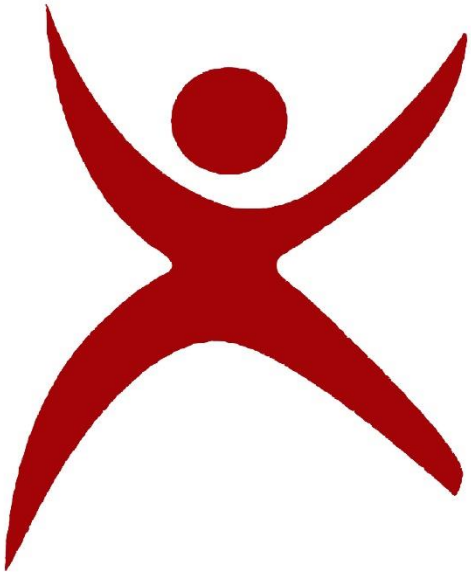
Rajiv Gandhi University of Knowledge Technologies
Andhra Pradesh

(*established through Act 18 of 2008, Government of Andhra Pradesh*)



COURSE STRUCTURE AND DETAILED SYLLABI

OF B. TECH PROGRAM

IN

MECHANICAL ENGINEERING

(*Effective from 2020-2021 batch onwards*)

DEPARTMENT OF MECHANICAL ENGINEERING

RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES

Andhra Pradesh

Nuzvid Campus :: RK Valley Campus :: Srikakulam Campus :: Ongole Campus

CONTENTS

		Metal Cutting and Machine Tools
		Metal Cutting and Machine Tools Lab
		Fluid Mechanics and Hydraulic Machinery Lab
		Heat Transfer
		Design of Transmission Elements
		Applied Thermodynamics
		Metrology and Mechanical Measurements
		Metrology and Mechanical Measurements Lab
		Heat Transfer Lab
		Applied Thermodynamics Lab
		Operations Research
		Finite Element Method
		Managerial Economics and Financial Analysis
		Computer Aided Modeling and Simulation Lab
	(vi)	**Professional Elective Courses**
		Mechanical Vibrations
		Tribology
		Advanced Mechanics of Solids
		Theory of Plates & Shells
		Rotor Dynamics
		Vehicle Dynamics
		Bio Mechanics
		Design Optimization
		Mechanics of Composite Materials
		Control Systems & Engineering
		Design for Manufacturability
		Micro Electro Mechanical Systems
		System identification & condition monitoring
		CAD/CAM
		Product Design and Development
		Power Plant Engineering
		Advanced Fluid Mechanics
		Advanced Heat Transfer
		Computational Fluid Dynamics
		Design of Heat Exchangers
		Design and Optimization of Thermal Systems
		Turbo Machinery
		Gas Dynamics and Jet Propulsion
		Fuels and Combustion
		Energy Conservation and Management
		Cryogenics

		Advanced IC Engines
		Renewable Energy Resources
		Nuclear Power Generation & Safety
		Automobile Engineering
		Industrial Automation
		Soft Computing
		Advanced Materials Technology
		Welding Technology
		Advanced Manufacturing Processes
		Additive Manufacturing
		Advanced Metal Forming
		Non Destructive Testing
		Computer Aided Automation & Manufacturing
		Surface Engineering
		Inspection and Quality Control
		CNC Machining
		Flexible Manufacturing System
		Mechatronics
		Nanotechnology
		Robotics and Applications
		Production Operations and Management
		Entrepreneur Resources Planning
		Advanced Operations Research
		Business Management and Development
		Supply Chain Management
		Industrial Engineering and Management
		Refrigeration and Air Conditioning
		Open Elective Courses offered by Mechanical Engineering Dept.
		Electro Mechanical Systems Engineering
		Nanomaterials
		Industrial Robotics
		Management Science and Productivity
		Automotive Engineering
		Total Quality Management and Reliability
	(vii)	**Seminars/Mini Projects/Projects**
		Summer Internship
		Project-I
		Project-II
	(viii)	**Courses Offered to Other Departments**
		Workshop (For Civil and Chemical Engineering)
		Engineering and Solid Mechanics (For Chemical Engineering)

		Mechanical Technology (For Chemical Engineering)
		Engineering Mechanics (For Metallurgy & Materials Engineering)
		Workshop Manufacturing Practices (For Metallurgy & Materials Engineering)
		Engineering Graphics and Computer Drafting (For Computer Science & Engineering)
	(ix)	**Courses for Minor Degree in Mechanical Engineering**
		Basic Mechanical Engineering
		Computer Aided Design and Analysis
		Production and Operations Management
		Mechanical Design
		Product Design and Development
		Manufacturing Processes Lab
		Computer Aided Modeling and Simulation Lab
	(x)	**Courses for Minor degree in Renewable Energy Resources**
		Introduction to thermal sciences (for non-ME)
		Advanced thermal sciences (for ME)
		Solar energy
		Geothermal and Bio-mass energy
		Wind and Tidal energy
		Non-conventional energy sources Lab
		Energy economics and management
		Mini project
	(xi)	**Course for Minor degree in Robotics and Drone Technology**
		Introduction to robotics
		Mechanics of robots
		Control of robotic systems
		Introduction to drones
		Dynamics and control of drones
		Drone lab
		Robotics lab

Chapter-1

General, Course structure, Theme and semester-wise credit distribution

A. Definition of Credit:

1 Hour Lecture (L) per week	1 credit
1 Hour Tutorial (T) per week	1 credit
3 Hours Practical (Lab)/week	1.5 credits

B. Total number of credits: 160

C. Minimum number of contact hours/weeks per semester: 15 weeks of teaching

i. For 1 credit course: 15 contact hours per semester
ii. For 2 credit course: 30 contact hours per semester
iii. For 3 credit course: 45 contact hours per semester
iv. For 4 credit course: 60 contact hours per semester

D. Course code and definition, Abbreviations

Course code	Definitions
L	LECTURE
T	TUTORIAL
P	PRACTICAL
ME	CORE COURSES
BSC	BASIC SCIENCE COURSES
ESC	ENGINEERING SCIENCE COURSES
HSC	SOCIAL SCIENCES AND MANAGEMENT COURSES
PCC	PROFESSIONAL CORE COURSES
PEC	PROFESSIONAL ELECTIVE COURSES
OEC	OPEN ELECTIVE COURSES
MC	MANDATORY COURSE
SI	SUMMER INTERNSHIP
PROJ	MINI PROJECT/PROJECT

E. Structure of Program

S. No	Category	Break up of credits
1	Basic Science Courses	**23.5**
2	Engineering Science Courses	**22.5**
3	Humanities and Social Sciences including Management courses	**8.5**
4	Professional core courses	**66.0**
5	Professional Elective courses	**12.0**
6	Open Elective courses	**12.0**
7	Project work and internship in industry or elsewhere	**13.5**
8	Mandatory courses	**2.0**
	Grand Total	**160**

F. Semester-wise Credits Distribution

COURSE CODE	E1 - SEM1	E1 - SEM2	E2 - SEM1	E2 - SEM2	E3 - SEM1	E3 - SEM2	E4 - SEM1	E4 - SEM2	SUMMER INTERNSHIP	CREDITS
BSC	12.5	4	4	3	0	0	0	0	**0**	**23.5**
ESC	7	15.5	0	0	0	0	0	0	**0**	**22.5**
HSC	2.5	0	0	0	1.5	4.5	0	0	**0**	**8.5**
MC	0	0	0	0	0	0	0	2	**0**	**2**
PCC	0	0	18	19	19.5	9.5	0	0	**0**	**66**
PEC	0	0	0	0	0	6	3	3	**0**	**12**
OEC	0	0	0	0	0	0	6	6	**0**	**12**
PROJECT	0	0	0	0	0	0	4.5	6	**3**	**13.5**
Total Credits	**22**	**19.5**	**22**	**22**	**21**	**20**	**13.5**	**17**	**3**	**160**

Notations:

E1- SEM1: First Year Engineering First Semester

E1- SEM2: First Year Engineering Second Semester

E2 - SEM1: Second Year Engineering First Semester

E2 – SEM2: Second Year Engineering Second Semester

E3 - SEM1: Third Year Engineering First Semester

E3 - SEM2: Third Year Engineering Second Semester

E4 - SEM1: Fourth Year Engineering First Semester

E4 - SEM2: Fourth Year Engineering Second Semester

SUMMER INTERNSHIP: Summer Internship Program

RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES
(Constituted under the Act 18 of 2008)
NUZVID*RK VALLEY***SRIKAKULAM***ONGOLE**
B. TECH. MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

Semester Wise Structure of Curriculum

COURSE STRUCTURE
Mandatory Induction Program

3 Weeks Duration
Physical activity Creative Arts Universal Human Values Literary Proficiency Modules Lectures by Eminent people Visit to local areas Familiarization of Dept./Branch Innovations

I Year – SEMESTER – I

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MA1101	BSC	Differential Equations and Multivariable Calculus	**3-1-0**	**4**
20EG1181	HSC	English Language Communication Skills Lab-I	**1-0-3**	**2.5**
20PY1102	BSC	Engineering Physics	**3-1-0**	**4**
20EE1109	ESC	Basic Electrical and Electronics Engineering	**3-1-0**	**4**
20CY1103	BSC	Engineering Chemistry	**3-0-0**	**3**
20ME1181	ESC	Workshop Practice	**0-0-3**	**1.5**
20EC1189	ESC	Basic Electrical & Electronics Engineering Lab	**0-0-3**	**1.5**
20BS1183	BSC	Engineering Physics & Chemistry Lab	**0-0-3**	**1.5**
		Total credits		**22**

I Year – SEMESTER – II

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MA1201	BSC	Mathematical Methods	**3-1-0**	**4**
20ME1213	ESC	Engineering Mechanics	**3-1-0**	**4**
20ME1201	ESC	Material Science & Metallurgy	**3-0-0**	**3**
20CS1208	ESC	Programming and Data Structures	**3-0-0**	**3**
20ME1214	ESC	Engineering Graphics and Computer Drafting	**1-0-3**	**2.5**
20CS1288	ESC	Programming and Data Structures Lab	**0-0-3**	**1.5**
20ME1281	ESC	Material Science and Metallurgy Lab	**0-0-3**	**1.5**
20BE1201	MC	Environmental Science	**2-0-0**	**0**
			Total Credits	**19.5**

II Year – SEMESTER – I

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MA2103	BSC	Transform Calculus	**3-1-0**	**4**
20ME2101	PCC	Kinematics of Machinery	**3-1-0**	**4**
20ME2102	PCC	Thermodynamics	**3-1-0**	**4**
20ME2103	PCC	Mechanics of Solids	**3-1-0**	**4**
20ME2104	PCC	Manufacturing Processes	**3-0-0**	**3**
20ME2181	PCC	Mechanics of Solids Lab	**0-0-3**	**1.5**
20ME2105	PCC	Computer Aided Machine Drawing	**0-0-3**	**1.5**
			Total Credits	**22**

II Year – SEMESTER – II

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20ME2201	PCC	Design of Machine Elements	**3-1-0**	**4**
20ME2202	PCC	Dynamics of Machinery	**3-1-0**	**4**
20ME2203	PCC	Fluid Mechanics & Hydraulic Machinery	**3-1-0**	**4**
20ME2204	PCC	Metal Cutting and Machine Tools	**3-1-0**	**4**
20MA2201	BSC	Probability and Statistics	**3-0-0**	**3**
20ME2281	PCC	Metal cutting and Machine Tools Lab	**0-0-3**	**1.5**
20ME2282	PCC	Fluid Mechanics & Hydraulic Machinery Lab	**0-0-3**	**1.5**
20HS2201	MC	Indian Constitution	**2-0-0**	**0**
			Total Credits	**22**

III Year – SEMESTER – I

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20ME3101	PCC	Heat Transfer	**3-1-0**	**4**
20ME3102	PCC	Design of Transmission Elements	**3-1-0**	**4**
20ME3103	PCC	Applied Thermodynamics	**3-1-0**	**4**
20ME3104	PCC	Metrology and Mechanical Measurements	**3-0-0**	**3**
20ME3181	PCC	Metrology and Mechanical Measurements Lab	**0-0-3**	**1.5**
20ME3182	PCC	Heat Transfer Lab	**0-0-3**	**1.5**
20ME3183	PCC	Applied Thermodynamics Lab	**0-0-3**	**1.5**
20EG3182	HSC	English Language Communication Skills Lab-II	**0-0-3**	**1.5**
			Total Credits	**21**

III Year – SEMESTER – II

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20ME3201	PCC	Operations Research	**3-1-0**	**4**
20ME3202	PCC	Finite Element Method	**3-1-0**	**4**
20BM3201	HSC	Managerial Economics and Financial Analysis	**3-0-0**	**3**
20ME32XX	PEC	Program Elective Course-1	**3-0-0**	**3**
20ME32XX	PEC	Program Elective Course-2	**3-0-0**	**3**
20ME3281	PCC	Computer Aided Modeling and Simulation Lab	**0-0-3**	**1.5**
20EG3283	HSC	English Language Communication Skills Lab-III	**0-0-3**	**1.5**
			Sub Total Credits	**20**
20ME3291	**Summer Internship**			**3**
			Total Credits	**23**

IV Year – SEMESTER – I

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20ME41XX	PEC	Program Elective Course-3	**3-0-0**	**3**
20XX41XX	OEC	Open Elective Course-1	**3-0-0**	**3**

20XX41XX	OEC	Open Elective Course-2	**3-0-0**	**3**
20ME4192	PROJ-1	Project	**0-0-9**	**4.5**
			Total Credits	**13.5**

IV Year – SEMESTER – II

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20ME42XX	PEC	Program Elective Course-4	**3-0-0**	**3**
20XX42XX	OEC	Open Elective Course-3	**3-0-0**	**3**
20XX42XX	OEC	Open Elective Course-4	**3-0-0**	**3**
20ME42XX	MC	Community Service	**0-0-0**	**2**
20ME4293	PROJ-2	Project	**0-0-12**	**6**
			Total Credits	**17**

LIST OF PROFESSIONAL ELECTIVE

COURSES (PEC) DESIGN STREAM

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MEXX21	PEC	Mechanical Vibrations	3-0-0	3
20MEXX22	PEC	Tribology	3-0-0	3
20MEXX23	PEC	Advanced Mechanics of Solids	3-0-0	3
20MEXX24	PEC	Theory of Plates & Shells	3-0-0	3
20MEXX25	PEC	Rotor Dynamics	3-0-0	3
20MEXX26	PEC	Vehicle Dynamics	3-0-0	3
20MEXX27	PEC	Bio Mechanics	3-0-0	3
20MEXX28	PEC	Design Optimization	3-0-0	3
20MEXX29	PEC	Mechanics of Composite Materials	3-0-0	3
20MEXX30	PEC	Control Systems & Engineering	3-0-0	3
20MEXX31	PEC	Design for Manufacturability	3-0-0	3
20MEXX32	PEC	Micro Electro Mechanical Systems	3-0-0	3
20MEXX33	PEC	System Identification & Condition Monitoring	3-0-0	3
20MEXX34	PEC	CAD/CAM	3-0-0	3
20MEXX35	PEC	Product Design and Development	3-0-0	3

THERMAL STREAM

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MEXX36	PEC	Power Plant Engineering	3-0-0	3
20MEXX37	PEC	Advanced Fluid Mechanics	3-0-0	3
20MEXX38	PEC	Advanced Heat Transfer	3-0-0	3

20MEXX39	PEC	Computational Fluid Dynamics	3-0-0	3
20MEXX40	PEC	Design of Heat Exchangers	3-0-0	3
20MEXX41	PEC	Design and Optimization of Thermal Systems	3-0-0	3
20MEXX42	PEC	Turbo Machinery	3-0-0	3
20MEXX43	PEC	Gas Dynamics and Jet Propulsion	3-0-0	3
20MEXX44	PEC	Fuels and Combustion	3-0-0	3
20MEXX45	PEC	Energy Conservation and Management	3-0-0	3
20MEXX46	PEC	Cryogenics	3-0-0	3
20MEXX47	PEC	Advanced IC Engines	3-0-0	3
20MEXX48	PEC	Renewable Energy Resources	3-0-0	3
20MEXX49	PEC	Nuclear Power Generation & Safety	3-0-0	3
20MEXX50	PEC	Automobile Engineering	3-0-0	3
20MEXX73	PEC	Refrigeration & Air Conditioning	3-0-0	3

MANUFACTURING STREAM

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MEXX51	PEC	Industrial Automation	3-0-0	3
20MEXX52	PEC	Soft Computing	3-0-0	3
20MEXX53	PEC	Advanced Materials Technology	3-0-0	3
20MEXX54	PEC	Welding Technology	3-0-0	3
20MEXX55	PEC	Advanced Manufacturing Processes	3-0-0	3
20MEXX56	PEC	Additive Manufacturing	3-0-0	3
20MEXX57	PEC	Advanced Metal Forming	3-0-0	3
20MEXX58	PEC	Non Destructive Testing	3-0-0	3
20MEXX59	PEC	Computer Aided Automation & Manufacturing	3-0-0	3
20MEXX60	PEC	Surface Engineering	3-0-0	3
20MEXX61	PEC	Inspection and Quality Control	3-0-0	3
20MEXX62	PEC	CNC Machining	3-0-0	3
20MEXX63	PEC	Flexible Manufacturing System	3-0-0	3
20MEXX64	PEC	Mechatronics	3-0-0	3
20MEXX65	PEC	Nanotechnology	3-0-0	3
20MEXX66	PEC	Robotics and Applications	3-0-0	3

INDUSTRIAL ENGINEERING & MANAGEMENT STREAM

Subject Code	Subject Category	Subject Name	L-T-P	Credits
20MEXX67	PEC	Production Operations & Management	3-0-0	3
20MEXX68	PEC	Entrepreneur Resources Planning	3-0-0	3
20MEXX69	PEC	Advanced Operations Research	3-0-0	3
20MEXX70	PEC	Bossiness Management and Development	3-0-0	3
20MEXX71	PEC	Supply Chain Management	3-0-0	3
20MEXX72	PEC	Industrial Engineering and Management	3-0-0	3

LIST OF OPEN ELECTIVE COURSES (OEC) OFFERED BY DEPARTMENT OF MECHANICAL ENGINEERING TO OTHER DEPARTMENTS

OPEN TO ALL BRANCHES				
Subject Code	**Subject Category**	**Subject Name**	**L-T-P**	**Credits**
20MEXX15	OEC	Electro Mechanical Systems Engineering	3-0-0	3
20MEXX16	OEC	Nanomaterials	3-0-0	3
20MEXX17	OEC	Industrial Robotics	3-0-0	3
20MEXX18	OEC	Management Science and Productivity	3-0-0	3
20MEXX19	OEC	Automotive Engineering	3-0-0	3
20MEXX20	OEC	Total Quality Management and Reliability	3-0-0	3
Courses offered by Mechanical Engineering Department to other departments				
For CIVIL AND CHEMICAL ENGINEERING				
20MEXY85	ESC	Workshop	0-0-3	1.5
FOR CHEMICAL ENGINEERING				
20ME1111	ESC	Engineering and Solid Mechanics	3-0-0	3
20ME2112	ESC	Mechanical Technology	3-0-0	3
FOR METALLURGICAL & MATERIALS ENGINEERING				
20ME1113	ESC	Engineering Mechanics	2 -1-0	3
20ME1186	ESC	Workshop Manufacturing Practices	0-0-3	1.5
FOR COMPUTER SCIENCE AND ENGINEERING				
20ME1114	ESC	Engineering Graphics and Computer Drafting	1-0-3	2.5

MINOR DEGREE IN MECHANICAL ENGINEERING
COURSE STRUCTURE

S. No	Course Code	Subject Category	Name of the subject	L-T-P	Credits
1	20MEM101	PCC	Basic Mechanical Engineering	3-0-0	3
2	20MEM102	PCC	Computer Aided Design and Analysis	3-1-0	4
3	20MEM103	PCC	Production and Operations Management	3-0-0	3
4	20MEM104	PCC	Mechanical Design	3-1-0	4
5	20MEM105	PCC	Product Design and Development	3-0-0	3
6	20MEM181	PCC	Manufacturing Process Lab	0-0-3	1.5
7	20MEM182	PCC	Computer Aided Modeling and Simulation Lab	0-0-3	1.5
				Total credits	20

MINOR DEGREE IN RENEWABLE ENERGY RESOURSES
COURSE STRUCTURE

S. No	Course Code	Subject Category	Name of the subject	L-T-P	Credits
1	20MEM201	PCC	Introduction to thermal sciences (for non-ME) Advanced thermal sciences (for ME)	3-1-0	4
2	20MEM202	PCC	Solar energy	3-0-0	3
3	20MEM203	PCC	Geothermal and Bio-mass energy	3-0-0	3
4	20MEM204	PCC	Wind and Tidal energy	3-0-0	3
5	20MEM281	PCC	Non-conventional energy sources Lab	0-0-3	1.5
6	20MEM205	PCC	Energy economics and management	3-1-0	4
7	20MEM291	PCC	Mini project	0-0-3	1.5
				Total credits	20

MINOR DEGREE IN
ROBOTICS AND DRONE TECHNOLOGY
COURSE STRUCTURE

S. No	Course Code	Subject Category	Name of the subject	L-T-P	Credits
1	20MEM301	PCC	Introduction to robotics	3-0-0	3
2	20MEM302	PCC	Mechanics of robots	3-1-0	4
3	20MEM303	PCC	Control of robotic systems	3-0-0	3
4	20MEM304	PCC	Introduction to drones	3-0-0	3
5	20MEM305	PCC	Dynamics and control of drones	3-1-0	4
6	20MEM381	PCC	Drone lab	0-0-3	1.5
7	20MEM382	PCC	Robotics lab	0-0-3	1.5
				Total credits	20

I YEAR
I SEMESTER

CHAPTER 2

Course Code	Course Name	Course Category	L-T-P	Credits
20MA1101	Differential Equations and Multivariable Calculus	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Discuss the Solutions of first order differential equations
2. Discuss the Solutions of higher order linear differential equations
3. Understand the converge of infinite series with different tests.
4. Learn power series representation of functions and its validity
5. Understand Continuity and differentiability of multi-variable functions and its applications to discuss maximum and minimum
6. Discuss the convergence Improper integrals and apply Leibnitz rule

Course Content:

Unit – I **(10 Contact hours)**

Differential equations of first order and first degree:

Basic concepts, Variable Separable method, homogeneous differential equations, Exact differential equations, Integrating factor, Differentiable equations Reducible to exact, Linear differential equations, Bernoulli differential equations.

Unit - II **(11 Contact hours)**

Linear differential equations of higher order:

Homogenous differentiable equations, Non-homogeneous linear equations of higher order with constant coefficients with RHS term of the type $e^{ax}, sinax, cosax,$ polynomials in $x, e^{ax}\,V(x), xV(x),$ Methods of Undetermined Coefficients, Method of variation of parameters, Euler Cauchy equation.

Unit - III **(12 Contact hours)**

Sequences and Series

Definition of Sequences and convergence, Convergence of series, Comparison test, Ratio test, Root test, Absolute and Conditional convergence, Alternating series, Power series, Taylor's and Maclaurin's series.

Unit - IV **(12 Contact hours)**

Functions of several variables:

Limit, Continuity and Differentiability of functions of several variables, Partial derivatives and their geometrical interpretation, Differentials, Derivatives of Composite and Implicit functions, Chain rule, Jacobians, Derivatives of higher order, Homogeneous functions, Euler's theorem, and Harmonic functions.

Unit – V **(8 Contact hours)**

Applications of Functions of several Variable:

Taylor's expansion of functions of several variables, Maxima and Minima of functions of several variables - Lagrange's method of multipliers.

Unit – VI **(6 Contact hours)**

Beta and Gamma Function:

Beta and Gamma functions - elementary properties, Relation between Beta and gamma functions, Evaluation of Definite integral using Beta and Gamma functions, differentiation under integral sign, and differentiation of integrals with variable limits - Leibnitz rule.

Learning resources

Text book:

1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9th Edition

Reference Books:

1. TOM M. APOSTAL**,***' Calculus, Volume II'*, Wiley-India, Second Edition,
2. R. K. JAIN AND S. R. K. IYENGAR,' *Advanced Engineering Mathematics'*, Narosa Publishers, 3rd Edition.
3. B.S.GREWAL**, '***Higher Engineering Mathematics'*, Khanna Publishers, 42nd Edition.

Web resources:

1. NPTEL, IIT- Madras, 08-June-2017, Introduction to ordinary differential equations URL: https://nptel.ac.in/courses/111106100/12
2. NPTEL, IIT- Kanpur, 15-March-2016, Differential Calculus of Several Variables URL: https://nptel.ac.in/courses/111104092/11
3. NPTEL, IIT- Roorkee, 22-December-2017, Multivariable Calculus URL:https://nptel.ac.in/courses/111107108/
4. MatheMagician, 24–April-2017, Calculus - sequences and series, URL: https://www.youtube.com/playlist?list=PLJMXXdEk8kMAeBLj14HX0fhe_LypRc4aW
5.RGUKT Course Content

Course outcomes: At the end of the course, the student will be able to

CO 1	Solve first order differential equations.
CO 2	Solve higher order linear differential equations.
CO 3	Check the convergence of infinite series with different methods
CO 4	Discuss the power series representation of a function at various points.
CO 5	Explain limits and continuity, differentiability and partial derivatives of functions of multivariable and solve the extremum problems subjected to constraints.
CO 6	Apply Leibnitz rule and beta gamma functions to evaluate improper integrals.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course objectives:

Course code	Course Name	Course Category	L-T-P	Credits
20EG1181	English Language Communication Skills Lab-I	HSC	1-0-3	2.5

1. To facilitate computer-aided multi-media instruction enabling individualized and independent language learning
2. To sensitize the students to the nuances of English speech sounds, word accent, intonation and rhythm
3. To provide opportunities for practice in using English in day to day situations
4. To improve the fluency in spoken English and neutralize mother tongue influence
5. To train students to use language appropriately for debate, group discussion and public speaking

Course content:

Unit-I: **(06 Hours)**

Theory: An Ideal Family by Katherine Mansfield

Spoken Skills: Situational Dialogues – Role-play – Expressions in various situations – Self Introduction – Introducing others – Greetings – Apologies – Requests – Giving directions

Unit-II: **(06 Hours)**

Theory: Energy -Alternative sources of Energy

Panel Debate on "On-grid & off-grid support to public participation in the production of solar energy in India", Reading the Wikipedia content on "The Green New Deal". Reflective session on the prospects of "The Green New Deal in India"

Writing Skills: Letter Writing (Formal & Informal) and Hands on Session on Letter Writing

Unit-III: **(06 Hours)**

Theory: Transport - Problems & solutions

Group Discussion on "The Future of Bullet Trains in India"

PPT on "The Dedicated Freight Corridors & the Future of Indian Economy" – Introduction to Speech

Spoken Skills: Sounds – Vowels, Consonants and Diphthongs – Pronunciation Exercises (Basic Level)

Unit-IV: **(06 Hours)**

Theory: Technology - Evaluating technology

PPT on "3R: Reduce, Recycle, Reuse" - Solo Debate on "Can Block Chain Technology Mitigate the Issue of Cyber Crimes and Hacking?"

Presentation Skills: JAM –Description of Pictures, Photographs, Process, Talking about wishes, Information Transfer

Unit-V: **(06 Hours)**

Theory: Environment - Ecology versus Development

Listening Skills: Listening Activity on YouTube video on "Greening the Deserts" - Students' seminar on "Waste to Wealth: Examples from around the Globe".

Unit-VI: **(06 Hours)**

Theory: Industry - Selling products

Reading Skills: Reading the material on "4Ps: Product, Price, Place, and Promotion" Role play on "How to sell your product and services"

Reference Books:

1. Non – Detailed Text Book: Panorama – A Course on Reading published by Oxford University Press, India
2. English for engineers and technologists by Orient Black Swan
3. A Textbook of English Phonetics for Indian Students 2nd Ed T. Balasubramanian. (Macmillan), 2012.
4. Speaking English Effectively, 2nd Edition Krishna Mohan & NP Singh, 2011. (Macmillan).
5. A Hand book for English Laboratories, E.Suresh Kumar, P.Sreehari, Foundation Books,2011
6. English Pronunciation in Use. Intermediate & Advanced, Hancock, M. 2009. CUP
7. Basics of Communication in English, Soundararaj, Francis. 2012.. *New Delhi: Macmillan*
8. English Pronouncing Dictionary, Daniel Jones Current Edition with CD.Cambridge, 17th edition, 2011.

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the issues affecting the economy and environment in India and across the globe
CO 2	Develop the instinct for problem solution
CO 3	Develop the ability to collect materials on various socio-economic-technological issues and prepare PPT for presentation
CO 4	Improving listening skills
CO 5	Inculcate speaking as a behaviour by repeated practice and exposure

Assessment Method:

Course Nature: THEORY + LAB

Internal Assessment (40 Marks)	External Assessment (60 Marks)
Record Writing – 10 Marks	Reading Comprehension – 15 Marks
Attendance – 10 Marks	Writing – 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

Course code	Course name	Course Category	L-T-P	Credits

20PY1102	Engineering Physics	BSC	3-1-0	4

Course Learning Objectives:

1. To gain the basic knowledge in the areas of Differential calculus and Integral Calculus.
2. To gain basic knowledge on the oscillatory motion of a system under certain conditions and its impact on the amplitude and energy of an oscillator.
3. To gain the basic knowledge on Wave motion in solid media with the special focus on ultrasonic frequency range and its applications.
4. To learn the basic knowledge about Electromagnetic wave equations vividly.
5. To gain basic knowledge on Wave phenomena of Light such as Interference, Diffraction, Polarization. Basics of laser theory and its applications.
6. To learn the detail knowledge about structural, Thermal and Electrical Properties of Solids

Course Contents:

Unit I: Mathematical Physics (10 Hours)

Coordinate system: Cartesian, cylindrical and spherical coordinate system transformations, Differential Calculus: Gradient, Divergence, Curl and their physical significance, Integral Calculus: Line, Surface, and Volume Integrals, Integral theorem: Gauss and stokes theorems, Curvilinear Coordinates.

Unit II: Oscillations (10 Hours)

Oscillations**:** Simple Harmonic Oscillator (SHO), Damped Oscillations, Forced Oscillations, Amplitude and Velocity Resonance, Quality Factor, Coupled Oscillations &Normal modes, Coupled Pendulums & energy and Oscillation on N coupled modes.

Unit III: Waves (10 Hours)

Ultrasonic waves: Phase of wave. Phase Velocity and Group Velocity with specific examples, production – magnetostriction and piezoelectric methods - detection of ultrasound - acoustic grating – ultrasonic interferometer - industrial applications – Non-destructive testing - ultrasonic method: scan modes and practice.

Unit IV: Electromagnetic Waves (8 Hours)

Maxwell's Equations (integral and differential forms), Poynting theorem and conservation Laws, Wave Equation, Electromagnetic waves in vacuum and in Matter, its boundary conditions.

Unit V: Optics (10 Hours)

Fraunhoffer diffraction (Single slit), Fraunhoffer diffraction Double slit & multiple slits, Diffraction Grating, Rayleigh criterion for resolving power, Resolving power of microscope and telescope, Production of Plane polarized light & double refraction, Quarter & Half -wave plates, elliptical & circular polarized lights, Theory of Laser, *Einstein* coefficients, Types of Lasers: Three level Lasers (Ruby Laser) Gas Laser (He-Ne Laser) and four level laser (Nd-YAG laser)and semiconductors lasers, applications of lasers.

Unit VI: Solid state Physics (12 Hours)

(i) Basic Quantum mechanics:Wave function & probability interpretation, Time independent Schrodinger Equation and its Applications, Particle in a box (1D &3D),

(ii) Solid State Physics:Crystallography, Defects in crystals (qualitatively), Thermal Properties: Lattice heat

capacity, Einstein's theory of lattice specific heat, Deby"s theory of specific heat- T^3 law, Thermal expansion and Thermal conductivity. Superconductivity: Introduction- Transition temperature, Critical magnetic field, persistent currents, Meissner effect, isotopic effect, Type I and Type II superconductors (qualitatively) , Applications of superconductors (Magnetic resonance imaging" (MRI)).

Learning resources

TEXT BOOKS

1. Md. N. Khan, S. Panigrahi, '*Principles of Engineering Physics 1*' Cambridge University press 2016
2. Suresh Garg, C.K.Ghosh, Sanjay Gupta '*Oscillations and Waves*'PHI Learning, 10th edition.

REFERENCES

1. Hitendra K. Malik and A.K. Singh '*Engineering Physic*s' by , 3 August 2017
2. Dr. M.N Avadhanulu, Dr. P.G shirsagar Jan '*A Textbook of Engineering Physics'* S. Chand publications, old edition
3. David J Griffiths '*Introduction to Introduction to electrodynamics'*PHI Learning 3ed edition
4. 4. H.J. Pain '*The Physics of Vibrations and Waves'*Willey Student Edition,6th edition
5. Sear's and Zemansky *'University Physics'*, Pearson Edition.

Course outcomes: At the end of the course, the student will be able to

CO1	The student will be able to differentiate the Del, Gradient, Divergence, and Curl, and also Relations among them.
CO2	The student will be able to understand the oscillatory motion of a single and coupled system and transfer of energy in between particles.
CO3	Students will be able to understand the uses of ultrasonics in various fields.
CO4	Student will be able to understand the EM waves in different media like Vacuum, Matter and Conductor.
CO5	Students will be able to understand the phenomena of interference, diffraction and polarization exhibited by light waves and the characteristics of lasers.
CO6	The student will get a clear idea of crystal physics, Bragg's law of X-ray diffraction, Thermal and Electrical Conductivity of solids.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course Name**	**Course Category**	**L-T-P**	**Credits**

20EE1109	**Basic Electrical and Electronics Engineering**	**ESC**	**3-1-0**	**4**

Course Learning Objectives

1. To gain an understanding of the basics of Electricity, basic electrical elements
2. To state fundamental circuit laws, and recognize different circuit configurations
3. To analyze DC-Electrical circuits using different analysis methods, and circuit theorems
4. To gain basic understanding of single-phase and 3-phase AC-circuits
5. To explain the working principle, construction, and applications of DC, AC Electrical machines.
6. To understand the importance of Semiconductor devices, and to gain basic understanding of semi-conductor theory.
7. To gain basic understanding of diode, and transistor working, and study rectifier, and amplifier circuits as their important applications

Course content

Unit-I : DC Circuits (10 Contact hours)

Introduction, Basic definitions, Types of elements, Ohm's Law, Kirchhoff's Laws, Series, Parallel circuits, Star-delta and delta-star transformations, equivalent resistance calculation, Mesh and Nodal analysis, superposition theorem, thevenin's theorem and maximum power transfer theorem.

Unit-II: AC Circuits (10 Contact Hours)

Single-phase: Inductive circuits, capacitive circuits, series RL, RC and RLC circuits, resonance, **Three-phase:** star connection and delta connection.

Unit-III: DC Machines (10 Contact Hours)

Generator: Principle of operation of DC Generator, EMF equation, types, applications **Motor:** DC motor types, torque equation, applications, three point starter.

Unit-IV: AC Machines (10 Contact Hours)

Transformers: Principle of operation of single phase transformers, EMF equation, losses, efficiency and regulation.

Induction machine: Principle of operation of induction motor, slip-torque characteristics, applications.

Unit-V: Semiconductor Devices (10 Contact Hours)

Diode: types of semiconductors, P-N junction diode, V-I Characteristics, zener diode, Diode Applications. **Rectifiers:** Half wave, Full wave and Bridge rectifiers.

Unit-VI: Transistors (10 Contact Hours)

PNP and NPN Junction transistor, Transistor configurations, Transistor as an amplifier

Learning resources

Textbook

1. Kothari and Nagarath, *Basic Electrical and Electronics Engineering*, TMH Publications, 2nd Edition.

References

1. V. K. Mehta, *Principles of Electrical and Electronics Engineering*, S. Chand & Co.
2. Kothari and Nagarath, *Basic Electrical Engineering*, TMH Publications, 2nd Edition.

Web Resources

1. Prof T S Natarajan, NPTEL-IIT Madras, 'Basic Electronics' URL: https://nptel.ac.in/courses/122106025/
2. Prof U Umanand, IISC Bangalore, 'Basic Electrical Technology'. URL: http://nptel.ac.in/courses/108108076/
3. Prof S Aniruddhan, IIT Madras, 'Basic Electrical Circuits'. URL:https://onlinecourses.nptel.ac.in/noc16_ee03//

Course Outcomes: At the end of the course, the student will be able to

CO 1	Understand the fundamentals of Electricity, and identify basic electrical elements
CO 2	State fundamental circuit laws, and understand different circuit configurations
CO 3	Analyze DC electrical circuits
CO 4	Understand the single-phase and 3-phase AC-circuits
CO 5	Explain the working, construction, and applications of Electrical machines
CO 6	Understand the importance of Semiconductor devices, and gain basic understanding of semi-conductor theory.
CO 7	Understand transistor working, different diode rectifier circuits, and a transistor amplifier circuit

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits

20CY1103	**Engineering Chemistry**	**BSC**	**3-0-0**	**3**

Course Learning Objectives:

1. To get knowledge on types of water and problems and solution associated with water.
2. To gain the knowledge on fuels, its analysis and determining physical property of lubricants.
3. To acquire basic knowledge on electrochemical cells, its classification and corrosion factors
4. To know types of polymers and its characterization techniques
5. To understand the extent adsorption and surface coating methods

Course Content

UNIT- I: Water Technology (7 Hours)

Hard water:- Reasons for hardness – units of hardness - Boiler troubles – Priming and Foaming, Scale formation, Boiler corrosion, Caustic embrittlement - Internal treatments - Softening of Hard water : Lime – Soda process, Zeolite process and numerical problems based on these processes and Ion Exchange process - Water for drinking purposes- Purification – Sterilization and disinfection : Chlorination, Break point chlorination and other methods – Reverse Osmosis and Electro Dialysis.

UNIT- II: Fuels & Lubricants (7 Hours)

Fuels - Classification, examples, relative merits, types of coal, determination of calorific value of solid fuels, Bomb calorimeter, theoretical oxygen requirement for combustion,
proximate & ultimate analysis of coal, manufacture of metallurgical coke. Lubricants - Definition, theories of lubrication, Solid and liquid lubricants, Grease -characteristics of lubricants, viscosity, viscosity index, oiliness, pour point, cloud point, flash point, fire point, additives to lubricants, Solid lubricants.

UNIT- III: Electrochemistry and corrosion (7 Hours)

Overview of Fundamentals of Electrochemistry - Concentration Cells – Batteries: Dry Cell - Ni-Cd cells - Ni-Metal hydride cells- Li cells - Zinc – air cells.
Corrosion :- Definition – Theories of Corrosion (chemical & electrochemical) – Formation of galvanic cells by different metals, by concentration cells, by differential aeration and waterline corrosion – Passivity of metals – Pitting corrosion - Galvanic series – Factors which influence the rate of corrosion - Protection from corrosion – Design and material selection – Cathodic protection - Protective coatings: – Surface preparation – Metallic (cathodic and anodic) coatings
Fuel cells: - Hydrogen Oxygen fuel cells – Methanol Oxygen fuel cells

UNIT- IV Polymer Chemistry (8 Hours)

Introduction to polymerization techniques – bulk, solution, suspension, and emulsion polymerization. The visco elasticity of polymer (Glassy state, Visco-elastic state, Visco-fluid state, Solid phase, Liquid phase), glass transition temperature & its effect on polymer. Crystalline and amorphous structure of polymer, Degree of crystallinity, Types of polymer degradation-Chain-end

& Random degradation, Thermal Degradation, Mechanical Degradation, Ultrasonic wave Degradation, Photo degradation. Introduction, preparation and applications of bio-degradable polymers (PLA) and conducting polymers (PANI).

UNIT- V Surface Chemistry and Surface Coatings (9 Hours)

Adsorption-Types of adsorption-adsorption of gases on solids- adsorption from solutions- Types of isotherms Freundlich adsorption isotherm, Langmuir adsorption isotherm. Industrial applications of adsorption. Surface Coatings Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

Unit VI: Introduction to Nanomaterials and Nanotechnology (7 Hours)

Introduction to Nanostructures: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide Nanoparticles) Nanowires, Nanobiosensors: Science of Self-assembly - From Natural to Artificial Structures Nanoparticles in Biological Labeling and Cellular Imaging.

Learning Resources:

Text book:

1. P. C. Jain, Monica Jain, "*Engineering Chemistry*", Dhanpat Rai Publishing Company, 15th Edition, 2015
2. Shasi Chawla, "*Text Book of Engineering Chemistry*", Dhantpat Rai Publishing Company, New Delhi, 1st Edition, 2011.
3. Jain & Jain, *Engineering Chemistry*, 16th Edition, 2015

References:

1. Nelson Nemerow *Theories and Practices of Industrial waste treatment*.
2. *Engineering Chemistry* by Shikha Agarwal; Cambridge University Press, 2015 Edition.
3. Pahari A., Chauhan B., "Engineering Chemistry", Firewall Media, New Delhi, 2012.
4. Sivasankar B., "*Engineering Chemistry*", Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
5. AshimaSrivastava. Janhavi N N, "*Concepts of Engineering Chemistry*", ACME Learning Private Limited., New Delhi., 2010.
6. Vairam S., Kalyani P., Suba Ramesh., "*Engineering Chemistry*", Wiley India Pvt Ltd., New Delhi., 2011
7. Peter Atkins, Julia de Paula, *Physical Chemistry*, 9th Edition, Oxford University Press, 2011.
8. L. N. Ferguson, *Text Book of Organic Chemistry*, 2nd Edition, East-West Press, 2009.
9. E. Stocchi: *Industrial Chemistry*, Vol-I, , Ellis Horwood Ltd. UK.

10. Vasant R. Gowariker, Polymer Science, New Age International, 1986, ISBN 0852263074, 9780852263075
11. Fred W. Billmeyer, John Wiley & Sons, 3rd Edition, ISBN: 978-0-471-03196-3

Web resources:

1. RGUKT course content
2. Swayam, *Chemistry*, https://swayam.gov.in/chemistry/c/4/science

Course outcomes: At the end of the course, the student will be able to

CO 1	Develop different methods for attaining soft water by different treatment procedures.
CO 2	Analyze fuel property and determine efficiency of different fuels.
CO 3	Constructing electrochemical cell and take measures for prevention/protection of/from corrosion.
CO 4	Distinguish different types of polymers and analyze polymer rheology.
CO 5	Derive the methods for the adsorption isotherm and framing formulations of surface coatings.
CO 6	Understanding the fundamentals of nanomaterials and nanotechnology

Course Nature		Theory		
Assessment Method				
Assessment Tool	Weekly tests (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME1181	Workshop Practice	ESC	0-0-3	1.5

Course Learning Objectives:

1. To understand the process of preparing the mould cavity for sand casting
2. To understand the preparation and joining of metal work pieces using welding
3. To understand the preparation and assembly of work pieces using fitting
4. To make different products using sheet metal by Tin smithy operation
5. To understand wiring connections in different applications

List of Experiments: (Working Hours: 3hours per experiment)

Foundry	
1.	Preparation of Mould Cavity using Single Piece Solid Pattern
2.	Preparation of Mould Cavity using Split Piece Pattern
Welding	
3.	Preparation of Butt Joint using Shielded Metal Arc Welding
4.	Preparation of Lap Joint using Shielded Metal Arc Welding
5.	Filling the holes in a given metal work piece using Oxy-Acetylene Gas Welding
Fitting	
6.	Preparation of 'V' shape joint using Fitting Operation
7.	Preparation of 'L' shape joint using Fitting Operation
Tin smithy	
8.	Preparation of Tray by Tin smithy Operation
9.	Preparation of Cone by Tin smithy Operation
House Wiring	
10.	House wiring for one lamp and two lamps with single switch
11.	Staircase wiring connection
12	Go Down wiring connection
Carpentry	
13	Wood sizing exercise in planning, marking, sawing, chiseling and grooving to make i) Half lap joint
14	ii) Cross lap joint
Black smithy	
15	Round to Square
16	Fan Hook or S-Hook

Plastic Processing	
17	Injection Molding
18	Blow Molding

Learning resources

Text books:

1. Balasubramaniam, R., "Callister's Materials Science and Engineering", Wiley India Ltd, 2014. 2nd Edition.
2. Groover, M. P., "Fundamentals of modern Manufacturing", Wiley, 2011.4th Edition.
3. Rao, P. N., "Manufacturing Technology: Foundry, Forming and Welding", Mc Graw Hill, 2013. 4th Edition.

Course outcomes: At the end of the course, the student will be able to

CO 1	Prepare the mould cavity for sand casting
CO 2	Join the metal work pieces using arc and gas welding
CO 3	Prepare the work pieces using fitting operations for assembly
CO 4	Make different products using sheet metal by Tin smithy operations
CO 5	Give wiring connections in different applications

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20EC1189	Basic Electrical & Electronics Engineering Lab	ESC	0-0-3	1.5

Course Learning Objective:

1. To make student get familiarized with the electrical and electronic measuring equipments
2. To make understand the student the concepts of characteristics of Resistors, Capacitors and Inductors
3. To understand the behavior of electrical equipment
4. To understand the concepts of diodes, transistors and amplification

List of Experiments:

Familiarization with DSO, Function generators, RPS, FPS, Multi meter and other lab equipment's.

Section A: Electrical Engineering Lab

1. Verification of ohm's law, series and parallel circuits
2. Verification of Kirchhoff's Laws
3. Verification of Voltage division and Current division principles
4. Verification of circuit theorems
5. V-I characteristics of Incandescent and CFL lamp
6. V-I characteristics of Fluorescent lamp
7. A.C analysis of series R-L circuit and R-C circuit
8. Calibration of Energy meter
9. Open circuit characteristics of D.C Generator
10. Speed control of D.C shunt Motor
11. Three phase power measurement
12. Lab project

Section B: Electronics Engineering Lab

1. Familiarization with any CAD tools like multisim /Pspice/ ngspice for doing basic experiments
2. V-I characteristics of a P-N junction diode and zener diode
3. Half wave and center tapped full wave rectifier
4. Full wave bridge Rectifier with and without filters.
5. Design of a simple amplifier using BJT
6. Experiment on simple analog-modulation scheme
7. Simple experiment on Arduino kit and interfacing with sensors
8. Lab project

Course outcomes: At the end of the course, the student will be able to

1. Design basic circuits using P-N junction diode and Zener diode
2. Design rectifier circuits considering the practical aspects into consideration
3. Use circuit knowledge in analyzing Arduino boards
4. Designing simple experiments using Arduino board and sensors interfacing
5. Experimental verification of basic circuit laws and circuit theorem
6. Experimental analysis of V-I characteristics of different electrical and electronic equipments
7. Experimental analysis of electrical machines likes motors, generators etc
8. Design of a simple prototype project

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20BS1183	Engineering Physics & Chemistry Lab	BSC	0-0-3	1.5

Course Objectives:

1. The goal of this experiment is to learn the concept of semiconductors and motion of charged particle in presence of magnetic field.
2. The goal of this experiment is to learn how to determine the wavelength of given laser light using diffraction phenomenon and understand the applications of diffraction phenomenon.
3. The goal of this experiment is to demonstrate the effect which varying thermal conductivities on the heat flow through a given material. This will provide a better understanding of both thermal conductivity and thermal resistance
4. The goal of this experiment is to understand the concept of the normal mode frequency and beat frequency using coupled pendulum
5. The goal of this experiment is to determine the acceleration due to gravity (g) and radius of gyration about an axis through the center of gravity by means of a compound pendulum.
6. The goal of this experiment is to calculate the radius of curvature of a Plano convex lens by Newton's Ring experiment.
7. To understand the water quality in terms of hardness
8. To know the metal percentage present in alloys.
9. To study the physical property of chemical compounds
10. To identify efficiency of fuels
11. To understand catalytic activity from Adsorption Isotherm.

Experiments list

PHYSICS

1. Study of Hall effect and calculation of hall coefficient and concentration of charge carriers
2. Determination of wavelength of laser light using diffraction grating
3. Determination of thermal and electrical conductivity of metals
4. To determine the degree of coupling by using normal modes of coupled oscillations
5. To measure the acceleration due to gravity (g) and radius of gyration about an axis through the center of gravity
6. Determination of the radius of curvature of a Plano convex lens by Newton's Ring experiment

CHEMISTRY

1. Determination of temporary and permanent hardness of water using standard EDTA solution.
2. Determination of percentage of copper in brass
3. Determination of melting point/boiling point of a given substance
4. Determination of density and surface tension of liquids against air
5. Determination of viscosities of liquids.
6. Determine the Flash point and Fire point of chemical compounds
7. Adsorption of oxalic acid by Charcoal

Reference Books:

1) *Chemistry Practical Manual*, Lorven Publications
2) K. Mukkanti (2009) *Practical Engineering Chemistry*, B.S. Publication
3) Arthur J. Vogel, *A Textbook of Quantitative Analysis*.
4) Dr. Jyotsna Cherukuris *Lab Manual of engineering chemistry-II*, VGS Techno Series, 2012.

Course outcomes: At the end of the course, the student will be able to

CO 1. Calculate the hall coefficient, carrier density and carrier mobility of a given semiconductor. Student enrich with sound knowledge on concept of behavior of semiconductors in magnetic field.
CO 2. Determine the wavelength of given laser light using diffraction phenomenon and understand the applications of diffraction in day today life.
CO 3. Calculate thermal conductivities and electrical conductivity of given metal in Lab.
CO 4. Determine normal mode frequency and beat frequency using coupled pendulum. Student will also understand the concept of coupling and energy transform from one system to other through oscillation.
CO 5. Determine the acceleration due to gravity (g) and radius of gyration about an axis through the center of gravity by means of a compound pendulum.
CO 6. Calculate the radius of curvature of a Plano convex lens by Newton's Ring experiment.
CO 7. Ability to judge water quality of different places in terms of hardness. CO 8. Estimate metal percentage in brass
CO 9.Derive the physical characterization like size, surface tension and viscosity of chemical compounds.
CO 10.Analyze the physical properties of different fuels.
CO11.Derive adsorption isotherms and characterize catalyzing activity

Course Nature		Practical		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab Project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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I YEAR
II SEMESTER

Course code	Course Name	Course Category	L-T-P	Credits
20MA1201	Mathematical Methods	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Introduce vector spaces and linear transformation.
2. Discuss Eigen values and Eigen vectors of a matrix and various properties.
3. Setup double and triple integrals to find volume and surface area.
4. Discuss directional derivatives and application of Green's, Stokes and Gauss theorems.
5. Discuss numerical methods to find the roots of transcendental equations and Interpolation.
6. Evaluate integrals by using numerical methods and solving IVP.

Course Content:

Unit – I: Linear Algebra: (12 hours)

Vector Spaces, Linear Combinations of Vectors, Linear dependence and Independence, Basis and Dimension, Linear Transformations, Matrix Representations of Linear transformation.

Unit – II: Eigen values and Eigen vectors: (8 hours)

Solving system of Homogeneous and Non-Homogeneous equations by using Gauss elimination method. Characteristic roots and Characteristic Vectors of a matrix - Cayley-Hamilton Theorem (without proof); Finding inverse and power of a matrix by Cayley-Hamilton Theorem.

Unit-III: Multiple integrals: (10 hours)

Double and triple integrals, computations of surface and volumes, Jacobeans of transformations, change of variables in double integrals, Change of Order of double integrals, integrals dependant on parameters - applications.

Unit–IV: Vector calculus: (12 hours)

Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line, surface integrals and Volume integrals, Green, Gauss and Stokes theorems (without Proof) and problems.

Unit – V: Root finding Methods and Interpolation: (10 hours)

Roots of polynomial and transcendental equations – bisection method, Regula-falsi method and Newton-Raphson method, Finite differences, Newton's forward and backward interpolation formulae.

Unit – VI: Numerical integration and numerical solution of IVP: (8 hours)

Trapezoidal rule, Simpson's $1/3^{rd}$ rule and $3/8^{th}$ rule for numerical integration, Solution of IVP by Euler and Runga-Kutta method.

Learning resources

Text book:

1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9th Edition.

Reference Books:

1. R. K. Jain and S. R. K. Iyengar**, '***Advanced Engineering Mathematics',* Narosa Publishing House, New Delhi, 3rd Edition.
2**.** B.S.Grewal, '*A Text Book of Higher Engineering Mathematics'*, Khanna Publishers, 43rd Edition.
3. Gilbert Strang , 'Linear Algebra and its Applications*',* CENGAGE Learning 4th Edition.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc20_ma54/preview
2. https://onlinecourses.nptel.ac.in/noc21_ma11/preview
3. RGUKT content

Course outcomes: At the end of the course, the student will be able to

CO 1	Write Matrix representation for transformations.
CO 2	Find Eigen values and Eigen vector for a Matrix.
CO 3	Setup and evaluating double and triple integrals.
CO 4	Apply Green's Stokes and Gauss Divergence Theorems.
CO 5	Approximate the roots of polynomial and transcendental equations.
CO 6	Approximate the Integral value by numerical methods and solve IVP using numerical methods.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME1213	Engineering Mechanics	ESC	3-1-0	4

Course Objectives: The objectives of this course are to

1. Explain the resolution of a system of forces, compute their resultant and solve problems using equations of equilibrium.
2. Perform analysis of bodies lying on rough surfaces.
3. Locate the Centroid of a body and compute the area moment of inertia and mass moment of inertia of standard and composite sections.
4. Explain kinetics and kinematics of particles, projectiles, curvilinear motion, centroidal motion and plane motion of rigid bodies.
5. Understand the concept of dynamics of particles and analysis the motion of particle.
6. Explain the concepts of work-energy method and its applications to translation, rotation and plane motion and the concept of vibrations.

Course Contents:

Unit I: (Contact hours 10)

Introduction to Engineering Mechanics - Force systems, Forces acting at a point,Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple, Equilibrium of system of forces - Free body diagram; equations of equilibrium; problems in two and three dimensions;

Unit II: (Contact hours 14)

Trusses and frames: Introduction to trusses, Methods of joints, Method of Sections, analysis of frames

Friction: Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack

Unit III: (Contact hours 8) Centroid and Centre of Gravity: Centroid of Lines, Areas and Volumes from firstprinciple, Centroid of composite sections; Centre of Gravity and its implications. – Theorem of Pappus.

Unit IV: (Contact hours 8)

Area moment of inertia- Definition, Moment of inertia of plane sections from firstprinciples, Theorems of moment of inertia, Moment of inertia of standard sections andcomposite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem.

Mass Moment of Inertia: Moment of Inertia of Masses - Transfer Formula for Mass Moments of Inertia – Mass moment of inertia of composite bodies.

Unit V: **(Contact hours 12)**

Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, andpolar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potentialenergy.Impulse-momentum (linear, angular); Impact (Direct and oblique).

Unit VI: **(Contact hours 8)**

Kinetics of Rigid Bodies -Basic terms, general principles in dynamics; Types of motion,Instantaneous centre of rotation in plane motion and simple problems; D'Alembert'sprinciple and its applications in plane motion and connected bodies; Work Energyprinciple and its application in plane motion of connected bodies; Kinetics of rigid bodyrotation.

Text Books:

1. Beer and Johnston, Vector Mechanics for Engineers Statics and Dynamics, (9thedition) by, Tata McGraw Hill Publishing Company, New Delhi.
2. Engineering Mechanics, Arshad Noor Siddiquee, Zahid A. Khan, PankulGoel, 2018 Cambridge University Press

References

1. Tayal, A. K. "Engineering Mechanics-Statics and Dynamics." 2011.
2. Timoshenko S.P and Young D.H., "Engineering Mechanics", McGraw Hill International Edition, 1983.
3. Bhattacharyya, Basudeb. Engineering Mechanics. Oxford University Press India,2016.
4. Shames, I.H., and Krishna MohanaRao. G., "Engineering Mechanics – Statics and Dynamics", 4th Edition, Pearson Education (2006)

Web Resources:

1. https://nptel.ac.in/courses/112103109//
2. https://nptel.ac.in/courses/112103108//

Course outcomes: At the end of the course, students will be able to

CO 1	Solve resultant of forces acting on a body and analyze equilibrium of a body subjected to a system of forces.
CO 2	Solve problem on bodies subjected to friction.
CO 3	Evaluate the location of Centroid and calculate moment of inertia of a given section.
CO 4	Make a use of the concept of mass moment of inertia to real world applications.
CO 5	Apply the kinetics and kinematics concepts to a body undergoing rectilinear, curvilinear, rotatory motion and rigid body motion.
CO 6	Solve problems using work energy equations for translation, fixed axis rotation and plane motion and solve problems of vibration.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20ME1201	Material Science & Metallurgy	ESC	3-0-0	3

Course Learning Objectives:

1. Give basic knowledge of science behind materials & physical metallurgy.
2. Introduce the concept of structure property relations.
3. Lay the groundwork for studies in fields such as solid-state physics, mechanical behavior of materials, phase & phase diagram,
4. Lay the groundwork for studies in fields such as heat treatment, failure of materials & their protection,
5. Applications of composites and ceramics.
6. Develop intuitive understanding of the subject to present a wealth of real world engineering examples to give students a feel of how material science is useful in engineering practices

Course Contents

Unit –I **(Contact hours 8)**

Introduction: Why study materials science and engineering, classification of materials, properties of materials, atomic structure and bonding in solids, crystal structures, crystalline and non-crystalline materials, miller indices for directions and planes.

Imperfections in solids, point defects, vacancy, interstitialcy, point defects in ceramics, Frenkel and Schotkey defects, line defects, dislocations, edge dislocation, screw dislocation, interfacial and surface defects, grain boundaries, stacking faults, volumetric defects, deformation by slip, slip systems in FCC, BCC and HCPmetals, twinning in metals.

Unit II **(Contact hours 6)**

Constitution of alloys: necessity of alloying, classification of alloys, solid solutions - interstitial solid solutions and substitution solid solutions, Hume - Rothery principles for developing solid solutions, compounds- interstitial, intermetallics and electron compounds. Strengthening mechanisms: dislocation and plastic deformation, strengthening mechanisms in metals.

Unit-III **(Contact hours 7)**

Phase diagrams: introduction to equilibrium or phase diagrams, Gibb's phase rule, construction methods of phase diagrams, solidification of pure metals and alloys, kinetics of nucleation and growth, different phase reactions – isomorphous system, congruent melting alloy, eutectic, peritectic, monotectic. Phase transformation in solid state: allotropy, eutectoid and peritectoid phase reactions, finding composition and relative phase fractions by tie line and lever rule.

Unit-IV **(Contact hours 8)**

Iron-carbon system: phase diagram of pure iron, Fe-Fe_3C phase diagram, phase transformations with respect to temperature and composition, microstructure and property changes in iron-carbon diagrams. Steels and cast irons: classification of steels and cast irons, production routes, special steels – alloy steels, tool steels, die steels, properties and applications of steels and cast irons.

Unit-V **(Contact hours 8)**

Heat treatment of steels: annealing, normalizing, hardening, tempering, austempering and martempering of steels. Recovery, recrystallization and grain growth.CCT and TTT diagrams for steels, non-equilibrium transformation and microstructure, hardenability, Jominy end quench test, surface hardening of steels. Carburizing: pack carburizing, liquid carburizing, gas carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening methods. Diffusion mechanisms: steady and non-steady state diffusion, factors influencing diffusion.

Unit-VI **(Contact hours 8)**

Ceramic & Composite materials: Crystalline ceramics, glasses, cermets, abrasive materials, properties and applications of ceramics. Classification of composites, various methods of component manufacture of composites, properties and applications of composites. Introduction to corrosion, forms of corrosion, corrosion prevention.

Text books:

1. V. Raghavan, Materials Science and Engineering: A first course, Prentice Hall, 6th edition, 2015.

Reference Books:

1. G. E. Dieter, Mechanical Metallurgy, Mc-Graw Hill, 3rd edition, 2013.
2. W. F. Smith, Principles of materials Science and Engineering, 3rd edition, Mc- Graw Hill, 1995.
3. S. H. Avner, Introduction to Physical Metallurgy, 2nd ed., Mc-Graw Hill, 2008.
4. William D. Callister, Material science and Engineering: An Introduction, Wiley publications, 9th edition, 2013.
5. Materials Science, An Intermediate Text, William Hosford, 2011, Cambridge University press
6. Fatigue of Materials, S.Suresh, 2nd Ed, Cambridge University Press
7. Fracture Mechanics, Surya Kumar, Maiti, 2015, Cambridge University press

Video Reference links:

Title	Expert Name	Details of Expert	Web link
Material Science	Prof. S. K. Gupta	IIT Delhi	https://nptel.ac.in/courses/122102008/
Introduction to Materials Science and Engineering	Prof. Rajesh Prasad	IIT Delhi	https://nptel.ac.in/courses/113102080/

Course outcomes: At the end of the course, the student will be able to

CO 1	Identify the properties of metals with respect to crystal structure and grain size
CO 2	Classifyconstitution of alloys and solid solutions, strengthening mechanisms.
CO 3	Interpret the phase diagrams of materials
CO 4	Classify and distinguish different types of cast irons, steels and non-ferrous Alloys
CO 5	Applythe concepts of heat treatment of steels, diffusion mechanisms in practical problems.
CO 6	Make a use of ceramics and composites concepts in practical applications.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20CS1208	Programming and Data Structures	ESC	3-0-0	3

Course Learning Objectives:

1. To deduce adequate knowledge in programming language and problem-solving techniques.
2. To develop programming skills using the fundamentals of C Language.
3. To recognize the effective usage of arrays, structures, functions, pointers
4. To implement the memory management concepts.
5. To illustrate the usage of pointers and dynamic memory allocation.
6. Explore Data StructIRures and its applications.

Course Content:

Unit – I **(Contact hours 7)**

Introduction: Computer Hardware, Bits and Bytes, History of Programming Languages, Character Set, Variables and Identifiers, Built-In Data Types. Operators and Expressions, Constants and Literals, Simple Assignment Statement, Basic Input/output Statement, Simple 'C' Program, Conditional Statements and Loops.

Unit – II Arrays: **(Contact hours 8)**

One Dimensional Arrays, Array Manipulation, Searching, Insertion, Deletion of An Element from An Array; Finding the Largest/Smallest Element in An Array; Two Dimensional Arrays, Addition/Multiplication of Two Matrices, Transpose of square Matrix, Character Arrays.

Unit – III **(Contact hours 8)**

Functions: Function Declaration, Function Definition, Function Call, Call by Value, Call by Reference, Recursion, String Fundamentals, String Handling Functions.

Unit – IV **(Contact hours 8)**

Structure &Union: Structure Variables, Initialization, Structure Assignment, Nested Structure, Structures and Functions, Structures and Arrays: Arrays of Structures, Structures Containing Arrays, Unions.

Unit – V **(Contact hours 7)**

Pointer: Pointer Type Declaration, Pointer Assignment, Pointer Initialization, Pointer Arithmetic, Functions and Pointers, Arrays and Pointers, Pointer to Pointers, Dangling Memory, Dynamic Memory Allocations, Storage Classes.

Unit – VI **(Contact hours 7)**

Introduction to Data Structures: Linked List, Double Linked Lists, Stack, Stack Implementation Using Arrays, Stack Implementation Using Linked List.

Text book:

1. Reema Thareja, *'Data Structures using C'*, Oxford Higher Education,2nd Edition.

Reference Books:

1. E. BalaguruSwamy, " Programming in ANSI C", Mc Graw Hill, 7th Edition
2. Brian W. Kernighan, Dennis M. Ritchie, " The C Programming Language", Prentice Hall, 2nd Edition
3. Data structures using C by Reema Thareja, 2nd edition ,Oxford Higher Education

Web resources:

1. https://www.tutorialspoint.com/cprogramming/
2. https://www.programiz.com/c-programming
3. https://nptel.ac.in/courses/106105085/4
4. Indian Institute of Technology, Kharagpur, "Problem Solving through Programming in C", https://nptel.ac.in/courses/106105171/

Course outcomes: At the end of the course, the student will be able to

CO 1	Illustrate the flowchart and design an algorithm for a given problem and to develop one C program using Operators.
CO 2	Develop conditional and iterative statements to write C Programs.
CO 3	Describe C Programs that use the arrays and its usage.
CO 4	Exercise user defined functions to solve real time problems.
CO 5	Describe C Programs using pointers and to allocate memory using dynamic memory management functions
CO 6	Explore different data structures and understand.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME1214	Engineering Graphics and Computer Drafting	ESC	1-0-3	2.5

Course Objectives:

1. To know about emergence of Engineering Graphics as a refined communication tool and to be aware of International and national standards of practice for uniform presentation of drawings.
2. To adopt the projection of three dimensional object orthogonally on a set of vertical and horizontal planes and obtain the views of the frontal and the top surfaces.
3. To describe the position of a point and position of the line with respect to all the planes of projection and obtain its views.
4. To learn orthographic projections of various simple plane surfaces in simple and inclined positions.
5. To know about orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
6. To learn about different methodologies to be used for obtaining the two dimensional layout of the lateral surfaces of uncut solids.

Course contents:

Unit I: Introduction to Engineering Drawing (Contact hours 2T+6P)

Introduction to Engineering drawing – Tools and Standards, Geometric Constructions, Scales, Conics and Special Curves - ellipse, parabola, hyperbola, cycloids, Involutes.

Unit II: Orthographic projections (Contact hours 3T +9P)

Introduction to Orthographic Projections, Projection of points - projection of straight lines (only first angle projection method) inclined to both the principal planes - determination of true lengths and true inclinations by rotating line method and traces -

Unit III: Projection of Solids (Contact hours 2T+6P)

Projection of Planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method,

Projections of Solids: cube, prism, pyramid, cylinder, cone and sphere.

Unit IV: Section of Solids (Contact hours 2T+6P)

Sections of Solids - cube, prism, pyramid, cylinder, cone and sphere. Development of Surfaces – Parallel line method and Radial line method.

Unit V: Introduction to AutoCAD (Contact hours 8)

Computer Aided Design – Introduction to AutoCAD, Co-ordinate System (UCS) and their Commands, Basic Commands of Drawing and Editing, Dimensioning and Text.

Unit-VI: Computer Graphics **(Contact hours 8)**

Drawing practice with AutoCAD – Creating 2D Drawings of Objects from Isometric views (Iso to Ortho), Creating Isometric views form Orthographic views (Ortho to Iso) and Introduction to 3D drawings.

Learning resources Text

Books

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

References

1. Venugopal, K. and Raja, V.P., 2011. Engineering Drawing+ AutoCAD. New Age International.
2. Parthasarathy, N.S. and Murali, V., 2015. *Engineering Drawing.*

   Oxford University Press.
3. Narayana, K.L. & P Kannaiah (2008), *Text book on Engineering Drawing*, Scitech Publishers.

Online/Web Resources:

1. https://nptel.ac.in/courses/112103019//
2. https://nptel.ac.in/courses/112104172//

Course outcomes: At the end of the course, the student will be able to

CO 1	Aware of International and national standards of practice
CO 2	Imagine the views of the frontal and the top surfaces of an object
CO 3	Use the different drawing instruments
CO 4	Draw the orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other
CO 5	Understand the concepts of three dimensional views such as isometric, oblique Projections
CO 6	Use computer aided drafting techniques and will be familiar with one of the most powerful software ‘AutoCAD’

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Course Nature		**Theory + Lab**		
Assessment Method				
Assessment Tool	Weekly Charts	Monthly tests (3)	End Semester Test	Total
	Average (Mininimum 8 charts)	Best of two (Max Marks-10)	Max Marks-60	
Weightage (%)	20%	20%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20CS1288	Programming and Data Structures Lab	ESC	0-0-3	1.5

Course Learning Objectives:

1. The purpose of the course is to introduce the students to the field of program using C language.
2. To deduce adequate knowledge in programming language and problem-solving techniques.
3. To develop programming skills using the fundamentals of C Language.
4. To recognize the effective usage of arrays, structures, functions, pointers
5. To illustrate the usage of pointers and dynamic memory allocation.
6. Explore Data Structures and its applications.

Unit 1 **(Contact hours 5)**

Introduction

1. C Program to calculate the sum of Natural numbers.
2. C Program to find factorial of a number
3. C Program to generate multiplication table of a given number.
4. C Program to display Fibonacci sequence (up to given number)
5. C Program to Check whether a given number is prime or not
6. C Program to make a simple Calculator using switch case
7. C Program to check whether a number is palindrome or not
8. C Program to display factors of a given number
9. C Program to print Pyramids and Triangles using loops

Unit II **(Contact hours 8)**

Arrays

1. C Program to find second largest Element of an Array
2. C Program to add two matrix using multi-dimensional arrays.
3. C Program to multiply two matrix using multi-dimensional arrays.
4. C Program to find transpose of a matrix.
5. C Program to Sort Elements of an Array.

Unit III **(Contact hours 8)**

Functions

1. C Program to check whether given number is prime or not

using user-defined function.

2. C Program to check whether given number is Armstrong or not using user- defined function.
3. C Program to swap two integer values using call by value and call by reference.
4. C Program to find the sum of Natural numbers using recursion.
5. C Program to find the factorial of a given number using recursion.
6. C Program to calculate length of string without using strlen() function.
7. C Program to sort elements in Lexicographical order (Dictionary order) using in built string functions.

Unit IV **(Contact hours 8)**

Structures and Unions

1. C Program using structures to read and display the information about a student.
2. C Program to read, display, add and subtract two complex numbers.
3. C Program to read and display the information of a student using nested structure.
4. C Program, using an array of pointers to a structure, to read and display the data of students.
5. C Program to demonstrate arrays of Union variables.

Unit V **(Contact hours 8)**

Pointers

1. C Program to demonstrate, handling of pointers in C.
2. C Program to access array elements using pointers.
3. C Program to find the sum of n numbers with arrays and pointers.
4. C Program to swap two numbers using pointers and function
5. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using malloc() function.
6. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using calloc() function.

Unit VI **(Contact hours 8)**

Introduction to Data Structures

1. Write a program to create a linked list and perform insertions and deletions of all cases. Write functions to sort and finally delete the entire list at once.

2. Write a program to create a doubly linked list and perform insertions and deletions in all cases.
3. Write a program to perform push, pop and peek operations on a stack.
4. Write a program to implement a linked stack.

Course outcomes:

At the end of the course, the student will be able to

CO 1	Illustrate the flowchart and design an algorithm for a given problem and to develop one C program using Operators.
CO 2	Develop conditional and iterative statements to write C Programs.
CO 3	Describe C Programs that use the arrays and its usage.
CO 4	Exercise user defined functions to solve real time problems.
CO 5	Describe C Programs using pointers and to allocate memory using dynamic memory management functions
CO 6	Explore different data structures and understand.

References:

1. Rema Thareja, *Programming in C*, 3rd edition, Oxford Higher Education.
2. Rema Thareja, *Data structures using C*, 2nd edition ,Oxford Higher Education

Assessment Method

Assessment Tool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	15%	40%
End Semester Examination weightage (%)			60%

Course code	Course Name	Course Category	L-T-P	Credits
20ME1281	Material Science and Metallurgy Lab	ESC	0-0-3	1.5

Course Learning Objectives:

1. To distinguish the different microstructures of low, medium, high carbon steels.
2. To distinguish the different microstructures of ferrous and Non-ferrous alloys.
3. To understand the difference between hardness and hardenability.
4. To understand the effect of HAZ on properties of weld
5. To examine the grain size of various heat treated samples
6. To understand the variation of properties of sample after heat treatment.

List of experiments

1. Preparation and study of the Microstructure of Mild steels, low carbon steels, high – C steels.
2. Study of the Microstructures of Cast Irons.
3. Study of Microstructures of different alloy steels.
4. Study of the Microstructures of Non-Ferrous alloys.
5. Study of the Microstructures of Heat treated steels.
6. To study heat treatment processes (hardening and tempering) of steel specimen
7. To study heat treatment processes (Annealing) of steel specimen
8. Hardenability of steels by Jominy End Quench Test.
9. To find out the hardness of various heat treated and untreated plain carbon steels.
10. Study of microstructure of welded component and HAZ (Heat Affected Zone) macro and micro examination.
11. Study of grain size measurement of heat treated and untreated plain carbon steels
12. Measurement of depth of carbon induction in a carburized steels.
13. Microstructural and elemental analysis of steels by using scanning electron microscopy.
14. X-ray difractometry of mild steel (BCC), Aluminum (FCC) and Magnesium (HCP)

Learning resources

Text books:

1. B. L. Juneja, Workshop Practice, Cengage 2015.
2. K. Venugopal, Workshop Manual, Anuradha 2015.
3. Balasubramaniam, R., “Callister's Materials Science and Engineering”, Wiley India Ltd, 2014. 2nd Edition.

Course outcomes: At the end of the course, the student will be able to

CO 1	Distinguish the different microstructures of low, medium, high carbon steels.
CO 2	Distinguish the different microstructures of ferrous and Non-ferrous alloys.
CO 3	Understand the difference between hardness and hardenability.
CO 4	Analyze the effect of HAZ on properties of weld
CO 5	Examine the grain size of various heat treated samples
CO 6	Identify the variation of properties of sample after heat treatment.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course name	Course Category	L-T-P	Credits
20BE1201	Environmental Science	MC	2-0-0	0

Course Learning Objectives:

1. To provide knowledge about multidisciplinary nature of environment, various sources of natural energy.
2. Understanding of ecosystem structure and function etc.
3. Knowledge of biodiversity and conservation
4. Understanding of problems caused by pollution and its impact
5. Understanding about the various social issues related to environment.
6. Awareness for the Environment and human health

Course Content:

Unit-I: (9 Contact Hours)

The Multidisciplinary Nature of Environmental Studies and Natural Resources
The Multidisciplinary Nature of Environmental Studies: Definition, scope and importance; Need for public awareness.

Natural Resources: Renewable and Non Renewable Resources
Natural resources and associated problems.
a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resoureces for sustainable lifestyles.

Unit -II: Ecosystems (4 contact hours)
Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers,Energy flow in the ecosystem,Ecological succession, Food chains, food webs and ecological pyramids,Introduction, types, characteristic features, structure and function of the following ecosystem:-a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem, d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

Unit -III: **(4 contact hours)**

Biodiversity and It's Conservation

Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India,Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, Inida as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT-IV: Environmental Pollution **(6 contact hours)**

Cause, effects and control measures of:-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides.

UNIT- V: Social Issues and the Environment **(4 contact hours)**

From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rahabilitation of people; its problems and concerns. CaseStudies, Environmental ethics: Issues and possible solutions.• Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

UNIT-VI: Human Population and the Environment **(3 contact hours)**

Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Learning Resources

Text Book:

1. Erach Bharucha, '*Textbook of Environmental studies'*, UGC

Reference Books:

1. Clark RS, '*Marine Pollution'*, Clanderson Press, Oxofrd (TB).
2. De AK, '*Environmental Chemistry'*, Wiley Eastern Ltd.

Course Outcomes: At the end of the course, the student will be able to

CO1	Well understanding about their surrounding natural resources and their conservation
CO 2	Able to understand the ecosystem food chain and habitat.

CO 3	Develop the practices for conservation of biodiversity
CO 4	To well understand the pollution courses, impact and prevention from pollution
CO 5	Able to bring about an awareness of a variety of environmental concerns.
CO 6	It attempts to create a pro-environmental attitude and a behavioral pattern in society that is based on creating sustainable lifestyles.

For Theory Courses Only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	0	0	100%	100%

II YEAR
I SEMESTER

Course code	Course Name	Course Category	L-T-P	Credits
20MA2103	Transform Calculus	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Introduce partial differential equations and solutions of first order PDE.
2. Introduces the concept of transforms and their mathematical properties.
3. Apply Laplace transforms to solve the ordinary and partial differential equations which are not solvable by traditional analytical methods.
4. Write Fourier series expansion of periodic and non-periodic functions.
5. Introduce Fourier transforms and their properties.
6. Apply transformation techniques to solve boundary value problems.

Course Content:

Unit -I

Laplace Transform: (10 contact hours)

Definition of Laplace Transform, linearity property, conditions for existence of Laplace Transform. First and second shifting properties, Laplace Transform of derivatives and integrals, unit step functions, Dirac delta-function, error function.

Unit -II

Application of Laplace transforms: (10 contact hours)

Differentiation and integration of transforms, convolution theorem, inversion, periodic functions. Evaluation of integrals by Laplace Transform. Solution of Ordinary differential Equations.

Unit -III

Fourier Series: (12 contact hours)

Periodic functions, Fourier series representation of a function, Fourier series for Even and Odd functions, half range sine and cosine series, Fourier integral Theorem, Parseval's identity.

Unit -IV

Fourier Transform: (10 contact hours)

Fourier Transform, Fourier sine and cosine transforms. Linearity, scaling, frequency shifting and time shifting properties. Self reciprocity of Fourier Transform, convolution theorem.

Unit -V

Boundary Value Problems: (10 contact hours)

Relation between Fourier and Laplace Transforms, Solutions of boundary value problems by Fourier Transforms.

Unit – VI

Partial Differential Equations: (8 contact hours)

Introduction to partial differential equations, Formation of PDE, Lagrange's equation, Pp+Qq=R form, Variable separable method.

Learning resources

Text book:

1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9th Edition.

Reference Books:

1. M.K. Jain., '*Numerical solutions of differential equations',* Wiley Eastern, 1984, 2nd Edition.
2. M.K Jain, S.R.K Iyengar, R.K Jain., '*computational methods for PDE*,' Wiley Eastern 1994.
3. S.D. Conte &Carl de Boor., '*Elementary Numerical analysis an algorithmic approach'*, McGraw Hill, Newyork, 1980, 3rdEdition.
4. E. Ward Cheney**,** David R. Kindcaid.,' *Numerical methods and applications'*, Brooks / Cole, 2008.
5. Butcher, J.C, '*Numerical methods for ordinary differential equations'*, Wi- ley, Newyork, 2003.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc19_ma04/preview.
2. RGUKT content.

Course outcomes: At the end of the course, the student will be able to

CO 1	Solve the partial differential equations of first and second order.
CO 2	Solve the ordinary differential equations with discontinuous forcing terms.
CO 3	Able to analyze the solutions with various initial and boundary conditions.
CO 4	Able to write series expansions of periodic functions and their physical significance.
CO 5	Solve the various forms of ODEs and PDEs.
CO 6	Solve the various types of differential equations such as Integro- differential equations, System of differential equations.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2101	Kinematics of Machinery	PCC	3-1-0	4

Pre-requisites: Engineering Mechanics

Course Objectives:

1. The objective is to study the relative motion, velocity, and accelerations of the various elements in a mechanism.
2. In mechanical Engineering we come across number of mechanisms such as four bar/slider crank/double slider crank/straight line motion mechanism etc.
3. Mechanism deals with only relative motions. Once we make a study considering for us also there it is called kinetics.
4. To introduce the conceptsof CAMS and their applications.
5. The first course deals with mechanisms, their inversions straight line motion mechanisms steering mechanisms etc.
6. Also study of cams/gears & gear trains & belts are also introduced.

Course Contents:

Unit I: **(8 contact hours)**

Beginnings of Theory of Machines, Planar Mechanisms, Basic Kinematic Concepts, Elementary Mechanisms, Grubler's Criterion Four Link Chains, Kinematic Inversion.

Unit II: **(8 contact hours)**

Kinematic Analysis of Mechanisms, Velocities by Centro Method, Relative Velocity Method, Relative Acceleration Method, Acceleration Analysis Mechanisms , Analytical Determination of Velocity and Acceleration of the Piston.

Unit III: **(8 contact hours)**

Straight Line Motion and Universal Coupling, Condition for Exact Straight Line Motion, Exact Straight Line Motion Mechanisms, Approximate Straight Line Motion Mechanisms, Steering Gear Mechanism, Hooke's (Cardan, Universal) Joint.

Unit IV: **(12 contact hours)**

Cams, Types of Cams and Followers, Displacement Diagrams-Uniform Velocity, Uniform Acceleration, SHM and Cycloid, Disk Cam with Knife-Edge Follower, Translating Roller Follower, Translating Flat Follower, Oscillating Flat Follower, Cams of Specified Contour-Tangent with Roller follower.

Unit V: **(12 contact hours)**

Gears, Classification of Gears, Types of Motion, Gear Nomenclature, Law of Gear Tooth

Action, Involute as a Gear Tooth Profile, Layout of an Involute Gear Set, Producing Gear Teeth, Meshing Gears and Line of Contact, Interference of Involute Gears, Minimum Number of Teeth to Avoid Interference, Contact Ratio, Cycloidal Tooth Profiles, Cycloidal and Involute Tooth Forms,Helical, Spiral, Worm and Bevel Gears.

Unit VI: (12 contact hours)

Gear Trains, Classification of Gear Trains, Simple Gear Trains, Compound Gear Trains, Gear Train Applications to Machine Tools, Epicyclic Trains, Inversions of Epicyclic Trains, Differential Trains, Torque Distribution in Epicyclic Trains, Example of an Epicyclic Train, Coupled Epicyclic Trains, Wilson Four Speed Automobile Gear Box. Computer aided kinematic analysis with cases dealt in the class and visualize the Mechanisms and kinematic solutions.

Learning resources Text books:

1. Ratan, S. S. "*Theory of Machines*, Seventh Reprint." (1998): 405.

References

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. *Theory of Machines and Mechanisms*, Vol. 1. New York, NY: Oxford University Press, 2011.
2. RS Khurmi, *Theory of Machines*, Eurasia Publishing House, 2005.

Web Resources:

https://nptel.ac.in/courses/112104121/

Course Outcomes: At the end of the course, students will be able to

CO 1	Demonstrate knowledge in a suitable mechanism depending on application
CO 2	Develop displacement diagrams and cam profile diagram for followers executing different types of motions and various configurations of followers
CO 3	Develop velocity and acceleration diagrams for different mechanisms
CO 4	Select gear and gear train depending on application.
CO 5	Analyze Straight line and steering mechanisms
CO 6	Illustrate the function generation, path generation and motion generation.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2102	Thermodynamics	PCC	3-1-0	4

Course Objectives:

1. To learn about work and heat interactions, and balance of energy between system and its surroundings
2. To learn about application of First law to various energy conversion devices
3. To understand the difference between high grade and low grade energies and Second law limitations on energy conversion
4. To evaluate the properties of pure substances
5. To learn about gas, vapour and refrigeration cycles
6. To learn about basics of energy available for work

Course Contents:

Unit I: **(8 contact hours)**

Introduction to Thermodynamics

Fundamental Concepts: definitions of system and surrounding, concept of control volume, Types of Systems, Macroscopic and Microscopic viewpoints, thermodynamic state, concepts of simple compressible substances, processes, cycle and equilibrium; Temperature and Zeroth law; Thermodynamic properties and use of tables of thermodynamic properties; Idea of a generalized chart and the law of corresponding states; Concept of ideal gases and their equations of state; Thermodynamic concept of energy; Modes of work and heat transfer. Point and Path function.

Unit II: **(10 contact hours)**

First law of Thermodynamics

Joule's Experiments, The first law referred to cyclic and non-cyclic processes, concept of internal energy of a system, conservation of energy for simple compressible closed systems; Definitions of enthalpy and specific heats; PMM-1, Conservation of energy for an open system or control volume, steady & transient processes, important applications such as flow in a nozzle and diffuser, compressor and turbine, throttling, adiabatic mixing etc

Unit III: **(12 contact hours)**

Pure substances and Introduction to Properties of Mixtures and Phases

Pure substances: Definition of a pure substance, phase of a substance, triple point and critical points, sub-cooled liquid, saturated liquid, vapor pressure, two-phase mixture of liquid and vapor, saturated vapor and superheated vapor states of a pure substance with water as example. Representation of pure substance properties on p-T, p-V, T-S and h-s diagrams, p-V-T- surfaces, Mollier Charts.

Introduction to Properties of Mixtures and Phases: Maxwell relations; Clausius-

Clapeyronequation; Difference in heat capacities; Ratio of heat capacities; Joule- Thompson coefficient.

Unit IV: **(8 contact hours)**

Second law of Thermodynamics

The directional constraints on natural processes, Limitations of the First Law – Thermal Energy Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence / Corollaries, PMM of Second kind, Concept of reversibility and irreversibility, PMM of third kind, Carnot's principle, Carnot cycle and its specialties, Carnot principle; Absolute thermodynamic temperature scale; Clausius Inequality.

Unit V: **(10 contact hours)**

Entropy, Availability and Thermodynamics Property Relations

Entropy: Clasius inequality; statement, proof, application to a reversible cycle. $\oint$ (δQR/T) as independent of the path. Entropy; definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, calculation of entropy, role of T-s diagrams, representation of heat, Change in entropy in various thermodynamic processes, Tds relations, entropy balance for closed and open systems, Exergy analysis, Available and unavailable energy, **Thermodynamics Property Relations:** Amagat's and Dalton's model, Equation of state and properties of ideal gas mixtures, Change in entropy on mixing; introduction to real-gas mixtures; Gibbs phase rule.

Unit VI: **(12 contact hours)**

Gas Power Cycles and Refrigeration Cycles

Power Cycles: Otto, Diesel, Dual Combustion cycles, Brayton Cycle and improvement of Brayton Cycle – Description and representation on P–V and T-S diagram, Thermal Efficiency, Mean Effective Pressures on Air standard basis – comparison of Cycles. **Refrigeration Cycles:** Rankine cycles – Performance Evaluation – combined cycles, Bell- Coleman cycle, Vapour compression cycle-performance Evaluation.

Learning resources Text

Book:

1. P K Nag, *Engineering Thermodynamics,* TMH, New Delhi, 2012.
2. Yonus A Cengel & Michal A Boles, *Thermodynamics: An Engineering Approach,* McGraw Hill, 2015

References

1. C P Arrora, *Thermodynamics,* McGraw Hill, 2004
2. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., *Fundamentals of Thermodynamics,* John Wiley and Sons, 6th Edition, 2003,
3. Jones, J. B. and Duggan, R. E., *Engineering Thermodynamics,* Prentice-Hall of India, 1996.

4. Moran, M. J. and Shapiro, H. N., *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons, 1999.
5. Sanford Klien, *Thermodynamics,* Cambridge University Press, 2012.
6. William C Reynolds, *Thermodynamics Fundamentals and Engineering Applications,* 2018 Cambridge university Press.

Video Reference links:

Title	Expert Name	Details of Expert	Web link
Basic Thermodynamics	Prof. S.K. Som	From IIT Kharagpur	nptel.ac.in/courses/112105123/

Course Outcomes: After the end of course, the students will be able to

CO 1	Apply energy balance to systems and control volumes, in situations involving heat and work interactions
CO 2	Analyze the performance of energy conversion devices
CO 3	Distinguish between high grade and low grade energies
CO 4	Evaluate changes in thermodynamic properties of substances
CO 5	Demonstrate various gas and vapor power cycles
CO 6	Explain the concept of energy available for work

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2103	Mechanics of Solids	PCC	3-1-0	4

Course Objectives:

1. The objective is to learn the fundamental concepts of stress, strain, and deformation of solids with applications to bars, beams, and columns.
2. Detailed study of engineering properties of materials is also of interest.
3. Fundamentals of applying equilibrium, compatibility, and force-deformation relationships to structural elements are emphasized.
4. A detailed study of analysis of beams under bending, shear and torsional loads.
5. The students are introduced to advanced concepts of flexibility and stiffness method of structural analysis.
6. To acquire knowledge of applying concepts of engineering mechanics to design columns and struts.

Course Contents:

Unit-I: (16 contact hours)

Simple Stresses and Strains: Elasticity and Plasticity, Basics of stress and strain, Types of stresses & strains, Hooks Law, Stress-strain behavior of different materials, Elastic constants and their relations, applications of normal stresses and strains – Homogenousand composite bars having uniform and varying cross sections subjected to axial and thermal loads. Strain energy, resilience, toughness, modulus of resilience, proof resilience, gradual, sudden, impact and shock loads, Stresses on inclined planes, Principal stresses, principal strains, Mohr's circle for plane stress and plane strain conditions

Unit-II: (12 contact hours)

Shear and Bending in beams: Beams- Types of loads, supports, shear force and bendingmoment diagrams of statistically determinate beams with various loading conditions.Theory of simple bending, stress distribution in symmetrical and unsymmetrical sectionsdue to bending moment and shear force.

Unit-III: (8 contact hours)

Deflection of beams: Double integration method, Macaulay's method, Area momentmethod for determining slope and deflection of cantilever and simply supported beams

Unit-IV: (8 contact hours)

Torsion: Torsion of circular solid and hollow shafts, torsional rigidity, combined bending moment and torsion of shafts, power transmitted by shafts, shafts in series and parallel, strain energy stored due to torsion.

Unit-V: **(8 contact hours)**

Thin cylinders and Thick cylinders: Longitudinal and Hoop stresses, longitudinal, hoop and volumetric strains, change in dimensions due to internal pressure. Wire wound cylinders, spherical shells.

Unit-VI: **(8 contact hours)**

Columns and struts: Buckling of columns, Euler's theory, effective length, Rankine'sformula, columns with eccentric load and initial curvature.

Course Outcomes: After completing this course, the students will be able to

CO 1	Apply knowledge of materials and structural elements to the analysis of simple structures.
CO 2	Develop shear force and bending moment diagram of beams.
CO 3	Analyze the different types of stresses in the beams.
CO 4	Identify problem, formulation and solution using a range of analytical methods.
CO 5	Analyze and interpret Lab data relating to behavior of structures and the materials they are made of, and undertake associated Lab work individually and in teams.
CO 6	Evaluate the different types of stresses in the columns and struts.
CO 7	Analyze the behavior of the solid bodies subjected to various types of loading

Learning resources Text books

1. Y.C. Fung, *"Foundations of Solid Mechanics*", Prentice Hall Inc.
2. Strength of materials, G.Gunneswara Rao, 2018, Cambridge University press

References:

1. James M Gere, "*Mechanics of Materials",* Thomson Learning Inc., Sixth Edition
2. Popov, *Solid Mechanics,*
3. P. Beer, E.R. Johnston, J. T. De Wolf and D. F. Mazurek, "*Mechanics of Materials*", McGraw Hill, Sixth Edition

Web Resources:

https://nptel.ac.in/courses/105102090/
https://nptel.ac.in/courses/105106116/

Course Nature		**Theory**		
Assessment Method				
AssessmentTool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2104	Manufacturing Processes	PCC	3-0-0	3

Course Learning Objectives:

1. To have proper knowledge on various manufacturing processes.
2. To have proper knowledge on cost effective material options based on the near net shape and surface finish.
3. To understand the problems of a component during its manufacturing.
4. To understand the steps involved in manufacturing a component.
5. To understand the effect of manufacturing processes on properties of a component.
6. To communicate more effectively with the industrial people in manufacturing terminology.

Course Contents:

Unit-I **(8 Contact hours)**

Casting: Introduction, Advantages of casting and its applications, Steps involved in making a casting. **Patterns and Pattern makin**g: Types of patterns, Materials used for patterns, Pattern allowances, **Moulding sand**: Molding sand composition, Testing sand properties, Sand preparation, Reclamation of molding sand. **Core:** Core sands, Types of cores, Core prints, Chaplets, Forces acting on the molding flasks, **Gating systems:** Elements of gating system, Gating system design, Risering Design.

Unit II **(7 Contact hours)**

Melting and Casting Quality: Melting Practices, Casting Cleaning, Casting Defects.
Special casting processes: Shell Moulding, Precision Investment Casting, Permanent Mould Casting, Die Casting, Vacuum Die Casting, Low Pressure Die Casting, Centrifugal Casting, Continuous Casting, Squeeze Casting, Slush Casting, Vacuum Casting Thixocasting.

Unit-III **(9 Contact hours)**

Fundamentals of Metal Forming: Plastic deformation, Hot and cold working, Strain hardening, Recovery, Recrystallization and grain growth. **Rolling**: Principle, Types of rolling mills and products, Roll passes, Forces in rolling and power requirements. **Extrusion and Drawing:** Basic extrusion process and its characteristics, Hot extrusion and cold extrusion, Impact extrusion, Hydrostatic extrusion. Wire drawing, rod and tube drawing, Load estimation for drawing and tube making. **Forging:** Principles of forging, Tools and dies, Types: Smith forging, Drop Forging, Forging hammers, Rotary forging, forging defects, Load

estimation in forging process.

Unit-IV **(6 Contacthours)**

Sheet metal forming: Press tool operations, shearing, drawing, Hot and cold spinning, bending, stretch forming, Piercing, Coining, Embossing. Sheet metal Die Design, **Special forming**: Hydro forming, High energy rate forming.

Unit-V **(9 Contact hours)**

Welding: Classification of welding process, Arc welding, Weld bead geometry, V-I Characteristic curves of power source , Problems on V-I Characteristic, Shielded metal arc welding, Submerged arc welding, Gas Tungsten arc welding, Gas Metal arc welding. Co2 welding, Gas welding, Gas cutting, Applications and advantages and disadvantages of the above processes, Resistance welding, Seam welding, Projection welding, Upset welding, and Flash butt welding. Heat affected zones in welding, Methods to minimize HAZ, Soldering & Brazing: Types and its applications, Special welding processes: Thermit welding, Friction welding, Diffusion Bonding, Electron beam welding, and Laser beamwelding.

Unit-VI **(6 Contact hours)**

Powder metallurgy: Introduction, Production and characterization of powders, Compaction of metal powders, sintering of powder compacts, Post sintering operations, Applications.

Plastics processing: Thermo plastics, thermosetting plastics, Injection Moulding, Blow Moulding, Thermo Forming, Thermosetting plastics processing. Fiber reinforced plastics processing-Hand lay up technique, Filament winding, Resin transfer moulding, Vaccum assisted resin transfer moulding, Pultrusion.

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Learning resources

Text Books:

1. M. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 6th Edition, John Wiley & Sons 2016.

References:

1. Savitha Sharma, Manufacturing processes, international publications 4th edition, 2011.
2. P.C. Sharma, “A text book of production technology”, S. Chand and Company, 4th edition, 2003.
3. Rajendra Singh, Introduction to basic manufacturing processes: new age publications: 2nd edition, 2014.

Web resources: NPTEL, December 31, 2009, “Manufacturing Processes” URL: https://nptel.ac.in/courses/112107145/

Course outcomes: At the end of the course, the student will be able to

CO 1	Explain various manufacturing processes.

CO 2	Select the type of casting process one has to adopt for manufacturing a designed component.
CO 3	Choose the types of joining process required for joining of metals
CO 4	Demonstrate the deformation behavior of a material during processing.
CO 5	Define the advantages and applications of powder metallurgy.
CO 6	Illustrate the operations of metal forming and forging.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20ME2181	Mechanics of Solids Lab	PCC	0-0-3	1.5

Course Objectives:

1. The objective is to learn the fundamental concepts of stress, strain, and deformation of solids with applications to bars, beams, and columns.
2. Detailed study of engineering properties of materials is also of interest.
3. Fundamentals of applying equilibrium, compatibility, and force deformation relationships to structural elements are emphasized.
4. To study the elastic behavior of the materials in linear, shear and torsional loads.
5. The students are introduced to advanced concepts of flexibility and stiffness method of structural analysis.
6. The course builds on the fundamental concepts of engineering mechanics course.

Course Contents:

Experiment I: To study the stress-strain characteristics (Tension) of ductile and brittle materials by using UTM.
Experiment II: To study the stress-strain characteristics (Compression) of ductile and brittle materials by using UTM.
Experiment III: To carry out bending test (III-point bending mode) using UTM
Experiment IV: To carry out shear test on steel using UTM.
Experiment V: To determine the young's modulus of elasticity of material of beam with simply supported end conditions.
Experiment VI: Determination of the hardness using Brinell, Rockwell and Vickers Hardness tester
Experiment VII: To determine the notched and un-notched Impact strength using Izod Impact tester.
Experiment VIII: To determine the notched and un-notched Impact strength using charpy Impact tester.
Experiment IX: To conduct torsion test on MS rods.
Experiment X: Spring test (Compression and Elongation).
Experiment XI: To determine the Euler buckling load experimentally and to compare it with Euler's theory.
Experiment XI: To study the fatigue strength of the materials.
Course Outcomes: At the end of course, the student will be able to

CO 1	Analyze the behavior of the solid bodies subjected to various types of loading.

CO 2	Apply knowledge of materials and structural elements to the analysis of simple structures.
CO 3	Undertake problem identification, formulation and solution using a range of analytical methods.
CO 4	Analyze and interpret Lab data relating to behavior of structures and the materials they are made of, and undertake associated Lab work individually and in teams.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2105	Computer Aided Machine Drawing	PCC	0-0-3	1.5

Pre-requisites: Engineering graphics and Computer Drafting.

Course objectives:

1. To familiarize with the standard conventions for different materials and machine parts in working drawings.
2. To make part drawings including sectional views for various machine elements.
3. To prepare assembly drawings given the details of part drawings.
4. To learn about computer aided drafting techniques
5. To be familiarize with one of the most powerful software.
6. Use of software to prepare drawing of different machine elements.

Course contents:

Unit I:

Introduction - Classification of Drawings,Introduction to Sectional views of Machine parts – Full section, Half section with examples.

Unit II:

Screwed fasteners – Nomenclature, Forms of threads, Multi start threads, Bolted joints, Foundation bolts. **Riveted joints** – Introduction, Nomenclature, Classification of Riveted joints.

Unit III:

Keys, Cotter, and Pin-joints – Introduction, Saddle keys, Sunk Keys, Round keys, Woodruff key. Cotter joint with sleeve, socket and spigot joint, Cotter joint with Gib and Knuckle joint.

Unit IV:

Shaft couplings - Box and split muff couplings, Flanged, Flexible, Universal and Oldham couplings. **Shaft bearings** – Journal bearings including Plummer block and Foot step bearing, Brackets and Hangers. Welding symbols.

Unit V:

Introduction to Modeling – Types like 2D wire frame, 3d wireframe, surface modeling and solid modeling, View ports**;** Creation of 3D Primitives like Cylinder, Cone**;** Creation of Simple Machine Parts related to Part Drawing using Modeling Software like CATIA, Creo and Solid Works.

Unit VI:

Assembly drawing – Creation of various engine components and machine tool components (Preferably Stuffing box, Eccentric, Screw jack, Plummer block, Petrol Engine Connecting rod and

Lathe tail stock) by Modeling Software like CATIA, Creo and Solid Works and Assembling them.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Develop engineering and working drawings with dimensions and bill of material during design and development.
CO 2	Develop assembly drawings using part drawings of machine components.
CO 3	Explain Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs, ribs.
CO 4	Distinguish the types of sections – selection of section planes and drawing of sections and auxiliary sectional views. Parts not usually sectioned.
CO 5	Demonstrate Types of Drawings – working drawings for machine parts.

References/Text Books:

1. Narayana, K. L. *Machine drawing*. New Age International, 2009.
2. Gill, P. S. "*A book on machine drawing*." 2001.
3. Bhattacharyya, Basudeb. *Machine Drawing*. Oxford University Press, 2011.
4. Pohit, Goutam. *Machine Drawing with AutoCAD*. Pearson Education India, 2004.

Course Nature		**Theory + Lab**		
Assessment Method				
Assessment Tool	Weekly Charts	Monthly tests (3)	End Semester Test	Total
	Average (Min 8 experiments)	Best of two (Max Marks-20)	Max Marks-60	
Weightage (%)	20%	20%	60%	100%

II YEAR
II SEMESTER

Course code	Course Name	Course Category	L-T-P	Credits
20ME2201	Design of Machine Elements	PCC	3-1-0	4

Pre-requisites: Engineering Mechanics, Mechanics of Solids, Manufacturing Processes, Metallurgy and Material Science.

Course Objectives:

1. To understand the general design procedures and principles in the design of machine elements.
2. To study different materials of construction and their properties and factors determining the selection of material for various applications.
3. To determine stresses under different loading conditions.
4. To provide an over view on different machine elements and their applications
5. To learn the design procedure of different fasteners, joints, shafts and couplings.
6. To learn the design procedures of different riveted and weld joints.

Course Contents:

Unit I: **(8 contact hours**

Introduction - General considerations & procedure of Machine Design, Common engineering materials & their mechanical properties, Material selection, Modes of failure, Theories of failure, Factor of safety

Unit II: **(12 contact hours)**

Design for static and dynamic load - Design for fluctuating stresses – Endurance limit – Estimation of Endurance strength – Gerber's curve– Modified Goodman's line– Soderberg's line. Stress concentration–Theoretical stress Concentration factor– Fatigue stress concentration factor- Notch Sensitivity – Design for fluctuating stresses.

Unit III: **(12 contact hours)**

Riveted joints - methods of failure of riveted joints strength equations-efficiency of riveted joints-eccentrically loaded riveted joints.

Welded joints - Design of fillet welds-axial loads-circular fillet welds under bending, torsion. Welded joints under eccentric loading.

Design of bolted joints

Unit IV: **(12 contact hours)**

Keys, Cotters and Knuckle Joints - Design of keys-stresses in keys - cottered joints- spigot and socket, sleeve and cotter, jib and cotter joints-Knuckle joints.

Unit V: **(8 contact hours)**

Shafts: Design of solid and hollow shafts for strength and rigidity – Design of shafts for combined bending and axial loads – Shaft sizes – BIS code.

Unit VI: **(8 contact hours**

Shaft Couplings: Rigid couplings – Muff, Split muff and Flange couplings. Flexible couplings – Flange coupling (Modified).

Course Outcomes: At the end of the course, students will be able to

CO 1	Identify the principles of design, material selection, component behavior subjected to loads, and criteria of failure.
CO 2	Distinguish the various types of loadings and the behavior of materials to these Loads
CO 3	Formulate the concepts of principal stresses, stress concentration in machine members and fatigue loading
CO 4	Evaluate machine component design on the basis of strength and rigidity
CO 5	Analyze the stresses and strains induced in a machine element.
CO 6	Analyze the stresses and strains induced in fasteners, joints, shafts and couplings.

Text Books:

1. Bhandari, V. B. *Design of machine elements*. Tata McGraw-Hill Education, 2010.

References

1. Khurmi, R. S., and J. K. Gupta. *Machine Design*. S. Chand, 2005.
2. Shigley, Joseph Edward, and Larry D. Mitchell. "Mechanical engineering design." McGraw-Hill Book Co., 1983, (1983): 869.
3. Fundamentals of Machine Design Vol 1 , Ajeet Kumar, Cambridge University Press, 2017
4. Fundamentals of Machine Design Vol 2, Ajeet Kumar, Cambridge University Press, 2017

Web Resources: https://nptel.ac.in/courses/112105125//
https://nptel.ac.in/courses/112105124//

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20ME2202	Dynamics of Machinery	PCC	3-1-0	4

Pre-requisite: Kinematics of machinery

Course Objectives:

1. The objective is to introduce some of the components mainly used in IC Engines and make analysis of various forces involved.
2. Subject deals with topics like inertia forces in slider crank mechanism; IC Engine components & the analysis like governors is introduced.
3. It also deals with balancing of rotating & reciprocating parts.
4. Studies are made about balancing of multi cylinder engines, Radial engines etc. study of primary & secondary forces are considered while balancing.
5. Finally, they are introduced to the topic of vibrations. The study deals with linear, longitudinal, & torsional vibrations.
6. The idea is to introduce the concept of natural frequency and the importance of resonance and critical speeds.

Course Contents:

Unit I: **(12 contact hours)**

Static Force Analysis; Reciprocating Engine Mechanism, Quick Return Mechanism, Four Link Mechanism, Friction in Linkages, Slider in Equilibrium under the Action of Concurrent Forces, Slider in Equilibrium under the Action of Non concurrent Forces, Inertia Forces of A Reciprocating Engine Mechanism, Four Link Mechanism, Quick Return Mechanism, More Details of Reciprocating Engine Mechanism.

Unit II: **(12 contact hours)**

Dynamics of Reciprocating Engine Mechanism, Correction Torque, Bearing Loads of A Reciprocating Engine Example, Turning Moment Diagram and Flywheel, Turning Moment Diagram and Crankshaft Speed Fluctuation, Fly Wheel, Flywheel of An Internal Combustion Engine, Flywheel of A Punch Press, Analytical Expressions for the Turning Moment, Flywheel for Reciprocating Machinery.

Unit III: **(8 contact hours)**

Balancing of rotating components; Unbalance in one Plane, Unbalance in Several Planes, Balancing Machines Balancing of Linkages; Inertia Force of A Reciprocating Mass,Balancing of Multi cylinder In-Line Engine, Firing Order.

Unit IV: **(10 contact hours)**

Mechanisms for Control: Governors and Gyroscopes; Illustration Of Mechanisms In Control, Governors, Watt Governor, Porter Governor, Pronell Governor, Performance Parameters,

Spring Controlled Fly-Ball [Hartnell] Governor, Spring Controlled Governor With Auxiliary Spring [Wilson-Hartnell Governor], Spring Controlled Governor with Bell Crank attached to the Sleeve, Hartung Governor, Pickering Governor, Governor Effort and Power, Controlling Force, Friction and Insensitiveness, Centrifugal Effect of the Revolving Arms.

Unit V: **(8 contact hours)**

Gyroscopes, Gyroscopic Forces and Couple, Thin Rod Rotating About Its Centroidal Axis, Gyroscopic Stabilization, Stability of A Four Wheel Vehicle Moving on A Curved Path, Stability of A Two Wheel Vehicle.

Unit VI: **(10 contact hours)**

Introduction to Mechanical vibrations-Types of vibrations, Longitudinal vibrations; Free and Forced vibrations (un damped) ,Whirling of shafts, Torsional vibrations (single Rotor and Two-rotor system), critical speeds of shafts. Damped vibrations, effect of damping, vibration isolation.

Course Outcomes: At the end of the course, students will be able to

CO 1	Explain various mechanisms used in machines
CO 2	Analyze stabilization of sea vehicles, aircrafts and automobile vehicles.
CO 3	Evaluate frictional losses, torque transmission of mechanical systsms.
CO 4	Analyze dynamic force analysis of slider crank mechanism and design of flywheel.
CO 5	Evaluate the natural frequencies of continuous systems starting from the general equation of displacement. .
CO 6	Solve problems related to balancing of reciprocating and rotary masses.

Learining Resource Books

1. Rattan, Sarjit S. *Theory of Machines*. Tata McGraw-Hill Education, 2014.

Reference Books:

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. *Theory of Machines and Mechanisms*. Vol. 1. New York, NY: Oxford University Press, 2011
2. Mallik, Asok Kumar, Amitabha Ghosh, and Gunter Dittrich. *Kinematic Analysis and Synthesis of Mechanisms*. CRC Press, 1994.

Web Resources: https: //nptel.ac.in/courses/112101096//
https://nptel.ac.in/courses/112104114//

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2203	Fluid Mechanics & Hydraulic Machinery	PCC	3-1-0	4

Course Objectives:

1. To learn about the properties of fluids
2. To understand the statics of fluid and kinematics & kinetics of fluid flow
3. To understand internal and external flow of fluids
4. To understand the importance of dimensional analysis
5. To obtain the force exerted by a jet of fluid on various configurations of plates
6. To analyze the flow in hydraulic turbines and pumps

Course contents:

Unit-I: **(Contact hours 8)**

Introduction and Basic concepts : Definition of fluid, distinction between a fluid and a solid, concept of continuum, Properties of fluids- mass density, specific weight, specific volume, specific gravity, dynamic and kinematic viscosity, Newton's law of viscosity, variation of viscosity with temperature, vapour pressure, boiling point, cavitation, compressibility and surface tension, capillarity.

Pressure and Fluid Statics : Fluid pressure at a point, Pascal's law, pressure variation with temperature, density and altitude, Measurement of pressure- Piezometer, U-Tube Manometer, Single Column Manometer, U-Tube Differential Manometer, Micro manometers, pressure gauges, Hydrostatic forces on horizontal, vertical, inclined and curved surfaces, Buoyancy and stability of floating and submerged bodies.

Unit-II: **(Contact hours 10)**

Kinematics of Fluids: Lagrangian and Eulerian description, Classification of fluid flow - steady and unsteady flow; uniform and non-uniform flow; laminar and turbulent flow; rotational and irrotational flow; compressible and incompressible flow; ideal and real fluid flow; one, two and three dimensional flows; Stream line, path line, streak line and stream tube; stream function, velocity potential function. One-, two- and three - dimensional continuity equations in Cartesian coordinates, velocity and acceleration, types of motion of fluid, vortex flow.

Dynamics of Fluid: Euler equation, Bernoulli's equation and its applications (Venturimeter, orifice meter and pitot tube), Reynolds transport theorem - conservation of mass, Navier-Stokes equations Vortex Flow – Free and Forced.

Unit-III: **(Contact hours 10)**

Internal Flow: Loss of head through pipes, Darcy-Wiesbatch equation, minor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel, flow through siphon, power transmission through pipes, analysis of pipe networks, water

hammer in pipes, frictional loss in pipe flow, shear stress and velocity distribution in pipe flow.

External flow: Boundary Layer Analysis-Assumption and concept of boundary layer theory. Boundary-layer thickness, displacement, momentum & energy thickness, laminar and Turbulent boundary layers on a flat plate; Laminar sub-layer, smooth and rough boundaries, local and average friction coefficients, separation and Control of Boundary layer.

Unit-IV: **(Contact hours 10)**

Laminar and Turbulent flow: Laminar Flow- Laminar flow through circular pipes, annulus and parallel plates, Stoke's law. Turbulent Flow- Reynolds experiment, Transition from laminar to turbulent flow, definition of turbulence, scale and intensity, Causes of turbulence, instability, mechanism of turbulence and effect of turbulent flow in pipes. Reynolds stresses, semi-empirical theories of turbulence, Prandtl's mixing length theory, universal velocity distribution equation, Resistance to flow of fluid in smooth and rough pipes, Moody's diagram.

Dimensional analysis: introduction, Non dimensional numbers: Reynolds, Froude, Euler, Weber and Mach number, Dimensional homogeneity, methods of dimensional analysis-Rayleigh's method and Buckingham Pi theorem, model analysis, similitude, dimensionless numbers and its significance, model laws.

Unit-V: **(Contact hours 10)**

Fluid Machinery: Hydraulic Pumps: Centrifugal pumps- parts of a centrifugal pumps, work done by the centrifugal pump, multistage centrifugal pump, specific speed of centrifugal pump,priming of centrifugal pump, characteristic curves of centrifugal pumps and cavitation. Reciprocating pumps- parts of a reciprocating pump, work done by reciprocating pump, slip of reciprocating pump, indicator diagram.

Unit VI: **(Contact hours 12)**

Fluid Machinery: Hydraulic turbines: classification of turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine-working proportions, work done, efficiencies, hydraulic design –draft tube- theory functions and efficiency.

Performance of hydraulic turbines: Geometric similarity, Unit and specific quantities, characteristic curves, governing of turbines, selection of type of turbine, cavitation, surge tank, water hammer problem.

Course Outcomes: At the end of the course, students will be able to

CO 1	Analyze mathematically fluid flow situations and they will be able to evaluate the performance of turbines and pumps.
CO 2	Identify importance of various fluid properties at rest and in transit.
CO 3	Derive and apply general governing equations for various fluid flows

CO 4	Explain the concept of boundary layer theory and flow separation
CO 5	Create velocity and pressure profiles for any given fluid flow.
CO 6	Evaluate the performance characteristics of hydraulic turbines and pumps

Text Books:

1. R. K. Bansal, *Fluid Mechanics and Hydraulic Machines*, Laxmi Publications, Revised Ninth Edition, 2017.
2. P. M. Modi and S. M. Seth, *Hydraulics and Fluid Mechanics including Hydraulic Machines,*, Standard Book House.

References

1. Som & Biswas, *Introduction to Fluid Mechanics and Fluid Machines*, TMH, 2003.
2. Yunus A.Cengel, Jhon M. Cimbala, *Fluid Mechanics*, McGraw-Hill, 2006.
3. Sadhu Singh, *Fluid Mechanics*, Khanna Publishing House, Delhi.
4. Introductory Fluid Mechanics, *Katz, Cambridge Univeristy press*, 2014.
5. Frank. M. White, *Fluid Mechanics*, McGraw-Hill, 2008.

Video Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Fluid Mechanics	Prof. S.K. Som	IIT Kharagpur	http://nptel.ac.in/courses/112105171/

Text Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Introduction to Fluid Machines and Compressible Flow	Prof. S.K. Som	IIT Kharagpur	**http://nptel.ac.in/courses/112105182/**

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2204	Metal Cutting and Machine Tools	PCC	3-1-0	4

Course Learning Objectives:

1. To know and learn general mechanics of machining
2. To know in detail tool life & Wear
3. To identify lathe, milling, drilling machines
4. To identify Geometry of cutting tools
5. To identify jigs and fixtures.
6. To identify shapers, planers and slotters.

Course Content:

Unit – I (10 Contact hours)

Machining: Introduction, classification of manufacturing process, History of machining, scope and significance of machining, Concept of Generatrix and Directrix: Generatrix, Directrix and tool-work motion for various cutting tools; Geometry of cutting tools: geometry of single point cutting tools: Tool in hand, ASA system, Significance of SPTT, Orthogonal rake angle (ORS), Normal Rake System (NRS).

Unit – II (10 Contact hours)

Mechanics of machining: Chip formation mechanism, classification of chips, characteristics of continuous chip formation, shear angle, cutting strain, chip reduction coefficient, built up edge formation, orthogonal and oblique cutting, shear plane and shear zone theories, shear strain rate, cutting force analysis and estimation, Merchant circle diagram, power and specific energy in cutting, effects of tool geometry on cutting force, turning dynamometers principle and working.

Unit - III (10 Contact hours)

Heat generation and cutting temperature: Location of heat generation, effects of cutting temperature on job and tool, determination of cutting temperature using analytical techniques, Determination of cutting temperature using experimental techniques, control of cutting temperature and role of cutting fluid, effect of cutting tool geometry on cutting temperature, failures of cutting tools, cutting tool materials.

Tool life & Wear: Types of cutting tool wear, Wear mechanism, Types of tool wear, Tool life equation, cutting tool materials: Desired properties of tool material, Characteristics of cutting tool material, conventional and advanced cutting tool materials.

Unit - IV (10 Contact

hours)

Estimation of machining time: machining time for Lathe, drilling, milling, boring, shaping and planning; definition of machinability, control of chips and chip breakers, surface quality, characteristics of surface profile, evaluation, control of surface roughness and improvement of surface integrity.

Grinding & super finishing operations: Basic principles, grinding wheel specification, mechanism and mechanics of grinding, grindability, lapping, honing, super finishing techniques; **Economics of machining:** economy and optimization.

Unit - V **(10 Contact hours)**

Machine tool: Introduction to common machine tools and its operation for lathe, drilling, milling, grinding, broacher, reamers, shaper and planer. Design of high speed gear box: Layout of spindle speeds, gear layout and ray diagram.

Lathe Machine: Types of lathe machine, Parts of lathe machine, Specification of lathe machine, Attachments used in lathe machine, work holding and tool holding devices of different types of lathe machine, Kinematics of lathe machine, Capstan & turret lathes, Multi spindle automatic lathe, operations performed on lathe.

Drilling machine: Types of drilling machine, parts of drilling machine, Specification, Attachments, work holding, tool holding devices and operations of different types of drilling machine, kinematics of drilling machine.

Unit VI **(10 Contact hours)**

Milling machine:

Types of milling machine, parts of milling machine, Specification, Attachments, work holding, tool holding devices, operations of different types of milling machine, kinematics of milling machine.

Shaping, Planning & slotting machine:

Type of machines, specification, attachments, work holding, tool holding, and operations performed, kinematics of machines,

Gear Cutting: Principles, Universal indexing head utility, Different types of indexing; **Jig & fixtures:** principles of design of Jigs and fixtures, classification, principles of location and clamping, types of clamping & work holding devices, typical examples of Jigs and fixtures.

Learning resources Text

Books:

1. P.N. Rao, "*Manufacturing technology Metal Cutting and Machine Tools*", Vol. II, McGraw Hill, 3rd edition, 2013.
2. H Choudhury, *"Elements of Workshop Technology Vol: 2 Machine Tools*", Media promoters & publisher, 2010.

Reference Books:

1. B.S. Raghuwanshi, "*Workshop Technology*", vol. II, 10th edition, Dhanpat Rai & co, 2009.
2. Amitabhaghosh, A.S. Malik, "*Manufacturing Science*", East West

press, 2nd edition, 2010.
3. M. C. Shaw, "*Metal Cutting Principles*", Oxford, 2rd edition, 2012.
4. A.B. Chattopadhyay, "*Machining and Machine Tools",* Wiley Publications, 2011.
5. Manufacturing process, Casting, Forming and Welding
H S Shan, 2017, Cambridge University Press

Video Resources:

IIT Kharagupur, April 14 2010,'Manufacturing process II' URL:
http://nptel.ac.in/downloads/112105127/

Course outcomes: At the end of the course, the student will be able to

CO 1	Explain principles and strategies of machining
CO 2	Evaluate the estimation of machining time
CO 3	Identify the effects of heat generation and cutting temperature
CO 4	Inspect the grinding and super finishing operations
CO 5	Analyze the effects of tool geometry on cutting force
CO 6	Distinguish orthogonal and oblique cutting

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MA2201	Probability and Statistics	BSC	3-0-0	3

Course Learning Objectives:

1. Providing students with a formal treatment of probability theory.
2. Equipping students with essential tools for statistical analysis.
3. Fostering understanding through real-world statistical applications.
4. Develop skills in presenting quantitative data using appropriate diagrams, tabulations.
5. Use appropriate statistical methods in the analysis of simple datasets.
6. Instill the belief that Statistics is important for scientific research.

Course Content:

Unit – I

Probability: (8 Contact hours)

Probability introduction through Sets and Relative Frequency, Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem and Independent Events.

Unit – II

Distributive Functions: (10 Contact hours)

Discrete distributions: Bernoulli, Binomial, Poisson, Negative Binomial, Geometric and hyper geometric distributions (Find their mean, variance and problems). Continuous distributions: Uniform, Exponential, Normal, Beta and Gamma distributions.

Unit - III

Moment generating Functions (8Contact hours)

Functions of Random Variables, Correlation coefficient and Bivariate Normal Distribution. Probability Inequalities and Generating Functions, Moment Generating Function, Characteristic Function, Cumulant Generating Function, Probability Generating Function.

Unit – IV

Order statistics and Central limit theorem (08 Contact hours)

Order Statistics, Convergence of Sequence of Random Variables, Weak Law of Large Numbers, Strong Law of Large Numbers, Central Limit Theorem.

Unit – V

Sampling theory (6 Contact hours)

Definition of population, sampling, statistics and parameters. Types of sampling, Expected values of sample mean and variance, sampling distribution, standard error, sampling distribution of mean and sampling distribution of variance.

Unit-VI: **(6 Contact hours)**

Sampling –Distributions

Sampling -Distributions (t, F and Chi-square), confidence interval and interval estimation.

Learning resources

Text book:

1 William W. Hines and Douglas C. Montgomery, '*Probability and Statistics in Engineering'*, Willy Publications, 4th Edition.

Reference Books:

1. Sheldon Ross, '*A First Course in Probability'*, Pearson Publications, 9th Edition.
2. Athanasios Papoulis and S. Unnikrishna Pillai, '*Probability, Random Variables and Stochastic Processes'*, TMH, 4th Edition,.

Web resources:

1. https://nptel.ac.in/courses/117105085/
2. https://nptel.ac.in/courses/111106112/
3. https://nptel.ac.in/courses/111102111/
4. RGUKT Course Content

Course outcomes: At the end of the course, the student will be able to

CO 1	Apply Probability theory via Bayes Rule.
CO 2	Describe the properties of Discrete and Continuous distributions.
CO 3	Apply problem-solving techniques to solving real-world events.
CO 4	Apply selected probability distributions to solve problems.
CO 5	Develop problem-solving techniques needed to accurately calculate probabilities.
CO 6	Interpret and clearly present output from statistical analysis.

Probability and Statistics		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weight age (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2281	Metal cutting and Machine Tools Lab	PCC	0-0-3	1.5

Prerequisites: Manufacturing Process and Metal Cutting & Machine Tools

Course learning objectives:

1. To give basic idea of different types of machining processes like turning, milling, drilling etc.
2. To introduce the different types of machine tools used in machining of materials.
3. To make the students understand the tool nomenclature
4. The students are required to understand the parts of various machine tools and operate them.
5. They are required to understand the different shapes of products that can be produced on these machine tools.

Course content:

List of Experiments:

Lathe Machine Operations

1. To perform step turning on a given sample
2. To perform taper turning on a given sample
3. To perform knurling operation and thread cutting on a given sample
4. To perform thread cutting on a given sample

Shaping & Slotting Operations

5. Conversion of circular rod into square rod
6. To Make internal splines, space 90^0apart on the given hollow cylindrical work piece by using slotting machine.

Drilling operations

7. To perform drilling, tapping on the given workpiece according to the given dimensions

Milling Operations

8. Perform gear tooth cutting using milling machine
9. To perform surface milling on a metal work piece using milling machine

Grinding Machine Operations

10. To perform surface grinding operation on the given sample to the required dimensions

Tool design

11. Prepare a single point cutting tool as per the given nomenclature

Course outcomes: At the end of the course, the student will be able to:

CO 1	Get familiarity with Lathe machine and perform various Lathe operations.
CO 2	Get familiarity with Milling machine and perform different Milling operations
CO 3	Perform Drilling and Surface Grinding operations on different machines
CO 4	Operate different machine tools with understanding of work holders and operating principles to produce different part features to the desired quality.
CO 5	The student will understand the tool nomenclature and can be able to grind tool material.

Text Books:

1. S. K. Hajra Chowdary, A.K. Hajra B Chowdary, Nirjhar Roy*,"Elements of Workshop Technology,* Vol. I". Media Promoters and Publishers Pvt.Ltd, Mumbai,Scitech Publications, Chennai, 2013.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2282	Fluid Mechanics & Hydraulic Machinery Lab	PCC	0-0-3	1.5

Course Objectives:

To know various fluid flow measurements and to understand the principles and performance characteristics of fluid flow devices.

List of Experiments

1. Closed circuit Venturimeter
   (a) To calibrate a given Venturimeter and to study the variation of coefficient of discharge of it with discharge
2. Closed circuit orifice meter test rig
   (a) To calibrate a given orifice meter and to study the variation of coefficient of discharge of it with discharge
3. Orifice and free jet flow
   (a) Determination of coefficient of velocity from jet trajectory
   (b) Determination of coefficient of discharge under constant head
   (c) Determination of coefficient of discharge under varying head
4. Free and forced vortices
   (a) Investigation of forced vortices
   (b) Investigation of free vortices
5. Multistage centrifugal pump
   (a) To study the characteristics of multistage (2 stage) centrifugal pump, to calculate the efficiency and draw the following curves:
      - Discharge vs head
      - Discharge vs efficiency
      - Discharge vs power
6. Performance characteristics of variable speed centrifugal pump
7. Calibration of rotameter
8. Francis turbine
   (a) To determine the operation Francis turbine and to determine its typical operation characteristics

Text books

1. Kumar, K. L. *Engineering Fluid Mechanics*. S. Chand Publishing, 2008.
2. Jagdish Lal, *Hydraulic Machines*, Metropolitan Book Co, Delhi, 1995

Course Outcomes: At the end of the course, the student will be able to

CO1	Develop procedure for standardization of experiments.
CO2	Calibrate flow discharge measuring device used in pipes channels and tanks.
CO3	Determine fluid and flow properties.
CO4	Characterize laminar and turbulent flows.
CO5	Compute drag coefficients.
CO6	Test the performance of pumps and turbines.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course name	Course Category	L-T-P	Credits
20HS2201	Indian Constitution	MC	2-0-0	0

Course Learning Objectives:

1. The basic objective of the course is to provide knowledge about institutions
2. It help to understands the processes to governing the society in a systematic way.
3. It helps to establish social Justice, Liberty, Equity and Fraternity.
4. The course will introduce the idea of political system in general
5. It provides idea about working process of constitutional institutions.
6. To create awareness about the functioning of the judicial system in India.

Course Contents:

Unit I: **(5 Contact hours)**

Introduction-Constitution' meaning of the term, Indian constitution sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and duties, Directive Principles of State Policy.

Unit II: **(5 Contact hours)**

Union Government and its Administration-Structure of the Indian Union: Federalism, centre-state relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok sabha, Rajya sabha.

Unit III: **(5 Contact hours)**

Election commission- Election commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Unit IV: **(3 Contact hours)**

State Government and its Administration- Governor: Role and position, CM and Council of ministers, state secretariat: Organization, structure and functions.

Unit V: **(5 Contact hours)**

Local Administration-District's Administration head: Role and importance, Municipalities: Introduction, Mayor and role of Elected Representatives, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role, Block level: Organizational Hierarchy (different departments), Village level: Role of elected and appointed officials, Importance of grass root democracy.

Unit VI: **(5 Contact hours)**

Union Judiciary-Establishment and constitution of Supreme court, Appointment of Judges, Establishment of State High court, Establishment of common High court for 2 or more states, WRITS, PIL(Public Interest Litigation).

Learning resources

Text book:

1. Durga Das Basu, *Constitutions of India*, 23rd ed, LexisNexis Publication.

Reference Books:

1. 'Indian Polity' by Laxmikanth
2.'Indian Administration' by Subhash Kashyap
4.'Indian Administration' by Avasti and Avasti
5.'Government and Politics of India' by W.H.Mrrison Jones
6.'Constitution of India' by J.C.Johari

Course outcomes: At the end of the course, the student will be able to

CO 1	The students will understand their fundamental rules and duties.
CO 2	The students will learn the political system and the system of elections in India.
CO 3	It is to provide the students the institutions and processes to govern themselves in the manner they prefer.
CO 4	Students can also be able to utilize the laws and facilities provided by constution
CO 5	It will provide over all idea about our legal system.
CO 6	It will enable students more strong in terms of law and practice in day to day life.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weight age (%)	0	0	100%	100%

III YEAR
SEMESTER I

Course code	Course Name	Course Category	L-T-P	Credits
20ME3101	Heat Transfer	PCC	3-1-0	4

Course Objectives:

1. The aim of the course is to build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection and radiation.
2. To provide the platform to understand the concept of steady and unsteady conduction.
3. To provide the platform to understand the concept of forced and free convection.
4. To provide the platform to understand the concept of radiation
5. To provide the platform to understand the concept of heat exchanger and different type of heat exchanger
6. To provide the platform to understand the concept of condensation and boiling

Course contents:

Unit I: **(6 hours)**

Introduction: Introduction, Modes of heat transfer (Conduction, Convection, Radiation), Material properties of importance in heat transfer, thermal conductivity, Specific heat capacity, combined modes of heat transfer, concept of thermal contact resistance.

Unit II: **(12 hours)**

Heat Conduction: Steady state one-dimensional heat conduction with and without generation of heat in simple geometries: plane wall, cylindrical and spherical walls, electrical analogy, critical thickness of insulation, extended surfaces (fins) heat transfer : fin equation (Infinitely Long Fin, Negligible Heat Loss from the Fin Tip (Insulated fin tip),Convection (or Combined Convection and Radiation)), fin efficiency, fin effectiveness, Heat transfer in common configurations: plane walls, long cylinders, spheres, conduction shape factor, 2D steady state heat conduction, Unsteady conduction: Lumped heat capacity system, transient heat conduction in infinite and semi-infinite walls, Heisler chart, Biot number.

Unit III: **(12 hours)**

Convection: Forced convection: Non dimensional numbers and its physical meanings: Nusselt, Prandtl and Reynolds number, Derivation of energy equation, concept of thermal boundary layer and derivation of thermal boundary layer equation, flat plate in parallel flow (solution by energy integral method), cylinder in cross flow, internal flows: concept of thermally fully developed flow and its corollaries, fully developed pipe flow, fully developed channel flow with constant

wall heat flux, turbulent flow in pipes, Reynolds analogy. **Free convection:** Vertical plate at constant temperature, derivation of governing equation, recognition of dimensionless terms, and solution by integral method.

Unit IV: (10 hours)

Heat Exchangers: Classification of heat exchangers (parallel heat exchanger, counter flow heat exchanger, compact heat exchanger, cross-flow heat exchanger, Shell-and-tube heat exchanger, Regenerative heat exchanger, ccondenser, Boiler, concept of fouling factor, overall heat transfer coefficient, analysis of heat exchangers: LMTD and NTU methods.

Unit V: (10 hours)

Condensation and Boiling: Pool boiling – regimes- calculations on nucleate boiling, critical heat flux and film boiling. Film wise and drop wise condensation –nusselt's theory of condensation on a vertical plate - film condensation on vertical and horizontal cylinders using empirical correlations.

Unit VI: (10 hours)

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks. Computer aided heat transfer analysis with cases dealt in the class and visualize temperature distribution.

Learning resources

Text Books:

1. J. P. Holman, *Heat Transfer*, Eighth Edition, McGraw Hill, 1997

References:

1. . A. Bejan, *Heat Transfer*, John Wiley, 1993
2. F. P. Incropera, and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, John Wiley, Sixth Edition, 2007.
3. Massoud Kaviany, *Principles of Heat Transfer*, John Wiley, 2002
4. Yunus A Cengel, *Heat Transfer: A Practical Approach*, McGraw Hill, 2002
5. Heat Transfer, Sanford Klein, 2012 Cambridge University Press

Video Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Heat and Mass Transfer	Prof. U. N. Gaitonde, Prof. S. P. Sukhatme	IIT Bombay	**http://nptel.ac.in/courses/112101097/**

Course Outcomes: After completing the course, the students will be clearly able to

CO 1	Evaluate the concept of conduction and solve practical problems related to conduction.
CO 2	Analyze the concept of convection and solve practical problems related to forced and free convection.
CO 3	Analyze the concept of radiation and solve practical problems related to radiation.
CO 4	Evaluate the concept of heat exchanger and analyze different types of heat exchanger.
CO 5	Evaluate to improve the heat exchanging capacity of a heat exchanger.
CO 6	Analyze the practical problems related to radiation heat transfer in day to day life.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3102	Design of Transmission Elements	PCC	3-1-0	4

Pre-requisite: Design of Machine Elements

Course Objectives:

1. Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmission systems.
2. Reinforce the philosophy that real engineering design problems are open-ended and challenging
3. Impart design skills to the students to apply these skills for the problems in real life industrial applications
4. Inculcate an attitude of team work, critical thinking, communication, planning and scheduling through design projects
5. Create awareness amongst students about safety, ethical, legal, and other societal constraints in execution of their design projects.
6. Develop an holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems

Course contents:

Unit I: **(Contact hours 8)**

Design of springs: Helical, compound and leaf springs.

Unit II: **(Contact hours 10)**

Clutches & Brakes: Design of Clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and Band brakes: Self locking of brakes: Heat generation in Brakes**.**

Unit III: **(Contact hours 10)**

Design of belt drives: Belts, Ropes and Chains: Flat belts: Length & cross section, Selection of V-belts, ropes and chains for different applications.

Unit IV: **(Contact hours 12)**

Spur & Helical Gears: Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, Design for strength, Dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads.

Unit V: **(Contact hours 10)**

Lubrication and Bearings: Lubricants and their properties, Mechanisms of Lubrication, Bearing modulus, coefficient of friction, minimum oil film thickness, Heat Generated, Heat dissipated, Bearing Materials, Introduction to rolling contact bearings - Selection of Ball Bearings.

Unit VI: **(Contact hours 10)**

Design of IC engines parts: piston, connecting and crankshaft.

Learning resources

Textbooks

1. V.B. Bhandari,*Design of Machine Elements,* Tata McGraw Hill Publishing Company Ltd., New Delhi.

References

1. Joseph E. Shigley and Charles R. Mischke. *Mechanical Engineering Design:* McGraw Hill International Edition,
2. Robert L. Norton, *Machine Design:* Pearson Education Asia.
3. Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S. K. Somani,*Machine Design:* Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition.
4. Andrew D Dimarogonas, *Machine Design: A CAD Approach*: John Wiley Sons, Inc.

Course Outcomes: At the end of the course, students will be able to

CO 1	Understand and apply principles of design of a helical and leaf springs
CO 2	Synthesis the design of clutches and brakes
CO 3	Design belt drives, rope and chain drives for various applications.
CO 4	Design spur gears and helical gears for various applications
CO 5	Analyze rolling contact bearing and its selection from manufacturer's catalogue.
CO 6	Expertise in design of sliding contact bearing in industrial applications.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3103	Applied Thermodynamics	PCC	3-1-0	4

Course learning Objectives:

1. To familiarize with the terminology associated with IC engines and to understand the basics of IC engines.
2. To understand combustion, and various parameters and variables affecting it in various types of IC engines.
3. To learn about various systems used in IC engines and the type of IC engine required for various applications
4. To learn about the different types of gas turbine engines
5. To understand the basics of compressors and turbines
6. To understand the concept of rocket propulsion

Course contents:

Unit-I: Internal Combustion Engines (10 Contact hours)

Basic engine components, working principles of engines, classification of IC engines, application of IC engines, engine performance parameters, air standard cycles – Carnot, Stirling, Ericsson, Otto, Diesel, Dual, Lenoir, Atkinson, Brayton Cycles, Comparison of cycles, Testing and performance characteristics, Heat balance and Indicator Diagrams.

Unit-II: (10 Contact hours)

Fuels and Fuel ratings, Fuel feed systems - Carburetor, Mechanical & Electronic Fuel injection systems, Ignition Systems - Battery and Magneto ignition systems.

Unit-III: (10 Contact hours)

Normal and abnormal combustion in SI and CI Engines, Design and operating Parameters affecting engine performance, engine friction and lubrication, heat rejection and cooling, engine emissions and their control, Rotary Engines, Supercharging.

Unit V: Gas Turbine engine: (10 Contact hours)

Simple gas turbine cycle – single and twin shaft arrangements, intercooling, reheating, regeneration, closed cycles, optimal performance of various cycles, combined gas and steam cycles; Introduction to Axial-Flow Gas Turbine; Introduction to Centrifugal and Axial-Flow Compressors; Combustion Chambers.

Unit VI: Compressors (10 Contact hours)

Classification –positive displacement and roto dynamic machinery – Power producing and power absorbing machines, fan, blower and compressor – positive displacement and dynamic types – reciprocating and rotary types.

Reciprocating: Principle of operation, work required, Isothermal efficiency volumetric efficiency and effect of clearance, stage compression, under cooling, saving of work, minimum work condition for stage compression.

Unit VI: Jet and rocket propulsion **(10 Contact hours)**

Principle of jet propulsion, turbojet, turboprop, turbofan, pulsejet, ramjet, scramjet, thrust and propulsive efficiency; Rocket Propulsion**:** Introduction, principles of rockets, characteristics of rocket propulsion, classification of rockets, solid, liquid and nuclear propellant rocket, electrical arc plasma rocket.

Course Outcomes: At the end of the course, students will be able to

CO 1	Demonstrate the working of IC engines and effect of different parameters on the operational characteristics of IC Engines
CO 2	Describe the different types of cycles used in IC Engines
CO 3	Analyze the performance parameters of IC Engines
CO 4	Ccalculate the performance parameters of gas turbine engines
CO 5	Apply the compressor and turbine concepts in gas turbine engines
CO 6	Calculate the performance parameters of rocket engine

Learning resources

Text Books:

1. M. L. Mathur & R. P. Sharma, *Internal combustion engines,* Dhanpat Rai Publications, 2013.
2. H. Cohen, GFC. Rogers and HIH Saravanamuttoo, *Gas Turbine Theory*, Longman House, Burnt Mill, Harlow, 1996.

References

1. V Ganesan, *Internal Combustion Engines*, TMH, 2006.
2. Jack D. Mattingly, *Elements of Gas Turbine Propulsion,* TMH, 2005.
3. George P. Sutton, Oscar Biblarz, Rocket Propulsion Elements, John Wiley & Sons, 2001.

Video Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Basic Thermodynamics	Prof. S.K. Som	IIT Kharagpur	nptel.ac.in/courses/112105123/

Text Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Applied Thermodynamics	Prof. T. Sundararajan, Prof. U.S. Premananda Shet, Prof. J.M. Mallikarjuna	IIT Madras	http://nptel.ac.in/courses/112106133/

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3104	Metrology and Mechanical Measurements	PCC	3-0-0	3

Prerequisites: Basics of Mechanical Engineering & Engineering Physics

Course Objectives:

1. To understand the standards of measurement, principles of linear and angular measuring instruments.
2. To get acquainted with limits, fits, tolerances, interchangeability and gauge design
3. To understand the surface roughness terminology and types of various surface roughness measuring instruments and gear measurements terminology
4. To get acquainted with systems of mechanical measurements
5. To understand the principles of force and strain measuring instruments
6. To understand the measurement of temperature and flow measurement

Course contents:

Unit-I **(Contact hours: 10)**

Introduction: Definition and Concept of Metrology; Need of Inspection, Principles of Measurement, Measuring system and Accuracy of Measurement, Precision andAccuracy, Errors in Measurement, Material Standards, Wavelength Standards, Classification of standards, Line and End standards, Calibration of End bars. Numerical examples.

Liner measurement: Linear Measuring instruments; Steel rule, Calipers, Surface plate etc.; Testing flatness of surface plate; Tool Makers flat, V-block, Straight edge, Spirit level, Combination square etc, Precision Linear Measurement: Types of Verniers, Micrometers etc. Slip gauges-Indian standards on slip gauges, Adjustable slip gauges, Wringing of slip gauges, Problems on building of slip gauges (M87, M112).

Measurement of angles and tapers: Different methods, bevel protractor, angle slip gauges,

spirit levels, sine bar, sine plate, rollers, and spheres

Unit-II **(Contact hours: 7)**

Systems of limits, fits & Tolerances: Introduction, nominal size, tolerance limits, deviations, allowance, fits and their types, unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly. Indian Standard Institution System, British Standard System, International standard system for plain and screwed work.

Limit gauges: Taylor's principle, design of GO and NO GO gauges, plug, ring,

snap, gap, taper, profile and position gauges.

Unit-III **(Contact hours:7)**

Measurement of screw thread:

Terminology of screw threads, Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods, Best size wire. Screw thread gauges, Toolmaker's microscope.

Gear tooth Measurements: Tooth thickness measurement using constant chord method,

Addendum, Comparator method and Base tangent method, Measurement of pitch, Concentricity, Run out and Involute profile. Gear roll tester for composite error.

Unit–IV **(Contact hours: 7)**

Surface roughness measurement: Differences between surface roughness and surface waviness-numerical assessment of surface finish, CLA, R.M.S values, Rz values, methods of measurement of surface finish-Tomlinson's surface meter, profilograph, Talysurf, ISI symbols for indication of surface finish.

Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, optical flats and their uses, interferometer.

Geometric Shapes: Measurement of Straightness, Flatness, Parallelism, Squareness Testing, Circularity, Roundness testing.

Machine tool alignment tests: Alignment tests on lathe, milling, drilling machine tools, Coordinate measuring machine (CMM): Types of CMM, Role of CMM, and applications of CMM.

Unit–V **(Contact hours: 7)**

Mechanical measurement: Need of mechanical measurement, basic definitions: hysteresis, linearity and resolution of measuring instruments, threshold, drift, zero stability, loading effect and system response. Measurement methods, generalized measurement system, static performance characteristics, errors and their classification.

Transducers:

Transfer efficiency, Primary and Secondary transducers, Electrical transducers, Mechanical, Electronic transducers, Relative comparison of each type of transducers.

Measurement of force & torque: Force measurement: load cells, cantilever beams, proving rings, differential transformers. Measurement of torque: torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers

Measurement of Speed and acceleration: Mechanical, electrical and photoelectric tachometers, piezoelectric accelerometer, seismic accelerometer.

Unit–VI **(Contact hours: 7)**

Measurement of strain: Theory of strain gauges, Types, Electrical resistance strain gauge,

Preparation and mounting of Strain gauges, Gauge factor, Methods of strain measurement.

Temperature measurement and temperature measuring devices: Thermocouples, resistance temperature detectors, thermistor, liquid in glass thermometers, pressure thermometers, pyrometer, bi-metallic strip, Calibration of temperature measuring devices, numerical examples on flow measurement.

Measurement of Pressure: Elastic Transducers, Dead-weight Pressure gauge, McLeod gauge, Pirani gauge

Learning resources

Text Book:

1. Mahajan, *Engineering Metrology*, Dhanpat Rai & Co, 2010

Reference Books:

1. Bewoor, Anand K., and Vinay A. Kulkarni. *Metrology and Measurement.* McGraw-Hill Education, 2009.
2. Kumar, D.S., *Mechanical Measurements and Control*, Metropolitan, New Delhi.
3. Doeblein, E.O., "*Measurement Systems, Application Design*", McGraw Hill.
4. R. K. Jain, *Engineering Metrology*, Khanna Publishers, 19/e, 2005.
5. I.C. Gupta, *Engineering Metrology*, Dhanpat Rai & Sons, 2003
6. Raghavendra and Krishnamurthy, *Engineering Metrology and Measurements*, Oxford Publications, 2014
7. Thomas G Beckwith, *Mechanical Measurements*, Pearson publications.
8. Ernest O Doebelin, *Measurement systems,* Tata McGraw Hill publications.

VIDEO REFERENCE LINKS:

Title	**Expert Name**	**Details of Expert**	**Web link**
Mechanical Measurements and Metrology	Prof. Shunmugam M. S Prof. S.P. Venkateshan	IIT Madras	http://nptel.ac.in/courses/112106138/

WEB LINKS:

Title	Expert Name	Details of Expert	Web link
Mechanical Measurements and Metrology	Prof.Shunmugam M. S Prof. S.P. Venkateshan	IIT Madras	http://nptel.ac.in/courses/112106139/

Course outcomes: At the end of the course, the student will be able to:

CO 1	Understand the standards of measurement, principles of linear and angular measuring instruments
CO 2	Apply the concepts of limits, fits, tolerances, interchangeability and gauge Design
CO 3	Understand the surface roughness terminology and types of various surface roughness measuring instruments and gear measurements terminology
CO 4	Make use of different parameters of mechanical measurement systems
CO 5	Identify the principles of force and strain measuring instruments.
CO 6	Analyze and evaluate temperature and flow measurement

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3181	Metrology and Mechanical Measurements Lab	PCC	0-0-3	1.5

Prerequisites: Metrology & Mechanical Measurements

Metrology Lab

1. To calibrate the measuring instruments like Vernier caliper, Digital vernier caliper, Vernier height gauge, Vernier depth gauge, outside micrometer and inside micrometer.
2. Measurement of angles.
3. Inspection of crank shaft and jig plate.
4. Application of tool maker's microscope and profile projector.
5. Gear measurement and calibration of dial gauge.

Mechanical Measurements Lab

1. Calibration of pressure gauge using dead weight tester.
2. Study and calibration of LVDT transducer for displacement measurement.
3. Study and calibration of magnetic pickup sensor for the measurement of speed.
4. Calibration of capacitance transducer for angular displacement.
5. Study and calibration of torque measurement using AC induction motor.
6. Study and calibration of strain gauge for force and displacement measurement.
7. Study and calibration of impact by using piezoelectric transducer.
8. Study and calibration of static torque using fulcrum and weight.
9. Study and calibration vibration sensor.
10. Study and check the work of mechanical proving ring.
11. Study and calibration of the strain gauge.
12. Study and calibration of the pressure gauge.

Course outcomes: At the end of the course, the student will be able to

CO 1	Calibrate the Linear Measurement tools.
CO 2	Measure the taper angle of bore gauge, gear tooth thickness and elements of thread.
CO 3	Determine stresses in the material by using strain gauges.
CO 4	Calibrate displacement by using transducers
CO 5	Determine torque by using induction motor & Fulcrum and weight
CO 6	Conduct Alignment tests on machine tool.

Reference Books:

1. Bewoor, Anand K., and Vinay A. Kulkarni. *Metrology and Measurement.* McGraw-Hill Education, 2009.
2. Kumar, D.S., *Mechanical Measurements and Control,* Metropolitan, New Delhi.
3. Doeblein, E.O., "*Measurement Systems, Application Design*", McGraw Hill.
4. R. K. Jain, *Engineering Metrology*, Khanna Publishers, 19/e, 2005.
5. I.C. Gupta, *Engineering Metrology*, Dhanpat Rai & Sons, 2003
6. Raghavendra and Krishnamurthy, *Engineering Metrology and Measurements*, Oxford Publications, 2014
7. Thomas G Beckwith, *Mechanical Measurements*, Pearson publications. Ernest O Doebelin, *Measurement systems,* Tata McGraw Hill publications

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3182	Heat Transfer Lab	PCC	0-0-3	1.5

Objectives:

1. To demonstrate the concepts discussed in the Heat & Mass Transfer course
2. To experimentally determine thermal conductivity and heat transfer coefficient through various materials.
3. To experimentally measure effectiveness of heat exchangers
4. To conduct performance tests on refrigeration & air conditioning systems

List of Experiments:

1. Determination of thermal conductivity of a metal rod.
2. Determination of overall heat transfer co-efficient of a composite slab.
3. Determination of efficiency of a pin-fin.
4. Determination of heat transfer coefficient in natural convection.
5. Determination of heat transfer coefficient in forced convection.
6. Determination of emissivity of a given surface.
7. Determination of Stefan Boltzman constant.
8. Determination of effectiveness of parallel and counter flow heat exchangers.
9. Determination of heat transfer rate in drop and film wise condensation.
10. Determination of Thermal diffusivity of material in transient heat conduction

Course Outcomes:

CO 1	To practically relate to concepts discussed in the Heat & Mass Transfer course.
CO 2	To conduct various experiments to determine thermal conductivity and heat transfer coefficient in various materials
CO 3	To select appropriate materials & designs for improving effectiveness of heat transfer.
CO 4	To conduct performance tests and thereby improve effectiveness of heat exchangers.

Text Books:

1. J. P. Holman, *Heat Transfer*, Eighth Edition, McGraw Hill, 1997

References:

1. . A. Bejan, *Heat Transfer*, John Wiley, 1993
2. F. P. Incropera, and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, John Wiley, Sixth Edition, 2007.

3. Massoud Kaviany, *Principles of Heat Transfer*, John Wiley, 2002
4. Yunus A Cengel, *Heat Transfer: A Practical Approach*, McGraw Hill, 2002

5. Heat Transfer, Sanford Klein, 2012 Cambridge University Press

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3183	Applied Thermodynamics Lab	PCC	0-0-3	1.5

Objectives:

To understand the principles and performance characteristics of thermal devices

List of Experiments:

1. Determination of flash & fire points of a given liquid fuels
2. Determination of the viscosity of a given fuel oil
3. Flame propagation and stability
   a. Studying the characteristics of flame stability and methods to improve the stability limits
   b. Determination of flame speed based on cone method
   c. Determination of relation between flame speed and air-fuel ratio
   a. Smithells flame separation demonstrations
4. Determination of the Calorific value of a given fuel
5. Determination of performance characteristics of Four Stroke Petrol Engine
6. Determination of performance characteristics of Four Stroke Diesel Engine
7. Determination of performance characteristics of Four Cylinder Diesel Engine
8. Determination of performance characteristics of Variable Compression Four Stroke Single Cylinder Engine (Multi-Fuel Engine)
   a. Plotting a power curve
   b. Determination specific fuel consumption and efficiency
   c. Determining volumetric efficiency and air ratio
   d. Influence of compression ratio on petrol engine
   e. Influence of ignition point on petrol engine
   f. Determining the optimum ignition point
9. Performance test on vapor compression refrigeration test rig
10. Determination of performance characteristics of Absorption Refrigeration System.
11. Performance test on air conditioning test rig.

Outcomes:

The students who have undergone the Lab will be able to measure various properties of fuels and characterize the performance of thermal machinery.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course Code	Course Name	Course Category	L – T - P	Credits
20EG3182	English Language Communication Skills Lab-II	HSC	0-0-3	1.5

Course objectives:

1. To improve group discussion skills of the students
2. To help the students to write their CV and Internship application
3. To improve the telephonic etiquettes of the students
4. To help the students to take decision on their career

Course Content

Unit -I: **(06 Contact Hours)**

Group Discussion - How to think and analyze - How to initiate a topic - How to continue a topic - How to support or reject a point-of-view - How to defend your position - Managing distractions and mediating between contenders - How to summarize & conclude

Unit -II: **(06 Contact Hours)**

Telephonic conversation & Etiquettes - How to introduce oneself - How to introduce the main issue - How to keep the other person engaged - How to convince the other person - How to complain without irritating. - Giving assurance and asking for clarification - How to end a formal telephonic conversation

Unit -III: **(06 Contact Hours)**

Career Planning & Job-Skill Analysis - ASK: Talking about one's Attitudes, Knowledge, & Skills - SMART goals - Reading & Analysis of Job Advertisements

Unit -IV: **(06 Contact Hours)**

CV & Resume Writing - Difference between CV & Resume - Writing CV - Writing Resume - Writing Cover Letter

Unit -V: **(06 Contact Hours)**

Application for Internship - Application for internship in Academic Labs - Application for internship in Industries - Follow up the Application with reminders and requests

Unit -VI: **(06 Contact Hours)**

Interview Skills - Preparation for the Interview - Frequently asked questions - Dress Codes, Appearance, and Etiquettes. 6.4 Facing the Interview

References:

1. *Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson
2. British Council Material on Career Planning & Interviews
3. *Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs* by Sheetal Desarda, Notion Press
4. *Group Discussion and Interview Skills* by Priyadarshi Patnaik , Cambridge University Press India
5. *The Ultimate Guide to Internships: 100 Steps to Get a Great Internship and Thrive in It* by Eric Woodard
6. Telephone Etiquette by Robert DeGroot

Course outcomes: At the end of the course, the student will be able to

CO 1	Get used to a variety of GDs to understand the principles, finer nuances, and intricacies of the art
CO 2	Get exhaustive information on how to prepare for internship and interview
CO 3	Write his/her CV to remain well-prepared for the interviews
CO 4	Take decision on his/her career goals and plans
CO 5	Attain professional speaking skills to enhance his/her employability skills.

Assessment Method:

Course Nature: LAB

Internal Assessment (40 Marks)		**External Assessment (**60 Marks)	
Record Writing	– 10 Marks	Reading Comprehension	– 15 Marks
Attendance	– 10 Marks	Writing	– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)		Speaking (Viva-Voce)	– 15 Marks

III YEAR
II SEMESTER

Course code	Course Name	Course Category	L-T-P	Credits
20ME3201	Operations Research	PCC	3-1-0	4

Course Learning Objectives:

1. To formulate and solve mathematical model (linear programming problem) for a physical situations like production, distribution of goods and economics.
2. To identify the importance of minimization and maximization issues in transportation / manufacturing decision making.
3. To solve the assignment problems based on Hungarian method and also to obtain the knowledge of TORA.
4. To understand the game theory models.
5. To analyze the various project alternatives and estimate economic life of an asset.
6. To obtain the knowledge of queuing models and apply the same to industrial problems.

Course Content:

Unit – I **(Contact hours 12)**

Linear programming problems

Development of OR, Scope and applications of OR, Formulation of LP Models, Graphical solution, Simplex Method, Two phase method, Big M method, Duality theory.

Unit – I **(Contact hours 12)**

Transportation Problems

Mathematical form of transportation problem, balanced and unbalanced transportation problems, Initial basic feasible solution, North west corner method, least cost method, Vogel's approximation method, Optimality test, Modified distribution method, Degeneracy, Maximization case.

Unit – III **(Contact hours 8)**

Assignment Problems

Mathematical formulation of assignment problems, Hungarian method, Traveling salesman problems, Case studies on assignment problems. Introduction to TORA.

Unit – IV **(Contact hours 8)**

Game theory

Simple games, Two-person, zero sum game, Maximin and Minimax principles, Saddle point method, principle of dominance, Graphical method, 2×n and m×2 games.

Unit – V **(Contact hours 10)**

Replacement models

Failure mechanism of items, Bathtub curve, Replacement of items that deteriorate

with time- value of money changing with time- not changing with time- Individual and group replacement policy.

Unit – VI **(Contact hours 10)**

Queuing Models

Elements of queuing models, Poisson arrival and exponential service time distributions, M/M/1 Queue; Finite population models. Queuing cost models, Applications.

Text books:

1. Panneerselvam, *"Operations Research"* Prentice Hall of India", PHI, 2018.

Reference Books:

1. Taha, Hamdy A. *Operations research: an introduction*. 2007.
2. Hillier, Frederick S., and Gerald J. Lieberman. *Introduction to operations research*. McGraw-Hill Science, Engineering & Mathematics, 1995.
3. Gupta, PREM KUMAR, and Man Mohan. "Problems in operations research." *S. Chand & Company-2002* (2006).
4. Sharma, S. D. *"Operations Research"* Kedarnath Publisher, Meerut, 17th Edition 2014.

Web resources:

Title	**Expert Name**	**Details of Expert**	**Web link**
NPTEL video on Operations Research	Prof. S Srinivasan	IIT Madras	https://nptel.ac.in/syllabus/112106134/

Course outcomes: At the end of the course, the student will be able to

CO 1	Apply mathematics, science, computing and engineering knowledge to Operations Research problems.
CO 2	Solve the problem of transporting the products from origins to destinations with
	least transportation cost
CO 3	Solve the problem of assignment between jobs and operators optimally.
CO 4	Identify best strategies to be played by two players in a game
CO 5	Make a decision such as when to replace the existing equipment and best alternative to be selected
CO 6	Apply queuing theory for performance evaluation of engineering and management systems.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20ME3202	Finite Element Method	PCC	3-1-0	4

Course Objectives:

1. To learn basic principles of finite element analysis procedure.
2. To learn the theory and characteristics of finite elements that represent engineering structures.
3. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others.
4. Learn to model complex geometry problems and solution techniques.
5. To use commercially available software finite element method
6. To know when to use 1D, 2D , 3D elements in practical problems.

Unit I: **(Contact hours 10)**

Introduction: Equilibrium equations in elasticity subjected to body force, traction forces, and stress-strain relations for plane stress and plane strains. General dMEription of Finite Element Method, Application and limitations. Types of elements based on geometry. Node numbering, Half band width.

Unit II: **(Contact hours 10)**

Basic Procedure: Euler - Lagrange equation for bar, beam (cantilever / simply supported fixed) Principle of virtual work, principle of minimum potential energy, Raleigh's Ritz method. Direct approach for stiffness matrix formulation of bar element. Galerkin's method.

Unit III: **(Contact hours 10)**

Interpolation Models: Interpolation polynomials- Linear, quadratic and cubic. Simplex complex and multiplex elements. 2D PASCAL's triangle. CST elements-Shape functions and Nodal load vector, Strain displacement matrix and Jacobian for triangular and rectangular element.

Unit IV: **(Contact hours 10)**

Solution of 1-D Bars: Solutions of bars and stepped bars for displacements, reactions and stresses by using penalty approach and elimination approach. Guass-elimination technique.

Higher Order Elements: Langrange's interpolation, higher order one dimensional elements-Quadratic and cubic element and their shape functions. Shape function of 2-D quadrilateral element-linear, quadric element Iso- parametric, Sub

parametric and Super parametric elements. Numerical integration: 1, 2 and 3 gauge point for 1D and 2D cases.

Unit V: **(Contact hours 10)**

Trusses: Stiffness matrix of Truss element. Numerical problems.Beams: Hermite shape functions for beam element, Derivation of stiffness matrix. Numerical problems of beams carrying concentrated, UDL and linearly varying loads.

Unit VI: **(Contact hours 10)**

Heat Transfer: Steady state heat transfer, 1D heat conduction governing equations. Functional approach for heat conduction. Galerkin's approach for heat conduction. 1D heat transfer in thin fins.

References/Text Books:

1. David V. Hutton, *Fundamentals of Finite Element Analysis*
2. Seshu, P and Verlag, *Finite Element Methods.*

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the concepts behind variational methods and weighted residual methods in FEM.
CO 2	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element.
CO 3	Develop element characteristic equation procedure and generation of global stiffness equation will be applied.
CO 4	Apply Suitable boundary conditions to a global structural equation
CO 5	Identify how the finite element method expands beyond the structural domain
CO 6	Use commercial software like ABAQUS to solve design problems

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20BM3201	Managerial Economics and Financial Analysis	HSC	3-0-0	3

Course Learning Objectives:

1. To strengthen students managerial skill.
2. To enhance the conceptual clarity in economic concepts.
3. To develop to forecasting capability.
4. It will help to produce multi-disciplinary thought.
5. It will enhance their conceptual and practical/hand on practice in accounting.
6. It will help to implement and understand the uses of ratios.

Course Contents:

Unit I: **(6 hours)**

Introduction to managerial economics, consumer behavior, demand, demand analysis, demand forecasting, supply, supply analysis.

Unit II: **(7 hours)**

Theory of production, production functions, concept of cost, cost analysis, break even analysis.

Unit III: **(6 hours)**

Market structure-monopoly, oligopoly, monopolistic, prefect market; Types of business organizations-sole proprietorship, partnership, private ltd. Companies and public ltd. Companies, formation of company.

Unit IV: **(8 hours)**

Introduction to capital, capital sources, capital budgeting- NPV, IRR, Payback period, profitability index.

Unit V: **(8 hours)**

Introduction to financial accounting, rules of debit-credit, Double-Entry Book Keeping, Journal, Ledger, Trial Balance- Final Accounts (Trading Account, Profit and

Loss Account and Balance Sheet with simple adjustments, Preparation of

final account and other related accounting statements.

Unit VI: **(10 hours)**

Financial statements, comparative statement analysis, common- size statement analysis,

,ratio analysis, time series (only theories).

Learning resources

Text book:

1. Aryasri, A. R., *Managerial Economics & Financial Analysis*, McGraw Hill, 2014.

Reference Books:

1. Siddiqui., *Managerial Economics & Financial Analysis*, 2e, New Age International Private Limited, 2017.
2. . Pandey, I.M., "*Financial Management*", 11e, Vikas Publishing House, 2015.
3. . Prasanna Chandra., "*Financial Management: Theory and Practice*", 9e, Mc Graw Hill Education, 2015.
4. Principles of Engineering Economics with Applications, Khan Zahid, 2018, Cambridge University press.

Web resources:

1. Managerial Economics and Financial Analysis, Dr. Trupti , IIT Bombay

http://nptel.ac.in/courses/110101005/

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand basic economics as well as management concepts.
CO 2	This subject will provide implication facilities of concepts.
CO 3	Do primary data collection and classification.
CO 4	Forecast as well as generate trend series by utilizing the available secondary data.
CO 5	They have basic knowledge about accounting and its terminologies.
CO 6	Prepare and understand accounting tables.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME3281	Computer Aided Modeling and Simulation Lab	PCC	0-0-3	1.5

Course Objectives:

1. To impart the student's skills required for modelling and analysis using software package.
2. To impart skills required for writing MAT LAB Code
3. To study 2D and 3D beam deflections by using simulation software.
4. To study thermal analysis and fluid flow analysis by using simulation software.

Learning Outcomes:

Students will be able to

1. Model simple mechanical parts using modeling package
2. Analyze different engineering problems using analysis package
3. Write and execute MAT Lab code for solving engineering problems.

List of experiments:

a) Using Modeling Package: (Any three experiments)

1. Sketching of a drawing with dimensions
2. Modeling of Stuffing Box parts
3. Assembly of parts of Flanged Coupling
4. Modeling of parts of Eccentric and generation of orthographic views
5. Modeling of links of four bar mechanism and simulation of mechanism

b) Using analysis Package: (Any six experiments)

1. 2- D truss analysis.
2. Static Analysis of Beam.
3. Static Analysis of 3-D structure.
4. Steady state Heat Transfer Analysis.
5. Transient thermal analysis
6. Free vibration analysis of Beam.
7. Harmonic Analysis of a Beam
8. Analysis of Axisymmetric Problem.
9. Analysis of Plane Stress problem.
10. Stress analysis of a composite plate.
11. Buckling analysis of column.
12. Optimization of cantilever beam.
13. Fluid analysis of elbow using Ansys Fluent

14. Fluid flow and Heat Transfer analysis of elbow using ANSYS FLUENT
15. Radiation and Natural Convection analysis by using ANSYS FLUENT
16. Transient thermal analysis of a Cylindrical Pipe

C) Using MATLAB (Any two experiments)

Introduction to MATLAB–Vector and Matrix Manipulations–Matrix functions– Tools for Polynomials – Non linear algebraic equations - Solving Differential equations– writingfunctionsubroutines– basicinputandoutputfunctions–plotting functions.

1. Analysis of Bar structure using Finite Element Method
2. Analysis of Beam Structure using Finite Element Method
3. Analysis of Truss using Finite Element Method
4. Displacement, velocity and acceleration analysis of four bar mechanism.

Open Ended Experiment:

- Analysis of connecting rod with composite material

Reference Books:

1. Sham Tickoo, *SOLID WORKS 2017 for Designers*, CAD CIM Technologies, 3rd Edition
2. Saeed Moaveni, *Finite Element Analysis: Theory and Application with ANSYS*, Pearson Publishers
3. Rao V Dukkipati, *MATLAB for Mechanical Engineers*, New Age International Publishers.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20EG3283	English Language Communication Skills Lab-III	HSC	0-0-3	1.5

Course objectives:

1. To improve interpersonal skills of the students
2. To help the students to write professional letters and reports
3. To practice the etiquettes to be used at workplace
4. To reward hands on experience on managing meetings
5. To imbibe leadership qualities in the students

Course Content

Unit -I: **(06 Contact Hours)**

Professional Presentation - Collecting & Reading the materials to be presented - Analyzing the main points - Summarizing & concluding - Developing PPT - Delivery of the Presentation

Unit -II: **(06 Contact Hours)**

Report Writing & Writing Professional Emails & Applications – Routine Reports – Investigative Reports - Professional Emails - Formal Letters and Applications

Unit -III: **(06 Contact Hours)**

Agenda, Meetings, & Minutes - Setting the agenda for a meeting - Managing a meeting - Keynote address & vote of thanks - Publishing the minutes

Unit -IV: **(06 Contact Hours)**

People skills and small talks (2 minutes) - Talking to professional executives - Talking to colleagues - Talking to the boss - Talking to your team - Talking to the media delegates

Unit -V: **(06 Contact Hours)**

Corporate Etiquettes - How to introduce & greet - How to raise a question - How to clarify a doubt - How to say “yes” or “no” - Rapport building - Dining & winning - Counseling somebody - How to influence & motivate

Unit -VI: **(06 Contact Hours)**

Life Skills - Leadership communication - Interpersonal communication - Stress management - Time Management

References:

Business Communication Today, 12th Edition, Courtland L Bovee & John Thill, Pearson

1. British Council Material on communication
2. Training in Interpersonal Skills: Tips f: Tips for Managing People at Work **by** Robbins and Hunsaker
3. Soft Skills for Everyone, with CD **Paperback –**by Jeff Butterfield
4. Communication for business by Shirley Taylor, Pearson

Course outcomes: At the end of the course, the student will be able to

CO 1	The art of professional presentation
CO 2	Write professional reports and letters
CO 3	Conduct a formal meeting
CO 4	Develop people skills and corporate etiquettes
CO 5	Gain the basic knowledge about leadership communication, stress management and time management

Assessment Method:

Course Nature: LAB

Internal Assessment (40 Marks)		**External Assessment (**60 Marks)	
Record Writing	– 10 Marks	Reading Comprehension	– 15 Marks
Attendance	– 10 Marks	Writing	– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)		Speaking (Viva-Voce)	– 15 Marks

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PROFESSIONAL CORE ELECTIVES DESIGN STREAM

Course code	Course name	Course Category	L-T-P	Credits
20MEXX21	**Mechanical Vibrations**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To get adequate knowledge on different modes of vibrations
2. To analyze the different problems occurred in vibrations
3. To know the different measuring instruments used for measurement of vibrations
4. To get the knowledge on role of spring mass system in vibrations
5. To get the knowledge on different methods in vibrations
6. To get the idea of different analysis used in vibrations

Course contents

Unit I: **(Contact hours 7)**

Introduction: Types of vibrations, Definitions, Simple Harmonic Motion (S.H.M.), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier atheorem and problems. Undamped (Single Degree of Freedom) Free Vibrations: Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring.

Unit II: **(Contact hours 8)**

Damped free vibrations (1DOF): Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and Problems. Forced Vibrations (1DOF): Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping.

Unit III: **(Contact hours 7)**

Vibration Measuring Instruments and Whirling of shafts: Seismic Instruments, Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Whirling
of shafts with and without damping, discussion of speeds above and below critical speeds.

Unit IV: **(Contact hours 8)**

Systems with two degrees of Freedom: Principle modes of vibrations, Normal mode and natural frequencies of systems (without damping) – Simple spring mass systems, masses on tightly stretched strings, double pendulum, torsional systems, combined rectilinear and angular systems, geared systems and Problems. Undamped dynamic vibration absorber.

Unit V: **(Contact hours 7)**

Numerical Methods for multi degree freedom of systems: Introduction, Maxwell's reciprocal theorem, Influence coefficients, Rayleigh's method, Dunkerley's method, Stodola method, Holzer's method, Orthogonality of principal modes, method of matrix iteration.

Unit VI: **(Contact hours 8)**

Modal analysis and Condition Monitoring:Signal analysis, dynamic testing of machines and structures, Experimental modal analysis, Machine condition monitoring and diagnosis.

References:

1. W.T. Thomson, *Theory of Vibration with Application*
2. K Ogata, *Modern Control Engineering*.
3. B C Kuo and F. Golnaraghi, *Automatic Control Systems*.
4. R.E.D Bishop The mechanics of Vibration, Cambridge University Press, 2011

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the different problems encountered in vibrations in the real world
CO 2	Understand the different parameters involved in vibrations and apply the parameters while solving the problems.
CO 3	Measure the vibrations by using different measuring instruments.
CO 4	Solve different applications affected by the vibrations.
CO 5	Solve different problems by using different methods.
CO 6	Analyze the machines which are at typical vibrating conditions.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX22	Tribology	PEC	3-0-0	3

Course Objective:

1. To understand the concept of tribology and gain knowledge to solve practical problems incurred in tribology.
2. To provide the students with the fundamental concepts and principles of tribology and lubrication, with emphasis on the design, selection and performance of the main lubricated components such as pistons, bearings, gears etc.
3. The tribological and lubrication principles taught in this module will provide a basis for tackling tribological challenges encountered not just in traditional engineering applications but also in the newly emerging fields such as biotribology, environmental tribology
4. To understand the concepts of wear and different wear mechanisms occur in a material.
5. To make the students understand the importance of lubrication and different types of lubricants used in current engineering applications.
6. To enhance the knowledge on application of tribology such as gears, bearings etc.

Course contents:

Unit I: **(Contact hours 7)**

Introduction: Introduction to tribology, History of tribology, Interdisciplinary Approach Economic Benefits.

Unit II: **(Contact hours 8)**

Friction: Causes of Friction, Adhesion Theory, Abrasive Theory, Junction Growth Theory, Laws of Rolling Friction, Friction Instability.

Unit III: **(Contact hours 7)**

Wear: Wear Mechanisms, Adhesive Wear, Abrasive Wear, Corrosive Wear, Fretting Wear

Unit IV: **(Contact hours 8)**

Lubrication and Lubricants :Importance of Lubrication, Boundary Lubrication, Mixed Lubrication, Full Fluid Film Lubrication; Hydrodynamic, Elasto hydro dynamic lubrication, Types & Properties of Lubricants, Lubricants Additives.

Unit V: **(Contact hours 8)**

Fluid film lubrication: Fluid mechanics concepts, Equation of Continuity & Motion, Generalized Reynolds Equation with Compressible & Incompressible Lubricants

Unit VI: **(Contact hours 7)**

Application of Tribology: Introduction, Rolling Contact Bearings, Gears, and Journal Bearings - Finite Bearings

Text Books:

1. Dowson D, *History of Tribology*, Longman London, 1979.

References

1. Stachowiak G N,Batchelor A W and Stachowick G B. "Experimental methods in Tribology", Tribology Series 44, Editor D Dowson, 2004.
2. Michael M Khonsari,Applied Tribology (Bearing Design and Lubrication),John Wiley & Sons, 2001.
3. Fundamentals of Engineering Tribology with Applications, Hirani Harish, 2015, Cambridge University Press

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyze properties of lubricant and selection of proper lubricant for the given application
CO2	Demonstrate evolution of friction, lubrication, and wear processes.
CO3	Evaluate the friction and wear behavior of the given materials.
CO4	Analyze the detailed operation of selected anti-friction or anti-wear components.
CO5	Evaluate anti-friction and anti-wear components and the lubricants used therein.
CO6	Solve the problems to design a tribological system for optimal performance.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX23	Advanced Mechanics of Solids	PEC	3-0-0	3

Course Objective:

1. To understand the different types of stresses
2. To learn the concept shearing for different types unsymmetrical cross sections
3. To get the adequate knowledge on columns.
4. To get the adequate knowledge on plates
5. To understand classification of beams and their support
6. To understand the concepts regarding stress concentration

Course Contents

Unit – I **(Contact Hours 7)**

Three dimensional stress and strain: Principal stresses and strains, Mohr's circle representation of tri axial stresses and strains.

Unit – II **(Contact Hours 8)**

Unsymmetrical bending: Shear centers for sections with one axis of symmetry, shear center for any unsymmetrical Section, stress and deflection of beams subjected to unsymmetrical bending.

Unit -III **(Contact Hours 7)**

Bending of plates: Basic definition, stress curvature and moment relations, deferential equation of plate deflection. Boundary conditions simply supported rectangular plates, axis symmetric loadedCircular plates.Contact stresses: Point and line contact.

Unit – IV **(Contact Hours 7)**

Buckling of columns: Beam columns single concentrated load, number of concentrated loads, continuous lateral Load, end couple, couples at both ends triangular loads.

Unit – V **(Contact Hours 8)**

Stress concentration: Stress concentration in tension or compression members. Stresses in a plate with a circular hole, elliptical hole, small semi-circular grooves.

Unit – VI **(Contact Hours 8)**

Beam on Elastic Foundations: General theory, infinite, semi infinite, finite beams classification of beams. Beam supported by equally spaced elastic elements.

Learning resources

Text books:

1. R.C. Ugural, S.K. Fenster, *Advanced Strength and Applied Elasticity*, Elsevier.

References

1. Hugh ford Longmans, *Advanced Mechanics of Solids.*

2. Timoshenko, *Strength of Material* part-11 affiliated East-West press pvt. Ltd, .N. Delhi

3. L.S Srinath, *Mechanics of Solids*

4. Abdul Muubeen, *Mechanics of Solid*

Course Outcomes: At the end of the course, the student will be able to

CO 1	Analyze the types of stresses for given problem
CO 2	Design the column for a given loading condition
CO 3	Solve the different types of problems involved in buckling of columns
CO 4	Design the beam for a stiffness criteria and strength criteria
CO 5	Analyze the effect of stress concentration for different problems
CO 6	Design a plate for given loading condition with different types of boundary Conditions

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX24	Theory of Plates & Shells	PEC	3-0-0	3

Course Objectives:

1. To enable the student analyze and design thin shell structures including plates and shells
2. To impart Knowledge on the analysis of different types of plates and shells under different boundary conditions.
3. To impart knowledge on the behavior of plates and shell elements, their places of utility and of course the design procedure of such elements in practical applications.
4. To provide a knowledge of the fundamentals of theory of shells and folded plates
5. To enable the students to design thin shell structures
6. To enable the students to design cylindrical shell structures

Course content:

Unit I: **(Contact Hours 7)**

Classical plate theory: Classical Plate Theory – Assumptions – Differential Equation – Boundary Conditions.

Unit II: **(Contact Hours 8)**

Plates of various shades:Navier's Method of Solution for Simply Supported Rectangular Plates –Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions.

Unit III: **(Contact Hours 8)**

Governing Equation – Solution for Axi-symmetric loading – Annular Plates – Plates of other shapes.

Unit IV: **(Contact Hours 7)**

Eigen value analysis: Stability and free Vibration Analysis of Rectangular Plates.

Unit V: **(Contact Hours 7)**

Approximate methods**:** Rayleigh – Ritz, Galerkin Methods– Finite Difference Method – Application to Rectangular Plates for Static, Free Vibration and Stability Analysis.

Unit VI: **(Contact Hours 8)**

Shells:Basic Concepts of Shell Type of Structures – Membrane and

Bending Theories for Circular Cylindrical Shells.

Text books:

1. Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw-Hill Book Co. 1990.\

References

1. Flugge, W. "Stresses in Shells", Springer – Verlag, 1985.
2. Timoshenko, S.P. and Gere, J.M., "Theory of Elastic Stability", McGraw-Hill Book Co. 1986.

Course Outcomes: At the completion of this course, the student will be able to

CO 1	Understand the Simple bending of Plates and Different Boundary Conditions for plates.
CO 2	Analyze circular plates subjected to different kinds of loads.
CO 3	Understand the concept of Material Orthotropy, Structural Orthotropy and Plates on elastic foundation
CO 4	Design various types of shells structures and folded pipes
CO 5	Apply theory of plates and shells, to problems solving various geometries and boundary conditions.
CO 6	Apply the concepts using commercial softwares.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX25	Rotor Dynamics	PEC	3-0-0	3

Course objective:

1. To learn the concepts of mechanical vibrations those are applied to different rotor systems.
2. To develop expertise regarding rotor dynamics and vibration in rotating machinery.
3. To give a basic understanding of the rotor dynamics phenomena with the help of simple rotor models and subsequently the modern analysis methods for real life rotor systems.
4. To basic knowledge on two degrees of freedom rotor system
5. To determine the torsional vibrations of rotating machinery and its natural frequencies.
6. To monitor the condition of rotor.

Course content:

Unit I: **(Contact Hours 7)**

Introduction to Vibration and the Laval-Jeffcott Rotor Model: Co-ordinate systems, Steady state rotor motion, Elliptical motion, Single degree of freedom systems, Free and forced vibrations.

Unit II: **(Contact Hours 8)**

The two degrees of freedom rotor system, Geared systems, Translational motion, Natural frequencies and Natural modes, Steady state response to unbalance, the effect of flexible support.

Unit III: **(Contact Hours 8)**

Torsional Vibrations of Rotating Machinery: Modeling of rotating machinery shafting, Multi degree of freedom systems, Determination of natural frequencies and mode shapes, Branched systems, Numerical methods for fundamental frequency.

Unit IV: **(Contact Hours 9)**

Rigid Rotor Dynamics and Critical Speed: Rigid disk equation - Rigid rotor dynamics, Rigid rotor and flexible rotor, The gyroscopic effect on rotor dynamics, Whirling of an unbalanced simple elastic rotor, Unbalance response, Orbital Analysis and Cascade Plots, Simple shafts with several disks, Effect of axial stiffness, Determination of bending critical speeds, Campbell diagram.

Unit V: **(Contact Hours 6)**

Influence of Bearings on Rotor Vibrations: Support stiffness on critical

speeds- Stiffness and damping coefficients of journal bearings, Computation and measurements of journal bearing coefficients, Mechanics of Hydro dynamic Instability, Half frequency whirl and Resonance whip, Design configurations of stable journal bearings.

Unit VI: **(Contact Hours 7)**

Balancing of Rotors: Single plane balancing, Multi-plane balancing, Balancing of rigid rotors, Balancing of flexible rotors, Influence coefficient and modal balancing techniques for flexible rotors.

Learning resources

Text Books:

1. Admas M. L. Jr, 2001, *Rotating Machinery Vibration: From Analysis To Troubleshooting*, Marcel Dekker, Inc., New York.

References

2. Biezeno, C. and Grammel, R, 1959, *Engineering Dynamics*, Vol III. of Steam Turbines, D.Van Nostrand Co., Inc., New York.
3. Chen, W. J., Gunter, E. J. (2005). *Introduction to Dynamics of Rotor-Bearing Systems.* ISBN 1-4120-5190-8
4. Childs D., 1993, *Turbomachinery Rotordynamics: Phenomena, Modeling and Analysis.* Research Studies Pub., A Wiley-Interscience Publication, NY.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Understand the different types of vibrations involved in different problems.
CO 2	Analysis using the modern methods for real life rotor systems
CO 3	Determine the whirling speed of rotor
CO 4	Identify the effect of bearings on rotor vibrations
CO 5	Monitor the condition of rotors
CO 6	Understand the concept of balancing of rotors and analyse the different rotor System

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX26	Vehicle Dynamics	PEC	3-0-0	3

Course Objective:

1. Be able to analyse the dynamics of road vehicles.
2. Be familiar with the terminology of road vehicle dynamics, stability and handling.
3. Understand the dynamics of vehicles on the road during normal operation as well as during impact scenarios
4. Develop creative and innovative solutions to engineering challenges in vehicles
5. Assess, acquire and apply the competencies and resources appropriate to engineering activities
6. Describe, investigate and analyse complex engineering systems and associated issues in vehicle systems

Course Contents

Unit I: **(Contact Hours 7)**

Introduction: Fundamentals of vibration, Mechanical vibrating systems. Modeling & simulation. Model of an automobile-Single, two, multi degrees of freedom systems-Free, forced and damped vibration. Magnification factor-Transmissibility, Vibration absorber.

Unit II: **(Contact Hours 8)**

Multi Degree of Freedom Systems: Closed coupled system, Eigen valve problems, Far coupled systems-Orthogonality of mode shapes-Modal analysis, Forced vibration by matrix inversion.

Unit III: **(Contact Hours 8)**

Suspension and Tyres: Requirements. Spring mass frequency. Wheel hop, wheel wobble, wheel shimmy. Choice of suspension spring rate. Calculation of effective spring rate. Vehicle suspension in fore and apt directions. Ride characteristics of tyres, behaviour while cornering, and power consumed by tyre, effect of driving and braking torque- Gough's tyre characteristics.

Unit IV: **(Contact Hours 7)**

Vehicle Handling: Oversteer, under steer, steady state concerning. Effect of braking, driving torques on steering. Effect of camber, transient effects in concerning. Directional Stability of vehicles.

Unit V: **(Contact Hours 7)**

Stability of Vehicles: Load distribution. Calculation of tractive effort and reactions for different drives-Stability of a vehicle on a slope, on a curve and a banked road.

Unit VI: **(Contact Hours 8)**

Numerical Methods: Approximate methods for fundamental frequency, Dunker-Ley's lower bound, Rayleigh's upper bound-Holzer method for close-coupled systems and branched systems.

Learning resources

Text Books

1. Thomas D Gillespie,"*Fundamentals of Vehicle Dynamics*", SAE USA 1992.

References

1. Wong J Y,"*Theory of Ground Vehicles*", John Wiley & Sons, New York, 1978.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Develop physical and mathematical models to predict the dynamic response of vehicles.
CO 2	Apply vehicle design performance criteria and how to use the criteria to evaluate vehicle dynamic response
CO 3	Extend the mathematical analysis of the passenger car to heavy vehicles.
CO 4	Characterize changes in vehicle performance and vehicle/roadway interaction.
CO 5	Identify the specifications for vehicle control systems.
CO 6	Modify a model of a vehicle to enable it to meet design performance criteria

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX27	Biomechanics	PEC	3-0-0	3

Course Learning Objective:

1. Biomechanics is a course that provides background in muskuloskeletal anatomy and principles of biomechanics.
2. The objective of this course is to provide you with an overview of the major challenges in movement biomechanics and experience with the engineering tools we use to address these challenges.
3. Identify relationships between structure and function in tissues and the implications/importance of these relationships.
4. Identify a given bone, ligament or muscle by name, anatomic location, or function
5. The course provides an overview of musculoskeletal anatomy, the mechanical properties and structural behavior of biological tissues.
6. The student will be able to describe the biological, mechanical, and neurological mechanisms by which muscles produce movement

Course content

Unit I: **(Contact Hours 7)**

Introduction: What is Biomechanics, History, Perspectives in Biomechanics; Rigid Body Bio Mechanics; Anatomical Concepts in Biomechanics.

Unit II: **(Contact Hours 7)**

Material Characterization of Tissues: Classification of Tissues, Properties of Tissues from Mechanics Point of View, Modeling of Tissues.

Unit III: **(Contact Hours 7)**

Mechanics of Skeletal Muscles: Skeletal Muscles as Elastic fibres in one dimension, viscous behavior, Non-linear viscoelasticity;

Unit IV: **(Contact Hours 8)**

Continuum Mechanics Concepts in Modeling of large deformation; Stress in three- dimensional continuous media.

Unit V: **(Contact Hours 8)**

Motion: The time as an extra dimension; Deformation and rotation, deformation rate and spin; Constitutive modeling of solids and fluids.

Unit VI: **(Contact Hours 8)**

Cardiovascular Mechanics: Cardiovascular Physiology, Blood Flow Models, Blood Vessel Mechanics, Heart Valve Dynamics, and Prosthetic Valve Dynamics

Learning Sources

Text Books:

1. Fung, Y. C, *Biomechanics: Mechanical Properties of Living Tissues*, Springer Verlag, New York, 1981.

References

1. Hall, Susan Jean, and Donna Lysell. *Basic biomechanics*. Vol. 2. St. Louis: Mosby, 1995.
2. Biomechanics, Concepts and Computation, 2/ed Cees Oomens, 2018, Cambridge University press

Course Outcomes: At the end of the course, the student will be able to

CO 1	Understand how the laws of physics can explain body structure and function of humans and animals.
CO 2	Apply principles of physics when solving tasks associated with animal and human locomotion.
CO 3	Develop a plan to conduct and analyze results of simple biomechanics experiments
CO 4	Use engineering tools (hardware and software) for solving problems of biomechanics
CO 5	Learn how to independently search more information about topics in biomechanics
CO 6	Identify relationships between structure and function in tissues and the importance of these relationships.

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX28	Design Optimization	PEC	3-0-0	3

Course Objectives:

1. Introduction to optimization
2. Techniques for solving single variable optimization problems
3. Techniques for solving constraEined and unconstrained multi-variable problems
4. Modelling engineering design problems for optimization
5. To learn linear programming and minimisation techniques
6. To get adequate knowledge on general design applications

Course content

Unit I **(Contact Hours 8)**

Basic Concepts; Functions of One variable: Polynomial Approximations, Golden Section Method.

Unit II **(Contact Hours 8)**

Finding Bounds on the Solution; Constrained Functions of One Variable: Direct and Indirect Approaches.

Unit III **(Contact Hours 8)**

Unconstrained Functions of Many Variables: Zero-order, First-order and Second-order Methods.

Unit IV **(Contact Hours 7)**

Scaling of Variables and Constraints, Convergence Criteria; Constrained Functions of Many Variables.

Unit V **(Contact Hours 7)**

Linear Programming, Sequential Unconstrained Minimization Techniques.

Unit VI **(Contact Hours 7)**

Direct Methods; Approximation Techniques; Duality; General Design Applications.

Learning resources

Text Book

1. Rao, Singiresu S. *Engineering optimization: theory and practice*. John Wiley & Sons, 2009.

References:

1. Rao, Singiresu S. *Engineering optimization: theory and practice*. John Wiley & Sons, 2009.
2. Deb, Kalyanmoy. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.
3. SS Rao and Ravindra Reddy. *Principles of Design Optimization*

Course Outcome: At the end of the course, the student will be able to:

CO 1	Present basic concepts of functions and polynomials
CO 2	Compute solutions for the constrained and unconstrained functions
CO 3	Apply minimization techniques for design optimization
CO 4	Apply approximation techniques for design optimization
CO 5	Use Linear Programming techniques to solve design problems
CO 6	Apply the concept of general design to real-life problems

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX29	Mechanics of Composite Materials	PEC	3-0-0	3

Course Objectives:

1. To study the different types of composites and different types of constituent materials
2. To understand the difference between isotropic material and anisotropic material.
3. To study different manufacturing techniques used for preparing the composite commercially
4. To understand the different types of laminates and behavior of the laminate under loading conditions
5. To study the effect of thermal loading on the laminates and natural frequencies of the composite laminate plate.
6. The understand the failure theories for anisotropic materials and to design of the laminate under loading condition

Course Contents

Unit I **(Contact Hours 7)**

Introduction, Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.**(7)**

Unit II **(Contact Hours 7)**

Lamina constitutive equations & manufacturing, Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hook's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness. Manufacturing: Bag Moulding Compression Moulding – Pultrusion – Filament Winding – Other Manufacturing Processes**(8)**

Unit III **(Contact Hours 8)**

Flat plate laminate constitute equations: Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates

Unit IV **(Contact Hours 8)**

Lamina strength analysis Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill‟s Failure Criterion for Composites. Tensor

Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure

Unit V **(Contact Hours 8)**

Thermal analysis Assumption of Constant C.T.E‟s. Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E‟s. C.T.E‟s for special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

Unit VI **(Contact Hours 7)**

Analysis of laminated flat plates Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies.

Learning resources

Text books:

1. Gibson, R.F., "*Principles of Composite Material Mechanics*", Second Edition, McGraw-Hill, CRC press in progress, 1994.

References

1. Hyer, M.W., "*Stress Analysis of Fiber – Reinforced Composite Materials*", McGraw Hill, 1998.
2. Issac M. Daniel and Ori Ishai, "*Engineering Mechanics of Composite Materials*", Oxford University Press-2006, First Indian Edition - 2007
3. Agarwal, B.D., and Broutman L.J., "*Analysis and Performance of Fiber Composites*", John Wiley and Sons, New York, 1990.

Course Outcome: At the end of the course, the student will be able to:

CO 1	Identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
CO 2	Predict the elastic properties of both long and short fiber composites based on the constituent properties.
CO 3	Use ideas from matrix algebra to rotate stress, strain and stiffness tensors
CO 4	Understand the concept of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.
CO 5	Analyze a laminated plate in bending, including lamina properties and residual stresses from curing and moisture.
CO 6	Predict the failure strength of a laminated composite plate.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX30	Control Systems & Engineering	PEC	3-0-0	3

Course Objectives:

1. This course shall introduce the fundamentals of modelling and control of linear time invariant systems;
2. A study, primarily from the classical viewpoint of Laplace transforms and a brief emphasis on the state space formulation as well.
3. To build foundations of time/frequency analysis of systems as well as the feedback control systems.
4. Introduces analytical and design tools to study stability of systems in both time domain and frequency domain.
5. To analyse the system with Multiple Input and Multiple Output (MIMO) using state space analysis and techniques.
6. To introduce importance of controllers and compensators in control system design for stability criteria.

Course content:

Unit I: **(Contact Hours 7)**

Control System Modeling: Basic Elements of Control System – Open loop and Closed loop systems - Differential equation - Transfer function, Modeling of Electric systems, Translational and rotational mechanical systems - Block diagram reduction Techniques - Signal flow graph

Unit II: **(Contact Hours 7)**

Time Response Analysis**:** Time response analysis - First Order Systems - Impulse and Step Response analysis of second order systems - Steady state errors – P, PI, PD and PID Compensation, Analysis using MATEXPERIMENT.

Unit III: **(Contact Hours 8)**

Frequency Response Analysis**:** Frequency Response - Bode Plot, Polar Plot, Nyquist Plot

- Frequency Domain specifications from the plots - Constant M and N Circles – Nichol's Chart - Use of Nichol's Chart in Control System Analysis. Series, Parallel, series-parallel Compensators - Lead, Lag, and Lead Lag Compensators, Analysis using MATEXPERIMENT.

Unit IV: **(Contact Hours 8)**

Stability Analysis: Stability, Routh-Hurwitz Criterion, Root Locus

Technique, Construction of Root Locus, Stability, Dominant Poles, Application of Root Locus Diagram - Nyquist Stability Criterion - Relative Stability, Analysis using MATEXPERIMENT.

Unit V: **(Contact Hours 8)**

State Variable Analysis**:** State space representation of Continuous Time systems – State equations – Transfer function from State Variable Representation – Solutions of the state equations - Concepts of ControlExperimentility and Observability – State space representation for Discrete time systems.

Unit VI: **(Contact Hours 7)**

Sampled Data control systems – Sampling Theorem – Sampler & Hold – Open loop & Closed loop sampled data systems.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Mathematically model physical systems and study them in time domain, Laplace domain to understand system characteristics.
CO 2	Design a systems transient and steady state response by selecting a suitable controller and/or a compensator for a specific application
CO 3	Apply various time domain and frequency domain techniques to assess the system stability.
CO 4	Apply various control techniques to different applications (example: mechanical systems, electrical systems etc…)
CO 5	Test a systems Controllability and Observability using state space representation.
CO 6	Use state space analysis to study MIMO systems.

Learning Resources

Text Book

1. Bolton, William. *Instrumentation and Control Systems*. Newnes, 2015.

References:

1. B. C. Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
2. I. J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co.2008

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX31	Design for Manufacturability	PEC	3-0-0	3

Course Objective:

To teach students various steps in the product development process and the significance of early phases of design for economical production

1. To teach fundamental principles of design for economical production and application of these principles in practical design problems
2. To teach design of products for ease of assembly and manufacture
3. To teach interrelations among part geometry, tolerances, materials and manufacturing processes
4. To teach principles of robust design procedures and how to set values for various design variables so that the product meets the performance requirements and remains insensitive to variations in manufacturing and use
5. To analyze the design and economical behaviour in different manufacturing processes.

Course content

Unit I: (Contact Hours 8)

Introduction - Design philosophy, implementing DFM, Benefits of DFM Concurrent Engineering Involvement Design for Quality, Design for Life Cycle, Design for Cost, Enabling Technology, Concurrent Engineering and the Organization, Improving the Development Process Management Frameworks - Architecture, Management's concerns with Manufacturability, Team Building and Training Justification of DFM, Viewpoints for DFM

Unit II: (Contact Hours 8)

Quality Tools in DFM - Problem Solving Tools, Quality Function Deployment, Benchmarking, Supplier, Taguchi approach

Unit III: (Contact Hours 10)

Computer Aided Technology - CAD/CAM/CAE, Rapid Prototyping, Group Technology, CIM Creative Thinking in DFM, Tools General Product Design - Impact of Design concept and early project decisions, Evaluating

manufacturability of conceptual designs, Producibility, Geometric Tolerancing

Unit IV: **(Contact Hours 6)**

Design for Assembly - Principles, improving serviceability, recyclability ,Design for Machining - Principles, Non-Traditional Machining

Unit V: **(Contact Hours 6)**

Design for forming - Principles, fine blanking, roll forming, precision forming, metal spinning, tube fabrication

Unit VI: **(Contact Hours 7)**

Design for Forging, Casting. Design for Coating - Painting, powder coating, metal spraying Design for Heat Treatment Design for Fastening & Joining - Design guidelines for fasteners, adhesive assembly, welded assemblies Design for Materials: Plastics, Composites, Ceramics, Powder Metallurgy.

Course Outcome: At the end of the course, the student will be able to

CO 1	Explore the concept of Design for Manufacturability
CO 2	Evaluate fundamental principles of design to improve the ease of production while satisfying the performance requirements
CO 3	Solve the problem in DFM
CO 4	Design and analyze different types of manufacturing processes.
CO 5	Evaluate manufacturing processes based on part geometry and tolerances
CO 6	Design and solve economical behavior in different manufacturing processes.

Learning Resources

Text Book

1. Chitale, AK and Gupta, RC, "*Product Design and Manufacturing*", Prentice Hall of India Pvt Ltd.1997

References:

1. Dieter, George Elwood, "*Engineering Design - A Materials and Processing approach*", Mc Graw Hill International.
2. Bakerjian, Ramon, Ed., "*Design for Manufacturability,Tool and Manufacturing Engineers Handbook"*, Society of Manufacturing Engineers, Michigan 1992

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX32	Micro Electro Mechanical Systems	PEC	3-0-0	3

Course Objectives:

1. The objective of this course is to make students to gain basic knowledge on overview of MEMS (Micro electro Mechanical System)
2. To understand the different types of sensors and activators
3. To perform a detailed study on various fabrication techniques
4. This enables them to design, analysis, fabrication and testing the MEMS based components.
5. To understand polymer and optical MEMS
6. To introduce the students various opportunities in the emerging field of MEMS

Course Contents

Unit I: (Contact Hours 7)

Introduction: Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Micro fabrication - Silicon based MEMS processes
– New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection. **(8)**

Unit II: (Contact Hours 7)

Sensors and actuators-I: Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors - Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph - Applications – Magnetic Actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators- Actuation using Shape Memory Alloys.

Unit III: (Contact Hours 7)

Sensors and actuators-II :Piezo-resistive sensors – Piezo-resistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia , Acoustic, Tactile and Flow sensors.

Unit IV: (Contact Hours 8)

Micromachining I:Silicon Anisotropic Etching – Anisotrophic Wet Etching – Dry Etching
of Silicon – Plasma Etching – Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching

– Gas Phase Etchants.

Unit V: **(Contact Hours 8)**

Micromachining II:Case studies - Basic surface micro machining processes – Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antistriction methods – LIGA Process - Assembly of 3D MEMS – Foundry process.

Unit VI: **(Contact Hours 8)**

Polymer and optical MEMS: Polymers in MEMS– Polimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon - Application to Acceleration, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS.

Course Outcome: At the end of the course, the student will be able to

CO 1	Understand the concepts applicable to MEMS and their fabrication
CO 2	Identify the essential material properties for designing of MEMS
CO 3	Use the different kinds of mechanical loading and response of the members
CO 4	Design of the MEMS for a given application
CO 5	Analyze the various sensing and transduction technique
CO 6	Describe the concepts of the polymer and optical MEMS

Learning Resources

Text books

1. Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2006.

References

1. Stephen D Senturia, "Microsystem Design", Springer Publication, 2000.
2. Tai Ran Hsu, “MEMS & Micro systems Design and Manufacture” Tata McGraw Hill, New Delhi, 2002.
3. Nadim Maluf,“ An Introduction to Micro Electro Mechanical System Design”, Artech House, 2000.
4. Mohamed Gad-el-Hak, editor, “ The MEMS Handbook”, CRC press Baco Raton, 2000
5. James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher, 2010
6. Thomas M.Adams and Richard A.Layton, “Introduction MEMS, Fabrication and Application,” Springer 2012.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX33	System Identification & Condition Monitoring	PEC	3-0-0	3

Course Objectives:

1. To introduce the learner to the subject of system identification and provide an overview of the same.
2. To outline a procedure for system identification.
3. To understand the concepts of Identification of feedback systems.
4. To provide the brief knowledge on Dynamic testing of machines and structures.
5. To briefly review the various classes of Specialized techniques of condition monitoring
6. Case Studies Condition Monitoring & Applications Failure of fan bearings

Course Contents

Unit I: **(Contact Hours 6)**

The system identification problem - from data to model, recursive and batch. Model structures and input signals.

Unit II: **(Contact Hours 6)**

The least squares, prediction error and the instrumental variable approaches. The stochastic setting. Model validation and practical aspects. Identification of feedback systems.

UNIT III: **(Contact Hours 8)**

Recursive identification schemes, State space representations, Deterministic realisation theory, Subspace identification for multivariable (MIMO) systems, Stochastic realisation and subspace identification.

Unit IV: **(Contact Hours 9)**

Introduction, Specialized techniques of condition monitoring Acoustic imaging, Ultra sonic triangulation fault location Acoustic emission technique (AET)- Instrumentation, Magnetic testing Methods, Current flow Magnetization, Induction Magnetic Flow Method, Induction Threading bar method, Induction Magnetising Coil method. Thermography-Thermo graphic Equipment, Application of Thermography, Corrosion monitoring, Need for corrosion monitoring, Fields of application, Monitoring Techniques, Resistance techniques.

Unit V: **(Contact Hours 9)**

Fault diagnosis: Dynamic testing of machines and structures, experimental

modal analysis, machine condition monitoring and diagnostics. Condition monitoring and signature analysis applications: Introduction, noise monitoring, temperature monitoring, wear behaviour monitoring, corrosion monitoring, performance trend monitoring, selection of condition monitoring techniques, diagnosis.

Unit VI: **(Contact Hours 7)**

Condition Monitoring case Studies & Applications Failure of fan bearings- History of failures, Analysis of the failures, Solution. High frequency vibration of gas compressor- History of trouble, Analysis of trouble, Solution. Monitoring of cracks in rotors- Turbo compressor misalignment.

Course Outcome: At the end of the course, the student will be able to

CO 1	Explain the principles of system identification.
CO 2	Select appropriate procedure for system identification.
CO 3	Understand the concepts of Identification of feedback systems.
CO 4	Identify techniques of fault diagnosis.
CO 5	Analyze Dynamic testing of machines and structures.
CO 6	Distinguish various classes of Specialized techniques of condition Monitoring

Learning Resources

Text Books

1. Ljung, L., *System Identification - A Theory for the User*, Prentice-Hall, 1999.

References

1. T. Soderstrom and P. Stoica, *System Identification*, Prentice Hall International, 1994.

Web links:

1. https://nptel.ac.in/courses/103106078/

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX34	CAD/CAM	PEC	3-0-0	3

Course Objectives: The objective of the course is to enable students to

1. Provide basic foundation in computer aided design / manufacturing
2. Understand the fundamentals used to create and manipulate geometric models
3. Get acquainted with the basic CAD software designed for geometric modeling
4. Learn working principles of NC machines CNC control and part programming
5. Understand concept of Group Technology, FMS and CIM
6. To examine the overall configuration and elements of computer integrated manufacturing systems

Unit I: **(Contact Hours 7)**

Principles of computer graphics : Introduction, graphic primitives, point plotting, lines, Brenham's circle algorithm, ellipse, transformation in graphics, coordinate systems, view port, 2D and 3D transformation, hidden surface removal, reflection, shading and generation of characters.

Unit II: **(Contact Hours 8)**

Cad tools: Definition of CAD Tools, Types of system, CAD/CAM system evaluation criteria, brief treatment of input and output devices. Graphics standard, functional areas of CAD, Modeling and viewing, software documentation, efficient use of CAD software.

Unit III **(Contact Hours 7)**

Geometricmodelling: Types of mathematical representation of curves, wire frame models wire frame entities parametric representation of synthetic curves hermite cubic splines, Bezier curves, B-splines rational curves.

Unit IV **(Contact Hours 7)**

Surface Modeling: Mathematical representation of surfaces, Surface model, Surface entities surface representation, Parametric representation of surfaces, plane surface, rule surface, surface of revolution, Tabulated Cylinder.

Unit V **(Contact Hours 8)**

Parametric representation of synthetic surfaces: HermiteBicubic surface, Bezier surface, B- Spline surface, COONs surface, Blending surface, Sculptured surface, Surface

manipulation — Displaying, Segmentation, Trimming, Intersection, Transformations (both 2D and 3D).

Unit VI **(Contact Hours 8)**

CNC: Introduction, classification, design features and control features of CNC machines; Programming: G & M Code programming, Offline (APT-like) programming; Free form surface machining: Isoparametric, Isoplanar and Isoscallop machining strategies

Course Outcomes: At the end of the course, the student will be able to

CO 1	Describe basic structure of CAD workstation, Memory types, input/output devices and display devices and computer graphics
CO 2	Acquire the knowledge of geometric modeling and Execute the steps required in CAD software for developing 2D and 3D models and perform transformations
CO 3	Get brief idea on parametric representation of 2D and 3D surfaces.
CO 4	Explain fundamental and advanced features of CNC machines
CO 5	Describe the use of GT and CAPP for the product development
CO 6	Analyze the various elements and their activities in the Computer Integrated Manufacturing Systems.

Learning resources

TEXT BOOKS:

1. Groover, M. P., and E. Zimmers. "E. *CAD/CAM: Computer Aided Design and Manufacturing."*, 1984
2. Groover, Mikell P. *Automation, production systems, and computer-integrated manufacturing*. Prentice Hall Press, 2007.

References:

1. Rao, Posinasetti Nageswara. *CAD/CAM: principles and applications*. Tata McGraw-Hill Education, 2004.
2. Kuang Hua Chang . *Product manufacturing and cost estimation using CAD/CAE*, Elsevier Publishers

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX35	**Product Design and Development**	PEC	**3-0-0**	**3**

Course Learning Objectives:

1. To study the basic concepts of product design and development process.
2. To understand the industrial design process and optimization.
3. To understand the design for manufacturing concept.
4. To understand the Value engineering and its application.
5. To understand the application of creative thinking in ergonomics of product.
6. To understand the tools used in product design.

Course Content:

Unit – I **(7 hours)**

Introduction to Product Design

Introduction: Classification/ Specifications of Products, Product life cycle& Product mix, Introduction to product design, Modern product development process, Innovative thinking, Morphology of design.

Unit – II **(8 hours)**

Product Design Process

Conceptual Design: Generation, selection & embodiment of concept, Product architecture. Industrial design: process, need. Robust Design: Taguchi Designs & DOE. Design Optimization.

Unit – III **(7 hours)**

Design for Manufacturing & Assembly

Design for Mfg & Assembly: Methods of designing for Mfg & Assembly, Design for Maintainability, Designs for Environment, Product costing, legal factors and social issues. Engg ethics and issues of society related to design of products

Unit – IV **(8 hours)**

Value Engineering

Value Engineering / Value Analysis. : Definition. Methodology, Case studies, Economic analysis: Qualitative & Quantitative.

Unit – V **(7 hours)**

Ergonomics: Ergonomics / Aesthetics: Gross human autonomy, Anthropometry, Man-Machine interaction. Concepts of size and texture, colour .Comfort criteria. Psychological & Physiological considerations. Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.

Unit – VI **(8 hours)**

Advanced Product manufacturing Techniques

Concurrent Engineering, Rapid prototyping, Tools for product design – Drafting / Modelling software. CAM Interface, Patents & IP Acts, Overview, Disclosure preparation.

Learning resources

Text books:

1. Karl T Ulrich, Steven D Eppinger, "Product Design & Development." Tata Mc Graw Hill New Delhi 2003.

Reference Books:

1. Bralla J G "Handbook of Product Design for Manufacture, Mc Grawhill New York
2. Hollins B & Pugh S "Successful Product Design." Butter worths London.
3. David G Ullman, "The Mechanical Design Process." McGrawhill Inc Singapore 1992.
4. N J M Roozenberg , J Ekels , N F M Roozenberg " Product Design Fundamentals and Methods ." John Willey & Sons 1995.

Course outcomes: At the end of the course, the student will be able to

CO 1	Identify the needs and methods for Product design.
CO 2	Understand components of Design process and optimization.
CO 3	Utilize the concepts and the methods of design for manufacturing & assembly.
CO 4	Apply the principles of value engineering and its methods in manufacturing.
CO 5	Apply various ergonomics principle in to the product design.
CO 6	Inspect the advanced technologies in the manufacturing of a product.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

SYLLABUS OF PROFESSIONAL CORE ELECTIVES
THERMAL STREAM

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX36	Power Plant engineering	PEC	3-0-0	3

Prerequisites: Thermodynamics and Fluid Mechanics

Course Objectives:

1. Familiarize the sources of energy, power plant economics and environmental aspects.
2. Describe power plant economics and environmental considerations.
3. Identify the working components of the steam, gas power plants.
4. Recognize the characteristics of hydrographs and its applications in practice.
5. Explain renewable energy sources; characteristics, working principle, classify types, layouts, and plant operations.
6. Impart types of nuclear power plants, and outline working principle and advantages and hazards.

Course Contents

Unit I **(Contact Hours 7)**

Introduction to the Sources of Energy - Resources and Development of Power in India. Power Plant Economics and Environmental Considerations: Capital Cost, Investment of Fixed Charges, Operating Costs, General Arrangement of Power Distribution, Load Curves, Load Duration Curve. Definitions of Connected Load, Maximum Demand, Demand Factor, Average Load, Load Factor, Diversity Factor - Tariff - Related Exercises. Effluents from Power Plants and Impact on Environment - Pollutants and Pollution Standards - Methods of Pollution Control. Inspection and Safety Regulations.

Unit II **(Contact Hours 8)**

Steam Power Plant : Modern High Pressure and Supercritical Boilers - Analysis of Power Plant Cycles - Modern Trends in Cycle Improvement - Waste Heat Recovery, Fluidized Bed Boilers., Fuel and Handling Equipments, Types of Coals, Coal Handling, Choice of Handling Equipment, Coal Storage, Ash Handling Systems.

Combustion Process : Properties of Coal - Overfeed and Under Feed Fuel Beds, Travelling Grate Stokers, Spreader Stokers, Retort Stokers, Pulverized Fuel Burning

System And Its Components, Combustion Needs and Draught System, Cyclone Furnace, Design and Construction, Dust Collectors, Cooling Towers And Heat Rejection. Analysis of Pollution from Thermal Power Plants - Pollution Controls.CO_2 Recorders.

Unit III **(Contact Hours 7)**

Diesel Power Plant: Diesel Power Plant: Introduction - IC Engines, Types, Construction- Plant Layout with Auxiliaries - Fuel Storage

Gas Turbine Plant: Introduction - Classification - Construction - Layout with Auxiliaries - Principles of Working Closed and Open Cycle Gas Turbines. Advantages And Disadvantages Combined Cycle Power Plants.

Unit IV **(Contact Hours 8)**

Hydro Electric Power Plant: Water Power - Hydrological Cycle / Flow Measurement - Drainage Area Characteristics - Hydrographs - Storage and Pondage - Classification of Dams and Spill Ways.

Hydro Projects and Plant: Classification - Typical Layouts - Plant Auxiliaries - Plant Operation Pumped Storage Plants.

Unit V **(Contact Hours 7)**

Power From Non-Conventional Sources: SolarEnergy- *Solar cells and modules*,Utilization of Solar Collectors- Principle of its Working, Wind Energy - Types of Turbines - HAWT & VAWT-Tidal Energy. MHD power Generation.

Unit VI **(Contact Hours 8)**

Nuclear Power Station: Nuclear Fuel - Nuclear Fission, Chain Reaction, Breeding and Fertile Materials - Nuclear Reactor -Reactor Operation.

Types of Reactors: Pressurized Water Reactor, Boiling Water Reactor, Sodium-Graphite Reactor, Fast breeder Reactor, Homogeneous Reactor, Gas Cooled Reactor, Radiation Hazards and Shielding - Radioactive Waste Disposal.

Learning resources

Text Books:

1. P.K. Nag, *Power Plant Engineering*, 3/e, TMH, 2013.
2. Arora and S. Domkundwar, *A course in Power Plant Engineering*, Dhanpat Rai & Co (P) Ltd, 2014.

Reference Books:

1. Rajput, *A Text Book of Power Plant Engineering*, 4/e,Laxmi Publications,2012.
2. Ramalingam, *Power plant Engineering*, Scietech Publishers, 2013
3. Sharma, P.C. *Power Plant Engineering*, S.K. Kataria Publications,2012.

Course Outcomes: At the end of this course, the student will be able to

CO 1	Identify sources of energy, power plant economics, and environmental aspects.
CO 2	Organize power plant economics and environmental considerations.
CO 3	Select the working components of the steam, gas power plants.
CO 4	Apply the characteristics of hydrographs in practice.
CO 5	Distinguish types of renewable energy sources and their working principle.
CO 6	Make use of the working principle of nuclear power plants.

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX37	Advanced Fluid Mechanics	PEC	3-0-0	3

Prerequisites: Fluid Mechanics

Course Objectives:

1. Emphasize mathematical formulation of various flow problems
2. Include advanced theories of flow mechanics so that students can expertise and pursue research in the relevant areas
3. Familiarization of boundary layer theory and flow separation concepts.
4. Application of boundary layer theory on turbulent flow.
5. Compare the parameters of the Compressible flow.
6. Include the fundamental concepts of "Computational Fluid Mechanics" that will help in undertaking the projects at undergraduate.

Course Contents:

Unit-I **(Contact hours 7)**

Basic Concepts and Fundamentals: Definition and properties of Fluids,Fluid as continuum, Langragianand Eulerian description, Velocityand stress field, Fluid statics, FluidKinematics, GoverningEquations of Fluid Motion: Reynolds transport theorem, Integral and differential forms ofgoverning equations: mass, momentum and energyconservation equations.

Unit-II **(Contact hours 8)**

Navier-Stokes equations, Euler’s equation, Bernoulli’s Equation, Exact Solutions of Navier-Stokes Equation: Couette flows, Poiseuille flows, fully developed flows in non- circular cross-sections, Unsteadyflows, Creeping flows.

Unit-III **(Contact hours 8)**

Laminar Boundary Layers: Boundary layer equations,Boundary layer thickness,Boundary layer on a flat plate,similarity solutions, Integral form ofboundary layer equations,Approximate Methods, Flowseparation, Entry flow into a duct.

Unit-IV **(Contact hours 7)**

Turbulent Flows: Introduction, Fluctuations and time-averaging, general equations ofturbulent flow, Turbulent boundarylayer equation, Flat plate turbulentboundary layer, Turbulent pipe flow,Prandtl mixing

hypothesis,Turbulence modeling, Freeturbulent flows.

Unit-V **(Contact hours 8)**

Compressible Flows: Speed of sound and Machnumber, Basic equations for onedimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fannoand Rayleigh curve, Mach waves,Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows,Compressible viscous flows,Compressible boundary layers.

Unit-VI **(Contact hours 7)**

Introduction to CFD: Boundary conditions, Basic discretization–Finite differencemethod, Finite volume method and Finite element method.

Learning resources

Text Books:

1. Frank M. White, *Fluid Mechanics*, Tata McGraw-Hill, Singapore, Sixth Edition,
   2008.

References

1. Batchelor G.K, *An Introduction to Fluid Dynamics*, Cambridge University Press, 1983.
2. Fox W. Robert, McDonald T. Alan, *Introduction to Fluid Mechanics*, Fourth Edition, John Wiley & Sons, 1995.
3. Frank M. White, *Viscous Fluid Flow*, Third Edition, McGraw-Hill Series of Mechanical Engineering, 2006.
4. John D. Anderson Jr, *Modern Compressible Flow withHistorical Perspective*, McGraw-Hill, 1990.
5. John D. Anderson Jr., *Fundamentals of Aerodynamics*,McGrawHill, 2005.

Course outcomes: At the end of this course, the student will be able to

CO 1	Examine the various mathematical formulation of various flow problems
CO 2	Utilize advanced theories of flow mechanics so that students can expertise and pursue research in the relevant areas
CO 3	Evaluate boundary layer theory and flow separation concepts.
CO 4	Utilize boundary layer theory on turbulent flow.
CO 5	Compare the parameters of the Compressible flow.
CO 6	Identify the fundamental concepts of "Computational Fluid Mechanics" that will help in undertaking the projects at undergraduate

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX38	Advanced Heat Transfer	PEC	3-0-0	3

Prerequisites: Heat Transfer

Course Objectives:

1. Rigorous treatment of governing equations and solution procedures for the three modes will be provided in an advanced approach.
2. Distinguish the natural and forced convection and its applications.
3. Familiarize on condensation and boiling
4. Classify the types of heat exchangers.
5. Study on radiation heat transfer and its components.
6. Solve multi-mode heat transfer problems in industry.

Course Contents:

Unit-I **(Contact hours 8)**

Conduction Heat Transfer: Derivation of conduction equation in three dimensions – initial and boundary conditions, heat conduction with heat generation, heat transfer through extended surfaces, two-dimensional steady state conduction.

Transient conduction - lumped capacitance formulation, unsteady conduction from a semi infinite solid,

Applications: Solving real life steady and transient conduction problems with numerical methods or computer programs.

Unit-II **(Contact hours 8)**

Convective Heat Transfer

Forced convection: Introduction, heat transfer in high velocity flow, empirical relations for pipe and tube flow, flow across cylinders, spheres and tube banks, liquid-metal heat transfer,

Natural Convection: Introduction, empirical relations for free convection, free convection from vertical planes, cylinders, horizontal cylinders, horizontal plates, inclined surfaces, spheres and enclosed space, non-newtonian fluids, combined free and forced convection, Applications: Solving real life forced and free convection problems with numerical methods or computer programs.

Unit-III **(Contact hours 8)**

Convection with change of phase:

Condensation: Laminar film on a vertical surface, Turbulent film on a vertical surface, Film condensation in other configurations, Drop condensation, and effect of non- condensable gases in condensing equipment. Boiling: Pool boiling regimes, Nucleate boiling and peak heat flux, Film boiling and minimum heat flux, Flow boiling,

Applications: Solving real life condensation and boiling problems with numerical methods or computer programs.

Unit-IV **(Contact hours 7)**

Heat Exchangers, overall heat transfer coefficient, concept of fouling factor**,** analysis and design of heat exchangers using LMTD and ε-NTU methods.

Applications: Solving real lifeheat exchanger problems with numerical methods or computer programs.

Unit-V **(Contact hours 7)**

Radiation heat transfer - Radiation effect on temperature measurements, radiation properties of a participating medium, emissivity and absorptivity of gases and gases mixtures, heat transfer from the human body, radiative exchange and overall heat transfer in furnaces.

Applications: Solving real life radiation problems with numerical methods or computer programs.

Unit-VI **(Contact hours 7)**

Multi-mode Heat Transfer:Solving multi-mode heat transfer problems of gas cooled nuclear reactors, electronics cooling appliances, and so on using numerical methods or computer programs.

Learning resources

Text Books:

1. Mills, A. F., *Heat and Mass Transfer*, Irwin, Chicago, Ill., 1995.
2. Incropera, F. P., and DeWitt, D. P., *Fundamentals of Heat and Mass Transfer*, Wiley, New York, 1996.

Course Outcomes: At the end of this course, the student will be able to

CO 1	List out the equations for the three modes will be provided in an advanced approach.
CO 2	Distinguish the natural and forced convection and its applications.
CO 3	Make use of concepts like condensation and boiling
CO 4	Analyze and classify the types of heat exchangers.
CO 5	Solve the radiation heat transfer problems in practice.
CO 6	Solve multi-mode heat transfer problems in industry

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX39	Computational Fluid Dynamics	PEC	3-0-0	3

Prerequisites: Fluid Mechanics and Heat Transfer

Course Objectives:

1. Distinguish the difference between finite difference method and finite volume methods.
2. Analyze the numerous solution methods like elliptical equation, Gaussian elimination and Von Neumann stability analysis etc.
3. Acquire hyperbolic equations and Burgers equations.
4. Study of formulations of incompressible viscous flows
5. Evaluate the Euler equations, and Navier-stokes system of equations,
6. To include the in depth concepts of "Computational Fluid Mechanics" that will help in undertaking the projects at undergraduate.

Course Contents:

Unit I **(Contact Hours 8)**

Introduction: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions, Derivation of finite difference equations.

Unit II **(Contact Hours 8)**

Solution Methods: Solution methods of elliptical equations — finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equationsexplicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

Unit III **(Contact Hours 8)**

Hyperbolic Equations: Explicit schemes and Von Neumann stability analysis, implicit schemes, multi-step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

Unit IV **(Contact Hours 7)**

Formulations of Incompressible Viscous Flows: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

Unit V **(Contact Hours 7)**

Treatment of Compressible Flows: Potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

Unit VI **(Contact Hours 7)**

Finite Volume Method: Finite volume method via finite difference method, formulations for two and three-dimensional problems.

Standard Variational Methods: Linear fluid flow problems, steady state problems, Transient problems.

Learning resources

Text Book:

1. John D. Anderson, *Computational Fluid Dynamics: Basics with applications*,
   Mc Graw Hill. 2002.

Reference Book:

1. T. J. Chung, *Computational fluid dynamics*, Cambridge University press,2002
2. Computational Fluid Dynamics, 2nd Edition,
   T.J.Chung, Cambridge University Press, 2014
3. A First Course in Computational Fluid Dynamics,
   S.Balachander, Cambridge University Press, 2017

Study Materials (Web Links):

1. http://nptel.ac.in/courses/112104116/

Course Outcomes: At the end of this course, the student will be able to

CO 1	Distinguish the difference between finite difference method and finite volume methods.
CO 2	Analyze the numerous solution methods like elliptical equation, Gaussian elimination and Von Neumann stability analysis etc.
CO 3	Acquire hyperbolic equations and Burgers equations.
CO 4	Gain enhanced knowledge in performing flow analysis (both heat and mass flow).
CO 5	Make use of the Euler equations, and Navier-stokes system of equations.
CO 6	Use CFD software to model relevant engineering flow problems. Analyze the CFD results. Compare with available data, and discuss the findings.

Course Nature		**Theory**		
Assessment Method				
AssessmentTool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX40	Design of Heat Exchangers	PEC	3-0-0	3

Prerequisites: Heat Transfer

Course Objectives:

1. Familiarization with classification and design of heat exchangers.
2. Acquaintance of the complete terminology of Heat exchangers
3. Understanding of design of double pipe heat exchangers
4. Analyze the design of Shell & tube heat exchangers
5. Learn about the design of compact heat exchangers
6. The course will also briefly cover Heat transfer of enhancement and performance evaluation of heat exchangers

Course Contents:

Unit I **(Contact Hours 7)**

Different classification and basic design methodologies for heat exchanger**:** Classification of heat exchanger, selection of heat exchanger, overall heat transfer coefficient.

Unit II **(Contact Hours 8)**

LMTD method for heat exchanger analysis for parallel, counter, multi-pass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, fouling, cleanliness factor, percent over surface, techniques to control fouling, additives, rating and sizing problems, heat exchanger design methodology.

Unit III **(Contact Hours 7)**

Design of double pipe heat exchangers: Thermal and hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop.

Unit IV **(Contact Hours 7)**

Design of Shell & tube heat exchangers: Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.

Unit V **(Contact Hours 8)**

Design of compact heat exchangers: Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop.

Unit VI **(Contact Hours 8)**

Heat Transfer Enhancement and Performance Evaluation: Enhancement of heat transfer, Performance evaluation of Heat Transfer Enhancement technique. Introduction to pinch analysis.

Learning resources

Text books:

1. Sadik, Kakac, *Heat Exchanger Selection*, Rating and Thermal Design,CRC Press
2. Ramesh K Shah, *Fundamentals of Heat Exchanger Design*,Wiley Publication

References

1. Kays, V.A. and London, A.L,*Compact Heat Exchangers*, McGraw Hill
2. Kuppan, T, Macel Dekker, *Heat Exchanger Design Handbook*, CRC Press
3. Schunder E.U., *Heat Exchanger Design Hand Book*, Hemisphere Pub.
4. Donald Q Kern, *Process Heat transfer*, McGraw Hill.

Course Outcomes: At the end of this course, the student will be able to

CO 1	Design the heat exchangers in industry.
CO 2	Identify the types of parameters required to design the Heat exchangers
CO 3	Solve the problems of double pipe heat exchangers
CO 4	Solve the problems of Shell & tube heat exchangers
CO 5	Inspect thedesign of compact heat exchangers
CO 6	Apply the enhancement techniques to evaluate the heat exchangers.

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX41	Design and Optimization of Thermal Systems	PEC	3-0-0	3

Prerequisites: Thermodynamics

Course Objectives:

1. Obtain knowledge of modelling of thermal systems.
2. Obtain the advanced knowledge on design of thermal systems with useful design strategies.
3. Learn economic considerations while designing a new thermal system.
4. Acquire optimization methods involved in designing of system.
5. Study about the advanced search methods for optimization.
6. Solve the advanced Optimization problems by using dynamic, linear, geometric Programming methods.

Course contents:

Unit I **(Contact hours 8)**

Modeling of Thermal Systems: types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods for numerical simulation.

Unit II **(Contact hours 6)**

Acceptable Design of a Thermal System: initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems.

Unit III **(Contact hours 8)**

Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems.

Unit IV **(Contact hours 7)**

Problem Formulation for Optimization: optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers and optimization of constrained and unconstrained problems, applicability to thermal systems.

Unit V **(Contact hours 8)**

Search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic

programming and other methods for optimization, knowledge-based design and additional considerations, professional ethics.

Unit VI **(Contact hours 8)**

Optimization: Objective function formulation, Constraint equations, Mathematical formulation, Calculus method, Dynamic programming, Geometric programming, linear programming methods, solution procedures. Equation fitting, Empirical equation, best fit method, method of least squares. Modeling of thermal equipments such as turbines, compressors, pumps, heat exchangers, evaporators and condensers.

Learning resources

Text Books:

1. W.F. Stoecker, *Design of Thermal Systems* - McGraw-Hill
2. Y. Jaluria, *Design and Optimization of Thermal Systems* –CRC Press

Reference Books:

1. Bejan, G. Tsatsaronis, M.J. Moran, *Thermal Design and Optimization* – Wiley.
2. R. F. Boehm, *Developments in the Design of Thermal Systems* – Cambridge University Press.
3. N.V. Suryanarayana, *Design & Simulation of Thermal Systems* – MGH.

Course outcomes: At the end of this course, the student will be able to

CO 1	Design the modelling of thermal systems.
CO 2	Apply the advanced knowledge on design of thermal systems with useful design strategies.
CO 3	Apply the economic considerations while designing a new thermal system.
CO 4	Make use of optimization methods involved in designing of thermal system.
CO 5	Distinguish the advanced search methods for optimization.
CO 6	Solve the advanced Optimization problems by using dynamic, linear, geometric Programming methods.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX42	Turbo Machinery	PEC	3-0-0	3

Prerequisites: Hydraulic machinery and Heat Transfer

Course Objectives:

1. To familiarize the turbomachine parts and efficiencies.
2. To obtain the advanced knowledge on Thermodynamics of fluid flow.
3. To analyze the energy exchange procedure in turbo machines and blade terminology.
4. To analyze the flow, discharge and effect of blade angles, degree of reactions in the Turbo machines.
5. To recognize the operating parameters of the Pumps and Compressors.
6. To identify the operating parameters of the radial flow turbines.

Course contents:

Unit I **(Contact hours 8)**

Introduction: Definition of turbomachine, parts of turbomachines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynold's number, Unit and specific quantities, model studies. Application of first and second law's of thermodynamics to turbomachines, Efficiencies of turbomachines.

Unit II **(Contact hours 8)**

Thermodynamics of fluid flow: Static and Stagnation states- Incompressible fluids and perfect gases, Overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process.Flow of fluids in Turbo machines – flow and pressure distribution over an airfoil section – Effect of compressibility cavitation – Bladeterminology.

Unit III **(Contact hours 8)**

Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor.

Unit IV **(Contact hours 8)**

General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade

discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles.

Unit V **(Contact hours 6)**

Centrifugal pumps and compressors – Inlet section – Cavitation – flow in the impeller channel – flow in the discharge casing pump and compressor characteristic.

Unit VI **(Contact hours 7)**

Radial flow turbines – inward flow turbines for compressible fluids – inward flow hydraulic – velocity and flow coefficients – gas turbine blading – Kaplan turbine – pelton wheels.

Learning resources

Text books:

1. William W. Peng, *Fundamentals of Turbomachinery*, Wiley 2002.
2. J.Lal, *Hydraulic Machines*, Metropolitan Books Co. Ltd, N.Delhi, 1956.

References

1. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill
2. Simon Haykin, *Neural Networks*, Prentice Hall**.**
3. J.M. Zurada, *Introduction to artificial neural systems*, Jaico Publishers
4. H.J. Zimmermann, *Fuzzy set theory and its applications*, III Edition, Kluwer Academic Publishers, London.

Course Outcomes: At the end of this course, the student will be able to

CO 1	Distinguish the turbomachine parts and efficiencies.
CO 2	Apply the advanced knowledge on Thermodynamics of fluid flow.
CO 3	Analyze the energy exchange procedure in turbo machines and blade terminology.
CO 4	Evaluate the flow, discharge and effect of blade angles, degree of reactions in the turbo machines.
CO 5	Make use of the operating parameters in designing the Pumps and Compressors.
CO 6	Identify the operating parameters of the radial flow turbines.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX43	Gas Dynamics and Jet Propulsion	PEC	3-0-0	3

Prerequisites: Advanced Thermodynamics

Course Objectives:

1. Acquire knowledge on different parameters involved in the compressible flow.
2. Understand the features of compressible isentropic flows and irreversibility like shocks.
3. Familiarize the concepts of Non-isentropic flow in constant area ducts, Rayleigh and fanno flows.
4. Acquaint the Theory of jet propulsion
5. Acquire knowledge on different jet propulsion engines.
6. To learn about the ramjet and scramjet engine

Course content:

Unit I: **(Contact hours 7)**

Introductory concepts

Compressibility, Thermodynamic concepts, Conservation equations, Communication in gases, Stagnation state, One Dimensional Flow: Pressure waves in gases, Communication in gases, Stagnation state, Differential equations for 1D flow, Isentropic Flow with area variations, Numerical examples

Unit II: **(Contact hours 7)**

Normal, Oblique and Other shocks

Normal Shock Concept, Normal Shock relations, Moving normal shocks, Numerical Examples (stationary &moving), Concept and theory, Oblique Shock relations, Property variations, Detached Shocks, Shock Reflections, Numerical Examples, Shock- Shock Interactions

Unit III: **(Contact hours 7)**

Expansions and Nozzle flow

1-D Expansion wave, Expansion Fan, Prandtl Meyer Function, Smooth expansions/compressions, Numerical Examples, Shock Expansion Theory: Theory, Examples and its applications, Quasi-1D flow with area variations, Geometric Choking,
Numerical Examples, Divergent Nozzles, Convergent-Divergent Nozzles, Numerical Examples, Multiple Choking points

Unit IV: **(Contact hours 8)**

Non-isentropic flows and basics of jet propulsions

Crocco's Theorem, Fanno Flow, Numerical Examples Rayleigh Flow, Numerical Examples, and Various Choking mechanisms, Thrust, Modes of Propulsion, Operation of a Basic Gas Turbine Engine, Turbojet, Afterburning Turbojet and Turbofan Engine

Unit V: **(Contact hours 8)**

Detailed Analysis of the parts of a Gas Turbine Engine

Intake – Subsonic, Compressor Aerodynamics, Combustor, Turbine Aerodynamics, Nozzles, Turbofan Engine

Unit VI: **(Contact hours 8)**

Emerging Trends, Ramjet & Turboramjet Engine, Scramjet Engine, Thrust Equation, Thrust Calculations: Turbojet, Turbofan, Ramjet Engine

Learning resources

Text Books:

1. V. Babu, *Fundamentals of Gas Dynamics*, Ane Books India, 2008
2. V. Babu, *Fundamentals of Propulsion*, Ane Books India, 2009

Reference Books:

1. E. Rathakrishnan, *Gas Dynamics*, PHI Learning Pvt. Ltd., 2013
2. R. Zucker, O. Biblarz, *Fundamentals of Gas Dynamics*, John Wiley & Sons, 2002.
3. Becker, *Gas Dynamics*, Academic Press, 1968
4. H.S. Mukunda, *Understanding Aerospace Chemical Propulsion*, Interline Publishing, 2004.
5. Ahmed F. El-Sayed, *Aircraft Propulsion and Gas Turbine Engines*, CRC Press, 2008

Video Reference links:

Title	Expert Name	Details of Expert	Web link
Gas Dynamics	Dr. T. M. Muruganandam	IIT Madras	**http://nptel.ac.in/courses/101106044/**

Gas Dynamics and Propulsion	Prof. V. Babu	IIT Madras	**http://nptel.ac.in/courses/112106166/**

Text Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Gas Dynamics	Dr. Vinayak Kulkarni	IIT Guwahati	**http://nptel.ac.in/courses/112103021/**

Course Outcomes: At the end of this course, the student will be able to

CO 1	Identify the different parameters involved in the compressible flow.
CO 2	Make use of features of compressible isentropic flows to evaluate the shock relations.
CO 3	Solve the problems on concepts of Non-isentropic flow in constant area ducts, Rayleigh and fanno flows.
CO 4	Utilize the theory of jet propulsion and calculate the performance parameters of jet propulsion.
CO 5	Distinguish the different jet propulsion engines.
CO 6	Evaluate the performance parameter for ramjet and scramjet engines

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX44	Fuels and Combustion	PEC	3-0-0	3

Course objectives:

1. To learn about various fuels and their properties.
2. To learn about the classification and composition of solid fossil fuels like coal.
3. To learn about the classification and composition of liquid fossil fuels like petroleum.
4. To learn about the classification and composition of gaseous fossil fuels like natural gas.
5. To learn about liquefaction and gasification of solid fuels
6. To learn about kinetics of combustion

Course contents:

Unit I **(Contact hours 8)**

Introduction: History of solid fuel, History of liquid fuels and gaseous fuels, Production, present scenario and consumption, Fundamental definitions, properties and various measurements, Definitions and properties of solid fuels, Definitions and properties of liquid and gaseous fuels,Various measurement techniques.

Unit II **(Contact hours 8)**

Solid Fossil fuel (Coal): Coal classification, composition and basis, Coal mining, Coal preparation and washing, Combustion of coal and coke making, Action of heat on different coal samples, Different types of coal combustion techniques, Coal tar distillation, Coal liquefaction ,Direct liquefaction, Indirect liquefaction, Coal gasification.

Unit III **(Contact hours 8)**

Liquid Fossil fuel (Petroleum): Exploration of crude petroleum, Evaluation of crude, Distillation, Atmospheric distillation, Vacuum distillation, Secondary processing, Cracking, Thermal cracking, Visbreaking, Coking, Catalytic cracking, Reforming of naphtha, Hydrotreatment, dewaxing, DE asphalting, Refinery equipment.

Unit IV **(Contact hours 6)**

Gaseous Fuels: Natural gas and LPG, Producer gas, Water gas, Hydrogen, Acetylene, Other fuel gases.

Unit V **(Contact hours 7)**

Combustion Technology: Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation.

UnitVI **(Contact hours 8)**

Mechanism and kinetics of combustion, Flame properties, Combustion burners, Combustion furnaces, Internal combustion engines.

Textbook:

1. Irvin Glassman, *Combustion*, 2nd ed., Academic Press.
2. Richard A. Dave, I.P, *Modern Petroleum Technology*, Vol 1, Upstream, Ed. 6th ed., John Wiley & Sons. Ltd.

References:

1. Alan G. Lucas, I.P, *Modern Petroleum Technology*, Vol 2, Downstream, Ed., 6th ed., John Wiley & Sons. Ltd.
2. B.K. Bhaskar Rao, *Modern Petroleum Refining Processes*, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd. Report on the project "Coal Combustion Study", sponsored by Tata Iron and Steel Company Ltd., Jamshedpur.

Course outcomes: At the end of this course, the student will be able to

CO 1	Distinguish the various fuels and their properties.
CO 2	Explain the classification and composition of solid fossil fuels like coal.
CO 3	Explain the classification and composition of liquid fossil fuels like petroleum.
CO 4	Explain the classification and composition of gaseous fossil fuels like natural gas.
CO 5	Distinguish the liquefaction and gasification of solid fuels.
CO 6	Analyze the kinetics of combustion process.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX45	Energy Conservation and Management	PEC	3-0-0	3

Prerequisites: Applied Thermodynamics

Course Objectives:

1. To introduce the demand and supply of energy with reference of national energy consumption data.
2. To assess the need and instruments of energy auditing.
3. Brief introduction to Power transmission system and its efficiency.
4. To provide the knowledge about the illumination concepts.
5. To analyze the energy conservation measures in different thermal systems.
6. To impart knowledge in the domain of energy conservation

Course Contents

Unit I **(Contact hours 7)**

Introduction to energy & power scenario of world, National Energy consumption data and environmental aspects associated with energy utilization.

Unit II **(Contact hours 6)**

Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing.

Unit III **(Contact hours 8)**

Components of EB billing, HT and LT supply, transformers, cable sizing; Concept of capacitors, power factor improvement, harmonics; Electric motors- motor efficiency computation, energy efficient motors.

Unit IV **(Contact hours 8)**

Illumination- Lux, Lumens, types of lighting, efficacy, LED lighting and scope of energy conservation in lighting.

Unit V **(Contact hours 8)**

Thermal systems, Boilers, Furnaces and Thermic Fluid heaters- efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories.

Unit VI **(Contact hours 8)**

Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration& Air Conditioning systems, Cooling Towers, DG sets. Energy Economics- discount period, payback period, internal rate of return, net present value; Life Cycle costing- ESCO concept.

Text Books

1. Witte L.C., Schmidt P.S. and Brown D.R., *Industrial Energy Management and Utilization*, Hemisphere Publ., Washington, 1988.
2. Callaghn P.W., *Design and Management for Energy Conservation*, Pergamon Press, Oxford, 1981.

References

1. Murphy W.R. and McKay G., *Energy Management*, Butterworths, London, 1987.
2. *Energy Manager Training Manual*, Bureau of Energy Efficiency (BEE) under Ministry of Power, GOI, 2004 (available at www.energymanager training.com).

Course Outcomes: At the end of this course, the student will be able to

CO 1	Identifythe demand and supply of energy of the world
CO 2	Explain the need and instruments of energy auditing.
CO 3	Assess the parameter of power transmission system and its efficiency.
CO 4	Make use of the illumination concepts.
CO 5	Evaluate the energy conservation measures in different thermal systems.
CO 6	Understand the concepts of energy conservation techniques.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX46	Cryogenics	PEC	3-0-0	3

Prerequisites: Thermodynamics

Coarse Objectives

1. Understand principles of cryogenic systems.
2. Understand air and helium liquefaction processes
3. Classify cascade refrigeration systems.
4. Understand principles of ultra-low temperature systems and their applications
5. Understand the cryogenic instrumentation.
6. Analyze the storage systems used in cryogenic applications

Course Content

Unit-I **(Contact hours 7)**

Introduction to Cryogenic Systems: Applications Areas of Cryogenic Engineering Low temperature properties of engineering materials – Mechanical properties, Thermal properties, Electrical properties. Introduction the Thermodynamically Ideal system Production of low temperatures – Joule Thompson Effect, Adiabatic expansion.

Unit-II **(Contact hours 6)**

Gas Liquification Systems: Liquification systems for Air Simple Linde – Hampson System, Claude System, Heylndt System, Dual pressure, Claude. Liquefaction cycle Kapitza System. Comparison of Liquefaction Cycles Liquefaction cycle for hydrogen, helium and Neon, Critical components of liquefaction systems.

Unit-III **(Contact hours 8)**

Gas Cycle Cryogenic Refrigeration Systems: Classification of Cryo coolers Stirling cycle Cryo – refrigerators, Ideal cycle – working principle. Schmidt's analysis of Stirling cycle Various configurations of Stirling cycle refrigerators Integral piston Stirlingcryo-cooler, Free displacer split type StirlingCryo coolers, Gifford McmahonCryo- refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator, Cryogenic regenerators.

Unit IV **(Contact hours 8)**

Ultra-low-temperature refrigerators: Definition and Fundamentals regarding ultra-low temperature refrigerators, Magneto Caloric Refrigerator 3He-4He Dilution refrigerator. Pomeranchuk cooling. Measurement

systems for low temperatures, Temperature measurement at low temperatures, Resistance thermometers, Thermocouples, Thermistors, Gas Thermometry. Liquid level sensors.

Unit-V (Contact hours 8)

Vacuum Technology: Fundamental principles. Production of high vacuum, Mechanical vacuum pumps, Diffusion pumps, Cryo-pumping, Measurement of high vacuum level. Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation Powder & Fibers Opacified powder insulation, Gas filled powders & Fibrous materials Multilayer super-insulation, Composite insulation.

Unit-VI (Contact hours 8)

Cryogenic Fluid Storage and Transfer Systems: Design of cryogenic fluid storage vessels, Inner vessel, Outer Insulation, Suspension system, Fill and drain lines. Cryogenic fluid transfer, External pressurization, Self pressurization, Transfer pump.

Application of Cryogenic Systems, Cryogenic application for food preservation – Instant Quick Freezing techniques 11.2 Super conductive devices, Cryogenic applications for space technology.

Textbooks

1. Randall F. Barron, *Cryogenics Systems*, Second Edition Oxford University Press New York, Clarendon Press, Oxford, 1985.
2. K. D.Timmerhaus and T.M. Flynn, Cryogenic Process Engineering, Plenum Press, New York,1989.
3. A. R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005

Reference

1. Traugott H.K. Frederking and S.W.K. Yuan, Cryogenics - Low Temperature Engineering and Applied Sciences, Yutopian Enterprises, 2005.
2. R.W. Vance, Cryogenic Technology, John Wiley & Sons, Inc., New York, London
3. Pipkov, "Fundamentals of Vacuum Engineering", Meer Publication.

Hyperlinks:

National Institute of Standards and Technology: http://www.nist.gov/index.html

Course Outcomes: At the end of this course, the student will be able to

CO 1	Identify the principles of working of cryogenic systems.

CO 2	Distinguish the air and helium liquefaction processes
CO 3	Classify cascade refrigeration systems.
CO 4	Explain principles of ultra-low temperature systems and their applications
CO 5	Utilize the instrumentation techniques in cryogenic.
CO 6	Evaluate the parameters required to design the storage systems used in cryogenic applications

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX47	Advanced IC Engines	PEC	3-0-0	3

Prerequisites: Applied Thermodynamics

Course Objectives

To make the student understand the

1. Engine operating parameters like fuel-air mixtures, temperature andcycles
2. Supercharging, turbo charging and flow through ports and valves
3. Combustion process in SI engine and CI engine
4. Emissions formation during the combustion cycle and their treatment.
5. Metering and flow of charge in SI engines
6. Modern trends in IC engines

Course Contents

Unit I **(Contact hours 8)**

Introduction – Historical Review – Engine Types – Design and operating Parameters. **Cycle Analysis:** Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine

Cycles – Real Engine cycles - differences and Factors responsible – Computer Modeling.

Unit II **(Contact hours 7)**

Gas Exchange Processes: Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging.

Charge Motion: Mean velocity and turbulent characteristics – Swirl, Squish – Pre- chamber Engine flows.

Unit III **(Contact hours 8)**

Combustion in S.I Engines: Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing P-θ diagram.

Combustion in CI engines: Essential Features –Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

Unit IV **(Contact hours 8)**

Pollutant Formation and Control: Nature and extent of problems –

Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate Emissions – Measurement –
Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean, NOx, Catalysts.

Unit V **(Contact hours 8)**

Engine Heat Transfer: Importance of heat transfer, heat transfer and engine energy balance, Convective heat transfer, radiation heat transfer, Engine operating characteristics. Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen.

Unit VI **(Contact hours 6)**

Modern Trends in IC Engines: Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Design the parameters like fuel-air mixtures and cycle analysis
CO 2	Explain the combustion process in SI and CI engines and control the pollutant Formation
CO 3	Evaluate the flow in carburetor and Intake manifolds.
CO 4	Identify the importance of heat transfer, heat transfer and engine energy balance.
CO 5	Assess the fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen
CO 6	Utilize the modern concepts like Lean burn, HCCI, GDI

Text Book:

1. J.B Heywood, *I.C. Engines Fundamentals*, TMH, 2002

References:

1. Ganesan, V. *Internal combustion engines*. McGraw Hill Education (India) Pvt Ltd, 2015.
2. G.K. Pathak & DK Chevan, *I.C. Engines*, Standard Publications
3. V.Ganesan, *Computer Simulation of C.I. Engine Process*/ /University Press
4. HN Gupta, *Fundamentals of IC Engines*, 2nd edition, PHI.
5. Fergnson, *I.C. Engines*, Wiley.
6. Teylor, *The I.C. Engine in theory and Practice Vol.I*, IT Prof. AndVol.II

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX48	Renewable Energy Resources	PEC	3-0-0	3

Course Learning Objectives

1. To introduce the different types of renewable energy sources
2. Know the need of renewable energy resources, historical and latest developments
3. To make the student to be aware of the need for energy conservation and to fulfill the current demand with renewable energy sources.
4. Understanding basic characteristics of renewable sources of energy and technologies for their utilization
5. Outline division aspects and utilization of renewable energy sources for both domestics and industrial application
6. Analyze the environmental aspects of renewable energy resources.

Course content

Unit I **(Contact hours 7)**

Introduction: Renewable Sources of Energy-Grid-Supplied Electricity-Distributed Generation- Renewable Energy Economics-Calculation of Electricity Generation Costs – Demand side Management Options –Supply side Management Options-Modern Electronic Controls of Power Systems.

Unit II **(Contact hours 8)**

Wind Power Plants: Appropriate Location -Evaluation of Wind Intensity -Topography - Purpose of the Energy Generated -General Classification of Wind Turbines-Rotor Turbines-Multiple-Blade Turbines Drag Turbines - Lifting Turbines-Generators and Speed Control used in Wind Power Energy Analysis of Small Generating Systems.

Unit III **(Contact hours 8)**

Photovoltaic Power Plants: Solar Energy-Generation of Electricity by Photovoltaic Effect -Dependence of a PV Cell Characteristic on Temperature-Solar cell Output Characteristics-Equivalent Models and Parameters for Photovoltaic Panels-Photovoltaic Systems-Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy.

Unit IV **(Contact hours 8)**

Fuel Cells: The Fuel Cell-Low and High Temperature Fuel Cells-Commercial and Manufacturing Issues Constructional Features of Proton

Exchange-Membrane Fuel Cells
–Reformers-Electrolyzer Systems and Related Precautions-Advantages and Disadvantages of Fuel Cells-Fuel Cell Equivalent Circuit-Practical Determination of the Equivalent Model Parameters -Aspects of Hydrogen as Fuel.

Unit V **(Contact hours 6)**

Biomass Energy: Classification of biomass. Physicochemical characteristics of biomassas fuel. Biomassconversion routes.
Ocean Energy: Principle of ocean thermal energy conversion system, Principles of Wave and Tidal energy conversion.
Geothermal energy: Origin of geothermal resources, type of geothermal energy deposits. Hydrogen as a source of energy.

Unit VI **(Contact hours 8)**

Storage Systems: Energy Storage Parameters-Lead–Acid Batteries-Ultra Capacitors- Flywheels -Superconducting Magnetic Storage System-Pumped Hydroelectric Energy Storage - Compressed Air Energy Storage - Storage Heat -Energy Storage as an Economic Resource.

Text Books

1. Godfrey Boyle, *Renewable Energy*, Oxford University Press, 2004
2. Solanki, *Renewable Energy Technologies: Practical Guide for Beginners*, PHI Learning Pvt. Ltd., 2008.

Reference Books

1.D. Mukherjee: *Fundamentals of Renewable Energy Systems,* New Age International
publishers,

2007.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez: *Grid Converters for Photovoltaic and Wind Power Systems*, John Wiley & Sons, 2011.
3. Gilbert M. Masters: *Renewable and Efficient Electric Power Systems*, John Wiley & Sons, 2004.

Course Outcomes: After the end of this course the student will be able to

CO 1	Identify the basic properties of different renewable sources of energy and technologies for the utilization

CO 2	Utilize the main elements of technical systems designed for utilization of renewable sources of energy
CO 3	Explain the advantages and disadvantages of different renewable sources of Energy
CO 4	Solve the energy potential problems of renewable sources of energy
CO 5	Explain the correlation between different operational parameters
CO 6	Select engineering approach to problem solving when implementing the projects on renewable sources of energy.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX49	Nuclear Power Generation & Safety	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the need for nuclear power and familiarize with basic terms
2. To learn the working of nuclear fission reactions and breeding
3. To classify and learn different types of nuclear reactors
4. To make the student learn the different types of materials used in nuclear plants
5. To learn about nuclear disposal – its types and the challenges associated
6. To understand the safety measures to be followed and the after effects of radiation

Course Content:

Unit - I **(Contact hours 8)**

Introduction to Nuclear Engineering

Introduction, Why Nuclear Power for Developing Countries, Atomic Nuclei, Atomic Number and Mass Number, Isotopes, Atomic Mass Unit, Radioactivity and Radioactive Change Rate of Radioactive Decay, Mass – Energy Equivalence, Binding Energy

Unit - II **(Contact hours 7)**

Nuclear Reactions - Types

Release of Energy by Nuclear Reaction, types of Nuclear Reactions, Initiation of Nuclear Reaction, Nuclear Cross – section, Nuclear Fission, The Fission Chain Reaction, moderation, Fertile Materials and Breeding

Unit - III **(Contact hours 8)**

Nuclear Reactors

Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurized Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Program for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plant

Unit - IV **(Contact hours 6)**

Nuclear Materials

Introduction, Fuels, Cladding and Structural Materials Coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials

Unit - V **(Contact hours 8)**

Nuclear Waste & Its Disposal

Introduction, Unit of Nuclear Radiation, Types of Nuclear Waste, Effects of Nuclear Radiation, Radioactive Waste Disposal System, Gas Disposal System

Unit – VI **(Contact hours 8)**

Safety Rules

Personal Monitoring, Radiation Protection (Radiation Workers, Non-Radiation Workers, Public at large), Radiation Dose (Early effect, Late effect, hereditary effect)

Text books:

1. P.K.Nag, *Power Plant Engineering*, Tata McGraw Hill.
2. Arora &Domkundwar, *Power Plant Engineering*, Dhanpat Rai & Co.
3. J.H.Horlock, *Combined Power Plants*,Pergamon Press.

Reference Books:

1. Black / Veatch, "*Power Plant Engineering*" , CBS Publishers & Distributors
2. Sh. H.Cohen, G.F.C. Rogers. H.I.H.Saravanamuttoo, "*Gas Turbine Theory*" –by Longman Scientific & Technical.

Web resources:

1. NPTEL, Dec 31 2009**,** *'Nuclear Power Generation'* URL**:** https://www.youtube.com/watch?v=uulD0KVkmWg
2. NPTEL, Dec 22 2017, *'Fundamentals of Nuclear Power Generation'* URL: https://www.youtube.com/watch?v=oPZrUW9GQRg

Course outcomes: At the end of the course, the student will be able to

CO 1	Explain the concepts of atomic, mass number, binding energy, etc.
CO 2	Make use of the concepts of nuclear fission reaction
CO 3	Identify, classify and differentiate the working of various types of reactors
CO 4	Distinguish the different types of control rod, moderator materials, etc.
CO 5	Utilize the processes associated in nuclear waste disposal and the associated types
CO 6	Identify the safety rules adopted in nuclear plants and the after effects of radiation.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX50	Automobile Engineering	PEC	3-0-0	3

Course Objectives:

1. To introduce the basic structure of an automobile
2. Familiarization of different components in the automobile transmission systems.
3. To provide brief idea about the Braking system and suspension system of an automobile.
4. To make student understand the different steering mechanisms of an automobile.
5. Provide knowledge about the cooling system and electrical system of an automobile.
6. Brief introduction to different fuels used in an automobiles and their impact on environment.

Course Content

Unit I **(Contact hours 8)**

Introduction: Layout of automobile – introduction chassis and body components. Types of Automobile engines – power unit – Introduction to engine lubrication – engine servicing.

S.I. and C.I. Engine Fuel supply systems: Mechanical and electrical fuel pump – petrol injection, Introduction to MPFI and GDI Systems. Requirements of diesel injection systems, types of injection systems, DI Systems IDI systems, Testing of fuel pumps, Introduction CRDI and TDI Systems.

Unit II **(Contact hours 8)**

Transmission System: Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh, constant mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. Propeller shaft, Hotch-Kiss drive, Torque tube drive, universal joint, differential rear axles, wheels and tyres.

Unit III **(Contact hours 8)**

Braking System: Mechanical brake system - Hydraulic brake system - Master cylinder - wheel cylinder tandem master cylinder; requirement of brake fluid, Pneumatic and vacuum brakes. **Suspension System:** Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, Independent suspension system.

Unit IV **(Contact hours 6)**

Steering System: Steering geometry – camber, castor, king pin rake, combined angle toe

in, center point steering; types of steering mechanism – Ackerman steering mechanism, Davis steering mechanism, steering gears – types, steering linkages.

Unit V **(Contact hours 8)**

Cooling System: Cooling Requirements, Air Cooling, Liquid Cooling, Thermo, water and Forced Circulation System – Radiators – Types – Cooling Fan - water pump, thermostat, evaporative cooling – pressure sealed cooling – antifreeze solutions. **Electrical System:** Charging circuit, generator, current – voltage regulator – starting system, bendix drive mechanism solenoid switch, lighting systems, Horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.

Unit VI **(Contact hours 7)**

Emissions from Automobiles: Pollution standards National and international – Pollution Control – Techniques.

Energy alternative: Solar, Photo-voltaic, hydrogen, Biomass, alcohols, LPG, CNG, liquid Fuels and gaseous fuels, Hydrogen as a fuel for IC Engines, their merits and demerits.

Course Outcomes: After completion of the course the student will be able to

CO 1.	Describe the basic structure of an automobile
CO 2.	Distinguish the different components in the automobile transmission systems.
CO 3.	Demonstrate the Braking system and suspension system of an automobile.
CO 4.	Design the different steering mechanisms of an automobile.
CO 5.	Explain the cooling system and electrical system of an automobile.
CO 6.	Differentiate the different fuels used in an automobiles and their impact on environment.

Text books:

1. Kirpal Singh, *Automobile Engineering*, 7th ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., *Automobile Engineering*, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., *Automotive Mechanics*, 2nd ed., East-West Press, 1999.
4. Heisler H, *Advanced Engine Technology*, SAE International Publ., USA, 1998.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX73	Refrigeration & Air Conditioning	PEC	3-0-0	3

Course objectives:

1. Learning the fundamental principles and different methods of refrigeration and air conditioning.
2. Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
3. Comparative study of different refrigerants with respect to properties, applications and environmental issues.
4. Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
5. Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems

Course contents:

Unit I **Contact Hours: 7**

Introduction to refrigeration: Necessity and applications, unit of refrigeration and C.O.P, mechanical refrigeration, types of ideal cycle of refrigeration.

Refrigerants: Desirable properties, commonly used refrigerants, nomenclature.

Unit -II **Contact Hours: 7**

Air refrigeration: Bell Coleman cycle and Brayton cycle, Open and Dense air systems, Actual refrigeration system, refrigeration needs of aircrafts, adoption of air refrigeration, Justification, types of systems, problems.

Unit III **Contact Hours: 8**

Vapour compression refrigeration: Working principle, essential components of plant, simple vapor compression refrigeration cycle, Multi pressure systems – multistage compression, multi evaporator system, Cascade system, use of p – h charts, problems.

System components: Compressors- general classification, comparison, advantages and disadvantages, Condensers - classification, working, Evaporators - classification, working, Expansion devices - types, working.

Unit IV **Contact Hours: 8**

Vapour Absorption Sytem: Calculation of max COP, description and working of NH_3 - water system, Li - Br, water system, principle of operation of three fluid absorption system and salient features, **Steam jet refrigeration:** Principle of working, application, merits and demerits.

Non-Conventional Refrigeration Methods: Principle and operation of thermoelectric refrigerator and Vortex tube or Hirsch tube.

Unit V **Contact Hours: 8**

Introduction to air conditioning: Psychrometric properties and processes, sensible and latent heat loads, S–load characterization and SHF, need for ventilation, infiltration, concepts of RSHF, ASHF, ESHF & ADP, concept of human comfort and effective temperature, comfort air conditioning, industrial air conditioning requirements, air conditioning load calculations.

Unit VI **Contact Hours: 7**

Air conditioning systems: Classification of equipment, cooling, heating, humidification and dehumidification, filters, grills and registers, deodorants, fans and blowers, heat pump, heat sources, different heat pump circuits, application.

Course outcomes:

CO1 - Illustrate the fundamental principles and applications of refrigeration and air conditioning system
CO2 - Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems
CO3 - Present the properties, applications and environmental issues of different refrigerants
CO4 - Calculate cooling load for air conditioning systems used for various
CO5 - Operate and analyze the refrigeration and air conditioning systems.

Textbooks:

1. Arora,C.P., Refrigeration & Air Conditioning, Tata McGraw Hill, New Delhi, 1995.
2. Stoecker, W.F., Refrigeration & Air Conditioning, McGraw Hill, New York, 1958.
3. Stoecker, W.F., & Jones J.W., Refrigeration & Air Conditioning, McGraw Hill, New York, 1982.

Reference Books:

1. Dossat, Refrigeration & Air Conditioning, 2nd ed., Wiley Eastern Limited, New Delhi, 1989.
2.Jordan &Priester, Refrigeration & Air Conditioning, 2nd ed., Prentice Hall India Pvt. Ltd, 1985.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

SYLLABUS OF PROFESSIONAL ELECTIVES COURSES
MANUFACTURING STREAM

Course Code	Semester II	Course Category	L-T-P	Credits
20MEXX51	Industrial Automation	PEC	3-0-0	3

Course Learning Objectives:

1. To know and learn General function of Industrial Automation.
2. To know in detail Automation Storage Systems
3. To Categorize Input/Output Modules
4. To identify Automatic Identification Methods
5. To identify Principles, Strategies and merits of Automation
6. To get knowledge about Industrial control systems

Course Content:

Unit – I **(Contact hours 7)**

Principles and Strategies of Automation: Power to Accomplish the Automated Process, program of Instruction, Control System, Advanced automation Functions: safety Monitoring, maintenance and repair Diagnostics, error Detection and Recovery, levels of automations, Merits and Demerits of automation.

Unit – II **(Contact hours 8)**

Material Handling systems and Design: Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage systems-Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.

Unit - III **(Contact hours 7)**

Automatic identification methods: Overview of Automatic Identification Methods, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies.

Unit - IV **(Contact hours 8)**

Industrial control systems: Process Industries Vs Discrete Manufacturing Industries, Levels of Automation in the two industries, Variables and Parameters in the two industries. Continuous Vs Discrete control-Continuous Control System, Discrete Control

System. Control system components-Sensors, Actuators, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Input/output Devices for Discrete Data.

Unit – V **(Contact hours = 7)**

Industry 4.0: Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Unit VI **(Contact hours = 8)**

Modeling and Simulation for Plant Automation: Introduction, need for system Modeling, Building Mathematical Model of a Plant, Modern Tools & Future Perspective.

Learning resources

Text books:

1.GrooverM.P.,"*Automation production Systems and Computer Integrated Manufacturing*", Pearson Education, 2013.

3. Tiess Chiu Chang and Richard A. W., "*An Introduction to Automated Process Planning Systems",* Tata McGraw-Hill Publishing Company, New Delhi, 2012.

Reference books :

1. Klafter, R.D., Chmielewski, T. A. and Negin M., " *Robot Engineering-An Integrated Approach*", Prentice Hall of India, New Delhi, 2012.

2. Craig J. J., "*Introduction to Robotics Mechanics and Control*", 3 rd Edition, Pearson Higher.

Web resources

Video resources:

Indian institute of technology kharagpur, April 22 2015, '*Industrial automation and control'* URL: http://www.nptelvideos.in/2012/11/industrial-automation-and-control.html?m=1

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand principles and strategies of industrial automation.
CO 2	Design material storage systems for an automated factory.
CO 3	Devise automated shopfloor controls and part identification methods.
CO 4	Outline the IoT Technologies used in a manufacturing plant and their role in Industry.
CO 5	Understand advantages of industrial automation.
CO 6	Design material handling systems for an automated factory.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX52	Soft computing	PEC	3-0-0	3

Course Learning Objectives:

1. To understand history of optimization and classical optimization methods
2. To understand evolutionary optimization and methods
3. To understand optimization methods using swarm intelligence
4. To understand neural network types, training and clustering
5. To understand fuzzy logic, fuzzy controllers and fuzzy clustering
6. To understand interaction of combined GA-NN-FL

Course Content:

Unit – I **(6 Contact hours)**

Introduction: hard computing, soft computing, hybrid computing.

Optimization: statement of optimization problem, classification of optimization problems and some traditional Methods:

Analytical methods of optimization: necessary and sufficient conditions of optimality, **constraint handling methods:** substitution, constrained variation, Lagrange multiplier, **bounding methods:** exhaustive search method, bisection, Fibonacci, golden section, **Random search methods:** random walk method, random jump, **Direct search methods:** Cauchy or steepest descent method

Unit – II **(8 Contact hours)**

Introduction to Genetic Algorithms: binary coded GA, constraint handling GA, genetic operators. Some specialized Genetic Algorithms: real coded GA, micro GA, visualized interactive GA, scheduling GA

Unit – III **(8 Contact hours)**

Advanced optimization algorithms: Non-dominated sorting genetic algorithm, differential evolution, evolution strategies, simulated annealing, particle swarm optimization, ant colony optimization, artificial bee-colony, bat algorithm, artificial life.

Unit – IV **(10 Contact hours)**

Fundamentals of Neural Networks: introduction,

The Artificial Neuron: Calculating the Net Input Signal, Activation Functions, Artificial Neuron Geometry, Artificial Neuron Learning, Augmented Vectors, Gradient Descent Learning Rule, Widrow-Hoff Learning Rule, Generalized Delta Learning Rule, Error-Correction Learning Rule,

Supervised Learning NN: Neural Network Types, Feed forward Neural Networks,

Functional Link Neural Networks, Product Unit Neural Networks, Simple Recurrent Neural Networks, Time-Delay Neural Networks, Cascade Networks,

Supervised Learning Rules: The Supervised Learning Problem, Gradient Descent Optimization, Scaled Conjugate Gradient, Leap Frog Optimization, Particle Swarm Optimization, Functioning of Hidden Units, Ensemble Neural Networks

Unsupervised Learning Neural Networks, self-organizing map,

Radial basis function NN: Radial Basis Function Network Architecture, Radial Basis Functions, Training Algorithms, Radial Basis Function Network Variations.

Unit – V **(8 Contact hours)**

Fuzzy Sets: Formal Definitions, Membership Functions, Fuzzy Operators, Fuzzy Set Characteristics, Fuzziness and Probability,

Fuzzy Logic and Reasoning: Linguistics Variables and Hedges, Fuzzy Rules, Fuzzy Inferencing: Fuzzification,Inferencing, Defuzzification;

Fuzzy Controllers: Components of Fuzzy Controllers, Fuzzy Controller Types: Table-Based Controller, Mamdani Fuzzy Controller, Takagi-Sugeno Controller.

Fuzzy Clustering:fuzzy c-mean clustering, entropy based clustering.

Unit – VI **(5 Contact hours)**

Combined Genetic Algorithms Fuzzy Logic, Combined Genetic Algorithms Neural Networks, Combined Neural Networks Fuzzy Logic, Combined GA-NN-FL

Text book:

1. Engelbrecht A P, Computational Intelligence, John Weily& Sons, Chichester, West Sussex PO19 8SQ, England, 2007
2. Engineering optimization, S. S. Rao
3. D. K. Pratihar**,** Soft computing: Fundamentals and applications, Alpha Science, 2013.
4. A. Konar, Computational Intelligence,
5. Goldberg D. E, genetic algorithm in search optimization and machining learning, Pearson education, 2002.

Reference Books:

1. Haykin S, Neural networks and learning machines, Pearson education, 3rd edition, 2016
2. Klir G J and Yuan B, Fuzzy sets and fuzzy logic theory and applications, Pearson education, 2nd edition, 2015.
3. Sun J., and Wu X.J., *Particle swarm optimization: Classical and quantum perspectives*, CRC Press, 2012.

Web resources:

IITK Feb 03 2018 Introduction to soft computing https://www.youtube.com/watch?v=K9gjuXjJeEM&list=PLJ5C_6qdAvBFqAYS0P9INA ogIMklG8E-9

Course outcomes: At the end of the course, the student will be able to

CO 1	Have understanding of history of optimization and solve problems using classical techniques
CO 2	Optimize systems using genetic algorithms
CO 3	Optimize systems using swarm intelligence
CO 4	Design neural systems for system identification and clustering
CO 5	Design fuzzy systems for control and clustering
CO 6	Design integrated Genetic-Neuro-Fuzzy systems for identification, control and clustering

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course name	Course Category	L-T-P	Credits
20MEXX53	Advanced Materials Technology	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the classification and properties of materials.
2. Focuses on the processing, behavior and applications of polymers.
3. Focuses on the classification, processing and applications of composite materials.
4. To understand the classification, processing and functionality of Smart materials.
5. To understand the processing, behavior and applications of biomaterials.
6. To understand the concepts and applications of materials and selection of materials.

Course Content:

Unit I: **(6 Contact hours)**

Introduction

Classification of materials with special reference to advanced materials. Introduction to material properties, role of materials in technological development, need of modern engineered materials, nanomaterials, history of materials development, classification, applications and processing of ceramics, refractory materials, abrasives,

Unit II: **(10 Contact hours)**

Polymer materials:

Applications and processing of polymers: introduction; stress – strain behavior; macroscopic deformation; viscoelastic deformation; fracture of polymers; miscellaneous mechanical characteristics; deformation of semi crystalline polymers; factors that influence the mechanical properties of semi crystalline polymers; deformation of elastomers; crystallization; melting; the glass transition; melting and glass transition temperatures; factors that influence melting and glass transition temperatures; plastics; elastomers; fibers; miscellaneous applications; advanced polymeric materials; polymerization; polymer additives; forming techniques for plastics; fabrication of elastomers; fabrication of fibers and films.

Unit III: **(10 Contact hours)**

Composites

Introduction; large – particle composites; dispersion – strengthened composites; influence of fiber length; influence of fiber orientation and concentration; the fiber phase; the matrix phase; polymer – matrix composites; metal – matrix composites; ceramic – matrix composites; carbon – carbon composites; hybrid composites; processing of fiber – reinforced composites; laminar composites; sandwich panels, liquid state methods and solid state methods. surface composite materials, applications and manufacturing methods.

Unit IV: **(6 Contact hours)**

Functional materials

Processing of functionally graded materials, classification, applications, principles and mechanisms behind special properties in magnetic materials, piezoelectric materials, semiconductors, smart materials, applications and future scope.

Unit V: **(7 Contact hours)**

Biomaterials

History of biomaterials, classification of biomaterials: materials perspective – metallic, ceramic, polymer and composite based materials; based on functioning – bonier, bioactive, bioresorbable, regenerative. Steps involved in developing novel biomaterials, designing new biomaterials, designing medical devices and implants, manufacturing processes, hip joints, knee joints, orthopedic implants, cardiovascular implants, challenges and future scope.

Unit VI:

Materials selection and applications **(6 Contact hours)**

Introduction; site specific design, materials for extreme environmental conditions, high entropy alloys, corrosion resisting alloys, wear resisting alloys, materials for automobile applications, aerospace applications, marine applications, electric and electronics applications. Selection criteria for different applications.

Economic issues, environmental and social issues in materials technology: component design; materials; manufacturing techniques; recycling issues in materials science and engineering.

Text books:

1. *Jon Binner, Paul Hogg and John Murphy, Advanced Materials Source Book, Elsevier publishers, 1995*
2. William D. Callister, Jr. ,*Materials Science and Engineering An Introduction*, John Wiley & Sons, Ltd., Singapore, 2006
3. Sam Zhang, Lin Li, Ashok Kumar., *Materials Characterization Techniques*, Taylor & Francis Group, CRC Press, New York, 2008

Reference books:

1. Joon Park and R.S. Lakes, *Biomaterials – An Introduction*, Springer publishers, 2nd ed., 2006.

Web resources:

IIT Kharagpur, December 2009, *Advanced Materials and Processes*, https://nptel.ac.in/courses/113105057/

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the classification and properties of materials

CO 2	Understand the processing, behavior and applications of polymers.
CO 3	Understand the classification, processing and applications of composite materials
CO 4	Understand the classification, processing and functionality of Smart materials
CO 5	Understand the processing, behavior and applications of biomaterials
CO 6	Understand the concepts and applications of materials and selection of materials

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course name	Course Category	L-T-P	Credits
20MEXX54	Welding Technology	PEC	3-0-0	3

Course Learning Objectives:

1. To have proper understanding about the full potential in the welding field.
2. To have proper understanding about the various welding processes.
3. To have proper understanding about the problems occur during welding of various materials.
4. To have proper understanding about the use of appropriate welding process for a given problem.
5. To have proper understanding about the welding parameters effect on mechanical properties of the welded joints.
6. To communicate more effectively with the industrial people with welding terminology.

Course Content:

Unit I **Contact hours: 5**

Introduction to Welding, Classification – Welding and Allied Processes, Welding Arc, Structure and Characteristics, Types, Arc Blow, Methods of Arc Initiation, Arc Stability and Efficiency, Welding Machine Characteristics (Arc and Solid State) – Volt Ampere Characteristics, AC Welding, DC Welding Power Source,Rectified D.C. Welding Power Sources, Synergic And Pulsed Welding Techniques.

Unit II **Contact hours: 8**

Heat Flow in Welding – Temperature Distribution in Welding, Efficiency of Heat Sources, Heat Flow and Cooling Rates in Welding, Welding Stresses– Causes, Measurement and Calculations, Method of Relieving and Controlling, Distortion in Welding.

Unit III **Contact hours: 8**

Arc welding processes: Manual metal arc welding, submerged arc welding, gas metal arc welding, tungsten inert gas welding, flux cored arc welding;High energy density welding processes – plasma arc welding, electron beam welding, and laser beam welding; resistance spot welding.

Unit IV **Contact hours: 8**

Resistance Welding– Introduction, Principle, Equipment, Resistance Spot Welding and Seam Welding, Resistance Projection Welding and Applications; solid state welding techniques – friction welding, friction stir welding, ultrasonic welding.
Weldability– Weldability Assessment, Weldability Tests – Hot Cracking Tests, Cold Cracking Tests, Actual Welding Tests, hot ductility test.

Unit V **Contact hours: 8**

Welding Metallurgy of Ferrous alloys – welding issues in low carbon steels, welding issues in low alloy steels, welding issues in austenitic stainless steels, preheat, post heat, and post weld heat treatment.

Unit VI **Contact hours: 8**

Welding metallurgy of non-ferrous alloys – welding issues in aluminium alloys, welding issues in titanium alloys, welding issues in nickel base super alloys, welding issues in magnesium alloys.

Text books

1. R. W. Messler Jr., Principles of welding, WileyVCH, 1999.
2. R. S. Parmar, Welding processes and technology, Khanna publishers,3rd edition,

References

1. P N Rao, Manufacturing Technology: Foundry, Forming and Welding, Tata McGraw Hill, 4thedition, 2013.
2. Richard Little, Welding and Welding Technology, McGrawHill, 1973.

Web resources: Video material:

NPTEL, December 31 2009, "Welding" URL: https://nptel.ac.in/courses/112107144/27

Course outcomes: At the end of the course, the student will be able to

CO 1	Know about various welding processes.
CO 2	Know about the various weldability tests.
CO 3	Know about the welding issues in ferrous alloys.
CO 4	Know about the welding issues in non-ferrous alloys.
CO 5	Identify various methods to improve the mechanical properties of the weld joints.
CO 6	Identify appropriate welding methods to various applications in industrial scenario.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX55	Advanced Manufacturing Processes	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the need of advanced manufacturing process and classification of AMP.
2. Focuses on the mechanical energy based processes like AJM, WJM, and USM.
3. Focuses on the electrical energy based processes like EDM.
4. To understand the chemical and electro chemical energy based processes.
5. To understand the thermal energy based processes.
6. To understand the ECG, ECH, EDDG, ECDG processes.

Course Content:

Unit I **(5 Contact hours)**

Introduction: Advanced machining Process (AMP), need of AMP, classification, brief overview.

Unit II **(12 Contact hours)**

Mechanical energy based processes: Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water Jet Machining (WJM), Ultrasonic Machining (USM), working principles, equipment used, process parameters, MRR, applications.

Unit III **(12 Contact hours)**

Electrical energy based processes: Electric Discharge Machining (EDM), working principle, equipment, process parameters, surface finish and MRR, electrode/Tool materials, power and control circuits, tool wear, dielectric, flushing, Wire cut EDM, applications.

Unit IV **(12 Contact hours)**

Chemical and electro chemical energy based: Chemical machining and Electro-Chemical machining (CHM and ECM), etchants, maskant, techniques of applying maskants, photochemical machining, process parameters, surface finish and MRR, numerical related to ECM. Applications. Principles of ECM, equipment, surface roughness, MRR, electrical circuit, process parameters.

Unit V **(12 Contact hours)**

Thermal Energy based processes Laser Beam machining and drilling (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining (EBM). Principles, equipment, types, beam control techniques, applications. Ion Beam Machining, Sputtering yield.

Unit VI **(12 Contact hours)**

Hybridization of various advanced machining processes like Electro Chemical Grinding (ECG) and Electro Chemical Honing (ECH**),** EDDG, ECDG.

Text books

1. Hassan El Hofy, '*Advanced manufacturing process'*, McGraw Hill, 2005.
2. V.K. Jain,'*Advanced Machining Processes*', Allied Publishers, 2007.
3. Benedict G.F, '*Non-traditional manufacturing process*', CRC press.

Reference books:

1. Pandey P.C*, 'Modern machining processes'*, TMH, 2008.
2. P. K. Mishra, '*Nonconventional machining*', Narosa Publication, 2007.

Web resources:

IIT Kanpur, July 2012, *Advanced Machining Process*, https://youtu.be/Jg6YXvTO5FE

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the need of advanced manufacturing process and classification of AMP.
CO 2	Understand the mechanical energy based processes like AJM, WJM, and USM.
CO 3	Understand the electrical energy based processes like EDM
CO 4	Understand the chemical and electro chemical energy based processes
CO 5	Understand the thermal energy based processes
CO 6	Understand the ECG, ECH, EDDG, ECDG processes

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX56	Additive Manufacturing	PEC	3-0-0	3

Pre-requisite:

CAD/CAM

Course Learning Objectives:

1. To make understand the importance of additive manufacturing technology and its innovation.
2. To have proper knowledge on various additive manufacturing processes.
3. To understand the problems of a component during its manufacturing.
4. To understand the steps and difficulties involved in additive manufacturing process to produce a component.
5. To make understand the difference between the additive manufacturing and conventional manufacturing.
6. To make understand the latest trends and opportunities in additive manufacturing field.

Course Contents

Unit - I **Contact Hours: 8**

Introduction

Introduction to Additive Manufacturing, Additive Manufacturing Processes, Distinction Between Additive Manufacturing and CNC Machining, Benefits and Applications. Reverse engineering Technology

Development of Additive Manufacturing Technology

Computer-Aided Design Technology, Laser Technology, Printing Technologies, Programmable Logic Controllers, Materials, Computer Numerically Controlled Machining, Classification of Additive Manufacturing Processes, Metal Systems, Hybrid Systems.

Unit – II **Contact Hours: 12**

Generalized Additive Manufacturing Process Chain

Eight Steps in Additive Manufacturing, Metal Systems: Use of Substrates, Energy Density, Weight, Accuracy, Speed; Maintenance of Equipment, Materials Handling Issues, Design For Additive Manufacturing.

Vat Polymerization Processes. Introduction, Vat Photopolymerization Materials, Reaction Rates, Laser Scan Vat Polymerization, Photopolymerization Process Modelling, 3D Scanners: Vector scan VP machines, Scan Patterns: Layer-Based Build Phenomena and Errors, WEAVE, STAR-WEAVE, ACES Scan Pattern

Unit – III **Contact Hours: 8**

Powder Bed Fusion Processes

Introduction, Materials: Metals, Polymers, Ceramics, and Composites; Powder Fusion Mechanisms: Solid State Sintering, Chemically Induced Sintering, LPS and Partial Melting, Full Melting, Part Fabrication; Process Parameters and Modeling, Powder Handling: Powder Handling Challenges, Powder Handling Systems, Powder Recycling; Advantages and Limitations.

Unit – IV **Contact Hours: 8**

Direct Energy Deposition (DED) Processes

Introduction, General DED Process Description, Material Delivery: Powder Feeding, Wire Feeding; DED Systems: Laser Based Metal Deposition Processes, Electron Beam Based Metal Deposition Processes, Process Parameters, Typical Materials and Microstructure, Processing-Structure-Properties Relationships, Advantages and Limitations.

Unit – V **Contact Hours: 10**

Extrusion-Based Systems

Introduction, Material Loading, Liquification, Extrusion, Solidification, Positional Control, Bonding, Support Generation, Plotting and Path Control, Fused Deposition Modeling (FDM), Limitations of FDM, Bioextrusion.

Sheet Lamination Processes

Introduction, Bond-Then-Form Processes, Form-Then-Bond Processes, Materials, Material Processing, Ultrasonic Additive Manufacturing (UAM), UAM Process Parameters and Process Optimization, Microstructures and Mechanical Properties of UAM Parts, UAM Applications.

Unit – VI **Contact Hours: 14**

Post-Processing

Introduction, Support Material Removal: Natural Support Post-Processing, Synthetic Support Removal; Surface Texture Improvements, Accuracy Improvements: Sources of Inaccuracy, Model Pre-Processing to Compensate for Inaccuracy; Machining Strategy, Preparation for Use as a Pattern, Property Enhancements Using Non-Thermal Techniques, Property Enhancements Using Thermal Techniques.

Software Issues for Additive Manufacturing

Introduction, Preparation of CAD Models: The STL File, STL File Format, Binary/ASCII, Creating STL Files from a CAD System, Calculation of Each Slice Profile, Technology-Specific Elements, Problems with STL Files, STL File Manipulation, Direct Slicing of the CAD Model, Color Models, Multiple Materials,

Use of STL for Machining, Additional Software to Assist AM, The Additive Manufacturing File Format

Text books

1. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer, 2015.
2. A. Gebhardt, Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, LAP LAMBERT Academic Publishing, 2012.

References

1. C. K. Chua, K. F. Leong, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific Publishing Company, 2014.

Web resources:

Video material:

NPTEL, January 2 2017, "Additive manufacturing"
URL: https://nptel.ac.in/courses/112104204/47

Course outcomes: At the end of the course, the student will be able to

CO 1	Know various additive manufacturing processes.
CO 2	Know the type of additive manufacturing process one has to adopt for producing a component.
CO 3	Know the advantages and limitations of a given process to produce a component.
CO 4	Know the importance of materials used for producing a designed component.
CO 5	Know how additive manufacturing is different from conventional manufacturing processes.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Corse category	L-T-P	Credits
20MEXX57	Advanced Metal Forming	PEC	3-0-0	3

Course Learning Objectives:

1. Introduction and learning basics of theory of plasticity, formulation of plastic basic deformation problems and different methods of solution.
2. Application of theory of plasticity for solving metal forming problems, Numerical methods in metal forming processes.
3. Friction and Lubrication in cold and hot working, and its effects in different forming processes.
4. Technological advances in metal forming processes, forging, rolling, extrusion, wire drawing and sheet metal forming.
5. Computer aided die design for forging, extrusion, and wire drawing, automation in metal forming processes.
6. Advances in sheet metal forming concept of formability and its evaluation Hydro- forming of sheets and Tubes.

Course Content:

Unit - I **(Contact hours 8)**

Introduction and overview of the metal forming processes, forging , rolling, extrusion, wire drawing and sheet metal forming-difference between forming and other manufacturing processes, basic elements of theory of plasticity.

Unit – II **(Contact hours 7)**

Formulation of plastic deformation problems and different methods of solutions related to basic forming processes, application of theory of plasticity for solving metal forming problems.

Unit - III **(Contact hours 7)**

Numerical methods in metal forming, advantages and disadvantages of numerical methods in metal forming processes, frictional effects in cold and hot metal working processes.

Unit - IV **(Contact hours 7)**

Technological advances in metal forming processes, forging, rolling, extrusion, wire drawing and sheet metal forming processes. Application of computer Numerical Control in metal forming processes.

Unit - V **(Contact hours 8)**

Computer aided die design for forging, extrusion and wire drawing,

automation in metal forming processes.

Unit – VI **(Contact hours 8)**

Advances in sheet metal forming –concept of formidability and its evolution- Hydro forming of sheets and tubes.

–Learning resources

Text book:

1. Metal forming processes G R Nagapal.
2. Fundamentals of metal forming processes by Juneja. New age international publications, second edition.
3. Technology of metal forming processes by Kumar. PHI publications.

Reference Books:

1. Prakash M. Dixitand Uday S. Dixit, *Modeling of Metal Forming and Machining Processes,* Springer publications.
2. Heinz Tshaetsch, *Metal forming Practice,* Springer's.

Web resources:

1. https://nptel.ac.in/ courses/112106153/

Course outcomes: At the end of the course, the student will be able to

CO 1	The students will understand the basic differences between metal forming and other manufacturing processes.
CO 2	The student can be understand, how to generate the problems related to metal forming processes.
CO 3	Can be done analysis related to Metal forming processes. And can be estimated how the nature of friction is effecting Metal forming processes
CO 4	The student will be able to understand how to incorporate the advanced technologies in metal forming processes
CO 5	Can be applying the NC and CNC coding for the metal forming processes.
CO 6	Can be used computers for the usage of metal forming processes, and how the day to advancement technology is applied in the field of metal forming processes.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Corse category	L-T-P	Credits
20MEXX58	Non Destructive Testing	PEC	3-0-0	3

Course Learning Objectives:

1. Be able to List and define different defects that occur in fabrication shown through Non-Destructive Examination/Destructive Testing
2. Be able to identify the types of equipment used for each Non-Destructive and Destructive Examination.
3. Be able to explain the purpose of the Equipment, Application, and standard techniques required to perform major non-destructive and destructive examinations of welds.
4. Be able to go to specific Code, Standard, or Specification related to each testing method.
5. Have the knowledge and essential skills to identify strengths and weaknesses in materials used in fabrication.

Course Contents

Unit-I **(8 Contact hours)**

Introduction to Non Destructive Testing, Nondestructive versus Destructive Tests. Conditions for Effective Nondestructive Testing. Visual Optical methods, Dye penetrant testing, Basic principle, Types of dyes and methods of application, Developer application and Inspection.

Magnetic particle testing, Basic theory of magnetism, Magnetization methods, Field indicators, Particle application, Inspection. Evaluation of Test Results and Reporting, Applications, Advantages and Limitations

Unit-II **(8 Contact hours)**

Eddy current testing, Basic principle; Faraday's law, Inductance, Lenz's law, Self and Mutual Inductance, Impedance plane, Inspection system and probes, System calibration. Alternating Current Principles, Eddy Currents, Test Equipment, Eddy Current Applications and Signal Display. Advantages and Limitations.

Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers. Test method, Distance and Area calibration, Weld inspection by UT. Techniques, Variables, Evaluation of Test Results, Applications, Advantages and Limitations

Unit-III **(7 Contact hours)**

Acoustic emission testing: Basic principle, Sources of acoustic emission, Source

parameters, Kaiser-Felicity theory, Equipment and Data display, Source location schemes. Principles of Acoustic Emission Testing, Advantages and Limitations of Acoustic Emission Testing

Unit-IV **(7 Contact hours)**

Radiography: X-rays and Gamma rays and their properties, X-ray generation, X-ray absorption and atomic scattering. Techniques and Procedures, Radiographic Evaluation, Applications, Advantages and Limitations of Radiography.

Unit-V **(8 Contact hours)**

Image formation, Image quality, Digital Radiography, Image interpretation, Radiation Shielding. Comparison and selection of NDT methods. Thermography:principles, detectors, equipment, applications

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Unit-VI **(8 Contact hours)**

Statistical quality control, control charts, control chart attribute and variables and acceptance sampling; quality assurance and ISO 9000:2000

Text books

1. Hull B., *Non-destructive testing* Springer; Softcover reprint of the original 1st ed. 1988 edition, 2012
2. Jayamangal Prasad, C. G. KrishnadasNair, *Non-destructive test and evaluation of materials,* McGraw Hill Education; 2 edition , 2011
3. Louis Cartz, *Nondestructive Testing,* ASM International, 1995

Reference books

1. Srivastava K.C, *Handbook of magnetic particle testing* 2003
2. Grant E.L, Larenwork R.S, *Statistical quality control* McGraw Hill Education; 7 edition 2000
3. ASM Handbook, Vol. 17, *Nondestructive Evaluation and Quality Control,* ASM International; 9th Revised edition edition 1989

Video Reference links:

Title	Expert Name	Details of Expert	Web link
Non-destructive testing	Dr. Ranjit Bauri	IIT Madras	http://nptel.ac.in/courses/113106070/

Course outcomes: At the end of the course, the student will be able to

CO 1	The students can able to use the various non-destructive testing and testing Methods
CO 2	Understand for defects and characterization of industrial components
CO 3	Understand and identify the types of equipment used for each Non-Destructive and Destructive Examination.
CO 4	Analyze the purpose of the Equipment, Application, and standard techniques required to perform major non-destructive and destructive examinations of welds
CO 5	The students can able to use the specific Code, Standard, or Specification related to each testing method.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Corse category	L-T-P	Credits
20MEXX59	Computer Aided Automation & Manufacturing	PEC	3-0-0	3

Course Learning Objectives:

1. Evaluation of Computer Aided Manufacturing (CIM) and Computer Aided Design (CAD). Computer Aided Manufacturing (CAM) CAD/CAM integration.
2. Review of automation and control technologies, material handling technologies, data communication technologies.
3. Automatic data acquisition technologies, database management technologies.
4. Various manufacturing systems, Group Technology & Cellular Manufacturing Systems, Flexible Manufacturing Systems, Transfer lines, Automated Assembly Systems.
5. Quality Control Systems. Computer-Aided Process Planning. Concurrent Engineering. Production Planning and Control Systems.
6. Lean and Agile Manufacturing. Web-based manufacturing.

Course Content:

Unit – I **(Contact 7 hours)**

Introduction to computer integrated manufacturing (CIM), computer aided design (CAD) and computer aided manufacturing(CAM) basic objectives of CIM, CAD and CAM.

Unit – II. **(Contact 8 hours)**

Introduction to automation and data acquisition technologies, different types of data acquisition technologies, data communication technologies and their types.

Unit – III **(Contact 7 hours)**

Basics of Automatic data acquisition technologies, database management technologies. Various manufacturing systems and its applications.

Unit – IV **(Contact 8 hours)**

Evolution of Group Technology & Cellular Manufacturing Systems, Flexible Manufacturing Systems, Flexible manufacturing cell, Transfer lines, Automated Assembly Systems.

Unit – V **(Contact 7 hours)**

Quality Control Systems. Computer-Aided Process Planning. Concurrent Engineering. Production Planning and Control Systems.

Unit – VI **(Contact 8 hours)**

Lean, green and Agile Manufacturing. Differences among lean, green and agile manufacturing Web-based manufacturing. Six sigma. Factors influencing six sigma.

Learning resources

Text book:

1. Groover, M. P., *Automation production systems, and computer-integrated*

manufacturing, second edition, Prentice-Hall of India, New Delhi, 2001.

2. PN Rao, *CAD/ CAM Principles and applications* , second edition ,Tata McGraw Hill, by 2007.

Reference Books:

1. Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.

Web resources:

https:nptel.ac.in/courses/112102101//

Course outcomes: At the end of the course, the student will be able to

CO 1	The students can understand the basic things related CAD, CAM and CIM
CO 2	Students able to differentiate basic manufacturing and computer manufacturing
CO 3	They can attain the knowledge related to acquisition of different data for the management of different types of manufacturing systems.
CO 4	They can analyze different types of flexible manufacturing technologies
CO 5	The quality of manufacturing, and its accuracy and precision can be evaluated.
CO 6	This area gives immense knowledge related to the advanced technologies adopted by the industries to stream line

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX60	Surface Engineering	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the importance of surface engineering techniques, scope, and general principles.
2. Focuses on the conventionally available surface material removal, material addition and surface modification techniques.
3. Focuses on the advanced techniques and to understand the micro-structural and compositional modifications.
4. To understand the different types of coating methods.
5. To understand the behavior and characteristics of the surface coatings.
6. To understand the functionality and its different types of applications.

Course Content:

Unit – I:

Fundamentals of surface engineering (Contact hours 4)

Introduction: Engineering components, surface dependent properties and failures, importance and scope of surface engineering. Surface and surface energy: Structure and types of interfaces, surface energy and related equations. Surface engineering: classification, definition, scope and general principles.

Unit – II: (Contact hours 10)

Conventional surface engineering practices

Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing / puffing. Surface engineering by material addition: From liquid bath - hot dipping. Surface engineering by material addition: Electrodeposition / plating. Surface modification of steel and ferrous components: Pack carburizing. Surface modification of ferrous and non ferrous components: Aluminizing, calorizing, diffusional coatings. Surface modification using liquid/molten bath: Cyaniding, liquid carburizing. Surface modification using gaseous medium: Nitriding, carbonitriding.

Unit – III: (Contact hours 10)

Advanced surface engineering practices

Surface engineering by energy beams: General classification, scope and principles, types and intensity/energy deposition profile. Laser assisted microstructural modification – surface melting, hardening, shocking and similar processes. Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys. Electron beam assisted

modification and joining. : Ion beam assisted microstructure and compositional modification. Surface engineering by spray techniques: Flame spray, Plasma coating, cold spray.

Unit – IV: **(Contact hours 6)**

Surface coatings and surface modifications

Evaporation - Thermal / Electron beam, Sputter deposition of thin films & coatings, Sputter deposition of thin films & coatings – Magnetron & Ion Beam, Modified PVD, CVD coating processes, Plasma and ion beam assisted surface modification.

Unit – V: **(Contact hours 7)**

Characterization of coatings and surfaces

Measurement of coating thickness, porosity and adhesion. Measurement of residual stress. Surface microscopy and topography by scanning probe microscopy.

Unit – VI: **(Contact hours 7)**

Functional Coatings & Applications

Functional and nano structured coatings and applications. Surface passivation of semiconductors and effect on electrical properties. Thin film technology for multilayers for electronic, optical and magnetic devices.

Learning resources

Text book:

1. K.G. Budinski, '*Surface Engineering for Wear Resistances'*, Prentice Hall, Englewood Cliffs, 1988 Edition.
2. M. Ohring, '*The Materials Science of Thin Films'*, Academic Press Inc, 2005 Edition.

Reference Books:

1. P.H Morton I.I.T , '*Surface Engineering & Heat Treatment'*, Brooke field, 1991 Edition.
2. Metals Handbook, Vol.5, '*Surface Cleaning, Finishing & Coating'*, ASM, Metals Park Ohio, 9th Edition.
3. M.G. Fontana, '*Corrosion Engineering',* M.C. Graw Hill, N. York, 1987 Edition.

Web resources:

1. IITM, Metallurgy and materials science NPTEL surface engineering coating technology web course.
2. IIT Roorkee, March 12 2017, Surface Engineering of Nano materials, URLhttps://nptel.ac.in/courses/113107075/

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the importance of surface engineering techniques and scope
CO 2	Describe the different material removal and addition processes
CO 3	Understand the micro-structural and compositional modifications.
CO 4	Understand the different types of coating methods
CO 5	Identify the testing approaches to evaluate a modified surface

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX61	Inspection and Quality Control	PEC	3-0-0	3

Course Learning Objectives:

1. To recap the various measurement methods and learn the measurement standards
2. To learn applications of measurements and modern concepts related to it
3. To introduce quality control concepts
4. To make the student learn the concepts of six sigma
5. To learn about control charts and their applications, solve some problems
6. To understand and familiarize with the concepts of acceptance sampling

Course Content:

Unit - I **(7 hours)**

Linear Measurement and Angular Measurement Standards

Accuracy, Precision, Readability, Sensitivity, Linear measuring instruments - Vernier – micrometerGauge blocks- dial indicator-comparators – Angle standards – Vernier bevel protractor-sine bar – autocollimator. Shop floor standards and their calibration, light interference, Method of coincidence, Slip gauge calibration, Measurement errors, Limits, fits, Tolerance, Gauges, Gauge design

Unit - II **(8 hours)**

Measurement Applications and Modern Concepts

Measurement of screw threads and gears – Radius measurement – surface finish measurement - Measurement of straightness – flatness-parallelism – squareness-roundness – circularity. Image processing and its application in Metrology, Co-ordinate measuring machine, Types of CMM, Probes used, Application, Non-contact CMM using Electro-optical sensors for dimensional metrology

Unit - III **(8 hours)**

Introduction to Quality Control

Introduction, Definition of Quality, Basic Concept of Quality, Definition of SQC, Benefits and Limitation of SQC, Quality Assurance, Quality Control: Quality Cost-Variation in Process, Causes of Variation.

Unit - IV **(7 hours)**

Process control for Variables

Theory Of Control Chart- Uses Of Control Chart – Control Chart For Variables – X Chart, R Chart And □Chart -Process Capability – Process Capability Studies And

Simple Problems. Six Sigma Concepts

Unit - V **(8 hours)**

Process control for Attributes

Control Chart for Attributes –Control Chart for Non Conformings – P Chart and Np Chart – Control Chart for Nonconformities – C and U Charts, State of Control and Process Out of Control Identification in Charts, Pattern Study

Unit – VI **(7 hours)**

Acceptance Sampling

Lot By Lot Sampling – Types – Probability of Acceptance in Single, Double, Multiple Sampling Techniques – O.C. Curves – Producer's Risk and Consumer's Risk. AQL, LTPD, AOQL Concepts-Standard Sampling Plans for AQL and LTPD- Uses Of Standard Sampling Plans

Learning resources

Text book:

4. R.K. Jain, '*Engineering metrology'*, Khanna Publishers, 2009.
5. Douglas.C. Montgomery, '*Introduction to Statistical Quality Control*', 4th Edition, John Wiley 2001.

Reference Books:

1. Galyer J.F. and Shotbolt C.R. *'Metrology for Engineers*' ELBS, 1992
2. Hune, K.J. '*Engineering Metrology'*, Kalyani Publishers, India, 1980 3.John.S. Oakland. '*Statistical Process Control'*, 5th Edition, Elsevier, 2005

Web resources:

2. NPTEL, Nov 15 2018**, '***Inspection & Quality Control in Manufacturing'*URL**:** https://www.youtube.com/watch?v=oIG_NDb2g3U

2.NPTEL, Feb 15 2017, *'Inspection, testing and Quality Control'*URL: https://www.youtube.com/watch?v=Jfx0ITTPwfw

Course outcomes: At the end of the course, the student will be able to

CO 1	Student should be able to relate the measurement methods and the respective Standards
CO 2	The student shall understand the concepts relating to image processing and CMM operation

CO 3	The student understands the concept of quality control, its benefits and Limitations
CO 4	The student shall be able to understand and implement six sigma concepts
CO 5	The student shall be made familiar with process control variables and different control charts
CO 6	Various types of sampling plans will be instructed and acceptance sampling concepts are explained thoroughly to the student

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Semester	Course Category	L-T-P	Credits
20MEXX62	CNC Machining	PEC	3-0-0	3

Course Objectives:

1. To Know and identify the various types of CNC machining operations.
2. Understand the terminology, basic principles, equipment and techniques used in CNC machining.
3. Correctly apply CNC machine code to create desired machine output .
4. Select appropriate tooling for CNC machining centers.
5. Explain and demonstrate simple G & M code programing for a mills and lathes.
6. Successfully operate a CNC mill and lathe.

Course Content:

Unit – I **(Contact hours 5)**

Introduction: Introduction to Turner Trade, First Aid, Security Measures, Machinesand Tools, MeasuringInstruments, CuttingTools, LatheMachine, CuttingSpeed, Feedtime, Maintenance of Machines, types of Lathe

Unit - II **(Contact hours 6)**

Introduction of CNC

Computer Training, CNC History, Types of CNC Machines, Types of Control panels, Tool Selection, Work zero setup, Coordinate Geometry, CNC tooling,

Fundamentals of Numerical Control - NC, CNC and DNC. Classification of CNC machines - Axes, Configurations, Control Strategies.

Unit - III **(Contact hours 7)**

Computational Algorithms for Interpolation - Linear, Circular and Parametric. Manual Part Programming- Formats. Codes and Cycles. CNC Programming: Part programming fundamentals, Manual Part Programming, APT Programming, CNC programming,Turning Program, Miling Programming.

Unit - IV **(Contact hours 8)**

CNC lathe set-up, part modifications on CNC lathe, CNC lathe operations, CNC lathe programming cam software operations, CNC mill set-up, part modifications on CNC mill, CNC mill operations, CNC mill programming.

Unit - V **(Contact hours 10)**

Advanced Programming Techniques for CNC Millling and Turning Centers, Macros and Parametric Programming Techniques, Computer Assisted Process Planning - Techniques, Algoritms, CAM Sofrware.

Unit – VI **(Contact hours 9)**

Sculptured surface machining - algorithms for multi surface and CVerification of CNC part programs. Data Standards of CNC - STEP NC. Open Architecture and Distributed CNC manufacturing, Preventive Maintenance, CNC Machine Maintenance, Safety and Maintenance.

Learning resources

Text book:

1. Richard A. Gizelbach, "*CNC machining*" ,Goodheart-Willcox ,June 26th 2009

Reference books :

1. B.S Pabla, M.adhithan ,"*CNC machines*" New Age International,1994

Web resources

Video resources:

Indian institute of technology kharagpur, september 27 2016, '*computer numerical control of machine tools and processes'* URL: http://nptel.ac.in/courses/112105211

Course outcomes: At the end of the course, the student will be able to

CO 1	Set up a CNC Lathe and Perform Part Modifications on CNC Lathe
CO 2	Operate a CNC Lathe and Program CNC Lathe
CO 3	Set up a CNC Mill and Perform Part Modifications on CNC Mill.
CO 4	Operate a CNC Mill and Program a CNC Mill
CO 5	Perform CAM Software Operations
CO 6	Practice Safety and Maintenance

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX63	Flexible Manufacturing System	PEC	3-0-0	3

Course objectives

1. Introduction and need of FMS
2. Knowledge of group technology (GT)
3. Detailed study of FMS layouts and Processing stations
4. Study of materials movement and storage systems
5. Study of tool management in FMS
6. FMS software introduction

Unit I **(Contact hours 6)**

FMS Introduction and Description

Limitations with conventional manufacturing, Need for FMS Introduction, Definition, Basic Component of FMS, Significance of FMS, General layout and configuration of FMS, Principle Objectives of FMS, Benefits and limitations of FMS, Area of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology, Hierarchy of CIM, FMS Justification.

Unit II

Group Technology **(Contact hours 8)**

Introduction, Definition, Reasons for Adopting Group Technology, Benefits of Group Technology Production flow analysis, System planning- Objective, guide line, system definition and sizing. Human resource- Objective, staffing, supervisor role. Affecting Many Areas of a Company, Obstacles to Application of GT.

Unit III **(Contact hours 7)**

Classification of FMS Layout

Layouts and their Salient features, Single line, dual line, loop, ladder, robot centre type etc.

Processing stations

Salient features Machining Centers, Turning centre, Coordinate measuring machine (CMM), Washing/ Deburring station.

Unit IV **(Contact hours 8)**

Automated Material Movement and Storage System

Introduction, Types of AGV and Their principle of working, Advantages, Limitation and General AGV Guide path, Robots, Benefits of using Industrial

Robots, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet Flotation System, Queuing Carrousels and Automatic Work Changers, Coolant and Chip Disposal and Recovery system.

Unit V **(Contact hours 8)**

Cutting Tools and Tool Management

Introduction, Control of Cutting Tools, Tool Management, Tool Strategies, Tool Preset, Identification and Data Transfer, Tool Monitoring and Fault Detection. Production Planning and Control, Scheduling and loading of FMS.

Unit VI **(Contact hours 8)**

FMS Software

Introduction, General structure and requirements, Functional descriptions, Operational overview, Computer simulation, FMS installation - Objective, Acceptance testing, Performance Goals, Expectations, Continued support.

Text books

1. William W Luggen, “Flexible Manufacturing Cells and System” Prentice Hall of Inc New Jersey, 1991
2. Groover, M.P “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt.Ltd. New Delhi 2009

Reference

1. Reza A Maleki “Flexible Manufacturing system” Prentice Hall of Inc New Jersey, 1991
2. John E Lenz “Flexible Manufacturing” marcel Dekker Inc New York ,1989.
3. Flexible Manufacturing System by H. K. Shivanand, M. M. Benal, V. Koti, New Age Pub.
4. Approach to Computer Integrated Design and Manufacturing Nanua Singh, John Wiley and Sons, 1998.
5. Buffa, E.S., Modern Production and Operation Management, New York, 1985.

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand FMS and its Applications
CO 2	Implement Group technology
CO 3	Classify and explain FMS layouts and Processing stations
CO 4	Explain the material handling systems used in FMS
CO 5	Understand tool management in FMS
CO 6	Install the FMS software and analyze FMS using simulation techniques

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX64	Mechatronics	PEC	3-0-0	3

Course Objective:

The main objective of this course is

1. To introduce the integrative nature of Mechatronics.
2. To describe the different components and devices of mechatronics systems.
3. To give a brief idea on solid state electronic devices such as diodes, amplifiers.
4. To provide the basic knowledge on Hydraulic and pneumatic actuation systems and their in various engineering applications.
5. To introduce the student to the concepts of Digital electronics and systems.
6. To understand the concepts of system interface and data acquisition systems.
7. To provide the basic idea of real time mechatronics systems and future trends of mechatronics.

Course outcomes:

Unit-I: **(Contact Hours 7)**

Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

Unit-II: **(Contact Hours 8)**

Solid state electronic devices – PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering.

Unit-III : **(Contact Hours 7)**

Hydraulic and pneumatic actuating systems – Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro- pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

Unit-IV: **(Contact Hours 8)**

Digital electronics and systems, digital logic control, micro processors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

Unit-V: **(Contact Hours 7)**

System interfacing and data acquisition – Data Acquisition Systems, Analog to

Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, interfacing motor drives.

Unit -VI: **(Contact Hours 8)**

Dynamic models and analogies, System response. Process Controllers – Digital Controllers, Programmable Logic Controllers, Design of mechatronics systems & future trends.

Course outcomes: After completion of this course, the student shall be able to

CO 1	Describe the different components and devices of mechatronics systems.
CO 2	Differentiate solid state electronic devices
CO 3	Possesses solid knowledge on Hydraulic and pneumatic actuation systems
CO 4	Understand the concepts of Digital electronics and systems.
CO 5	Understand the concepts of system interface and data acquisition systems.
CO 6	Use the various mechatronics systems devices and components in the design of electro mechanical systems.

Text Book

1. KP Ramachandran, GK VijayaRaghavan& MS Balasundaram, *Mechatronics: Integrated Mechanical Electronics Systems,* WILEY India Edition.

References

1. Smaili A, Mrad F, *Mechatronics,* Oxford University Press.
2. Newton C Braga, *Mechatronics,* Source Book, Thomson Publications, Chennai.
3. N. Shanmugam, *Mechatronics* –/ Anuradha Agencies Publishers.
4. Devdasshetty, Richard, and Thomson, *Mechatronics System Design*.
5. M.D.Singh and J.G.Joshi, *Mechatronics*, PHI.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX65	Nanotechnology	PEC	3-0-0	3

Objectives:

1. The properties of nano particles are strongly dependent on size and shape.
2. This course different classes of nano materials such as tubed, balls and etc.
3. The students will get indepth knowledge in synthesis and fabrication
4. charecterization of nano materials.
5. Carbon nanotechnology and applications of the nanotechnology also explained

Content:

Unit-I : **(Contact Hours: 6)**

Introduction: History of nanoscience, definition of nanometer, nano materials, nanotechnology. Why nanomaterials? Crystal symmetry, crystal directions, crystal planes. Properties of materials influenced by nanosize: mechanical properties, electrical properties, dielectric properties, thermal properties, magnetic properties, opto-electronic properties. Levels of structures, effect of size reduction on properties.

Unit-II: **(Contact Hours: 8)**

Different classes of nanomaterials: classification based on dimensionality-quantum dots, wells and wires-carbon-based nanomaterials (bucky balls, nanotubes, graphene)–metal based nanomaterials (nanogold, nanosilver and metal oxides)-nanocomposites, nanopolymers, nanoglasses, nanoceramics, biological nanomaterials.

Unit-III: **(Contact Hours: 7)**

Synthesis and fabrication: Synthesis of bulk polycrystalline samples, growth of single crystals. Synthesis techniques for preparation of nanoparticle – bottom up approach – sol gel synthesis, hydrothermal growth, thin film growth, PVD and CVD; top down approach
– ball milling, micro fabrication, lithography, mechanical processing-severe plastic deformation techniques.

Unit-IV: **(Contact Hours: 8)**

Charecterization of nanomaterials: X-Ray diffraction and Scherrer method, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning probe microscopy, atomic force microscopy, piezo-response microscopy, X-ray photoelectron

spectroscopy, small angle X-Ray diffraction, particle size analysis, photoluminescence spectra, Raman spectroscopy.

Unit-V: **(Contact Hours: 7)**

Carbon nanotechnology: Carbon allotropes, applications of nanocrystalline diamond films, grapheme, and carbon nanotubes. Synthesis of diamond – nucleation of diamond, growth and morphology. Synthesizing, applications of grapheme, carbon nanohorns and carbon nanotubes (single walled and multiwall CNT).

Unit-VI: **(Contact Hours: 9)**

Applications and challenges: Applications in material science, biology and medicine, surface science, energy and environment. Applications of nanostructured thin fins, applications of quantum dots. Limitations in processing, handling, toxicity and issues with safety measures.

Text Books

1. M.S Ramachandra Rao, Tatsuo Okada, Nano science and nano technology, Wiley publishers, 2013
2. B.S. Murty, P. Shankar, B. Raj, B.B. Rath, J. Murday, Textbook of Nanoscience and Nanotechnology Springer publishers, 2013

Reference

1. Charles P. Poole, Jr., Frank J.Owens, Introduction to Nano Technology Wiley publishers. USA, 2007
2. Jermy J Ramsden, Nanotechnology, Elsevier publishers, USA, 2016
3. M.A Shah, K.A Shah, Nanotechnology the Science of Small Wiley Publishers, 2015

VIDEO LINKS:

Title	**Expert Name**	**Details of Expert**	**Web link**
Nanotechnology	Prof. A.K. Ganguli	IIT Delhi	https://nptel.ac.in/syllabus/118102003/

Course outcomes: At the end of the course, the student will be able to

CO 1	Analyze different types of the nano-materials and the how the size effect the different properties.
CO 2	Select the fabrication techniques and characterization of nanomaterials for a given problem
CO 3	Use carbon-nano-technology technique for preparing samples
CO4	Design applications of nanocomponents in medical and other industries
CO5	Analyze different techniques for charecterization of materials
CO6	Define the synthesis of nano-materials

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX66	**Robotics and Applications**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To understand the history and elements of robots
2. To understand the analysis of position and orientation of robot mechanisms
3. To understand the kinematic analysis of robot mechanisms
4. To study the static force analysis of robots
5. To study the dynamic force analysis of robots
6. To study the motion planning and design of control implementation of robots

Course Content:

Unit – I **(Contact hours: 6)**

Introduction -brief history, types, classification and usage, Science and Technology of robots, Elements of robots – links, joints, actuators, and sensors, Applications of robots in different fields.

Unit – II **(Contact hours: 8)**

Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms, different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force- torque sensors, proximity and distance measuring sensors, and vision.

Unit – III **(Contact hours: 8)**

Kinematics of robots, Introduction, Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots, Solution procedures using theory of elimination, Inverse kinematics solution for the general 6R serial manipulator.

Unit – IV **(Contact hours: 7)**

Velocity and static analysis of robot manipulators Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators.

Unit – V **(Contact hours: 8)**

Dynamics of manipulators, Mass and inertia of links, Lagrangian formulation for equations of motion for serial and parallel manipulators, Generation of symbolic equations of motion using a computer, Simulation (direct and inverse) of dynamic equations of motion, Examples

of a planar 2R and four-bar mechanism, Recursive dynamics, Commercially available multibody simulation software (ADAMS) and Computer algebra software Maple

Unit – VI **(Contact hours: 8)**

Motion planning and control Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes, Simulation and experimental case studies on serial and parallel manipulators, Control of constrained manipulators, Cartesian control, Force control and hybrid position/force control, Advanced topics in non-linear control of manipulators.

Text book:

1. Ghosal,A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008.

Reference Books:

1. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, vision and intelligence, McGraw - Hill, 1987.
2. Modern Robotics , Mechanics, Planning, and Control, Kelvin Lynch, 2018 Cambridge University PressO

Web resources:

1. Prof. Khatib, Introduction to Robotics, Stanford University, https://see.stanford.edu/Course/CS223A

Course outcomes: At the end of the course, the student will be able to

CO 1	Have understanding of brief history and various elements of robot mechanisms
CO 2	Identif the D-H notation of a robot mechanism and perform position analysis and trajectory planning
CO 3	Perform kinematic analysis of given robot mechanism for velocity and Acceleration
CO 4	Do static force analysis of a given robot
CO 5	Carryout dynamic force analysis by various methods such as Lagrangian or Newton mechanics
CO 6	Derive the system equations and design various controllers for following the designed trajectory

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

PROFESSIONAL ELECTIVES COURSES INDUSTRIAL ENGINEERING AND MANAGEMENT STREAM

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX67	Production Operations & Management	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the basic knowledge of Operations management
2. To identify different layouts for facilities planning
3. To analyze different functions of production planning
4. To describe various types of process engineering methods
5. To calculate different aspects of dimensional analysis
6. To get the knowledge of forecasting

Course Content:

Unit – I **(7 Contact hours)**

Operations Management:

Objectives, Operations Management: Functions and Scope, Types of Production Systems, Operations Strategy. Product Life Cycle, Value Engineering Concepts, Design for X (DFX), Ergonomics in Product Design, Rapid Prototyping: Concept, Advantages.

Unit – II **(7 Contact hours)**

Facility Planning:

Factors Affecting Plant Location, Plant Location: Case Studies Location Evaluation Methods-I, Location Evaluation Methods-II.Facility Layout and Planning-I, Facility Layout and Planning-II, Factors Influencing Plant Layout, Material Flow Patterns, Tools and Techniques used for Plant Layout Planning.

Unit – III **(8 Contact hours)**

Production Planning and Control:

Process Planning, Aggregate Production Planning, Capacity Planning: Introduction, Capacity Planning: Examples. Production Control, Sequencing, Sequencing Problems-I, Sequencing Problems-II, Master Production Scheduling (MPS).

Unit – IV **(8 Contact hours)**

Process Planning and Process Engineering:

Introduction, Function, Pre-requisites and steps in process planning, Factors affecting process planning, Make or buy decision, plant capacity and machine capacity. Process Engineering: Preliminary Part Print Analysis: Introduction, Establishing the General Characteristics of work piece, determining the principal Process, Functional surfaces of the

work piece, Nature of the work to be Performed, Finishing and identifying operations.

Unit – V **(8 Contact hours)**

Aggregate Planning and Master Scheduling: Variables Used in Aggregate Planning, Aggregate Planning Strategies, Master Scheduling

Material and Capacity Requirements Planning: Objectives, MRP Inputs and Outputs, Bill of Materials, MRP Logic, Safety Stock, Lot Sizing and System Updating, CRP Inputs and Outputs: Loading, Steps in the Loading

Unit – VI **(7 Contact hours)**

Production Forecasting: Introduction of production forecasting, The strategic role of forecasting in supply chain, Time frame, Demand behavior, Forecasting methods-Qualitative and Quantitative, Accuracy of Forecast methods.

Learning resources

Text book:

1. Pannerselvam R, '*Production and Operations Management'*, Prentice Hall India, 3 rd Edition, 2013.

Reference Books:

1. Kanishka Bedi, '*Production and Operations Management'*, Oxford University Press, 2007.
2. Russel and Taylor, '*Operations Management'*, Wiley, 7 th Edition, 2010.
3. Chary S. N, '*Production and Operations Management'*, Tata McGraw Hill, 5 th Edition, 2008.
4. Chase Jacobs, Aquilano & Agarwal., '*Operations Management'*, Tata McGraw Hill, 11th edition, 2006.
5. Mahadevan B, '*Operations Management Theory and practice'*, Pearson Education, 2 nd edition, 2010.

Web resources:

Title	Expert Name	Details of Expert	Web link
NPTEL video on Operations Management	Prof. Indradeep Singh	IIT Roorkee	https://nptel.ac.in/syllabus/112107238/

Course outcomes: At the end of the course, the student will be able to

CO 1	Effective Forecasting of Production functions, Enhanced Planning of Product Design and Service Operations. Facility Planning and Project Management.
CO 2	Apply the decision models to various real time problems
CO 3	Solve and analyze problems using different forecasting techniques.
CO 4	Evaluate and rank capacity locations, plan and schedule production by solving the problems.
CO 5	Describe MRP & CRP concepts, inventory types and its objectives and calculate EOQ using various models.
CO 6	Describe the concept of operations management and productivity

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX68	Enterpreneur Resource Planning	PEC	3-0-0	3

Course Learning Objectives:

1. To learn the basic concepts of ERP.
2. To learn different technologies used in ERP.
3. To learn the concepts of ERP Manufacturing Perspective and ERP Modules.
4. To learn what are the benefits of ERP
5. To study and understand the ERP life cycle.
6. To learn the different tools used in ERP.

Course Content:

Unit - I **(8 hours)**

Introduction to ERP: Evolution of ERP; what is ERP? Reasons for the Growth of ERP; Scenario and Justification of ERP in India; Evaluation of ERP; Various Modules of ERP; Advantage of ERP.

Unit - II **(7 hours)**

An Overview of Enterprise: An Overview of Enterprise; Integrated Management Information; Business Modeling; ERP for Small Business; ERP for Make to Order Companies; Business Process Mapping for ERP Module Design; Hardware Environment and its Selection for ERP Implementation.

Unit - III **(8 hours)**

ERP and Related Technologies: ERP and Related Technologies; Business Process Reengineering (BPR); Management Information System (MIS); Executive Information System (EIS); Decision support System (DSS); Supply Chain Management (SCM).

Unit - IV **(7 hours)**

ERP System and Market: ERP system: Introduction; Finance, Plant Maintenance, Quality Management, Materials Management.ERP Market: Introduction, SAP AG, Baan Company, Oracle Corporation, People Soft, JD Edwards World Solutions Company, System Software Associates, Inc. (SSA); QAD; A Comparative Assessment and Selection of ERP Packages and Modules.

Unit - V **(7 hours)**

ERP Implementation Lifecycle: ERP Implementation Lifecycle: Issues in

Implementing ERP Packages; Pre-evaluation Screening; Package Evaluation; Project Planning Phase; Gap Analysis; Reengineering; Configuration; Implementation; Team Training; Testing; Going Live; End-User Training; Post Implementation (Maintenance Mode)

Unit – VI **(8 hours)**

Selection of ERP vendors and Future Directions: Vendors; Consultants and Users; In- House Implementation - Pros and Cons; Vendors; Consultants; End User.Future Directions in ERP; New Markets; New Channels; Faster Implementation Methodologies; Business Modules and BAPIs.

Learning resources

Text book:

1. O'Leary, *Enterprise Resource Planning Systems*, Cambridge University Press.

Reference Books:

1. August-Wilhelm Scheer, *Business Process Engineering*, Springer Verlag Publication, (1999).
2. Langenwalter, *Enterprise Resources planning and Beyond*, St Lucie Press, (2009)
3. Carol Ptak & Eli Schragenheim, *ERP: Tools, Techniques, and Applications for integratingthe Supply Chain*, St Lucie Press, (2000).
4. Alexis Leon, *ERP Demystified*, 2/E, Tata Mc Graw Hill, (2010)
5. Summer, *Enterprise Resource Planning*, Pearson Education

Web resources:

Title	Expert Name	Details of Expert	Web link
ICAI video on ERP	CA Pankajdesh Pande	ICAI India	https://www.youtube.com/watch?v=2Hc8qCM6fxM

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the basic concepts of ERP.
CO 2	Identify different technologies used in ERP.
CO 3	Apply the concepts of ERP Manufacturing Perspective and ERP Modules
CO 4	Discuss the benefits of ERP
CO 5	Implement the ERP life cycle
CO 6	Apply different tools used in ERP.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX69	Advance Operations Research	PEC	3-0-0	3

Course Learning Objectives:

1. To formulate and solve mathematical model (Non linear programming problem) for a physical situations like production, distribution of goods and economics.
2. To understand the importance of integer programming
3. Able to learn stochastic and geometric programming.
4. Able to understand the concept dynamic programming and apply to inventory.
5. Able to know the importance of multi criteria optimization techniques.
6. Able to learn Genetic algorithm and

Course Content:

Unit - I **(7 hours)**

Non - linear Programming: Classical Optimization techniques and Kuhn Tucker theory - One dimensional minimization — Unconstrained and Constrained minimization methods
–Quadratic programming.

Unit – II **(8 hours)**

Integer programming: Integer and Mixed Integer and Zero - One Programming

Unit - III **(8 hours)**

Stochastic programming - Geometric programming problem and applications.

Unit - IV **(7 hours)**

Dynamic Programming: Characteristics of dynamic programming problems - single and multi - stage models — Practical applications to inventory and Cargo loading problems.

Unit - V **(7 hours)**

Multi - criteria Optimization: Introduction to multicriteria optimization - Methods of solution. Goal programming and applications.

Unit - VI **(8 hours)**

Optimization Techniques

Meta Hemistich - genetic Algorithms, Simulated Annealing, Tabu search, Ant Colony Optimization algorithms.

Learning resources

Text book:

1. Taha, Hamdy. A., Operations Research an Introduction.PHI Edition, 6th Edition.
2. Rao, S.S., Optimisation theory and practice — PHI.

Reference Books:

1. Hiller & Liberaman, Operations Research — Tata McGrawhill,7t Edition,2002.
2. Kalyanmoy Deb, Optimization for Engineering Design Algorithms and Examples (1996).
3. Sharma, S. D.. "Operations Research" Kedarnath publisher, Meerut, 17th Edition 2014.
4. Gupta Prem Kumar and Hira, D.S., "Problems in Operations Research", S. Chand and Co., 2010.

Web resources:

Title	**Expert Name**	**Details of Expert**	**Web link**
NPTEL video on Advance Operations Research	Prof. C. Balaji	IIT Madras	https://nptel.ac.in/courses/112106064/28

Course outcomes: At the end of the course, the student will be able to

CO 1	Solve nonlinear problems using Kuhn Tucker conditions.
CO 2	Solve integer programming problems.
CO 3	Solve Un-constrained and constrained minimization problems using programming methods
CO 4	Apply dynamic programming for real world problems.
CO 5	Solve multi objective problems using Goal programming.
CO 6	Develop meta heuristic algorithms to solve optimization problems.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX70	Business Management and Development	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the concept of business organization and its forms.
2. To understand the planning and organizing in business organization.
3. To understand the importance of leadership and motivation in business management.
4. To understand the nature and scope of directing and controlling in business environment.
5. To understand the functional areas of management.
6. To understand the role and importance of management in marketing.

Course Content:

Unit - I **(10 hours)**

Introduction to business & Forms of Organization: Forms of Business Organization: Sole Proprietorship, Joint Hindu Family Firm, Partnership firm, Joint Stock Company, Cooperative society; Limited Liability Partnership; Choice of Form of Organization, Government - Business Interface; Rationale and Forms of Public Enterprises. International Business, Multinational Corporations, Ethics in business, corporate social responsibility, Business Sustainability.

Unit - II **(6 hours)**

Planning & Organizing: Planning premises, types and steps in plans, decision making and forecasting, types of decision, steps in decision making, Organizing: Organization Structure, principles of organizing, Authority and span of control, delegation and decentralization, Line and staff relationship.

Unit - III **(7 hours)**

Leadership & Motivation: Concept and Styles; Trait and Situational Theory of Leadership. Motivation: Concept and Importance; Maslow Need Hierarchy Theory; Herzberg Two Factors Theory.

Unit - IV **(7 hours)**

Directing & Controlling: Nature and scope, Co-ordination, types of interdependence, Process of controlling, making controlling effective,

techniques of controlling.

Unit - V **(7 hours)**

Functional Areas of Management: Human Resource Management: Concept and Functions; Basic Dynamics of Employer-Employee Relationship. Finance Management: Concept and Objectives; source of funds.

Unit – VI **(8 hours)**

Marketing Management: Marketing Concept; Marketing Mix; Product Life Cycle; Pricing Policies and Practices.

Learning resources

Text book:

1. Harold Koontz, "*Essentials of Management*", Tata McGraw-Hill Education, New Delhi, 8th Edition.
2. Charles Hill, Steven McShane, "*Principles of Management*", Tata McGraw-Hill Education, New Delhi, 1st Edition.

Reference Books:

1. Ricky W. Griffin, "*Management*", Cengage Learning, New Delhi, 10th Edition.
2. Kaul, V.K., "*Business Organization and Management*", Pearson Education, New Delhi, 1st Edition.

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the concept of business organization and its forms.
CO 2	Understand the planning and organizing in business organization.
CO 3	Understand the importance of leadership and motivation in business management.
CO 4	Understand the nature and scope of directing and controlling in business environment.
CO 5	Understand the functional areas of management.
CO 6	Understand the role and importance of management in marketing.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course name	Course Category	L-T-P	Credits
20MEXX71	Supply Chain Management	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the managerial decision strategies relating to suppliers and related logistics
2. To understand the designing of supply chain network
3. To understand and estimate the demand and supply by using forecasting techniques
4. To compute the tradeoffs between the supplier and the purchaser for continuous process operation
5. To understand importance in supply chain management.
6. To understand and optimal utilization of financial resources

Course Content:

Unit - I **(7 hours)**

Introduction to Supply Chain Management- Supply chain – objectives – importance – decision phases – process view – competitive and supply chain strategies – achieving strategic fit..

Unit II **(6 hours)**

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Unit - III **(8 hours)**

Designing the Supply Chain Network:

Designing the distribution network – role of distribution – factors influencing distribution

– design options – e-business and its impact – distribution networks in practice – network design in the supply chain – role of network – factors affecting the network design decisions – modeling for supply chain.

Unit - IV **(8 hours)**

Planning Demand and Supply- Role of forecasting – demand forecasting – approaches

– role of IT.

Planning and Managing Inventories- Safety inventory and its appropriate level – impact of supply uncertainty, aggregation and replenishment policies.

Unit - V **(8 hours)**

Transportation Networks and Sourcing:

Role of transportation – modes and their performance – transportation infrastructure and policies - design options and their trade-offs – Tailored transportation. Sourcing – supplier scoring and assessment.

Unit - VI **(8 hours)**

Coordination in a Supply Chain- Lack of supply chain coordination and the Bullwhip effect – obstacle to coordination – managerial levels – building partnerships and trust – continuous replenishment and vendor-managed inventories – collaborative planning, forecasting and replenishment.

Learning resources

Text book:

1. Sunil Chopra and Peter Meindl. *Supply Chain Management Strategy, Planning and Operation.*

Reference Books:

1. Donald Bowersox, David Closs and M. Bixby Cooper. *Supply Chain Logistics Management*
2. David Simchi-Levi, Philip Kaminsky and Edith Simchi-Levi. *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies.*

Web resources:

Title	**Expert Name**	**Details of Expert**	**Web link**
NPTEL video on SCM	Prof. G. Srinivasan	IIT Madras	https://nptel.ac.in/courses/110106045/

Course outcomes: At the end of the course, the student will be able to

CO 1	Understand the importance of Supply chain management in logistics
CO 2	Apply the knowledge of designing of network for SCM
CO 3	Solve demand and supply forecasting problems
CO 4	Lean the demand of the materials and maintain zero inventories with proper supply chain.
CO 5	Understand the importance of logistics for purchasing raw materials and maintain continuous chain with suppliers and customers
CO 6	Know various factors influencing the supply chain management decisions

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course name	Course Category	L-T-P	Credits
20MEXX72	Industrial Engineering and Management	PEC	3-0-0	3

Course Learning Objectives:

1. Get the knowledge of how to set standard time and identify best way of performing a job.
2. Get the knowledge of how to forecast demand for existing and new products. Get the knowledge of choosing best layout for a given plants
3. Identify the priority rules and algorithms for better performance measures while scheduling the jobs.
4. Identify the statistical techniques to improve the quality
5. Understand fundamental functions of inventory control techniques and management to find how much quantity to be purchased or manufactured.
6. Get the knowledge of how to schedule projects using CPM and PERT.

Course Content:

Unit I: **(5 Contact hours)**

Work measurement and method study

Productivity, Productivity measurement, Method study, Steps involved, Recording techniques, Flow process chart, Man-Machine charts, Micro-motion study, principle of motion economy, Therbligs, Work measurement: stop-watch method, setting standard times, standard time calculations, work sampling, job evaluation, wage incentive plans.

Unit II: **(8 Contact hours)**

Production Planning and Control

Functions of PPC, pre planning phase, active planning phase, post planning phase, Forecasting, types of forecasting methods, Qualitative methods: market survey, Delphi method, Quantitative methods: time series methods, moving average, weighted average, exponential smoothing, causal methods, regression models, trend, cyclic and seasonal components.

Unit III: **(8 Contact hours)**

Production-distribution system design

Facility layout planning. Sequencing and scheduling, n jobs and one machine problem, priority rules, n jobs 2 machines problem of same sequence and different sequence, Johnson's rule and extension rule, Assembly line balancing, Break Even Analysis,

Unit IV: **(8 Contact hours)**

Quality Engineering and management

Definition of Quality, Dimensions of Quality, statistical quality control, Control Charts, $\bar{X}$, R, p, C charts, Taguchi Quality Loss Function.

Unit V: **(8 Contact hours)**

Inventory control

Introduction to inventory management, important and objectives of inventory management, costs associated with inventory. Derivation of economic order quantity (EOQ), Problems on EOQ. Deterministic models, Introduction to production model, Derivation of economic batch quantity (EBQ), Problems on EBQ. Lead time, reorder point, safety stock. Quantity discounts, Selective inventory control techniques, ABC, VED, SDE, FSND, GOLF, XYZ.

Unit VI: **(8 Contact hours)**

Project Management

Introduction to project management, guidelines to draw network diagrams, critical path method (CPM), program evaluation and review technique (PERT), crashing.

Text Books:

1. Chary, S. N., *Theory and Problems in Production and Operations Management*. 3e, Tata McGraw-Hill Education. 2006.

Reference Books:

1. Kanawaty, George. *Introduction to Work Study*. 4e, International Labour Organization, 2016.
2. Joseph G. Monks, "*Schaum's Outline of the Theory and Problems of Operations Management",* 2e, McGraw Hill Book Company, 1987.
3. Barnes, R. M. *"Motion and Time Study Design and Measurement of Work*", 7e, Wiley, 2009.
4. Elwood S. Buffa, and Rakesh K.Sarin, *"Modern Production/Operations Management",* 8th Edition, John Wiley and Sons, 2007.

Video Reference links:

https://nptel.ac.in/courses/112107142/

Course outcomes: At the end of the course, the student will be able to

CO 1	Estimate standard time for a given job. Record the existing job performing method and propose new method of doing the job.
CO 2	Estimate future sales demand of existing as well as new products.
CO 3	Evaluate various priority rules and algorithms to schedule jobs in shop floor.
CO 4	Apply different quality control techniques
CO 5	Estimate the best order quantity to purchase/manufacture and time between purchases/manufacture
CO 6	Solve project management problems to know project completion time.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

LIST OF OPEN ELECTIVE COURSES (OEC) OFFERED BY DEPARTMENT OF MECHANICAL ENGINEERING TO OTHER DEPARTMENTS

Course code	Course name	Course Category	L-T-P	Credits
20MEXX15	Electro Mechanical Systems Engineering	OEC	3-0-0	3

Course Objective:

The main objective of this course is

1. To introduce the integrative nature of Mechatronics.
2. To describe the different components and devices of mechatronics systems.
3. To give a brief idea on solid state electronic devices such as diodes, amplifiers etc.
4. To provide the basic knowledge on Hydraulic and pneumatic actuation systems and their in various engineering applications.
5. To introduce the student to the concepts of Digital electronics and systems.
6. To understand the concepts of system interface and data acquisition systems.

Course outcomes:

Unit-I: **(Contact Hours 7)**

Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

Unit-II: **(Contact Hours 8)**

Solid state electronic devices – PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering.

Unit-III : **(Contact Hours 7)**

Hydraulic and pneumatic actuating systems – Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

Unit-IV:

(Contact Hours 8)

Digital electronics and systems, digital logic control, micro processors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

Unit-V: **(Contact Hours 7)**

System interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, interfacing motor drives.

Unit -VI: **(Contact Hours 8)**

Dynamic models and analogies, System response. Process Controllers – Digital Controllers, Programmable Logic Controllers, Design of mechatronics systems & future trends.

Course outcomes: After completion of this course, the student shall be able to

CO 1	Describe the different components and devices of mechatronics systems.
CO 2	Differentiate solid state electronic devices
CO 3	Possesses solid knowledge on Hydraulic and pneumatic actuationsystems
CO 4	understand the concepts of Digital electronics and systems.
CO 5	understand the concepts of system interface and data acquisition systems.
CO 6	Use the various mechatronics systems devices and components in the design of electro mechanical systems.

Text Book

1. KP Ramachandran, GK VijayaRaghavan& MS Balasundaram, *Mechatronics: Integrated Mechanical Electronics Systems,* WILEY India Edition.

References

1. Smaili A, Mrad F, *Mechatronics*, Oxford Higher Education, Oxford University Press.
2. N. Shanmugam, *Mechatronics* –/ Anuradha Agencies Publishers.
3. M.D.Singh and J.G.Joshi, *Mechatronics*, PHI.
4. W. Bolton Mechatronics – *Electronic Control Systems in Mechanical and Electrical Engg*. 4th Edition, Pearson, 2012.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX16	Nanomaterials	OEC	3-0-0	3

Objectives:

1. The properties of nano particles are strongly dependent on size and shape.
2. This course different classes of nano materials such as tubed, balls and etc.
3. The students will get indepth knowledge in synthesis and fabrication charecterization of nano materials.
4. Carbon nanotechnology and applications of the nanotechnology also explained

Course Content:

Unit-I : **(Contact Hours: 6)**

Introduction: History of nanoscience, definition of nanometer, nano materials, nanotechnology. Why nanomaterials? Crystal symmetry, crystal directions, crystal planes. Properties of materials influenced by nanosize: mechanical properties, electrical properties, dielectric properties, thermal properties, magnetic properties, opto-electronic properties. Levels of structures, effect of size reduction on properties.

Unit-II: **(Contact Hours: 8)**

Different classes of nanomaterials: classification based on dimensionality-quantum dots, wells and wires-carbon-based nanomaterials (bucky balls, nanotubes, graphene)–metal based nanomaterials (nanogold, nanosilver and metal oxides)-nanocomposites, nanopolymers, nanoglasses, nanoceramics, biological nanomaterials.

Unit-III: **(Contact Hours: 7)**

Synthesis and fabrication: Synthesis of bulk polycrystalline samples, growth of single crystals. Synthesis techniques for preparation of nanoparticle – bottom up approach – sol gel synthesis, hydrothermal growth, thin film growth, PVD and CVD; top down approach – ball milling, micro fabrication, lithography, mechanical processing-severe plastic deformation techniques.

Unit-IV: **(Contact Hours: 8)**

Charecterization of nanomaterials: X-Ray diffraction and Scherrer method, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning probe microscopy, atomic force microscopy, piezo-response microscopy, X-ray photoelectron

spectroscopy, small angle X-Ray diffraction, particle size analysis, photoluminescence spectra, Raman spectroscopy.

Unit-V: **(Contact Hours: 7)**

Carbon nanotechnology: Carbon allotropes, applications of nanocrystalline diamond films, grapheme, and carbon nanotubes. Synthesis of diamond – nucleation of diamond, growth and morphology. Synthesizing, applications of grapheme, carbon nanohorns and carbon nanotubes (single walled and multiwall CNT).

Unit-VI: **(Contact Hours: 9)**

Applications and challenges: Applications in material science, biology and medicine, surface science, energy and environment. Applications of nanostructured thin fins, applications of quantum dots. Limitations in processing, handling, toxicity and issues with safety measures.

Text Books

1. M.S Ramachandra Rao, Tatsuo Okada, Nano science and nano technology, Wiley publishers, 2013
2. B.S. Murty, P. Shankar, B. Raj, B.B. Rath, J. Murday, Textbook of Nanoscience and Nanotechnology Springer publishers, 2013.

Reference

1. Charles P. Poole, Jr., Frank J.Owens, Introduction to Nano Technology Wiley publishers. USA, 2007
2. Jermy J Ramsden, Nanotechnology, Elsevier publishers, USA, 2016
3. M.A Shah, K.A Shah, Nanotechnology the Science of Small Wiley Publishers, 2015.

VIDEO LINKS:

Title	**Expert Name**	**Details of Expert**	**Web link**
Nanotechnology	Prof. A.K. Ganguli	IIT Delhi	https://nptel.ac.in/syllabus/118102003/

Course outcomes: At the end of the course, the student will be able to

CO 1	Analyze different types of the nano-materials and the how the size effect the different properties.
CO 2	Select the fabrication techniques and characterization of nanomaterials for a given problem
CO 3	Use carbon-nano-technology technique for preparing samples

CO4	Design applications of nanocomponents in medical and other industries
CO5	Analyze different techniques for charecterization of materials
CO6	Define the synthesis of nano-materials

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20MEXX17	Industrial Robotics	OEC	3-0-0	3

Course Learning Objectives:

1. To understand the history and elements of robots
2. To understand the analysis of position and orientation of robot mechanisms
3. To understand the kinematic analysis of robot mechanisms
4. To study the static force analysis of robots
5. To study the dynamic force analysis of robots
6. To study the motion planning and design of control implementation of robots

Course Content:

Unit - I **(5 hrs)**

Introduction -brief history, types, classification and usage, Science and Technology of robots, Elements of robots – links, joints, actuators, and sensors, Applications of robots in different fields.

Unit - II **(8 hrs)**

Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms, different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force- torque sensors, proximity and distance measuring sensors, and vision.

Unit - III **(8 hrs)**

Kinematics of robots, Introduction, Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots, Solution procedures using theory of elimination, Inverse kinematics solution for the general 6R serial manipulator.

Unit - IV **(8 hrs)**

Velocity and static analysis of robot manipulators Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators.

Unit - V **(8 hrs)**

Dynamics of manipulators, Mass and inertia of links, Lagrangian formulation for equations of motion for serial and parallel manipulators, Generation of symbolic equations of motion using a computer, Simulation (direct and inverse) of dynamic equations of motion, Examples of a planar 2R and four-bar mechanism, Recursive dynamics, Commercially available multibody simulation software (ADAMS) and Computer algebra software Maple

Unit – VI **(8 hrs)**

Motion planning and control Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes, Simulation and experimental case studies on serial and parallel manipulators, Control of constrained manipulators, Cartesian control, Force control and hybrid position/force control, Advanced topics in non-linear control of manipulators.

Text book:

2. Ghosal,A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008.

Reference Books:

3. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, vision and intelligence, McGraw - Hill, 1987.

Web resources:

2. Prof. Khatib, Introduction to Robotics, Stanford University, https://see.stanford.edu/Course/CS223A

Course outcomes: At the end of the course, the student will be able to

CO 1	Have understanding of brief history and various elements of robot mechanisms
CO 2	Give the D-H notation of a robot mechanism and perform position analysis and trajectory planning
CO 3	Perform kinematic analysis of given robot mechanism for velocity and acceleration
CO 4	Do static force analysis of a given robot
CO 5	Carryout dynamic force analysis by various methods such as Lagrangian or Newton mechanics
CO 6	Derive the system equations and design various controllers for following the designed trajectory

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course name	L-T-P	Credits
20MEXX18	Management Science and Productivity	3-0-0	3

Course Learning Objectives:

1. Get the knowledge of how to set standard time and identify best way of performing a job.
2. Get the knowledge of how to forecast demand for existing and new products. Get the knowledge of choosing best layout for a given plants
3. Identify the priority rules and algorithms for better performance measures while scheduling the jobs.
4. Identify the statistical techniques to improve the quality
5. Understand fundamental functions of inventory control techniques and management to find how much quantity to be purchased or manufactured.
6. Get the knowledge of how to schedule projects using CPM and PERT.

Course Content

Unit I: **(5 Contact hours)**

Work measurement and method study

Productivity, Productivity measurement, Method study, Steps involved, Recording techniques, Flow process chart, Man-Machine charts, Micro-motion study, principle of motion economy, Therbligs, Work measurement: stop-watch method, setting standard times, standard time calculations, work sampling, job evaluation, wage incentive plans.

Unit II: **(8 Contact hours)**

Production Planning and Control

Functions of PPC, pre planning phase, active planning phase, post planning phase, Forecasting, types of forecasting methods, Qualitative methods: market survey, Delphi method, Quantitative methods: time series methods, moving average, weighted average, exponential smoothing, causal methods, regression models, trend, cyclic and seasonal components.

Unit III: **(8 Contact hours)**

Production-distribution system design

Facility layout planning. Sequencing and scheduling, n jobs and one machine problem, priority rules, n jobs 2 machines problem of same sequence and different sequence, Johnson's rule and extension rule, Break Even Analysis,

Unit IV: **(8 Contact hours)**

Quality Engineering and management

Definition of Quality, Dimensions of Quality, statistical quality control, Control Charts, $\bar{X}$, R, p, C charts, Taguchi Quality Loss Function.

Unit V: **(8 Contact hours)**

Inventory control

Introduction to inventory management, important and objectives of inventory management, costs associated with inventory. Derivation of economic order quantity (EOQ), Problems on EOQ. Deterministic models, Introduction to production model, Derivation of economic batch quantity (EBQ), Problems on EBQ. Lead time, reorder point, safety stock. Quantity discounts, Selective inventory control techniques, ABC, VED, SDE, FSND, GOLF, XYZ.

Unit VI: **(8 Contact hours)**

Project Management

Introduction to project management, guidelines to draw network diagrams, critical path method (CPM), program evaluation and review technique (PERT), crashing.

Text Books:

2. Chary, S. N., *Theory and Problems in Production and Operations Management*. 3e, Tata McGraw-Hill Education. 2006.

Reference Books:

5. Kanawaty, George. *Introduction to Work Study*. 4e, International Labour Organization, 2016.
6. Joseph G. Monks, "*Schaum's Outline of the Theory and Problems of Operations Management",* 2e, McGraw Hill Book Company, 1987.
7. Barnes, R. M. *"Motion and Time Study Design and Measurement of Work*", 7e, Wiley, 2009.
8. Elwood S. Buffa, and Rakesh K.Sarin, *"Modern Production/Operations Management",* 8th Edition, John Wiley and Sons, 2007.

Video Reference links:

https://nptel.ac.in/courses/112107142/

Course outcomes: At the end of the course, the student will be able to

CO 1	Estimate standard time for a given job. Record the existing job performing method and propose new method of doing the job.
CO 2	Estimate future sales demand of existing as well as new products.
CO 3	Evaluate various priority rules and algorithms to schedule jobs in shop floor.
CO 4	Apply different quality control techniques
CO 5	Estimate the best order quantity to purchase/manufacture and time between purchases/manufacture
CO 6	Solve project management problems to know project completion time.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX19	Automotive Engineering	OEC	3-0-0	3

Course Objectives:

1. To introduce the basic structure of an automobile
2. Familiarization of different components in the automobile transmission systems.
3. To provide brief idea about the Braking system and suspension system of an automobile.
4. To make student understand the different steering mechanisms of an automobile.
5. Provide knowledge about the cooling system and electrical system of an automobile.
6. Brief introduction to different fuels used in an automobiles and their impact on environment.

Course Content

Unit I **(Contact hours 8)**

Introduction: Layout of automobile – introduction chassis and body components. Types of Automobile engines – power unit – Introduction to engine lubrication – engine servicing.

S.I. and C.I. Engine Fuel supply systems: Mechanical and electrical fuel pump – petrol injection, Introduction to MPFI and GDI Systems. Requirements of diesel injection systems, types of injection systems, DI Systems IDI systems, Testing of fuel pumps, Introduction CRDI and TDI Systems.

Unit II **(Contact hours 8)**

Transmission System: Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh, constant mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. Propeller shaft, Hotch-Kiss drive, Torque tube drive, universal joint, differential rear axles, wheels and tyres.

Unit III **(Contact hours 8)**

Braking System: Mechanical brake system - Hydraulic brake system - Master cylinder - wheel cylinder tandem master cylinder; requirement of brake fluid, Pneumatic and vacuum brakes. **Suspension System:** Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, Independent suspension system.

Unit IV **(Contact hours 6)**

Steering System: Steering geometry – camber, castor, king pin rake, combined angle toe in, center point steering; types of steering mechanism – Ackerman steering mechanism,

Davis steering mechanism, steering gears – types, steering linkages.

Unit V (Contact hours 8)

Cooling System: Cooling Requirements, Air Cooling, Liquid Cooling, Thermo, water and Forced Circulation System – Radiators – Types – Cooling Fan - water pump, thermostat, evaporative cooling – pressure sealed cooling – antifreeze solutions. **Electrical System:** Charging circuit, generator, current – voltage regulator – starting system, bendix drive mechanism solenoid switch, lighting systems, Horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.

Unit VI (Contact hours 7)

Emissions from Automobiles: Pollution standards National and international – Pollution Control – Techniques.

Energy alternative: Solar, Photo-voltaic, hydrogen, Biomass, alcohols, LPG, CNG, liquid Fuels and gaseous fuels, Hydrogen as a fuel for IC Engines, their merits and demerits.

Course Outcomes: After completion of the course the student will be able to

CO 1.	Describe the basic structure of an automobile
CO 2.	Distinguish the different components in the automobile transmission systems.
CO 3.	Demonstrate the Braking system and suspension system of an automobile.
CO 4.	Design the different steering mechanisms of an automobile.
CO 5.	Explain the cooling system and electrical system of an automobile.
CO 6.	Differentiate the different fuels used in an automobiles and their impact on environment.

Text books:

1. Kirpal Singh, *Automobile Engineering*, 7th ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., *Automobile Engineering*, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., *Automotive Mechanics*, 2nd ed., East-West Press, 1999.
4. Heisler H, *Advanced Engine Technology*, SAE International Publ., USA, 1998.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEXX20	Total Quality Management and Reliability	OEC	3-0-0	3

Course Learning Objectives:

1. Get the knowledge about value of quality in product design.
2. Introduce the principles and techniques of Statistical Quality Control and their practical uses in product and/or process design and monitoring.
3. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
4. Identify the priority rules and algorithms for better performance measures while scheduling the jobs.
5. Illustrate the basic concepts and techniques of modern reliability engineering tools.
6. Identify the cost and budgeting of improving reliability.

Course Content

Unit I **(6 hours)**

Quality value and engineering – Quality engineering in product design and production process – system design –parameter design – tolerance design, Quality costs – quality improvement.

Unit II **(9 hours)**

Statistical Process control X, R, p, c charts, other types of control charts, processcapability, process capability analysis, process capability index. Acceptance sampling by variables and attributes, design of sampling plans, single, double, sequential and continuous sampling plans, design of various sampling plan.

Unit III **(8 hours)**

Loss function, tolerance design – *N* type, L type, S type; determination of tolerance for these types. Online quality control–variable characteristics attribute characteristics, parameter design.

Unit IV **(7 hours)**

Quality function deployment–House of quality, QFD matrix, and total quality management concepts. Quality information systems, quality circles, introduction to ISO 9000 standards.

Unit V **(7 hours)**

Reliability– Evaluation of design by tests - Hazard Models, Linear, Raleigh, Weibull. Failure Data Analysis, reliability prediction based on Weibull distribution, Reliability improvement.

Unit VI **(8 hours)**

Complex system- Reliability, reliability of series, parallel, standby systems, reliability prediction and system effectiveness. Maintainability- Availability, economics of reliability engineering, replacement of items, maintenance costing and budgeting, reliability testing.

Text Books:

1. G Taguchi, *Quality Engineering in Production Systems*, McGraw Hill, 1989.

Reference Books:

1. Ross, P.J. and Ross, P.J., 1988. *Taguchi techniques for quality engineering: loss function, orthogonal experiments, parameter and tolerance design* (No. TS156 R12). New York: McGraw-Hill.
2. Srinath, L.S., 1991. *Reliability engineering*. Affiliated East-West Press.
3. Balagurusamy, E., 1984. *Reliability engineering*. Tata McGraw-Hill Education.
4. Eugene Grant and Richard Leavenworth, *Statistical Process Control*, McGraw Hill.
5. Juran, J.M., 1993. *Quality Planning and Analysis; from product development through use* (No. 04; TS156, J8 1993.).
6. W. A. Taylor, *Optimization &Variation Reduction in Quality*, Tata McGraw Hill.

Video Reference links:

Title	Expert Name	Details of Expert	Web link
NPTEL Quality Management	Prof T. Bagchi	IIT Kharagpur	https://nptel.ac.in/courses/110104080/

Course outcomes: At the end of the course, the student will be able to

CO 1	Identify the cost and economic aspects of quality in products/systems.
CO 2	Apply basic techniques to improve quality, having backdrop of statistics and probability

CO 3	Use control charts to analyze for improving the process quality. Describe different sampling plans
CO 4	Implement Quality function deployment in a given system/process
CO 5	Identify the cost and economic aspects of reliability in products/systems.
CO 6	Evaluate the level of reliability using various reliability engineering tools for products/systems.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

COURSES OFFERED TO OTHER ENGINEERING DEPARTMENTS
COMMON TO CIVIL AND CHEMICAL ENGINEERING

Course code	Course Name	Course Category	L-T-P	Credits
20MEXY85	**Workshop**	**ESC**	**0-0-3**	**1.5**

Course Learning Objectives:

1. To understand different machining operations on different machines
2. To understand the process of preparing the mold cavity for sand casting
3. To understand the preparation and joining of metal work pieces using welding
4. To understand the preparation and assembly of work pieces using fitting
5. To make different products using sheet metal by Tin smithy operation
6. To understand the joining of wood pieces by Carpentry operation
7. To understand wiring connections in different applications

List of Experiments: (Working Hours: 3hours per experiment) 1.Plain Turning, Step Turning and Taper Turning on Lathe Machine 2.Surface Machining and Drilling operations on Milling Machine 3.Preparation of Mould Cavity using Single Piece Solid Pattern 4.Preparation of Mould Cavity using Split Piece Pattern 5.Preparation of Butt Joint using Shielded Metal Arc Welding 6.Preparation of Lap Joint using Shielded Metal Arc Welding
7.Filling the holes in a given metal work piece using Oxy-Acetylene Gas Welding 8.Preparation of 'V' shape joint using Fitting Operation
9.Preparation of 'L' shape joint using Fitting Operation 10.Preparation of Tray and Cone by Tin smithy Operation 11.Preparation of Dove tail joint by Carpentry Operation 12.Preparation of 'T' joint by Carpentry Operation
13.House wiring for one lamp and two lamps with single switch 14.Staircase wiring connection
15.Go Down wiring connection

Learning resources:

Text books:

1. Balasubramaniam, R., "*Callister's Materials Science and Engineering*", Wiley India Ltd, 2014. 2nd Edition

References

1. Groover, M. P., "*Fundamentals of modern Manufacturing*", Wiley, 2011.4th Edition.
2. Rao, P. N., "*Manufacturing Technology: Foundry, Forming and Welding*", McGraw Hill, 2013. 4th Edition

Course outcomes: At the end of the course, the student will be able to

CO1	Evaluating different machining operations on different machines
CO2	Analyzing the process of preparing the mold cavity for sand casting
CO3	Build the preparation and joining of metal work pieces using welding
CO4	Compose the preparation and assembly of work pieces using fitting
CO5	Make different products using sheet metal by Tin smithy operation
CO6	Select the joining of wood pieces by Carpentry operation
CO7	Criteria in wiring connections in different applications

Course Nature	**Practical**			
Assessment Method				
Assessment Tool	Experiments	Record	Viva-Voce/Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

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FOR CHEMICAL ENGINEERING

Course code	Course name	Course Category	L-T-P	Credits
20ME1111	Engineering and Solid Mechanics	ESC	3-0-0	3

Course Learning Objectives:

1. To introduce the students to the fundamentals of Engineering Mechanics
2. To make the student learn about force systems, axioms and dynamics of rigid bodies
3. To introduce the concepts of solid mechanics to the students
4. To make the students learn concepts of deformable media: like stress and strain tensors, strain rates, constitutive relations
5. To make the students learn the applications of 1 and 2 Dimensional problems relating to above concepts

Course Content:

Unit-I **(Contact hours 8)**

Introduction

Introduction to Engineering Mechanics - Force systems, Forces acting at a point, Moment of a force about a point; couple moment; reduction of a force system to a force and a couple. Equilibrium of system of forces: Free body diagram; equations of equilibrium; problems in two dimensions; Analysis of plane trusses.

Unit-II **(Contact hours: 8)**

Friction: Types of friction, Limiting friction, Laws of Friction, Problems on Static and Dynamic Friction.

Centroid and Centre of Gravity: Centroid of Areas from first principle, Centroid of composite sections; Centre of Gravity and its implications.

Unit-III **(Contact hours 6)**

Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem

Unit – IV **(Contact hours: 8)**

Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). Relative motion; Newton's 2nd law (rectangular, path, and polar coordinates).

Unit – V **(Contact hours: 8)**

Simple Stresses and Strains: Elasticity and Plasticity, Basics of stress and strain, Types of stresses & strains, Generalized Hooks Law, Stress-strain behavior of different materials, Elastic constants and their relations, applications of normal stresses and strains, strain energy, resilience, toughness

Shear and Bending in beams: Beams-Types of loads, supports, shear force and bending moment diagrams of statistically determinate beams with various loading conditions

Unit-VI **(Contact Hours: 7)**

Theory of simple bending, Bending formula and its assumption, stress distribution in symmetrical sections.

Torsion: Torsion formula and its assumption, Torsion of circular solid and hollow shafts, torsional rigidity, torsion of shafts, power transmitted by shafts.

Learning resources

Text book:

1. Russell C. Hibbeler, '*Mechanics of Materials'*, PEARSON Publishers, 9th Edition.

Reference Books:

1. F. P. Beer, E. R. Johnston and J. T. DeWolf, '*Mechanics of Materials'*, Tata McGraw Hill, India.
2. L. E. Malvern, '*Introduction to the Mechanics of a Continuous Medium'*.

Web resources:

1. **NPTEL: IIT ROORKEE, Jul 31, 2009,** ***'Lec-1 Solid Mechanics'***

URL**:** https://www.youtube.com/watch?time_continue=2&v=A1SWKe6ZwVc

2. **NPTEL, Introduction and review – Lectures 1 to 40, *'Strength of Materials'***

URL: https://nptel.ac.in/courses/112107146/

Course outcomes: At the end of the course, the student will be able to

CO1	Examine the use of basic concepts of Resolution and composition of forces
CO2	Analyze beams, truss or any engineering component by applying conditions of Equilibrium
CO3	List advantages and disadvantages of various geometric sections used in engineering design
CO4	Compare the different stresses and strains occurring in components of structure
CO5	Calculate the deformations such as axial, normal deflections under different loading conditions
CO6	The student will be able to understand concept of Principal moment of Inertia and apply the same for solving various problems

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME2112	Mechanical Technology	ESC	3-0-0	3

Course Learning Objectives:

1. To impart basic knowledge on basics of thermodynamics and Laws of thermodynamics.
2. To introduce basic knowledge about special casting, molding procedures and different welding techniques used in industry.
3. To impart basic knowledge on power transmission by gear and belt drives.
4. To know the working of thermal power plants, boilers and turbines.
5. To teach the working principle of Internal Combustion Engines.
6. To introduce basic knowledge on Refrigeration & Air Conditioning

Course Content:

Unit - I **(07 Contact hours)**

Basics of Thermodynamics: Introduction and definition of thermodynamics, Dimensions and units, systems, surroundings and universe, Reversibility and Irreversibility, Quasi- static process, Energy, Heat and Work. Introduction to Law of Thermodynamics: Zeroth Law of Thermodynamics, First law of thermodynamics and Second law of thermodynamics.

Unit - II **(09 Contact hours)**

Casting: Introduction, General method in making a Casting, pattern: types, materials and allowances. Moulding materials and equipment, Preparation, properties of moulding sands.

Welding: Principles of gas welding and arc welding, Soldering and Brazing.

Unit - III **(07 Contact hours)**

Power Transmission: Introduction to belt and gears drives, types of gears, Difference between open belts and cross belts, power transmission by belt drives. (theoretical treatment only).

Unit - IV **(07 Contact hours)**

Thermal Power Plant: Thermal power plant layout- Four circuits-Rankine cycle, Boilers: Fire tube Vs Water Tube; BobCock and Wilcox, Cochran Boilers, Steam Turbines, Impulse Vs Reaction Turbines, Compunding of Turbines.

Unit – V **(7 Contact hours)**

IC Engines: Introduction, Main components of IC engines, working of 4-stroke petrol engine and diesel engine, working of 2- stroke petrol engine and diesel engine, difference between petrol and diesel engine, difference between 4- stroke and 2-stroke engines.

Unit – VI **(7 Contact hours)**

Refrigeration & Air Conditioning: Definition – COP, Unit of Refrigeration, Applications of refrigeration system, vapour compression refrigeration system, simple layout of summer air conditioning system.

Learning resources

Text book:

1. Fundamentals of Mechanical Engineering / G.S.Sawheny- PHI.
2. An Integrated Course in Mechanical Engineering / R.K.Rajput /Birala Publications.
3. I.C. Engines / V. GANESAN- TMH.
4. Strength of Materials by R.K. Rajput, S.Chand& Company.
5. Thermal Engineering / R.K. Rajput / Lakshmi Publications.

Reference Books:

1. Thermodynamics and Heat Engines / R. Yadav / Central Book Depot.
2. Strength of Materials by R.K.Bansal, Laxmi Publishers.
3. Engineering Mechanics Statics and dynamics by A.K.Tayal, Umesh Publication, Delhi.
4. Fundamentals of I.C.Engines - P.W. Gill, J.H. Smith &Ziurys- IBH & Oxford pub.

Web resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. RGUKT Course Content

Course outcomes: At the end of the course, the student will be able to

CO 1	Awareness on basics of thermodynamics and Laws of thermodynamics.
CO 2	Students will be familiarized with some of the special casting and molding procedures used in industry and different welding techniques with their respective applications.
CO 3	Imparted knowledge about gear and belt drives used in automobile and industrial applications.
CO 4	Understand the basic components of Thermal plant
CO 5	Imparted knowledge about IC Engines, External combustion Engines.
CO 6	Knowledge of Refrigeration and air conditioning systems, which is playing prominent role in the present day industry.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

FOR METALLURGICAL & MATERIALS ENGINEERING

Course code	Course Name	Course Category	L-T-P	Credits
20ME1113	Engineering Mechanics	ESC	2-1-0	3

Course Objectives: The objectives of this course are to

1. Explain the resolution of a system of forces, compute their resultant and solve problems using equations of equilibrium.
2. Perform analysis of bodies lying on rough surfaces.
3. Locate the Centroid of a body and compute the area moment of inertia and mass moment of inertia of standard and composite sections.
4. Explain kinetics and kinematics of particles, projectiles, curvilinear motion, centroidal motion and plane motion of rigid bodies.
5. Understand the concept of dynamics of particles and analysis the motion of particle.
6. Explain the concepts of work-energy method and its applications to translation, rotation and plane motion and the concept of vibrations.

Course Contents:

Unit I: **(Contact hours 12)**

Introduction to Engineering Mechanics - Force systems, Forces acting at a point, Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple.Equilibrium of system of forces - Free body diagram; equations of equilibrium; problems in two and three dimensions; Analysis of plane trusses.

Unit II: **(Contact hours 8)**

Friction: Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack.

Unit III: **(Contact hours 8)**

Centroid and Centre of Gravity: Centroid of Lines, Areas and Volumes from first principle, Centroid of composite sections; Centre of Gravity and its implications. – Theorem of Pappus.

Unit IV: **(Contact hours 12)**

Area moment of inertia-Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular

Axis Theorem.

Mass Moment of Inertia: Moment of Inertia of Masses - Transfer Formula for Mass Moments of Inertia – Mass moment of inertia of composite bodies.

Unit V: **(Contact hours 12)**

Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy.Impulse-momentum (linear, angular); Impact (Direct and oblique).

Unit VI: **(Contact hours 8)**

Kinetics of Rigid Bodies -Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies; Work Energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation.

Text Books:

1. Beer and Johnston, *Vector Mechanics for Engineers Statics and Dynamics*, (9th edition) by, Tata McGraw Hill Publishing Company, New Delhi.

References

1. Tayal, A. K. "*Engineering Mechanics-Statics and Dynamics*." 2011.
2. Timoshenko S.P and Young D.H., "*Engineering Mechanics",* McGraw Hill International Edition, 1983.
3. Bhattacharyya, Basudeb. *Engineering Mechanics*. Oxford University Press India, 2016.
4. Shames, I.H., and Krishna MohanaRao. G., "Engineering Mechanics – Statics and Dynamics", 4th Edition, Pearson Education (2006)

Web Resources:

https://nptel.ac.in/courses/112103109//

https://nptel.ac.in/courses/112103108//

Course outcomes: At the end of the course, students will be able to

CO 1	Solve resultant of forces acting on a body and analyze equilibrium of a body subjected to a system of forces.
CO 2	Solve problem on bodies subjected to friction.
CO 3	Evaluate the location of Centroid and calculate moment of inertia of a given section.
CO 4	Make a use of the concept of mass moment of inertia to real world applications.
CO 5	Apply the kinetics and kinematics concepts to a body undergoing rectilinear, curvilinear, rotatory motion and rigid body motion.
CO 6	Solve problems using work energy equations for translation, fixed axis rotation and plane motion and solve problems of vibration.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20ME1186	Workshop Manufacturing Practices	ESC	0-0-3	1.5

List of Experiments

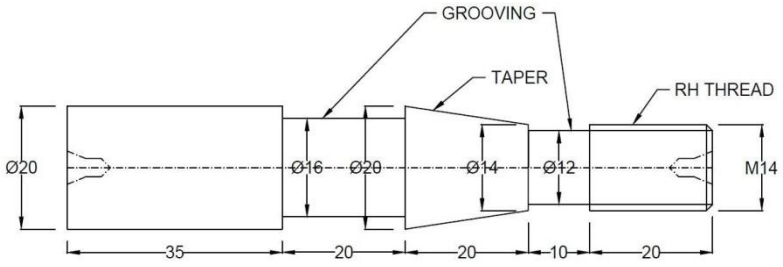
1. **Safety**
   a) Introduction to Workshop, Safety and Safety rules, Safety Slogans.
   b) Demonstration of tools and Equipment's used for safety purpose.

2. **Carpentry**
   a. Study of tools, materials and equipment's used in Carpentry.
   b. Preparation of dovetail lap joint.
   c. Preparation of cross half lap joint.

3. **Fitting**
   a) Study of tools, materials and equipment's used in fitting.
   b) Preparation of Square fit from the given mid steel pieces
   c) Preparation of V fit from the given mid steel pieces

4. **Sheet Metal forming**
   a) Study of sheet metal forming tools.
   b) Fabrication of a Square Tray from G.I sheet

5. **Machining**
   a. Study the characteristic features of lathe, milling and drilling machines
   b. Preparation of the part shown in the sketch from a mild steel rod on a Lathe.



ALL DIMENSIONS ARE IN MM

6. **Smithy**

a) Study of tools, operations and equipment's used in blacksmithy
b) Conversion of Round Rod to Square Rod through hot forging.

7. Welding

a) Preparation of arc welding of butt joints, lap joints and tee joints
b) Gas welding practice

8. Foundry

a) Study of foundry tools
b) Prepare Green Sand Mould for Bend Pattern

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

FOR COMPUTER SCIENCE AND ENGINEERING

Course code	Course Name	Course Category	L-T-P	Credits
20ME1114	Engineering Graphics and Computer Drafting	ESC	1-0-3	2.5

Course Objectives:

1. To know about emergence of Engineering Graphics as a refined communication tool and to be aware of International and national standards of practice for uniform presentation of drawings.
2. To adopt the projection of three dimensional object orthogonally on a set of vertical and horizontal planes and obtain the views of the frontal and the top surfaces.
3. To describe the position of a point and position of the line with respect to all the planes of projection and obtain its views.
4. To learn orthographic projections of various simple plane surfaces in simple and inclined positions.
5. To know about orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
6. To learn about types of cutting planes and to obtain views of simple solids.
7. To learn about different methodologies to be used for obtaining the two dimensional layout of the lateral surfaces of uncut solids.
8. To learn about computer aided drafting techniques and to be familiarize with one of the most powerful software ‘AutoCAD’.

Course contents:

Unit I: Introduction to Engineering Drawing (Contact hours 7)

Introduction to Engineering drawing – Tools and Standards, Geometric Constructions, Scales, Conics and Special Curves - ellipse, parabola, hyperbola, cycloids, Involutes.

Unit II: Orthographic projections (Contact hours 6)

Introduction to Orthographic Projections, Projection of points - projection of straight lines (only first angle projection method) inclined to both the principal planes - determination of true lengths and true inclinations by rotating line method and traces -

Unit III: Projection of Solids (Contact hours 8)

Projection of Planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method,

Projections of Solids: cube, prism, pyramid, cylinder, cone and sphere.

Unit IV: Section of Solids **(Contact hours 8)**

Sections of Solids - cube, prism, pyramid, cylinder, cone and sphere. Development of Surfaces – Parallel line method and Radial line method.

Unit V: Introduction to AutoCAD **(Contact hours 8)**

Computer Aided Design – Introduction to AutoCAD, Co-ordinate System (UCS) and their Commands, Basic Commands of Drawing and Editing, Dimensioning and Text.

Unit-VI: Computer Graphics **(Contact hours 8)**

Drawing practice with AutoCAD – Creating 2D Drawings of Objects from Isometric views (Iso to Ortho), Creating Isometric views form Orthographic views (Ortho to Iso) and Introduction to 3D drawings.

Course outcomes: At the end of the course, students will be able to

CO 1	Student will be aware of International and national standards of practice.
CO 2	Student will be familiar with obtaining the views of the frontal and the top surfaces of an object.
CO 3	Student will be able to know to use the different drawing instruments.
CO 4	Student will be aware of orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
CO 5	Students will understand the concepts of three dimensional views such as isometric, oblique projections.
CO 6	Student will know about computer aided drafting techniques and will be familiar with one of the most powerful software 'AutoCAD'

Learning resources

.**Text Books**

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

References

1. Venugopal, K. and Raja, V.P., 2011. Engineering Drawing+ AutoCAD. New Age International.
2. Parthasarathy, N.S. and Murali, V., 2015. *Engineering Drawing.*

   Oxford University Press.
3. Narayana, K.L. & P Kannaiah (2008), *Text book on*

Engineering Drawing, Scitech Publishers.

Online/Web Resources:

1. https://nptel.ac.in/courses/112103019//
2. https://nptel.ac.in/courses/112104172//
3. Prof Anupam Saxena, NPTEL-IIT Kanpur, 'Engineering Drawing' URL: https://nptel.ac.in/courses/112104172/
4. Prof Anupam Saxena, NPTEL-IIT Kanpur, 'Computer Aided Engineering Design'. URL: https://nptel.ac.in/syllabus/112104031/

Course Nature		**Theory + Lab**		
Assessment Method				
Assessment Tool	Weekly Charts	Monthly tests (3)	End Semester Test	Total
	Average (Minimum 8 charts)	Best of two (Max Marks-10)	Max Marks-60	
Weightage (%)	20%	20%	60%	100%

MINOR DEGREE IN MECHANICAL ENGINEERING DETAILED SYLLABUS

Course Code	Course Name	Course Category	L-T-P	Credits
20MEM101	Basic Mechanical Engineering	PCC	3-0-0	3

Course Learning Objectives: The objective of this course is to

1. Discuss the basic concepts of Thermodynamics
2. Discuss the first & second law of Thermodynamics and their application for closed and open systems
3. Discuss the types of turbines, boilers, condensers
4. Discuss modes of heat transfer, types of I.C Engines and Refrigeration systems
5. Explain types of Manufacturing processes
6. Explain various types of machine tools and their operations

Course Contents

Unit I

Power Transmission: Belt drives, Gear drives, Basics of Automotive vehicle: Brakes types, clutch, differential. Introduction: Introduction to Thermodynamics, concept of a system, types of systems, thermodynamic equilibrium, properties, state, process and cycle, zeroth law, energy interactions, heat and work, types of work, work interaction in a closed system for various process.

Unit II

First and Second law of Thermodynamics: cycle and process, specific heats, heat interaction in a closed system for various processes, limitations of first law, concept of heat engine and reversed heat engine, efficiency/COP. Second law: Kelvin-Planck and Clausius statements, Carnot cycle, Carnot efficiency, statement of Clausius inequality, property of entropy, T-S and P-V diagrams.

Unit III

Thermal Power Plant: Thermal Power Plant Layout: four circuits, Rankine cycle, Boilers: Fire tube vs Water tube; Babcock & Wilcox, Cochran Boilers, Steam turbines: Impulse vs Reaction Turbines, compounding of turbines: Pressure compounding, velocity compounding, pressure velocity compounding, condensers: Types- Jet and surface condensers, cooling towers.

Unit IV

Internal Combustion Engines and Refrigeration: IC Engines: 2-stroke and 4-stroke Engines, S.I Engine and C.I. Engine: Differences, P-V and T-S diagrams.

Refrigeration Systems and Refrigerants: Principle and working of standard vapour compression refrigeration system and brief description of refrigerants.

Heat Transfer: Heat transfer Modes, Thermal Resistance concept, Conduction:

Composite walls and cylinders, combined conduction and convection: Overall Heat transfer coefficient, simple numerical problems.

Unit V

Manufacturing Processes: Engineering materials: Classification, properties of materials, manufacturing processes: Metal casting, moulding, patterns, metal working: Hot working and cold working, Metal forming: extrusion, forging, rolling, drawing. Welding: Gas welding, arc welding, soldering and brazing

Unit VI

Machine tools and Machining processes: Machine tools: Lathe machine, lathe operations, milling machine types, milling operations, shaper and planner machine differences, quick return motion mechanism, drilling machine operation, grinding machine operations

Text Books

1. M.L. Mathur, F.S. Mehta and R.P. Tiwari, Elements of Mechanical Engineering, Jain Brothers, New Delhi,
2. Gupta and Prakash, Engineering Heat Transfer, Nemchand& Brothers, New Delhi.
3. B.S. Rahuvanshi, Workshop Technology 1 & 2, Dhanpath Rai and sons, New Delhi

Course Outcomes: At the end of the course, the student will be able to

CO 1	Understand mechanics of power transfer through belt and gear drives
CO 2	Understand basics of thermodynamics and components of a thermal plant
CO 3	Understand the first and second law of thermodynamcis
CO 4	Understand the basics heat transfer, refrigeration and I.C engines
CO 5	Identify engineering material, manufacturing methods encountered in engineering practice
CO 6	Understand functions and operations of machine tools

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MEM102	Computer Aided Design and Analysis	PCC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Learn basic principles of finite element analysis procedure
2. Learn the theory and characteristics of finite elements that represent engineering structures.
3. Know when to use 1D, 2D , 3D elements in practical problems.
4. Model complex geometry problems and solution techniques
5. Distinguish the difference between finite difference method and finite volume methods.
6. Evaluate the Euler equations, and Navier-stokes system of equations.

Course Contents

Unit I

Introduction: Historical Perspective of FEM and applicability to mechanical engineering problems. Mathematical Models and Approximations:mathematical models for structural problems,Energy Approach-Integral formulation, Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models; Ritz, Rayleigh-Ritz and Gelarkin's methods. Philosophy and general process of Finite Element method.

Unit II

Finite Element Formulation: Concept of discretization, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility, Assembly and boundary considerations. Finite element Method in One Dimensional Structural problems: Structural problems with one dimensional geometry. Formulation of stiffness matrixBoundary conditions and their incorporation: Elimination method, Formulation for Truss elements.

Unit III

Two dimensional Problems: Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, subparametric, Isoparametric and superparametric elements. Introduction to Three Dimensional Problems.

Unit IV

Basics of fluid mechanics (properties of fluids, kinematics and dynamics of fluids) Illustration of the CFD approach: CFD as an engineering analysis tool, Derivation of flow governing equations. Initial and boundary conditions; wellposedness, Turbulence modeling. Discretization of the governing equations using, finite difference / volume

methods, Concepts of consistency, stability and convergence.

Unit V

Design and analysis of 2D problems (flow over a flat plate, flow over a aerofoil, flow over a circle, flow over an automobile (car and truck)) by using ansys 18 software.

Unit VI

Design and analysis of 3D problems (flow over a cylinder, flow over a sphere, flow over a aerofoil, flow over an automobile (car and truck)) by using ansys 18 software..

Text Books

1. H. K. Versteeg, and W. Malalasekara, *Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson Education, 2008.
2. John D. Anderson, Jr., *Computational Fluid Dynamics The Basics with Applications*, McGraw Hill, 1995
3. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
4. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
5. SingiresuS.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012

Course Outcomes: At the end of the course, the student will be able to

CO 1	Understand the concepts behind variational methods and weighted residual methods in FEM.
CO 2	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element
CO 3	Develop element characteristic equation procedure and generation of global stiffness equation will be applied.
CO 4	Able to apply Suitable boundary conditions to a global structural equation, and reduce it to a solvable form.
CO 5	Emphasize mathematical formulation of various flow problems
CO 6	Include advanced theories of flow mechanics so that students can expertise and pursue research in the relevant areas

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20MEM103	Production and Operations Management	PCC	3-0-0	3

Course Learning Objectives:

1. To understand the basic knowledge of Operations management
2. To identify different layouts for facilities planning
3. To analyze different functions of production planning
4. To describe various types of process engineering methods
5. To calculate different aspects of dimensional analysis
6. To get the knowledge of forecasting

Course Content:

Unit – I **(7 Contact hours)**

Operations Management:

Objectives, Operations Management: Functions and Scope, Types of Production Systems, Operations Strategy. Product Life Cycle, Value Engineering Concepts, Rapid Prototyping: Concept, Advantages.

Unit – II **(7 Contact hours)**

Facility Planning:

Factors Affecting Plant Location, Plant Location: Case Studies Location Evaluation Methods. Facility Layout and Planning, Factors Influencing Plant Layout, Material Flow Patterns, Tools and Techniques used for Plant Layout Planning.

Unit – III **(8 Contact hours)**

Production Planning and Control:

Process Planning, Aggregate Production Planning, Capacity Planning: Introduction, Capacity Planning: Examples. Production Control, Sequencing, Sequencing Problems, Master Production Scheduling (MPS).

Unit – IV **(8 Contact hours)**

Process Planning

Introduction, Function, Pre-requisites and steps in process planning, Factors affecting process planning, Make or buy decision, plant capacity and machine capacity.

Aggregate Planning and Master Scheduling: Variables Used in Aggregate Planning, Aggregate Planning Strategies, Master Scheduling

Unit – V **(8 Contact hours)**

Material and Capacity Requirements Planning: Objectives, MRP Inputs and Outputs, Bill of Materials, MRP Logic, Safety Stock, Lot Sizing and System Updating, CRP Inputs and Outputs: Loading, Steps in the Loading

Unit – VI **(7 Contact** hours)

Production Forecasting: Introduction of production forecasting, The strategic role of forecasting in supply chain, Time frame, Demand behavior, Forecasting methods- Qualitative and Quantitative, Accuracy of Forecast methods.

Learning resources Text book:

1. Pannerselvam R, '*Production and Operations Management'*, Prentice Hall India, 3 rd Edition, 2013.

Reference Books:

1. Kanishka Bedi, '*Production and Operations Management'*, Oxford University Press, 2007.
2. Russel and Taylor, '*Operations Management'*, Wiley, 7 th Edition, 2010.
3. Chary S. N, '*Production and Operations Management'*, Tata McGraw Hill, 5 th Edition, 2008.
4. Chase Jacobs, Aquilano & Agarwal., '*Operations Management'*, Tata McGraw Hill, 11th edition, 2006.
5. Mahadevan B, '*Operations Management Theory and practice'*, Pearson Education, 2 nd edition, 2010.

Web resources:

Title	Expert Name	Details of Expert	Web link
NPTEL video on Operations Management	Prof. Indradeep Singh	IIT Roorkee	https://nptel.ac.in/syllabus/112107238/

Course outcomes: At the end of the course, the student will be able to

CO 1	Effective Forecasting of Production functions, Enhanced Planning of Product Design and Service Operations. Facility Planning and Project Management.
CO 2	Apply the decision models to various real time problems
CO 3	Solve and analyze problems using different forecasting techniques.
CO 4	Evaluate and rank capacity locations, plan and schedule production by solving the problems.
CO 5	Describe MRP & CRP concepts, inventory types and its objectives and calculate EOQ using various models.
CO 6	Describe the concept of operations management and productivity

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MEM104	Mechanical Design	PCC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Discuss the mechanical properties of the material.
2. Analyze the structural members subjected to bending, torsional loads
3. Understand the buckling of column
4. Evaluate the structural member subjected to deflection
5. Understand theories of failure of materials
6. Understand the design of machine elements in fatigue loading

Course Contents

Unit–I:

Introduction: Simple Stresses &Strains : Elasticity and plasticity, types of stresses &strains, stress – strain diagram for ductile and brittle materials, working stress, factor of safety, lateral strain, Poisson's ratio, Generalized Hooke's law, volumetric strain, Elastic moduli & the relationship between them, Strain energy, Resilience, toughness. **Shear Force and Bending Moment:** Definition of beam, types of beams, Concept of shear force and bending moment, S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads, point of contra flexure.

Unit–II:

Torsion of Circular Shafts

Theory of pure torsion, derivation of Torsion equations, assumptions made in the theory of pure torsion, torsional moment of resistance, Polar section modulus, power transmitted by shafts. **Flexural Stresses :**Theory of simple bending, assumptions, derivation of bending equation, neutral axis, determination bending stresses, section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle sections.

Unit-III:

Principal Stresses and Strains: Introduction, stresses on an inclined section of a bar under axial loading, compound stresses, Normal and tangential stresses on an inclined plane for biaxial stresses, Two perpendicular normal stresses accompanied by a state of simple shear, Mohr's circle of stresses, Principal stresses and strains.

Unit-IV:

Beams Deflection:

Bending into a circular arc, slope, deflection and radius of curvature, Double integration and Macaulay's methods, determination of slope and deflection for cantilever, simply supported & over hanging beams subjected to point loads, uniformly varying, uniformly distributed load. **Columns and struts:** Buckling and stability, column with pinned ends, column with other supports, effective length, limitations of Euler's formula

Unit – V

Concept of Machine Design: Types of loads, stresses and strain, modes of failure, Principal stresses, theories of failure, Rankine theory, Guests theory, Von Mises theory, selection of failure theories

Unit-VI

Introduction: What is stress concentration? Importance in design, How stress concentration leads to failure? How stress concentration is accounted for in the design, Stress concentration factors, Theoretical and actual stress concentration factors, Notch sensitivity, Ductile and Brittle materials. **Dynamic loading:** Practical examples, S – N curve, Definition of endurance limit, Gerber's Parabola, Goodman's line, Soderberg Line and the Line of safe stress, How machine elements are designed under dynamic loading,

Learning resources

Text Books

1. E. Popov, Engineering Mechanics of Solids, Prentice hall, 1998.
2. F. P. Beer, E. Russell Johnston, J. T. Dewolf, Mechanics of materials, McGraw hill, 3rd edition, 2004.

References

1. Bhandari, V B., Design of Machine Elements, 3/e, Tata McGraw Hill Book Company, New Delhi, 2009.
2. Shigley, J.E and Mischke, C. R. Mechanical Engineering Design, 6/e, Tata McGraw Hill, 2005.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Apply knowledge of materials and structural elements to the analysis of simple structures.
CO 2	The student will be able to analyze the different types of stresses in the beams.
CO 3	Analyze the behavior of the solid bodies subjected to various types of Loading
CO 4	The student will be able to analyze the different types of stresses in the beams.
CO 5	Understands the concepts of principal stresses, stress concentration in machine members and fatigue loading
CO 6	Understand the concepts of theories of failure of a material under different loading.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MEM105	Product Design and Development	PCC	3-0-0	3

Course Learning Objectives: The objective of this course is to

1. Understand the basic components of product design
2. Know how to select materials based on their mechanical properties
3. Understand the design considerations related to the casting, welding and machining techniques.
4. Understand the difference between the additive manufacturing and conventional manufacturing
5. Understand the importance of additive manufacturing technology and its innovation.
6. Understand the steps and difficulties involved in additive manufacturing process to produce a component.

Course Contents

Unit -I

Need and identification of problem: Identifying customer needs, customer requirements, Establishing the Engineering Characteristics, Quality function development; Concept Generation and Evaluation: Creative thinking and problem solving, functional decomposition and synthesis, Morphological methods. Decision making and Evaluation methods: Comparision based on absolute criteria, Pugh concept selection method, Weighted decision matrix, Analytic Hierarchy process. Embodiment design: Product architecture, configuration design, parametric design, dimension and tolerances.

Unit II

Selection of Materials and Shapes: Physical and Mechanical properties of Engineering material (Metals, Polymers, Ceramics and Composite materials). Selection of Materials: Material performance index, Examples and case studies related to selection of materials. Selection of shapes, Examples and case studies related to selection of shapes.Review of Manufacturing process: Classification of manufacturing process. Design for casting: Types of patterns, allowances, design of gating system, types of casting techniques, casting defects,

Unit III

Design recommendation for casting. Design of Bulk deformation process: Types of bulk deformation process like forging, rolling, extrusion, defect in each bulk deformation
process, design recommendations for bulk deformation process. Design for sheet metal

forming process: shearing, bending, deep drawing, defects in deep drawing, design consideration for sheet metal forming. Design for Machining: Turning, Milling, Drilling, Grinding, Non-Traditional Machining techniques like AJM, USM, EDM, ECM, LBM, EBM, design consideration in machining. Design for Powder Metallurgy: Powder preparation, compacting, sintering, finishing operation, design consideration in powder metallurgy.

Unit IV

Design for Welding: Types of welds and weld joints, residual stress and its effects, welding distortion, steps to reduce distortion. Fusion welding: welding zone, heat affected zone, hot cracking, cold cracking, defects in welding, design consideration in welding. Design for Heat treatment: Annealing, types of annealing, hardening, tempering, normalizing, quenching design consideration in heat treatment.

Unit V

Introduction to Additive Manufacturing, Generalized Additive Manufacturing Process Chain: Eight Steps in Additive Manufacturing, Metal Systems: Use if Substrates, Energy Density, Weight, Accuracy, Speed; Maintenance of Equipment, Materials Handling Issues, Design For Additive Manufacturing.Vat Polymerization Processes. Introduction, Vat Photopolymerization Materials, Reaction Rates, Laser Scan Vat Polymerization, Photopolymerization Process Modelling, Scan Patterns.

Unit VI

Powder Bed Fusion Processes: Introduction, Materials: Metals, Polymers, Ceramics, and Composites; Powder Fusion Mechanisms: Solid State Sintering, Chemically Induced Sintering, LPS and Partial Melting, Full Melting, Part Fabrication; Process Parameters and Modeling, Powder Handling: Powder Handling Challenges, Powder Handling Systems, Powder Recycling; Advantages and Limitations. Direct Energy Deposition (DED) Processes: Introduction, General DED Process Description, Material Delivery: Powder Feeding, Wire Feeding; DED Systems: Laser Based Metal Deposition Processes, Electron Beam Based Metal Deposition Processes, Process Parameters, Typical Materials and Microstructure, Processing-Structure-Properties Relationships, Advantages and Limitations.

Text Books

1. G Dieter, Engineering Design- a materials and processing approach, McGraw Hill, NY, 2000.
2. M F Ashby, Material selection in Mechanical Design, Butterworth-Heinemann, 1999
3. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer, 2015.
4. A. Gebhardt, Understanding Additive Manufacturing: Rapid

Prototyping, Rapid Tooling, Rapid Manufacturing, LAP
LAMBERT Academic Publishing, 2012.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Know the basic steps involved in product design
CO 2	Know the different material and their selection methodology
CO 3	Understand the design consideration for various manufacturing techniques
CO 4	Know the advantages and limitations of a given process to produce a component.
CO 5	Know various additive manufacturing processes.
CO 6	Know the type of additive manufacturing process one has to adopt for producing a component.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MEM181	Manufacturing Processes Lab	PCC	0-0-3	1.5

Course Learning Objectives: The objective of this Lab is to

1. Give basic idea of different types of machining processes like turning, milling, drilling etc.
2. Introduce the different types of machine tools used in machining of materials.
3. Understand the parts of various machine tools and operate them.
4. Understand the different shapes of products that can be produced on these machine tools.
5. Explain the difference between the conventional and CNC machine tools
6. Introduce the concepts of G-codes and M-codes

List of Experiments

1. Experiment to perform step turning, taper turning, boring, drilling, reaming, facing operation on mild steel specimen on lathe machine
2. Experiment to perform drilling, contour boring, counter sinking, reaming, spotting operation on mild steel specimen using drilling machine.
3. Experiment to perform milling, slotting on mild steel specimen using milling machine
4. Experiment to perform surface grinding operation on surface grinding machine.
5. Experiment to perform turning, step turning, boring, drilling, reaming, facing operation on aluminium specimen using CNC turning center.
6. Experiment to produce contour profile using CNC machining centre
7. Experiment to produce gear using CNC wire cut EDM
8. Experiment to produce spur gear using Rapid prototyping machine

Learning resources

Text Books:

2. M. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 6th Edition, John Wiley & Sons 2016.

References:

4. Savitha Sharma, Manufacturing processes, international publications 4th edition, 2011.

5. P.C. Sharma, "A text book of production technology", S. Chand and Company, 4th edition, 2003.
6. Rajendra Singh, Introduction to basic manufacturing processes: new age publications: 2nd edition, 2014.

Course Outcomes: At the end of the course, the student will be able to

CO 1	Get familiarity with Lathe machine and perform various Lathe operations.
CO 2	Get familiarity with Milling machine and perform different Milling Operations
CO 3	Perform Drilling and Surface Grinding operations on different machines
CO 4	Operate different machine tools with understanding of work holders and operating principles to produce different part features to the desired quality.
CO 5	Write a program using G-codes and M-codes
CO 6	Manufacture a product which has complex shapes

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course Name	Course Category	L-T-P	Credits
20MEM182	Computer Aided Modeling and Simulation Lab	PCC	0-0-3	1.5

Course Objectives:

1. To impart the student's skills required for modelling and analysis using software package.
2. To impart skills required for writing MAT LAB Code
3. To study 2D and 3D beam deflections by using simulation software.
4. To study thermal analysis and fluid flow analysis by using simulation software.

Learning Outcomes:

Students will be able to

1. Model simple mechanical parts using modeling package
2. Analyze different engineering problems using analysis package
3. Write and execute MAT Lab code for solving engineering problems.

List of experiments:

b) Using Modeling Package: (Any three experiments)

6. Sketching of a drawing with dimensions
7. Modeling of Stuffing Box parts
8. Assembly of parts of Flanged Coupling
9. Modeling of parts of Eccentric and generation of orthographic views
10. Modeling of links of four bar mechanism and simulation of mechanism

b) Using analysis Package: (Any six experiments)

17. 2- D truss analysis.
18. Static Analysis of Beam.
19. Static Analysis of 3-D structure.
20. Steady state Heat Transfer Analysis.
21. Transient thermal analysis
22. Free vibration analysis of Beam.
23. Harmonic Analysis of a Beam
24. Analysis of Axisymmetric Problem.
25. Analysis of Plane Stress problem.
26. Stress analysis of a composite plate.
27. Buckling analysis of column.

28. Optimization of cantilever beam.
29. Fluid analysis of elbow using Ansys Fluent
30. Fluid flow and Heat Transfer analysis of elbow using ANSYS FLUENT
31. Radiation and Natural Convection analysis by using ANSYS FLUENT
32. Transient thermal analysis of a Cylindrical Pipe

c) Using MATLAB (Any two experiments)

Introduction to MATLAB–Vector and Matrix Manipulations– Matrix functions– Tools for Polynomials – Non linear algebraic equations - Solving Differential equations– writing function subroutines–basic input and output functions–plotting functions.

5. Analysis of Bar structure using Finite Element Method
6. Analysis of Beam Structure using Finite Element Method
7. Analysis of Truss using Finite Element Method
8. Displacement, velocity and acceleration analysis of four bar mechanism.

Open Ended Experiment:

- Analysis of connecting rod with composite material

Reference Books:

1. Sham Tickoo, SOLID WORKS 2017 for Designers, CAD CIM Technologies, 3rd Edition
2. Saeed Moaveni, Finite Element Analysis: Theory and Application with ANSYS, Pearson Publishers
3. Rao V Dukkipati, MATLAB for Mechanical Engineers, New Age International Publishers.

Assessment Method

Weightage (%)	Internal Marks	External Marks	Total Marks
10%	40%	60%	100%