusion Problem**	
5.1	1-D and 2-D steady Convection Diffusion	2
5.2	Peclet number	1
5.3	SIMPLE Algorithm, pressure correction equation,Staggered gird	2
6.0	**CFD Applications**	
6.1	Introduction, Concepts of different models, Applications.	1
6.2	**Turbulence model**	
6.2.1	Advantages and Limitations of One equation and two equations models of RSM	1
6.2.2	Advantages and Limitations of DNS, LES	1
6.3	**Combustion model**	
6.3.1	Advantages and Limitations of Simple chemical reacting system model	1
6.3.2	Advantages and Limitations of Eddy break up model	1
6.3.3	Advantages and Limitations of Probability Distribution Function model.	
	Total	**36**

Course Designers

1.	Prof.P.Maran	Professor	Mechanical Engineering	pmmech@tce.edu
2.	Dr.M.S.Govardhanan	Assistant Professor	Mechanical Engineering	govardhanans@tce.edu

22MEPE0	DESIGN OF THERMAL SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

The design of thermal systems requires a unified approach that treats thermodynamics, fluid mechanics, and heat transfer as parts of one interconnected area, in which suitable solutions to real-life design and analysis problems can be obtained only when all these aspects are considered simultaneously. Thermal systems that include heat exchanger, refrigeration and air-conditioning systems, combustion system, solar thermal systems are dealt with.

Prerequisite

- Thermal Engineering
- Fluid Mechanics
- Heat and Mass Transfer

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Develop heat exchangers for steam, refrigeration and automobile radiators.	TPS3	70	65
CO2	Develop a cooling tower design and evaluate its performance.	TPS3	70	65
CO3	Calculate the performance of a furnace using the direct and indirect methods.	TPS3	70	65
CO4	Design and performance analysis of solar liquid flat plate collector.	TPS3	70	65
CO5	Design and performance evaluation of solar air heaters	TPS3	70	65
CO6	Evaluate the various loads in a cold storage system.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L										S	
CO2	S	M	L	L										S	
CO3	S	M	L	L										S	
CO4	S	M	L	L										S	
CO5	S	M	L	L										S	
CO6	S	M	L	L										S	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40	5	10	20							4	5	10
CO2			30	5	10	20							4	5	8
CO3			30	5	10	15							4	5	8
CO4									40	5	10	20	4	5	8
CO5									20	5	10	20	2	5	8
CO6									40	5	10	15	2	5	8

Syllabus

Heat Exchangers: Classification of Steam Condensers-Jet Condenser and Surface Condenser – Classification of refrigerant condensers- Air-Cooled Condenser and Water-Cooled Condenser, Vacuum efficiency and Condenser efficiency – Heat transfer in Condenser- heat transfer in the condensing fluid (hot fluid), heat transfer through the wall, heat transfer through the layer of scale, heat transfer through the cold fluid –Heat transfer in Automobile radiators.

Design of Cooling Tower: Factors affecting cooling of water in a cooling tower- Classifications of cooling tower-Induced draught cooling tower, Natural draught cooling tower-Cooling range and approach-Performance analysis of a cooling water.

Design of Furnaces: Types and classification of different furnaces, Characteristics of an efficient furnace, Performance evaluation of a typical furnace- Direct and indirect method.

Design of Solar flat-plate collectors: General description of flat-plate collectors-Liquid collector & Air collector – Thermal losses- Conductive, convective and radiative losses, Energy balance equation. Efficiency of flat-plate collector- collector efficiency, instantaneous solar collector efficiency, collector heat removal factor, flat-plate collector efficiency improvement, Thermal analysis of flat-plate collector and useful heat gained by the fluid, collector performance, effect of dusting and shading, selection of materials for flat-plate collectors.

Design of flat-plate air heating collectors (Solar air heaters):Variables for design of air heaters, types of air heaters, performance of solar air heaters, Application of solar air heaters, heating and drying of agricultural products, theory of solar drying, moisture content and its measurement, Mass and heat balance in gain drying, Heat utilization factor (HUF), methods of grain drying.

Design of cold storage system: Types of Cold storage, Refrigeration system-Safety measures - Refrigeration load calculations-Transmission load, Load due to workmen-Air change load-Electrical load-Product load

Text Books

1. R.K. Rajput, "**Thermal Engineering**", Eleventh Edition, Laxmi Publications, 2020.
2. P.K. Nag, "**Power Plant Engineering**", Fourth Edition, Mc-Graw Hill Educations, 2017.
3. R.K. Rajput, "**A text book of Refrigeration and Air Conditioning**", Reprint, S.K. Kataria& Sons, 2013.
4. G.D. Rai, " solar energy utilization", Fifth edition, Khanna Publishers,2005

Reference Books &Web Resources

1. ISHRAE Refrigeration Hand Book-2015
2. https://beeindia.gov.in/sites/default/files/3Ch7.pdf
3. https://www.beeindia.gov.in/sites/default/files/2Ch4.pdf

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Heat Exchangers**	
1.1	Classification of Steam Condensers-Jet Condenser and Surface Condenser – Classification of refrigerant condensers- Air-Cooled Condenser and Water-Cooled Condenser	2
1.2	Vacuum efficiency and Condenser efficiency – Heat transfer in Condenser- heat transfer in the condensing fluid (hot fluid), heat transfer through the wall, heat transfer through the layer of scale, heat transfer through the cold fluid – Problems	3
1.3	Heat Transfer in Automobile radiators	1
2	**Design of Cooling Tower**	
2.1	Factors affecting cooling of water in a cooling tower- Classifications of cooling tower-Induced draught cooling tower, Natural draught cooling tower	2
2.2	Cooling range and approach-Performance analysis of a cooling water, problems	4
3	**Design of Furnaces**	
3.1	Types and classification of different furnaces,	2
3.2	Characteristics of an efficient furnace, Performance evaluation of a typical furnace- Direct and indirect method.	4
4	**Design of Solar liquid flat-plate collectors**	
4.1	General description of flat-plate collectors-Liquid collector & Air collector – Thermal losses- Conductive, convective and radiative losses, Energy balance equation.	2
4.2	Efficiency of flat-plate collector- collector efficiency, instantaneous solar collector efficiency, collector heat removal factor, flat-plate collector efficiency improvement,	2
4.3	Thermal analysis of flat-plate collector and useful heat gained by the fluid, collector performance, effect of dusting and shading, selection of materials for flat-plate collectors.	2
5	**Design of flat-plate air heating collectors (Solar air heaters)**	
5.1	Variables for design of air heaters, types of air heaters, performance of solar air heaters	2
5.2	Application of solar air heaters, heating and drying of agricultural products, theory of solar drying, moisture content and its measurement	2
5.3	Mass and heat balance in gain drying, Heat utilization factor (HUF), methods of grain drying	2
6	**Design of cold storage system**	
6.1	Types of Cold storage, Refrigeration system-Safety measures	2
6.2	Refrigeration load calculations: Transmission load, Load due to workmen-Air change load	2
6.3	Electrical load, Product load	2
	Total	36

Course Designers

1. Dr.A.ValanArasu Professor Mechanical Engg. avamech@tce.edu
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3. Dr.P.Maran Professor Mechanical Engg. pmmech@tce.edu
4. Dr.M.S.Govardhanan Asst. Professor Mechanical Engg. govardhanans@tce.edu

22MEPF0	DESIGN OF HYDRAULIC AND PNEUMATIC CIRCUITS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

This course aims to provide exposure to the function of hydraulic and pneumatic components, its selection and application in the design of hydraulic and pneumatic circuits. Design of Electrical and PLC based pneumatic and hydraulic circuits helps the students in developing an innovative automation system.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the properties of hydraulic fluids and air required forhydraulic and pneumatic systems.	TPS2	70	70
CO2	Select suitable pumps, motors and cylinders for the statedapplications.	TPS3	70	65
CO3	Calculate speed, pressure, flow and power for the fluid power rcircuits	TPS3	70	65
CO4	Design the Hydraulic circuits for the given application	TPS3	70	65
CO5	Design the pneumatic circuits for the given application	TPS3	70	65
CO6	Design the pneumatic circuit using logic and ladder diagram, wiring diagram for the given application	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			30	8	10									5	
CO2			30	8	10	25							2	5	10
CO3			40	4	10	25							2	5	10
CO4									30	4	10	20	2	5	10
CO5									30	8	10	20	2	5	10
CO6									40	8	10	10	2	5	10

Syllabus

INTRODUCTION: Need for Automation, Hydraulic, pneumatic – Properties of hydraulic fluids – General types of fluids – Applications of Pascals Law- Properties of air Kinetic theory of gases – Boyle"s Law - Laminar and Turbulent flow – Reynold"s number Selection criteria.

FLUID POWER GENERATING / UTILIZING ELEMENTS: Hydraulic pumps and motor- gear, vane, piston pumps - Motors -motors-selection and specification- Pump performance – Variable displacement pumps . Drive characteristics – Compressors – Filter, Regulator, Lubricator Unit – Air control valves -Linear actuator – Single acting, Double acting special cylinders like tanden, Rodless, Telescopic, Cushioning mechanism, Construction of double acting cylinder, Limited rotation motor, mounting details, power packs – construction. Reservoir, accumulators — standard circuit symbols.

CONTROL AND REGULATION ELEMENTS: Direction flow and pressure control valves- Directional control valve — 3/2 way valve — 4/2 way valve — 5/2 way valve . Shuttle valve — check valve . Pressure control valve — Simple and compound relief valve , Pressure reducing valve, sequence valve, counter balance valve. Flow control valve Fixed and adjustable. Methods of actuation, electro hydraulic servo valves - Different types- characteristics and performance

HYDRAULIC CIRCUITS : Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits design methodology- design and selection of components - safety and emergency mandrels – Cascade method – Case Studies on Engineering Applications.

PNEUMATIC CIRCUITS: switching circuits - fringe conditions modules and these integration sequential circuits - cascade methods - mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map

ELECTRICAL CONTROL OF PNEUMATIC CIRCUITS – Use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design – use of PLC in hydraulic and pneumatic circuits – Fault finding– application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

Textbook (s)

1. Anthony Esposito, “Fluid Power with Applications”, Prentice Hall, 2009.
2. Jagadeesha T, “Pneumatics Concepts, Design and Applications”, Universities Press, 2015.

Reference Books & Web Resources

1. Andrew Parr, Hydraulics and Pneumatics: A technician's and engineer'sguide [Kindle Edition]
2. W.Bolton, Mechatronics, Electronic control systems in Mechanical andElectrical Engineering Pearson Education, 2011.
3. James L. Johnson “Introduction to Fluid Power” Delmar Thomson Learning Publishers 2003.CMTI Handbook
4. Prof. Somashekhar S, “ Oil Hydraulics and pneumatics” – IIT Madras , Chennai - https://archive.nptel.ac.in/courses/112/106/112106300/#

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**INTRODUCTION:**	
1.1	Need for Automation, Hydraulic, pneumatic circuits	1
1.2	Properties of hydraulic fluids – General types of fluids – Applications of Pascals Law- Properties of air Kinetic theory of gases	1
1.3	Boyle"s Law - Laminar and Turbulent flow – Reynold"s number Selection criteria.	1
2	**FLUID POWER GENERATING / UTILIZING ELEMENTS:**	
2.1	Hydraulic pumps and motor- Gear, vane, piston pumps - Reservoir,	1
2.2	Motors -types of motors-selection and specification-	1
2.3	Pump performance – Variable displacement pumps . Drive characteristics	1
2.4	Compressors – Filter, Regulator, Lubricator Unit – Air control valves -Linear actuator – Single acting, Double acting special cylinders like tanden, Rodless, Telescopic, Cushioning mechanism,	2
2.5	Construction of double acting cylinder, Limited rotation motor, mounting details, power packs – construction.	1
2.6	Accumulators – standard circuit symbols.	1
3	**CONTROL AND REGULATION ELEMENTS:**	
3.1	Direction flow and pressure control valves- Directional control valve – 3/2 way valve – 4/2 way valve – 5/2 way valve .,	1
3.2	Shuttle valve – checkvalve. Pressure control valve — Simple and compound relief valve	1
3.3	pressure reducing valve, sequence valve, counter balance valve. Flow control valve Fixed and adjustable .	1
3.4	Methods ofactuation, electro-hydraulic servo valves - Different types- characteristics and performance	2
4	**HYDRAULIC CIRCUITS**	
4.1	Reciprocation, quick return, sequencing, synchronizing circuits	1
4.2	Accumulator circuits - industrial circuits - Press circuits	1
4.3	Hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits design methodology	1
4.4	Design and selection of components - safety and emergency mandrels – Cascade method - Case Studies on Engineering Applications	1
5	**PNEUMATIC CIRCUITS**	
5.1	Switching circuits - fringe conditions modules and these integration	1
5.2	Sequential circuits - cascade methods - mapping methods	2
5.3	Step counter method - compound circuit design	2
5.4	Combination circuit design- Karnaugh - Veitch map	1
6	**ELECTRICAL CONTROL OF PNEUMATIC CIRCUITS**	
6.1	Use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design	2
6.2	Use of PLC in hydraulic and pneumatic circuits – Fault finding– application -fault finding	1
6.3	Hydro pneumatic circuits - use of microprocessors for sequencing	1
6.4	PLC, Low-cost automation - Robotic circuits	1
	Total	**36**

Course Designers

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22MEPK0	MANUFACTURING OF COMPOSITE MATERIALS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. Composite materials are preferred over traditional materials for their properties which are stronger, lighter or less expensive. This course covers the fundamentals of composite materials and manufacturing g of various composite materials.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the classification, characteristics and the applications ofcomposites in various domains	TPS2	70	70
CO2	Summarize the various Reinforcements and Matrix used in compositematerials	TPS2	70	70
CO3	Select the appropriate processing method for polymer matrixcomposites	TPS3	70	65
CO4	Select the proper fabrication method for metal matrix composites	TPS3	70	65
CO5	Choose the suitable processing method in ceramic matrix compositesand carbon- carbon Composites	TPS3	70	65
CO6	Choose the suitable processing method in Nanocomposites	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1.	S	M	L	M	-	-	-	M	L	L	-	-	L	-	L
CO2.	S	M	L	M	-	-	-	M	L	L	-	-	L	-	L
CO3.	S	M	L	M	-	-	-	M	L	L	-	-	M	-	M
CO4.	S	M	L	M	-	-	-	M	L	L	-	-	M	-	M
CO5.	S	M	L	M	-	-	-	M	L	L	-	-	M	-	M
CO6.	S	M	L	M	-	-	-	M	L	L	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			30	8	10								2	5	
CO2			30	8	10	25							2	5	
CO3			40	4	10	25							4	5	15
CO4									30	4	10	20	4	5	15
CO5									30	8	10	20	4	5	10
CO6									40	8	10	10	4	5	10

Syllabus

Composite Materials: Definition- Need-Classifications- Characteristics- Applications in various industries -Aircraft, Military, Space Applications, Automotive, Sporting Goods, Marine ,Infrastructure. Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight **Reinforcements and Matrix Materials** :Reinforcements -Types - Fibers– Glass fiber, Boron fiber,carbon fiber, organic fiber, ceramic and metallic fibers - whiskers–Fabrication of Glass fibre andcarbon fibre- Matrix materials– Polymers, Classification of Polymers — Properties of Thermo andThermosetting Plastics- Metals and ceramics and their properties – interfaces – Wettability – Types ofbonding at the interface — Physical and chemical properties.

Manufacturing of Polymer Matrix Composites: Polymer matrix composites: hand layup, spray up technique,filament winding, Pultrusion, resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet Moulding Compound – thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding – interfaces in PMCs - Mechanical properties and application of PMCs – recycling of PMCs.

Manufacturing of Metal Matrix Composites: Metallic matrices: Aluminum, titanium, magnesium, copperalloys – Processing of MMCs: liquid state, Solid state, in situ fabrication techniques – diffusionbonding – powder metallurgy techniques - interfaces in MMCs – mechanical properties – machiningof MMCs — Applications.

Manufacturing of Ceramic Matrix Composites (CMC) and Carbon-Carbon Composites: Processingof CMC: cold pressing, sintering, reaction bonding, liquid infiltration, lanxide process –In situ chemical reaction techniques: chemical vapour deposition, chemical vapour impregnation, sol-gel method – Interfaces in CMCs — mechanical properties and applications of CMCs — Carbon-carbon Composites – Carbon Fiber Reinforcements Matrix Systems -Processing of Carbon-Carbon Composites -Properties and applications.

Manufacturing of Nanocomposites - Classifications - Polymer Nanocomposites -Clay–Polymer Nanocomposites -Graphite–Polymer Nanocomposites - Nanofiber-Reinforced Composites - Particulate Nanocomposites -Organic–Inorganic Hybrids (Nano-composites) - Applications of Polymer Nanocomposites - Metal Matrix Nanocomposites - Processing of Metallic Nanocomposites - Properties and applications.

Textbook (s)

1. M. Balasubramanian ,**Composite materials and Processing**, Taylor & Francis Group, LLC, CRCPress, 2014.
2. Krishnan K Chawla, Composite **Materials: Science and Engineering**, International Edition,Springer, 2012

Reference Books & Web Resources

1. Mallick P.K., Fiber Reinforced Composites: Materials, Manufacturing and Design, CRC press, New Delhi, 2010.
2. Mallick, P.K. and Newman.S., Composite Materials Technology, Hanser Publishers, 2003.

3. Bhagwan D. Agarwal and Lawrence J. Broutman, Analysis and Performance of Fiber Composites, John Wiley and Sons Indian Edition, 2018.
4. Prof.J. Ramkumar,“ Manufacturing of composites”, NPTEL,IIT Kanpur - https://nptel.ac.in/courses/112104221/
5. Prof.Nachiketa Tiwari,“Introduction to composites”, NPTEL, IIT Kanpur https://nptel.ac.in/courses/112104168/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Composite Materials**	
1.1	Definition- Need-Classifications- Characteristics	1
1.2	Applications -Aircraft and Military Applications, Space Applications, Automotive Applications, Sporting Goods Applications, Marine Applications,Infrastructure	1
1.3	Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight	2
2	**Selection of engine and transmission for an automobile**	
2.1	Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - whiskers	1
2.2	Polymers, Classification of Polymers - Properties of Thermoand Thermosetting Plastics -metals and ceramics and their properties – interfaces – Wettability	2
2.3	Metals and ceramics and their properties - interfaces - Wettability	1
2.4	Types of bonding at the interface	1
2.5	Physical and chemical properties	1
3	**Manufacturing of Polymer Matrix Composites**	
3.1	Manufacturing methods: Polymer matrix composites: hand layup, Spray up technique , filament winding, Pultrusion	2
3.2	Resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet moulding Compound	2
3.3	Thermoplastic matrix composites — film stacking, diaphragm forming, thermoplastic tape laying, injection moulding interfaces in PMCs	1
3.4	Mechanical properties and application of PMCs	1
3.5	Recycling of PMCs	1
4	**Manufacturing of Metal Matrix Composites:**	
4.1	Metallic matrices: Aluminium, titanium, magnesium, copper alloys	1
4.2	Processing of MMCs: liquid state, Solid state, in situ fabrication techniques - Diffusion bonding- powder metallurgytechniques	2
4.3	Interfaces in MMCs	1
4.4	Mechanical properties	1
4.5	Machining of MMCs – Applications.	1
5	**Manufacturing of Ceramic Matrix Composites (CMC) and Carbon-Carbon Composites**	
5.1.1	**Manufacturing of CMCs:** Cold pressing, Sintering, Reaction bonding, Liquid infiltration method	1
5.1.2	Lanxideprocess –In situ chemicalreaction techniques: Chemical vapour deposition, Chemical vapour impregnation, Sol-gel methods	1
5.2	Interfaces in CMCs —	1
5.3	Mechanical properties and applications of CMCs	

No.	Topic	No. of Periods
5.4	**Manufacturing of Carbon- Carbon Composites**: Carbon-carbon Composites – Carbon Fiber Reinforcements-Matrix Systems -	1
5.5	Carbon-Carbon Composites -Mechanical Properties and applications.	2
5.1.1	**Manufacturing of CMCs:** Cold pressing, Sintering, Reaction bonding, Liquid infiltration method	1
5.1.2	Lanxide process –In situ chemical reaction techniques: Chemical vapour deposition, Chemical vapour impregnation, Sol-gel methods	1
5.2	Interfaces in CMCs	1
5.3	Mechanical properties and applications of CMCs	
5.4	**Manufacturing of Carbon- Carbon Composites**: Carbon-carbon Composites – Carbon Fiber Reinforcements-Matrix Systems -	1
6	**Nanocomposites**	
6.1	Nanocomposites - Classifications - Polymer Nanocomposites -Clay Polymer Nanocomposites -GraphitePolymer Nanocomposites - Nanofiber-Reinforced Composites -ParticulateNanocomposites..	2
6.2	Organic–Inorganic Hybrids (Nano-composites) - Applications of Polymer Nanocomposites -	2
6.3	Metal Matrix Nanocomposites - Processing of Metallic Nanocomposites -applications -properties	1
	Total	36

Course Designers

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22MEPL0	DESIGN FOR SHEET METAL PROCESSING

Category	L	T	P	C	Terminal Exam Type
PSE	2	1	-	3	Theory

Preamble

Sheet metal is one of the most versatile material in the manufacturing industry. It is made from steel, aluminium, brass, copper, tin, nickel, titanium and precious metals. And its uses expand across many different industries including transportation, aerospace, domestic appliances, consumer electronics, industrial furniture, farm equipment, body panels for modern vehicles, machinery, metal sinks, beverage cans and more. Sheet metal can be shaped in many different ways to meet many different requirements. The technology uses a variety of materials and a wide range of processes for shaping finished components and products. Sheet metal manufacturing produces parts that typically have high strength, good surface and accurate tolerances. This course covers the various sheet metal processes and provides essential basic theoretical knowledge required for designing sheet metal parts.

Prerequisite

- Mechanics of Materials

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the various types of sheet metal cutting operations, presses, accessories and cutting dies.	TPS2	70	70
CO2	Develop strip layout and determine stripping force & cutting force for a given part.	TPS3	70	65
CO3	Design press tool die sets with required elements for a given part with cutting operations.	TPS3	70	65
CO4	Explain the various sheet metal non-cutting operations and types of non-cutting dies.	TPS2	70	70
CO5	Determine blank length, bending force, blank size, no of draws and drawing force for a given part.	TPS3	70	65
CO6	Design press tool die sets with required elements for a given part with non-cutting operations.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	L	-	-	-	S	-	-
CO3	S	M	L	-	-	-	-	-	L	L	-	-	S	-	M
CO4	M	L	-	-	-	-	-	-	-	-	-	-	--	-	-
CO5	S	M	L	-	-	-	-	-	L	-	-	-	S	-	-
CO6	S	M	L	-	-	-	-	-	L	L	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / Cos	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	10	20	-	-	-	-	-	-	-	6	10	-
CO2	-	-	30	-	10	20	-	-	-	-	-	-	2	-	10
CO3	-	-	50	-	-	40	-	-	-	-	-	-	2	-	20
CO4	-	-	-	-	-	-	-	20	-	10	20	-	6	10	-
CO5	-	-	-	-	-	-	-	-	40	-	10	20	2	-	10
CO6	-	-	-	-	-	-	-	-	40	-	-	40	2	-	20

Syllabus

Sheet Metal Cutting operations: Types of Cutting operations, Simple Press – Construction, Press types for utensils manufacture and Specifications, Cutting action in Punch and Dies, Die Clearance, Types of Dies – Simple, Compound, Progressive and Combination dies, Punches, Press Accessories - Pilots, Strippers and Pressure Pads - Functions, Defects, causes and remedies in Cutting Operations.
Calculation of parameters for cutting operations: Development of Strip Layout, Stock Utilization, Centre of Pressure, Calculation of Stripping Forces and Cutting Forces.
Die design for cutting operations: Principle of die set design, Die and Punch Design for Cutting operations – Simple Die, Compound Die and Progressive Die,
Sheet Metal Non-Cutting Operations: Types of Non-Cutting operations, Types of Bending Dies, Bending Parameters, Types of Forming Dies, Types of Drawing Dies, Drawing parameters, Defects, causes and remedies in non-cutting operations.
Calculation of parameters for non-cutting operations: Determination of Blank length for bending, Calculation of Bending Force, Determination of Blank size for drawing, Calculation of Drawing Force, Determination of Number of Draws.
Die design for non-cutting operations: Principle of die set design for non-cutting operations, Die and Punch Design for Drawing, Die and Punch Design – Combination Die.

Textbooks

1. Cyril Donaldson, George H LeCain, V C Goold and Joyjeet Ghose, **"Tool Design"**, McGraw Hill Education Pvt. Ltd, New Delhi, Fourth Edition, 2012.
2. Serope Kalpakjian and Steven R. Schmid, "**Manufacturing Engineering and Technology**", Addition Wesley Longman Pvt. Ltd., First Indian reprint, 2000.

Reference Books & Web Resources

1. Nagpal, G.R, **"Tool Engineering & Design"**, Khanna Publishers, Delhi, Sixth edition, Fourth Reprint, 2011.
2. Eugene Ostergaard, **"Basic Die making"**, McGraw Hill Education Pvt. Ltd, New Delhi, 2013.
3. **"Design Data Handbook"**, PSG College of Technology, Coimbatore, 2016.
4. Semiatin, S.L, "**ASM Handbook Volume 14B: Metalworking: Sheet Forming",** 2006.
5. ASTM, **"Fundamentals of Tool Design"**, Prentice Hall of India, 2003.
6. P H JOSHI, **"Press Tools Design and Construction",** S Chand & Company, 2017.
7. **"NTTF Press Tool Standards"** - https://archive.org/stream/NttfPressToolStandardsEBookGeneralCopy/Nttf-Press-Tool-Standards-eBook-General-Copy_djvu.txt
8. **Mod-1 Lec-10 Sheet Metal Working – Presses -** https://www.youtube.com/watch?v=0z7dYQHhQUI
9. **Principle of Mechanical Press -** https://www.youtube.com/watch?v=6KsqVKGvgrg
10. **Sheet Metal Operations - Part-1** - https://www.youtube.com/watch?v=L0YgSmfwzWY
11. Prof. A. De, **"Design for sheet metal forming processes"** - https://nptel.ac.in/courses/112/101/112101005

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Sheet Metal Cutting operations**	
1.1	Types of Cutting operations	1
1.2	Simple Press-Construction	1
1.3	Press types for utensils manufacture and Specifications	1
1.4	Cutting action in Punch and Dies, Die Clearance	1
1.5	Types of Dies	1
1.6	Punches, Press Accessories – Functions,	1
1.7	Defects, causes and remedies in Cutting Operations	1
2	**Calculation of parameters for cutting operations**	
2.1	Development of Strip Layout	1
2.2	Stock Utilization	1
2.3	Centre of Pressure	1
2.4	Calculation of Stripping force and Cutting Forces	1
3	**Die design for cutting operations**	
3.1	Principle of die set design for cutting operations	2
3.2	Die and Punch Design for Cutting operations – Simple Die	2
3.3	Die and Punch Design for Cutting operations – Compound Die	2
3.4	Die and Punch Design for Cutting operations – Progressive Die	2
4	**Sheet Metal Non-Cutting Operations**	
4.1	Types of Non-Cutting operations	1
4.2	Types of Bending Dies, Bending Parameters	1
4.3	Types of Forming Dies	1
4.4	Types of Drawing Dies, Drawing parameters	1
4.5	Defects, causes and remedies in Non-Cutting Operations	1
5	**Calculation of parameters for non-cutting operations**	
5.1	Determination of Blank length for bending	1
5.2	Calculation of bending force	1
5.3	Determination of Blank size for drawing	1
5.4	Determination of Drawing Force and Number of Draws	1
6	**Die design for non-cutting operations**	
6.1	Principle of die set design for non-cutting operations	2
6.2	Die and Punch Design for drawing operations	3
6.3	Die and Punch Design – Combination Die	3
	TOTAL	**36**

Course Designers

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22MEPM0	NON-TRADITIONAL MACHINING PROCESSES

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Unconventional manufacturing processes is a group of manufacturing processes that remove excess material by various techniques involving mechanical, thermal, chemical energy or combinations of these energy sources. No sharp cutting tools are need to be used in order to complete the required manufacturing processes. Extremely hard and brittle materials are difficult to machine by conventional machining practices. Hence, it needs an alternative method over conventional machining processes. Unconventional processes are the viable solution and also it promotes longer tool life due to no direct contact between the tool and work material interface. Tools used in unconventional processes are more accurate and higher precision compared to conventional cutting tools. These processes are widely used where a lot of hard and brittle materials such as tungsten carbide, high speed steels, stainless steels, ceramics, etc. which cannot be processed by the conventional machining process.

Prerequisite

- Machining Processes

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the characteristics, energy sources and economics of advanced machining processes.	TPS2	70	70
CO2	Select a suitable mechanical energy based unconventional machining process for the given requirement.	TPS3	70	65
CO3	Choose a suitable thermoelectric energy based unconventional machining process for the given requirement.	TPS3	70	65
CO4	Describe chemical energy based machining processes.	TPS2	70	70
CO5	Explain electrochemical energy based machining processes.	TPS2	70	70
CO6	Identify a suitable high energy machining process for the given requirement.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-
CO4	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	6	10	-	-	-	-	-	-	-	2	6	-
CO2	-	-	40	7	15	20	-	-	-	-	-	-	2	6	13
CO3	-	-	40	7	15	20	-	-	-	-	-	-	2	6	13
CO4	-	-	-	-	-	-	-	30	-	6	25	-	6	8	-
CO5	-	-	-	-	-	-	-	30	-	7	25	-	6	8	-
CO6	-	-	-	-	-	-	-	-	40	7	10	20	2	6	14

Syllabus

Advanced Machining Processes: Reasons, Different energy sources, applications and comparison over conventional machining processes. General characteristics of advanced machining processes. Advantages, limitations and applications. Economics and trends in advanced machining processes.

Mechanical Energy based methods: Abrasive Jet machining (AJM) - Working principle, Equipment, process parameters & capabilities. Water Jet Machining (WJM) - Principle, Equipment, process parameters & capabilities. Abrasive Water Jet Machining (AWJM) - Principle, Equipment, process parameters & capabilities. Ultrasonic Machining (USM) - Working principle, Equipment, process parameters & capabilities. Comparison, Selection of suitable method based on the requirement.

Thermoelectric Energy based methods: Electrical Discharge Machining (EDM) - Principle, Equipment, dielectric fluid, electrode, process parameters, capabilities, design considerations and summary. Wire cut Electrical Discharge Machining (WEDM) – Working principle, Equipment, process parameters, capabilities and applications. Electron Beam Machining (EBM) - Principle, Equipment, process parameters & capabilities, Comparison, Selection of suitable method based on the requirement.

Chemical Energy based methods: Chemical Machining (CM) - Principle, process parameters, design considerations, Masking, Etching operation, applications. Photochemical Machining (PCM) – Principle, process parameters & capabilities. Comparison.

Electrochemical Energy based methods: Electrochemical Machining (ECM) - Working principle, Equipment, Electrolytes, ECM tools, process parameters, capabilities and applications. Electrochemical Grinding (ECG) – Principle, process parameters & capabilities. Comparison.

High Energy Machining Processes: Laser Beam Machining (LBM) - Working principle, Equipment, process parameters & capabilities. Ion Beam Machining (IBM) - Principle, Equipment, process parameters & capabilities. Plasma Beam Machining (PBM) - Principle, Equipment, process parameters & capabilities. Comparison, Selection of suitable method based on the requirement.

Textbook (s)

1. Gary F.Benedict, “Nontraditional Manufacturing Processes”, CRC Press, 2019.
2. Serope Kalpakjian and Steven R.Schmid, “Manufacturing Engineering and Technology”, Eighth Edition, Pearson Education, 2019.

Reference Books & Web Sources

1. Omkar. K and Samrat. P, “Non-Traditional Machining”, Notion Press, 2021
2. P.L.Jain, “Principles Of Foundry Technology”, Tata McGraw Hill, Fifth Edition, 2009.
3. Jagadeesha. T, “Non-Traditional Machining Processes”, IK International Publishing House Pvt. Ltd., 2016

NPTEL and other videos

1. https://youtu.be/cxU1zUOpGLk
2. https://youtu.be/Sfj8_9oRCNk
3. https://youtu.be/aWQsEX1TrSI
4. https://youtu.be/Vw-cUiBLuHw
5. https://youtu.be/jhM01_mwygg
6. https://youtu.be/eBg4hgbLW5s
7. https://youtu.be/L1D5DLWWMp8
8. https://youtu.be/4iB7kkCy1xM
9. https://youtu.be/tTnXn498F90

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Advanced Machining Processes:**	
1.1	Reasons, Different energy sources, applications and comparison over conventional machining processes.	2
1.2	General characteristics of advanced machining processes. Advantages, limitations and applications. Economics and trends in advanced machining processes.	2
2.	**Mechanical Energy based methods:**	
2.1	Abrasive Jet machining (AJM) - Working principle, Equipment, process parameters & capabilities.	2
2.2	Water Jet Machining (WJM) - Principle, Equipment, process parameters & capabilities.	1
2.3	Abrasive Water Jet Machining (AWJM) - Principle, Equipment, process parameters & capabilities.	2
2.4	Ultrasonic Machining (USM) - Working principle, Equipment, process parameters & capabilities.	2
2.5	Comparison, Selection of suitable method based on the requirement.	2
3.	**Thermoelectric Energy based methods:**	
3.1	Electrical Discharge Machining (EDM) - Principle, Equipment, dielectric fluid, electrode, process parameters, capabilities, design considerations and summary.	2
3.2	Wire cut Electrical Discharge Machining (WEDM) – Working principle, Equipment, process parameters, capabilities and applications.	2
3.3	Electron Beam Machining (EBM) - Principle, Equipment, process parameters & capabilities	2
3.4	Comparison, Selection of suitable method based on the requirement.	2
4.	**Chemical Energy based methods:**	
4.1	Chemical Machining (CM) - Principle, process parameters, design considerations, Masking, Etching operation, applications.	2
4.2	Photochemical Machining (PCM) – Principle, process parameters & capabilities. Comparison.	1
5.	**Electrochemical Energy based methods**:	
5.1	Electrochemical Machining (ECM) - Working principle, Equipment, Electrolytes, ECM tools, process parameters, capabilities and applications.	2
5.2	Electrochemical Grinding (ECG) – Principle, process parameters & capabilities.	2

	Comparison.	
6.	**High Energy Machining Processes:**	
6.1	Laser Beam Machining (LBM) - Working principle, Equipment, process parameters & capabilities.	2
6.2	Ion Beam Machining (IBM) - Principle, Equipment, process parameters & capabilities.	2
6.3	Plasma Beam Machining (PBM) - Principle, Equipment, process parameters & capabilities.	2
6.4	Comparison, Selection of suitable method based on the requirement.	2
	TOTAL	**36**

Course Designers:

1.	Dr.K. Chockalingam	Professor	Mechanical	kcmech@tce.edu
2.	Dr.C. Paramasivam	Professor	Mechanical	cpmech@tce.edu
3.	Dr.M. Kannan	Assistant Professor	Mechanical	mknmech@tce.edu

22MEPR0	GEOMETRIC MODELING

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

The concept of geometric modeling is evolved rapidly due to the development of computer graphics, computer-aided design, and manufacturing technologies. Geometric modeling is the base for computer-aided design (CAD) and it embraces computational geometry and extends to the field of solid modeling, creating an elegant synthesis of geometry. The construction of an entity is usually a computer-aided operation. Computer graphics, Computer-aided design and computer-aided manufacturing have been the driving forces behind the rapid development of geometric modeling schemes. Robotics, computer vision and artificial intelligence are also making increasing demands on geometric modeling capabilities.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Define the coordinate system for the development of geometric models.	TPS2	70	70
CO2	Develop and manipulate the different types of curves using parametric equations.	TPS3	70	65
CO3	Develop and manipulate the different types surfaces using parametric equations.	TPS2	70	70
CO4	Develop and manipulate the solid models using different modeling approaches.	TPS3	70	65
CO5	Implement the transformation and projection over the geometric model.	TPS3	70	65
CO6	Implement the neutral file formats over the given CAD model.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	25	-	2	10		-	-	-	-	-	-	2	10	-
CO2	-	10	40	4	15	50	-	-	-	-	-	-	4	5	10
CO3	-	25		4	15		-	-	-	-	-	-	4	10	-
CO4	-	-	-	-	-	-	-	20	20	4	15	20	4	5	10
CO5	-	-	-	-	-	-	-	20	20	4	15	20	4	5	10
CO6								10	10	2	10	10	2	5	10

Syllabus

Coordinate systems: Geometric coordinate systems - Cartesian, Cylindrical and Spherical coordinate systems. Display coordinate systems - Global, Local, View, and Screen coordinate systems.
Mathematical modeling of Curves: Define - Parametric and non-parametric forms of analytical and synthetic curves. Analytical Curve modeling - Line Segment, Circle, Ellipse. Synthetic Curve modeling - Hermite Cubic Spline, Bezier, B-spline, and Rational Curves - Synthetic Curve manipulation techniques.
Mathematical modeling of Surfaces: Define - Parametric and non-parametric forms of analytical and synthetic surfaces. Analytical surface modeling - Parametric form of a plane, loft, Cylindrical, Surface of revolution. Synthetic Surface modeling - Hermite Bicubic Spline, Bezier, B-spline - Synthetic Surface Manipulation techniques.
Mathematical modeling of Solids: Boundary Representation, Constructive Solid Geometry, Analytical Solid Modeling, Sweep representation schemes. Manipulation - Solid Manipulation Techniques.
Transformation: 2D and 3D transformation techniques - Translation, Rotation, Scaling and Reflection. Principle of concatenated transformation.
Graphic Standards and mode of data transfer: Define graphics standard, geometrical data, direct and indirect data transfer. Neutral file formats - Data Exchange Format (DXF), Initial Graphics Exchange Specification (IGES) and Stereolithography or Standard Tessellation Language (STL).

Textbook (s)

1. Ibrahim Zeid, "**Mastering CAD/CAM**", Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2013.
2. Amarendra N Sinha and Arun D Udai, "**Computer Graphics**", Tata McGraw Hill Education (P) Ltd., Second reprint, 2009.

Reference Books & Web Resources

1. Michael E. Mortenson, "**Geometric Modeling**", Industrial Press, Third edition, 2006.
2. Rogers, "**Mathematical Elements for computer Graphics**", Tata Mcgraw Hill Education Private Limited, 2009.
3. Rajiv Chopra, "**Computer Graphics**: A Practical Approach, Concepts, Principles, Case Studies", S.Chand and Company Ltd., First Edition, 2011.
4. NPTEL Course: Computer Aided Design and Manufacturing
   Url: https://nptel.ac.in/courses/112102101/
5. Journal: Computer-Aided Design, Elsevier publication, ISSN: 0010-4485.
   URL: https://www.journals.elsevier.com/computer-aided-design

Course Contents and Lecture Schedule

Module No.	Topics	No. of Periods
1	**Coordinate systems**	
1.1	Geometric co-ordinate systems - Cartesian, Cylindrical and Spherical coordinate systems	2
1.2	Display co-ordinate systems - Global, Local, View and Screen coordinate systems	1
2	**Mathematical modeling of Curves**	
2.1	Define - Parametric and non-parametric forms of analytical and synthetic curves	1
2.2	Analytical Curve modeling - Line Segment, Circle, Ellipse.	1
2.3	Synthetic Curve modeling - Hermite cubic spline, Bezier curve	2
	Synthetic Curve modeling - B-spline and Rational Curves	2
2.4	Synthetic Curve manipulation techniques.	1
3	**Mathematical modeling of Surfaces**	
3.1	Define - Parametric and non-parametric forms of analytical and synthetic surfaces	1
3.2	Analytical surface modeling - Parametric form of a plane, loft surface	1
	Analytical surface modeling - Cylindrical, Surface of revolution	1
3.3	Synthetic Surface modeling - Hermite bicubic spline, Bezier surface	2
	Synthetic Surface modeling - B-spline	2
3.4	Synthetic Surface Manipulation techniques.	1
4	**Mathematical modeling of Solids**	
4.1	Boundary representation scheme	2
4.2	Constructive Solid Geometry, Analytical Solid Modeling	2
4.3	Sweep representation scheme	1
4.4	Solid Manipulation Techniques	1
5	**Transformation and Projection techniques**	
5.1	2D transformation techniques - Translation, Rotation	1
	2D transformation techniques - Scaling and Reflection	1
5.2	3D transformation techniques - Translation, Rotation	1
	3D transformation techniques - Scaling and Reflection	1
5.3	Principle of concatenated transformation	2
6	**Graphic Standards and mode of data transfer**	
6.1	Define - Graphics standard, Geometrical data	1
6.2	Direct and indirect data transfer	1
6.3	Neutral file formats - Data Exchange Format (DXF), Initial Graphics Exchange Specification (IGES) and Stereolithography or Standard Tessellation Language (STL).	4
	Total	**36**

Course Designers

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22MEPW0	TOTAL QUALITY MANAGEMENT

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Quality is the Mantra for success or even for the survival of any organization in this competitive global market. Total Quality Management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world- class competition. It integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach. At the end of the course the students are expected to recognize the quality issues in an organization and analyze the ways to solve those using TQM techniques, and demonstrate skills in using modern TQM tools and software to analyze problems.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain fundamental, Evolution and principles of TQM.	TPS2	70	70
CO2	Explain the concepts of Statistical process control	TPS2	70	70
CO3	Identify the solution for Particular problem through Quality control tools	TPS3	70	65
CO4	Implement different techniques of TQM for continuous improvement in an organization.	TPS3	70	65
CO5	Prepare Quality systems manuals and documents in compliance with international standards.	TPS3	70	65
CO6	Implement the Quality Management Systems in a different organization environment.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	_	_	L	_	_	L	_	_	_	_	_	_	_
CO2	M	L	_	-	L	_	_	L	_	_	_	_	_	_	_
CO3	S	M	L	-	M	_	_	L	M	L	_	_	_	_	M
CO4	S	M	L	_	M	_	L	L	_	_	L	_	_	_	L
CO5	S	M	L	_	M	_	L	L	_	_	_	_	_	_	M
CO6	S	M	L	-	M	-	L	L	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	10								4	5	
CO2		20		10	10								4	5	
CO3			60			60							4	5	15
CO4								15	20	10	10	20	4	5	15
CO5								10	20	5	5	20	2	5	10
CO6								15	20	5	5	20	2	5	10

Syllabus

Introduction: Fundamentals of TQM Historical developments important philosophies- (Deming, Juran, Cross by, Ishikawa) and their impact of quality- Quality planning, Quality statement Quality policy Deployment, introduction to BPR and analysis of Quality Costs – TQM implementation stages **Principles of TQM:** Customer focus Customer satisfaction customer perception of quality, customer complaints, Employee involvement - Empowerment and Team work- Supplier Quality Management. **Process Monitoring:** statistical fundamentals - Normal curve - Seven tools of quality Histogram, Check Sheet, Cause and Effect Diagram, Control chart, Pareto Chart, Scatter Diagram, Stratification Diagram. Control charts for variables and attributes, Process Capability analysis and New Seven management tools. **TQM Techniques:** - PDSA cycle, 5S, Kaizen. Quality Functions Deployment (QFD) house of Quality, QFD process and benefits, Benchmarking process, TPM Concepts, Failure Mode Effect Analysis (FMEA) DFMEA (Design),PFMEA (Process) and SFMEA (System) concept, stages and Juran Trilogy. **Quality Management Systems:** Need for ISO 9001: 2015 Elements, Implementation, Documentation and Auditing. ISO14001:2015, ISO 26000, ISO 27000 and ISO 45001 Concept requirements and benefits - Case studies.

Reference Books & Web Resources

1. Dale H.Besterfiled, Carol Besterfiled-Michna. Glen H. Beseterfiled and Mary Besterfield- Sacre, “Quality Management” , Pearson Education Asia, 2004.
2. Shridhara Bhat, “TQM Text and Cases”, Himalaya Publishing House, 2002.
3. Berk, Joseph and Berk, S, “The Essence of TQM”, Prentice Hall of India, 1998.
4. Narayan and Sreenivasan, “Quality Management- Concepts and Tasks”, New Age International, 1996.
5. Sharma D.D, “Total Quality Management” Sultan Chand & Sons,2005.
6. https://www.youtube.com/watch?v=ksR4Xy6tFcM - Introduction to TQM
7. https://www.youtube.com/watch?v=yWlAOFs04go

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Fundamentals of TQM Historical developments	1
1.2	Important philosophies - (Deming, Crossby,Ishikawa) & their impact of quality.	2
1.3	Juran’s philosophies and its impact of quality	1
1.4	Quality planning and Quality statement	1
1.5	Quality policy Deployment and Introduction to BPR	1
1.6	Analysis of Quality Costs	1
1.7	TQM implementation Stages	1

2	**Principles of TQM**	
2.1	Customer Focus customer satisfaction	1
2.2	Customer perception of quality	1
2.3	Customer complaints	1
2.4	Employee involvement - Empowerment andTeam work	1
2.5	Supplier Quality Management	1
3	**Process Monitoring**	
3.1	Statistical fundamentals , Normal curve	1
3.2	Seven tools of quality - Histogram, Check Sheet, Cause and Effect Diagram, Control chart, Pareto Chart, Scatter Diagram,Stratification Diagram	2
3.3	Charts for variables	
3.4	Charts for attributes	1
3.5	Process Capability analysis	
3.6	New seven management tools	1
4	**TQM Techniques**	
4.1	PDSA cycle and 5S	1
4.2	Kaizen	1
4.3	Quality Functions Deployment (QFD)	1
4.4	House of Quality	1
4.5	QFD process and benefits	1
4.6	Benchmarking process	1
4.7	TPM Concepts	1
4.8	FMEA DFMEA (Design),PFMEA (Process) and SFMEA (System)concept, stages	2
4.9	Juran Trilogy	1
5	**Quality Management Systems**	
5.1	Need for ISO 9001: 2015, Elements	1
5.2	Implementation	1
5.3	Documentation and Auditing	1
5.4	ISO14001:2015, ISO 26000 and ISO 27000 Concept - Requirements and benefits	2
5.5	ISO 45001 - Requirements and benefits	1
5.6	Case studies	1
	Total	**36**

Course Designers

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22MEPX0	OBSERVATION SKILLS

Category	L	T	P	C	Terminal Exam Type
PSE	1	-	-	1	-

Preamble

This elective course is designed as per the guideline prescribed by Visionary Learning Community of India (VLCI) Programme with an objective to "CREATE NEXT GENERATION MANUFACTURING CHANGE LEADERS" by transforming Engineering graduates in to Role Ready Engineers. The syllabus and the implementation procedure is developed by Prof. Shoji Shiba, Globally acclaimed authority on Breakthrough Management & Total Quality Management, Japan & Mr.Takeyuki Furuhashi, Expert in Flow Manufacturing, Japan. Here, the objective is to impart the different observation techniques. M/s. TAFE Pvt. Ltd., Madurai is an Industrial demonstrator in order to implement this course under the category of programme specific elective.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the action of seeing and observing	TPS2	70	70
CO2	Prepare labels using 4W1H format with an observation in inside the company/campus	TPS3	70	65
CO3	Prepare labels using 4W1H format with an observation in public places	TPS3	70	65
CO4	Explain the effect of ignoring safety & cleanliness	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	S	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	S	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	S	S	M	-	-	-	-	-
CO4	M	L	-	-	-	-	-	S	S	M	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2					
	Theory						Theory					
	Assignment-1			TEST-1			Assignment-2			TEST-2		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3
CO1		60			40							
CO2		40				60						
CO3								60				60
CO4								40			40	

- 100% Continuous assessment only. No terminal examination.
- As this elective course addresses industry-specific requirements, the student has to pass this course in the first attempt. No further attempts are allowed.
- Student can take up the remaining VLCI courses only if he/she pass this course in the first attempt.

Syllabus

SAFETY AND CLEANLINESS:

IN PUBLIC PLACES: Introduction - Cleanliness and Safety, Process of observation–Pre-training test, Seeing Vs observing, preparing the mind for effective observation, steps in observation process. **Presentation of observation** - Introduction of 4W1H Format, Label writing, Label grouping. **Activities** - Learning by watching video, Site Visits - Home & Housing society, College campus, Public transport site etc. and post-training activities.

IN FACTORY: Introduction – factory/industry, **Cleanliness in factory –** Need of cleanliness, practices/measures to keep cleanliness, Examples of Cleanliness. **Safety in a Factory** - Introduction to safety, unsafe condition &unsafe act, **methods of ensuring Safety**-personal protective equipment, machine guarding, electrical safety, material handling equipment and ergonomics. **Effect of ignoring safety &cleanliness** - Impact of safety & cleanliness in factory, Types & examples of accidents-pictures and videos. **Activities - Factory visit** - Observing of safety & cleanliness, Label marking. **Preparation of report -** Factory Layout, unsafe locations and its problems, unclean locations and its problems, **Final presentation -** on observed safety and cleanliness.

Textbook (s)

1. Sharad Anerao, Rana T.S., and Ashish Patil, "Module-1: Observation Skills - Safety & Cleanliness", Nutan Maharashtra Institute of Engineering and Technology, Talegaon, Pune & Samarth Vidya Sankul, Vishnupuri, Telegaon Dabhade – Pune, 1st Edition, 2018

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**SAFETY AND CLEANLINESS IN PUBLIC PLACES:**	
1.1	**Introduction** - cleanliness and Safety, Process of observation – Pre-training test, Seeing Vs observing, preparing the mind for effective observation, steps in observation process.	2
1.2	**Presentation of observation** - Introduction of 4W1H Format, Label writing, Label grouping.	2
1.3	**Activities -** Learning by watching video, Site visits - Home & Housing society, College campus, Public transport site etc. and post-training activities.	
2	**SAFETY AND CLEANLINESS IN FACTORY:**	
	Introduction – Layout and scenario of factory	2
2.1	**Cleanliness in factory** – Need of cleanliness, practices/measures to keep cleanliness, Examples of Cleanliness.	2
2.2	**Safety in a Factory** - Introduction to safety, unsafe condition & unsafe act, **methods of ensuring Safety** - personal protective equipment, machine guarding, electrical safety, material handling equipment and ergonomics.	2
2.3	**Effect of ignoring safety & cleanliness** - Impact of safety & cleanliness in factory, Types & examples of accidents - pictures and videos.	2
2.4	**Activities - Factory visit** - Observing of safety & cleanliness, Label marking. **Preparation of report -** Factory Layout, unsafe locations and its problems, unclean locations and its problems,	
3.	**Final presentation -** on observed safety and cleanliness.	
	Total	**12**

Course Designers

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22MEPY0	EVOLUTION OF MODERN MANUFACTURING

Category	L	T	P	C	Terminal Exam Type
PSE	1	-	-	1	-

Preamble

This elective course is designed as per the guideline prescribed by Visionary Learning Community of India (VLCI) Programme with an objective to “CREATE NEXT GENERATION MANUFACTURING CHANGE LEADERS” by transforming Engineering graduates in to Role Ready Engineers. The syllabus and the implementation procedure is developed by Prof. Shoji Shiba, Globally acclaimed authority on Breakthrough Management & Total Quality Management, Japan & Mr.Takeyuki Furuhashi, Expert in Flow Manufacturing, Japan. M/s. TAFE Pvt. Ltd., Madurai is an Industrial demonstrator to implement this course under the category of programme specific elective. Here, the objective is to introduce factory to the students through different methods of production like craftsman and mass production with relevant examples. Also, it imparts the student about the system dynamic model and the historical evolution of different products.

Prerequisite

- 22MEPX0 – Observation Skills

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Develop System Dynamic (SD) model of factory through observation	TPS3	70	65
CO2	Develop Input-Process-Output (IPO) model for the given parts	TPS3	70	65
CO3	Explain the different type of production	TPS2	70	70
CO4	Explain the concept of factory language	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	S	-	-	-	-	-	-	-
CO3	M	L	-	-	-	-	-	S	S	M	-	-	-	-	-
CO4	M	L	-	-	-	-	-	S	S	M	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2					
	Theory						Theory					
	Assignment-1			TEST-1			Assignment-2			TEST-2		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20	40		20	40						
CO2		20	40		20	40						
CO3								50			50	
CO4								50			50	

- 100% Continuous assessment only. No terminal examination.
- As this elective course addresses industry-specific requirements, the student has to pass this course in the first attempt. No further attempts are allowed.
- Student can take up the remaining VLCI courses only if he/she pass this course in the first attempt.

Syllabus

Manufacturing: Introduction, System Dynamic (SD) model through observation, Activity 1: List the man-made things around you and classify them. **Input-Process-Output model of manufacturing:** Introduction, Activity 2: Identify the raw material and process to manufacture the given product, drawing of IPO model for the given product. **Evolution of craftsman (Job) production:** Example, characteristics, advantages and disadvantages identify the input, process and output for the given craftsman product, Activity 3 – Compare home kitchen and mechanized kitchen and write advantages and disadvantages. **Assembly line production:** characteristics, examples for evolution of manufacturing like garments, difference between the job and mass production, Activity 4: Relate the individual (Tailor) skills Vs use of machines (Garment Factory) in case of stitching of garments. **Case study:** Study on craftsman, batch and mass production industry and comparison. Activity 5: Report writing and presentation. **Factory concept:** Types of waste, things seen in factory, Organization of men, Types of materials, IPO model for college canteen/kitchen, flow model of information, material and operator, factory language – vocabulary.

Textbook (s)

1. Dr.Jayant Kittur and Prof.Sachin Kulkarni, **"Module-2: Evolution of Modern Manufacturing"**, Nutan Maharashtra Institute of Engineering and Technology, Talegaon -Pune & Samarth Vidya Sankul, Vishnupuri, Telegaon Dabhade – Pune, 1st Edition, 2018

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Manufacturing:** Introduction, System Dynamic (SD) model through observation	2
1.1	Activity 1: List the man-made things around you and classify them.	
2.	**Input-Process-Output model of manufacturing:** Introduction	2
2.1	Activity 2: Identify the raw material and process to manufacture the given product, draw the IPO model for the given product	
3.	**Evolution of craftsman (Job) production:** Example, characteristics, advantages and disadvantages, identify the input, process and output for the given craftsman product	2
3.1	Activity 3: Compare home kitchen and mechanized kitchen and write advantages and disadvantages	
4.	**Assembly line production:** characteristics, examples for evolution of manufacturing like garments, difference between the job and mass production	2
4.1	Activity 4: Relate the individual (Tailor) skills Vs use of machines (Garment Factory) in case of stitching of garments	
5.	**Case study:** Studies on craftsman, batch and mass production industry and comparison	2
5.1	Activity 5: Report writing and presentation	
6.	**Factory concept:** Types of waste, things seen in factory, Organization of men, Types of materials	1
6.1	IPO model for college canteen/kitchen, flow model of information material and operator. Factory language – vocabulary.	1
	Total	**12**

Course Designers

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4. Mr.C. Vignesh	Assistant Professor	Mechanical Engineering	cvmech@tce.edu
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22MEPZ0	MODERN MANUFACTURING BASIC KNOWLEDGE AND SKILLS

Category	L	T	P	C	Terminal Exam Type
PSE	1	-	-	1	-

Preamble

This elective course is designed as per the guideline prescribed by Visionary Learning Community of India (VLCI) Programme with an objective to "CREATE NEXT GENERATION MANUFACTURING CHANGE LEADERS" by transforming Engineering graduates in to Role Ready Engineers. The syllabus and the implementation procedure is developed by Prof. Shoji Shiba, Globally acclaimed authority on Breakthrough Management & Total Quality Management, Japan & Mr.Takeyuki Furuhashi, Expert in Flow Manufacturing, Japan.

M/s. TAFE Pvt. Ltd., Madurai is an Industrial demonstrator to implement this course under the category of programme specific elective. The objective is to make awareness on the necessity of technical knowledge and skills required for factory. Also, it imparts about the different aspects of self-discipline, time management, brain storming, team work, factory language and organization of factory.

Prerequisite

- 22MEPX0 – Observation Skills
- 22MEPY0 – Evolution of Modern Manufacturing

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the ways to strengthen the one's self discipline	TPS2	70	70
CO2	Practice the different principle of time management in their professional career	TPS3	70	65
CO3	Illustrate the concepts of brainstorming for the given industrial problem	TPS3	70	65
CO4	Explain the importance and benefits of team work to achieve the goal of an industry	TPS2	70	70
CO5	Communicate easily with people working at different levels in an industry more effectively through factory language	TPS2	70	70
CO6	Visualize the structure of manufacturing organization in order move effectively to fulfil the goal of an industry	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	S	S	M	-	-	-	-	-
CO4	-	-	-	-	-	-	-	S	S	M	-	-	-	-	-
CO5	-	-	-	-	-	-	-	S	M	S	-	-	-	-	-
CO6	-	-	-	-	-	-	-	S	M	M	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2					
	Theory						Theory					
	Assignment-1			TEST-1			Assignment-2			TEST-2		
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20			10							
CO2		20	20		10	35						
CO3		20	20		10	35						
CO4								30			20	
CO5								10			10	
CO6								10	50		10	60

- 100% Continuous assessment only. No terminal examination.
- As this elective course addresses industry-specific requirements, the student has to pass this course in the first attempt. No further attempts are allowed.
- Student can take up the remaining VLCI courses only if he/she pass this course in the first attempt.

Syllabus

Self-discipline: Introduction, principles of self-discipline, ways to strengthen self-discipline, self-motivation, and exercising self-discipline. **Time management:** Time zones, Kinds of people, Tips for time management, Brain exercises, Habits of successful people, Benefits of time management, Obstacles to effective time management, Identification of time waster, Procrastination – ways to overcome procrastination, Principles of time management - Eisenhower matrix and Pareto principle (80/20 Rule), Busy Vs Productive, Body language – Introduction, components of body language – Proxemics, Oculesics, Haptics, Kinesics, paralanguage, Chronemics, Chromatics, Olfactics and Ortifacts. **Brainstorming**: Types, Primary rules of brainstorming, Applications, Benefits, Rules of brainstorming, Traditional brainstorming Vs Advanced brainstorming, Creative thinking techniques. **Team work:** Introduction, Difference between of workgroup and team, Characteristic of good team, Types of teams, Importance and benefits of team work. **Conflict management:** Styles of conflict management, types of conflicts, Activity on identifying the type of conflict, reasons for conflicts, method to resolve conflict. **Factory language:** Importance and benefits. **Organization of factory:** Introduction, Forms of organization structure.

Reference Materials & web sourece

1. Ashish Patil, Sharad Anerao, Vishvas Patil and Prof.Sachin Kulkarni, “Module-3: Modern Manufacturing Basic Knowledge and Skills”, Private circulation material, 2019.
2. NPTEL course on “Body Language: Key to Professional Success” https://nptel.ac.in/courses/109/107/109107154/
3. Conflict Management: https://www.dailymotion.com/video/x63gswk
4. Team work: https://nptel.ac.in/courses/110/105/110105034/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Self-discipline:** Introduction, principles of self-discipline, ways to strengthen self-discipline, self-motivation, and exercising self-discipline.	1
2.	**Time management:** Time zones, Kinds of people, Tips for time management, Brain exercises, Habits of successful people, Benefits of time management, Obstacles to effective time management, Identification of time waster	1

Module No.	Topic	No. of Periods
2.1	Procrastination – ways to overcome procrastination, Principles of time management - Eisenhower matrix and Pareto principle (80/20 Rule), Busy Vs Productive	2
2.2	Body language – Introduction, components of body language – Proxemics, Oculesics, Haptics, Kinesics, paralanguage, Chronemics, Chromatics, Olfactics and Ortifacts	1
3.	**Brainstorming**: Types, Primary rules of brainstorming, Applications, Benefits, Rules of brainstorming, Traditional brainstorming Vs Advanced brainstorming, Creative thinking techniques.	2
4.	**Team work:** Introduction, Difference between of workgroup and team, Characteristic of good team, Types of teams, Importance and benefits of team work.	2
4.1	**Conflict management:** Styles of conflict management, types of conflicts, Activity on identifying the type of conflict, reasons for conflicts, method to resolve conflict.	1
5.	**Factory language:** Importance and benefits.	1
6.	**Organization of factory:** Introduction, Forms of organization structure.	1
	Total	**12**

Course Designers

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4. Mr.C. Vignesh — Professor Assistant — Mechanical Engineering — cvmech@tce.edu
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22MERE0	MECHANICAL VIBRATIONS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Vibration is the motion of a particle or a body or a system of connected bodies displaced from a position of equilibrium. Most vibrations produce increased stresses, energy losses, wear and bearing loads. Predicting and measuring the vibration in a dynamic system is essential to improve the system performance. This course covers the basic principles of vibration, modelling and their application in mechanical systems.

Prerequisite

- Kinematics and Dynamics of Machinery

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the importance of vibration in design of Machine parts.	TPS2	70	70
CO2	Determine the natural frequency of free vibrations of singledegree of freedom with and without damping.	TPS3	70	65
CO3	Determine the natural frequency of forced vibrations of singledegree of freedom with and without damping.	TPS3	70	65
CO4	Determine the natural frequency of two degree of freedomvibrations.	TPS3	70	65
CO5	Determine the equation of motion and the natural frequency ofmulti degree of freedom vibration systems.	TPS3	70	65
CO6	Explain the suitable methods for measuring and controlling themotions of mechanical systems.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	_
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / COs	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1				10						10			2		
CO2			50	05	10	30				05	10	30	2	5	10
CO3			50	05	10	30				05	10	30	2	5	15
CO4									50				2	5	15
CO5									50					5	20
CO6													2		10

Syllabus

Fundamentals of Vibration:
Sources of vibration- Elements of vibratingsystem- Mathematical models-Types of vibration – steady state, random, Free, forced, undamped, damped Content of the syllabus - Module wise
Single degree freedom system free vibration systems: Single degree freedom free vibration system with and without damping –Types of Damping- Viscous, coulomb and hysteretic damping, longitudinal systems, transverse systems and torsional system, logarithmic decrement-
Single degree freedom system forced vibration systems - forced vibration system with and without damping -vibration isolation and force transmissibility- vibration analysis -magnification factor.
Two-Degree Freedom System: Equations of motions-free, forced and torsional vibration of Undamped and damped system. Torsional system-Spring coupled system – mass coupled system –coordinates coupling and principles coupling, orthogonal properties.
Multi-Degree Freedom System: Free vibrations of damped and Undamped system, Longitudinal, Transverse, Torsional systems, influence coefficients — Eigen values and Eigen vectors - Determination of natural frequencies- Rayleigh, Dunkerley and Holzer methods – Continuous System.
Measurements and Control: Vibration Measuring Devices: Transducers, vibration pickups- Vibration exciters: mechanical, hydraulic, –Frequency measuring instruments: single reed, multi reed and stroboscope. Experimental modal analysis.- FFT analyzers - Vibration control devices- isolators, absorbers and balancing

Textbook (s)

1. Rao, S.S.," **Mechanical Vibrations,"** Addison Wesley Longman, Reprint 2015.
2. G.K.Groover., **"Mechanical Vibrations"**, New Chand &Bros, Roorkee, Reprint 2014.

Reference Books & Web Resources

1. Ramamurti. V, **"Mechanical Vibration Practice with Basic Theory"**, Narosa, New Delhi, Reprint 2015.
2. Rao V. Dukkipati and J,Srinivas, **"Text book of Mechanical Vibrations"**, Prentice Hall ofIndia, New Delhi, Reprint 2014.
3. Thomson, W.T. **"Theory of Vibration with Applications"**, CBS Publishers and Distributors, New Delhi, 2018.
4. Ambekar.A.G. **"Mechanical Vibrations and Noise engineering"**, Prentice Hall of India, New Delhi, 2006.
5. **Prof. Rajiv Tiwari** Department of Mechanical Engineering, Indian Institute of Technology, Guwahati – NPTEL course
6. **Prof. S.K. Dwivedy ,** Department of Mechanical Engineering, Indian Institute of Technology, Guwahati – NPTEL course

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Fundamentals of Vibration**	
1.1	Sources of vibration	1
1.2	Elements of vibrating system	1
1.3	Mathematical models	1
1.4	Types of vibration	
1.5	Steady state, random, Free, forced, Undamped,damped.	1
2	**Single degree freedom system free vibration systems**	
2.1	Single degree freedom free vibration system with andwithout damping	2
2.2	Types of Damping- Viscous, coulomb and hysteretic damping	2
2.3	Longitudinal systems, transverse systems and torsional system	2
2.4	Logarithmic decrement	1
3	**Single degree freedom system forced vibrationsystems**	
3.1	Forced vibration system with and without damping	2
3.2	Vibration isolation and force transmissibility	1
3.3	Vibration analysis	1
3.4	magnification factor	1
4	**Two-Degree Freedom System**	
4.1	Equations of motions	1
4.2	Free, forced and torsional vibration of Undamped anddamped system	1
4.3	Torsional system	1
4.4	Spring coupled system	1
4.5	Mass coupled system	1
4.6	Coordinates coupling and principles coupling	1
4.7	Orthogonal properties.	1
5	**Multi-Degree Freedom System**	
5.1	Free vibrations of damped and Undamped system	1
5.2	Longitudinal, Transverse, Torsional systems	1
5.3	Influence coefficients	1
5.4	Eigen values and Eigen vectors	1
5.5	Determination of natural frequencies	
5.5.1	Rayleigh method	4
5.5.2	Dunkerley method	
5.5.3	Holzer method – Continuous System	
6	**Measurements and Control**	
6.1	Vibration Measuring Devices: Transducers, vibration pickups	1
6.2	Vibration exciters: Mechanical, Hydraulic	1
6.3	Frequency measuring instruments: single reed, multireed and stroboscope. Experimental modal analysis	1
6.4	FFT analyzers	1
6.5	Vibration control devices- isolators, absorbers and balancing.	1
	Total	36

Course Designers

1.	Dr. V. Balasubramani	Associate Professor	Mechanical Engineering	vbmech@tce.edu
2.	Mr. C. Vignesh	Assistant Professor	Mechanical Engineering	cvmech@tce.edu

22MERF0	BIOMATERIALS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Biomaterials can be derived either from nature or synthesized in the laboratory using a variety of chemical approaches utilizing metallic components, polymers, ceramics or composite materials. It can be used every day in orthopaedic applications, dental applications, surgery, and drug delivery. Biomechanics is the study of the structure and function of the mechanical aspects of biological systems, at any level from whole organisms to organs, cells and cell organelles using the methods of mechanics. The primary objective of this course is to impart the knowledge on biomaterials needed to solve challenges in bioengineering.

Prerequisite

- Materials Science and Metallurgy

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the effect of physiological fluid and mechanical properties associated with biomaterials	TPS2	70	70
CO2	Select a suitable metallic implant material for the given requirement	TPS3	70	65
CO3	Suggest a suitable polymeric implant material for the required biological environment.	TPS3	70	65
CO4	Choose a ceramic implant material for the given requirement	TPS3	70	65
CO5	Describe the mechanics involved in composite implant materials	TPS2	70	65
CO6	Select a suitable screening technique to verify biocompatibility of biomaterials	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	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

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		3	14								4	10	
CO2			40	3	14	25							2	10	10
CO3			40	3	13	25							4		10
CO4									40	3	14	25	2	10	10
CO5								20		3	14		4	10	
CO6									40	3	14	25	4		10

Syllabus

Introduction: Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.

Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve implants-Tailor made composite in medium.

Polymeric implant materials: Polyolefin's, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetyls. (Classification according to thermo sets, thermoplastics and elastomers). Viscoelastic behavior: creep-recovery, stress-relaxation, strain rate sensitivity. Importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking. Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric membranes and their biological applications.

Ceramic implant materials: Definition of bio ceramics. Common types of bio ceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction).

Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement (short and long fibers, fibers pullout). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.

Biocompatibility & Toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situimplantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

Textbook (s)

1. Ratner, Hoffman, Schoet and Lemons, "Biomaterials Science: An introduction to Materials in Medicine", Second Edition: Elsevier Academic Press, 2004.

Reference Books & Web Resources

1. B. Basu, D. Katti and Ashok Kumar; "Advanced Biomaterials: Fundamentals, Processing and Applications", John Wiley & Sons, Inc., USA, 2009.
2. Fredrick H. Silver and David L Christiansen, "Biomaterials Science and Biocompatibility", Springer, 1999
3. Jonathan Black, "Biological Performance of Materials: Fundamentals of Biocompatibility" Fourth Edition: CRC Taylor & Francis Group, London, 2006.
4. NPTEL (http://nptel.ac.in/courses/113104009/#)

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction**	
1.1	Definition of biomaterials, requirements & classification of biomaterials	1
1.2	Comparison of properties of some common biomaterials.	1
1.3	Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system).	2
1.4	Surface properties of materials, physical properties of materials, mechanical properties.	2
2	**Metallic implant materials**	
2.1	Stainless steel, Co-based alloys, Ti and Ti-based alloys	1
2.2	Importance of stress-corrosion cracking.	1
2.3	Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion.	2
2.4	Hard tissue replacement implant: Orthopedic implants, Dental implants.	2
2.5	Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve implants-Tailor made composite in medium.	2
3	**Polymeric implant materials**	
3.1	Polyolefin's, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetyls. (Classification according to thermo sets, thermoplastics and elastomers).	2
3.2	Viscoelastic behavior: creep-recovery, stress-relaxation, strain rate sensitivity.	1
3.3	Importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking.	2
3.4	Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric membranes and their biological applications.	2
4	**Ceramic implant materials**	
4.1	Definition of bio ceramics. Common types of bio ceramics: Aluminum oxides, Glass ceramics, Carbons	1
4.2	Importance of wear resistance and low fracture toughness.	1
4.3	Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction).	2
5	**Composite implant materials**	
5.1	Mechanics of improvement of properties by incorporating different elements.	1
5.2	Composite theory of fiber reinforcement (short and long fibers, fibers pullout).	1
5.3	Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.	1
6	**Biocompatibility & Toxicological screening of biomaterials**	
6.1	Definition of biocompatibility, blood compatibility and tissue compatibility.	1
6.2	Toxicity tests: acute and chronic toxicity studies (in situimplantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.	3
	Total	32

Course Designers

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22MERJ0	INDUSTRY 4.0

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the drivers necessary for the transformation. Industrial Internet of Things (IIoT) is an application of IoT in industries to modify the various existing industrial systems. IIoT links the automation system with enterprise, planning and product lifecycle.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain about the enablers of Industry 4.0	TPS2	70	70
CO2	Design a simple architecture and build a road map for introducing Industry 4.0	TPS3	70	65
CO3	Select networking-related protocols for Industry 4.0	TPS3	70	70
CO4	Analyze the various data processing techniques in Industry 4.0	TPS3	70	65
CO5	Select suitable technology to implement Industry 4.0 based on the requirement	TPS3	70	65
CO6	Prepare report on case study in Industry 4.0	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	-	-	-	-	-	-	-	-	M
CO2	S	M	L	-	M	-	-	-	-	-	-	-	-	-	S
CO3	S	M	L	-	M	-	-	-	-	-	-	-	-	-	S
CO4	S	M	L	-	M	-	-	-	-	-	-	-	-	-	S
CO5	S	M	L	-	M	-	-	-	-	-	-	-	-	-	S
CO6	S	M	L	-	M	-	-	-	-	-	-	-	-	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	3	10	-	-	-	-	-	-	-	2	5	-
CO2	-	-	35	3	10	30	-	-	-	-	-	-	2	5	12
CO3	-	-	35	4	10	30	-	-	-	-	-	-	2	5	12
CO4	-	-	-	-	-	-	-	-	30	3	10	20	2	5	12
CO5	-	-	-	-	-	-	-	-	30	3	10	20	2	5	12
CO6	-	-	-	-	-	-	-	-	40	4	10	20	-	5	12

Syllabus

Introduction to Industry 4.0 Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories, Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality.

Architecture of Industry 4.0 Characteristics of Industry 4.0, Value Chain, Design Principles, Building Blocks of Industry 4.0, Industry 4.0 Reference Architecture.

Protocols for Industry 4.0 Functional requirement, Web 3.0, Internet of things (IoT), Middleware for IoT, Industrial internet systems, Network layers and protocols.

Data in Industry 4.0 Data sensing, Data processing, Communication and networking, Cybersecurity in Industry 4.0, Cloud Computing, Fog Computing, Machine Learning and Data Science.

Implementation of Industry 4.0 Real-Time Asset Tracking, Condition Monitoring for Predictive Maintenance, Dynamic Scheduling, Implementation of Blockchain, Facility Layout Optimization.

Case Study in Industry 4.0 Factories and Assembly Line, Food Industry, Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries.

Textbooks

1. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, First Edition, Apress, 2017
2. Yingfeng Zhang, Fei Tao, “Optimization of Manufacturing Systems Using the Internet of Things”, Academic Press, 2017

Reference Books & Web Resources

1. Carlos Toro, Wei Wang, Humza Akhtar, “Implementing Industry 4.0: The Model Factory as the Key Enabler for the Future of Manufacturing”, Springer, 2021.
2. Antonis Mavropoulos, Anders Waage Nilsen, “Industry 4.0 And Circular Economy”, First Edition, Wiley, 2020.
3. NPTEL course titled “Introduction to Industry 4.0 and Industrial Internet of Things” by Prof. Sudip Misra, IIT Kharagpur. https://onlinecourses.nptel.ac.in/noc20_cs69/preview
4. edX course titled “Industry 4.0: How to Revolutionize your Business” by Prof. Eric Tsui, The Hong Kong Polytechnic University. https://www.edx.org/course/industry-40-how-to-revolutionize-your-business

Course Contents and Lecture Schedule

S. No.	Topic	No. of Periods
1	**Introduction to Industry 4.0**	
1.1	Globalization and Emerging Issues, The Fourth Revolution	1
1.2	LEAN Production Systems, Smart and Connected Business Perspective	1
1.3	Smart Factories, Cyber Physical Systems and Next Generation Sensors	2
1.4	Collaborative Platform and Product Lifecycle Management	1
1.5	Augmented Reality and Virtual Reality	1
2	**Architecture of Industry 4.0**	
2.1	Characteristics of Industry 4.0	1
2.2	Value Chain, Design Principles	1
2.3	Building Blocks of Industry 4.0	2
2.4	Industry 4.0 Reference Architecture	2
3	**Protocols for Industry 4.0**	
3.1	Functional requirement	1
3.2	Web 3.0	1
3.3	Internet of things (IoT)	1
3.4	Middleware for IoT	1
3.5	Industrial internet systems	1
3.6	Network layers and protocols	1
4	**Data in Industry 4.0**	
4.1	Data sensing, Data processing	1
4.2	Communication and networking	1
4.3	Cybersecurity in Industry 4.0	1
4.4	Cloud Computing, Fog Computing	1
4.5	Machine Learning and Data Science	2
5	**Implementation of Industry 4.0**	
5.1	Real-Time Asset Tracking	1
5.2	Condition Monitoring for Predictive Maintenance	1
5.3	Dynamic Scheduling	1
5.4	Implementation of Blockchain	2
5.5	Facility Layout Optimization	1
6	**Case Study in Industry 4.0**	
6.1	Factories and Assembly Line, Food Industry, Healthcare, Power Plants	2
6.2	Inventory Management & Quality Control, Plant Safety and Security	1
6.3	Facility Management	1
6.4	Oil, chemical and pharmaceutical industry	1
6.5	Applications of UAVs in Industries	1
	Total	36

Course Designers

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22MERN0	DECISION SUPPORT SYSTEM

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Decision Support System (DSS) is a computer-based information system that supports business or organizational decision-making activities. DSS serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance. DSS include knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concepts, types and applications of DSS, steps in DSS	TPS2	70	70
CO2	Suggest a method of DSS to create a model for complex systems	TPS2	70	70
CO3	Apply various techniques in Decision Support Systems for effective decision making in different situation.	TPS3	70	65
CO4	Design a DSS Model based structures of real life product.	TPS3	70	65
CO5	Integrate different DSS Systems for effective implementations.	TPS3	70	65
CO6	Analyze the impact of DSS for managers, resources, Organization development and Productivity in the competitive environment.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	L	-	-	L	-	-	-	-	-	-	-
CO2	M	L	-	-	L	-	-	L	-	-	-	-	-	-	_
CO3	S	M	L	-	M	-	-	L	M	L	-	-	-	-	M
CO4	S	M	L	-	M	-	L	L	-	-	L	-	-	-	L
CO5	S	M	L	-	M	-	L	L	-	-	-	-	-	-	M
CO6	S	M	L	-	M	-	L	L	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	10								4	5	
CO2		20		10	10								4	5	
CO3			60			60							4	5	15
CO4								15	20	10	10	20	4	5	15
CO5								10	20	5	5	20	2	5	10
CO6								15	20	5	5	20	2	5	10

Syllabus

Decision Support Systems

An Overview. Managers and Decision Making, Managerial Decision Making and Information Systems, Managers and Computerized Support, The Need for Computerized Decision Support and the Supporting, Technologies, A Framework for Decision Support, The Concept of Decision Support Systems, Group Support Systems, Executive Information (Support) Systems, Expert Systems.

Decision Making, Systems, Modeling, and Support

Decision Making: Introduction and Definitions, Systems, Models, A Preview of the Modeling Process, The Intelligence Phase, The Design Phase, The Choice Phase, Evaluation: Multiple Goals, Sensitivity Analysis, What - If, and Goal Seeking, The Implementation phase, how Decisions are supported, Alternative Decision Making Models.

Decision Support Systems (DSS)

An Overview, DSS Configurations- Characteristics and Capabilities and Components of DSS, The Data Management Subsystem, Data Mining, Data Ware housing - The Model Management Subsystem, The Knowledge - Based Management Subsystem, The User Interface (Dialog) Subsystem, The User, DSS Hardware, Distinguishing DSS from Management Science and MIS, DSS Classifications.

Implementing and Integrating Decision Support Systems

Implementation: An Overview, The Major Issues of Implementation, Implementation Strategies, System Integration, Generic Models of MSS Integration, Models of ES and DSS Integration, Integrating EIS, DSS, and ES, and Global Integration, Intelligent DSS, Intelligent Modeling and Model Management, Integrated Systems - Issues in Integration.

Impacts of Decision Support Systems

Introduction, Overview of Impacts, Organizational Structure and Related Areas, MSS Support to Business Process Reengineering, Personnel Management Issues, Impact on Individuals, Impacts on Productivity, Quality, and Competitiveness, Decision Making and Manager's Job, Issues of Legality, Privacy and Ethics. Intelligent Systems and Employment Levels.

Textbook (s)

1. Efraim Turban, Jay E. Aronson, **"Decision Support Systems and Intelligent Systems"**, Sixth Edition, Prentice Hall, 2001.

Reference Books & Web Resources

1. G.M Marakas, **"Decision Support Systems in the 21th century"**, Prentice Hall, 1999.
2. C.Holsapple, A.Whinston, **"Decision Support Systems: A Knowledge based Approach"**, Prentice Hall, 2001.
3. Elamsri, Navathe, **"Fundamentals of Data base systems"**, Addison Wesley, 2003.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. of Periods
1.	**Management Support Systems** - An Overview	
1.1	Managers and Decision Making, Managerial Decision Making and Information Systems	1
1.2	Managers and Computerized Support	1
1.3	The Need for Computerized Decision Support and the Supporting	1
1.4	A Framework for Decision Support - The Concept of Decision Support Systems	1
1.4.1	Group Support Systems, Executive Information (Support) Systems	1
1.4.2	Expert Systems	1
2.	**Decision Making, Systems, Modeling, and Support**	
2.1	Decision Making: Introduction and Definitions - Systems and Models	1
2.2	A Preview of the Modeling Process	1
2.3	The Intelligence Phase	1
2.3.1	The Design Phase and The Choice Phase	1
2.3.2	Evaluation: Multiple Goals	1
2.3.3	Sensitivity Analysis	1
2.3.4	What - If, and Goal Seeking and The Implementation phase	1
2.4	how Decisions are supported and Alternative Decision Making Models.	1
3.	**Decision Support Systems (DSS)-** An Overview - DSS Configurations	
3.1	Characteristics and Capabilities - Components of DSS	1
3.2	The Data Management Subsystem - Data Mining, Data Ware housing	1
3.3	The Model Management Subsystem	1
3.4	The Knowledge - Based Management Subsystem	2
3.5	The User Interface (Dialog) Subsystem - The User, DSS Hardware	1
3.6	Distinguishing DSS from Management Science and MIS	1
3.7	DSS Classifications	1
4	**Implementing and Integrating Management Support Systems** - Implementation: An Overview	
4.1	The Major Issues of Implementation	1
4.2	Implementation Strategies & System Integration	1
4.3	Generic Models of MSS Integration	1
4.4	Models of ES and DSS Integration	1
4.5	Integrating EIS, DSS, and ES, and Global Integration	1
4.6	Intelligent DSS, Intelligent Modeling and Model Management	1
4.7	Integrated Systems - Issues in Integration.	1
5	**Impacts of Management Support Systems**	
5.1	Introduction, Overview of Impacts	1
5.2	Organizational Structure and Related Areas	1
5.3	MSS Support to Business Process Reengineering	1
5.4	Personnel Management Issues	1
5.5	Impact on Individuals, Productivity, Quality, and Competitiveness	1

Sl.No.	Topics	No. of Periods
5.6	Decision Making and Manager's Job - Issues of Legality, Privacy and Ethics	1
5.7	Intelligent Systems and Employment Levels.	1
Total		36

Course Designers

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3.	ML. Mahadevan	Associate Professor	Mechanical Engineering	mlmmech@tce.edu

22MERS0	PRODUCT DESIGN AND DEVELOPMENT

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

The focus of Product Design and Development is integration of the marketing, design, and manufacturing functions of the firm in creating a new product. The course aims at giving adequate exposure to product design and development process and the various methods and techniques that are used in real-life to realize successful products.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain and classify the product design and development processes	TPS2	70	70
CO2	Identify methodical approach to collect customer statement and convert them into need statement	TPS3	70	65
CO3	Identify methodical approach to convert need statement into product specification and generate product concept for the same.	TPS3	70	65
CO4	Evaluate and test the concepts for the final product specification.	TPS3	70	65
CO5	Implement the suitable product architecture, prototyping	TPS3	70	65
CO6	Explain about industrial design process, design protection and Intellectual Property.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L													
CO2	S	M	L			L	L			M			M		M
CO3	S	M	L			L	L			M			M		M
CO4	S	S	S	M		L	L			S			M		M
CO5	S	S	M	L		L				M			S		M
CO6	M	L													

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / Cos	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1				10	20								4	10	
CO2			50	5	10	20							2	5	10
CO3			50	5	10	20							4	5	10
CO4									50		10	20	2	5	10
CO5									50		10	20	4	5	10
CO6										10	20		4	10	

For Assignment Part

The individual student / group of students of maximum number of four have to develop digital and physical functional or non-functional prototype models of a new product/ existing product with enhanced feature involving the following areas:

- Automotive components
- Tool and die components
- Press tool components
- Consumer product
- Agricultural equipment., etc

Students should apply product design and development concept such as

1. Identification opportunities through survey, Literature review
2. Conversion of customer requirement to need statements
3. Generation of product specification and Product concept
4. Concept testing and Final product specification
5. Implementation of product architecture
6. Identification of IPR Possibility

The fabricated models may be in the form of RP models, clay models, Machined models, sheet metal models or cardboard models etc…

The design and development of the product will be reviewed The Assignment mark will be based on the demonstration of the new product developed, report submission and oral examination on the same by team of faculties/course handling faculties

Syllabus

PRODUCT PLANNING - Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy- Establishing the Relative Importance of the Needs-Case study - Reflecting on the Results and the Process –

PRODUCT SPECIFICATIONS – Specifications –Specifications Established-Establishing Target Specifications–QFD-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation- Clarify the Problem- Search Externally-Search Internally-Explore Systematically- Case study -Reflect on the Results and the Process

CONCEPT SELECTION- Concept Selection- Overview of Methodology- The Decision matrix – Pugh"s method - Concept Screening- Concept Testing-Define the Purpose of the Concept Test- Choose a Survey Population- Choose a Survey Format- Communicate the Concept- Measure Customer Response- Interpret the Results- Case study -Reflect on the Results and the Process –

COSTING – Material – manufacturing –assembly – structure - Ergonomics and aesthetic aspects.

PRODUCT ARCHITECTURE- Implications of the Architecture- Establishing the Architecture--- System-Level Design Issues - Case study.

INDUSTRIAL DESIGN PROCESS – Introduction – Factors to be considered for industrial design process.

INTELLECTUAL PROPERTY –patent types - copyright – trademark – trade secret

Textbook (s)

1. Ulrich, Karl T. and Steven D. Eppinger, "**Product Design and Development**", Irwin /McGraw-Hill , 6th Edition, 2015.

Reference Books & Web Resources

1. David G.Ullman, "**The Mechanical Design Process**", Tata McGraw Hill , 2011
2. Orwin, Homewood, "**Effective Product Design and Development**", Stephen Rosenthal, Business One 1992,ISBN, 1-55623-603-4
3. Stuart Pugh, "**Tool Design – Integrated Methods for successful Product Engineering**", Addison Wesley Publishing,Neyourk,NY,1991, ISBN 0-202-41639-5
4. Kevin Otto, and Kristin Wood, "**Product Design – Techniques in Reverse Engineering and New Product Development**", Pearson Education, First edition,2000, ISBN 81- 7758-821-4"
5. NPTEL Course: Product Design and Development
   Url: https://nptel.ac.in/courses/112107217

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.0	**PRODUCT PLANNING**	
1.1	Product Planning Process- Identify Opportunities	2
1.2	Evaluating and Prioritizing Projects- Allocating Resources and Timing	2
1.3	Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs, Raw Data from Customers.	2
1.4	Interpreting Raw Data in Terms of Customer Needs, Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs	2
1.5	Case study- Reflecting on the Results and the Process	2

No.	Topic	No. of Periods
2.0	**PRODUCT SPECIFICATIONS**	
2.1	Specifications - Specifications Established-Establishing Target Specifications	2
2.2	QFD-Setting the Final Specifications-Concept Generation.	2
2.3	The Activity of Concept Generation	1
2.4	Clarify the Problem- Search Externally-Search Internally	2
2.5	Explore Systematically- Case study .	2
2.6	Reflect on the Results and the Process	1
3.0	**CONCEPT SELECTION**	
3.1	Concept Selection- Overview of Methodology.	1
3.2	The Decision matrix – Pugh"s method	1
3.3	Concept Screening-Concept Testing-Define the Purpose of the Concept Test	2
3.4	Choose a Survey Population- Choose a Survey Format-Communicate the Concept.	2
3.5	Measure Customer Response-Interpret the Results.	1
3.6	Case study -Reflect on the Results and the Process.	1
3.7	COSTING: Material – manufacturing –assembly – structure.	2
3.8	Ergonomics and aesthetic aspects	1
4.0	**PRODUCT ARCHITECTURE**	
4.1	Implications of the Architecture-Establishing the Architecture-System- Level Design Issues. -Case study	2
5.0	**INDUSTRIAL DESIGN PROCESS AND INTELLECTUAL PROPERTY**	
5.1	Industrial Design Process – Introduction – Factors to be considered for industrial design process	1
5.2	Intellectual Property –patent types – copyright – trademark – trade secret	1
	Total	36

Course Designers

1.	Dr. K. Chockalingam	Professor	Mechanical Engineering	kcmech@tce.edu
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22MERT0	DESIGN FOR WELDING

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Welding is an inevitable process in the fabrication of parts. So, in order to make the process effective and improve the quality of the product, there is a need to design weld joints and know the engineering and science behind the process. In order to perform Welding in some applications, the design of Welding fixtures is also essential to improve the productivity of the process. This course aims to provide knowledge on Welding joints and its design techniques to optimize productivity, cost, and design of Welding Fixtures based on applications.

Prerequisite

- Metal Joining Processes

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the types of weld joints and applications of the weld joints.	TPS2	70	70
CO2	Determine the various types of stresses in the given weld joints.	TPS3	70	65
CO3	Determine the Weldability and energy density of the welding process	TPS3	70	65
CO4	Select the types of fixtures and positioners based on the given application	TPS3	70	65
CO5	Determine the welding process cost and time.	TPS3	70	65
CO6	Selection and design of the welding process based on given application/part geometry	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M
CO5	S	M	M	-	-	-	-	-	-	-	-	-	M	-	S
CO6	S	M	S	-	-	S	-	L	-	-	-	L	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
C01	-	30		10	10	-	-	-	-	-	-	-	2	5	-
C02	-	-	35	5	10	25	-	-	-	-	-	-	2	5	12
C03	-	-	35	5	10	25	-	-	-	-	-	-	2	5	12
C04	-	-	-	-	-	-	-	-	30	5	10	15	2	5	12
C05	-	-	-	-	-	-	-	-	30	5	10	20	2	5	12
C06	-	-	-	-	-	-	-	-	40	5	10	20	-	5	12

Syllabus

Types of weld joints and applications of the weld joints
Basic types of Joints and symbols, Applicable weld for Joints, Edge preparation for Weld joints Welding Positions and Weld Reinforcements. Comparison of Weld joints based on applications Calculation of Leg size, Throat size and Overlap,

Types of stresses in the given weld joints
Loads acting on the Weld Joints, Stress Distribution in Weld joints, Calculation of Stresses in Weld Joints, Calculation of weld parameters based on Stress acting on it, Effect of Residual Stress and its remedies

Weldability and Energy density of the welding process
Weldability of Materials, Determination of Heat input, Deposition rate and Weight of weld metal Calculation of Arc size, Energy Density and process efficiency in GMAW, Calculation of Current, Voltage and Power density in LBW and EBW.

Fixtures and positioners
Different types of welding fixtures, Desirable features for welding fixtures, Different types of positioners Desirable features for positioners, Use of Tack Welding and Turn Rolls

Welding process cost and time
Factors influencing Cost of Welding, Estimation of welding time, Cost estimation based on Welding process, Cost Control in Welding, Weld Quality and Cost ,Selection of welding Process based on Cost

Selection and design of the welding process
Codes and Standards, Weld procedure, qualification and certification, Selection welding process based on application – Automotive Manufacturing, Selection welding process based on application – Power Plants, Safety considerations in Welding

Textbook (s)

1. Omer W. Blodgett, "Design of Welded Structures", Hassell Street Press, 1st Edition, Reprint 2021.

Reference Books & Web Resources

1. Welding Handbook, AWS, Vol. 5, 7th edition, 1984
2. Omer W. Blodgett, James F. Lincoln, Design of Welded Structures, Arc Welding Foundation, 1st Edition Reprint 2016.
3. https://archive.nptel.ac.in/courses/112/107/112107089/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Types of weld joints and applications of the weld joints.**	
1.1	Basic types of Joints and symbols	1
1.2	Applicable weld for Joints	1
1.3	Edge preparation for Weld joints	1
1.4	Welding Positions and Weld Reinforcements	1
1.5	Comparison of Weld joints based on applications	1
1.6	Calculation of Leg size, Throat size and Overlap	1
2	**Types of stresses in the given weld joints.**	
2.1	Loads acting on the Weld Joints	1
2.2	Stress Distribution in Weld joints	1
2.3	Calculation of Stresses in Weld Joints	2
2.4	Calculation of weld parameters based on Stress acting on it.	2
2.5	Effect of Residual Stress and its remedies	1
3	**Weldability and Energy density of the welding process**	
3.1	Weldability of Materials	1
3.2	Determination of Heat input, Deposition rate and Weight of weld metal	2
3.3	Calculation of Arc size, Energy Density and process efficiency in GMAW.	1
3.4	Calculation of Current, Voltage and Power density in LBW and EBW.	1
4	**Fixtures and positioners**	
4.1	Different types of welding fixtures	2
4.2	Desirable features for welding fixtures	1
4.3	Different types of positioners	1
4.4	Desirable features for positioners	1
4.5	Use of Tack Welding and Turn Rolls	1
5	**Welding process cost and time**	
5.1	Factors influencing Cost of Welding	1
5.2	Estimation of welding time	1
5.3	Cost estimation based on Welding process	1
5.4	Cost Control in Welding	1
5.5	Weld Quality and Cost	1
5.6	Selection of welding Process based on Cost	2
6	**Selection and design of the welding process**	
6.1	Codes and Standards	1
6.2	Weld procedure, qualification and certification	1
6.3	Selection welding process based on application – Automotive Manufacturing	1
6.4	Selection welding process based on application – Power Plants	1
6.5	Safety considerations in Welding	1
	Total	36

Course Designers

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22MERY0	MATERIAL FLOW MAPPING

Category	L	T	P	C	Terminal Exam Type
PEES	1	-	-	1	-

Preamble

This elective course is designed as per the guideline prescribed by Visionary Learning Community of India (VLCI) Programme with an objective to "CREATE NEXT GENERATION MANUFACTURING CHANGE LEADERS" by transforming Engineering graduates in to Role Ready Engineers. The syllabus and the implementation procedure is developed by Prof. Shoji Shiba, Globally acclaimed authority on Breakthrough Management & Total Quality Management, Japan & Mr.Takeyuki Furuhashi, Expert in Flow Manufacturing, Japan. M/s. TAFE Pvt. Ltd., Madurai is an Industrial demonstrator to implement this course under the category of programme elective for expanded scope. The objective is to introduce the concept of material flow mapping chart called VmapQ. The flow management tools can be of great use for any industry to smoothen material flow and thereby improving cash flow which in turn will improve factory business health.

Prerequisite

- 22MEPX0 – Observation Skills
- 22MEPY0 – Evolution of Modern Manufacturing
- 22MEPZ0 – Modern Manufacturing Basic Knowledge and Skills

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the different kinds of flow in an industry	TPS2	70	70
CO2	Observe the material flow in kitchen, canteen, or an industry	TPS3	70	65
CO3	Explain the kinds of material stores practiced in industry	TPS2	70	70
CO4	Prepare VmapQ material flow chart for the given environment	TPS3	70	65
CO5	Compare material flow at factory with kitchen	TPS2	70	70
CO6	Identify the different kinds of waste for the given environment	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	S	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	S	-	-	-	-	-	-	-
CO3	M	L	-	-	-	-	-	S	S	M	-	-	-	-	-
CO4	S	M	L	-	-	-	-	S	S	M	-	-	-	-	-
CO5	M	L	-	-	-	-	-	S	M	S	-	-	-	-	-
CO6	S	M	L	-	-	-	-	S	M	M	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2					
	Theory						Theory					
	Assignment-1			TEST-1			Assignment-2			TEST-2		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3
CO1		30			20							
CO2		20	20		10	50						
CO3		30			20							
CO4								10	30		10	40
CO5								20			10	
CO6								10	30		10	30

- 100% Continuous assessment only. No terminal examination.
- As this elective course addresses industry-specific requirements, the student has to pass this course in the first attempt. No further attempts are allowed.
- Student can take up the remaining VLCI courses only if he/she pass this course in the first attempt.

Syllabus

Introduction to flow, different kinds of flow in an industry. Understanding flow through video with open ended questions. Observing the material flow with a help of videos. Flow Vs Process: Example of expressway traffic, Hospital, Kitchen etc. Benefits of understanding material flow.

Activity 1: Identify along with simple layout the different process and flow involved for the given environment.

Introduction to material flow mapping tool called "VmapQ" (Quick Visual Map). Definition of material flow and VmapQ. Meaning and types of material stores in an industry like Raw Material (RM), Work-in-Progress (WIP) and Finished Good (FG) stores and its conventional representation.

Activity 2: Identify the material flow for the given environment like kitchen, canteen, college, restaurant or any factory.

Preparation of VmapQ material flow chart for canteen, kitchen, hospital or any factory. Step-by-step procedure: 1. Data collection for distance travelled and WIP as per format, 2. Observation on safety, cleanliness and quality as per the format, 3. Procedure for the preparation of VmapQ:- 3.1 Guideline for chart making, 3.2 Visualize and drawing layout of the given environment, 3.3 Visualize location of RM & FG stores, 3.4 Visualize location of WIP stores, 3.5 Visualize main material flow, 3.6 Preparation of safety, cleanliness and quality labels as per 4W1H format, 3.7 Making A4 sheet report and 3.8 Presentation procedure.

Activity 3: Preparation of VmapQ material flow chart with respect to a product or process given and compare the material flow at the factory with kitchen.

Introduction to different kinds of waste **-** Visualizing the waste, Definition and types of waste, Focus on 3 major wastes like Defects, Transportation and WIP.

Activity 4: Record different kinds of waste prevailing for the given environment like college, hospital, restaurant, shopping mall, industry etc.

Textbook (s)

1. Narendra Deshpande, Kakasaheb Dhere and Vishvas Patil "VLCI Module-4: Introduction of Flow Management System", Private circulation, 2019.

Reference Books & Web Resources

1. Material flow simulation of a cement process industry: https://youtu.be/bAKBX2VoMn0
2. Road drive Japan expressway: https://youtu.be/5WOqHLZUrbo
3. Delhi traffic congestion: https://youtu.be/iEIk3RpV6RA, https://youtu.be/wA9XMbWXVO8
4. Introduction to waste: https://youtu.be/_NkqwMitQ8o
5. Eight kinds of waste: https://youtu.be/bet_Qqgc86U

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction to flow**	
1.1	Introduction to flow, different kinds of flow in an industry. Understanding flow through video with open ended questions.	2
1.2	Observing the material flow with a help of videos. Flow Vs Process: Example of expressway traffic, Hospital, Kitchen etc. Benefits of understanding material flow.	2
1.3	**Activity 1:** Identify along with simple layout the different process and flow involved for the given environment.	
2	**VmapQ**	
2.1	Introduction to material flow mapping tool called "VmapQ" (Quick Visual Map). Definition of material flow and VmapQ.	1
2.2	Meaning and types of material stores in an industry like Raw Material (RM), Work-in-Progress (WIP) and Finished Good (FG) stores and its conventional representation.	1
2.3	**Activity 2:** Identify the material flow for the given environment like kitchen, canteen, college, restaurant or any factory.	
3	**Preparation of VmapQ**	
3.1	Step-by-step procedure for the preparation of VmapQ material flow chart for canteen, kitchen, hospital or any factory	2
3.2	Preparation of labels on safety, cleanliness and quality as per 4W1H format, Making A4 sheet report and Presentation procedure.	2
3.3	**Activity 3:** Preparation of VmapQ material flow map with respect to a product or process given.	
3.4	**Factory visit:** Prepare VmapQ for the factory visited and present it as per the procedure given.	
4	**Types of waste**	
4.1	Introduction to different kinds of waste, Visualizing the waste.	
4.2	Definition and types of waste. Focus on 3 major wastes like Defects, Transportation and WIP.	1
	Activity 4: Record different kinds of waste prevailing for the given environment like college, hospital, restaurant, shopping mall, industry etc.	1
	Total	**12**

Course Designer s

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22MERZ0	FLOW MANAGEMENT CONCEPTS

Category	L	T	P	C	Terminal Exam Type
PEES	2	-	-	2	-

Preamble

This elective course is designed as per the guideline prescribed by Visionary Learning Community of India (VLCI) Programme with an objective to "CREATE NEXT GENERATION MANUFACTURING CHANGE LEADERS" by transforming Engineering graduates in to Role Ready Engineers. The syllabus and the implementation procedure is developed by Prof. Shoji Shiba, Globally acclaimed authority on Breakthrough Management & Total Quality Management, Japan & Mr.Takeyuki Furuhashi, Expert in Flow Manufacturing, Japan. M/s. TAFE Pvt. Ltd., Madurai is an Industrial demonstrator to implement this course under the category of programme elective for expanded scope. Here, the objective is to impart the different flow management concepts to the students in order to achieve a stable production even though the fluctuating customer requirements in terms of product variety and quantity.

Prerequisite

- 22MEPX0 – Observation Skills
- 22MEPY0 – Evolution of Modern Manufacturing
- 22MEPZ0 – Modern Manufacturing Basic Knowledge and Skills
- 22MERY0 – Material Flow Mapping

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Develop Heijunka-1 model for the given product mix	TPS3	70	65
CO2	Explain the Heijunka-2 scheduling concept	TPS2	70	70
CO3	Prepare Vmap-1 chart for the given overall operation flow of a business	TPS3	70	65
CO4	Prepare Vmap-2 chart for the given plant layout	TPS3	70	65
CO5	Prepare Vmap-3 chart for the given cell layout	TPS3	70	65
CO6	Explain the concept of standardized work	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	-	-	-	-	-	-	-
CO2	M	L	-	-	-	-	-	S	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	S	S	M	-	-	-	-	-
CO4	S	M	L	-	-	-	-	S	S	M	-	-	-	-	-
CO5	S	M	L	-	-	-	-	S	M	M					
CO6	M	L	-	-	-	-	-	S	M	M	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-1						Assessment-2					
	Theory						Theory					
	Assignment-1			TEST-1			Assignment-2			TEST-2		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20	20		10	30						
CO2		20			20							
CO3		20	20		10	30						
CO4								20	20		10	30
CO5								20	20		10	30
CO6								20			20	

- 100% Continuous assessment only. No terminal examination.
- As this elective course addresses industry-specific requirements, the student has to pass this course in the first attempt. No further attempts are allowed.
- Student can take up the remaining VLCI courses only if he/she pass this course in the first attempt.

Syllabus

Concept of Heijunka-1, benefits in OEM assembly, Takt-time based production, development of Heijunka-1 model for the given product mix. Introduction to Heijunka-2, parameters to evaluate production flow, sustaining synchronized flow, summary of Heijunka-2, comparison of traditional single architecture flow and dual architecture of Heijunka-2 system, Heijunka-2 planning procedure, common steps of execution & control system, VSME way of scheduling methods.

Introduction to Vmap-1, 2 & 3 and benefits. Key points and procedure to prepare Vmap-1, calculation of different parameters. Concepts of Vmap-2, steps to make Vmap-2, evaluation and presentation. Seven steps to create effective layout. Vmap-3 benefits, visualizing flow at cell level, steps to prepare Vmap-3. Introduction to standardized work and benefits.

Textbook (s)

1. Narendra Deshpande, Kakasaheb Dhere and Vishvas Patil "VLCI Module-4: Introduction of Flow Management System", Private circulation, 2019.

Reference Books & Web Resources

1. Material flow simulation of a cement process industry: https://youtu.be/bAKBX2VoMn0

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Heijunka-1**	
1.1	Concept of Heijunka-1, benefits in OEM assembly, Takt-time based production	2
1.2	development of Heijunka-1 model for the given product mix	2
2.	**Heijunka-2**	
2.1	Introduction to Heijunka-2, parameters to evaluate production flow, sustaining synchronized flow, summary of Heijunka-2,	2
2.2	comparison of traditional single architecture flow and dual architecture of Heijunka-2 system, Heijunka-2 planning procedure,	2
2.3	common steps of execution & control system, VSME way of scheduling methods.	2
3.	**Vmap-1, 2 & 3**	
3.1	Introduction to Vmap-1, 2 & 3 and benefits	2
3.2	Key points and procedure to prepare Vmap-1, calculation of different parameters.	3

No.	Topic	No. of Periods
3.3	Concepts of Vmap-2, steps to make Vmap-2, evaluation and presentation. Seven steps to create effective layout.	3
3.4	Vmap-3 benefits, visualizing flow at cell level, steps to prepare Vmap-3.	3
4.	**standardized work**	
4.1	Introduction to standardized work and benefits.	3
	Total	**24**

Course Designers

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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
ELECTIVE COURSES FOR MINOR SPECIALIZATION
MECHANICAL ENGINEERING

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

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22MEQA0	AUTOMOBILE ENGINEERING

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

Automobile engineering draws on almost all areas of engineering: thermodynamics and combustion, fluid mechanics and heat transfer, mechanics, stress analysis, materials science, electronics and control, dynamics, vibrations, machine design, linkages and so forth. This course intends to provide a fundamental understanding of the various subsystems of an automobile.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain types of engines and their function	TPS2	70	70
CO2	Explain the process of air and fuel induction, combustion and emission	TPS2	70	70
CO3	Discuss the powertrain of an automobile	TPS2	70	70
CO4	Illustrate various types of braking system and calculate brake force	TPS3	70	65
CO5	Calculate steering geometry parameters	TPS3	70	65
CO6	Differentiate between dependent and independent suspension system	TPS2	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	15	15	-							2	10	-
CO2	-	40	-	20	20	-							2	10	-
CO3	-	30	-	15	15	-							2	10	-
CO4							-	-	30	5	10	15	-	10	15
CO5							-	-	30	5	10	15	2	10	15
CO6							-	40	-	20	20		2	10	-

Syllabus

Introduction: Classification of Internal Combustion Engines, Engine Components, Operation of Four Stroke Engines, Two Stroke Engines, Engine Cycles, Engine Performance, Supercharging.

Combustion:
Combustion in Spark Ignition Engines, Combustion in Compression Ignition Engines, Carburetion, Fuel Introduction Systems, Engine Emissions, Emission Control Systems

Transmission:
Automotive Powertrain, Automotive Clutch, Transmission, Powertrain Analysis, Transmission Matching

Braking system:
Introduction to Brake System, Components of Brake System, Hydraulic Brake, Air Brake, Antilock Brake System, Braking effort calculation

Steering system:
Introduction to Steering System, steering geometry, Manual Steering System, Power Steering System, Wheel Alignment, Introduction to Suspension System

Suspension system:
Components of Suspension System, Dependent and Independent Suspension, Introduction to Electric and Hybrid Powertrain, Tyres. Interior and exterior devices-Air bag, Wind screen wiper, Air conditioner

Textbook (s)

1. R. Sakthivel, Faisal O. Mahroogi, S. Narayan, S. Abubakar,M. U. Kaisan and Youssef Alammari, Introduction to Automotive Engineering, 1st edition, Wiley, 2019
2. Dr.N.K.Giri, Automobile Mechanics Eight Edition, Khanna publishers Pvt. Ltd,New Delhi 2011.
3. Kirpal Singh, Volume-1&2, 13th Edition, Standard Publishers Distributers, 2017.
4. S.S.Srivnivasan ,Automotive Mechanics , McGraw Hill Education; 2 edition 2017

Reference Books &Web Resources

1. Joseph Heitner, Automotive Mechanics, principle and practices, East West Press, (Second Edition), 2001
2. Richard Stone and Jeffrey K. Ball, Automotive Engineering Fundamentals SAE International, 2011

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction:**	
1.1	Classification of Internal Combustion Engines, Engine Components,	1
1.2	Operation of Four Stroke Engines, Two Stroke Engines,	1
1.3	Engine Cycles, Engine Performance, Supercharging.	2
2	**Combustion**	
2.1	Combustion in Spark Ignition Engines, ,	2
2.2	Combustion in Compression Ignition Engines	2
2.3	Carburetion, Fuel Introduction Systems,	1
2.4	Engine Emissions, Emission Control Systems	1
3	**Transmission:**	
3.1	Automotive Powertrain	1
3.2	Automotive Clutch	1
3.3	Transmission	2
3.4	Powertrain Analysis, Transmission Matching	2
4	**Braking system:**	
4.1	Introduction to Brake System, Components of Brake System,	1
4.2	Hydraulic Brakes	2
4.3	Air Brake	1
4.4	Antilock Brake System, braking effort calculation	2

No.	Topic	No. of Periods
5	**Steering system**	
5.1	Introduction to Steering System, steering geometry	2
5.2	Manual Steering System	2
5.3	Power Steering System	2
5,4	Wheel Alignment, Introduction to Suspension System	1
6	**Suspension system:**	
6.1	Components of Suspension System	1
6.2	Dependent and Independent Suspension	2
6.3	Introduction to Electric and Hybrid Powertrain,	2
6.4	Tyres	1
6.5	Interior and exterior devices-Air bag, Wind screen wiper, Air conditioner	1
	Total	36

Course Designers

1.	Dr. B. Karthikeyan	Asst.Professor	Mechanical Engineering	bkmech@tce.edu
2.	Dr. M.S.Govardhanan	Asst.Professor	Mechanical Engineering	govardhanans@tce.edu

22MEQB0	3D PRINTING

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

3D Printing and design is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in Industry 4.0 environment.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the fundamentals and process chain of 3D Printing.	TPS2	70	70
CO2	Explain of file formats and software packages used for 3D printing machine.	TPS2	70	70
CO3	Choose a suitable Photopolymerization / Powder Bed Fusion 3D printing process for an application / product.	TPS3	70	65
CO4	Select a suitable deposition 3D printing process for an application / product.	TPS3	70	65
CO5	Select the suitable process parameter of 3D printing process for a given product/application	TPS3	70	65
CO6	Select the different Post processing methods for 3D Printed parts	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	10								4	5	
CO2		20		10	10								4	5	
CO3			60	10	10	40							2	5	15
CO4									40	10	10	20	4	5	15
CO5									40	5		20	4		15
CO6									20	5	10	20	2		15

Syllabus

3D Printing: Introduction - Prototyping fundamentals - Historical development - Need for time compression in product development - processes chain- Classification of 3D Printing - Advantages of 3D Printing.
CAD (Computer Aided Design) for 3D Printing: CAD model preparation, Data Interfacing - CAD Data formats - STL File Format, Binary/ASCII – Creating STL Files from a CAD System - Problems with STL Files - STL File Manipulation - Part orientation and support generation.
Photopolymerization: Stereolithography (SL) – Principles – Materials - Process details - Process parameter - Applications.
Powder Bed Fusion: Selective laser Sintering (SLS) – Principles – Materials - Process details - Process parameter - Applications.
Extrusion-Based RP Systems: Fused Deposition Modelling (FDM) – Principles – Materials- Process details - Process parameter - Applications
Direct Deposition: Direct Metal Deposition (DMD) – Principle - Materials - Process details - Process parameter - Applications.
Post processing of AM parts: Introduction - Support material removal - surface texture improvement- accuracy improvement - aesthetic improvement - property enhancements using thermal techniques - property enhancements using non-thermal techniques
Applications: Aerospace - Health Care - Defence – Automotive – Construction - Food Processing – Electronics. Demonstration to Create 3D model using Additive manufacturing Method

Textbook (s)

1. Lan Gibson, David W. Rosen and Brent Stucker, **"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",** Springer, 2010.

Reference Books & Web Resources

1. Andreas Gebhardt, **"Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing",** Hanser Publisher, 2011.
2. Khanna Editorial, **"3D Printing and Design",** Khanna Publishing House, Delhi.
3. CK Chua, Kah Fai Leong, **"3D Printing and Rapid Prototyping- Principles and Applications",** World Scientific, 2017.
4. L. Lu, J. Fuh and Y.S. Wong, **"Laser-Induced Materials and Processes for Rapid Prototyping",** Kulwer Academic Press, 2001.
5. Patri K. V enuvinod and Wei yin Ma, **"RAPID PROTOTYPING Laser-based and Other Technologies"** Springer Science+Business Media, LLC, 2004.
6. Pham D T and Dimov S S, "**Rapid Manufacturing**", The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
8. https://nptel.ac.in/courses/112/104/112104265/ -- Rapid Manufacturing.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**3D Printing (Additive Manufacturing)**	
1.1	Introduction - Prototyping fundamentals - processes chain -	2
1.2	Historical development - Need for time compression in product development	2
1.3	Classification of AMT process - Advantages of AM	1
2	**CAD (Computer Aided Design) for 3D Printing**	
2.1	CAD model preparation - Data Interfacing	1
2.2	CAD Data formats - STL File Format, Binary/ASCII – Creating STL Files from a CAD System - Problems with STL Files - STL File Manipulation	2
2.3	Part orientation and support generation	2
3	**Photopolymerization and Powder Bed**	
3.1	Photopolymerization: Stereolithography (SL) – Principles – Materials - Process details	2
3.2	Process parameter - Process Selection for various applications.	2
	Powder Bed Fusion: Selective laser Sintering (SLS) and Selective Laser Melting (SLM) - Principles – Materials - Process details -	2
	Process parameter - Process Selection for various applications	2
4	**Extrusion and Direct Deposition**	
4.1	Extrusion-Based RP Systems: Fused Deposition Modelling (FDM) – Principles – Process details -	2
4.2	Process parameter, Process Selection for various applications,	2
4.3	Beam Deposition: Direct Metal Deposition (DMD) – Process details -	2
4.4	Process parameter - Process Selection for various applications	2
5	**Post processing of 3D Printed parts**	
5.1	Support material removal - surface texture improvement	1
5.2	accuracy improvement, aesthetic improvement	2
5.3	property enhancements using thermal techniques.	2
5.4	property enhancements using non-thermal techniques.	1
6	**Applications**	
6.1	Aerospace - Health Care - Defence	1
6.2	Automotive – Construction - Food Processing – Electronics.	1
6.3	Demonstration to Create 3D model using Additive manufacturing Method	2
	Total	36

Course Designers

1. Dr. K. Chockalingam Professor Mechanical Engineering kcmech@tce.edu
2. Mr. T. Prakash Assistant Professor Mechanical Engineering tpmech@tce.edu
3. Mr. M. Karthic Assistant Professor Mechanical Engineering mkmect@tce.edu

22MEQC0	COMPOSITE MATERIALS

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. Composite materials are preferred over traditional materials for their properties which are stronger, lighter or less expensive. This course covers the fundamentals of composite materials and manufacturing of various composite materials.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the classification, characteristics and the applications ofcomposites in various domains	TPS2	70	70
CO2	Summarize the various Reinforcements and Matrix used in compositematerials	TPS2	70	70
CO3	Select the appropriate processing method for polymer matrixcomposites	TPS3	70	65
CO4	Select the proper fabrication method for metal matrix composites	TPS3	70	65
CO5	Choose the suitable processing method in ceramic matrix composites	TPS3	70	65
CO6	Choose the suitable processing carbon-carbon Composites	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			30	8	10								2	5	
CO2			30	8	10	25							2	5	
CO3			40	4	10	25							4	5	15
CO4									30	4	10	20	4	5	15
CO5									30	8	10	20	4	5	10
CO6									40	8	10	10	4	5	10

Syllabus

Composite Materials: Definition- Need-Classifications- Characteristics- Applications in variousindustries -Aircraft, Military, Space Applications, Automotive, Sporting Goods, Marine, Infrastructure.Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight

Reinforcements and Matrix Materials :Reinforcements -Types - Fibers– Glass fiber, Boron fiber,carbon fiber, organic fiber, ceramic and metallic fibers - whiskers–Fabrication of Glass fibre andcarbon fibre-Matrix materials– Polymers, Classification of Polymers – Properties of Thermo andThermosetting Plastics- Metals and ceramics and their properties – interfaces – Wettability – Types ofbonding at the interface — Physical and chemical properties.

Manufacturing of Polymer Matrix Composites: Polymer matrix composites: hand layup,spray up technique, filament winding, Pultrusion, resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet Moulding Compound – thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding – interfaces in PMCs - Mechanical properties and application of PMCs – recycling of PMCs.

Manufacturing of Metal Matrix Composites: Metallic matrices: Aluminum, titanium, magnesium, copperalloys – Processing of MMCs: liquid state, Solid state, in situ fabrication techniques – diffusionbonding – powder metallurgy techniques - interfaces in MMCs – mechanical properties – machiningof MMCs — Applications.

Manufacturing of Ceramic Matrix Composites (CMC): Processing of CMC: cold pressing, sintering, reaction bonding, liquid infiltration, lanxide process –In situ chemical reaction techniques: chemical vapour deposition, chemical vapour impregnation, sol-gel method – Interfaces in CMCs — mechanical properties and applications of CMCs

Manufacturing of Carbon-Carbon Composites Carbon-carbon Composites – Carbon Fiber Reinforcements Matrix Systems -manufacturing methods of Carbon-Carbon Composites - Properties and applications.

Textbook (s)

1. M. Balasubramanian, Composite **materials and Processing**, Taylor & Francis Group, LLC, CRCPress, 2014.
2. Krishnan K Chawla, Composite **Materials: Science and Engineering**, International Edition, Springer, 2012

Reference Books & Web Resources

1. Mallick P.K., Fiber Reinforced Composites: Materials, Manufacturing and Design, CRC press, New Delhi, 2010.
2. Mallick, P.K. and Newman.S., Composite Materials Technology, Hanser Publishers, 2003.
3. Bhagwan D. Agarwal and Lawrence J. Broutman, Analysis and Performance of Fiber Composites, John Wiley and Sons Indian Edition, 2018.

4. Prof.J.Ramkumar, " Manufacturing of composites", NPTEL,IIT Kanpur - https://nptel.ac.in/courses/112104221/
5. Prof.Nachiketa Tiwari, "Introduction to composites", NPTEL, IIT Kanpur https://nptel.ac.in/courses/112104168/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Composite Materials**	
1.1	Definition- Need-Classifications- Characteristics	1
1.2	Applications -Aircraft and Military Applications, Space Applications, Automotive Applications, Sporting Goods Applications, Marine Applications, Infrastructure	1
1.3	Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight	2
2	**Selection of engine and transmission for an automobile**	
2.1	Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - whiskers	1
2.2	Polymers, Classification of Polymers — Properties of Thermo and Thermosetting Plastics -metals and ceramics and their properties – interfaces – Wettability	2
2.3	Metals and ceramics and their properties — interfaces — Wettability	1
2.4	Types of bonding at the interface	1
2.5	Physical and chemical properties	1
3	**Manufacturing of Polymer Matrix Composites**	
3.1	Manufacturing methods: Polymer matrix composites: hand layup, Spray up technique , filament winding, Pultrusion	2
3.2	Resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet moulding Compound	2
3.3	Thermoplastic matrix composites — film stacking, diaphragm forming, thermoplastic tape laying, injection moulding interfaces in PMCs	1
3.4	Mechanical properties and application of PMCs	1
3.5	Recycling of PMCs	1
4	**Manufacturing of Metal Matrix Composites:**	
4.1	Metallic matrices: Aluminium, titanium, magnesium, copper alloys	1
4.2	Processing of MMCs: liquid state, Solid state, in situ fabrication techniques - Diffusion bonding- powder metallurgytechniques	2
4.3	Interfaces in MMCs	1
4.4	Mechanical properties	1
4.5	Machining of MMCs – Applications.	1
5	**Manufacturing of Ceramic Matrix Composites**	
5.1	Cold pressing, Sintering, Reaction bonding, Liquid infiltration method	2
5.2	Lanoxide process –In situ chemical reaction techniques: Chemical vapour deposition, Chemical vapour impregnation, Sol-gel methods	2
5.3	Interfaces in CMCs	1
5.4	Mechanical properties and applications of CMCs	2
6	**Manufacturing of Carbon- Carbon Composites**	
6.1	Carbon-carbon Composites – Carbon Fiber Reinforcements -	1

No.	Topic	No. of Periods
	Matrix Systems -	
6.2	Manufacturing methods of Carbon-Carbon Composites -	2
6.3	Properties and applications .	1
	Total	36

Course Designers

1.	Dr. V. Balasubramani	Associate Professor	Mechanical Engineering	vbmech@tce.edu
2.	Mr. C. Vignesh	Assistant Professor	Mechanical Engineering	cvmech@tce.edu
3.	Mr. M.Sermaraj	Assistant Professor	Mechanical Engineering	msjmech@tce.edu

22MEQD0	SYSTEMS APPROACH FOR ENGINEERS

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

In the Global economy, it is required that every engineer simultaneously performs as a scientist/engineer/manager, with a constant eye on the most value-added output relevant for the company. Such interdisciplinary thinking also promotes the ability to acquire and use all available resources (Knowledge Integration) from within the company and outside. This course enables System Thinking among students and makes them to realise its effectiveness in creating a product or process, which is very much the needed in the industry today.

Prerequisite

- Design Thinking

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain about the context, principles and working of systems	TPS2	70	70
CO2	Explain about the Systems Thinking, System Engineering and its applications	TPS3	70	65
CO3	Choose the various types of Inputs required to achieve the desired outputs of a System	TPS3	70	65
CO4	Illustrate the transformation occurring inside a given system	TPS3	70	65
CO5	Select suitable diagnostics tools to identify the vital signs in transformations occurring in System	TPS3	70	65
CO6	Apply System approach frame work to real world problems	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	-	M	-	-	M	-	-	-
CO4	S	M	L	-	-	-	-	-	M	-	-	M	-	-	-
CO5	S	M	L	-	-	-	-	-	M	-	-	M	-	-	-
CO6	S	M	L	-	-	-	-	-	S	-	-	M	-	-	-

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		40		10	10								5	5	
CO2			30	10	10	20							5	5	5
CO3			30	10	10	20							5	5	10
CO4									30	10	10	10	5	5	5
CO5									30	10	10	10	5	5	10
CO6									40	10	10	20	5	5	10

Syllabus

System Definition: Global economy and its impact on the workers, Transformation skills for Engineers, Definition of System by Experts, Principles of System, Real-time Examples on Principles of System, Apparent and Subtle System, Defining the Context of System, Real-time Examples on Context of System.

Systems Thinking: Systems Engineering and its Significance, Physical and Service Processes, Need for System Thinking, Levels of System Thinking - Awareness, Analysis and Synthesis, Need for System Approach.

Inputs and Outputs of System: System approach Frame work Categories, New Solutions Vs. Replication Solutions, Perceived needs for achieving the solutions, Input Investment and Expense, Types of Cost, Input Need and Constraints, End user need, Output Technical output, Output - System Output, Relationship between System and Technical Outputs.

Transformation: Phenomenon in Process, Operational parameters, Process improvement

Diagnostics: Diagnostic tools and their use, Vital signs in transformation and their recognition, Sensitivity Analysis.

Application of System approach: System Documentation and implementation, Benefits of Digital Data, Case Studies on System approach, Student Activity (Development, Review and Presentation).

Textbook (s)

1. Dr.K. Subramanian, “The System Approach”, Hanser Gardner Publications, First Edition 2000.

Reference Books & Web Resources

1. Learning Material provided by Dr. K. Subramanian, President, STIMS Institute San Jose, California, USA. 3.
2. https://stimsinstitute.files.wordpress.com

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**System Definition:**	
1.1	Global economy and its impact on the workers	1
1.2	Transformation skills for Engineers	1
1.3	Definition of System by Experts	1
1.4	Principles of System	1
1.5	Real-time Examples on Principles of System	1
1.6	Apparent and Subtle System	1
1.7	Defining the Context of System	1
1.8	Real-time Examples on Context of System.	1
2	**Systems Thinking**:	
2.1	Systems Engineering and its Significance	1

No.	Topic	No. of Periods
2.2	Physical and Service Processes	1
2.3	Need for System Thinking	1
2.4	Levels of System Thinking - Awareness, Analysis and Synthesis	1
2.5	Need for System Approach.	1
3	**Inputs and Outputs of System:**	
3.1	System approach Frame work - Categories	1
3.2	New Solutions Vs. Replication Solutions	1
3.3	Perceived needs for achieving the solutions	1
3.4	Input Investment and Expense	1
3.5	Types of Cost	1
3.6	Input - Need and Constraints	1
3.7	End user need	1
3.8	Output -Technical output	1
3.9	Output - System Output	1
3.10	Relationship between System and Technical Outputs.	1
4	**Transformation**:	
4.1	Phenomenon in Process	1
4.2	Operational parameters	1
4.3	Process improvement	1
5	**Diagnostics**:	
5.1	Diagnostic tools and their use	1
5.2	Vital signs in transformation and their recognition	1
5.3	Sensitivity Analysis	1
6	**Application of System approach**	
6.1	System Documentation and implementation	2
6.2	Benefits of Digital Data	1
6.3	Case Studies on System approach	2
6.4	Student Activity (Development, Review and Presentation).	2
	Total	36

Course Designer

1. Dr.M.Balamurali Assistant Professor Mechanical Engineering balacim82@tce.edu

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015

DEPARTMENT OF MECHANICAL ENGINEERING

Honours and Minor Specialization for the students those who joined in 2022

Honours				Minor
Vertical 1 Thermal Systems	**Vertical 2 Materials and Design**	**Vertical 3 Manufacturing Automation**	**Vertical 4 Product and Process Management**	**Mechanical Engineering**
Programme Specific Electives (PSE)				
22MEPA0 - Energy Conversion Systems	**22MEPF0 - Design of Hydraulic and Pneumatic Circuits**	**22MEPL0 - Design for Sheet Metal Processing**	22MEPS0 - Process Planning and Cost Estimation	22MEQA0 - Automobile Engineering
22MEPB0 - Refrigeration and Air Conditioning	22MEPG0 -Machine Tool Design	**22MEPM0 -Non-Traditional Machining Processes**	22MEPT0 - Supply Chain Management	22MEQB0 - 3D Printing
22MEPC0 - Computational Fluid Dynamics	22MEPH0 -Experimental Methods for Engineers	22MEPN0 -Material Handling Systems Engineering	22MEPU0 - Work study and Ergonomics	22MEQC0 -Composite Materials
22MEPD0 - Turbomachines	22MEPJ0 -Non-Destructive Testing Techniques	22MEPQ0 – Geometric Dimensioning and Tolerancing	22MEPV0 - Organizational Behaviour	22MEQD0 -Systems Approach for Engineers
22MEPE0 - Design of Thermal Systems (MOOC)	**22MEPK0 - Manufacturing of Composite Materials (MOOC)**	**22MEPR0 - Geometric Modeling (MOOC)**	**22MEPW0 – Total Quality Management (MOOC)**	22MEQE0 -Thermal Management Systems
Programme Electives for Expanded Scope (PEES)				
22MERA0 - Energy Management in Thermal Systems	**22MERE0 - Mechanical Vibrations**	**22MERJ0 - Industry 4.0**	**22MERN0 - Decision Support System**	22MEQF0 -Design of Mechanical Systems
22MERB0 - Solar Energy Systems	**22MERF0 - Biomaterials**	22MERK0 - Robotics	**22MERS0 - Product Design and Development**	22MEQG0 -Integrated Product Development
22MERC0 - Gas Turbines and Propulsion Systems	22MERG0 - Mechanics of Composite Materials	22MERL0 - Additive Manufacturing	**22MERT0 - Design for Welding**	22MEQH0 -Lean Six Sigma
22MERD0 - Vehicle Technologies	22MERH0 -Tribology in Machine Design	22MERM0 - AI for Mechanical Engineers	22MERU0 - Design for Manufacture and Assembly	22MEQJ0 -Safety Engineering

VLCI Courses	
Programme Specific Electives (PSE)	**Programme Electives for Expanded Scope (PEES)**
22MEPX0 - Observation Skills	22MERY0 - Material Flow Mapping
22MEPY0 - Evolution of Modern Manufacturing	22MERZ0 - Flow Management Concepts
22MEPZ0 - Modern Manufacturing Basic Knowledge and Skills	

Passed in Board of Studies on 03.05.2023

Approved in 65th Academic Council Meeting on 27.05.2023

22MEPD0	TURBOMACHINES

Category	L	T	P	C	Terminal Exam Type
PSE	3	0	-	3	Theory

Preamble

Turbo machines are energy conversion devices in which energy is transferred either to (or) from a continuously flowing fluid by the dynamic action of one (or) more moving blade rows on a rotor. This course deals with the study of construction, working, energy transfer and performance calculations of both compressible and incompressible flow turbo machines like turbines, compressors, and pumps.

Prerequisite

- Engineering Thermodynamics
- Thermal Engineering
- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the energy transfer, reheating and preheating effects, and compute the efficiencies of turbomachines.	TPS3	70	65
CO2	Describe cascade nomenclatures and utilize dimensional and model analysis to turbomachines.	TPS2	70	70
CO3	Evaluate the performance parameters of Centrifugal and Axial flow Compressors	TPS3	70	65
CO4	Estimate the performance parameters of Steam and Gas Turbines	TPS3	70	65
CO5	Evaluate the performance parameters of Centrifugal Pumps	TPS3	70	65
CO6	Estimate the performance parameters of Hydraulic Turbines	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	S	M	M	-	-	-	M	-
CO2	M	L	-	-	-	-	-	S	M	M	-	-	-	M	-
CO3	S	M	L	-	-	-	-	S	M	M	-	-	-	M	-
CO4	S	M	L	-	-	-	-	S	M	M	-	-	-	M	-
CO5	S	M	L	-	-	-	-	S	M	M	-	-	-	M	-
CO6	S	M	L	-	-	-	-	S	M	M	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			30	5	10	15							2	6	10
CO2		30	-	10	20	-							2	6	-
CO3			40	5	10	25							-	6	15
CO4									40	5	10	25	2	6	15
CO5									30	5	10	15	2	-	10
CO6									30	5	10	15	2	6	10
												Total	10	30	60

Syllabus

Energy transfer and Efficiencies: Introduction, Classification, Continuity equation, Laws of thermodynamics, Newton's second law of motion, Energy Transfer in Turbo machinery- Euler's Turbine Equation, Components of energy transfer, Performance Parameters, Work done, Preheating and Efficiencies of Compressor, Numerical problems. Work done, Reheating and Efficiencies of Turbine, Numerical problems.

Cascades, Dimensional and Model Analysis: Cascade Testing- Blade Types, Forces acting on blades, Blade nomenclature, Compressor cascade and Turbine cascade nomenclatures, Cascade testing and losses, Dimensional analysis - Dimensions and equations, Advantages, Buckingham Pi Theorem, Model Analysis-Advantages, Similarity – Geometric, Kinematic and Dynamic, Specific speed, Unit quantities

Compressible Flow Machines

Compressors - Centrifugal Compressors - Velocity triangle, Slip factor, Work done, Impeller blade types, Numerical problems. Characteristics-Stall, Surging and Choking. Axial Flow Compressors - Velocity triangle, Degree of reaction, Stage loading, Numerical problems, multi-stage performance, Characteristics – Stalling.

Turbines - Axial Flow Impulse Turbine – Single stage, Velocity triangles and Work output, Mollier diagram, Degree of reaction, Blade-loading coefficient, Numerical problems, Multi Stage-Pressure compounding, Velocity Compounding and Pressure-velocity compounding, Numerical Problems. Reaction Turbine- Velocity diagram, Stage efficiency. Reheat factor, Numerical problems, Losses in turbines, Governing of turbines. Radial Flow Gas Turbine-Velocity diagrams and Mollier diagram, Spouting velocity, Efficiency, Numerical problems.

Incompressible Flow Machines

Pumps - Centrifugal Pumps – Velocity triangles, Work done, Slip factor, Pump losses, Numerical problems, Impeller Blade Shape, NPSH, Specific speed, Cavitation.

Turbines - Impulse Turbine-Pelton wheel, Velocity triangles, Work done and Efficiencies, Numerical problems, Reaction Turbine-Francis turbine, Velocity triangles, Work done, Efficiencies, Turbine characteristics, Numerical problems, Axial Flow Turbine- Kaplan turbine, Velocity triangles, Work done, Efficiencies, Numerical problems, Cavitation.

Textbook (s)

1. S. M. Yahya, "Turbines, Compressors & Fans", McGraw Hill Education, 2017.
2. A.Valan Arasu, "Turbo Machines", Second Edition, Vikas publishing house Pvt Ltd, 2013.

3. S.L.Dixon, "Fluid Mechanics, Thermodynamics of Turbo machinery" Butterworth- Heinemann Publishers, 7th edition, 2014.

Reference Books & Web Resources

1. Rama S. R. Gorla and Aijaz A. Khan "Turbo machinery Design and Theory", Marcel Dekker Inc. USA, 2003.
2. V. Kadambi and Manohar Prasad "An Introduction to Energy Conversion, Volume III
3. Turbomachinery", New Age International Publishers (P) Ltd. 2011.
4. B.K. Venkanna, 'Fundamentals of Turbomachinery', PHI Learning Pvt. Ltd., 2009.
5. William W Perg, "Fundamentals of Turbomachinery", John Wiley & Sons, Inc. 2008.
6. G.Gopalakrishnan and D.Prithvi Raj, "A Treatise of Turbomachines", Scitech Publications, 2008.
7. NPTEL Material on Basics of Turbomachines: http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/machine/ui/TOC.htm
8. NPTEL material on Turbomachinery Aerodynamics: http://nptel.ac.in/courses/101101058/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
	Turbomachines	
1	**Energy transfer and Efficiencies**	
1.1	Introduction, Classification, Continuity equation, Laws of thermodynamics, Newton's second law of motion.	1
1.2	Energy Transfer in Turbo machinery- Euler's Turbine Equation, Components of energy transfer.	1
1.3	Performance Parameters- Compression and Expansion processes on T-S diagrams, Work done.	1
1.3.1	Preheating and Efficiencies of Compressor, Numerical problems.	1
1.3.2	Reheating and Efficiencies of Turbine, Numerical problems.	1
2	**Cascades, Dimensional and Model Analysis**	
2.1	**Cascade Nomenclatures and Testing**	
2.1.1	Blade nomenclature, Blade Types, Forces acting on blades,	1
2.1.2	Compressor cascade and Turbine cascade nomenclatures, Cascade testing and losses	1
2.2	**Dimensional analysis:** Dimensions and equations, Advantages, Buckingham Pi Theorem - Problems	1
2.3	**Model Analysis**	
2.3.1	Advantages, Similarity – Geometric, Kinematic and Dynamic	1
2.3.2	Specific speed, Unit quantities	1
	Compressible Flow Machines	
3	**Compressors**	
3.1	**Centrifugal Compressors -** Velocity triangle, Slip factor, Work done, Impeller blade types	1
3.1.1	Numerical problems.	2
3.1.2	Characteristics-Stall, Surging and Choking	
3.2	**Axial Flow Compressors** - Velocity triangle, Degree of reaction, Stage loading	1
3.2.1	Numerical problems	2
3.2.2	Multi-stage performance, Characteristics – Stalling.	1
4	**Turbines**	
4.1	**Axial Flow Turbine** **Impulse Turbine** – Single stage, Velocity triangles and Work output, Mollier	1

No.	Topic	No. of Periods
	diagram	
4.1.1	Degree of reaction, Blade-loading coefficient, Numerical problems.	1
4.1.2	Multiage Turbines -Pressure compounding, Velocity compounding and Pressure-velocity compounding, Numerical Problems.	2
4.2	**Reaction Turbine**- Velocity diagram, Stage efficiency. Reheat factor	1
4.2.1	Numerical problems.	2
4.2.2	Losses in turbines, Governing of turbines	1
4.3	**Radial Flow Gas Turbine**-Velocity diagrams and Mollier diagram, Spouting velocity, Efficiency, Numerical problems	2
	Incompressible Flow Machines	
5	**Hydraulic Pumps**	
5.1	**Centrifugal Pumps** – Velocity triangles, Work done, Slip factor, Pump losses, Impeller Blade Shapes	1
5.1.1	Numerical problems.	2
5.1.2	NPSH, Specific speed, Cavitation.	1
6	**Hydraulic Turbines**	
6.1	**Impulse Turbine**-Pelton wheel, Velocity triangles, Work done and Efficiencies, Numerical problems.	2
6.2	**Reaction Turbine**- Francis turbine, Velocity triangles, Work done, Efficiencies, Turbine characteristics, Numerical problems	2
6.3	**Axial Flow Turbine** - Kaplan turbine, Velocity triangles, Work done, Efficiencies, Numerical problems, Cavitation	1
	Total	**36**

Course Designers

1. Dr. A. Valan Arasu Professor Mechanical Engineering avamech@tce.edu
2. Dr. B. Karthikeyan Asst.Professor Mechanical Engineering bkmech@tce.edu

22MEPG0	MACHINE TOOL DESIGN

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Machine tools are the heart of manufacturing industries, and their design plays a pivotal role in shaping modern production processes. A machine tool is a machine for handling or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformations. Machine tools employ some sort of tool that does the cutting or shaping.

Prerequisite

- Design of Machine elements
- Design of Transmission systems

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the machine tool mechanisms for auxiliary motion, kinematics and motion transmission.	TPS2	70	70
CO2	Design the Multi speed Gear Box and feed drives for mechanical applications.	TPS3	70	65
CO3	Design the machine tool structures for beds and housings.	TPS3	70	65
CO4	Design the machine tool structures for columns and tables, saddles and carriage.	TPS3	70	65
CO5	Design the guideways and for mechanical applications.	TPS3	70	65
CO6	Design the spindles and bearings for mechanical applications.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	S	M	-	-	-	-	-	-	-	-	-	-	-	S
CO3	S	S	M	-	-	-	-	-	-	-	-	-	-	-	S
CO4	S	S	M	-	-	-	-	-	-	-	-	-	-	-	S
CO5	S	S	M	-	-	-	-	-	-	-	-	-	-	-	S
CO6	S	S	M	-	-	-	-	-	-	-	-	-	-	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	5	20	-	-	-	-	-	-	-	2	5	-
CO2	-	-	30	5	10	20	-	-	-	-	-	-	2	5	10
CO3	-	-	50	5	10	25	-	-	-	-	-	-	2	5	15
CO4	-	-	-	-	-	-	-	-	30	5	10	20	-	5	20
CO5	-	-	-	-	-	-	-	-	30	5	10	15	2	5	10
CO6	-	-	-	-	-	-	-	-	40	5	10	20	2	5	10
Total													10	25	65

Syllabus

INTRODUCTION TO MACHINE TOOL DESIGN

Introduction to Machine Tool Drives and Mechanisms, Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission.

REGULATION OF SPEEDS AND FEEDS

Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

DESIGN OF MACHINE TOOL STRUCTURES - I

Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Machine Tool Constructional Features, Design of Beds and Design of Housings,

DESIGN OF MACHINE TOOL STRUCTURES - II

Machine Tool Constructional Features –Design of Columns – Design of bases and tables – Design of cross rails, Design of Arms, Design saddles and Carriage.

DESIGN OF GUIDEWAYS

Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slide ways, Design of Anti-Friction Guideways, Combination Guideways,

DESIGN OF SPINDLES AND SPINDLE SUPPORT Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings.

Text Book

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 3rd edition 2017

Data Book

1. PSG College, “Design Data: Data Book of Engineers”, Kalaikathir Achchagam, 2019

Reference Books

1. N. S. Acherkhan, “Machine Tool Design”, Volume 1,2,3 and 4 University Press of the Pacific, 2000
2. F. Koenigsberger, Machine Tool Structures, Pergamon Press,1970.
3. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2015
4. K Pal, S. K. Basu, “Design of Machine Tools”, 6th Edition. Oxford IBH, 2018

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**INTRODUCTION TO MACHINE TOOL DESIGN**	
1.1	Introduction to Machine Tool Drives and Mechanisms	1
1.2	Auxiliary Motions in Machine Tools	1
1.3	Kinematics of Machine Tools	1
1.4	Motion Transmission	1
2	**REGULATION OF SPEEDS AND FEEDS**	
2.1	Aim of Speed and Feed Regulation	1
2.2	Stepped Regulation of Speeds	1
2.3	Multiple Speed Motors	1
2.4	Ray Diagrams and Design Considerations	2
2.5	Design of Speed Gear Boxes	2
2.6	Feed Drives, Feed Box Design	2
3	**DESIGN OF MACHINE TOOL STRUCTURES - I**	
3.1	Functions of Machine Tool Structures and their Requirements	1
3.2	Design for Strength, Design for Rigidity	1
3.3	Materials for Machine Tool Structures	1
3.4	Machine Tool Constructional Features	1
3.5	Design of Beds and Housings	1
3.6	Design of Housings	1
4	**DESIGN OF MACHINE TOOL STRUCTURES - II**	
4.1	Design of Columns	2
4.2	Design of bases and tables	1
4.3	Design of Arms	1
4.4	Design saddles and Carriage	1
5	**DESIGN OF GUIDEWAYS AND POWER SCREWS**	
5.1	Functions and Types of Guideways	1
5.2	Design of Guideways	2
5.3	Design of Aerostatic Slide ways	2
5.4	Design of Anti-Friction Guideways	2
5.5	Combination Guideways	1
6	**DESIGN OF SPINDLES AND SPINDLE SUPPORT**	
6.1	Machine Tool Compliance on Machining Accuracy	1
6.2	Design of Spindles	2
6.3	Antifriction Bearings	1
	Total	36

Course Designers

1	Dr. V. Balasubramani	Associate Professor	Mechanical Engineering	vbmech@tce.edu
2	Mr. C. Vignesh	Assistant Professor	Mechanical Engineering	cvmech@tce.edu

22MEPH0	EXPERIMENTAL METHODS FOR ENGINEERS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Engineers are able to perform successful experiments, and it is equally important that they know or be able to estimate the accuracy of their measurements. This course discusses a rather broad range of instruments and experimental measurement techniques.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the uses of electrical and sensing devices in the measurement process	TPS2	70	70
CO2	Determine the component area using appropriate dimensional measurements	TPS3	70	65
CO3	Apply the pressure and flow measurement techniques for an engineering application	TPS3	70	65
CO4	Calculate the temperature of an engineering application using electrical and mechanical effects	TPS3	70	65
CO5	Select the force, torque and vibration measurement devices for given application	TPS3	70	65
CO6	Apply the Principle of design of experiments in measurements	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	L
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	-	L
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	-	L
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory		
	Assignment-1			CAT-1			Assignment-2			CAT-2			Terminal Examination		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	5	10	-	-	-	-	-	-	-	2	05	-
CO2	-	-	40	5	20	10	-	-	-	-	-	-	2	5	10
CO3	-	-	30	10	20	20	-	-	-				2	5	10
CO4	-	-	-	-	-	-	-	-	40	5	10	10	2	10	10
CO5	-	-	-	-	-	-	-	-	30	5	20	10		10	10
CO6	-	-	-	-	-	-	-	-	30	10	10	20	2	5	10
												Total	10	40	50

Syllabus

Electrical Measurements and Sensing Devices

Forces of Electromagnetic Origin: Waveform Measures - Basic Analog Meters - Basic Digital Meters - Amplifiers: Differential Amplifiers, Operational Amplifiers, Signal Conditioning - The Electronic Voltmeter: Digital Voltmeters - The Oscilloscope: Oscilloscope Selection - Counters-Time and Frequency Measurements - Transducers: Variable-Resistance Transducer, Differential Transformer (LVDT), Capacitive Transducers, Piezoelectric Transducers, Photoconductive Transducers, Ionization Transducers, Hall-Effect Transducers, Digital Displacement Transducers - Comparison of Analog and Digital Instruments-

Displacement and Area Measurement

Dimensional Measurements: Gage Blocks, Optical Methods – Interferometer, Pneumatic Displacement Gage - Area Measurements: The Planimeter- Graphical and Numerical Methods for Area Measurement - Surface Areas

Pressure and Flow Measurement

Mechanical Pressure Measurement Devices: Dead-Weight Tester, Bourdon-Tube Pressure Gage, Diaphragm and Bellows Gages, The Bridgman Gage - Low-Pressure Measurement: McLeod Gage, Pirani Thermal-Conductivity Gage, Knudsen Gage, Ionization Gage, Alphatron. Flow Measurement by Drag Effects: Hot-Wire and Hot-Film Anemometers, Magnetic Flowmeters, Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Smoke Methods -

Temperature Measurement

Temperature Measurement by Mechanical Effects: Bimetallic strip, Fluid-expansion thermometers. Temperature Measurement by Electrical Effects: Electrical-Resistance Thermometer, Resistance Temperature Detector, Thermistors, Thermocouples, Quartz-Crystal Thermometer. Temperature Measurement by Radiation: Optical pyrometer - Effect of Heat Transfer on Temperature Measurement, Transient Response of Thermal Systems. Thermocouple Compensation - Temperature Measurements in High-Speed Flow

Force, Motion and Vibration Measurement

Elastic Elements for Force Measurements - Torque Measurements - Strain Measurements - Electrical-Resistance Strain Gages - Measurement of Resistance Strain-Gage Outputs - Temperature Compensation - Strain-Gage Rosettes - Unbonded Resistance Strain Gage - Simple Vibration Instruments - Vibrating Rod- Principles of the Seismic Instrument - Practical Considerations for Seismic Instruments -

Design of Experiments

Introduction - Types of Experiments - Experiment Design Factors - Experiment Design Protocol and case studies.

Textbook

1. J. P. Holman.,“ Experimental Methods for Engineers”, McGraw Hill Book Company,2023.

Reference Books

1. Thomas G. Beckwith, Roy D. Marangoini, John H. Lienhard V., “Mechanical Measurements”, Pearson; 5th edition, 2020
2. A.K. Sawhney , Puneet Sawhney, “ A Course in Mechanical Measurements and Instrumentation & Control”, Dhanpat Rai & Co. (P) Limited , 2017
3. B. C. Nakra, K. K. Chaudhry, “Instrumentation, Measurement and Analysis”, McGraw Hill Education India Private Limited; Fourth edition (1 August 2016)
4. James W. Dally, William F. Riley, Kenneth G. McConnell, “Instrumentation for Engineering Measurements”, John Wiley & Sons, 2020.
5. R.K. Jain, ‘”Mechanical and Industrial Measurements”, Khanna Publishers,2000.
6. Ernest O. Doebelin, Measurement Systems: Application and Design’’, McGraw Hill Higher Education; 4th edition, 2020

Course Contents and Lecture Schedule

Module Number	Topic	No of Lectures
1.0	**Electrical Measurements and Sensing Devices**	
1.1	Introduction - Forces of Electromagnetic Origin - Waveform Measures - Basic Analog Meters - Basic Digital Meters -	1
1.2	Amplifiers : Differential Amplifiers, Operational Amplifiers - Signal Conditioning - The Electronic Voltmeter	1
1.3	Digital Voltmeters - The Oscilloscope - Oscilloscope Selection - Counters—Time and Frequency Measurements -	1
1.4	Transducers: Variable-Resistance Transducer, Differential Transformer (LVDT), Capacitive Transducers -	1
1.5	Transducers: Piezoelectric Transducers, Photoconductive Transducers, Ionization Transducers	1
1.6	Transducers: Hall-Effect Transducers, Digital Displacement Transducers, Comparison of Analog and Digital Instruments	1
2.0	**Displacement and Area Measurement**	
2.1	Dimensional Measurements: Gage Blocks - Optical Methods, Interferometer	1
2.2	Pneumatic Displacement Gage	1
2.3	Area Measurements: Planimeter	1
2.4	Graphical and Numerical Methods for Area Measurement	2
2.5	Surface Areas measurements	1
3.0	**Pressure and Flow Measurement**	
3.1	Pressure Measurement Devices: Dead-Weight Tester, Bourdon-Tube Pressure Gage.	1
3.2	Diaphragm and Bellows Gages,The Bridgman Gage	1
3.3	Low-Pressure Measurement: The McLeod Gage, Pirani Thermal-Conductivity Gage.	1
3.4	The Knudsen Gage,The Ionization Gage, Alphatron.	1

Module Number	Topic	No of Lectures
3.5	Flow Measurement by Drag Effects: Hot-Wire and Hot-Film Anemometers, Magnetic Flowmeters	1
3.6	Shadowgraph, Schlieren, Interferometer	1
3.7	Laser Doppler Anemometer, Smoke Methods	1
4.0	**Temperature Measurement**	
4.1	Temperature Measurement by Mechanical Effects :Bimetallic strip, Fluid expansion thermometers,	1
4.2	Temperature Measurement by Electrical Effects: Electrical-Resistance Thermometer, Resistance Temperature Detector, Thermistors-Thermocouples, Quartz-Crystal Thermometer.	1
4.3	Temperature Measurement by Radiation: Optical pyrometer	1
4.4	Effect of Heat Transfer on Temperature Measurement	1
4.5	Transient Response of Thermal Systems	1
4.6	Thermocouple Compensation: Temperature Measurements in High-Speed Flow	1
5.0	**Force, Torque and Vibration Measurement**	
5.1	Elastic Elements for Force Measurements and Torque Measurements	1
5.2	Strain Measurements: Electrical-Resistance Strain Gages ,Measurement of Strain.	1
5.3	Gage Outputs, Temperature Compensation, Strain-Gage Rosettes, Unbonded Resistance Strain Gage.	1
5.4	Simple Vibration Instruments: Vibrating Rod	1
5.5	Principles of the Seismic Instrument: Practical Considerations for Seismic Instruments	1
6.0	**Design of Experiments**	
6.1	Types of Experiments	1
6.2	Experiment Design Factors	1
6.3	Experiment Design Protocol	1
6.4	Case studies.	2
	Total	**36**

Course Designers:

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22MEPJ0	NON-DESTRUCTIVE TESTING TECHNIQUES

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Non-destructive testing (NDT) is a type of testing that is used to test a component or system without causing damage. NDT is typically used to inspect materials and components for flaws, such as cracks, voids, inclusions, and porosity. This method can also be used to measure the thickness of materials and the hardness of metals. There are varieties of NDT techniques in use. NDT plays an extremely important role in quality control, flaw detection and structural health monitoring covering a wide range of industries. It is an essential tool in many industries, including the aerospace, automotive, defence, oil and gas, construction and manufacturing sectors. This course will equip students with necessary knowledge of fundamental science behind the commonly used NDT methods to build the basic understanding on the underlying principles and also the process details of each of these NDT methods, their applications and limitations.

Prerequisite

- Metal Casting Processes
- Metal Joining Processes

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the working principles, methods and instrumentation of different surface non-destructive techniques.	TPS2	70	70
CO2	Select the appropriate non-destructive method to detect surface defects of the given component.	TPS3	70	65
CO3	Interpret the test results of various surface non-destructive methods.	TPS3	70	65
CO4	Describe the principles, methods and equipment of various internal non-destructive techniques.	TPS2	70	70
CO5	Choose the appropriate non-destructive method to detect internal defects of the given component.	TPS3	70	65
CO6	Interpret the test results of different internal non-destructive methods.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	L	-	-	-	-	-	S	-	L
CO3	S	M	L	-	-	-	L	-	-	-	-	-	S	-	L
CO4	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	L	-	-	-	-	-	S	-	L
CO6	S	M	L	-	-	-	L	-	-	-	-	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / Cos	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	60	-	20	40	-	-	-	-	-	-	-	10	20	-
CO2	-	-	25	-	-	25	-	-	-	-	-	-	-	-	12
CO3	-	-	15	-	-	15	-	-	-	-	-	-	-	-	8
CO4	-	-	-	-	-	-	-	60	-	20	40	-	10	20	-
CO5	-	-	-	-	-	-	-	-	25	-	-	25	-	-	12
CO6	-	-	-	-	-	-	-	-	15	-	-	15	-	-	8
												Total	20	40	40

Syllabus

Overview of NDT: Significance of testing materials, Concepts of Non-destructive testing, Relative merits and limitations, NDT versus Mechanical testing.

Non-Destructive Testing for surface defects:

Visual Examination: Fundamentals, vision, lighting, environmental factors, visual perception, Visual examination methods – direct and indirect methods, Visual examination aids - mirrors, magnifiers, borescopes and fiberscopes, Results interpretation, Light sources and special lighting.

Liquid/Dye Penetrant Inspection: Basic principle, applications, advantages and limitations, Types of dyes and methods of application, Developers and cleaners, Developer application, Inspection Procedure, Methods and Interpretation of results.

Magnetic Particle Inspection: Principle, Theory of magnetism, Magnetisation methods, Magnetic Particles, Testing Procedure, Demagnetization - Principles and methods, Residual magnetism, Interpretation of test indications, Advantages, limitations and applications.

Radiography Testing: Sources – X rays and Gamma rays, Characteristics of rays, Absorption, Scattering, Types and use of filters and screens, Imaging modalities - film radiography and digital radiography, Continuous Inspection, Problems in shadow formation, Exposure factors, Inverse square law, Exposure charts, Penetrometers, Image interpretation, Safety in radiography.

Non-Destructive Testing for Internal defects:

Eddy Current Testing: Generation of eddy currents, Properties, Eddy current Sensing elements, Probes, Instrumentation, Types of arrangement, Interpretation of results, Advantages, limitations and applications.

Thermography: Principle, Contact & Non-Contact inspection methods, Active & Passive methods, Liquid Crystal – Concept, Techniques for applying liquid crystals, Advantages, limitations and applications, Infrared thermography - Infrared detectors, Instrumentation and methods, Interpretation of results.

Ultrasonic Testing: Types of ultrasonic waves, Principles of wave propagation, Characteristics, Attenuation, Production of ultrasonic waves, Couplands, Probes, Transducers, Principle, Inspection methods - Pulse echo, Transmission and Resonance techniques, Types of scanning, Straight beam and Angle beam inspection of welds, Time of Flight Diffraction technique, Thickness measurement by ultrasonic method, A-scan, B-scan and C-scan, Instrumentation, Data representation, Interpretation of results, Advantages, Limitations and Applications.

Acoustic Emission Testing: Sources of Acoustic Emission (AE), Types of AE signal, AE wave propagation, Source location, Kaiser effect, AE transducers, Basic principle, AE parameters, Equipment and Data display, Interpretation of Results, Advantages, Limitations and Applications.

Textbooks

1. J. Prasad and C. G. K. Nair, **Non-Destructive Test and Evaluation of Materials**, Tata McGraw Hill Education, 2nd edition, 2017.
2. Baldev Raj, T.Jayakumar and M.Thavasimuthu, **Practical Non Destructive Testing**, Narosa Publishing House, 2019.

Reference Books & Web Resources

1. Ravi Prakash, “Non-Destructive Testing Techniques”, 1st revised edition, New Age International Publishers, 2010.
2. Chuck Hellier, **“Handbook of Nondestructive Evaluation”**, Mc Graw Hill, 2012.
3. ASM Metals Handbook, Volume -17, **"Nondestructive Evaluation and Quality Control"**, American Society of Metals, USA, 2018.
4. Charles, J. Hellier, **“Handbook of Non-destructive evaluation”**, McGraw Hill, New York 2020.
5. Paul E Mix, **“Introduction to Non-destructive testing: a training guide”**, Wiley, 2nd Edition New Jersey, 2005.
6. Louis Cartz, **"Nondestructive Testing"**, ASM International, USA, 1995.
7. https://archive.nptel.ac.in/courses/113/106/113106070/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1.	**Overview of NDT:**	
1.1	Significance of testing materials, Concepts of Non-destructive testing, Relative merits and limitations, NDT versus Mechanical testing	1
2	**Non-Destructive Testing for Surface Defects:**	
2.1	**Visual examination:** Fundamentals, vision, lighting, environmental factors, visual perception	1
2.2	Visual examination methods – direct and indirect methods, Visual examination aids - mirrors, magnifiers, borescopes and fiberscopes	2
2.3	Results interpretation, Light sources and special lighting.	1
2.4	**Liquid/Dye Penetrant Inspection:** Basic principle, applications, advantages and limitations.	1
2.5	Types of dyes and methods of application, Developers and cleaners, Developer application	1
2.6	Inspection Procedure, Methods and Interpretation of results	1
2.7	**Magnetic Particle Inspection:** Principle, Theory of magnetism, Magnetisation methods	2
2.8	Magnetic Particles, Testing Procedure, Demagnetization - Principles and methods, Residual magnetism	1
2.9	Interpretation of test indications, Advantages, limitations and applications.	1
2.10	**Radiography Testing:** Sources – X rays and Gamma rays, Characteristics of rays, Absorption, Scattering, Types and use of filters and screens	2

2.11	Imaging modalities - film radiography and digital radiography, Continuous Inspection, Problems in shadow formation, Exposure factors, Inverse square law, Exposure charts	2
2.12	Penetrometers, Image interpretation, Safety in radiography.	1
3	**Non-Destructive Testing for Internal Defects:**	
3.1	**Eddy Current Testing:** Generation of eddy currents, Properties	1
3.2	Eddy current Sensing elements, Probes, Instrumentation, Types of arrangement	2
3.3	Interpretation of results, Advantages, limitations and applications.	1
3.4	**Thermography:** Principle, Contact & Non-Contact inspection methods, Active & Passive methods	1
3.5	Liquid Crystal – Concept, Techniques for applying liquid crystals, Advantages, limitations and applications,	1
3.6	Infrared thermography, Infrared detectors, Instrumentation and methods, Interpretation of results.	1
3.7	**Ultrasonic Testing:** Types of ultrasonic waves, Principle of wave propagation, Characteristics, Attenuation, Production of ultrasonic waves, Couplands, Probes, Transducers	2
3.8	Principle, Inspection methods - Pulse echo, Transmission and Resonance techniques, Types of scanning, Straight beam and Angle beam inspection of welds, Time of Flight Diffraction technique	2
3.9	Thickness measurement by ultrasonic method, A-scan, B-scan and C-scan	2
3.10	Instrumentation, Data representation, Interpretation of results, Advantages, Limitations and Applications.	1
3.11	**Acoustic Emission Testing:** Sources of acoustic emission, Types of AE signal, AE wave propagation	2
3.12	Source location, Kaiser effect, AE transducers, Basic principle, AE parameters, Equipment and Data display	2
3.13	Interpretation of Results, Advantages, Limitations and Applications.	1
	TOTAL	**36**

Course Designers

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22MEPN0	MATERIAL HANDLING SYSTEMS ENGINEERING

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

This course deals with material handling by which materials are moved, stored and tracked in any industrial/commercial infrastructure. Applying ergonomic principles in the design of material handling and storage system considering the physical properties, quantities and distance to be moved and type of production facility

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Map the process and material flow in manufacturing environment.	TPS2	70	70
CO2	Assess the potential failure modes in material storage and handling between POM/POS to POC.	TPS3	70	65
CO3	Calculate REBA/RULA score for static posture analysis in storage and material handling design	TPS3	70	65
CO4	Measures of material handling systems	TPS3	70	65
CO5	Develop standardized inventory storage and handling work procedures.	TPS3	70	65
CO6	Choose appropriate material transport system for logistics.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	10								4	10	
CO2			40	5	5	30							4		12
CO3			40	5	5	30							2		12
CO4									30	5	10	20	4	5	12
CO5									30	5	10	20	4	5	12
CO6									40	5	5	20	2		12
												Total	20	20	60

Syllabus

Material Handling System: Need, scope, definitions and terminologies, types, elements, Organization for logistics management and control. Inbound logistics and outbound logistics, Process flow charting/mapping techniques.

Material Handling Facilities: Types of Material Handling Equipments (AGVs, Fork lift, prime movers, stackers, lifts etc) including bulk material handling equipment, selection criteria for MHES. Design considerations, selection of materials. Estimation of number of facilities required; cost estimation and control. Introduction to thermoforming/injection moulded crate design and manufacturing for kitting of the parts.

Ergonomics in design: Application of RULA & REBA (static posture analysis) in MHF design, MHF design considerations for plastic parts, painted Parts, machined parts, fragile parts, c class parts, inter-plant material movement, and in-direct areas.

Measures of material handling system: Reliability, maintainability, serviceability, availability factors, Supply supports, TPM for MHF, manufacturing consideration: processes, methods and tools, assembly and dismantling of MHF, system feasibility analysis, system operational requirements, Supportability analysis, functional analysis, MTBF and MTTR for MHFs, flexibility in MHFs, traceability of MHFs and MHEs, salvaging of MHFs and MHEs

Storage systems: Creation of modern stores and storage systems: concept of stores, types of stores, storage facilities, considerations for creation of stores, estimation of docks, truck turn- around time, truck window time, inventory and types, Deterministic inventory models (without shortages) - EOQ, WIP, material retention point, model store concept.

Analysis of Material Transport Systems: Analysis of Vehicle based system- determination of number of vehicles in AGVs and determination of delivery distance. Conveyor analysis single direction, continuous loop and re-circulating conveyors. Transportation model - optimal schedule using LCM, VAM and MODI method

Textbook (s)

1. Blanchard and Benjamin "Logistics Engineering and Management" 6th International Edition, Prentice Hall Inc, 2004.
2. Gopalakrishnan, P and Abid Haleem, "Handbook of Materials Management " PHI Learning private limited, 2015.

Reference Books & Web Resources

1. Christopher M, "Logistics and Supply Chain Management - Creating Value Adding Networks", Prentice Hall, 2005.
2. Mikel P.Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", PHI Publishers, 3rd Edition 2018.
3. Prauss L, "The Green Multiplier - a Study of Environmental Protection and Supply Chain", Antonn Rauss Limited, Palgrave Macmillan, 2005.
4. Taylor G.D, "Logistics Engineering handbook", CRC Press, 2008.
5. TVSM Material Handling Facilities Design Guidelines and ManualsBook1 (Author(s), Title, edition, publisher, year of publication)
6. Inventory management: https://nptel.ac.in/courses/110/105/110105095/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Material Handling System**	
1.1	Need, scope, Definitions and terminologies	1
1.2	Types, elements, Organization for logistics management and control	1
1.3	Inbound logistics and outbound logistics	1
1.4	Process flow charting/Mapping - techniques	1
2	**Material Handling Facilities**	
2.1	Types of Material Handling Equipments(AGVs, Fork lift, prime movers, stackers, lifts etc) Including bulk Material Handling Equipment	2
2.2	Selection criteria for MHES	1

No.	Topic	No. of Periods
2.3	Design considerations, Selection of materials	1
2.4	Estimation of number of facilities required	1
2.5	Cost estimation and control	1
2.6	Introduction to Thermoforming/Injection moulded crate design and Manufacturing of kitting of parts	1
3	**Ergonomics in design**	
3.1	Application of RULA & REBA (static posture analysis) in MHF design	2
3.2	MHF design considerations for plastic parts	1
3.3	Painted Parts, machined parts, Fragile parts, c class parts	1
3.4	Inter-plant material movement, and in-direct areas	1
4	**Measures of material handling system**	
4.1	Reliability, Maintainability, Serviceability, Availability factors	1
4.2	Supply supports	1
4.3	TPM for MHF	1
4.4	Manufacturing consideration: processes, methods and tools	1
4.5	Assembly and dismantling of MHF	1
4.6	System feasibility analysis, System operational requirements	1
4.7	Supportability analysis, Functional analysis	1
4.8	MTBF and MTTR for MHFs, Flexibility in MHFs	1
4.9	Traceability of MHFs and MHEs, Salvaging of MHFs and MHEs	1
5	**Storage systems**	
5.1	Creation of modern stores and storage systems	1
5.2	Concept and types of stores, Storage facilities	1
5.3	Considerations for creation of stores	1
5.4	Estimation of docks, truck turn-around time, truck window time	1
5.5	Inventory and types, Deterministic inventory models (Purchase, production model without shortage), WIP	1
5.6	Material retention point, Model store concept	1
6	**Analysis of Material Transport Systems**	
6.1	Analysis of Vehicle based system - determination of number of vehicles in AGVs	1
6.2	Determination of delivery distance	1
6.3	Conveyor analysis single direction	1
6.4	Continuous loop and re-circulating conveyors	1
6.5	Transportation model - optimal schedule using LCM, VAM and MODI method	1
	Total	36

Course Designers

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2. Mr. M. Karthic — Assistant Professor — Mechanical Engineering — mkmect@tce.edu

22MEPQ0	GEOMETRIC DIMENSIONING AND TOLERANCING

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Geometric Dimensioning and Tolerancing (GD & T) communicates the design intent like fit, Assembly and Function, Manufacturing Process flow, and Inspection Process. GD & T is the basic requirement to enter all the departments such as Product Design, Manufacturing and Quality. This Course will impart the insights of all the Geometric Tolerances, symbols, and their proper usage in the production/detailed drawings. Further it helps to interpret and produce a complete detail required to make or assembly requirement of various industries like Aerospace, Automotive, Heavy equipment, etc.

Prerequisite

- Production Drawing

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the various methods of dimensioning, Tolerancing and symbols.	TPS2	70	70
CO2	Interpret the datum symbols in drawing for manufacturing or assembly	TPS3	70	65
CO3	Incorporate material condition and material boundary symbols on a drawing	TPS3	70	65
CO4	Apply and interpret the form and orientation tolerances on a drawing	TPS3	70	65
CO5	Describe the purpose of composite positional tolerancing	TPS2	70	70
CO6	Interpret the Profile and Runout tolerance on drawing	TPS3	70	65
CO7*	Incorporate the GD & T concepts in drawing using CAD Package	TPS3	70	65

*CO7 is assessed for Continuous assessment only.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO5	M	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO7	S	M	L	-	L	-	-	-	-	-	-	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	10								4	8	
CO2			40	5	15	20							4	6	10
CO3			40	5	15	20							2	6	10
CO4									10	5	15	20	2	6	10
CO5								10		10	10		4	8	
CO6									10	5	15	20	4	6	10
CO7									70						
												Total	20	40	40

Assignments will be in the form of worksheets.

Syllabus

Dimensioning and Tolerancing - Dimensioning Units, Fundamental Dimensioning Rules, Definitions and Fundamentals of Tolerancing, Single Limits, Maximum Material Condition (MMC), Least Material Condition (LMC), Extreme Form Variation, Basic Fits of Mating Parts - Clearance Fit and Force Fit, Types of dimensioning - Chain Dimensioning, Baseline Dimensioning, Direct Dimensioning. **Symbols and Terms –** Dimensioning Symbols, Datum Feature Symbols, Datum Target Symbols, Geometric Characteristic Symbols, Material Condition and Material Boundary Symbols, Feature Control Frame, Basic Dimensions.

Datums - Datum Feature Symbol, Datum Feature, Datum Reference Frame Concept, Datum Target Symbols, Partial Datum Surface, Coplanar Surface Datums, Datum Axis, Datum Center Plane, Center of a Pattern of Features as the Datum Axis, Applying a Translation Modifier to a Datum Reference.

Material Condition and Material Boundary - Features of Size, Conventional Tolerance, Limits of Size, Perfect Form Boundary, Regardless of Feature Size (RFS) and Regardless of Material Boundary (RMB) Maximum Material Condition (MMC), Least Material Condition (LMC), Primary, Secondary and Tertiary Datum feature and RMB, Datum Precedence and Material Condition, Placing the Maximum Material Boundary (MMB) value in the Feature Control Frame, Material Condition Analysis and Applications, Material Boundary Calculation.

Form Tolerances – Straightness, Flatness, Circularity, Free State Variation, Cylindricity, Applying Form Control to a Datum Feature. **Orientation Tolerances –** Orientation, Parallelism, Perpendicularity, Combination of Parallelism and Perpendicularity, Angularity, Application of Orientation Tolerances.

Locational Tolerance - Positional Tolerance, Locating Multiple Features, Positional Tolerancing of Coaxial Features, Positional Tolerancing of Nonparallel Holes, Locating Slotted Features

Positional Tolerancing of Spherical Features, Fasteners, Projected Tolerance Zone, Concentricity Tolerance, Positional Tolerancing for Coaxiality, Symmetry.

Profile Tolerances - Profile Tolerances, Non-Uniform Profile Tolerance Zone, Specifying Basic Dimensions in a Note, Combination of Geometric Tolerances. **Runout Tolerances -** Runout Tolerances, combination of Geometric Tolerances, Specifying Independency. Tolerance stack-up analysis.

Text book

1. David A. Madsen, “Geometric Dimensioning and Tolerancing”, Ninth Edition, The Good heart Willcox Company Inc., 2013.

Reference Books

1. James D. Meadows, “Geometric Dimensioning and Tolerancing: Applications, Analysis & Measurement”, ASME Press, 2009.
2. Gene R. Cogorno, “Geometric Dimensioning and Tolerancing for Mechanical Design”, Third Edition, Mc Graw Hill, 2020.

3. Daniel E. Puncochar, “Interpretation of Geometric Dimensioning and Tolerancing”, Third Edition, Industrial Press New York, 2011.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction to dimensioning, Tolerancing, symbols and terms**	
1.1	Dimensioning Units, Fundamental Dimensioning Rules, Definitions and Fundamentals of Tolerancing, Single Limits,	2
1.2	Maximum Material Condition (MMC), Least Material Condition (LMC), Extreme Form Variation, Basic Fits of Mating Parts - Clearance Fit and Force Fit,	1
1.3	Types of dimensioning - Chain Dimensioning, Baseline Dimensioning, Direct Dimensioning.	1
1.4	Symbols and Terms – Dimensioning, Datum Feature Symbols	1
1.5	Datum Target, Geometric Characteristic Symbols,	1
1.6	Material Condition and Material Boundary Symbols, Feature Control Frame, Basic Dimensions.	1
2.	**Datums**	
2.1	Datum Feature Symbol, Datum Feature, Datum Reference Frame Concept	**1**
2.2	Datum Target Symbols, Partial Datum Surface, Coplanar Surface Datums	1
2.3	Datum Axis, Datum Center Plane, Center of a Pattern of Features as the Datum Axis	2
2.4	Applying a Translation Modifier to a Datum Reference.	1
3.	**Material Condition and Material Boundary -**	
3.1	Features of Size, Conventional Tolerance, Limits of Size, Perfect Form Boundary, Regardless of Feature Size (RFS) and Regardless of Material Boundary (RMB)	2
3.2	Maximum Material Condition (MMC), Least Material Condition (LMC), Primary, Secondary and Tertiary Datum feature and RMB	1
3.3	Datum Precedence and Material Condition, Placing the Maximum Material Boundary (MMB) value in the Feature Control Frame,	1
3.4	Material Condition Analysis and Applications, Material Boundary Calculation.	1
4.	**Form and Orientation Tolerances**	
4.1	Form tolerance - Straightness, Flatness, Circularity,	1
4.2	Free State Variation, Cylindricity, Applying Form Control to a Datum Feature	2
4.3	Orientation tolerance - Parallelism, Perpendicularity, Combination of Parallelism and Perpendicularity, Angularity	2
4.4	Application of Orientation Tolerances.	1
5.	**Locational Tolerance**	
5.1	Positional Tolerance, Locating Multiple Features	1
5.2	Positional Tolerancing of Coaxial Features, Positional Tolerancing of Nonparallel Holes, Locating Slotted Features	2
5.3	Positional Tolerancing of Spherical Features, Fasteners	2
5.4	Projected Tolerance Zone, Concentricity Tolerance	1
5.5	Positional Tolerancing for Coaxiality, Symmetry	1
6.	**Profile, Runout Tolerances and tolerance stack-up analysis**	
6.1	Profile Tolerances, Non-Uniform Profile Tolerance Zone, Specifying	1
6.2	Basic Dimensions in a Note, Combination of Geometric Tolerances.	1
6.3	Runout Tolerances - Runout Tolerances, combination of Geometric Tolerances, Specifying Independency	2

No.	Topic	No. of Periods
6.4	Tolerance stack-up analysis.	2
	Total	**36**

Course Designers

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3.	Mr. M. Karthic	Assistant Professor	Mechanical Engineering	mkmect@tce.edu

22MEPS0	PROCESS PLANNING AND COST ESTIMATION

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

To manufacture a product that meets the design specification, the manufacture of each component of the product must be thoroughly planned. However merely ensuring of quality and design specification is not enough. The manufacture of the product must be cost effective and meet the agreed deadlines to deliver. Process planning and costing process is an vital role of a manufacturing engineer.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO 1	Explain the steps in process planning	TPS2	70	70
CO 2.	Suggest the suitable process planning for given conditions.	TPS3	70	65
CO 3	Choose the appropriate techniques of controlling in cost in inventory.	TPS3	70	65
CO 4	Estimate the cost for the final product considering various costs.	TPS3	70	65
CO 5	Assess the cost for specific products.	TPS3	70	65
CO 6	Estimate the machining time and cost for specific products.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	15								2	10	
CO2		20	20	10	5	20							2	5	10
CO3			40	10	5	25							2	5	10
CO4									30	5	10	20	2	4	10
CO5									35	5	10	15	4		15
CO6									35	10	10	15	4		15
												Total	16	24	60

Syllabus

PROCESS PLANNING (PP) : Definition of process, process planning, objective and scope. General Manufacturing process and its types, approaches, development and significance of PP, steps in process selection. Process chart, Process flow diagram and analysis. Product- Meaning and classification, Influence of process engineering on product design.

PROCESS PLANNING ACTIVITIES: objectives of work study, process parameter calculation for various production processes, Process capability, and machine capability. Approaches to process planning- Manual PP, CAPP, Developing manufacturing logic and knowledge, Selection of process planning system, BOM- Case study.

COST CONTROL IN INVENTORY: Scope of inventory, Cost factors in inventory management, management of RM (Raw Material) Inventory, SSRM (Stock able Item, Spare Item, Repair Item, Maintenance Item). EOQ, lead time, safety stock, Shortage of inventory. Types of inventory control systems- Perpetual inventory control system, ABC method. Valuation of materials issued from store- FIFO, LIFO, etc.

COSTING AND ESTIMATION: Concept and Purpose of Estimating, Functions of Estimating Department, Concept of Costing, Costing versus Estimating, Types of Estimates, Estimating Procedure, Principal Constituents in a Cost Estimate – Elements of Cost – Introduction, Material Cost, Labour Cost, Expenses, overheads and Cost of Product (Ladder Cost).

COST ESTIMATION OF CASTING, FORGING, WELDING, and plastic injection molding: Estimation of cost for Casting processes, Welding processes, Forging processes, and Plastic injection molding processes.

ESTIMATION OF MACHINING COST: Introduction, Importance of machining time calculation. Calculation of machining time and cost - lathe operations and machine operations in Drilling, Boring, Milling, Shaping, and Grinding.

Textbook (s)

1. Panneerselvam R. and Sivasankaran P.," Process Planning And Cost Estimation" PHI Learning Private Limited, Delhi,2016.
2. Tony Arnold J. R., Stephen N. Chapman and Lloyd M. Clive, " Introduction to Materials Management" Pearson, 2008.

Reference Books &Web Resources

1. Ostwalal P.F. and Munez J., “Manufacturing Processes and systems”, 9th Edition, Wiley India Pvt. Ltd, 2008.
2. Adithan, M. **“**Process Planning And Cost Estimation**”**, New Age International (P) Limited, Publishers, New Delhi, 2007.
3. Kesavanetal, R. “Process Planning And Cost Estimation**”** New Age International (P) Limited, Publishers, New Delhi, 2016.
4. Russell R.S and Tailor B.W, “Operations Management”, Wiley Publishing, 2019.
5. https://www.youtube.com/watch?v=y24meNZbUoU
6. https://nptel.ac.in/courses/112107238
7. https://www.coursera.org/learn/construction-cost-estimating

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**PROCESS PLANNING**	
1.1	Definition of process, process planning, objective and scope	1
1.2	General Manufacturing process and its types, approaches, development and significance of PP	1
1.3	steps in process selection	1
1.4	Process chart, Process flow diagram and analysis	1
1.5	Product- Meaning and classification, Influence of process engineering on product design.	1
2	**PROCESS PLANNING ACTIVITIES**	
2.1	Objectives of work study	1
2.2	Process parameter calculation for various production processes	1
2.3	Process capability, and machine capability	1
2.4	Approaches to process planning- Manual PP, CAPP	1
2.5	Developing manufacturing logic and knowledge	1
2.6	Selection of process planning system	1
2.7	BOM- Case study	1
3	**COST CONTROL IN INVENTORY**	
3.1	Scope of inventory, Cost factors in inventory management	1
3.2	management of RM (Raw Material) Inventory, SSRM (Stock able Item, Spare Item, Repair Item, Maintenance Item)	1
3.3	EOQ, lead time, safety stock, Shortage of inventory	1
3.4	Types of inventory control systems- Perpetual inventory control system, ABC method	2
3.5	Valuation of materials issued from store- FIFO, LIFO, etc.	1
4	**COSTING AND ESTIMATION**	
4.1	Concept and Purpose of Estimating, Functions of Estimating Department	1
4.2	Concept of Costing, Costing versus Estimating, Types of Estimates	1
4.3	Estimating Procedure, Principal Constituents in a Cost Estimate	1

4.4	Elements of Cost – Introduction, Material Cost, Labour Cost, Expenses, overheads and Cost of Product (Ladder Cost)	1
5	**COST ESTIMATION OF CASTING, FORGING & WELDING**	
5.1	Estimation of cost for Casting processes	2
5.2	Estimation of cost for Welding processes	2
5.3	Estimation of cost for Forging processes	2
5.4	Estimation of cost for plastic injection molding processes	1
6	**ESTIMATION OF MACHINING COST**	
6.1	Introduction, Importance of Machine Time Calculation	1
6.2	Calculation of machining time and cost - lathe operations	1
6.3	Calculation of machining time and cost- Drilling	1
6.4	Calculation of machining time and cost - Boring	1
6.5	Calculation of machining time and cost - Milling	1
6.6	Calculation of machining time and cost- Shaping	1
6.7	Calculation of machining time and cost- Grinding	1
	Total	**36 hrs**

Course Designers

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2. Dr.R.Sivasankaran Assistant professor Mechanical Engineering rssmech@tce.edu

22MEPT0	SUPPLY CHAIN MANAGEMENT

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Supply Chain Management (SCM) is the management of a network of interconnected businesses in the ultimate provision of product and service packages required to end customers. SCM spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption. Organizations increasingly find that they must rely on effective supply chain, or networks, to compete in the global market and networked economy. Concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize entire business processes throughout a value chain of multiple components. During the past decades, globalization, outsourcing and information technology have enabled to successfully operate solid collaborative supply networks in which each specialized business partner focuses on only a few key strategic activities. This inter-organizational supply network can be acknowledged as a new form of organization.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the scope of Supply Chain Management and the Drivers of SC performance.	TPS2	70	70
CO2	Design suitable SC network for a given situation	TPS3	70	65
CO3	Solve the issues related to demand, inventory and Logistics in SCM	TPS3	70	65
CO4	Explain Sourcing, Coordination and current issues in SCM	TPS2	70	70
CO5	Execute Information Technology for the effective management of SC.	TPS3	70	65
CO6	Coordinate/integrate/customize supply chain tasks in a selected enterprise/environment.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	M
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	S
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	S
CO4	M	L	-	-	-	-	-	-	-	-	-	-	-	-	M
CO5	S	M	L	-	L	-	-	-	-	-	-	-	-	-	S
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	4	15	-	-	-	-	-	-	-	2	8	-
CO2	-	-	35	3	7	33	-	-	-	-	-	-	2	8	12
CO3	-	-	35	3	10	25	-	-	-	-	-	-	2	8	12
CO4	-	-	-	-	-	-	-	30	-	4	13	-	2	8	-
CO5	-	-	-	-	-	-	-	-	35	5	10	25	2	-	12
CO6	-	-	-	-	-	-	-	-	35	3	10	30	2	8	12
												Total	12	40	48

Syllabus

Strategy development to analyze supply chain: Evolution of Supply chain – Scope and importance of supply chain decisions – Decision phases in a supply Chain – Examples of Supply Chains – competitive and supply chain strategies – Achieving Strategic fit – Supply chain drivers and metrics.

Supply chain network design: Role of Distribution network – Factors influencing and design options - facility location and capacity allocation – Transportation networks - modeling approaches LP, MILP - network design in uncertain environment – evaluation using simulation models.

Planning, Coordinating demand and Managing inventories: Demand forecasting – Forecasting methods – Aggregate planning in supply chain - Bullwhip effect-information sharing – Planning and managing inventories – Discounting – Risk pooling – Centralized Versus Decentralized control.

Cross-functional drivers: Managing cross-functional drivers in supply chain - Sourcing Decisions in a Supply Chain – Logistics providers – supplier selection – Design collaboration - Pricing and Revenue Management in Supply Chain

Customization: Supplier integration into new product development – Mass customization.

Information Technology: Role of IT in supply chain - IT infrastructure – CRM – SRM - e-business – RFID - Future of IT in supply chain – Digital Integration – Decision Support System (DSS) for supply chain.

Textbook

1. Sunil Chopra and Dharam Vir Kalra, “Supply Chain Management: Strategy, Planning and Operations”, Seventh Edition, Pearson, 2023.

Reference Books & Web Resources

1. G. Srinivasan, “Quantitative Models in Operations and Supply Chain Management”, First Edition, PHI Learning Pvt. Ltd., 2010
2. David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, and Ravi Shankar, “Designing and Managing the Supply Chain Concepts, Strategies, and Case Studies”, Third Edition, Special Indian Edition, McGraw-Hill, 2019.
3. Janat Shah, “Supply Chain Management: Text and Cases”, Second Edition, Pearson Education India, 2016
4. V. V. Sople, “Supply Chain Management: Text and Cases”, First Edition, Pearson, 2011.
5. NPTEL course titled “Operations and Supply Chain Management” by Prof. G. Srinivasan, IIT Madras. https://nptel.ac.in/courses/110106045

6. NPTEL course titled "NOC: Modelling and Analytics for Supply Chain Management" by Prof. Anupam Ghosh and Prof. Kunal Kanti Ghosh, IIT Kharagpur. https://nptel.ac.in/courses/110105141

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Strategy development to analyze supply chain**	
1.1	Evolution of Supply chain – Scope and importance of supply chain decisions	1
1.2	Decision phases in a supply Chain	1
1.3	Examples of Supply Chains	1
1.4	competitive and supply chain strategies	1
1.5	Achieving Strategic fit	1
1.6	Supply chain drivers and metrics	2
2	**Supply chain network design**	
2.1	Role of Distribution network	1
2.2	Factors influencing and design options	2
2.3	facility location and capacity allocation	1
2.4	Transportation networks	1
2.5	modeling approaches LP, MILP	1
2.6	network design in uncertain environment	1
2.7	evaluation using simulation models	1
3	**Planning, Coordinating demand and Managing inventories**	
3.1	Demand forecasting – Forecasting methods	1
3.2	Aggregate planning in supply chain	1
3.3	Bullwhip effect-information sharing	1
3.4	Planning and managing inventories - Discounting	2
3.5	Risk pooling	1
3.6	Centralized Versus Decentralized control	1
4	**Cross-functional drivers**	
4.1	Managing cross-functional drivers in supply chain	1
4.2	Sourcing Decisions in a Supply Chain	1
4.3	Logistics providers	1
4.4	Supplier selection	1
4.5	Design collaboration	1
4.6	Pricing and Revenue Management in Supply Chain	2
5	**Customization**	
5.1	Supplier integration into new product development	1
5.2	Mass customization	1
6	**Information Technology**	
6.1	Role of IT in supply chain - IT infrastructure	1
6.2	CRM - SRM	1
6.3	e-business - RFID	1
6.4	Future of IT in supply chain – Digital Integration	1
6.5	Decision Support System (DSS) for supply chain	1
	Total	36

Course Designers

1. Dr. PL. K. Palaniappan Professor Mechanical Engineering kpal@tce.edu
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22MEPU0	WORK STUDY AND ERGONOMICS

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

Work study is a business efficiency technique combining the Time Study work with the Motion Study work. It is a major part of scientific management. The two techniques became integrated and refined into a widely accepted method applicable to the improvement and upgrading of work systems. This integrated approach to work system improvement is known as methods engineering and it is applied today to industrial as well as service organizations, including banks, schools and hospitals. Time and motion study have to be used together in order to achieve rational and reasonable results. It is particularly important that effort be applied in motion study to ensure equitable results when time study is used. Motion study can be considered the foundation for time study. The time study measures the time required to perform a given task in accordance with a specified method and is valid only so long as the method is continued. Once a new work method is developed, the time study must be changed to agree with the new method.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concepts, types, applications and steps in work study.	TPS2	70	70
CO2	Propose different method study techniques to reduce the time and activities for the given environment.	TPS3	70	65
CO3	Calculate the standard time for given situation in an organization using different techniques of work measurement.	TPS3	70	65
CO4	Design ergonomics based structures of real life product.	TPS3	70	65
CO5	Measure the REBA/RULA score for given posture and propose improvised method.	TPS3	70	65
CO6	Articulate the effect of environmental factors on human performance.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO6	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	5	15	-	-	-	-	-	-	-	4	6	-
CO2	-	-	40	5	10	25	-	-	-	-	-	-	4	5	13
CO3	-	-	40	5	10	25	-	-	-	-	-	-	4	6	13
CO4	-	-	-	-	-	-	-	-	40	5	10	25	4	5	13
CO5	-	-	-	-	-	-	-	-	40	5	10	25	-	-	13
CO6	-	-	-	-	-	-	-	20	-	5	15	-	4	6	-
												Total	20	28	52

Syllabus

Work Study: Productivity and standard of living, Techniques to reduce work content and ineffective time. Productivity matrix, Quality route to productivity, better asset utilization, wages and salary, job evaluation, job description, job analysis and merit rating, Leveraging IT for improved productivity – Case studies. Work Study - Introduction - Human factors.

Method Study: Introduction - Selection of jobs – Recording – Tools and Techniques - Charts, Diagrams, Template and Models - Examining - Developing the improved method - Principles of motion economy.

Work Measurement: Introduction to Work Measurement - Time study equipments - Selecting the job to be studied and making a Time Study- Rating - Allowances to Standard Time - Setting Time Standard for work with machines - Examples of time study. Other Techniques of work measurement - Production study - Activity Sampling - Synthesis - Analytical Estimating - Predetermined Motion Time Systems. The use of Time standards - Organization of a work study department.

Ergonomics: Psycho physiological Data – Anthropometry, information displays – Man Machine System - Working Environment –chair and table heights. Strength and force of body movements – speed and accuracy of motor responses - Work station design methods, Postural evaluation procedures – REBA&RULA.

Environmental Factors: Sources & effects of Noise, Vibration, lighting, temperature, humidity & atmosphere. Measures for monitoring control & mitigation.

Textbook (s)

1. Barnes, R.M, “Motion and Time Study, Design and measurement of work”, John Wiley sons (Asia), Seventh edition, 2003.
2. ILO, “Introduction to Work Study”, Oxford and IBH publishing, 2008.

Reference Books

1. Benjamin W.Niebel, Andris Freivalds,“Methods, standards and Work Design”, McGraw hill, Eleventh edition, 2012
2. Martin Helander, A Guide to human factors and Ergonomics, Taylor and Francis, 2006.
3. Bridger, R. S.”Introduction to Ergonomics”, 3rd ed. CRC Press, New York and London,2008
4. Philips, Chandler A, “Human Factors Engineering”, John Wiley and Sons, Inc. 2000
5. Maynard H.B, “Industrial Engineering Hand book”, McGraw-Hill,2008
6. Sanders, M.M. & McCormick, E.J. “Human Factors in Engineering & Design “7th ed., McGraw-Hill, NY,1993

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Work Study**	
1.1	Productivity and standard of living, Techniques to reduce work content and ineffective time.	2
1.2	Productivity matrix, Quality route to productivity, better asset utilization	2
1.3	Wages and salary, job evaluation, job description, job analysis and merit rating, Leveraging IT for improved productivity – Case studies	2
1.4	Work Study - Introduction - Human factors	2
2	**Method Study**	
2.1	Introduction - Selection of jobs – Recording – Tools and Techniques	1
2.2	Charts, Diagrams, Template and Models	2
2.3	Examining - Developing the improved method	2
2.4	Principles of motion economy.	1
3	**Work Measurement**	
3.1	Introduction to Work Measurement - Time study equipments - Selecting the job to be studied	2
3.2	making a Time Study- Rating - Allowances to Standard Time - Setting Time Standard for work with machines - Examples of time study.	2
3.3	Other Techniques of work measurement - Production study - Activity Sampling - Synthesis -	2
3.4	Analytical Estimating - Predetermined Motion Time Systems	1
3.5	The use of Time standards - Organization of a work study department.	1
4	**Ergonomics**	
4.1	Psycho physiological Data – Anthropometry	1
4.2	information displays – Man Machine System	2
4.3	Working Environment –chair and table heights	1
4.4	Strength and force of body movements	1
4.5	speed and accuracy of motor responses	1
4.6	Work station design methods	2
5	Postural evaluation	
5.1	Postural evaluation procedures – REBA & RULA	2
6	**Environmental Factors:**	
6.1	Sources & effects of Noise, Vibration, lighting, temperature, humidity & atmosphere.	2
6.2	Measures for monitoring control & mitigation	2
	Total	**36**

Course Designers

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2.	Dr. ML. Mahadevan	Associate Professor	Mechanical Engineering	mlmmech@tce.edu

22MEPV0	ORGANIZATIONAL BEHAVIOR

Category	L	T	P	C	Terminal Exam Type
PSE	3	-	-	3	Theory

Preamble

The main objective of the Organizational Behavior course is to help the students understand individual behavior, group behavior, and organizational systems behavior, and thereby develop the relevant skills to become effective persons in the organization and to make rational decisions. People have always been regarded as important in managing organizations. Human aspects are critical in each functional aspects of management and equally so for the effective utilization of resources. In view of this, organizational behavior has assumed great importance.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concept of organization and organizational behavior and its relevance.	TPS2	70	70
CO2	Integrate individual behavior with the characteristics of personality, perception, and emotions to assess the nature of human behavior.	TPS3	70	65
CO3	Map the managerial interpersonal communication using Transactional Analysis.	TPS3	70	65
CO4	Build an effective team with a study of group behavior	TPS3	70	65
CO5	Suggest an appropriate leadership style to suit the different organizational situations.	TPS3	70	65
CO6	Explain the different organizational Developments and their characteristics.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	L	L	M	M	M	L	L	-	-	L
CO2	S	M	L	-	-	S	S	M	S	S	S	L	-	-	L
CO3	S	M	L	-	-	S	S	M	S	S	S	L	-	-	L
CO4	S	M	L	-	-	S	S	M	S	S	S	L	-	-	L
CO5	S	M	L	-	-	S	S	M	S	S	S	L	-	-	L
CO6	M	L	-	-	-	L	L	M	M	M	L	L	-	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	4	20	-	-	-	-	-	-	-	2	10	-
CO2	-	-	40	8	10	20	-	-	-	-	-	-	4	5	10
CO3	-	-	40	8	10	20	-	-	-	-	-	-	4	5	10
CO4	-	-	-	-	-	-	-	-	40	8	10	20	4	5	10
CO5	-	-	-	-	-	-	-	-	40	8	10	20	4	5	10
CO6	-	-	-	-	-	-	-	20	-	4	20	-	2	10	-
												Total	20	40	40

Syllabus

Introduction to Organizational Behavior: Introduction to organization, organization and managers, Concept, need of Organizational behavior (OB) and its Importance, Key Elements of OB, Role and new challenges of Managers in OB.

Individual behavior: Introduction, organizational Diversity, values, attitudes, job satisfaction. Personality types, Factors influencing personality, personality Theories. Perception and individual decision making. Factors influencing perception, learning and learning theories, motivation at the workplace, Emotions - Emotional Labour, Emotional Intelligence Theories. Managing the emotions and stress.

Interpersonal behavior: meaning, Johari Window, Transactional Analysis- ego states, types of transactions, life positions, applications of T.A., managerial interpersonal styles, and communication. Conflict and Negotiation- Definition, Conflict Process.

Group behavior: Introduction, foundations, the concept of group and group dynamics, types of groups, theories of group formation, group norms, group cohesiveness, group decision making, inter-group behavior, the concept of team vs. group, types of teams, building and managing effective teams.

Leadership and power: Meaning, Importance, Leadership styles, Theories, Leaders vs. managers, Leading for the Future- Mentoring, Challenges to the Leadership. Power- Definition, Sources of power, Dependence, Power Tactics.

Organization System: Foundations of organization structure, organization design, organization culture, organization change, and managing across cultures. Organizational development Characteristics objectives. Organizational effectiveness. Human resource management policies and practices.

Textbook (s)

1. Stephen P. Robins, Organisational Behavior, PHI Learning / Pearson Education, 15th edition, 2012.

Reference Books &Web Resources

1. Joseph E. Champoux Organizational Behavior: Integrating Individuals, Groups, and Organizations, Fourth Edition, Routledge-Taylor and Francis group, 2011.
2. John B. Miner, Organizational Behavior: Foundations, Theories, and Analyses, Oxford University Press,2002.
3. K. Aswathappa, Organisational Behavior: Text, Cases & Games, Himalaya PublishingHouse, 12th edition, 2017.
4. Sushama Khanna, Understanding Organizational Behaviour, Oxford University Press, 4th Edition, 2016.
5. https://www.youtube.com/watch?v=-sLHfYnxh8s- Organizational Behaviour, Dr.Susmita Mukhopadhyay Vinod Gupta, School of Management, IIT -Kharagpur
6. https://nptel.ac.in/courses/110/105/110105034/- Organizational Behaviour (Web Course), Dr. Susmita Mukhopadhyay Vinod Gupta, School of Management, IIT -Kharagpur

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction to Organizational Behaviour:**	
1.1	Introduction to organization, organization and managers, Concept	1
1.2	Need of Organizational behavior (OB) and its Importance, Key Elements of OB	1
1.3	Role and new challenges of Managers in OB.	1
2	**Individual behavior:**	
2.1	Introduction, Diversity in organization, values, attitudes, job satisfaction.	1
2.2	Personality types, Factors influencing personality, personality Theories.	2
2.3	Perception and individual decision making. Factors influencing perception,	2
2.4	learning and learning theories, motivation at work place,	2
2.5	Emotions - Emotional Labour, Emotional Intelligence Theories. Managing the emotions and stress.	2
3	**Interpersonal behaviour:**	
3.1	Meaning, Johari Window, Transactional Analysis	1
3.2	Ego states, types of transactions, life positions, applications of T.A.,	1
3.3	Managerial interpersonal styles and communication.	2
3.4	Conflict and Negotiation- Definition, Conflict Process.	2
4	**Group behavior:**	
4.1	Introduction, foundations, concept of group and group dynamics, types of groups,	2
4.2	Theories of group formation, group norms, group cohesiveness, group decision-making,	2
4.3	Intergroup behavior, concept of team vs. group,	1
4.4	Types of teams, building and managing effective teams.	2
5	**Leadership and power:**	
5.1	Meaning, Importance, Leadership styles, Theories,	2
5.2	Leaders Vs Managers, Leading for the Future- Mentoring	1
5.3	Challenges to the Leadership. Power- Definition, Sources of power, Dependence, Power Tactics.	2
6	**Organization System:**	
6.1	Foundations of organization structure, organization design,	1
6.2	Organization culture, organization change, managing across cultures.	2
6.3	Organizational development Characteristics objectives. Organizational effectiveness.	1
6.4	Human resource management policies and practices.	2
	Total	**36**

Course Designers

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22MERA0	ENERGY MANAGEMENT IN THERMAL SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. Energy audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment. Energy Audit provides a "bench-mark" for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Discuss the energy scenario in the national and international level.	TPS2	70	70
CO2	Calculate the energy saving in the cogeneration and combined cycle	TPS3	70	65
CO3	Describe the environmental issues on air and water pollution.	TPS2	70	70
CO4	Describe the methods of an Energy Management Audit.	TPS3	70	65
CO5	Prepare an Energy Action Plan.	TPS3	70	65
CO6	Explicate in depth knowledge of about Financial Management.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	L	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	-	L	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			30	5	10								2	8	
CO2			30	5	15	50							2	8	10
CO3			40	5	10								2	8	
CO4									40	5	10	20	2	8	10
CO5									30	5	10	15	2	8	10
CO6									30	5	15	15	2	8	10
												Total	12	48	40

Syllabus

Energy Scenerio:
Primary and Secondary energy-Renewable and non-renewable energy-Indian energy scenario - Energy needs of growing economy- integrated energy policy-Energy intensity on purchasing Power Parity- Long term energy scenario in India-Electricity pricing in India-Energy Security-Energy Conservation and its importance.

Energy Conservation and energy saving:
Energy conservation in Thermal Systems: Waste heat recovery systems, Co-generation- Combined cycle: Types, Fluidized bed combustion- Heat pipe.

Environmental Issues
Air and water pollution: methods of control of Air and water pollution - acid rains- thermal pollution – radioactive legislations/Government policies.

Energy Management and Audit:
Need for Energy Audit- Types of energy audit – Energy management approach- Understanding energy cost, fuel cost and power cost- Bench marking energy performance- Maximising the system efficiencies – Optimizing the input energy requirements – Fuels and energy substitution – Energy audit instruments and metering – Energy audit regulation.

Energy Action Planning:
Energy policy, key elements, formulation, ratification – Location of energy management, top management support, Managerial function – Roles and responsibilities of Energy Manager, -Marketing and communicating- Training and Planning-Motivation information system.

Financial Management:
Investment: Need, appraisal and Criteria – Finance analysis techniques: payback period, Net Present Value (NPV), Return on Investment (ROI) and Interest Rate of Return (IRR)- Cash flow: Initial capital cost or net investment, net operating cash inflows, economic life, salvage value – Finanicing options: Dept financing, Equity financing, Retained Earnings, Capital Lease, True lease.

Textbook (s)

1. "General Aspects of Energy Management and Energy Audit", Bureau of Energy Efficiency, A statutory body under Ministry of Power, Government of India, First Edition, 2006.
2. K. Nagabhushan Raju, "Industrial Energy Conservation Techniques: Concepts, Applications and Case Studies", First Edition, Atlantic, 2007.
3. P. Venkataseshaiah, K.V. Sharma, " Energy Management and Conservation", First Edition, Dreamtech Press, 2020.

Reference Books & Web Resources

1. Subhash Gadhave, “Energy Audit and Management”, First Edition, Technical Publications, 2023.
2. B.L. Singhal, Amit L. Nehete, “Energy Audit and Management”, First Edition, TechKnowledge Publications, 2023.
3. Amlan Chakrabarti, “Energy Engineering and Management”, Second Edition, PHI Learning, 2019.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Energy Scenerio:**	
1.1	Primary and Secondary energy-Renewable and non-renewable energy	2
1.2	Indian energy scenario - Energy needs of growing economy	1
1.3	Integrated energy policy-Energy intensity on purchasing Power Parity	1
1.4	Long term energy scenario in India-Electricity pricing in India	1
1.5	Energy Security-Energy Conservation and its importance.	1
2.	**Energy Conservation and energy saving:**	
2.1	Energy conservation in Thermal Systems: Waste heat recovery systems, Co-generation	2
2.2	Combined cycle: Types	2
2.3	Fluidized bed combustion	1
2.4	Heat pipe	1
3.	**Environmental Issues**:	
3.1	Air and water pollution: methods of control of Air and water pollution	2
3.2	Acid rains- thermal pollution	2
3.3	Radioactive legislations/Government policies	2
4.	**Energy Management and Audit:**	
4.1	Need for Energy Audit- Types of energy audit	1
4.2	Energy management approach- Understanding energy cost, fuel cost and power cost	1
4.3	Bench marking energy performance- Maximizing the system efficiencies	2
4.4	Optimizing the input energy requirements – Fuels and energy substitution	1
4.5	Energy audit instruments and metering – Energy audit regulation.	1
5.	**Energy Action Planning:**	
5.1	Energy policy, key elements, formulation, ratification	1
5.2	Location of energy management, top management support, Managerial function	2
5.2.1	Roles and responsibilities of Energy Manager, Accountablity-Force field analysis	1
5.3	Marketing and communicating- Training and Planning	1
5.4	Motivation information system	1
6.	**Financial Management:**	
6.1	Investment: Need, appraisal and Criteria	1
6.2	Finance analysis techniques: payback period, Net Present Value (NPV), Return on Investment (ROI) and Interest Rate of Return (IRR)	1
6.3	Cash flow: Initial capital cost or net investment, net operating cash inflows, economic life, salvage value	2
6.4	Financing options: Dept financing, Equity financing, Retained Earnings, Capital Lease, True lease	2
	Total	**36**

Course Designers

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2.	Dr. B. Karthikeyan	Assistant Professor	Mechanical Engineering	bkmech@tce.edu

22MERB0	SOLAR ENERGY SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Solar power is a renewable energy source whose only limitation is our ability to convert it into electricity efficiently and economically. Solar collectors capture solar radiation from the sun. As a result of the captured energy, fluids and air can be heated or electricity can be generated. A solar panel can reach an efficiency of 15% to 20%, while a coal burner can reach an efficiency of 40%, and a natural gas burner can reach a efficiency of 60%. Even when the sun is not shining, solar energy contributes to the supply of electricity. Air conditioning systems that use solar energy are known as solar air conditioning. It is possible to achieve this through the use of passive solar design, solar thermal energy conversion, and photovoltaic energy conversion. A major focus of the course is the use of solar energy both for generating electricity and for heating water.A suitable method of storing energy is also discussed.

Prerequisite

- Thermal Engineering

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the performance of solar collectors.	TPS3	70	65
CO2	Describe the working of different solar water heating system.	TPS2	70	70
CO3	Calculate the efficiency of solar thermal power plant.	TPS3	70	65
CO4	Determine the performance of solar Photo Voltaic systems.	TPS3	70	65
CO5	Describe the type and working solar space conditioningsystems.	TPS2	70	70
CO6	Calculate the effectiveness of the energy storage materials	TPS3	70	65

Mapping with Programme Outcomes and Programme Specific Outcome

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	M	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	-	M	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Theory Assessment-1						Theory Assessment-2						Theory		
	Assignment-1			CAT-1			Assignment-2			CAT-2			Terminal Examination		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40	5	10	25							2	8	10
CO2		20		5	15	-							2	8	
CO3			40	5	15	20							2	8	10
CO4									40	5	10	25	2	8	10
CO5								20		5	15	-	2	8	
CO6									40	5	15	20	2	8	10
												Total	12	48	40

Syllabus

SOLAR COLLECTORS

Flat plate:Evacuated tube,Concentrated- Pool and Air collectors Construction:Function, Suitability, Comparison - Storage Tank - Solar Fluids-Performance analysis

SOLAR WATER HEATING SYSTEMS

Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools

SOLAR THERMAL POWER PLANTS

Collector, Receiver, Energy Transfer- Power cycles - Tower, Trough and Dish Systems – Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors - Combined and Binary Cycles –Solar Chimneys - Hybrid Systems.

PHOTOVOLTAIC PANELS

Structure and working of Solar Cells - Types, Stand alone PV systems - Schematics and Components, typical applications for lighting and water pumping, Grid connected PV system - Schematics and Components, balance of system component -Concentrating Photovoltaics (CPV) – Performance analysis.

SOLAR SPACE CONDITIONING SYSTEMS

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

ENERGY STORAGE MATERIALS

Thermal Storage Concepts - Materials for Sensible and Latent Heat Energy Storage- Organic, Inorganic Eutectic Materials - Materials for Low and High Temperature Storage Applications. Electrical Energy storage-Batteries: types.

Textbook (s)

1. Soteries A. Kalogirou, “Solar Energy Engineering: Processes and System”, Second Edition, Academic Press Inc., 2014.

Reference Books & Web Resources

1. John A. Duffie, William A. Bechman, “Solar Engineering of Thermal Processes”, John Wiley & Sons, Third Edition, 2006.
2. Brian Nortan, “Solar Energy Thermal Technology”, First Edition, Springer, 2011.
3. D. Yogi Goswami, “Principles of Solar Engineering”, Fourth Edition, Taylor and Francis Ltd., 2022.
4. Dorota Chwieduk, “Solar Energy in Building: Thermal balance for efficient heating and cooling”, First Edition, Academic Press, 2014.

5. G. Stryi-Hipp, “Renewable Heating and Cooling: Technologies and Applications”, First Edition, Woodhead Publishing Ltd, 2015.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Solar Collectors**	
1.1	Importance - Flat plate - Evacuated tube	2
1.2	Concentrated - Pool and Air collectors Construction – Function, Suitability, Comparison	1
1.3	Storage Tank Tank - Solar Fluids.	1
1.4	Performance analysis	2
2.	**Solar Water Heating Systems**	
2.1	Integral Collector Storage System	1
2.2	Thermosyphon System - Open Loop, Drain Down, Drain Back	2
2.3	Antifreeze Systems	1
2.4	Refrigerant Solar Water Heaters	1
2.5	Solar Heated Pools	1
3.	**Solar Thermal Power Plants**	
3.1	Collector, Receiver, Energy Transfer	1
3.2	Power cycles - Tower, Trough and Dish Systems	1
3.3	Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors	2
3.4	Combined and Binary Cycles	1
3.5	Solar Chimneys - Hybrid Systems	1
4.	**Photovoltaic Panels**	
4.1	Structure and working of Solar Cells - Types, Stand alone PV systems	1
4.2	Schematics and Components, typical applications for lighting and water pumping	1
4.3	Grid connected PV system - Schematics and Components, balance of system component	1
4.4	Concentrating Photovoltaics (CPV)	1
4.5	Performance analysis.	2
5.	**Solar Space Conditioning Systems**	
5.1	Liquid Type Solar Heating System With / Without Storage	2
5.2	Heat Storage Configurations	1
5.3	Heat Delivery Methods	1
5.4	Air-Type Solar Heating Systems	1
5.5	Solar Refrigeration and Air Conditioning	1
6.	**Energy Storage Materials**	
6.1	Thermal Storage Concepts	1
6.2	Materials for Sensible and Latent Heat Energy Storage	2
6.3	Organic, Inorganic Eutectic Materials	1
6.4	Materials for Low and High Temperature Storage Applications	1
6.5	Electrical Energy storage-Batteries: types	1
	Total	36

Course Designers

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22MERC0	GAS TURBINES AND PROPULSION SYSTEMS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Gas turbine and propulsion systems deal with the basic cycles of gas turbine and its different components. It also includes fundamentals of propulsion theory along with various rocket propulsion and jet propulsion systems. Further, it deals with the combustion process in the gas turbine.

Prerequisite

- Thermal Engineering
- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Solve the thermodynamic cycles involved in the gas turbine.	TPS3	70	65
CO2	Describe the characteristic features of gas turbine components.	TPS2	70	70
CO3	Describe the combustion chamber design and its performance.	TPS2	70	70
CO4	Select suitable matching of gas turbine components.	TPS3	70	65
CO5	Calculate performance parameters of air breathing Jet propulsion systems.	TPS3	70	65
CO6	Calculate performance parameters of Rocket propulsion systems.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	-	S	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	S	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	-	S	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	S	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	-	S	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	-	S	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40	5	20	25							2	8	10
CO2		30		5	20	-							2	8	-
CO3		30		5	20	-							2	8	-
CO4									30	5	10	20	2	8	10
CO5									30	5	10	15	2	8	10
CO6									40	5	10	20	2	8	10
												Total	12	48	40

Syllabus

Types of gas turbines- Open and closed cycle, air standard Brayton cycle, Actual Brayton cycle, methods of improving the efficiency and the specific output of simple cycle- regeneration, re-heating and inter cooling. Applications-electric power generation, marine, automotive and process applications.

Gas turbine components – Compressor and turbine - Centrifugal and Axial flow compressor and turbine - principle of operation, Non dimensional representation of compressor and turbine- performance characteristics of turbine and compressor - Blade materials, factors to be considered in the selection of materials, Blade cooling: external, internal, liquid cooling and air cooling.

Combustion system - types, factors affecting combustion chamber design and its performance- Requirements of the combustion chamber- Process of combustion in a gas turbine, combustion chamber geometry.

Matching of Gas Turbine Components: Component Characteristics - Equilibrium Running of a Gas Generator - Matching of Gas Generator with Free Turbine - Matching of Gas Generator with Nozzle.

Jet Propulsion - Working of turbo jet, turbo prop, turbo fan, ramjet and pulse jet engines - Performance calculation: Thrust equation, specific thrust, propulsive efficiency thermal efficiency and overall efficiency- Thrust Augmentation-after burner.

Rocket Propulsion - Comparison of air breathing and the rocket engines, classification of rockets- Performance calculations- specific impulse, specific propellant consumption, thrust power, Jet velocity, overall efficiency, propellant flow rate - Propellants and its desirable characteristics: liquid and solid propellant, working of solid, liquid and hybrid propellant rocket engines -Nuclear propulsion-Electro-dynamic propulsion- arc plasma rocket engine- ion rocket engine- magneto plasma rocket engine.

Textbook (s)

1. V. Ganesan, "**Gas Turbines**" 3rd Edition, McGraw Hill Education, 2017.
2. P.R. Khajuria and S.P.Dubey, "**Gas Turbines and Propulsive Systems**", Dhanpat Rai Publications, 2012.

Reference Books & Web Resources

1. M.L.Mathur, "Gas Turbine and Jet Rocket Propulsion", Standard Publishers Distributors, 2010.
2. P. Balachandran, "Fundamentals of Compressible Fluid Dynamics", PHI Learning Private Ltd, 2006.
3. S.M. Yahya, "Turbine, Compressors and Fans", 4th Edition, McGraw Hill, 2017.
4. https://nptel.ac.in/courses/112103262/ - IC Engines and Gas Turbine by Pranab K. Mondal, IIT Guwahati
5. https://nptel.ac.in/courses/112/103/112103281/ - Aircraft Propulsion by Vinayak N. Kulkarni, IIT Guwahati
6. https://nptel.ac.in/courses/101104078/ - Rocket Propulsion by D.P. Mishra, IIT Kanpur

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.0	**Gas turbine Types**	
1.1	Open and closed cycle, air standard Brayton cycle, Actual Brayton cycle	2
1.2	Methods of improving the efficiency and the specific output of simple cycle-regeneration.	1
1.3	Methods of improving the efficiency and the specific output of simple cycle- re-heating.	1
1.4	Methods of improving the efficiency and the specific output of simple cycle-inter cooling.	1
1.5	Applications-electric power generation applications, marine applications, automotive applications and process applications.	1
2.0	**Gas turbine components**	
2.1.	Compressors and Turbine – Centrifugal and Axial flow compressor and turbine-principle of operation.	2
2.2	Non dimensional representation of compressor and turbine-performance characteristics of turbine and compressor.	1
2.3	Blade materials, factors to be considered in the selection of materials,	1
2.4	Blade cooling: external, internal, liquid cooling and air cooling.	1
3.0	**Combustion**	
3.1	Combustion system - types, factors affecting combustion chamber design and its performance.	2
3.2	Requirements of the combustion chamber- the process of combustion in a gas turbine,	2
3.3	Combustion chamber geometry.	1
4.0	**Matching of Gas Turbine Components**:	
4.1	Need of Matching of components, Component Characteristics	1
4.2	Equilibrium Running of a Gas Generator	1
4.3	Matching of Gas Generator with Free Turbine	2
4.4	Matching of Gas Generator with Nozzle.	1
5.	**Air Breathing Jet Propulsion**	
5.1	Working of turbo jet, turbo prop, turbo fan, ramjet and pulse jet engines.	2
5.2	Performance calculation: Thrust equation, specific thrust, propulsive efficiency thermal efficiency and overall efficiency	1
5.4	Performance calculation: propulsive efficiency thermal efficiency and overall efficiency	2
5.5	Thrust Augmentation-after burner.	1

No.	Topic	No. of Periods
6.	**Rocket propulsion**	
6.1	Rocket Propulsion - Comparison of air breathing and the rocket engines, classification of rockets.	1
6.2	Performance calculations- specific impulse, specific propellant consumption, thrust power, Jet velocity, overall efficiency, and propellant flow rate.	2
6.3	Propellants and its desirable characteristics: liquid and solid propellant.	1
6.4	Working of solid, liquid and hybrid propellant rocket engines.	2
6.5	Nuclear propulsion-Electro-dynamic propulsion.	1
6.6	Arc plasma rocket engine- ion rocket engine.	1
6.7	Magneto plasma rocket engine.	1
	Total	**36**

Course Designers

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22MERD0	VEHICLE TECHNOLOGIES

Category	L	T	P	C	Terminal Exam Type
PEES	3	0	-	3	Theory

Preamble

The field of vehicle drive is currently undergoing major changes in the area of vehicle technology. The combustion engine, which is used for over 120 years, is though not nearly completely replaced in short and medium terms, but at least supplemented by electric and semi electric drives. On the other hand, there is a continuing development, driven by processes in electronics and sensor technology since the past decades: connected cars and the development of (advanced) driver assistance systems, which include purely supportive systems, further to systems that allow highly automated and, in the long term, fully automated driving. This is course is to introduce current and futuristic vehicle technologies.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the vehicle performance of conventional engines.	TPS3	70	65
CO2	Classify the latest trends in engine technology	TPS3	70	65
CO3	Explain the various types of combustion technology	TPS2	70	70
CO4	Distinguish the working of different types of transmission systems	TPS3	70	65
CO5	Determine steering geometry and braking effort of a vehicle	TPS3	70	65
CO6	Discuss the working and energy flow in various hybrid and electric configurations	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L		-	-	-	-	-	-	-	-	-	S	-
CO2	S	M	L		-	-	-	-	-	-	-	-	-	S	-
CO3	M	L	-		-	-	-	-	-	-	-	-	-	M	-
CO4	S	M	L		-	-	-	-	-	-	-	-	-	M	-
CO5	S	M	L		-	-	-	-	-	-	-	-	-	M	-
CO6	M	L	-		-	-	-	-	-	-	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40	5	10	20							2		15
CO2			30	5	10	30								6	15
CO3		30		5	15								2	6	
CO4									30	5	10	20	2	6	15
CO5									40	5	10	30	2	6	15
CO6								30		5	15		2	6	
												Total	10	30	60

Syllabus

Vehicle structure and engines
Types of automobiles vehicle construction and different layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines – components-functions and materials. Vehicle performance calculation.

Advanced engine technology
Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio and Turbocharged Engines, Electric Turbochargers, Variable Valve Timing (VVT), Intelligent Cylinder De-activation, After Treatment Technologies.

Combustion technology
Spark Ignition combustion, Compression Ignition Combustion, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition (RCCI), Gasoline Direct Injection Compression Ignition (GDCI).

Transmission systems
Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Overdrive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

Steering, Brakes and Suspension Systems
Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Design of hydraulic braking system. Antilock Braking System (ABS),electronic brake force distribution (EBD) and Traction Control.

Hybrid, Electric vehicles and Fuel cell technology
Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and developments. Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems – Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell- Recycling of Proton Exchange Membrane (PEM) fuel cells.

Textbooks

1. N.K.Giri, **Automotive Mechanics,** Khanna Publishers, 1998.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, **Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**, CRC Press, 2004.
3. Rakesh Kumar Maurya, **Characteristics and Control of Low Temperature Combustion Engines**, Springer Cham, Springer International Publishing AG 2018.
4. Balasubramanian Viswanathan, **Energy Sources- Fundamentals of Chemical Conversion Processes and Applications**, Elsevier Science, 2016.

Reference Books & Web Resources

1. Iqbal Hussein, **Electric and Hybrid Vehicles: Design Fundamentals**, CRC Press, 2003
2. James Larminie, John Lowry, **Electric Vehicle Technology Explained**, Wiley, 2003.
3. James E. Duffy, **Modern Automotive Technology**, Goodheart-Willcox Company, Inc.,2020.
4. Iqbal Husain, **Electric and Hybrid Vehicles: Design Fundamentals**, CRC Press, 2021

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**Vehicle structure and engines**	
1.1	Types of automobiles vehicle construction and different layouts, chassis, frame and body	1
1.2	Vehicle aerodynamics (various resistances and moments involved),	2
1.3	IC engines – components-functions and materials.	1
1.4	Vehicle performance calculation.	2
2	**Advanced engine technology**	
2.1	Gasoline Direct Injection, Common Rail Direct Injection	1
2.2	Variable Compression Ratio and Turbocharged Engines	2
2.3	Electric Turbochargers, VVT, Intelligent Cylinder De-activation	2
2.4	After Treatment Technologies	2
3	**Combustion technology**	
3.1	Spark Ignition combustion, Compression Ignition Combustion	1
3.2	Homogeneous Charge Compression Ignition	1
3.3	Premixed Charge Compression Ignition, Partially Premixed Compression Ignition	2
3.4	Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition	1
4	**Transmission systems**	
4.1	Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms	2
4.2	Overdrive, transfer box, fluid flywheel, torque converter,	2
4.3	propeller shaft, slip joints, universal joints, Differential and rear axle	2
4.4	Hotchkiss Drive and Torque Tube Drive	1
5	**Steering, Brakes and Suspension Systems**	
5.1	Steering geometry and types of steering gear box-Power Steering	2
5.2	Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems. Design of hydraulic braking system	2
5.3	Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control.	2
6	**Hybrid, Electric vehicles and Fuel cell technology**	
6.1	Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery)	1
6.2	Pure Electric Vehicle Technology – Challenges and developments.	1
6.3	Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems – On-board hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides,	2
6.4	Fuel cell control system - Alkaline fuel cell- Recycling of Proton Exchange Membrane (PEM) fuel cells.	1
	Total	**36**

Course Designers

1.	Dr.B. Karthikeyan	Asst.Professor	Mechanical	bkmech@tce.edu
2.	Dr.M.S.Govardhanan	Asst.Professor	Mechanical	govardhanans@tce.edu

22MERG0	MECHANICS OF COMPOSITE MATERIALS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. Composite materials are preferred over traditional materials for their properties which are stronger, lighter or less expensive. This course covers the fundamentals of composite materials and Mechanics of various composite materials such as analyzing the mechanical strength, stresses for different laminates, laminated plate and laminated beams.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the classification, characteristics and the applications of composites in various domains	TPS2	70	70
CO2	Determine the strength and stiffness of unidirectional composites.	TPS3	70	65
CO3	Calculate the stresses and strength of composite laminae.	TPS3	70	65
CO4	Determine the stresses and stiffness of fiber reinforced Laminates	TPS3	70	65
CO5	Determine the stresses and stiffness of laminates with different orientations of the reinforcement.	TPS3	70	65
CO6	Estimate the deformation and stresses of Laminated beams using beam theory.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	-	-	L
CO3	S	M	L	-	-	L	L	-	-	-	-	-	-	-	L
CO4	S	M	L	-	-	L	L	-	-	-	-	-	-	-	L
CO5	S	M	L	-	-	L	L	-	-	-	-	-	-	-	L
CO6	S	M	L	-	-	L	L	-	-	-	-	-	-	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	-	-	5	10	-	-	-	-	-	-	-	2	5	
CO2	-	-	50	5	10	25	-	-	-	-	-	-	2	5	10
CO3	-	-	50	5	10	30	-	-	-	-	-	-	2	5	15
CO4	-	-	-	-	-	-	-	-	35	5	10	25		5	15
CO5	-	-	-	-	-	-	-	-	35	5	10	15	2	5	10
CO6	-	-	-	-	-	-	-	-	30	5	10	15	2	5	10
												Total	10	30	60

Syllabus

Introduction to Composite Materials

Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers- fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites.

Behavior of Unidirectional Composites

Introduction - Longitudinal Behavior of Unidirectional Composites-Transverse Stiffness and Strength: Constant-Stress Model-Halpin-Tsai' Equations for Transverse Modulus. Transverse Strength-Prediction of Shear Modulus-Prediction of Poisson's Ratio. Failure Modes under different loads.

Strength of an Orthotropic Lamina

Introduction-Stress-Strain Relations and Engineering Constants: Specially Orthotropic Lamina, Generally OrthotropicLamina, Transformation of Engineering Constants. Hooke's Law and Stiffness and Compliance Matrices: General Anisotropic Material, Specially Orthotropic Material, Transversely Isotropic Material, Isotropic Material- Compliance Tensor and Compliance Matrix-Transformation of Stiffness and Compliance Matrices. Strengths of an Orthotropic Lamina.

Stresses and Stiffness of Laminated Composites

Introduction- Laminate Strains-Variation of Stresses in a Laminate-Resultant Forces and Moments: Synthesis of Stiffness Matrix -Laminate Description System -Determination of Laminae Stresses and Strains.

Stresses and Stiffness of special Laminates

Construction and Properties of Special Laminates: Symmetric Laminates- Unidirectional, Cross-Ply and Angle-Ply Laminates-Quasi-isotropic Laminates.

Deformation and stressesof Laminated Beams

Introduction-Governing Equations for Laminated Beams- Euler's beam theory- Timoshenko beam theory-Determination of beams due to transverse load.

Textbook (s)

1. Agarwal, B. D. and Broutman, L. J., "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York, 4th edition, 2017.
2. Robert M. Jones, "Mechanics of Composite Materials**",** CRC Press Inc; 2nd edition,2022.

Reference Books &Web Resources

1. Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press,3rdEdition, 2019.
2. Gibson R F, Principles of Composite Material Mechanics, McGraw-Hill, 1994, CRC press, 4th Edition, 2016
3. M.H. Datoo, "Mechanics of Fibrous Composites", Springer; Reprinted 2020.
4. Hyer M. W., and Scott R White, "Stress Analysis of Fiber – Reinforced Composite Materials" McGraw-Hill, Reprinted 2020

5. Issac M Daniel and OriIshai, “Engineering Mechanics of Composite Materials”, Oxford University Press, 2023.
6. Debabrata Chakraborty. “Mechanics of Fiber Reinforced Polymer Composite Structures”, IIT Guwahati - https://onlinecourses.nptel.ac.in/noc22_me40/preview

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction to Composite Materials**	
1.1	Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers- fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials.	2
1.2	Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite	2
1.3	Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites.	2
2	**Behavior of Unidirectional Composites**	
2.1	Introduction - Longitudinal Behavior of Unidirectional Composites-Transverse Stiffness and Strength	2
2.2	Constant-Stress Model-Halpin-Tsai' Equations for Transverse Modulus.	1
2.3	Transverse Strength-Prediction of Shear Modulus-Prediction of Poisson's Ratio	2
2.4	Failure Modes under different loads.	1
3	**Strength of an Orthotropic Lamina**	
3.1	Introduction-Stress-Strain Relations and Engineering Constants: Specially Orthotropic Lamina, Generally OrthotropicLamina.	2
3.2	Transformation of Engineering Constants. Hooke's Law and Stiffness and Compliance Matrices: General Anisotropic Material, Specially Orthotropic Material, Transversely Isotropic Material, Isotropic Material.	2
3.3	Compliance Tensor and Compliance Matrix-Transformation of Stiffness and Compliance Matrices. Strengths of an Orthotropic Lamina-Maximum-Stress Theory-Maximum-Strain Theory-Maximum-Work Theory.	2
4	**Stresses and Stiffness of Laminated Composites**	
4.1	Introduction- Laminate Strains-Variation of Stresses in a Laminate	2
4.2	Resultant Forces and Moments: Synthesis of Stiffness Matrix -Laminate Description System.	2
4.3	Determination of Laminae Stresses and Strains.	2
5	**Stresses and Stiffness of special Laminates**	
5.1	Construction and Properties of Special Laminates: Symmetric Laminates-Unidirectional,	2
5.2	Cross-Ply and Angle-Ply Laminates	2
5.3	Quasi-isotropic Laminates.	2
6	**Deformation and stresses of Laminated Beams**	
6.1	Introduction - Governing Equations for Laminated Beams	2
6.2	Euler’s beam theory- Timoshenko beam theory	2
6.3	Determination of beams due to transverse load.	2
	Total	**36**

Course Designers

1	Dr.S.Arunkumar	Assistant Professor	Mechanical Engineering	sakmech@tce.edu
2	Dr.M.Sermaraj	Assistant Professor	Mechanical Engineering	msjmech@tce.edu

22MERH0	TRIBOLOGY IN MACHINE DESIGN

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Tribology is the study of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear. Friction is the resistance to relative motion, wear is the loss of material due to that motion, and lubrication is the use of a fluid to minimize friction and wear. Tribology is important because so much energy is lost to friction in mechanical components. To use less energy, it needs to be minimized the amount that is wasted. Significant energy is lost due to friction in sliding interfaces. Therefore, finding ways to minimize friction and wear through new technologies in tribology is critical to a greener and more sustainable world.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain tribology and its technological significance.	TPS2	70	70
CO2	Explain the theories/laws of sliding and rolling friction and the effect of viscosity.	TPS2	70	70
CO3	Apply the consequences of wear, wear mechanisms, wear theories and analysis the wear problems.	TPS3	70	65
CO4	Apply the theories of hydrodynamic and the advanced lubrication techniques in metal working.	TPS3	70	65
CO5	Apply the adhesion property in different applications and learn about different bearing materials.	TPS3	70	65
CO6	Select the nature of engineering surfaces, their topography and surface characterization techniques.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	S	-	M
CO2	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	10	15	-	-	-	-	-	-	-	2	4	-
CO2	-	30	-	10	15	-	-	-	-	-	-	-	2	4	-
CO3	-	-	40	10	15	25	-	-	-	-	-	-	2	4	10
CO4	-	-	-	-	-	-	-	-	30	10	10	15	2	4	10
CO5	-	-	-	-	-	-	-	-	30	10	10	15	2	4	10
CO6	-	-	-	-	-	-	-	-	40	10	10	10	2	4	10
												Total	12	48	40

Syllabus

Introduction to Tribology: Tribology in Design, Tribology in Industry, Economic Aspects of Tribology. Tribological Parameters Like Friction, Wear and Lubrication. The Topography of Engineering Surface, Contact Between Surfaces. Types of Bearings, Comparison of Sliding and Rolling Contact Bearings.

Friction: Introduction - Measurement of Friction - Friction of Metals, Ceramic Materials, Polymers, Rolling Friction- Laws of Rolling Friction, Relation Between Temperature and Friction. Stick-Slip, Prevention of Stick-Slip.

Wear: Types of Wear, Various Factors Affecting Wear - Theories of Wear, Wear Mechanisms - Measurement of Wear. Wear Regime Maps, Alternative Form of Wear Equations. Lubricated and Unlubricated Wear of Metals, Materials Used in Different Wear Situations.

Lubricants: Fundamentals of Viscosity and Viscous Flow - Principle and Application of Hydrostatic, Hydrodynamic Lubrication, Elastohydrodynamic Lubrication, Boundary Lubrication. Types of Lubricants, Properties of Lubricants. Effect of Speed and Load on Lubrication, Frictional Polymers. Lubrication in Metal Working: Rolling, Forging, Drawing and Extrusion.

Adhesion and Bearing Materials: Introduction, Adhesion Effect by Surface Tension, Purely Normal Contact and Shear. Dependence of Adhesion on Material and Geometric Properties. Bearing Materials: Introduction, Rolling Bearing, Fluid Film Lubricated Bearing, Dry Bearing, Bearing Constructions.

Surface Engineering: Introduction - Concept and Scope of Surface Engineering. Surface Modification – Transformation Hardening, Surface Melting, Thermo chemical Processes. Surface Coating – Plating and Anoding Processes, Fusion Processes, Vapor Phase Processes. Selection of Coating for Wear and Corrosion Resistance.

Textbook (s)

1. B Bhushan, Introduction to Tribology, John Wiley & Sons, Inc, New York, 2013.
2. Halling J, “Principles of Tribology“, McMillan Press Ltd.,2011.

Reference Books

1. Ernest Rabinowicz, Friction and Wear of Materials, John Wiley & sons, 2013.
2. Ian Hutchings, Philip Shipway, Tribology: Friction and Wear of Engineering Materials, Butterworth Heinemann, 2017.
3. Prasanta Sahoo, Engineering Tribology, PHI Learning Private Ltd, New Delhi, 2011.
4. B Bhushan, B K Gupta, Handbook of tribology: materials, coatings and surface treatments”, McGraw-Hill,1997.
5. Halling J, “Principles of Tribology“, McMillan Press Ltd.,2011.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction to tribology**	
1.1	Introduction to Tribology- Tribology in Design, Tribology in Industry, Economic Aspects of Tribology	1
1.2	Tribological Parameters Like Friction, Wear and Lubrication	1
1.3	The Topography of Engineering Surface, Contact Between Surfaces.	2
1.4	Types of Bearings, Comparison of Sliding and Rolling Contact Bearings.	2
2	**Friction**	
2.1	Introduction - Measurement of Friction: Weight ratio, Spring balance, Titled plane.	1
2.2	Friction of Metals, Ceramic Materials, Polymers.	2
2.3	Rolling Friction- Laws of Rolling Friction, Relation Between Temperature and Friction.	2
2.4	Stick-Slip, Prevention of Stick-Slip.	1
3	**Wear**	
3.1	Types of Wear, Factors Affecting Wear: Significance, Influence and impact.	1
3.2	Theories of Wear, Wear Mechanisms	2
3.3	Measurement of Wear: Dry sand rubber wheel, Pin on drum, Pin on disc.	1
3.4	Wear Regime Maps, Alternative Form of Wear Equations	1
3.5	Lubricated and Unlubricated Wear of Metals, Materials Used in Different Wear Situations.	1
4	**Lubricants**	
4.1	Fundamentals of Viscosity and Viscous Flow	1
4.2	Principle and Application of Hydrostatic Lubrication, Hydrodynamic Lubrication, Elasto hydrodynamic Lubrication and Boundary Lubrication	2
4.3	Types of Lubricants, Properties of Lubricants	1
4.4	Effect of Speed and Load on Lubrication.	1
4.5	Lubrication in Metal Working: Rolling, Forging, Drawing and Extrusion.	1
5	**Adhesion and Bearing Materials**	
5.1	Adhesion: Introduction, Adhesion Effect by Surface Tension, Purely Normal Contact and Compression Plus Shear.	2
5.2	Dependence of Adhesion on Material and Geometric Properties.	1
5.3	Bearing Materials: Introduction	1
5.4	Rolling Bearing, Fluid Film Lubricated Bearing	1
5.5	Dry Bearing, Bearing Constructions	1
6	**Surface Engineering**	
6.1	Introduction to Surface Engineering, Concept and Scope of Surface Engineering.	1
6.2	Surface Modification – Transformation Hardening, Surface Melting, Thermo chemical Processes	2
6.3	Surface Coating – Plating and Anoding Processes, Fusion Processes, Vapor Phase Processes	2
6.4	Selection of Coating for Wear and Corrosion Resistance	1
	Total	36

Course Designers

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2. Dr. S. Arunkumar Assistant Professor Mechanical Engineering sakmech@tce.edu

22MERK0	ROBOTICS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

This course is designed to provide a deep understanding of mechanical structures, robot configurations, and the intricate sub-systems that power industrial and mobile robots. From mastering the fundamental principles of kinematics and dynamics to delving into advanced topics like motion planning and control systems, this course covers every aspect of Robotics vital for mechanical engineering graduates.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the working of the subsystems of robotic manipulator and wheeled mobile robot.	TPS2	70	70
CO2	Develop the forward kinematic model of multi-degree of freedom (DOF) manipulator and inverse kinematic model of two and three degrees of freedom planar robot arm and wheeled robot.	TPS3	70	65
CO3	Develop static force and dynamic model of two degrees of freedom planar robot arm.	TPS3	70	65
CO4	Generate a trajectory in joint space using cubic polynomial and trigonometric functions with given kinematic constraints of two and three degree of freedom (DOF) manipulator.	TPS3	70	65
CO5	Explain knowledge representation methods for task planning of robotic applications.	TPS2	70	70
CO6	Select suitable control schemes, actuators, and sensors used in robots.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	L	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	L	-	-	-	-	-	-	-	M	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	-	10	15	-	-	-	-	-	-	-	2	8	-
CO2	-	-	35	5	15	25	-	-	-	-	-	-	2	8	10
CO3	-	-	35	5	-	25	-	-	-	-	-	-	2	-	15
CO4	-	-	-	-	-	-	-	-	35	-	10	25	-	8	15
CO5	-	-	-	-	-	-	-	30	-	5	15	-	2	8	-
CO6	-	-	-	-	-	-	-	-	35	5	15	25	2	8	10
												Total	10	40	50

Syllabus

Introduction to Robotics: Mechanical structure: Robot Configuration - Robot Anatomy, Subsystems/ Elements of Industrial Robot. Mobile robot locomotion: Introduction, key issues for locomotion, wheeled locomotion-wheel design, geometry, stability, maneuverability and controllability. Performance characteristics of robots. Applications: Progressive advancement in Robots Point to point and continuous motion applications, Mobile manipulators and its applications.

Kinematic Model: Forward Kinematics for two DOF manipulator Algebraic method, Mechanical structure and notations, Coordinate frames, Description of objects in space, Transformation of vectors, Fundamental rotation matrices (principal axes and fixed angle rotation) Description of links and joints, Denavit - Hartenberg (DH) notation, Forward Kinematics for multi-Degrees of Freedom (DOF) manipulator. Inverse kinematics of two DOF planar manipulator - Manipulator workspace. Mobile Robot kinematics: kinematic model and constraints, Mobile robot workspace-motion control.

Force Model: Static model: Differential relationship - Velocity analysis Jacobian matrix Determination of forces and equivalent torques for joints of two link planar robot arm. Dynamic model: Euler Lagrangian formulation - Forward and inverse dynamic model for two DOF planar manipulator.

Trajectory planning: Definitions and planning tasks, Joint space techniques Motion profiles Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion - Cartesian space techniques. Navigation: Graph search and potential field path planning - navigation architecture offline and online planning

Robot Task Planning Modeling and Task Specification: Problems in task planning: Spatial relationship, obstacle avoidance and grasp planning Expert System and Knowledge Engineering: Construction of expert system, Rule-based systems Knowledge representation.

Control System: Manipulator control problem: Linear second-order model of manipulator. Functions of controller and power amplifier. Control Schemes: PID control scheme, Position and force control schemes. Joint actuators: stepper motor, servo motor. Robotic sensors and its classification: Internal sensors: Position, velocity, acceleration and force information. External Sensors: Contact sensors: Limit switches, piezo-electric, pressure pads. Non-contact sensors: Range sensors, Vision sensor - robotic vision system, Description of components of vision system.

Textbooks

1. S K Saha, “Introduction to Robotics”, Second Edition, Mcgraw Hill, 2014.
2. Illah Reza Nourbakhsh and Roland Siegwart, “Introduction to Autonomous Mobile Robots”, MIT Press, 2011.

Reference Books & Web Resources

1. Saeed B Niku, “Introduction to Robotics: Analysis, Control, Applications”, John Wiley & Sons, 2020.
2. John J Craig, “Introduction to Robotics, Mechanics and Control”, Third Edition, Pearson education, 2005.
3. Howie Choset, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, MIT Press, 2005.
4. K.S. Fu, R.C Gonzalez and C.S. Lee, “Robotics- Control, Sensing, Vision and Intelligence”, Tata McGraw-Hill, 2008.
5. Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar, “Robot Modelling and Control”, John Wiley & Sons, 2020.
6. Beetz, Michael, et al. "AI Reasoning Methods for Robotics." Springer Handbook of Robotics, 2016.
7. Sun, Xiaolei, and Yu Zhang. "A review of domain knowledge representation for robot task planning." Proceedings of the 2019 4th International Conference on Mathematics and Artificial Intelligence, 2019.
8. NPTEL course titled “Mechanics and Control of Robotic Manipulators” by Prof. Santhakumar Mohan, IIT Palakkad. https://nptel.ac.in/courses/112106304
9. NPTEL course titled “Introduction to robotics” by Dr. Krishna Vasudevan, Dr. T Asokan, Dr. Balaraman Ravindran, IIT Madras. https://nptel.ac.in/courses/107106090

Course Contents and Lecture Schedule

S. No.	Topic	No. of periods
1	**Mechanical Structure**	
1.1	Robot Configuration - Robot Anatomy	1
1.1.1	Sub- systems of Industrial Robot	1
1.1.2	Mobile robot locomotion: Introduction, key issues for locomotion	1
1.2	Wheeled locomotion - wheel design, geometry, stability, maneuverability and controllability	1
1.3	Performance characteristics of robots	1
1.4	Applications - Progressive advancement in Robots Point to point and continuous motion. Applications: Mobile manipulators and its applications	
2	**Kinematic Model**	
2.1	Coordinate Description - Forward Kinematics for two DOF manipulator Algebraic method	1
2.1.1	Mechanical structure and notations, Coordinate frames, Description of objects in space	1
2.1.2	Transformation of vectors, Fundamental rotation matrices (principal axes and fixed angle rotation)	1
2.1.3	Description of links and joints, Denavit - Hartenberg (DH) notation	1
2.1.4	Forward Kinematics for multi-Degrees of Freedom (DOF) manipulator.	1

S. No.	Topic	No. of periods
2.2	Inverse kinematics of two DOF manipulator – Manipulator workspace.	1
2.3	Mobile Robot kinematics: kinematic model and constraints, Mobile robot workspace-motion control.	1
3	**Force Model**	
3.1	Static Force Model - Differential relationship – Velocity analysis Jacobian matrix	1
3.1.1	Determination of forces and equivalent torques for joints of two link planar robot arm	1
3.2	Dynamic model - Euler-Lagrangian formulation	1
3.2.1	Forward dynamic model for two DOF manipulator	2
3.2.2	Inverse dynamic model for two DOF manipulator	1
4	**Motion planning**	
4.1	Trajectory Planning: Definitions and planning tasks, Joint space techniques - Cartesian space techniques	1
4.1.1	Motion profiles: Cubic polynomial motion	2
4.1.2	Linear Segmented Parabolic Blends	1
4.1.3	Cycloidal motion	1
4.2	Navigation: Graph search path planning, Potential field path planning	2
5	**Robot Task Planning**	
5.1	Modeling and Task Specification	1
5.2	Problems in task planning: Spatial relationship, obstacle avoidance and grasp planning	1
5.3	Expert System and Knowledge Engineering: Construction of expert system, Rule - based systems	1
5.4	Knowledge representation - First Order Logic	2
6	**Control System**	
6.1	The manipulator control problem	1
6.1.1	Linear second order model of manipulator, functions of controller and power amplifier	1
6.2	Control Schemes: PID control scheme, Position and force control schemes	1
6.3	Joint actuators: stepper motor, servo motor	1
6.4	Robotic sensors and its classification	1
6.4.1	Internal sensors: Position, velocity, acceleration and force information	
6.4.2	External Sensors: Contact Sensors - Limit switches, piezo electric, pressure pads	1
6.4.2	Non-contact sensors: Range sensors, Vision sensor robotic vision system, Description of components of vision system	
	Total	**36**

Course Designers

1.	Dr. C. Paramasivam	Professor	Mechanical Engineering	cpmech@tce.edu
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3.	Mr. C. Selva Kumar	Assistant Professor	Mechanical Engineering	cskmech@tce.edu

22MERL0	ADDITIVE MANUFACTURING

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

Additive Manufacturing (AM) is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology. Additive manufacturing improves product development by enabling better communication in a concurrent engineering environment and also reduces product development cycle time. This course aims to provide knowledge on the additive manufacturing and its application, advantages, limitations and also provides concepts of reverse engineering

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the concepts of prototypes, process chain, applications and selection of AM Techniques	TPS2	70	70
CO2	Describe the file formats, software packages need and steps involved in reverse engineering	TPS2	70	70
CO3	Select the solid-based AM process for a given component /part drawing/applications	TPS3	70	65
CO4	Identify the liquid-based AM process for a given component /part drawing/applications	TPS3	70	65
CO5	Choose the powder-based AM process for a given component /part drawing/applications	TPS3	70	65
CO6	Suggest the suitable rapid tooling method for given application/product	TPS3	70	65
CO7*	Demonstrate to recreate, and manipulate the 3D data points from given component.	TPS3	70	65
CO8*	Create 3D model using Additive manufacturing Method.	TPS3	70	65

*COs (CO7 and CO8) are assessed through continuous assessment only.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO7	S	M	L	-	M	-	-	-	M	-	-	-	-	-	-
CO8	S	M	L	-	M	-	-	-	M	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1				5	15								6	6	
CO2		10		5	15								6	6	
CO3		10		5	-	25							2	6	10
CO4				5	-	25							2	6	10
CO5								10		10	15	25	2	6	10
CO6								10		10	15	25	2	5	15
CO7			80										-	-	-
CO8									80				-	-	-
												Total	20	35	45

Syllabus

Introduction: Definition - Roles of Prototypes - Need for time compression in product development - History of AM Process - Fundamentals of AM Process - Classification of AM Process - Process chain of AM Process.

Reverse Engineering: Introduction – Definition – Generic Process – Scanning – Point Processing – Geometric model development – Applications of reverse engineering. CAD model preparation, Data Interfacing - CAD Data formats - STL File Format - STL File Manipulation - Part orientation and support generation.

Solid Based AM: Fused Deposition Modeling (FDM) – Principle – Process parameters –Support system removal - BASS – Water soluble support system – Advantages and limitations – Applications. Laminated Object Manufacturing (LOM) – Principle – Processes parameters- Advantages and limitations – Applications. **Multi-Jet Modeling System (MJM)** – Principle – Processes parameters - Advantages and limitations – Applications.

Liquid Based AM: Stereo Lithography Apparatus (SLA) – Principle – Process parameters - Post processes - Advantages and limitations – Applications. Solid Ground Curing (SGC) – Principle -Processes parameters - Advantages and limitations – Applications. **Solid Object Ultraviolet Laser Printer (SOUP)** - Principle - Processes parameters - Advantages and limitations - Applications.

Powder based AM: Selective Laser Sintering (SLS)- Principle - Processes parameters - Advantages and limitations - Applications. Direct Metal Laser Sintering (DMLS)- Principle - Processes parameters - Advantages and limitations - Applications. **Direct Shell Production Casting (DSPC)** - Principle - Processes parameters - Advantages and limitations - Applications.

Rapid Tooling of AM: Classification of Rapid Tooling – Direct soft tooling - SLS of sand casting – Direct AIM – SL Composite tooling - Indirect soft tooling – Arc spray metal tooling - Silicon rubber molds –Spin casting with vulcanized rubber molds - Direct hard tooling – Rapid tool – Laminated metal tooling – Indirect hard tooling - 3D Keltool – EDM Electrodes - Ecotool.

Applications of AM: Applications of AM in product design, aerospace, automotive, Jewellery and biomedical industry. **Guidelines for process selection**: Introduction, selection methods for a part, challenges of selection

Practical Component (Continuous Assessments Only)
Demonstration of creation of 3D data cloud points from given component by reverse engineering principle
Manipulation of 3D data points 3D model generation using additive manufacturing method.

Textbook

1. Chua, C.K. Leong, K.F. and Lim, C.S. **"Rapid Prototyping: Principles and Applications"**, World Scientific, New Jersey,2010.

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. Ian Gibson, David W. Rosen and Brent Stucker, "**Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing**" Springer, 2015.
5. Vinesh Raja, Kiran J. Fernandes., "**Reverse Engineering: An Industrial Perspective**" Springer Series in Advanced Manufacturing, 2008.
6. Patri K. V enuvinod and Wei yin Ma., "**Rapid Prototyping Laser-based and Other Technologies**" Springer Science+Business Media, LLC, 2004.
7. **NPTEL Course:** Rapid Manufacturing
URL: https://nptel.ac.in/courses/112/104/112104265/

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction**	
1.1	Definition - Roles of Prototypes - Need for time compression in product development -	1
1.2	History of AM Process - Fundamentals of AM Process - Classification of AM Process - Process chain of AM Process	1
2	**Reverse Engineering and CAD**	
2.1	Introduction – Definition – Generic Process – Scanning – Point Processing	1
2.2	Geometric model development – Applications of reverse engineering.	1
2.3	CAD model preparation, Data Interfacing - CAD Data formats	1
2.4	STL File Format - STL File Manipulation - Part orientation and support generation.	1
3	**Solid Based AM**	
3.1	Fused Deposition Modeling (FDM) – Principle – Process parameters – Support system removal - BASS – Water soluble support system – Advantages and limitations – Applications.	2
3.2	Laminated Object Manufacturing (LOM) – Principle – Processes parameters- Advantages and limitations – Applications.	2
3.3	Multi-Jet Modeling System (MJM) – Principle – Processes parameters - Advantages and limitations – Applications.	2
4	**Liquid Based AM**	
4.1	Liquid Based AM: Stereo Lithography Apparatus (SLA) – Principle – Process parameters - Post processes - Advantages and limitations – Applications.	2

No.	Topic	No. of Periods
4.2	Solid Ground Curing (SGC) – Principle -Processes parameters - Advantages and limitations – Applications.	2
4.3	Solid Object Ultraviolet Laser Printer (SOUP) - Principle - Processes parameters - Advantages and limitations - Applications.	2
5	**Powder based AM**	
5.1	Powder based AM: Selective Laser Sintering (SLS)- Principle - Processes parameters - Advantages and limitations - Applications.	2
5.2	Direct Metal Laser Sintering (DMLS)- Principle - Processes parameters - Advantages and limitations - Applications.	2
5.3	Direct Shell Production Casting (DSPC) - Principle - Processes parameters - Advantages and limitations - Applications.	2
6	**Rapid Tooling of AM and Application**	
6.1	Classification of Rapid Tooling – Direct soft tooling - SLS of sand casting – Direct AIM – SL Composite tooling - Indirect soft tooling	3
6.2	Arc spray metal tooling - Silicon rubber molds –Spin casting with vulcanized rubber molds	3
6.3	Direct hard tooling – Rapid tool – Laminated metal tooling – Indirect hard tooling - 3D Keltool – EDM Electrodes - Ecotool.	3
6.4	**Applications of AM:** Applications of AM in product design, aerospace, automotive, Jewellery and biomedical industry.	2
6.5	**Guidelines for process selection**: Introduction, selection methods for a part, challenges of selection	1
	Total	36

Course Designers

1. Dr. K. Chockalingam — Professor — Mechanical Engineering — kcmech@tce.edu
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22MERM0	AI FOR MECHANICAL ENGINEERS

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

This course introduces the fundamental principles of Artificial Intelligence, covering topics such as Neural networks, Supervised Learning, Unsupervised Learning and Reinforcement Learning. This comprehensive curriculum equips students with the foundational knowledge and skills to understand, implement, and utilize artificial intelligence in diverse contexts. Reinforcement learning equips mechanical engineers with adaptive problem-solving techniques, enabling intelligent decision-making for complex systems such as, robotics, control systems, and optimization.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe different terminologies and methods adopted in artificial intelligence.	TPS2	70	70
CO2	Make use of neural network techniques to solve the given problem.	TPS3	70	65
CO3	Choose a suitable supervised learning algorithm for the interpreting the given data.	TPS3	70	65
CO4	Identify a relevant unsupervised learning technique for a given scenario.	TPS3	70	65
CO5	Explain the foundational concepts of reinforcement learningand compare different exploration and exploitation strategies.	TPS2	70	70
CO6	Select suitable reinforcement learning techniques to solve practical problems in mechanical engineering.	TPS3	70	65
CO7*	Demonstrate an AI technique for a mechanical engineering or societal problem.	TPS3	70	65

* CO7 is assessed in continuous assessment only.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO2	S	S	M	-	-	-	-	-	-	-	-	-	-	-	M
CO3	S	S	M	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	S	M	-	-	-	-	-	-	-	-	-	-	-	M
CO5	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO6	S	S	M	-	-	-	-	-	-	-	-	-	-	-	M
CO7	S	M	L	-	M	-	-	-	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	10	10	-	-	-	-	-	-	-	2	5	-
CO2	-	-	30	5	10	20	-	-	-	-	-	-	2	5	15
CO3	-	-	50	10	10	30	-	-	-	-	-	-	2	-	20
CO4	-	-	-	-	-	-	-	-	10	10	10	20	2	5	15
CO5	-	-	-	-	-	-	-	-	-	10	10	-	2	5	-
CO6	-	-	-	-	-	-	-	-	10	5	10	30	-	-	20
CO7	-	-	-	-	-	-	-	-	80	-	-	-	-	-	-
												Total	10	20	70

Syllabus

Introduction to Artificial Intelligence: Classification - Applications – Learning associations – Regression- learning Techniques. **Terminology**: Over fitting – Training, testing and validation sets – Receiver Operator Characteristic Curve-Unbalanced datasets

Neural networks: Functions of Neural Network – Types – Artificial neural network - Single layer perceptron (SLP)–Multi-layer perceptron (MLP) – Back propagation of error – Applications

Supervised Learning: Linear and Logistic regression – Polynomial regression – Support vector machine (SVM) – K-Nearest Neighbors (KNN)– Decision Tree and Random Forest –Linear Discriminant Analysis(LDA)- Applications

Unsupervised Learning: K – Means clustering – Independent component analysis (ICA) - Principal Component Analysis (PCA) and Self Organizing Map–Applications

Reinforcement Learning: Overview of Reinforcement Learning, Introduction to Markov Decision Processes, Dynamic Programming Approaches, Monte Carlo Methods, Temporal Difference Learning, Exploration vs. Exploitation Strategies, Deep Reinforcement Learning – Applications

Demonstration of an AI Technique:*(Assessed in continuous assessment only)* Make use of any computational tool (Python/ MATLAB/ R tool) to demonstrate the working of an AI technique.

Textbooks

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective. CRC Press, second edition 2015.
2. Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An Introduction. MIT press, 2018.

Reference Books &Web Resources

1. Tom M Mitchell, “Machine Learning”, McGraw-Hill, Indian Edition, 2017.
2. Manaranjan Pradhan, U Dinesh Kumar, “Machine Learning using Python”, Wiley, First Edition, 2019.
3. Y. S. Abu-Mostafa, M. Magdon-Ismail, and H.-T. Lin, “Learning from Data”, AML Book Publishers, First Edition, 2012.
4. P. Flach, “Machine Learning: The art and science of algorithms that make sense of data”, Cambridge University Press, First Edition, 2012
5. NPTEL course titled “Introduction to Machine Learning” by Prof. Sudeshna Sarkar, IIT Kharagpur, https://nptel.ac.in/courses/106105152/
6. Coursera course titled “Machine Learning” by Prof. Andrew Ng, Standford University URL: https://www.coursera.org/learn/machine-learning
7. NPTEL course titled “Reinforcement Learning” by Prof. BalaramanRavindran, IIT Madras. URL:https://onlinecourses.nptel.ac.in/noc19_cs55/preview
8. Coursera course titled “Reinforcement Learning Specialization” by Prof. Adam White, University of Alberta. URL:https://www.coursera.org/specializations/reinforcement-learning

Course Contents and Lecture Schedule

S. No.	Topic	No. of periods
1	**Introduction to Artificial Intelligence:**	
1.1	Classification, Applications, Learning associations	1
1.2	Regression, Learning Techniques	1
2	**Terminology**:	
2.1	Over fitting, Training, testing and validation sets	1
2.2	Receiver Operator Characteristic Curve, Unbalanced datasets	
3	**Neural networks**	
3.1	Functions of Neural Network – Types	1
3.2	Artificial neural network	2
3.3	Single layer perceptron - Multi-layer perceptron (MLP)	2
3.4	Back propagation of error	1
3.5	MLP applications	
4	**Supervised Learning**:	
4.1	Linear, Logistic regression and Polynomial regression	1
4.2	Support vector machine (SVM)	2
4.3	K-Nearest Neighbors (KNN)	2
4.4	Decision Tree and Random Forest	2
4.6	Linear Discriminant Analysis(LDA)	1
5	**Unsupervised Learning:**	
5.1	K – Means clustering	2

S. No.	Topic	No. of periods
5.2	Independent component analysis (ICA)	2
5.3	Principal Component Analysis (PCA)	2
5.4	Self-Organizing Map	1
6	**Reinforcement Learning**	
6.1	Overview of Reinforcement Learning	1
6.2	Introduction to Markov Decision Processes	1
6.3	Dynamic Programming Approaches	1
6.4	Monte Carlo Methods	1
6.5	Temporal Difference Learning	2
6.6	Exploration vs. Exploitation Strategies	1
6.7	Deep Reinforcement Learning	1
7	**Demonstration of an AI Technique:** *(Assessed in continuous assessment only)*	
7.1	Make use of any computational tool (Python/ MATLAB/ R tool) to demonstrate the working of an AI technique.	3
	Total	36

Course Designers

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22MERU0	DESIGN FOR MANUFACTURE AND ASSEMBLY

Category	L	T	P	C	Terminal Exam Type
PEES	3	-	-	3	Theory

Preamble

The term "design for manufacture" (or DFM) means the design for ease of manufacture of the collection of parts that will form the product after assembly and "design for assembly" (or DFA) means the design of the product for ease of assembly. Thus, "design for manufacture and assembly" (DFMA) is a combination of DFA and DFM. DFMA is used:

- As the basis for concurrent engineering studies to provide guidance to the design team in simplifying the product structure, to reduce manufacturing and assembly costs, and to quantify the improvements.
- As a benchmarking tool to study competitors' products and quantify manufacturing and assembly difficulties.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the importance of the Design for Manufacture and Assembly (DFMA)	TPS2	70	70
CO2	Explain the design guidelines for sand casting, die casting, machining, and sheet metal forming processes	TPS2	70	70
CO3	Appraise the design of assembly of components in manual, automated and robot assembly systems	TPS3	70	65
CO4	Redesign the component for ease of sand casting / extrusion / stamping	TPS3	70	65
CO5	Redesign the component for ease of machining	TPS3	70	65
CO6	Redesign the component for ease of assembly	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-	L
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	S
CO5	S	M	L	-	-	-	-	-	-	-	-	-	S	-	S
CO6	S	M	L	-	-	-	-	-	-	-	-	-	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	15	-	7	10	-	-	25	-	5	10	-	4	6	-
CO2	-	20	-	3	20	-	-	-	-	-	-	-	4	6	-
CO3	-	-	-	-	-	-	-	-	35	5	10	30	4	6	10
CO4	-	-	35	-	-	30	-	-	-	-	-	-	-	6	16
CO5	-	-	30	-	-	30	-	-	-	-	-	-	-	6	16
CO6	-	-	-	-	-	-	-	-	40	-	-	40	-	-	16
												Total	12	30	58

Syllabus

Design for Manufacture: Introduction and economics of process selection – General design principles for manufacturability

Casting: Design considerations for sand cast – die cast – injection moulding – permanent mold cast parts

Forming: Design considerations for metal extruded parts – Impact/Cold extruded Parts – Stamped Parts – Forged parts - Design for Sheet metal forming

Machining: Design considerations for turned parts – drilled parts – milled, planed, shaped and slotted parts – Ground parts.

Design for Assembly: Need and applications – Poke-Yoke in assembly - Compound assembly – Selective and Interchangeable assembly - General guidelines of design for assembly – design for manual assembly: guidelines for part handling, insertion and fastening – Effect of symmetry, part thickness and size and weight on handling time and on grasping and manipulation – Effect of Chamfer design on insertion operations.

Design for Automated Assembly: Effect of feed rate on cost – high speed automatic insertion – Design for feeding and orienting – Design for Robot assembly: types of robot assembly system – design rules – case studies.

Text book

1. Geoffrey Boothroyd, Peter Dewhurst, Winston A Knight, “Product Design for Manufacture and Assembly”, Third Edition, CRC press, 2010.

Reference Books & Web Resources

1. Geoffrey Boothroyd, “Assembly Automation and Product Design”, Second Edition, Taylor and Francis India, 2013
2. Daniel E Whitney, “Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development”, Oxford University Press, 2004
3. David M. Anderson, “Design for Manufacturability & Concurrent Engineering; How to Design for Low Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production”, CIM Press, 2010.
4. Harry Peck, “Designing for Manufacture”, Pitman Publications, 1983.
5. O. Molloy, S. Tilley and E.A. Warman (1998) Design for Manufacturing and Assembly: Concepts, architectures and implementation, First Edition, 1998 Edition, Springer (reprint of 1st edition – 2012).
6. NPTEL course titled “Design for Manufacture and Assembly (DFMA)” by Prof. Abinash Kumar Swain, IIT Guwahati. https://nptel.ac.in/courses/107103012
7. NPTEL course titled “Design for Manufacturing” by Prof. A. De, IIT Bombay. https://nptel.ac.in/courses/112101005

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Design for Manufacture**	
1.1	Introduction and economics of process selection	1
1.2	General design principles for manufacturability	2
2	**Casting**	
2.1	Design considerations for sand cast	2
2.2	Die cast – Injection moulding	1
2.3	Permanent mold cast parts	1
3	**Forming**	
3.1	Design considerations for metal extruded parts	2
3.2	Impact/Cold extruded Parts	1
3.3	Stamped Parts	1
3.4	Forged parts	1
3.5	Design for Sheet metal forming	2
4	**Machining**	
4.1	Design considerations for turned parts	2
4.2	Drilled parts	1
4.3	Milled, Planed, and Shaped parts	2
4.4	Slotted and Ground parts	1
5	**Design for Assembly**	
5.1	Need and applications – Poke-Yoke in assembly	1
5.2	Compound assembly	1
5.3	Selective and Interchangeable assembly	1
5.4	General guidelines of design for assembly	1
5.5	Design for manual assembly: guidelines for part handling, insertion and fastening	2
5.6	Effect of symmetry, part thickness and size and weight on handling time and on grasping and manipulation	2
5.7	Effect of Chamfer design on insertion operations	1
6	**Design for Automated Assembly**	
6.1	Effect of feed rate on cost	1
6.2	High speed automatic insertion	1
6.3	Design for feeding and orienting	1
6.4	Design for Robot assembly: types of robot assembly system	2
6.5	Design rules – case studies	2
	Total	36

Course Designers

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22MEQE0	THERMAL MANAGEMENT SYSTEMS

Category	L	T	P	C	Terminal Exam Type
EM	3	0	-	3	Theory

Preamble

Heat transfer mechanisms have become increasingly important in Engineering practice since they play a crucial role in the design of vehicles, power plants, refrigerators, electronic devices, buildings, and bridges. The purpose of this course is to provide students with an understanding of how thermal systems work and the principles of heat transfer involved in those systems. As a key goal of this course, students will gain an understanding of heat transfer mechanisms, and apply the knowledge to analyze heat transfer systems in real-world engineering applications.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the application of heat transfer in real world engineering devices.	TPS2	70	70
CO2	Calculate the rate of conduction heat transfer under steady state	TPS3	70	65
CO3	Compute the rate of conduction heat transfer under transient state	TPS3	70	65
CO4	Determine the rate of convection heat transfer.	TPS3	70	65
CO5	Compute the rate of radiation heat exchange between surfaces	TPS3	70	65
CO6	Determine the size and heat transfer rate of heat exchangers using LMTD and NTU method	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		5	10	-							2	12	-
CO2			40	10	10	25							2	6	10
CO3			40	10	10	20							-	6	10
CO4									30	5	10	15	2	6	10
CO5									30	5	15	15	-	6	10
CO6									40	5	15	15	2	6	10
												Total	08	42	50

Syllabus

Thermal management applications:
Electronic cooling- Thermal management in power electronics, electrical machines, electrical vehicles – transformers – setting of concrete and tar - ventilation in building, CPU cooling.

Steady State Conduction:
Introduction- Modes of heat transfer, Fourier law of conduction, One dimensional steady state heat conduction: plane wall, hollow cylinder and sphere- Conduction with inner heat sources: plane wall and solid cylinders - Heat transfer through extended surfaces: long fins, short fins with negligible heat loss from the fin tip (insulated fin tip), longitudinal and circumferential and triangular fins, efficiency and effectiveness.

Transient Conduction:
Introduction - Lumped heat capacity systems- Heat flow in a semi - infinite body: initial temperature with suddenly immersed in liquid and convection boundary conditions - Heat flow in an infinite body: Plane wall, Cylindrical wall and Spherical wall - Heisler and Grober charts.

Convection:
Forced Convection-Significance of Reynold Number, Prandlt number and Nusselt number -Flow over flat plates- Flow through tubes, Flow across cylinder

Natural Convection-Significance of Grashoff number -Flow over flat plates- Flow through tubes, Flow across cylinder

Radiation:
Introduction- Stefan - Boltzman law - emissive power – monochromatic emissive power - Weins law - Kirchoff's law- Radiative properties, Emissivity, absorptivity, reflectivity, transmissivity, radiosity - Radiation shape factor - Reciprocity theorem. Heat exchange between black and gray surfaces

Heat Exchangers:
Introduction -Classification- overall heat transfer co-efficient- fouling factor- LMTD method-NTU method.

Textbook (s)

1. Holman, J.P., **"Heat Transfer"**, 10th Edition, McGraw Hill Education, 2017.

Data Book

1. Kothandaraman, C.P., **"Heat And Mass Transfer Data Book",** 9th Edition, New Age International, 2018.

Reference Books & Web Resources

1. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, and Adrienne S. Lavine, "**Principles of Heat and Mass Transfer**", Wiley, 2013.
2. Nag P.K., **"Heat and Mass Transfer"**, 3rd Edition, Mc Graw Hill Education, 2011.
3. Mahesh M. Rathore, "**Engineering Heat and Mass Transfer**", LaxmiPublication , 4th Edition, 2023.

4. Necati Ozisik, "**Heat Transfer – a Basic Approach**", McGraw Hill, 1994.
5. Rajput, R.K., "**A Text Book of Heat and Mass Transfer**", 7th Edition, S.Chand& Company Ltd, 2018.
6. Som, S.K. "**Introduction to Heat Transfer**", PHI Learing Private Ltd, 2008.
7. Frank Kreith, Mark S. Bohn, "**Principles of Heat Transfer"**, Sixth Edition, Brooks/cole, Thomson Asia Private Ltd., Singapore, 2001.
8. Sachdeva, R.C., **"Fundamentals of Engineering Heat and Mass Transfer"**, New Age International Publishers, 2017.
9. Kothandaraman, C.P., **"Fundamentals of Heat and Mass Transfer",** 4th Edition, New Age International, 2012.
10. https://nptel.ac.in/courses/112108149/ - Lecture Notes
11. https://nptel.ac.in/courses/112101097/ - Video Lectures by P.Sukhatme, Mechanical Engineering, IIT Bombay.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Thermal management applications**	
1.1	Electronic cooling, Thermal management in power electronics, electrical machines	1
1.2	electrical vehicles-transformers	1
1.3	setting of concrete and tar- ventilation in building,	1
1.4	CPU cooling.	1
2.	**Steady State Conduction**	
2.1	Introduction- Modes of heat transfer, Fourier law of conduction.	1
2.2	One dimensional steady state heat conduction: plane wall, hollow cylinder and sphere.	2
2.3	Conduction with inner heat sources: plane wall and solid cylinders.	2
2.4	Heat transfer through extended surfaces: long fins, short fins with negligible heat loss from the fin tip (insulated fin tip),	1
2.5	longitudinal and circumferential and triangular fins, efficiency and effectiveness.	2
3.	**Transient Conduction**	
3.1	Introduction - Lumped heat capacity systems.	2
3.2	Heat flow in a semi - infinite body: initial temperature with suddenly immersed in liquid and convection boundary conditions.	2
3.3	Heat flow in an infinite body: Plane wall, cylindrical wall and Spherical wall - Heisler and Grober charts.	2
4.	**Convection**	
4.1	Forced Convection-Significance of Reynold Number, Prandtl number and Nusselt number.	1
4.2	Flow over flat plates- Flow through tubes, Flow across cylinder.	1
4.3	Natural Convection-Significance of Grashoff number.	2
4.4	Flow over flat plates- Flow through tubes, Flow across cylinder.	2
5	**Radiation**	
5.1	Introduction- Stefan - Boltzman law - emissive power – monochromatic emissive power - Weins law.	1
5.2	Kirchoff's law- Radiative properties, Emissivity, absorptivity, reflectivity, transmissivity, radiosity.	2
5.3	Radiation shape factor - Reciprocity theorem.	1
	Heat exchange between black and gray surfaces	2

No.	Topic	No. of Periods
6.	**Heat Exchangers**	
6.1	Classification- overall heat transfer co-efficient- fouling factor.	2
6.2	LMTD method.	2
6.3	NTU method.	2
	Total	**36**

Course Designers

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22MEQF0	DESIGN OF MECHANICAL SYSTEMS

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

Design of Mechanical Systems is a fundamental area of study in mechanical engineering that plays a pivotal role in modern industries related mechanical design process.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Apply the principles of static equilibrium to solve particles and compute the center of gravity and area moment of inertia for simple shapes.	TPS3	70	65
CO2	Determine the stresses, strains, principal stresses, elastic constants and their relations of a structural member.	TPS3	70	65
CO3	Explain the concepts of machine design and selection materials.	TPS2	70	70
CO4	Calculate the design parameter for simple machine parts by applying design concepts	TPS3	70	65
CO5	Design of shafts, keys and couplings under different loading conditions.	TPS3	70	65
CO6	Design of helical coil springs, leaf springs.	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	5	30	5	5	35	-	-	-	-	-	-	3	5	10
CO2	-	5	30	5	5	35	-	-	-	-	-	-	3	5	10
CO3	-	30	-	-	10	-	-	-	-	-	-	-	3	5	-
CO4	-	-	-	-	-	-	-	-	30	5	5	20	3	5	15
CO5	-	-	-	-	-	-	-	-	30	5	5	25	3	-	15
CO6	-	-	-	-	-	-	-	-	40	5	5	25		-	15
												Total	15	20	65

Syllabus

Statics of Particles: Fundamental principles and Concepts-Laws of mechanics- of Transmissibility – Parallelogram, Triangle and Polygon law of forces – Resultant of concurrent and non-concurrent coplanar forces. Static Equilibrium – Conditions of equilibrium in statics – Lami"s Theorem – Free body Diagram-Distributed Forces: Centroid and Centre of Gravity – Simple plane figures and Area Moment of Inertia.

Stress and Strain: Concept of stress and strain, tension, compression, shearing stress and strain, stress-strain relationship, Hooke's law, Poisson's ratio, elastic constants and their relations. Principal stresses and planes, Major and Minor principal stresses-Beams: Types of beams, Bending equation and Torsion equation.

Machine Design Concepts: Introduction to Machine Design – General Considerations in Machine Elements Design – Machine Design Process/Procedure. Engineering Materials and its properties – Selection of Materials – Standardization.

Design of machine components: Calculate the deformation, stress, strain and dimensions for machine components.

Design of shafts and couplings: Design of shafts – Pure twisting moment, Design of keys (Parallel key)-Design of rigid couplings – Muff couplings

Energy storing elements: Design of Helical Coil Springs – Compression springs subjected to axial loads. Design of concentric springs subjected to axial loads

Textbook (s)

1. Beer F.P. and Johnston Jr. E.R., „Vector Mechanics for Engineers: Statics and Dynamics", Twelfth Edition, Tata McGraw Hill, 2019.
2. Ferdinand P. Beer and E. Russell Johnston Jr., "Mechanics of Materials", McGraw Hill Book Company, 2014.
3. Robert L. Norton, "Machine Design: An Integrated Approach", Fifth Edition, Pearson, 2018.
4. V.B. Bhandari, "Design of Machine Elements", Fourth Edition, McGraw Hill Education India Pvt. Ltd., 2017.

Data Book

1. PSG College, "Design Data: Data Book of Engineers", Kalaikathir Achchagam, 2019

Reference Books &Web Resources

1. S. Rajasekaran and G. Sankarasubramanian, „Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., New Delhi, Third Edition, 2005.
2. Egor P. Popov, "Engineering Mechanics of Solids", Second Edition, Pearson Education Ltd, 2015.
3. B. Maiti, Dr. S.K. Roychowdhury, G. Chakraborty, "Design of Machine Elements 1", NPTEL, IIT Kharagpur - https://nptel.ac.in/courses/112105125/
4. Kathryn Wingate, "Machine Design Part 1", Coursera, Georgia Institute of Technology - https://www.coursera.org/learn/machine-design1

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Statics of Particles**	
1.1	Fundamental principles and Concepts	1
1.2	Laws of mechanics- Principles of Transmissibility – Parallelogram, Triangle and Polygon law of forces	2
1.3	Resultant of concurrent and non-concurrent coplanar forces	2
1.4	Static Equilibrium – Conditions of equilibrium in statics – Lami's Theorem	2
1.5	Determination of Centroid of simple shapes.	2
1.6	Determination of Area Moment of Inertia of simple shapes.	2
2	**Stress and Strain**	
2.1	Concept of stress and strain, tension, compression, shearing stress and strain	2
2.2	Stress-strain relationship, Hooke's law, Poisson's ratio, elastic constants and their relations	2
2.3	Principal stresses and planes, Major and Minor principal stresses	2
2.4	Beams: Types of beams, Bending equation and Torsion equation.	1
3	**Machine Design Concepts**	
3.1	Introduction to Machine Design	1
3.2	General Considerations in Machine Elements Design	1
3.3	Machine Design Process/Procedure	1
3.4	Selection of Materials and Standardization.	2
4	**Design of machine components**	
4.1	Calculate the deformation in the component	1
4.2	Calculate the stress, strain in the component	1
4.3	Determination of dimensions for engineering components.	1
5	**Design of shafts and couplings**	
5.1	Design of shafts–Pure twisting moment	2
5.2	Design of keys (Parallel key)	1
5.3	Design of rigid couplings - Muff couplings	2
6	**Energy Storing Elements**	
6.1	Nomenclature of Helical Compression Coil Springs	1
6.2	Design of Helical Coil Springs- Compression springs subjected to axial loads	2
6.3	Design of concentric springs subjected to axial loads.	2
	Total	36

Course Designers

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22MEQG0	INTEGRATED PRODUCT DEVELOPMENT

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

A dynamic and highly competitive business environment requires an increasingly efficient and controllable product development process. This dynamic process demand more creative and innovative solutions that provide the challenging and diverse requirements of the customer. Integrated product development encourages developers to consider all elements present in the product lifecycle, from design to disposal, including user requirements, quality level, functions, value, solutions, costs, and schedule. This course aims to prepare the students to move forward in innovative settings.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain concept of product development, Requirement Engineering, DFX, Sustenance Engineering and End of life, Intellectual Property Rights and Confidentiality	TPS2	70	70
CO2	Describe the Product Development Methodologies.	TPS2	70	70
CO3	Perform the PESTLE Analysis for a given product	TPS3	70	65
CO4	Conduct the Requirement Engineering analysis to authenticate the final product specifications.	TPS3	70	65
CO5	Explain the integration / validation process for a given product.	TPS2	70	70
CO6	Prepare the specific product development process for a given industry.	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	30			20		8	20		2	16	
CO2			40	6	30								2	16	-
CO3			40	4		20							-	-	12
CO4									30	4		20	2	8	12
CO5									30	4	20		2	10	-
CO6									20	4		20	2	-	16
												Total	10	50	40

Syllabus

Product Development: Global Trends Analysis and Product decision, Types of various trends affecting product decision, Social Trends (Demographic, Behavioral,Psychographic), Technical Trends (Technology, Applications, Tools, Methods), Economical Trends (Market, Economy, GDP, Income Levels, Spending Pattern, target cost, Total Cost ofOwnership), Environmental Trends (Environmental Regulations and Compliance), Political/Policy Trends (Regulations, Political Scenario, IP Trends and Company Policies).
PESTLE Analysis.

Introduction to Product Development Methodologies and Management
Overview of Products and Services (Consumer product, Industrial product, Specialty products etc.,), Types of Product Development: NPD, Re-Engineering (Enhancements, Cost Improvements), Reverse Engineering, Design Porting & Homologation, Overview of Product Development methodologies: Over the Wall, Waterfall, V-Model, Stage-Gate Process, Spiral &Systems Engineering.
Product Life Cycle: S-Curve, Reverse Bathtub Curve, Product Development Planning and Management: Budgeting, Risk, Resources and Design Collaboration, Scheduling, Change Management, Product Cost Management.

Requirements and System Design: Requirement Engineering, Types of Requirements: Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental and Industry, Requirement Engineering: Gathering (VOC), Analysis (QFD), Design Specification, Traceability Matrix and Analysis & Requirement Management.

Design and Testing: Conceptualization Industrial Design and User Interface Design,
Introduction to Concept generation Techniques, Concept Screening & Evaluation, Detailed Design, Design Verification.

Prototyping: Types of Prototypes - Mock-up, Industrial design prototypes, Design of Experiment experimental prototypes, Alpha, Beta, and preproduction prototypes. Rapid prototyping Techniques.

Manufacturing/Purchase and Assembly of Systems: Design for X, DFMA**,** Design for Environment, Design for Maintenance and Service**.** Integration of Mechanical, Embedded and S/W systems.

Introduction to Product validation processes and stages: Industry specific (DFMEA, FEA, CFD,FTA), Product Validation. Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing), Product Testing standards and Certification Industry specific. Product Documentation overview only (Compliance Documentation, Catalogue, Brochures, user manual).

Sustenance Engineering and End-of-Life (EoL) Support:: Maintenance and Repair, Enhancement, Obsolescence Management, and EoL Disposal.

Business Dynamics Engineering Services Industry: Engineering Services Industry overview, Product development in Industry versus Academia, IPD Essentials -Introduction to vertical specific product development processes- Product development Trade-offs.

Intellectual Property Rights and Confidentiality- IPR types, Security and configuration management.

Textbook

1. Karl T.Ulrich and Steven D.Eppinger , Product Design And Development. 7th Edition, McGraw Hill International Edns.2020.

Reference Books

1. IT-ITeS SSC NASSCOM, Foundation Skills in Integrated Product Development, 2015.
2. Kevin N.Otto, Kristin L. wood, Product Design, 2nd Edition, Prentice Hall, 2013.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Product Development:**	
1.1	Global Trends Analysis and Product decision, Types of various trends affecting product decision, Social Trends Technical Trends, Economical Trends, Environmental Trends, Political/Policy Trends, PESTLE Analysis.	2
1.2	Introduction to Product Development Methodologies and Management: Overview of Products and Services, Types of Product Development: NPD,	1
1.3	Re-Engineering, Reverse Engineering, Design Porting & Homologation, Overview of Product Development methodologies: Over the Wall, Waterfall, V-Model, Stage-Gate Process, Spiral &Systems Engineering	2
1.4	Product Life Cycle: S-Curve, Reverse Bathtub Curve	1
1.5	Product Development Planning and Management: Budgeting, Risk, Resources and Design Collaboration, Scheduling, Change Management, Product Cost Management	2
2	**Requirements and System Design:**	
2.1	Requirement Engineering, Types of Requirements: Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental and Industry,	2
2.2	Requirement Engineering: Gathering (VOC), Analysis (QFD)	2
2.3	Design Specification, Traceability Matrix and Analysis & Requirement Management.	2
3	**Design and Testing:**	
3.1	Conceptualization Industrial Design and User Interface Design, Introduction to Concept generation Techniques, Concept Screening & Evaluation	2
3.2	Detailed Design, Design Verification	2
4	**Prototyping:**	
4.1	Types of Prototypes - Mock-up, Industrial design prototypes, Design of Experiment experimental prototypes, Alpha, Beta, and preproduction prototypes.	2
4.2	Rapid prototyping Techniques.	2
5	**Manufacturing/Purchase and Assembly of Systems:**	
5.1	Design for X, DFMA**,** Design for Environment, Design for Maintenance and Service**.** Integration of Mechanical, Embedded and S/W systems.	2
5.2	Introduction to Product validation processes and stages: Industry specific (DFMEA, FEA, CFD,FTA), Product Validation.	2
5.3	Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing), Product Testing standards and Certification.	2
5.4	Industry specific. Product Documentation overview only (Compliance Documentation, Catalogue, Brochures, user manual).	2
6	**Sustenance Engineering and End-of-Life (EoL) Support:**	
6.1	Maintenance and Repair, Enhancement, Obsolescence Management, and EoL Disposal.	2
6.2	**Business Dynamics Engineering Services Industry:** Engineering Services Industry overview, Product development in Industry versus Academia, IPD Essentials -Introduction to vertical specific product development processes- Product development Trade-offs.	2

No.	Topic	No. of Periods
6.3	**Intellectual Property Rights and Confidentiality**- IPR types, Security and configuration management.	2
	Total	36

Course Designers

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22MEQH0	LEAN SIX SIGMA

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

Lean six sigma is a production practice that deals with the Identification and Elimination of waste in all levels of an organization. Lean is centered on preserving value with less work. Six - Sigma is a Business management Strategy that seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing the variability in manufacturing and business processes.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concepts of Lean and Six Sigma.	TPS2	70	70
CO2	Suggest the methods to Identify the wastes of VA/NVA for improving productivity through Value Stream Mapping.	TPS3	70	65
CO3	Assess lean metrics and benchmark the target to given processes.	TPS3	70	65
CO4	Implement six sigma tools to reduce the waste in production process in an organization.	TPS3	70	65
CO5	Suggest the methods to achieve Six Sigma level in different quality issues.	TPS3	70	65
CO6	Adapt the DFSS concept in different manufacturing and service sectors	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		5	10								4	5	-
CO2			40	5	10	30							4	5	10
CO3			40	5	5	30							4	5	10
CO4									40	5	10	30	4	5	10
CO5									40	5	10	30	4	5	10
CO6									20			10	0	5	10
												Total	20	30	50

Syllabus

Lean: evolution of lean; traditional versus lean manufacturing; LEAN and SIX SIGMA ford production system AND Toyota's foray in lean

Lean tools - Process mapping value stream, 3 M; 7 types of Muda; 7 major losses reduction. cell layout - concept of kaizen; steps involved in kaizen deployment; kanban concepts ; types of Kanban ; and practical application ; push vs pull; changeover time reduction - single minute exchange of die; concept of TPM; poka-yoke; 5S; maintenance - preventive, time based and condition based; autonomous maintenance, JIT, Autonomation, DFMA

Lean metrics identify lean metrics; kaizen cloud identification in VSM; lean assessment. improving targets and benchmarks.

six sigma: statistical process control - **six sigma methods –** DMAIC, **Preparation phase:** Organizational success factors **–** leadership, six sigma as strategic initiative, internal communication strategy and tactics, formal launch, organizational structure, six sigma training plan, project selection, assessing organizational readiness, pitfalls. Work as a process – vertical functions and horizontal processes.

Define phase: DMAIC phases, overview, project charter – voice of the customer – high level process map – project team – case study.

Measure and analyse phase: types of measures – introduction to statistical methods – sampling plan – data collection – choosing statistical software – measure tools – process maps, pareto charts, cause and effect diagrams, histograms, six sigma measurements – measurement system analysis – process capability calculations. analyze– process analysis – hypothesis testing – statistical tests and tables – tools for analyzing relationships among variables – survival analysis.

Improve and control phase: process redesign – generating improvement alternatives – design of experiments – pilot experiments – cost/benefit analysis – implementation plan. Control phase control plan – process scorecard – failure mode and effects analysis –final project report and documentation. DMADV.

Design For Six Sigma – six sigma in manufacturing and services case studies & Sustainability of Lean Six Sigma.

Text book (s)

1. Michael L. George, David Rowlands, Bill Kastle ,What is Lean Six Sigma, Tata McGraw-Hill,2003

Reference Books &Web Resources

1. Thomas Pyzdek, The Six Sigma Handbook , McGraw-Hill, 2014
2. James P. Womack , Daniel T. Jones ,Lean Thinking, Free press business, 2013.
3. Kai Yang and Basemel-Haik, “Design for Six-Sigma: A Roadmap for Product Development”, McGraw Hill, 2009.
4. N. Gopalakrishnan, simplified lean manufacture: Elements, rules, tools and implementation, Prentice Hall of India, NewDelhi 2013

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Lean:**	
1.1	Evolution of lean; traditional versus lean manufacturing;	1
1.2	Ford production system concept of lean; Toyota’s foray in lean	1
2	**Lean tools**	
2.1	Process mapping value stream, 3 M; 7 types of Muda; 7 major losses reduction.	2
2.2	Cell layout - concept of kaizen; steps involved in kaizen deployment;	1
2.3	Kanban concepts ; types of Kanban ; and practical application ; push vs pull; changeover time reduction - single minute exchange of die;	2
2.4	Concept of TPM; poka-yoke; 5S	2
2.5	Maintenance - preventive, time based and condition based; autonomous maintenance, JIT, Autonomation, DFMA	2
3	**Lean metrics**	
3.1	Identify lean metrics	1
3.2	Kaizen cloud identification in VSM	1
3.3	Lean assessment, improving targets and benchmarks.	2
4	**Six sigma**	
4.1	Statistical process control	1
4.2	Six sigma methods – DMAIC,	1
4.3	**Preparation phase:** Organizational success factors **–** leadership, six sigma as strategic initiative,	1
4.4	Internal communication strategy and tactics, formal launch, organizational structure, six sigma training plan,	1
4.5	Project selection, assessing organizational readiness, pitfalls. work as a process – vertical functions and horizontal processes.	1
4.6	**Define phase:** DMAIC phases, overview, project charter – voice of the customer – high level process map –project team – case study.	2
5	**Measure and analyse phase:**	
5.1	Types of measures – introduction to statistical methods – sampling plan – data collection –	2
5.2	Choosing statistical software – measure tools – process maps, pareto charts, cause and effect diagrams, histograms, six sigma measurements –	2
5.3	Measurement system analysis – process capability calculations.	1
5.4	Analyze– process analysis – hypothesis testing – statistical tests and tables – tools for analyzing relationships among variables – survival analysis.	2
5.5	Improve phase: Process redesign – generating improvement alternatives – design of experiments – pilot experiments	2

No.	Topic	No. of Periods
5.6	cost/benefit analysis – implementation plan.	1
5.7	Control phase: control plan – process scorecard – failure mode and effects analysis –final project report and documentation. DMADV.	2
6	**Design For Six Sigma**	
6.1	Six sigma in manufacturing and services case studies & Sustainability of Lean Six Sigma.	2
	Total	**36**

Course Designers

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22MEQJ0	SAFETY ENGINEERING

Category	L	T	P	C	Terminal Exam Type
EM	3	-	-	3	Theory

Preamble

Safety engineering is an engineering discipline which assures that engineered systems provide acceptable levels of safety. It is strongly related to industrial engineering/systems engineering, and the subset system safety engineering. This course is very much useful for improve the Green and clean Environmental aspect.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the concepts and techniques of Safety Engineering	TPS2	70	70
CO2	Identify the different hazards of occupational health in different Industries	TPS3	70	65
CO3	Explain the various Industrial safety Acts in National and International standards	TPS2	70	70
CO4	Suggest the possible techniques or methods to overcome the safety issues in different types of Industry	TPS3	70	65
CO5	Interpret the results of safety engineering in different industries with Environment pollution	TPS3	70	65
CO6	Adapt the Hazardous Waste Management techniques to reduce the waste in industry	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	25	-	10	10	-	-	-	-	-	-	-	4	5	-
CO2	-	-	50	5	5	50	-	-	-	-	-	-	4	5	11
CO3	-	25	-	10	10	-	-	-	-	-	-	-	4	5	-
CO4	-	-	-	-	-	-	-	-	35	5	10	20	4	5	13
CO5	-	-	-	-	-	-	-	-	35	-	10	20	-	5	13
CO6	-	-	-	-	-	-	-	-	30	5	10	20	4	5	13
												Total	20	30	50

Syllabus

Concepts and Techniques: History of Safety movement –Evolution of modern safety concept - planning for safety for optimization of productivity -productivity, quality and safety - line and staff functions for safety - budgeting for safety - safety policy. Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, evaluation of performance of supervisors on safety.

Occupational Health hazards

Physical Hazards: Noise - vibration and Ionizing radiation - types, effects, instruments, permissible exposure limit, monitoring instruments. **Chemical Hazards:** Recognition of chemical hazards - dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose. **Biological Hazards** : Classification of Biohazardous agents – examples, bacterial agents, viral agents, fungal, parasitic agents, infectious diseases.

Industrial Safety Acts

Factories Act – 1948 Statutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young person's – special provisions – penalties and procedures - Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948. **International Acts and Standards** Occupational Safety and Health act of USA (The Williames - Steiger Act of 1970) – Health and safety work act (HASAWA 1974, UK) – OSHAS 18000 – American National Standards Institute (ANSI).

Safety in Electrical, chemical, Fire and Mechanical Industries

Safety in Electrical Industry : Earth leakage circuit breaker (ELCB) - cable wires - maintenance of ground-ground fault circuit interrupter - use of low voltage-electrical guards - Personal protective equipment – safety in handling hand held electrical appliances tools and medical equipments.

Safety in Chemical Industry: pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

Fire Safety: alarm and detection systems – CO2 system, foam system, dry chemical powder (DCP) system, halon system – need for halon replacement – smoke venting. Portable extinguishers – flammable liquids – tank farms -fire fighting systems.

Safety in Mechanical Industry: safety in Metal working machinery and wood working machines, Safety in welding and gas cutting, Safety in cold farming and hot working of metals, Safety in finishing, inspection and testing

Environment Safety

Air Pollution - Classification and properties of air pollutants – Pollution sources – Effects of air pollutants on human beings, Animals, Plants and Materials. **Water Pollution** - Classification of water pollutants-health hazards-sampling and analysis of water-water treatment. **Hazardous Waste Management -** waste identification, characterization and classification technological options for collection, treatment and disposal of hazardous waste.

Textbook (s)

1. Blake R.B., "**Industrial Safety**" Prentice Hall, Inc., New Jersey, 2008.
2. Dan Petersen, "**Techniques of Safety Management**", McGraw-Hill Company, Tokyo, 1981.

Reference Books

1. Krishnan N.V. ,**"Safety in Industry"** Jaico Publishery House, 1996.
2. John V. Grimaldi and Rollin H. Simonds, **"Safety Management"** by, All India Travelers Book seller, New Delhi, 1989
3. Kapoor ND. Handbook of Industrial Law th revised edition 2013. . Handbook of Industrial Law 14th revised edition 2013.
4. Danuta Koradecka, **Handbook of Occupational Health and Safety**, CRC, 2010.

5. Benjamin O.Alli, **Fundamental Principles of Occupational Health and Safety**, ILO 2008
6. **“Accident Prevention Manual”** – NSC, Chicago, 1982.
7. **“Occupational safety Manual”** BHEL, Trichy, 1988.
8. **The Factories Act 1948**, Madras Book Agency, Chennai, 2000
9. **The Environment Act (Protection) 1986**, Commercial Law Publishers (India) Pvt.Ltd, New Delhi.
10. Power Engineers – **Handbook of TNEB**, Chennai, 1989.
11. **Safety in the use of wood working machines**, HMSO, UK 1992.
12. Health and Safety in welding and Allied processes, welding Institute, UK, High Tech. Publishing Ltd., London, 1989.
13. Heinrich H.W. “**Industrial Accident Prevention**” McGraw-Hill Company, New York, 1980
14. Miller G. T, **Environmental Science: Working with the Earth**, 11th Edition, Wadsworth Publishing Co., Belmont, CA, 2006
15. Hammer, M.J., and Hammer M.J, **Water and Wastewater Technology**, Pearson Prentice Hall, 2006

Course Contents and Lecture Schedule

No.	Topics	No. of Periods
1.	**Concepts and Techniques**	
1.1	History of Safety movement and Evolution of modern safety concept	1
1.2	Planning for safety for optimization of productivity	1
1.3	Productivity, quality and safety	1
1.4	line and staff functions for safety - budgeting for safety - safety policy	1
1.5	Incident Recall Technique (IRT), disaster control,	1
1.6	Job safety analysis, safety survey, safety inspection,	1
1.7	Safety sampling, evaluation of performance of supervisors on safety.	1
2.	**Occupational Health hazards**	
2.1	**Physical Hazards**: Noise - vibration and Ionizing radiation	1
2.2	Types, effects, instruments, permissible exposure limit, monitoring instruments	1
2.3	**Chemical Hazards:** Recognition of chemical hazards	1
2.4	Dust, fumes, mist, vapour, fog, gases, types, concentration	1
2.5	Exposure vs. dose	1
2.6	**Biological and Ergonomical Hazards**: Classification of Biohazardous agents	1
2.7	Examples, bacterial agents, viral agents, fungal, parasitic agents, infectious diseases	1
3.	**Industrial Safety Acts**	
3.1	**Factories Act** – 1948 Statutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young person's	2
3.2	Special provisions – penalties and procedures	1

3.3	Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948	1
3.4	**International Acts and Standards** Occupational Safety and Health act of USA (The Williames - Steiger Act of 1970)	1
3.5	Health and safety work act (HASAWA 1974, UK), OSHAS 18000 – American National Standards Institute (ANSI).	1
4	**Safety in Electrical, chemical, Fire and Mechanical Industries**	
4.1	**Safety in Electrical Industry :** Earth leakage circuit breaker (ELCB) - cable wires - maintenance of ground-ground fault circuit interrupter - use of low voltage-electrical guards	1
4.2	Personal protective equipment – safety in handling hand held electrical appliances tools and medical equipments	1
4.3	**Safety in Chemical Industry:** pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.	1
4.4	**Fire Safety:** alarm and detection systems – CO2 system, foam system, dry chemical powder (DCP) system	1
4.5	Halon system – need for halon replacement – smoke venting. Portable extinguishers – flammable liquids – tank farms -fire fighting systems.	1
4.6	**Safety in Mechanical Industry**: safety in Metal working machinery and wood working machines, Safety in welding and gas cutting,	2
4.7	Safety in cold farming and hot working of metals, Safety in finishing, inspection and testing	1
5	**Environment Safety**	
5.1	**Air Pollution** - Classification and properties of air pollutants – Pollution sources	2
5. 2	Effects of air pollutants on human beings, Animals, Plants and Materials	2
5.3	**Water Pollution** - Classification of water pollutants-health hazards-sampling and analysis of water-water treatment	2
6	**Hazardous Waste Management**	
6.1	waste identification, characterization and classification	1
6.2	technological options for collection, treatment and disposal of hazardous waste	1
	Total	**36**

Course Designers

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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
INDUSTRY SUPPORTED COURSES

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

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List of Industry Supported Courses		
S.No	**Course code**	**Course Name**
1.	22ME1A0	MANUFACTURING OF AEROSPACE MATERIAL
2.	22ME2A0	AUTOMOTIVE PRODUCT BUILD
3.	22ME2B0	JIGS AND FIXTURES DESIGN

22ME1A0	MANUFACTURING OF AEROSPACE MATERIALS

Category	L	T	P	C	Terminal Exam Type
PEES	1	-	-	1	Theory

Preamble

Materials used for aircraft are expected to be light weight and at the same time, they should possess required mechanical, thermal, physical, corrosion and tribological properties based on the intended application. Aircraft structural application demands high strength to weight ratio, excellent fatigue, flexural and corrosion properties. In contrast, aero-engine parts demand high thermal fatigue, thermal stability, hot corrosion resistance and low cycle fatigue, creep resistance properties. These requirements make a choice of the material unique in aircrafts. Ina brief, composites and Al, Mg, Ni and Ti alloys are used in aircraft structures whereas super alloys, MMC and Ti alloys are preferred for aero-engine applications. The components for aircraft are usually fabricated with casting, forging, powder metallurgy and machining processes. However, the product acceptance has very strict quality requirements in terms of NDTs. In this course, aircraft materials and manufacturing processes are offered with the aid of case studies

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the various materials for aerospace components	TPS2	70	70
CO2	Suggest a suitable manufacturing process to manufacture the Aerospace component	TPS3	70	65
CO3	Suggest a suitable inspection process to inspect the aerospace materials	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	L	-	-	-	S	-	-	-	-	-	-	-	-	M	-
CO2	S	L	S	-	S	L	-	-	-	-	-	-	-	M	-
CO3	S	L	S	-	S	L	-	-	-	-	-	-	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	5	5	-							-	20	-
CO2	-	-	30	5	5	35							-	10	30
CO3	-	-	50	5	5	35							-	10	30
												Total		40	60

Syllabus

Introduction – Overview Light alloys - Al, Mg, Ti alloys, Polymer matrix / Ceramic matrix based composite material - CFRP/GFRP/C-C/C-SiC composite usages in airframe and engine, Aerospace material testing, Advanced Mg alloys, High entropy alloys & composites.

Manufacturing processes - Metal additive manufacturing – Laser / electron beam powder bed fusion and Wire Arc Additive Manufacturing, Severe Plastic Deformation processes – Equal Channel Angular Pressing, Multidirectional forging, Precision forging, Friction Stir Processing along with case studies. Advanced Forging Process Map and Simulations- Metal Matrix Composites processing -Stir casting and powder metallurgy along with case studies.
NDT techniques for aircraft component qualification – Florescent penetrant inspection, Magnetic particle inspection, ultrasonic testing and Radiography testing, Case studies for NDT testing.

Reference Books &Web Resources

1. Stefano Gialanella, Alessio Malandruccolo, 'Aerospace Alloys', Springer International Publishing, 2020.
2. Adrian P. Mouritz,' Introduction to Aerospace Materials', Woodhead Publishing, 2012.
3. Kumar Jata, Eui Whee Lee, William Frazier, Nack J.Kim, 'Light weight Alloys for Aerospace Application', Wiley, 2001.
4. George E Dieter,' Mechanical metallurgy',3rd Edition,Mc-Graw Hill Education Pvt. Ltd., Delhi, 2017.
5. Serope Kalpakjian and Steven Schmid,' Manufacturing Processes for Engineering Materials, 5th Edition, Pearson,2007.
6. Polmear, I,J, 'Light Alloys: Metallurgy of the Light Metals',Wiley,1995
7. VijendraSingh,'PhysicalMetallurgy',StandardPublications,NewDelhi,2010.
8. RaoP.N,'ManufacturingTechnology:Foundry,FormingandWelding'-Volume1, 4th Edition, McGraw Hill Education, New Delhi,2013.
9. RaoP.N,'Manufacturing Technology:MetalCuttingandMachineTools'-Volume2, 3rd Edition, McGraw Hill Education, New Delhi,2013.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	Introduction–Overview Light alloys-Al, Mg, Ti alloys	
1.1	Polymer matrix /Ceramic matrix based composite material -CFRP/GFRP/C-C/C-SiC composite usages in airframe and engine	1
1.2	Aerospace material testing–Advanced Mg alloys–High entropy alloys & composites.	1
1.3	Introduction–Overview Light alloys-Al, Mg, Ti alloys	1
2	**Manufacturing processes**	
2.1	Metal additive manufacturing – laser / electron beam powder bed fusion and Wire Arc Additive Manufacturing	1
2.2	Severe Plastic Deformation processes–Equal Channel Angular Pressing, Multidirectional forging, Precision forging, Friction Stir Processing along with case studies.	2
2.3	Precision forging, Friction Stir Processing along with case studies.	1
2.4	Advanced Forging Process	1
2.5	Metal Matrix Composites processing by Stircasting with case studies	2
3	**NDT techniques for aircraft component qualification**	
3.1	Flurocent penetrant inspection, Magnetic particle inspection,	2

No.	Topic	No. of Periods
	Ultrasonic testing and Radiography testing.	
3.2	Case studies for NDT testing.	1
	Total	**13**

Course Designers

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22ME2A0	AUTOMOTIVE PRODUCT BUILD

Category	L	T	P	C	Terminal Exam Type
PEES	2	-	-	2	Theory

Preamble

This course exposes the students to the knowledge regarding how the manufacturing companies are developing products/ processes in a structured manner. This course also provides the step-by-step detail insight of engineering concepts and tools used in automotive product/process development process and, it will largely help the students to adopt the manufacturing culture and their operations.

Prerequisite

- Metal Casting and Forming Process
- Metal Joining and Sheet metal working
- Production drawing
- Machining process
- Manufacturing Automation

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Describe the Product Design and Development process in Original Equipment Manufacturers (OEM) and their Tier-1/Tier-2 suppliers	TPS2	70	70
CO2	Explain the Elements of plan and define phase in Automotive industry	TPS2	70	70
CO3	Identify the engineering Concepts, tools used to develop the product/process and method for Process design and development	TPS3	70	65
CO4	Apply the tool for Product and Process Validation and Choose the Corrective action with feedback on the Product Development process	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	-	-	M
CO2	M	L	-	-	-	-	-	-	-	-	-	-	-	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M
CO4	S	M	L	-	-	-	-	-	-	-	-	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Practical Assessment-1						Practical Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	**Review 1**: Project-based learning approach with customized assessment rubric evaluation						**Review 2**: Project-based learning approach with customized assessment rubric evaluation						5	10	
CO2													5	10	10
CO3													5	10	15
CO4													5	10	15

For Internal assessment (Practical Only)

- Two Reviews
- Practical: Project-based learning approach with customized assessment rubric evaluation

For Terminal assessment (Theory only)

- Theory terminal test will be conducted

Syllabus

Introduction: Product development overview, History, OEM (Original Equipment Manufacturer) and Tier-1/Tier-2, IATF 16949 (International Automotive Task Force), Certification Body, Requirements of IATF 16949, APQP overview and Methods, Customer requirement, Project planning, APQP team and their roles and responsibility.

Plan and Define: Product Line-up, Sourcing Process, Vertical Integration, Customer input requirements, Benchmarking and Teardown, Cost target and Estimating, Quality Target, QFD(Quality Functional Deployment), Bill of Material (BOM). Case Study-1.

Product Design and Development/Proto build: Quality,History, Drawing and specification, Proto builds, DFMEA (Design Failure Mode and Effect Analysis): Definition and need for DFMA, Inputs to the DFMEA, Developing DFMEA. Failure modes, effects and causes, Occurrence, Design prevention and detection control, Risk priority number (RPN), Recommended action, SC (Significant Characteristics) and CC (Critical Characteristics) characteristics DVP&R (Design Verification Plan & Report): Introduction to DVP&R, Type of testing method, Analytical, CAD/CAE, Physical, Durability and life cycle testing, Homologation/Regulatory requirements, Engineering Signoff– Cost estimating process and Program Approval Case Study-2

Process design and development: Facilities, tools, and gauges, Manufacturing process flow, Process FMEA, SC/CC, MSA (Measurement system Analysis) overview, SPC (Statistical Process Control) overview, Operator process instructions -Case Study-3

Product and Process Validation: Production trial run, Production control plan, Production validation testing, Part submission warrant (PSW), Production Part approval process (PPAP) and requirements-Case Study-4

Corrective action and customer feedback: TGW (Things Gone Wrong), TGR (Things Gone Right), Customer feedback, DFMEA update, Warranty Analysis, Input to new product, On-going product updates.

Textbook (s)

1. D.H. Stamatis, "**Advanced Product Quality planning: A road to success**", CRC Press, 2018

Reference Books &Web Resources

1. AIAG Manuals, IATF 16949 - APQP, SPC, MSA, FMEA, PPAP, Sep 2018
2. Ulrich, Eppinger, Product Design and Development, McGraw hill, 2012

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Introduction**	
1.1	Product development overview, History, OEM and Tier-1/Tier-2, IATF 16949, Certification Body, Requirements of IATF 16949, APQP overview and Methods	1
1.2	Requirements of IATF 16949, APQP overview and Methods, Customer requirement, Project planning	1
2	**Plan and Define**	
2.1	Product line-up and sourcing, Customer input requirements, Bench marking and Teardown process, Program approval-Case study-1	2
2.2	Cost Estimating and Quality Target, QFD, Bill of Material (BOM), Program cost and Quality Target	2
3	**Product Design and Development/Proto build**	
3.1	Quality history and product line-up, Proto Drawings, Specifications, Customer drawings, Proto parts and to support proto builds	3
3.2	Brief introduction about FMEA. Definition and need for DFMA Developing DFMEA. Inputs to the DFMEA, Failure modes, effects and causes, Occurrence, Design prevention and detection control, Risk priority number (RPN), Recommended action, SC and CC characteristics,	3
3.3	Introduction to DVP&R, Type of testing method, Analytical, CAD/CAE, Physical, Bogey, degradation testing, Regulatory requirements, Final Engineering sign-off,Cost Estimating process and Program ApprovalCase Study-2	4
4	**Process design and development**	
4.1	Facilities, tools, and gauges, Manufacturing process flow, Operator process instructions, Packaging specifications	2
4.2	Process FMEA, SC/CC, Work instruction	3
4.3	Measurement system evaluation overview, Normal curve, Normality assessment, Statistical Process Control overview, Case study-3	3
5	**Product and Process Validation**	
5.1	Production trial run, Production control plan Production validation testing	1
5.2	Part submission warrant (PSW), Production Part approval process (PPAP) and requirements, Case study-4	2
6	**Corrective action and customer feedback**	
6.1	TGW, TGR, Customer feedback, DFMEA update, Warranty Analysis, Input to new product, On-going product updates,	1
	Total	28

Course Designers

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22ME2B0	JIGS AND FIXTURES DESIGN

Category	L	T	P	C	Terminal Exam Type
PEES	2	-	-	2	Theory

Preamble

The successful running of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand a fast and easy method of positioning work for accurate operations. Jigs and fixtures are production tools used to accurately manufacture duplicate and interchangeable parts. Jigs and fixtures are specially designed so that large numbers of components can be machined or assembled identically, and to ensure interchangeability of components. This course provides knowledge for the students to make an optimal design of Jigs and Fixtures for the real-time components, which is much essential in today's manufacturing Industries.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain about different types of Jigs and Fixtures	TPS2	70	70
CO2	Select a suitable locating, clamping, guiding methods and devices for a given component	TPS3	70	65
CO3	Design a suitable drill Jig for a given component	TPS3	70	65
CO4	Design a suitable fixture for a given component based on the manufacturing process	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	**L**	-	-	-	-	-	-	-	-	-	-	L	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	S	-	S
CO4	S	M	L	-	-	-	-	-	-	-	-	-	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	-	-	-	-	-	-	-	-	-	-	5	10	-
CO2	-	20	20	-	-	-	-	-	-	-	-	-	5	10	10
CO3	-	10	15	-	-	-	-	-	-	-	-	-	5	10	15
CO4	-	10	15	-	-	-	-	-	-	-	-	-	5	10	15
												Total	20	40	40

Syllabus

Introduction of Jigs and Fixtures: Definition – Role in industries – Functions - Difference between Jigs and Fixtures - Basic Principles – Elements - Outputs – Advantages – Disadvantages – Applications.
Location: Definition and purpose of location - Degrees of freedom - Principles of location – 3-2-1 principle - Types of locators - Locating methods - Errors caused in locating - Necessity of fool proofing.
Clamping: Principles of clamping - Types of clamps.
Guiding: Guiding Elements – Classification of drill bushes - Types of bushes - Jig bushes as per IS-666-1972
Design of Jigs: Types of Jigs - Design considerations in Jigs - Design of Jigs for given component – Case Study.
Design of Fixtures: Principles of Fixtures used in Machining, Assembly and Welding - Modular fixtures - Quick change fixtures – Applications - Design of fixtures for given component – Case Study.

Textbook (s)

1. Donaldson. C, “Tool Design”, Tata McGraw-Hill, 4th Edition, 2012.

Reference Books & Web Resources

1. Joshi. P.H, “Jigs & Fixtures”, Tata McGraw-Hill, 3rd Edition, 2017.
2. Kempster M.H.A, “Fundamentals of Tool Design”, Prentice Hall of India, 2003.
3. Edward G Hoffman, “Jigs & Fixture Design”, Thomson Delmar Learning, 5th Edition, 2004.
4. Handbook of Jig and Fixture Design, Society of Manufacturing Engineers, 2nd edition, 1989
5. ASTME, “Fundamentals of Tool Design”, Prentice Hall of India, 2003.
6. https://nptel.ac.in/courses/112/105/112105127/

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1.	**Introduction of Jigs and Fixtures**	
1.1	Definition, Role, Functions and Difference between Jigs and Fixtures	01
1.2	Basic Principles and Elements of Jigs and Fixtures	01
1.3	Outputs, Advantages, Disadvantages and Applications of Jigs and Fixtures	01
2.	**Location**	
2.1	Definition, Purpose of location and Degrees of freedom	01
2.2	Principles of location, 3-2-1 Principle	01
2.3	Types of locators	01
2.4	Locating methods	01
2.5	Errors caused in locating and necessity of fool proofing	01
3.	**Clamping**	
3.1	Principles of clamping	02
3.2	Types of clamps	02
4.	**Guiding**	
4.1	Guiding Elements, Classification of drill bushes	01
4.2	Types of bushes, Jig bushes as per IS-666-1972	02
5.	**Design of Jigs**	

5.1	Types of Jigs	02
5.2	Design considerations in Jigs	01
5.3	Design of Jigs – Case Study	03
6.	**Design of Fixtures**	
6.1	Principles of Fixtures used in Machining, Assembly and Welding	02
6.2	Modular fixtures, Quick change fixtures, Applications	02
6.3	Design of fixtures – Case Study	03
	Total	28

Course Designers

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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
INTERDISCIPLINARY ELECTIVE COURSES

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

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22MEGA0	DIGITAL MANUFACTURING

Category	L	T	P	C	Terminal Exam Type
IE	3	-	-	3	Theory

Preamble

Digital manufacturing is an integrated approach to manufacture products with the aid of computer hardware and software. The transition to digital manufacturing has become more popular with the rise in the quantity and quality of computer systems in manufacturing environment. This course aims to expose students to acquire basic knowledge in digital manufacturing principles, techniques, and applications to thrive in the rapidly evolving field of digital manufacturing.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the various manufacturing processes used in manufacturing industries.	TPS2	70	70
CO2	Develop a solid model and perform the transformation.	TPS3	70	65
CO3	Develop a CNC program for a simple part drawing.	TPS3	70	65
CO4	Select a suitable Additive Manufacturing process for a given application/product.	TPS3	70	65
CO5	Explain IoT systems for a given manufacturing environment.	TPS2	70	70
CO6	Describe Industry 4.0 for a given real-time application.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	L					L							
CO2	S	M	L			M		L							
CO3	S	M	L			M		L							
CO4	S	M	L			M		L							
CO5	M	L	L			M		L							
CO6	M	L	L			M		L							

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	20								2	14	
CO2			40	5	10	20							2		15
CO3			40	5	10	20							2		15
CO4									50	5	20	20	2		20
CO5								25		5	20		2	12	
CO6								25		10	20		2	12	
												Total	12	38	50

Syllabus

Manufacturing processes used in manufacturing

Introduction: Metal Casting Processes-Expendable mould (Sand casting) and Permanent mould (Die casting) with demonstration, Metal Removal-Production of round and prismatic parts, Metal Forming-Bulk forming (Forging), Metal Joining-Arc welding and Gas Metal Arc welding, Basics of CNC Machining.

Digital Techniques used in Solid modeling

3D Modelling-Boundary representation and Constructive Solid Geometry techniques. 2D Transformation-Translation, scaling, mirroring and rotation. Data exchange formats-IGES and DXF.

Digital techniques used in the manufacturing

CNC Programming-Turning and Milling operation, Materials requirement Planning, Demonstration on CNC Machining.

Additive Manufacturing

CAD software for Additive Manufacturing – Stereolithography, Fused Deposition Modelling – Post Processing – Demonstration on Additive Manufacturing.

IoT in Digital Manufacturing

Introduction to IoT – IoT Communication Protocols used in CNC machines, Sensors and Actuators used in CNC machines, Communication Devices used in CNC machines, Integration with Cloud – Case Studies

Industry 4.0

Evolution of Digital Manufacturing – Architecture of Industry 4.0 – Protocols for Industry 4.0 – Implementation of Industry 4.0 – Case Studies.

Textbook (s)

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
2. Ibrahim Zeid, "Mastering CAD/CAM", Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2013.
3. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
4. Mikell P.Groover, Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson, Fourth Edition, 2012.
5. Pethuru Raj, Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, Auerbach Publications, First edition, 2017.
6. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, First Edition, 2017.

Reference Books & Web Resources

1. Mikell P.Groover, "Fundamental of Modern Manufacturing", Wiley India Edition, Third Edition, Reprint, 2012.
2. HMT, "Mechatronics", Tata McGraw-Hill Publishing Company Limited, New Delhi ,2017.
3. Michael E. Mortenson, "Geometric Modelling", Industrial Press, Third edition, 2006.
4. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
5. Arsheep Bahga, Vijay Madisetti, "Internet Of Things – A Hands-On Approach", First Edition, Universities Press, 2015
6. **NPTEL Course**: Computer Aided Design and Manufacturing
   Url: https://nptel.ac.in/courses/112102101/
7. **edX Course** : "Industry 4.0: How to Revolutionize your Business" by Prof. Eric Tsui, The Hong Kong Polytechnic University.
   https://www.edx.org/course/industry-40-how-to-revolutionize-your-business

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Manufacturing processes used in manufacturing**	
1.1	Introduction to Metal Casting Processes – Expendable mould (Sand casting) and Permanent mould (Die casting) with demonstration.	2
1.2	Introduction to Metal Removal – Production of round and prismatic parts	1
1.3	Introduction to Metal Forming – Bulk forming (Forging)	1
1.4	Introduction to Metal Joining – Arc welding and GMAW	1
1.5	Basics of CNC Machining	1
2	**Digital techniques used in modeling and analysis**	
2.1	3D Modelling – B-rep and CSG	2
2.2	2Dtransformation - Translation, scaling, mirroring and rotation	2
2.3	Data exchange formats – IGES and DXF	2
3	**Digital techniques used in manufacturing**	
3.1	CNC Programming – Turning operations	2
3.2	CNC Programming –Milling operations	2
3.3	Materials Requirement Planning (MRP)	1
3.4	Demonstration on CNC Machining	1
4	**Additive Manufacturing**	
4.1	CAD software for Additive Manufacturing – Stereolithography	2
4.2	Fused Deposition Modelling	1
4.3	Post Processing	1
4.4	Demonstration on 3D printing	1
5	**IoT in Digital Manufacturing**	
5.1	Introduction to IoT	1
5.2	IoT Communication Protocols used in CNC machines.	1
5.3	Sensors and Actuators used in CNC machines.	1
5.4	Communication Devices used in CNC machines.	1
5.5	Integration with Cloud	1
5.6	Case Studies	1
6	**Industry 4.0**	
6.1	Evolution of Digital Manufacturing	2
6.2	Architecture of Industry 4.0	1
6.3	Protocols for Industry 4.0	1
6.4	Implementation of Industry 4.0	1

No.	Topic	No. of Periods
6.5	Case Studies	2
	Total	36

Course Designers

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6.	Mr. M. Karthic	Assistant Professor	Mechanical Engineering	mkmech@tce.edu

22MEGB0	SIX SIGMA

Category	L	T	P	C	Terminal Exam Type
IE	3	-	-	3	Theory

Preamble

Six Sigma methodologies enable organizations to achieve high quality in their products. It can be applied to organization wide products, processes and services. It uses data and statistical tools to systematically improve processes and sustain their improvements. Organizations have developed and improved their business processes effectively by using Six Sigma tools. The most important benefit of Six Sigma comes is in the form of financial gains that result from the elimination of defects and optimization of processes. This course imparts knowledge on six sigma to solve real life problems in an industrial environment.

Prerequisite

- NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the concepts of Six Sigma.	TPS2	70	70
CO2	Describe the different six sigma methodologies	TPS2	70	70
CO3	Prepare action plan to reduce variations in manufacturing process(es) of a product	TPS3	70	65
CO4	Identify root causes of variations and prepare action plan to eliminate it.	TPS3	70	65
CO5	Use control charts and plan to improve the Quality of product or services.	TPS3	70	65
CO6	Select the suitable lean tools to improve six sigma level in an Industry.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L													
CO2	M	L													
CO3	S	M	L						S						
CO4	S	M	L												
CO5	S	M	L												
CO6	S	M	L												

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20		10	20								2	5	-
CO2		20		10	20								2	5	-
CO3			60		10	30							2	5	10
CO4									40		10	30	-	5	20
CO5									30		10	20	2	5	15
CO6									30		10	20	2	5	15
												Total	10	30	60

Syllabus

Introduction and Methodologies of Six Sigma

Basics concepts of Six Sigma – Need and significance of Six Sigma – Fundamentals of Statistical Distribution – Statistical Processes – Define, Measure, Analyze, Improve, and Control (DMAIC) – Identify, Design, Optimize, and Verify (IDOV) – Design for Six Sigma (DFSS) – DMAIC tools and applications.

Define Phase

Project Charter – Total Productive Maintenance (TPM) – Critical to Quality Characteristics (CTQ's) – Suppliers, Inputs, Process, Outputs and Customer (SIPOC).

Measure Phase

Data types (Attribute and Variable, Discrete and Continuous) – Process Map – Histogram – Normality – Process Capability.

Analyze Phase

Failure Mode and Effects Analysis (FMEA) – Quality Function Deployment (QFD) – Graphical Plots (Box plot and Run Chart) – Cause and Effect Diagram – Root Cause Analysis (RCA) – Pareto Chart.

Improve Phase

Mistake Proofing – Decision Analysis – Improved Process Map – Revised FMEA.

Control Phase

Control Chart – Control plan – Lean Methodologies – Value Stream Mapping (VSM) – Types of Wastes – 5S – Kaizen.

Textbook (s)

1. Thomas Pyzdek and Paul Keller, "The Six Sigma Handbook" , 4th Edition McGraw-Hill, 2014

Reference Books &Web Resources

1. Kai Yang and Basemel-Haik, "Design for Six-Sigma: A Roadmap for Product Development", McGraw Hill, 2009.
2. Hitoshi Kume, "Statistical methods for Quality Improvement", Productivity Press (India) Pvt Ltd, First Indian Edition, 2006
3. Jeffrey K. Liker, "The Toyota Way", Tata McGraw Hill, 2004

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**Introduction and Methodologies of Six Sigma**	
1.1	Basic concepts of Six sigma	1
1.2	Need and significance of Six Sigma	1
1.3	Fundamentals of Statistical distribution	2
1.4	Statistical Processes	2
1.5	Define, Measure, Analyze, Improve, and Control (DMAIC)	1
1.6	Identify, Design, Optimize, and Verify (IDOV)	2
1.7	Design for Six Sigma (DFSS), DMAIC tools and applications	2
2	**Define Phase**	
2.1	Project Charter, Total Productive Maintenance (TPM)	2
2.2	Critical to Quality Characteristics (CTQ's) - Suppliers, Inputs, Process, Outputs and Customer (SIPOC)	1
3	**Measure Phase**	
3.1	Data types (Attribute & Variable, Discrete and Continuous)	2
3.2	Process Map, Histogram, Normality, Process Capability	2
4	**Analyze Phase**	
4.1	Failure Mode and Effects Analysis (FMEA), Quality Function Deployment (QFD)	2
4.2	Graphical Plots (Box plot and Run Chart)	2
4.3	Cause and Effect Diagram, Root Cause Analysis (RCA), Pareto Chart	2
5	**Improve Phase**	
5.1	Mistake Proofing, Decision Analysis	2
5.2	Improved Process Map, Revised FMEA	2
6	**Control Phase**	
6.1	Control phase: Control Chart	2
6.2	Control phase: Control Plan	2

No.	Topic	No. of Periods
6.3	Lean Methodologies, Value Stream Mapping and types of Wastes	2
6.4	5S and Kaizen	2
Total		36

Course Designers

1.	Prof. S. Karthikeyan	Professor	Mechanical Engineering	skarthikeyanlme@tce.edu
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22MEGD0	ENERGY GENERATION AND UTILIZATION

Category	L	T	P	C	Terminal Exam Type
IE	3	-	-	3	Theory

Preamble

Energy is the lifeblood of modern society, powering our homes, industries, and transportation systems. This course delves into the intricacies of energy generation and utilization, and explores a diverse array of topics, ranging from traditional fossil fuels to renewable sources, as well as emerging technologies.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine Work transfer, heat transfer and Carnot efficiency.	TPS3	70	65
CO2	Determine the Performance parameters of Diesel engine power plants	TPS3	70	65
CO3	Determine the power developed and cycle efficiency of gas turbine power plants.	TPS3	70	65
CO4	Calculate efficiency, steam rate and heat rate of Steam power cycle and explain the nuclear power reactor	TPS3	70	65
CO5	Describe the working of renewable energy power generation systems such as Solar, wind, bio-mass and recent power generation techniques.	TPS2	70	70
CO6	Describe working of energy utilizing devices such as refrigerator, air conditioner, compressor, pump.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L												
CO2	S	M	L												
CO3	S	M	L												
CO4	S	M	L												
CO5	M	L													
CO6	M	L													

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			20	5	10	20							2	6	10
CO2			40	-	10	20							2	6	10
CO3			40	5	10	20							2	6	10
CO4			-						50	10	10	20	2	6	10
CO5			-					25		10	20	-	4	10	-
CO6			-					25		10	20	-	4	10	-
												Total	16	44	40

Syllabus

Basics of Thermodynamics: System, state, properties, process, cycle –Reversible and irreversible, energy transfer, zeroth and first law of thermodynamics – heat engine cycle- Carnot cycle and efficiency.

Diesel engine power generation: working – two stroke and four stroke Diesel engine, air standard efficiency, thermal efficiency, performance parameters – Calculation, Support system for power generation – Cooling, lubrication, Starting, air supply system.

Gas turbine power generation: working – open and close cycle gas turbine, air standard efficiency of simple Brayton cycle – calculation, method of improving the Brayton cycle efficiency, working of jet engine.

Steam turbine power generation: Steam formation - working of boiler, high pressure steam, properties of steam – wet, dry saturated and superheated steam. **Steam turbine:** working – impulse and reaction turbine, **Rankine Cycle:** Simple Rankine cycle- thermal efficiency, steam rate and heat rate calculations. **Nuclear power generation:** working – BWR, PWR, and FBR powerplant.

Renewable Energy power generation: Solar power generation- thermal energy collectors, PV power system – working, selection of site. Wind power generation: Working – vertical axis and horizontal axis wind turbines, power in the wind, selection of site. Biomass power generation: Bio gasification, incineration, Biodiesel generation **Recent Power generation Techniques:** Fuel cells, MHD, OTEC power generation, hydrogen generation techniques.

Utilization of energy in Thermal systems: Refrigeration - Definition, working principle, methods of refrigeration – vapour compression and aqua - ammonia vapour absorption refrigeration system, **Air-conditioning:** Properties of moist air, conditioning of air, Summer and winter Air-conditioning system- construction and working . **Compressor:** Reciprocating Compressor – working, Rotary compressor – working. **Pump:** construction and working- Centrifugal pump and Reciprocating pump.

Textbook (s)

1. Nag P.K., "**Power Plant Engineering**"- fourth edition, Tata McGraw Hill ,New Delhi, 2017.

2. Rajput R.K., **"A Text Book of Power Plant Engineering",** Laxmi Publications (P) Ltd.,Fifth edition 2016
3. Rai G.D., "**Non- Conventional Energy Sources",** fourth edition 2015, Khanna Publishers, New Delhi
4. Rajput R.K., **"A Text Book of Thermal Engineering",** Laxmi Publications (P) Ltd.,Eleventh edition 2020

Data Book

1. R.S.Khurmi, J.K.Gupta **"Steam tables with Mollier Diagram"** 8th edition January 2008, S Chand Publisher

Reference Books &Web Resources

1. M.M.El-Wakil, **"Power plant Technology",** Tata McGraw Hill, New Delhi, 2010.
2. A.K.Raja, Srinvastava, Amit Praksh, **"Power Plant Engineering** " New age International 2016
3. Technology of Bio-Fuels(Ethanol & Biodiesel) Engineers India Research Institute (2010)
4. https://nptel.ac.in/courses/121106014/ Non conventional Energy resources, IIT Madras
5. https://www.youtube.com/watch?v=mpHZWYpKDJg, Energy resources and Technology IIT Kharagpur.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Basics of Thermodynamics**:	
1.1	System, state, properties, process, cycle	1
1.2	Reversible and irreversible, energy transfer, zeroth and first law of thermodynamics	2
1.3	heat engine cycle- Carnot cycle and efficiency.	2
2	**Diesel engine power generation:**	
2.1	working – two stroke and four stroke Diesel engines.	1
2.2	air standard efficiency, thermal efficiency, performance parameters – Calculation,	3
2.3	Support system for power generation – Cooling, lubrication, Starting, air supply system.	2
3	**Gas turbine power generation:**	
3.1	working – open and close cycle gas turbine, air standard efficiency of simple Brayton cycle – calculation	4
3.2	method of improving the Brayton cycle efficiency, working of jet engine.	1
4	**Steam turbine power generation:**	
4.1	Steam formation - working of boiler, high pressure steam, properties of steam – wet, dry saturated and superheated steam.	3
4.2	Steam turbine: working – impulse and reaction turbine, Rankine Cycle: Simple Rankine cycle- thermal efficiency, steam rate and heat rate calculations	3
4.3	**Nuclear power generation:** working – BWR, PWR, and FBR powerplant.	2
5	**Renewable Energy power generation:**	

No.	Topic	No. of Periods
5.1	Solar power generation- thermal energy collectors, PV power system – working, selection of site.	2
5.2	Wind power generation: Working – vertical axis and horizontal axis wind turbines, power in the wind, selection of site.	1
5.3	Biomass power generation: Bio gasification, incineration, Biodiesel generation	2
5.4	**Recent Power generation Techniques:** Fuel cells, MHD, OTEC power generation, hydrogen generation techniques.	2
6	**Utilization of energy in Thermal systems:**	
6.1	Refrigeration-Definition, working principle, methods of refrigeration – vapour compression refrigeration system and aqua - ammonia vapour absorption refrigeration system	2
6.2	Air-conditioning: Properties of moist air, conditioning of air, Summer and winter Air-conditioning system- construction and working.	1
6.3	Compressor: Reciprocating Compressor – working, Rotary compressor – working.	1
6.4	Pump: construction and working- Centrifugal pump and Reciprocating pump.	1
	Total	**36**

Course Designers

1. Prof. A.Valan arasu | Professor | Mechanical Engineering | avamech@tce.edu
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3. Prof. P.Maran | Professor | Mechanical Engineering | pmmech@tce.edu
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22EG660 PROFESSIONAL COMMUNICATION

Category	L	T	P	Credit
HSS	0	1	2	2

Terminal Exam Type-Lab

Preamble

The prime focus of this course is to enhance the employability and career skills of students with an emphasis on grooming them as value-driven professionals. The practice of essential language skills improves their ability to communicate persuasively and ensures their industry-readiness to face real-life challenges.

Prerequisite

Basics of Technical English

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate adequate soft skills relevant for workplace	TPS3	70%	70%
CO2	Listen and respond to native and non-native accented delivery	TPS3	65%	65%
CO3	Interpret general/technical topics in group discussion	TPS3	70%	70%
CO4	Present effectively both in general and technical contexts and interviews	TPS3	70%	70%
CO5	Exhibit verbal aptitude skills through reading and writing	TPS3	70%	70%
CO6	Write error-free business correspondence	TPS3	70%	70%

Mapping with Programme Outcomes

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

CO5								**L**	**M**	**S**		**S**
CO6								**M**	**S**	**S**		**M**
S- Strong; M-Medium; L-Low												

Internal Assessment

Students' performance will be continuously assessed in various classroom activities that include Listening, Speaking, Reading and Writing components for 50 marks as detailed below:

Listening Test **- 10**

Speaking Test (Group Discussion, Mock interview and Technical Presentation) **- 25**

Reading and Writing Test **- 15**

Total **- 50**

End Semester Assessment (LAB):

Listening Test **- 20**

Group Discussion **- 20**

Self-introduction and Personal Interview / BEC - Vantage speaking Task 2 **- 20**

General Aptitude Test **- 30**

Resume submission **- 10**

Total **-100**

List of Experiments/Activities with CO Mapping

S.No	Activities	Hours		CO Mapping
		T	P	
1	1.1. Introduction to soft skills 1.2. Hard skills vs soft skills	2		CO1
2	Listening Practice and Test		2	CO2
3	Reading and reasoning practice from Technical passages/articles/dailies	1		CO5
4	1-minute Self-Introduction (based on interview style)	1		CO4
5	GD Techniques	1		CO3
6	GD Practice		3	CO3
7	Interview Techniques	1		CO4

8	Mock interview		3	CO4
9	Presentation skills	1		CO4
10	Technical presentation		3	CO4
11	General Aptitude Practice and test – Vocabulary Development / Sentence completion / Error spotting /Analogy		3	CO5
12	Business Correspondence – BEC - Vantage speaking Task II	1		CO6
13	Basics of Technical Writing	1		CO5
14	Preparation of Resume	1		CO4

Text Book:

Work book prepared by the Faculty of Dept. of English.

Reference Books & Web Resources:

1. Brooks, Margret. Skills for Success. Listening and Speaking. Level 4 Oxford University Press, Oxford: 2011.
2. Brook-Hart, Guy. Business Benchmark. Upper-intermediate: Student's book, Volume 1. Cambridge University Press: 2013.
3. Patnaik, Priyadarshi. Group Discussion and Interview Skills - Cambridge University Press India; Second edition (1 September 2015).
4. Hughes, Glyn and Josephine Moate. Practical English Classroom. Oxford University Press: Oxford, 2014.
5. www.cambridgeenglish.org (BEC - LSRW)
6. www.examenglish.com (Online Exams for international ESL Exams)
7. www.testpreppractice.net (GRE Tests -Vocabulary /Analogy / Sentence Completion / Reading)
8. https://www.freshersworld.com (Placement Papers)

Extensive Reading:

Who Moved My Cheese? - Spencer Johnson, Ebury Publishing, 2002.

Course Designers:

1	Dr. A. Tamilselvi (Convenor),Professor,English	tamilselvi@tce.edu
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3	Dr. G. Jeya Jeevakani , Assistant Professor,English	gjjeng@tce.edu
4	Dr. M. Sarpparaje, Assistant Professor,English	mseeng@tce.edu

22ES390	DESIGN THINKING

Category	L	T	P	Credit
ESC	1	-	4	3

Preamble

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

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify a specific social need to be addressed	TPS 3	70	80
CO2	Identify stakeholder's requirements for the societal project	TPS 3	70	80
CO3	Develop measurable criteria in which design concepts can be evaluated	TPS 3	70	80
CO4	Develop prototypes of multiple concepts using user's feedback	TPS 3	70	80
CO5	Select the best design solution among the potential solutions with its functional decomposition	TPS 5	70	80

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

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

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics

- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

Syllabus

1.0 Project Identification: Needs Assessment, Stakeholder Identification, Stakeholder Requirement Project Time Constraint.
2.0 Specification Development: Description Problem Environment, Creation of Stakeholder's Profiles Development of Low-cost Prototypes, Development of Task-Analysis, Comparison with Benchmark Products, Development of Customer Specification, Development of Evaluation Criteria,
3.0 Conceptual Design: Conduct of Functional Decomposition, Brainstroming of possible solutions, Creation of Prototypes for Multiple Concepts, Refinement of Design Specification on users' feedback, Evaluation of Potential Solutions, Selection of best design

Learning Resources

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

Course Contents and Lecture Schedule

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

Course Designers:

1. Dr.S.J.Thiruvengadam sjtece@tce.edu

GUIDELINES FOR PROJECT COURSES

Project I, Project II, Project III and Project IV

B.E. / B.Tech. DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU
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THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI 625015

GUIDELINES FOR PROJECT COURSES

In the curriculum of 2022 B.E./B.Tech. Programmes, 12 credits have been assigned for **Project work in the specific discipline.** The curriculum was designed based on around 4 focus/broad areas. This has been split into **4 project courses** namely Project I, Project II, Project III and Project IV in semesters 5,6, 7 and 8 respectively.

Choice of Focus Areas: HoDs are requested to provide choice for the students to choose one of the broad/focus areas to carry out project work in 5, 6, 7 and 8th semesters. The number of students in each broad/focus areas shall be based on the faculty and infrastructure availability.

Project Continuity and Switching: The students shall be given a big project in the chosen broad/focus area so that it can be spread over all four semesters with specific outcomes at each semester. In case, a student wants to switch from one focus area to other area. It has to be approved by the Head of the Department and project coordinator.

Internal Marks: Three reviews shall be conducted in each semester to monitor the progress of the project. Review 1; 10 Marks, Review 2: 15 Marks, Review 3: 15 Marks. Total = 40 Marks.

Viva Voce Examinations: For external examinations, HoD shall appoint two examiners in each focus/broad area to conduct the Viva Voce examination in semesters 5. 6 and 7. Project guides are also one of the examiners, along with the two examiners appointed by the HoD. External exam will be conducted for 60 Marks.

Final Viva Voce Examination: In 8th Semester, Viva Voce will be conducted by an external examiner, HoD / HoD Nominee as internal examiner and Project Guides. External exam will be conducted for 60 Marks.

This structured approach ensures that students engage in a comprehensive project experience throughout their undergraduate studies, with regular monitoring of progress and formal evaluation through viva voce examinations. It also allows for flexibility by permitting students to switch focus areas with appropriate approvals.

22CHAB0	CONSTITUTION OF INDIA

Category	L	T	P	Credit
AC	2	0	0	0

Preamble

On the successful completion of the course, the students will be able to explain the basic features and fundamental principles of Constitution of India. The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the “basic structure” of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of “Constitutionalism” – a modern and progressive concept historically developed by the thinkers of “liberalism” – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of “constitutionalism” in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India’s legacy of “diversity”. It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own AICTE Model Curriculum for Mandatory Courses & Activities (Non-Credit) for Undergraduate Degree in Engineering & Technology ancient legal heritage and cultural values. No law can be “static” and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it “as one of the strongest court in the world”

Course Outcome:

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the meaning of the constitution law and constitutionalism and Historical perspective of the Constitution of India	TPS2	70	70
CO2	Explain the salient features and characteristics of the Constitution of India, scheme of the fundamental rights and the scheme of the Fundamental Duties and its legal status	TPS2	70	70
CO3	Explain the Directive Principles of State Policy, Federal structure and distribution of legislative and financial powers between the Union and the States, and Parliamentary Form of Government.	TPS2	70	70
CO4	Explain the amendment of the Constitutional Powers and Procedure, the historical perspectives of the constitutional amendments in India, and Emergency Provisions.	TPS2	70	70

CO5	Explain the Local Self Government – Constitutional Scheme in India, Scheme of the Fundamental Right to Equality,	TPS2	70	70
CO6	Explain the scheme of the Fundamental Right to certain Freedom under Article 19, and Scope of the Right to Life and Personal Liberty under Article 21	TPS2	70	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Syllabus

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

Assessment Pattern

	Theory Assessment-1 CAT-1			Theory Assessment-2 CAT-2			Theory Assessment - 3 Seminar		
TPS / COs	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	8	25	-	-	-	-	-	15	-
CO2	8	25	-	-	-	-	-	17	-
CO3	9	25	-	-	-	-	-	17	-
CO4	-	-	-	8	25	-	-	17	-
CO5	-	-	-	8	25	-	-	17	-
CO6	-	-	-	9	25	-	-	17	-

References

1. Durga Das Basu, 'Introduction To The Constitution Of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
2. Constitution of India, National Portal of India, Web link: https://www.india.gov.in/my-government/constitution-india

Course Designers:

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

22CHAC0	ESSENCE OF INDIAN KNOWLEDGE	Category	L	T	P	Credit
		AC	2	0	0	0

Preamble

On the successful completion of the course, the students will be able to explain the concept of Indian Traditional Knowledge along with Indian Modern Knowledge. Traditional Knowledge Systems or Indigenous Knowledge Systems are a body of knowledge, which is very ancient and deep rooted. They have their origins in the remote past. Their systematisation and canonisation gave rise to the elite (the Greater Tradition) science. The nature of Traditional Knowledge System is diverse. It covers, among other things, literary, artistic and scientific works; songs, dances, medical treatments and practices; manufacturing and industry; and agricultural technologies and techniques. There is a dramatically growing national and international interest in incorporating Traditional Knowledge Systems, including Traditional Ecological Knowledge, into truly participatory approaches to development.

Course Outcome:

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

CO1	Explain the concept of Traditional Knowledge and Modern knowledge of India.	Understand
CO2	Explain the need and importance of protecting Traditional Knowledge, Knowledge sharing, and Intellectual property rights over Traditional Knowledge.	Understand
CO3	Explain about the use of Traditional Knowledge to meet the basic needs of human being.	Understand
CO4	Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle.	Understand
CO5	Explain the use of Traditional Knowledge in Manufacturing and Industry.	Understand
CO6	Explain about the cultural expression and modern applications of Traditional Knowledge	Understand

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO2	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO3	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO4	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO5	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO6	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Syllabus

Traditional and Modern Knowledge: Two Worlds of Knowledge - Phase of Explorers, Sir Arthur Cotton and Irrigation, Smallpox Vaccination, Late Nineteenth Century, Voelcker, Howard and Agriculture, Havell and Indian Art; Indians at the Encounter - Gaekwad of Baroda and Technical Education, Science Education and Modern Industries, Hakim Ajmal Khan and Ayurveda, R. N. Chopra and Indigenous Drugs, Gauhar Jaan and Indian Classical Music; Linking Science and the Rural - Tagore's Sriniketan Experiment, Marthandam, the YMCA Model, Gandhi's Thoughts on Development, Nehru's View of Growth; Post-Independence Era - Modernization and Traditional Knowledge, Social Roots of Traditional Knowledge Activism, Global Recognition for Traditional Knowledge. **Global Mechanisms of Protection and Sharing:** For Recognition and Protection - United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Labour Organization (ILO), UN Working Group on Indigenous Populations, Evolution of Other Organizations; Norms of Sharing - United Nations Environment Programme (UNEP), World Intellectual Property Organization (WIPO), World Trade

Organization (WTO); IPR and Traditional Knowledge - Theoretical Background, Positive Protections of TK, Defensive Strategies, IPR Facilitation for TK. **Traditional Knowledge for Basic Needs:** Indian Midwifery Tradition—The Dai System, Surface Flow Irrigation Tanks, Housing - A Human Right, Changing Priorities—Niyamgiri. **Biodiversity and Genetic Resources:** Jeevani - The Wonder Herb of Kanis, A Holistic Approach - FRLHT, Basmati - In the New Millennium, AYUSH-Based Cosmetics. **Traditional Knowledge in Manufacturing and Industry:** Drug Discovery, A Sweetener of Bengal, The Sacred Ring of Payyanur, Channapatna Toys. **Traditional Cultural Expressions:** Banarasi Saree, Music, Built and Tangible Heritage, Modern Yoga, Sanskrit and Artificial Intelligence, Climate Change and Traditional Knowledge.

Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar (Internal Exam)
	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

This course assessment is fully internal. There is no terminal examination.

Learning Resources:

1. Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.
2. Amit Jha," Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
3. Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
4. Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
5. NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: https://nptel.ac.in/courses/121/106/121106003/#.
6. Youtube video on "Introduction to Indian Knowledge Systems", Video link: https://www.youtube.com/watch?v=LZP1StpYEPM.
7. Youtube video on "12 Great achievements of Indian Civilization", Video link: https://www.youtube.com/watch?v=xmogKGCmclE.

Course Designers:

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- Dr.V.R.Venkatasubramani venthiru@tce.edu

22TAAA0 தமிழர் மரபு

L	T	P	C
1	0	0	1

அலகு I: <u>மொழி மற்றும் இலக்கியம்:</u> 3

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் –சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் – பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II: மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை: 3

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III: <u>நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்:</u> 3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV: <u>தமிழர்களின் திணைக் கோட்பாடுகள்:</u> 3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V: <u>இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு:</u> 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் – தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book

and Educational Services Corporation, Tamil Nadu)

12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

22TAAA0 HERITAGE OF TAMILS

1. Language and Literature: Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

2. Heritage - Rock art paintings to modern art - Sculpture: Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

3. Folk and Martial arts - Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

4. Thinai concept of Tamils – Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

5. Contribution of Tamils to Indian National Movement and Indian Culture: Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
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10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)

(Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

22TAAB0 <u>தமிழரும் தொழில்நுட்பமும்</u>

L T P C
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அலகு I: <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்:</u> 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II: <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்:</u> 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு– சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் – மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ–சாரோசெனிக் கட்டிடக் கலை.

அலகு III: <u>உற்பத்தித் தொழில் நுட்பம்:</u> 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV: <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்:</u> 3

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V: <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்:</u> 3

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
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12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

PAPER – 2
22TAAB0 TAMILS AND TECHNOLOGY

1. **Weaving and Ceramic Technology**: Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

2. **Design and Construction Technology:** Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period.

3. **Manufacturing Technology**: Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting,steel -Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

4. **Agriculture and Irrigation Technology:** Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea - Fisheries – Pearl - Conche diving - Ancient Knowledge of Ocean - Knowledge Specific Society.

5. **Scientific Tamil & Tamil Computing**: Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
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12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

DETAILED SYLLABI WITH
REVISED ASSESSMENT PATTERN
FOR THE COURSE
22ME350- PRODUCTION DRAWING

B.E. DEGREE PROGRAMME
IN
MECHANICAL ENGINEERING

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

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

22ME350	PRODUCTION DRAWING

Category	L	T	P	C	Terminal Exam Type
ESC	2	-	4	4	TCP

Preamble

Production Drawing is an indispensable communicating medium employed in industries to furnish all information required to manufacture and assembly of the components of a machine. It deals with the blue print reading and the preparation of orthographic projections of various machine parts and assemblies with all details of products regarding material, surface finish and tolerances along with fits as per ISO/BIS drawing standards for drawing practices through manual method.

Prerequisite

- Engineering Graphics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the ISO/BIS standards of production drawing	TPS2	70	70
CO2	Interpret the blue print drawing as per drawing standards	TPS2	70	70
CO3	Explain the tolerances, limits and fits used in production drawing	TPS2	70	70
CO4	Draw manual assembly drawing from the given part drawings	TPS3	70	65
CO5	Draw manual part drawing from the given assembly drawing	TPS3	70	65
CO6	Draw the manual detailed/production drawing from the given assembly/part drawing	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	L	-	S	-	-
CO2	S	M	L	-	-	-	-	-	-	-	L	-	S	-	-
CO3	S	M	L	-	-	-	-	-	-	-	L	-	S	-	-
CO4	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-
CO5	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-
CO6	S	M	L	-	-	-	-	-	-	-	M	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern (Revised)

	Internal Evaluation												*Terminal Examination		
	CAT- 1			CAT- 2			Plates/OCR			Model Exam			Theory		
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	40	-	-	-	-	-	-	-	-	6	-	-	6	-
CO2	-	20	-	-	-	-	-	-	-	-	12	-	-	12	-
CO3	-	40	-	-	-	-	-	-	-	-	12	-	-	12	-
CO4	-	-	-	-	-	30	-	-	30	-	-	20	-	-	20
CO5	-	-	-	-	-	30	-	-	30	-	-	20	-	-	20
CO6	-	-	-	-	-	40	-	-	40	-	-	30	-	-	30

Question pattern for Terminal Examination*

PART-A

Understand type 5 x 6 Mark = 30 Marks

PART – B

Apply type [either / or Type]

B1. Part to Assembly 1 x 20 Mark = 20 Marks
B2. Assembly to Part 1 x 20 Mark = 20 Marks
B3. Detailed/Production Drawing 1 x 30 Mark = 30 Marks

Total = 100 Marks

Syllabus

ISO/BIS Drawing standards for practice - Sizes of drawing sheet, lettering, terminologies of drawing layout, title block, scale, types of line & its application, methods of dimensioning, uses of different grades of pencils, drawing sheet folding method, **Sections** – hatching, cutting planes, revolved, removed, half and local sections. Classification of drawings, Difference between machine drawing over production drawing. **Conventional representation** – Materials, springs, gears, surface roughness, weld dimensioning, internal & external thread, bolts, nuts, screws and keys. **Blueprint Reading** – Interpretation of information from the given production/detailed drawing. **Limits and Tolerances** - Elements, system and arrangement of dimensioning, Indication of dimensional and geometrical tolerances, Indication of lay, Tolerance grade number of different manufacturing process, selection of tolerance grade, standard tolerance grade, computation of IT tolerance, positioning of tolerance, computation of fundamental deviations. **Fits** - Hole and Shaft basis system of fits, classifications, and calculation.
Assembly Drawing: Preparation of assembly drawing from the given part drawing like Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.
Part Drawing: Preparation of part drawing from the given assembly drawing like Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.
Production/Detailed drawings: Preparation of production/detailed drawing of part/assembly drawing like Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.

Textbook (s)

1. K.R.Gopalakrishna, “**Machine Drawing**”, Eighteenth Edition, Subhas Stores, Bangalore, 2013.
2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, “**Machine Drawing**”, Third Edition, New Age International Publishers, New Delhi, 2019.

Learning Resources

1. BIS-SP46:2003 standard recommendations for school practices.
2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, "**Production Drawing**", Third Edition, New Age International Ltd., New Delhi, 2014.
3. Thamos P.Olivo and Dr.C.Thamos Olivo, "**Basic Blueprint Reading and Sketching**", 9th edition, Industrial Press Inc, New York, 2011.
4. Walter W Sturtevant, "Practical Problems in Mechanical Drawing and Blue-Print Reading", Wentworth Press, 2016.
5. PS. Gill, "**A Text Book of Machine Drawing**", Seventh edition Reprint, S.K. Kataria & Sons. New Delhi. 2004.
6. RK. Dhawan, "**A Text book of Machine Drawing**", First Edition, Sultan Chand and Sons, New Delhi, 2015.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**ISO/BIS Drawing standards for practice**	
1.1	Sizes of drawing sheet, lettering, terminologies of drawing layout, title block, scale, types of line & its application, methods of dimensioning, uses of different grades of pencils, drawing sheet folding method,	2
1.2	Sections – hatching, cutting planes, revolved, removed, half and local sections. Classification of drawings, Difference between machine drawing over production drawing.	2
1.3	**Blue Print Reading** – Interpretation of information from the given production/detailed drawing.	2
1.4	**Conventional representation** – Materials, springs, gears, surface roughness, weld dimensioning, internal & external thread, bolts, nuts, screws and keys.	2
1.5	**Limits and Tolerances** - Elements, system and arrangement of dimensioning, Indication of dimensional and geometrical tolerances, Indication of lay, Tolerance grade number of different manufacturing process. selection of tolerance grade, standard tolerance grade, computation of IT tolerance, positioning of tolerance, computation of fundamental deviations.	6
1.6	**Fits** - Hole and Shaft basis system of fits, classifications, and calculation.	4
2	**Assembly Drawing**	
2.1	Preparation of assembly drawing from the given part drawing-1 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
2.2	Preparation of assembly drawing from the given part drawing-2 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
2.3	Preparation of assembly drawing from the given part drawing-3 (From the given Screw jack, Swivel Bearing, Drill Jig, Square way tool post, Clapper Block etc.)	4
3	**Part Drawing**	
3.1	Preparation of part drawing from the given assembly drawing-1 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
3.2	Preparation of part drawing from the given assembly drawing-2 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
3.3	Preparation of part drawing from the given assembly drawing-3 (From the given Steam Stop valve, Machine vice, Spark plug, Single way tool post, Lathe Travelling Rest, Pipe vice etc.)	4
4	**Production/Detailed drawing**	

No.	Topic	No. of Periods
4.1	Preparation of production/detailed drawing-1 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6
4.2	Preparation of production/detailed drawing-2 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6
4.3	Preparation of production/detailed drawing-3 (From the given Piston assembly, Milling Fixture, Pipe vice, Pierce and blank tool etc.)	6
	Total	60

List of Exercises

No.	Exercises	CO
	Assembly Drawing with respect to Lecture Schedule	
1.	Preparation of assembly drawing from the given part drawing-1	CO4
2.	Preparation of assembly drawing from the given part drawing-2	CO4
3.	Preparation of assembly drawing from the given part drawing-3	CO4
	Part Drawing with respect to Lecture Schedule	
4.	Preparation of part drawing from the given assembly drawing-1	CO5
5.	Preparation of part drawing from the given assembly drawing-2	CO5
6.	Preparation of part drawing from the given assembly drawing-3	CO5
	Production/Detailed drawing with respect to Lecture Schedule	
7.	Preparation of production/detailed drawing-1	CO6
8.	Preparation of production/detailed drawing-2	CO6
9.	Preparation of production/detailed drawing-3	CO6

Course Designers

1.	Dr. K. Chockalingam	Professor	Mechanical Engineering	kcmech@tce.edu
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DETAILED SYLLABUS
OF
REVISED INTERDISCIPLINARY ELECTIVE COURSE

B.E. DEGREE PROGRAMME
IN
MECHANICAL ENGINEERING

FOR THE STUDENTS ADMITTED IN THE
ACADEMIC YEAR 2023-24 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU
Phone: 0452 – 2482240, 41
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Passed in Board of Studies on 08.11.2024 Approved in 68th Academic Council Meeting on 21.12.2024

22MEGD1	ENERGY GENERATION AND UTILIZATION

Category	L	T	P	C	Terminal Exam Type
IE	3	-	-	3	Theory

Preamble

Energy is the lifeblood of modern society, powering our homes, industries, and transportation systems. This course delves into the intricacies of energy generation and utilization, and explores a diverse array of topics, ranging from traditional fossil fuels to renewable sources, as well as emerging technologies.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine Work transfer, heat transfer and Carnot efficiency.	TPS3	70	65
CO2	Determine the efficiency of Diesel engine power plants	TPS3	70	65
CO3	Determine the power developed and thermal efficiency of gas turbine power plants.	TPS3	70	65
CO4	Calculate thermal efficiency of Steam power cycle and explain the nuclear power reactor	TPS3	70	65
CO5	Describe the working of renewable energy power generation systems such as Solar, wind, bio-mass and recent power generation techniques.	TPS2	70	70
CO6	Describe working of energy utilizing devices such as refrigerator, air conditioner, compressor, pump.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L												
CO2	S	M	L												
CO3	S	M	L												
CO4	S	M	L												
CO5	M	L													
CO6	M	L													

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			20	5	10	20							2	6	10
CO2			40	-	10	20							2	6	10
CO3			40	5	10	20							2	6	10
CO4			-						50	10	10	20	2	6	10
CO5			-					25		10	20	-	4	10	-
CO6			-					25		10	20	-	4	10	-
												Total	16	44	40

Syllabus

Basics of Thermodynamics: System, state, properties, process, cycle –Reversible and irreversible, energy transfer, zeroth and first law of thermodynamics – heat engine cycle- Carnot cycle and efficiency.

Diesel engine power generation: working – two stroke and four stroke Diesel engine, efficiency– Calculation, Support system for power generation – Cooling, lubrication, Starting, air supply system.

Gas turbine power generation: working – open and close cycle gas turbine, simple Brayton cycle – Thermal efficiency calculation, working of Turbo jet and Turbo- prop Jet engines.

Steam turbine power generation: Steam formation - working of boiler, high pressure steam, properties of steam – wet, dry saturated and superheated steam. **Steam turbine:** working – impulse and reaction turbine, **Rankine Cycle:** Simple Rankine cycle with superheated steam at turbine inlet - thermal efficiency calculations. **Nuclear power generation:** working – BWR, PWR, and FBR powerplant.

Renewable Energy power generation: Solar power generation- thermal energy collectors, PV power system – working, selection of site. Wind power generation: Working – vertical axis and horizontal axis wind turbines, power in the wind, selection of site. Biomass power generation: Bio gasification, incineration, Biodiesel generation. **Recent Power generation Techniques:** Fuel cells-introduction, types, Hydroxy fuel cell construction and working, Concept of MHD and OTEC power generation, hydrogen generation technique- Electrolysis

Utilization of energy in Thermal systems: Refrigeration - Definition, working principle, methods of refrigeration – vapour compression refrigeration system, Domestic refrigerator. **Air-conditioning:** Properties of moist air, conditioning of air, Summer and winter Air-conditioning system- construction and working. **Compressor:** Reciprocating Compressor – working, Rotary compressor – working. **Pump:** construction and working- Centrifugal pump and Reciprocating pump.

Textbook (s)

1. Nag P.K., "**Power Plant Engineering**"- fourth edition, Tata McGraw Hill, New Delhi, 2017.
2. Rajput R.K., **"A Text Book of Power Plant Engineering",** Laxmi Publications (P) Ltd.,Fifth edition 2016
3. Rai G.D., "**Non- Conventional Energy Sources",** fourth edition 2015, Khanna Publishers, New Delhi
4. Rajput R.K., **"A Text Book of Thermal Engineering",** Laxmi Publications (P) Ltd.,Eleventh edition 2020

Data Book

1. R.S.Khurmi, J.K.Gupta **"Steam tables with Mollier Diagram"** 8th edition January 2008, S Chand Publisher

Reference Books &Web Resources

1. M.M.EI-Wakil, **"Power plant Technology",** Tata McGraw Hill, New Delhi, 2010.
2. A.K.Raja, Srinvastava, Amit Praksh, **"Power Plant Engineering** " New age International 2016
3. Technology of Bio-Fuels(Ethanol & Biodiesel) Engineers India Research Institute (2010)
4. https://nptel.ac.in/courses/121106014/ Non conventional Energy resources, IIT Madras
5. https://www.youtube.com/watch?v=mpHZWYpKDJg, Energy resources and Technology IIT Kharagpur.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Basics of Thermodynamics**:	
1.1	System, state, properties, process, cycle	1
1.2	Reversible and irreversible, energy transfer, zeroth and first law of thermodynamics	2
1.3	heat engine cycle- Carnot cycle and efficiency.	2
2	**Diesel engine power generation:**	
2.1	working – two stroke and four stroke Diesel engines.	1
2.2	Efficiency– Calculation	2
2.3	Support system for power generation – Cooling, lubrication, Starting, air supply system.	2
3	**Gas turbine power generation:**	
3.1	working – open and close cycle gas turbine, simple Brayton cycle – Thermal efficiency calculation	3
3.2	Working of jet engine- Turbojet and Turboprop	1
4	**Steam turbine power generation:**	
4.1	Steam formation - working of boiler, high pressure steam, properties of steam – wet, dry saturated and superheated steam.	3
4.2	Steam turbine: working – impulse and reaction turbine, Rankine Cycle: Simple Rankine cycle with superheated steam at turbine inlet - thermal efficiency calculations	3
4.3	**Nuclear power generation:** working – BWR, PWR, and FBR powerplant.	2
5	**Renewable Energy power generation:**	
5.1	Solar power generation- thermal energy collectors, PV power system –	2

No.	Topic	No. of Periods
	working, selection of site.	
5.2	Wind power generation: Working – vertical axis and horizontal axis wind turbines, power in the wind, selection of site.	1
5.3	Biomass power generation: Bio gasification, incineration, Biodiesel generation	2
5.4	**Recent Power generation Techniques:** Fuel cells-introduction, types, Hydroxy fuel cell construction and working, Concept of MHD and OTEC power generation, hydrogen generation technique- Electrolysis.	2
6	**Utilization of energy in Thermal systems:**	
6.1	Refrigeration-Definition, working principle, methods of refrigeration – vapour compression refrigeration system-domestic refrigerator	1
6.2	Air-conditioning: Properties of moist air, conditioning of air, Summer and winter Air-conditioning system- construction and working.	2
6.3	Compressor: Reciprocating Compressor – working, Rotary compressor – working.	2
6.4	Pump: construction and working- Centrifugal pump and Reciprocating pump.	2
	Total	**36**

Course Designers

1.	Prof. A. Valan arasu	Professor	Mechanical Engineering	avamech@tce.edu
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DETAILED SYLLABI
OF
VALUE ADDED COURSES

B.E. DEGREE PROGRAMME
IN
MECHANICAL ENGINEERING

FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2022-23 ONWARDS

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22MEVA0	INNOVATE IN COLLEGE LIFE

Category	L	T	P	C
VAC	-	-	-	-

Preamble

This course focusses on simplifying and improving learning process of a student, facilitates them to meet the demands on Higher Order Thinking Skills by enhancing their innovative ability, Encourages Self-Directed Learning and Sharpens the learning skills they already possess and provides them with new learning skills. Contents of the course are based on the principles of educational neuroscience, cognitive psychology, human biology, and pedagogy.

Pre requisite

Nil

Syllabus

How the Brain Learns: Physical and Electrochemical Changes in Brain during Learning, Factors Influencing these Changes, Subsystems Helping in Learning
Human Memory: Types of Memory-Sensory, Short-Term, &Long-Term, Mechanics of Memory Formation, Role of Sleep in Memory Consolidation, Role of Short-Term Memory in Academic Success, Prerequisites for Successful Thinking

Bloom's Taxonomy – Affective Domain, Psychomotor Domain, Cognitive Domain & Higher Order Thinking Skills, effectively using Affective Domain to Excel in other two Domains, Demands on Thinking Skills in Competitive and College Exams

Concentration of Mind: What is Concentration? Relevance of Short-Term Memory in Developing Concentration, Root Causes for Low Attention Span, Mind Distractors, Conscious and Non-conscious Ways for Developing Concentration

Challenges in Learning- Procrastination, Einstellung Effect, Superficial Concentration, Cramming (Sleepless Night), Limitations of Short-Term Memory, Memory Loss, Obstacles to Memory Retrieval, Lack of Attendance, Copying of Assignments.

Effective and efficient way of learning: Effective Ways for Consolidating the Learning in Long-Term Memory- Peer Learning & Reciprocal Teaching, Self-Testing & Metacognition, Effective Ways for Revising the Entire Syllabus on the Day before the Exam ,Effective Ways for Retrieving the Learned Material in the Exam Hall, Developing an Innovative Ability (Transfer) for Achieving Academic Excellence - What is it?, Why Do We Need it?, How to Develop it?, Great People's Advice and Practices -Nobel Laurette's Advice on Learning, Nobel Laurette's Learning Approaches during their Student Life, Prof. Richard Felder's Memo to Students, Learning Process Flow Diagram, Strategies for winning admission and scholarship for PG/Ph.D. studies in top universities

Out Comes /deliverables

This course addresses the challenges faced by the learning students such as Procrastination of studies and assignments, Distraction of mind during study hours, spend sleepless nights for exam preparation, Unaware of learner-friendly diet and lifestyle, to meet the demands on thinking skills in college and competitive exams (GATE, TANCET, CAT, MAT, Campus Placement, TNPSC, UPSC, etc.,)

Suggested readings and web resources

1. Richard M. Felder, Rebecca Brent, Teaching and Learning STEM, A Practical Guide, Jossey Bass, 2024.
2. Derek Bok, Our Underachieving Colleges – A candid look at how much our students learn, why they

should be learning more, Princeton University Press, 2008.
3. Kathryn R. Wentzel and Jere E. Brophy, Motivating Students to Learn, 4th edition Routledge Taylor and Francis Group. 2014.
4. Benjamin S. Bloom (Ed), Taxonomy of Educational Objectives, Cognitive Domain, Longman Higher Education, 1965.
5. James M. Lang, Small Teaching: Everyday Lessons from The Science of Learning, Jossey Bass, 2021.
6. James E. Zull, The Art of Changing The Brain: Enriching the Practice of Teaching by Exploring the Biology of Learning, Routledge, 2023.
7. L. Dee Fink, Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses (The Jossey-Bass Higher and Adult Education), 2013.
8. Daniel Coyle, The Talent Code, Greatness is not born, it's grown, Arrow Books, 2010.
9. Barbara Oakley, A Mind for Numbers, Tarcher Perigee, 2021.
10. Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel, Make it Stick: The Science of Successful Learning, Belknap Press, 2023.
11. Steven Johnson, Where Good Ideas Come from - Seven Patterns of Innovation, Penguin UK, 2011.
12. Scott H. Young, Ultra learning, Harper Collins, 2019.
13. Ellen J. Langer, The Power of Mindful Learning, Da Capo Press, 2016.
14. John J. Ratey, Spark: The Revolutionary New Science of Exercise and Brain, Little Brown and Company, 2013.
15. Susan A. Ambrose, Michael W. Bridges, Michele Diepietro, Marsha C. Lovett, and Marie K. Norman, How Learning Works, 7 Research based Principles for Smart Teaching, Wiley Desktop Editions, 2010.
16. Santiago Ramon Cajal, Advice for a Young Investigator, Bradford Books, 2004.
17. Michael D. Toth and David A. Sousa, The Power of Student Teams, Learning Science International, 2019.
18. Charles Duhigg, The Power of Habit: Why We Do, What We Do, and How to Change, Random House Books, 2013.
19. Brant Cortright, The Neurogenesis, Diet and Lifestyle, Psyche Media, 2015.
20. Anders Ericsson and Robert Pool, Peak: How all of us can achieve extraordinary things, Penguin Random House, 2017.
21. Bruce Lipton, The Biology of Belief, Hay House Publishers India, 2009.
22. Paulo Coelho, The Alchemist, A Fable About Following Your Dream, Harper, 2005.
23. Carol S. Dweck, Mindset: How You Can Learn to Fulfill Your Potential, Constable and Robinson, 2012

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	How the Brain Learns:	
1.1	Physical and Electrochemical Changes in Brain during Learning	2
1.2	Factors Influencing Physical and electrochemical Changes	1
1.3	Subsystems Helping in Learning	2
2	Human Memory:	
2.1	Types of Memory-Sensory, Short-Term, &Long-Term	2
2.2	Mechanics of Memory Formation	2
2.3	Role of Sleep in Memory Consolidation	1
2.4	Role of Short-Term Memory in Academic Success	1
2.5	Prerequisites for Successful Thinking	1
3	Bloom's Taxonomy:	
3.1	Affective Domain, Psychomotor Domain, Cognitive Domain & Higher Order Thinking Skills	2
3.2	effectively using Affective Domain to Excel in other two Domains	2
3.3	Demands on Thinking Skills in Competitive and College Exams	2
4	Concentration of Mind:	
4.1	What is Concentration? Relevance of Short-Term Memory in Developing	2

No.	Topic	No. of Periods
	Concentration,	
4.2	Root Causes for Low Attention Span, Mind Distractors	1
4.3	Conscious and Non-conscious Ways for Developing Concentration	1
5	Challenges in Learning:	
5.1	Procrastination, Einstellung Effect, Superficial Concentration, Cramming (Sleepless Night),	2
5.2	Limitations of Short-Term Memory, Memory Loss, Obstacles to Memory Retrieval, Lack of Attendance, Copying of Assignments	2
6	Effective and efficient way of learning:	
6.1	Effective Ways for Consolidating the Learning in Long-Term Memory-Peer Learning & Reciprocal Teaching, Self-Testing & Metacognition	2
6.2	Effective Ways for Revising the Entire Syllabus on the Day before the Exam, Effective Ways for Retrieving the Learned Material in the Exam Hall	1
6.3	Developing an Innovative Ability (Transfer) for Achieving Academic Excellence - What is it?, Why Do We Need it?, How to Develop it?	1
6.4	Great People's Advice and Practices -Nobel Laurette's Advice on Learning, Nobel Laurette's Learning Approaches during their Student Life	2
6.5	Prof. Richard Felder's Memo to Students, Learning Process Flow Diagram	1
6.6	Strategies for winning admission and scholarship for PG/Ph.D. studies in top universities	2
	Total	**35**

Course Designer profile

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22MEVB0	MODERN CHILLERS FOR HVAC

Category	L	T	P	C
VAC	-	-	-	-

Preamble

In the field of air conditioning, chilled water systems are considered to be the holy grail. Although they are large and complex, they are used in many of the tallest buildings in the world, such as the Burj Khalifa in Dubai, the Merdeka 118 in Malaysia, and many others. In most large buildings (hotels, offices, shopping malls, hospitals, etc.) the cooling and air conditioning systems are based on chilled water. The focus of this course is on the operation and maintenance of modern chillers.

Pre-requisite

Nil

Syllabus

Compressors for Chiller:
Screw Compressor for Low capacity chiller, Reciprocating Compressor for medium capacity chiller, Centrifugal Compressor for high capacity chiller, Case Studies

Types of Evaporators:
Direct Expansion Evaporators (DX – Evap)- Air cooled chiller (Single Pass and 2 Pass water Flow), Flooded Evaporators (Single and 2 Pass) – Water cooled chiller, Case Studies

Types of Condensers:
Air cooled Condensers -Forced Finned type, Water Cooled Condensers -Shell and Tube type, Case Studies.

Metering Devices or Expansion Valves:
Thermostatic Expansion Valve- conventional type, Electronic Expansion Valve- modern type, Case Studies

Cooling Towers & Air Handling Unit:
Induced Draft Cooling Tower, Forced Draft Cooling Tower, Air Handling Unit (AHU)- importance, Types- heat recovery AHU and AHU with 3-way valve, Case Studies.

Operation & Maintenance of Chillers
Leak Test and Refrigerant Charging methods, Periodical Maintenance, Annual Maintenance.

Out Comes /deliverables

1. Understanding the concept and applications of modern chillers
2. Optimizing and significantly reducing the building's chiller energy consumption
3. Current trends and opportunities in HVAC field.

Suggested readings and web resources

1. ISHARE Book on "Chiller Basics"
2. ISHARE Book on "All about AHU"
3. Herbert W. Stanford III," HVAC Water Chillers and Cooling Towers: Fundamentals, Application, and Operation", Second Edition, CRC press 2011

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Compressors for Chiller**	
1.1	Screw Compressor for Low capacity chiller	2
1.2	Reciprocating Compressor for medium capacity chiller	2
1.3	Centrifugal Compressor for high capacity chiller	1
	Case Studies	1
2	**Types of Evaporators**	
2.1	Direct Expansion Evaporators (DX – Evap)- Air cooled chiller (Single Pass and 2 Pass water Flow)	2
2.2	Flooded Evaporators (Single and 2 Pass) – Water cooled chiller	2
2.3	Case Studies	1
3	**Types of Condensers**	
3.1	Air cooled Condensers -Forced Finned type	2
3.2	Water Cooled Condensers -Shell and Tube type	2
3.3	Case Studies	1
4	**Metering Devices or Expansion Valves**	
4.1	Thermostatic Expansion Valve- conventional type	2
4.2	Electronic Expansion Valve- modern type	2
4.3	Case Studies	1
5	**Cooling Towers & Air Handling Unit**	
5.1	Induced Draft Cooling Tower	1
5.2	Forced Draft Cooling Tower	1
5.3	Air Handling Unit (AHU)- importance, Types-heat recovery AHU and AHU with 3-way valve	2
	Case Studies	1
6	**Operation & Maintenance of Chillers**	
6.1	Leak Test and Refrigerant Charging methods	2
6.2	Periodical Maintenance	1
6.3	Annual Maintenance	1
	Total	**30**

Course Designer profile

Mr. K. Subramanian, Working as Manager at KEERTHI AIRCONS (DAIKIN), Madurai. He has completed B.E. Mechanical Engineering. He has more than 28 years of experience in HVAC Industry in India and Abroad. He is an active member of ISHRAE Madurai Chapter. He has a vast experience in HVAC, Firefighting, Compressed air system, LPG system and all type of pumping system. He has successfully completed more than 300 projects in India and Abroad. In that more than 20 projects are over and above 1,000 TR HVAC projects with all other mechanical systems. He is well versed with International standards like ASHRAE, NFPA, SMACNA and LPCB etc.

Mr. K. A. Kaja Mohaideen is running a HVAC teaching institute named GULF TECHNICAL INSTITUTE in Gomathipuram, Madurai. He has completed Diploma in Refrigeration & Air Conditioning (DRAC). He has more than 42 years of experience in HVAC Industry in India and Abroad. He is an active member of ISHRAE Madurai Chapter. He has a vast experience in Chiller service and maintenance in hospital industry and five star hotels in India and Abroad. He has a good knowledge in HVAC controls.

B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
PROGRAMME ELECTIVE COURSE
22MESA0- HYBRID AND ELECTRIC VEHICLE TECHNOLOGY

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2022-23 ONWARDS

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22MESA0	HYBRID AND ELECTRIC VEHICLE TECHNOLOGY

Category	L	T	P	C	Terminal Exam Type
PSE	3	0	-	3	Theory

Preamble

In future transportation sector of any country, electric vehicles and hybrid electric vehicles will play a major role as internal combustion engine (ICE) based vehicles creates many problems such as creation of more pollution, higher running cost and poor energy conversion efficiency. ICE based vehicles need petroleum products which are getting depleted day by day. Hybrid electric vehicles (HEV) and electric vehicles (EV) produce less pollution and have higher energy conversion efficiency. This course introduces the fundamental concepts, analysis and design of hybrid electric and electric vehicles. The students learn about the various aspects of hybrid and electric vehicles such as their configuration, powertrain sizing, types of electric motors and energy storage devices, etc

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the basics of concepts of Electric vehicles (EVs) and hybrid electric vehicles (HEVs).	TPS2	70	70
CO2	Identify different types of batteries, their ratings, charging methods, and maintenance procedures used in electric vehicles.	TPS3	70	65
CO3	Select the suitable electric motor for applications in hybrid and electric vehicles.	TPS3	70	65
CO4	Apply the principles of hybrid and electric vehicle architecture to select and integrate appropriate powertrain components.	TPS3	70	65
CO5	Apply energy management strategies to ensure better economy and efficiency.	TPS3	70	65
CO6	Explain the functions and roles of various Electronic Control Units (ECUs) used in hybrid and electric vehicle subsystems.	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	M
CO2	S	M	L	-	-	L	-	-	-	-	L	-	L	M
CO3	S	M	L	-	-	-	-	-	-	-	-	-	L	-
CO4	S	M	L	-	-	-	-	-	-	-	L	-	L	M
CO5	S	M	L	-	-	L	-	-	-	-	L	-	-	L
CO6	S	M	L	-	-	L	-	-	-	L	-	-	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
COs \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		20	-	5	20	-							2	10	
CO2		-	40	5	10	25							2	5	12
CO3		-	40	-	10	25							2	5	12
CO4									40	5	10	25	2	5	12
CO5									40	-	10	25	2	5	12
CO6									20	5	20	-	2	10	
												TOTAL	12	40	48

Syllabus

INTRODUCTION

History of Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs), EV and HEV Components, Need for Electric Vehicle -overview of vehicle electronic system, general instrumentation block diagram, and typical instrumentation cluster layout. Advantages and Limitations of hybrid and electric Vehicles. Social and environmental importance of EVs and HEVs - Energy Consumption.

ENERGY SOURCES

Batteries: Battery Parameters - Different types of batteries –Lead acid, Lithium ion, and alkaline batteries - construction and working - battery rating - battery charging methods - testing and maintenance, Battery Thermal Management.

Hands-on training: Battery Simulator for charging and discharging, and Battery Management System (BMS).

MOTORS AND DRIVES

Types of Motors - DC motors - AC motors, PMSM motors, BLDC motors, switched reluctance motors working principle, construction and characteristics.

Hands-on training: BLDC motor tester circuit

HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS

Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV) - Power train components.

ENERGY MANAGEMENT STRATEGIES

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, comparison of energy management strategies, and Implementation issues.

HYBRID AND ELECTRIC VEHICLES TECHNOLOGY

Electronic control units (ECUs) and vehicle subsystems -electronic systems of power subsystems, electronic chassis subsystem, electronic systems of body subsystems (comfort and passive safety), multimedia subsystems.

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology — Challenges and developments.

Textbook (s)

1. Iqbal Hussein, **Electric and Hybrid Vehicles: Design Fundamentals,** CRC Press, 2021.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, **Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**, CRC Press, 2018.
3. Barry Hollembeak**, Automotive Electricity and Electronics"** Cengage Learning, Cliftorn Park, USA, 8th edition,2023.

Reference Books & Web Resources

1. James Larminie, John Lowry, **Electric Vehicle Technology Explained**, Wiley, 2003
2. James E. Duffy, **Modern Automotive Technology**, Goodheart-Willcox Company, Inc., 2020
3. Ronald k.J, "**Automotive Electronics Handbook**", 2nd Edition, McGraw Hill Publications, Columbus, 2009.
4. Robert Bosch, "**Automotive Hand Book**", SAE, 2000.
5. Robert Bosch, "**Automotive Electrics Automotive Electronics**", 5th Edition, Springer, Germany, 2010.
6. Tom Denton, "**Automobile Electrical and Electronics systems**", Routledge Taylor & Francis Group, London & New York, 2002

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**INTRODUCTION**	
1.1	History of Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs), EV and HEV Components	2
1.2	Need for Electric vehicle -overview of vehicle electronic system.	1
1.3	general instrumentation block diagram, and typical instrumentation cluster layout.	1
1.4	Advantages and Limitations of hybrid and electric Vehicles. Social and environmental importance of EVs and HEVs - Energy Consumption	2
2	**ENERGY SOURCES**	
2.1	Batteries: Battery Parameters - Different types of batteries – Lead acid	2
2.2	Lithium ion, and alkaline batteries - construction and working	2
2.3	Battery rating - battery charging method	1
2.4	Testing and maintenance, Battery Thermal Management	1
2.5	Hands-on training: Battery Simulator for charging and discharging, and Battery Management System (BMS)	1
3	**MOTORS AND DRIVES**	
3.1	Types of Motors- DC motors- AC motors	2
3.2	PMSM motors, BLDC motors	2
3.3	Switched reluctance motors working principle, construction and characteristics.	2
3.4	Hands-on training: BLDC motor tester circuit	1
4	**HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS**	
4.1	Architecture of Electric Vehicles (EV).	2

No.	Topic	No. of Periods
4.2	Architecture of Hybrid Electric Vehicles (HEV).	2
4.3	Plug-in Hybrid Electric Vehicles (PHEV).	1
4.4	Power train components.	1
5	**ENERGY MANAGEMENT STRATEGIES**	
5.1	Introduction to energy management strategies used in hybrid and electric vehicles	1
5.2	Classification, comparison of energy management strategies	1
5.3	Implementation issues	1
6	**HYBRID AND ELECTRIC VEHICLES TECHNOLOGY**	
6.1	Electronic control units (ECUs) and vehicle subsystems -electronic systems of power subsystems	2
6.2	electronic chassis subsystem, electronic systems of body subsystems (comfort and passive safety), multimedia subsystems.	2
6.3	Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery),	2
6.4	Pure Electric Vehicle Technology — Challenges and developments.	1
	Total	**36**

Course Designers

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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
REVISED CORE COURSE
22ME541- HEAT AND MASS TRANSFER
22ME561- DYNAMICS, INSTRUMENTATION AND QUALITY ASSURANCE LAB

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2023-24 ONWARDS

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22ME541	HEAT AND MASS TRANSFER

Category	L	T	P	C	Terminal Exam Type
PCC	3	-	-	3	Theory

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2023-24 ONWARDS)

Preamble

Heat and mass are two different forms of energy. As a branch of science, heat and mass transfer deals with the determination of the rates at which heat and mass are transferred. The study of heat and mass transfer mechanisms has become increasingly important in engineering practice as heat transfer plays a crucial role in the design of vehicles, power plants, refrigerators, electronic devices, buildings, and bridges, among others. In this course, students will develop a fundamental understanding of heat transfer principles, develop an intuitive understanding of the heat transfer mechanisms, and apply the knowledge to analyze heat transfer systems in real-world engineering applications. Using the knowledge of heat transfer, one can gain a basic understanding of the principle and mechanisms of mass transfer.

Prerequisite

- Thermal Engineering
- Fluid Mechanics

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Calculate the conduction heat transfer rates under steady state.	TPS3	70	65
CO2	Compute the conduction heat transfer rate under transient state.	TPS3	70	65
CO3	Determine the convection heat transfer rates under forced mode.	TPS3	70	65
CO4	Determine the convection heat transfer rates under natural mode.	TPS3	70	65
CO5	Compute the radiation heat transfer rate between surfaces.	TPS3	70	65
CO6	Determine the heat transfer rate in heat exchangers and mass transfer rate in diffusion and convection mode	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	L	-	-	-	-	L	L	S	L
CO2	S	M	L	-	-	L	-	-	-	-	L	L	S	L
CO3	S	M	L	-	-	L	-	-	-	-	L	L	S	L
CO4	S	M	L	-	-	L	-	-	-	-	L	L	S	L
CO5	S	M	L	-	-	L	-	-	-	-	L	L	S	L
CO6	S	M	L	-	-	L	-	-	-	-	L	L	S	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1						Theory Assessment-2						Theory Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1			40	5	10	25							6	5	10
CO2			20	5	-	15							2	-	10
CO3			40	5	10	25							4	5	10
CO4									40	5	-	25	4	-	10
CO5									40	5	10	25	2	5	10
CO6									20	5	10	15	2	5	10
Total			**100**	**15**	**20**	**65**			**100**	**15**	**20**	**65**	**20**	**20**	**60**

Syllabus

Steady State Conduction

Introduction, Modes of heat transfer, Fourier law of conduction, General heat conduction equation in Cartesian co-ordinates. One dimensional steady state heat conduction -plane wall, hollow cylinder and sphere numerical problems. Composite systems with combined mechanism, critical thickness of insulation, numerical problems. Conduction with inner heat sources - plane wall and solid cylinders, numerical problems. Heat transfer through extended surfaces-Heat transfer through long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip- longitudinal and circumferential and triangular fins - efficiency and effectiveness, numerical problems.

Transient Conduction

Introduction, Lumped heat capacity systems, numerical problems. Heat flow in a semi - infinite body- initial temperature with suddenly immersed in liquid and convection boundary conditions, numerical problems-Heat flow in an infinite body-Plane wall, and cylindrical wall - Heisler and Grober charts, numerical problems.

Forced convection

Introduction-Hydrodynamic, thermal boundary and concentration layers- Flow over flat plates- Laminar boundary layer thickness in terms of Reynolds number, Nusselt equation, Flow through tubes - Nusselt equation, Flow across cylinder- Nusselt equation, numerical problems

Free convection

Physical Mechanism of natural convection-Equation of Motion and the Grashof Number, Natural Convection over Surfaces- Horizontal and vertical plates, Horizontal and vertical cylinders, numerical problems

Radiation

Introduction, Wave theory and quantum theory- concepts of black body and gray body - Stefan - Boltzmann law - emissive power – monochromatic emissive power - Wein's law - Kirchhoff's law-numerical problems. Radiative properties, Emissivity, absorptivity, reflectivity, transmissivity, radiosity - Radiation shape factor - Reciprocity theorem. Heat exchange between black and gray surfaces, numerical problems - Reradiating surfaces.

Heat exchangers

Classification- overall heat transfer co-efficient- fouling factor- LMTD method, numerical problems -NTU method, numerical problems.

Mass transfer

Introduction to mass transfer- Fick's law of diffusion-Stefan's law - Analogy between momentum, heat and mass transfer-mass transfer in convection- convection mass transfer coefficient-numerical problems-Simultaneous heat and Mass transfer (qualitative treatment)

Textbooks

1. Sachdeva, R.C., **"Fundamentals of Engineering Heat and Mass Transfer"**, New Age International Publishers, 2017.
2. Yunus A.Cengel and Afshin Ghajar, "**Heat and Mass Transfer: Fundamentals and Applications**", 6th Edition, Mc Graw Hill Education, 2020.

Reference Books &Web Resources

1. Holman, J.P., **"Heat Transfer"**, 10th Edition, McGraw Hill Education, 2017.
2. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, and Adrienne S. Lavine, "**Principles of Heat and Mass Transfer**", Wiley, 2013.
3. Nag P.K., **"Heat and Mass Transfer"**, 3rd Edition, Mc Graw Hill Education, 2011.
4. Mahesh M. Rathore, "**Engineering Heat and Mass Transfer**", LaxmiPublication , 4th Edition, 2023.
5. Necati Ozisik, "**Heat Transfer – a Basic Approach**", McGraw Hill, 1994.
6. Rajput, R.K., "**A Text Book of Heat and Mass Transfer**", 7th Edition, S.Chand& Company Ltd, 2018.
7. Som, S.K. "**Introduction to Heat Transfer**", PHI Learing Private Ltd, 2008.
8. Frank Kreith, Mark S. Bohn, "**Principles of Heat Transfer"**, Sixth Edition, Brooks/cole, Thomson Asia Private Ltd., Singapore, 2001.
9. Kothandaraman, C.P., **"Fundamentals of Heat and Mass Transfer",** 4th Edition, New Age International, 2012.
10. https://nptel.ac.in/courses/112108149/ - Lecture Notes
11. https://nptel.ac.in/courses/112101097/ - Video Lectures by Prof.S.P.Sukhatme, Mechanical Engineering, IIT Bombay.

Data Book

1. Kothandaraman, C.P., **"Heat And Mass Transfer Data Book",** 9th Edition, New Age International, 2018.

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1	**Steady State Conduction**	
1.1	Introduction, Modes of heat transfer Fourier law of conduction, general heat conduction equation in Cartesian co-ordinates	2
1.2	One dimensional steady state conduction- plane wall, hollow cylinder and sphere numerical problems.	2
1.3	Composite systems with combined mechanism, Critical thickness of insulation, numerical problems.	1
1.4	Conduction with inner heat sources – plane wall and solid cylinders, numerical problems.	2
1.5	Heat transfer through long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip- longitudinal and circumferential and triangular fins - efficiency and effectiveness, numerical problems.	3
2	**Transient Conduction**	
2.1	Introduction, Lumped heat capacity systems, numerical problems.	1
2.2	Heat flow in a semi - infinite body- initial temperature with suddenly immersed in liquid and convection boundary conditions, numerical problems	1
2.3	Heat flow in an infinite body- Plane wall, Cylindrical wall and Spherical wall. Heisler and Grober charts, numerical problems.	2

No.	Topic	No. of Periods
3	**Forced convection**	
3.1	Introduction, Hydrodynamic, thermal and concentration boundary layers	1
3.2	Flow over flat plates: Laminar boundary layer thickness in terms of Reynolds number, Nusselt equation, numerical problems.	1
3.3	Flow through tubes - Nusselt equation, numerical problems.	1
3.4	Flow across cylinder- Nusselt equation, numerical problems.	1
4	**Free convection**	
4.1	Physical Mechanism of natural convection-Equation of Motion and the Grashof Number	1
4.2	Natural Convection over Surfaces- Horizontal and vertical plates, numerical problems.	1
4.3	Horizontal and vertical cylinders, numerical problems.	2
5	**Radiation**	
5.1	Introduction, Wave theory and quantum theory	1
5.2	Concepts of black body and gray body	1
5.3	Stefan – Boltzmann law – emissive power – monochromatic emissive power – Wein's law –Kirchhoff's law, numerical problems.	1
5.4	Radiative properties, emissivity, absorptivity, reflectivity, transmissivity, radiosity	1
5.5	Radiation shape factor – Reciprocity theorem	1
5.6	Heat exchange between black surfaces, numerical problems.	1
5.7	Reradiating surfaces, Heat exchange between gray surfaces, numerical problems.	1
6	**Heat exchangers**	
6.1	Classification- overall heat transfer co-efficient- fouling factor	1
6.2	LMTD method, numerical problems	1
6.3	NTU method, numerical problems	1
	Mass transfer	
6.4	Introduction to mass transfer- Fick's law of diffusion-Stefan's law	2
6.5	Analogy between momentum, heat and mass transfer, mass transfer in convection	1
6.6	Convection mass transfer coefficient- Numerical problems	2
6.7	Simultaneous heat and Mass transfer (Qualitative treatment)	1
	Total	**38**

Course Designers

1. Dr. A.Valan Arasu Professor Mechanical Engineering avamech@tce.edu
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22ME561	DYNAMICS, INSTRUMENTATION AND QUALITY ASSURANCE LAB

Category	L	T	P	C	Terminal Exam Type
PCC	-	-	2	1	Practical

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2023-24 ONWARDS)

Preamble

Force, torque, strain, displacement, and the measurement of dynamics parameters such as gyroscopic couple, balancing masses, whirling of speed, governor lift, moment of inertia, cam profile, and vibrations are among the practical knowledge of physical measurement techniques that students are exposed to in this course. Additionally, this course focuses on a variety of statistical quality control methods, control charts, and sampling strategies to help draw meaningful conclusions from the measured data.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Determine the Rotating mass, governor lift, whirling speed of shaft, Gyroscopic couple,	TPS3	70	65
CO2	Construct the given cam and follower profile diagram.	TPS3	70	65
CO3	Determine Natural frequency of two rotor and moment of inertia.	TPS3	70	65
CO4	Identify the error in torque, strain and Displacement measuring device.	TPS3	70	65
CO5	Construct control chart from the given variable and attribute data using data analytics/SQC packages/python	TPS3	70	65
CO6	Measure the performance of sampling plans using data analytics/SQC packages/python.	TPS3	70	65

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	S	M	M	M	-	-	M	-	-	-	M	-	M
CO2	S	M	L	-	M	-	-	M	-	-	-	M	-	M
CO3	S	S	M	L	M	-	-	M	-	-	-	M	-	M
CO4	S	S	L	L	M	-	-	M	-	-	-	M	-	M
CO5	S	M	M	L	S	-	L	-	-	L	-	M	-	M
CO6	S	M	S	L	-	-	L	-	-	L	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Continuous Assessment	
Laboratory Observation and record	75%
Model Test	25%
Terminal Examination (Duration: 3 hours)	
Terminal test and Viva Voce	100%

List of Experiments

S. No	Experiments (Any 12)	CO
1.	Determination of balancing masses in rotating systems.	CO1
2.	Determination of governor lift for the given speed range.	CO1
3.	Determination of whirling speed of the given shaft.	CO1
4.	Determination of Gyroscopic couple.	CO1
5.	Construct the given cam and follower profile diagram.	CO2
6.	Determination of natural frequency a Two rotor shaft system.	CO3
7.	Determination of moment of inertial of the given object.	CO3
8.	Identify the error of torque transducer measurement	CO4
9.	Identify the error of Strain gauge measurement	CO4
10.	Identify the error of LVDT measurement	CO4
11.	Develop the variable control chart with given samples/data and analyze it.	CO5
12.	Develop the attributes control chart with given samples/data and analyze it.	CO5
13.	Construct Operating characteristics curve with given scenario/data and analyze the varying parameter	CO6
14.	Construct evaluation metrics for operating curve with given samples/data	CO6

Learning Resources

1. **Dynamics of Machines**, https://nptel.ac.in/courses/112/104/112104114/ Prof. Amithbha Ghosh Indian Institute of Technology, Kanpur
2. NPTEL course titled **“**Quality Design and Control**” by Prof. Pradip Kumar Ray, IIT Kharagpur** Link: https://nptel.ac.in/courses/110105088

Course Designers

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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
INDUSTRY SUPPORTED COURSE
22ME1B0- TOTAL COST OF OWNERSHIP

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2022-23 ONWARDS

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22ME1B0	TOTAL COST OF OWNERSHIP

Category	L	T	P	C	Terminal Exam Type
PEES	1	-	-	1	Theory

Preamble

In today's complex and competitive business environment, organizations must make informed decisions when investing in assets, technologies, or services. One of the most critical concepts that support this decision-making process is the Total Cost of Ownership (TCO). TCO provides a comprehensive assessment of all direct and indirect costs associated with the purchase, deployment, operation, and eventual disposal or replacement of a product or system over its entire lifecycle. This course aims to expose students to acquire basic knowledge in Total Cost of Ownership.

Prerequisite

- Nil

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Explain the various components involved in Total Cost Ownership.	TPS2	70	70
CO2	Develop Cost Ownership model for a given scenario.	TPS3	70	65
CO3	Implement Total Cost Ownership model for a given scenario.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	L	L	-	-	-
CO2	S	M	L	L	M	L	-	M	M	L	L	-	-	-
CO3	S	M	L	L	M	L	-	M	M	L	L	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory						Theory						Theory		
	Assessment-1						Assessment-2						Terminal Examination		
	Assignment-1			CAT-1			Assignment-2			CAT-2					
TPS / COs	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	40	-										20	20	-
CO2	-	-	30										-	10	20
CO3	-	-	30										-	10	20
												Total	**20**	**40**	**40**

Syllabus

Components involved in Total Cost Ownership

Definition - History – Characteristics – Components - Raw Materials, Commodities, Maintenance, Repair and Operation Materials – Services and Non – Traditional goods.

Total Cost Ownership model

Identification of objectives - Building up a model - Designing phase – Development of a Process Flowchart - Creating the model – Validation of the model.

Implementation Total Cost Ownership

Total Cost Analysis Process - Improving the model – Implementation of Total Cost Ownership model – Case studies on effect of implementation of Total Cost Ownership models in industries.

Textbook

1. Gerardus Blokdyk, "Total Cost of Ownership A Complete Guide", 05 Star cooks Publisher, 2020.

Reference - Web Resource

1. Url: https://www.academia.edu/25629804/Total_Cost_Of_Ownership

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Components involved in Total Cost of Ownership**	
1.1	Definition - History	1
1.2	Characteristics of Total Cost Ownership	1
1.3	Components - Raw Materials, Commodities, Maintenance, Repair and Operation Materials.	1
1.4	Services and Non – Traditional goods	1
2	**Total Cost of Ownership model**	
2.1	Identification of objectives	1
2.2	Building up a model	1
2.3	Designing phase	1
2.4	Development of a Process Flowchart	1
2.5	Creating the Total Cost of Ownership model	1
2.6	Validation	1
3	**Total Cost of Ownership Analysis**	
3.1	Total Cost Analysis Process	1
3.2	Improving the model	1
3.3	Implementation of Total Cost of Ownership model	1
3.4	Case studies on the effect of implementation in industries.	2
	Total	14

Course Designers

1.	Mr.Anand Dhanaraj	Director Sales	Caterpillar Pvt Ltd, Bangalore.	Dhanaraj_Anandkumar@cat.com
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B.E. MECHANICAL ENGINEERING

DETAILED SYLLABI
OF
REVISED CORE COURSE
22ME421- DESIGN OF MACHINE ELEMENTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2024-25 ONWARDS

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22ME421	DESIGN OF MACHINE ELEMENTS

Category	L	T	P	C	Terminal Exam Type
PCC	3	0	0	3	Theory

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2024-25 ONWARDS)

Preamble

Machine Design is the creation of new and better machines that works safely, reliably and well. Mechanical design is a complex process, requiring many skills. Extensive relationships need to be subdivided into a series of simple tasks. The complexity of the process requires a sequence in which ideas are introduced and iterated. Thus, Machine Design is defined as the use of scientific principles, technical information and imagination in the description of a machine or a mechanical system to perform specific functions with maximum economy and efficiency. Here a method for designing the power system of an electric vehicle is presented.

Prerequisite

- Engineering Mechanics
- Mechanics of Materials

Course Outcomes

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

CO#	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Design of simple machine elements subjected to static and fatigue loading. including components used in electric vehicles.	TPS3	70	65
CO2	Design of shafts, keys and couplings under different loading conditions for mechanical applications.	TPS3	70	65
CO3	Design of welded joints subjected to different loading conditions	TPS3	70	65
CO4	Design of riveted joints and threaded joints subjected to different loading conditions	TPS3	70	65
CO5	Design of helical coil springs, leaf springs and flywheels for mechanical components and energy storage technologies in electric vehicles.	TPS3	70	65
CO6	Design of engine components like piston, connecting rod, crank shaft and components of electric vehicle	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	M	M	-	-	-	-	-	-	-	S	-	M
CO2	S	M	M	M	-	-	-	-	-	-	-	S	-	M
CO3	S	M	M	M	-	-	-	-	-	-	-	S	-	M
CO4	S	M	M	M	-	-	-	-	-	-	-	S	-	M
CO5	S	M	M	M	-	-	-	-	-	-	-	S	-	M
CO6	S	M	M	M	-	-	-	-	-	-	-	S	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory			Theory			Design Project	Theory		
	Assessment-1			Assessment-2				Terminal Examination		
TPS / COs	1	2	3	1	2	3	3	1	2	3
CO1	-	10	20	-	-	-	100	-	05	10
CO2	-	5	30	-	-	-		-	-	15
CO3	-	5	30	-	-	-		-	-	15
CO4	-	-	-	-	-	30		-	-	15
CO5	-	-	-	-	5	30		-	05	15
CO6	-	-	-	-	5	30		-	05	15
Total		**20**	**80**		**10**	**90**	**100**	-	**15**	**85**

Design Project: The students will do a Design project in which the students should identify the real-life application of the machine element and gather the input information for loads, materials etc., from the identified real-life application. The student has to follow the procedure for designing that machine element and compare it with that of the actual value. A final technical report has to be submitted.

Syllabus

Machine Design Concepts: Introduction to Machine Design – General Considerations in Machine Elements Design – Machine Design Process/Procedure– Standardization – Preferred Numbers – Factor of safety. Design for Static Load – Theories of Failure. Design for Fluctuating loads – Fatigue failure theories – Goodman equation – Soderberg equation.

Shafts and Couplings: Design of Shafts — combined twisting moment and bending moment - combined twisting moment, bending moment and axial loads. Design of Keys. Design of Couplings – Rigid and Flexible Couplings.

Design of Joints: Design of Welded joints — Lap and Butt joints — Welded joints subjected to transverse and eccentric loads. Riveted Joints — Design of different types of riveted joints — Pressure vessels — Structural Joints — Riveted joints subjected to eccentric loads. Design of Threaded Joints – Bolted Joints in simple Tension and Shear – Eccentrically Loaded Bolted Joints.

Energy Storing Elements: Design of Helical Coil Springs — Tension and Compression springs subjected to axial loads and eccentric loads. Design of parallel and concentric springs subjected toaxial loads - Design of Leaf Springs. Design of Flywheels for IC engines.

Components of Engine and Electric Vehicle: Design of Piston, Connecting Rod & Crank shafts — Sideand Centre Crank.

Electrical Vehicle Design and Modeling - Introduction to Electric Vehicles (EVs)-EV Powertrain Architecture (BEV, HEV, PHEV)-Overview of Electric Drive Systems-Types of Motors Used in EVs (BLDC, PMSM, Induction, SRM)-Motor Selection: Torque-Speed Requirements-Load Cycles and Duty Cycle Analysis in EV Applications- Energy storage technologies in electric vehicles- flywheel,

Textbooks

1. V.B. Bhandari, **“Design of Machine Elements”**, Fourth Edition, McGraw Hill Education IndiaPvt. Ltd., 2017.
2. Richard G Budynas and J Keith Nisbett **“Shigley’s Mechanical Engineering Design”**, Tenth Edition, Tata McGraw Hill, 2015.

Reference Books

1. Robert L. Norton, **“Machine Design: An Integrated Approach”**, Fifth Edition, Pearson,2018.
2. Alfred Hall, Alfred Holowenko, Herman Laughlin and S Somani, **“Schaum’s Outline –Machine Design”**, McGraw Hill Education India Pvt. Ltd., 2017
3. Robert C. Juvinall and Kurt M. Marshek, **“Machine Component Design”**, Wiley India Edition,2016.

4. Ansel C. Ugural, **“Mechanical Design of Machine Components”**, Second Edition, CRCPress, 2015
5. Anup Goel, “**Design of Machine Elements**”**,** First Edition, Technical Publications, 2016.
6. PSG College, **“Design Data: Data Book of Engineers”**, Kalaikathir Achchagam, 2019
7. Joseph E Shigley and Charles R Mischke, **“Standard Handbook of Machine Design”,** Third Edition, McGraw Hill Pvt. Ltd., 2004
8. K. Lingaiah, **“Machine Design Data Handbook”**, Second Edition, McGraw Hill Pvt. Ltd., 2010.
9. Seref Soylu, **“Electrical Vehicle Design and Modeling”** InTech, Croatia,2011

Course Contents and Lecture Schedule

No.	Topic	No. of Periods
1.	**Machine Design Concepts**	
1.1	Introduction to Machine Design	1
1.2	General Considerations in Machine Elements Design	
1.3	Machine Design Process/Procedure	
1.4	Standardization	
1.5	Preferred Numbers	
1.6	Design for Static Loads	
1.7	Theories of Failure	2
1.8	Design for Variable or Fluctuating Loads	1
1.9	Fatigue Failure Theories – Goodman & Soderberg Equation	
2	**Shafts and Couplings**	
2.1	Design of Shafts subjected to combined twisting & bending	1
2.2	Design of Shafts subjected to combined twisting, bending & axial loads	2
2.3	Design of Keys	1
2.4	Design of Couplings – Rigid Couplings	2
2.5	Design of Couplings – Flexible Couplings	1
3	**Design of Welded Joints**	
3.1	Design of Welded Joints – Lap and Butt Joints	1
3.2	Welded Joints subjected to axial loads, Bending and torsion	1
3.3	Eccentrically Loaded welded Joints	2
4	**Design of Riveted Joints and Threaded Joints**	
4.1	Design of Riveted Joints and its Types	1
4.2	Design of Riveted Joints for Pressure Vessels & Structural Joints	2
4.3	Design of Threaded Joints in Tension & Shear	1
4.4	Bolted Joints subjected to Eccentrical Loading	1
5	**Energy Storing Elements**	
5.1	Design of Helical Coil Springs – Axial Loads & Eccentric Loads	2
5.2	Springs in Parallel and Concentric Springs	1
5.3	Design of Leaf Springs	1
5.4	Design of Flywheels for IC engines	2
6	**Components of Engine and Electric Vehicle**	
6.1	Design of Connecting Rod	2
6.2	Design of Crankshafts	2
6.3	Design of Piston	2
	Electrical Vehicle Design and Modeling	
6.4	Introduction to Electric Vehicles (EVs)-EV Powertrain Architecture (BEV, HEV, PHEV)-Overview of Electric Drive Systems-	2
6.5	Types of Motors Used in EVs (BLDC, PMSM, Induction, SRM)-Motor Selection: Torque-Speed Requirements-Load Cycles and Duty Cycle	2

No.	Topic	No. of Periods
6.6	Analysis in EV Applications- Energy storage technologies in electric vehicles- flywheel,	2
	Total	**38**

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