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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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	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	

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

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

Passed in Board of Studies on 03.05.2023

Approved in 65th Academic Council Meeting on 27.05.2023

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. (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	2	0	3
Total			**15**	**3**	**8**	**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

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

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	3	-	-	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			**16**	**1**	**8**	**21**

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

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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	OEC	3	-	-	3
PRACTICAL						
22ME560	Dynamics and Measurement 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
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)

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	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			**16**	**-**	**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

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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)

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

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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

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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)

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

* 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)

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

* 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)

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	22MEPU0 - 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

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						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	-	-	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:

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

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						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	-	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:

1. Dr. V. Balasubramani — Associate Professor — Mechanical Engineering — vbmech@tce.edu
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						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	-	-	100	6	10	20	-	-	-	-	-	-	2	10	-
CO2	-	-			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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2. Dr.S. Saravana Perumaal Assistant Professor Mechanical Engineering sspmech@tce.edu

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						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	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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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. $1 + x^2 / 2! + x^4 / 4! +$... up to n terms
        ii. $x + x^3 / 3! + x^5 / 5! +$... 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
2.	Dr. A. M. Abirami	Associate Professor	Information Technology	abiramiam@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						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	-	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. Laboratory Manual
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					NA						Presentation on case study report					
CO2		20																
CO3			20															
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						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	-	-	-	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 of discontinuity- 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:

1. Dr.A.Anitha Assistant Professor Department of Mathematics anithavalli@tce.edu
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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						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	-	-	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

1.	Dr.B.Vellaikannan	Professor	Mathematics	bvkmat@tce.edu
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4.	Dr. P. Victor	Assistant Professor	Mathematics	pvmat@tce.edu
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 constants and 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						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	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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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						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	-	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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Passed in Board of Studies on 02.12.2022 Approved in 64th Academic Council Meeting on 11.01.2023

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						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	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

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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. Laboratory Manual
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. Laboratory Manual
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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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 metho	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						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	-	-	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:

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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						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	-
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

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Passed in Board of Studies on 03.05.2023 Approved in 65th Academic Council Meeting on 27.05.2023

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 & 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	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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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						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	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, process 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						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	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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Passed in Board of Studies on 02.12.2022 Approved in 64th Academic Council Meeting on 11.01.2023

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						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	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:

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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. Machining Practices Laboratory Manual, 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
2.	Dr.M.Balamurali	Assistant Professor	Mechanical Engineering	balacim82@tce.edu

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						Theory						Theory			
	Assessment-1						Assessment-2						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						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	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						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	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. Laboratory Manual
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

Passed in Board of Studies on 02.12.2022 Approved in 64th Academic Council Meeting on 11.01.2023

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			Theory			Integrated System Design Project	Theory		
	Assessment-1			Assessment-2				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:

1. Dr. M.Elango — Associate Professor — Mechanical Engineering — memech@tce.edu
2. Mr.M.Sermaraj — Assistant Professor — Mechanical Engineering — msjmech@tce.edu

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. Laboratory Manual
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
2.	Dr.K.Srithar	Professor	Mechanical Engineering	ksrithar@tce.edu
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			Practical		
	Model			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 prepare detailed 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:

1.	Dr. V. Balasubramani	Associate Professor	Mechanical Engineering	vbmech@tce.edu
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:

1. Dr. S. Muralidharan — Professor — Mechanical Engineering — murali@tce.edu
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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						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	-	-	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**	
5.1	Rectangular Elements -Quadrilateral Elements - Natural co-ordinate systems - Isoparametric elements	1
5.2	Shape functions for Iso parametric elements	1
5.3	Formulation of stress strain & strain displacement relation for Iso parametric Elements	1
5.4	Numerical integration using Gaussian Quadrature	1
5.5	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:

1. Dr. V. Balasubramani Associate Professor Mechanical Engineering vbmech@tce.edu
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)

MADURAI – 625 015, TAMILNADU

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Passed in Board of Studies on 03.05.2023

Approved in 65th Academic Council Meeting on 27.05.2023

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 bhattacharya, 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						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	10	30	30				10	30		2	5	10
CO2			40			30							2	5	10
CO3		20											6	5	-
CO4									40			30	2	5	10
CO5								20					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

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2. Prof. K. Srithar — Professor — Mechanical Engineering — ksrithar@tce.edu

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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4.	Dr.M.S.Govardhanan	Asst. Professor	Mechanical Engg.	govardhanans@tce.edu

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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 for hydraulic and pneumatic systems.	TPS2	70	70
CO2	Select suitable pumps, motors and cylinders for the stated applications.	TPS3	70	65
CO3	Calculate speed, pressure, flow and power for the fluid power r circuits	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

1.	Dr. V. Balasubramani	Associate Professor	Mechanical Engineering	vbmech@tce.edu
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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						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	-	-	-	-	-	-	-	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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Passed in Board of Studies on 03.05.2023 Approved in 65th Academic Council Meeting on 27.05.2023

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						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	-	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:

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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						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	-	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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Passed in Board of Studies on 03.05.2023 Approved in 65th Academic Council Meeting on 27.05.2023

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						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	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=yWIAOFs04go

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

1.	Mr.C. Kannan	Manager (Materials)	M/s. TAFE Pvt. Ltd., Madurai	ckannan@tafe.com
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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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3.	Dr C. Paramasivam	Professor	Mechanical Engineering	cpmech@tce.edu
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		
TPS / COs	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

1. Mr.C. Kannan — Manager (Materials) — M/s. TAFE Pvt. Ltd., Madurai — ckannan@tafe.com
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3. Dr C. Paramasivam — Professor — Mechanical Engineering — cpmech@tce.edu
4. Mr.C. Vignesh — Assistant Professor — 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

	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				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

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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						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	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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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						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				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
2.	Dr. PL. K. Palaniappan	Professor	Mechanical Engineering	kpal@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						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		10	10	-	-	-	-	-	-	-	2	5	-
CO2	-	-	35	5	10	25	-	-	-	-	-	-	2	5	12
CO3	-	-	35	5	10	25	-	-	-	-	-	-	2	5	12
CO4	-	-	-	-	-	-	-	-	30	5	10	15	2	5	12
CO5	-	-	-	-	-	-	-	-	30	5	10	20	2	5	12
CO6	-	-	-	-	-	-	-	-	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

1.	Dr.M.Balamurali	Assistant Professor	Mechanical Engineering	balacim82@tce.edu
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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_Qggc86U

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 Designers

1.	Mr.C. Kannan	Manager (Materials)	M/s. TAFE Pvt. Ltd., Madurai	ckannan@tafe.com
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Passed in Board of Studies on 03.05.2023 Approved in 65th Academic Council Meeting on 27.05.2023

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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Passed in Board of Studies on 03.05.2023

Approved in 65th Academic Council Meeting on 27.05.2023

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						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	-	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

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Passed in Board of Studies on 03.05.2023

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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					
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	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
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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						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): 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
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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						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		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

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