NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI

www.nec.edu.in

REGULATIONS – 2023

CURRICULUM & SYLLABUS

B. E. – MECHANICAL ENGINEERING

(Outcome Based Education & Choice Based Credit System)

DEPARTMENT OF MECHANICAL ENGINEERING

I. VISION

Producing globally competitive Mechanical Engineers with social responsibilities

II. MISSION

- Imparting quality education by providing excellent Teaching-Learning environment.
- Inculcating qualities of continuous learning, professionalism, team spirit, communication skill and leadership with social responsibilities.
- Promoting leading-edge research and development through collaboration with academia and industry.

III. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Graduates will have successful profession in Mechanical/allied Industries or Research/Academics orbusiness enterprise.

PEO 2: Graduates will broaden their horizons beyond Mechanical Engineering to address the societal andenvironmental concerns.

PEO 3: Graduates will have the attitudes and abilities of leaders to adapt the changing global scenario.

IV. PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Apply the concepts of Engineering Design to design, analyze and develop the Mechanical components and systems using the different analytical / CAD / experimental tools.

PSO 2: Apply the concepts of Thermal Engineering to design, analyze and develop theflow and energy systems using the different analytical / experimental / software tools.

PSO 3: Apply the concepts of Production and Industrial Engineering for analysis, optimization and development of mechanical systems.

V. PROGRAM OUTCOMES (POs)

PO 1: **Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization, to develop to the solution of complex engineering problems.

PO 2: **Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.

PO 3: **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.

PO 4: **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge, including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.

PO 5: **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.

PO 6: **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.

PO 7: **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.

PO 8: **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO 9: **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO 10: **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO 11: **Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

REGULATIONS 2023

Curriculum and Syllabus

SEMESTER – I

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Induction Programme – 2 weeks									**0**
Theory Courses									
1.	23SH11C	தமிழர்மரபு/ Heritage of Tamils	HSMC	1	0	0	0	1	1
2.	23SH12C	Mathematical Foundations for Engineers	BSC	3	1	0	0	4	4
3.	23SH13C	Introduction to Engineering	ESC	1	0	0	0	1	1
4.	23GN01C	Aptitude Essentials	EEC	1	0	0	0	1	1
Integrated Courses									
5.	23SH14C	Technical English	HSMC	1	0	2	0	3	2
6.	23SH15C	Engineering Physics	BSC	2	0	2	0	4	3
7.	23SH16C	Engineering Chemistry	BSC	2	0	2	0	4	3
8.	23ME11C	Engineering Graphics	ESC	2	0	4	0	6	4
			TOTAL	**13**	**1**	**10**	**0**	**24**	**19**

SEMESTER - II

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23SH21C	தமிழரும்தொழில்நுட்பமும் /Tamils and Technology	HSMC	1	0	0	0	1	1
2.	23GN05C	Professional Ethics and Human Values	HSMC	2	0	0	0	2	2
3.	23ME21C	Fourier Series, Complex Analysis and Calculus	BSC	3	1	0	0	4	4
4.	23ME22C	Materials Science	ESC	2	0	0	0	2	2
5.	23ME23C	Engineering Mechanics	ESC	3	1	0	0	4	4
Integrated Courses									
6.	23SH22C	Professional English	HSMC	1	0	2	0	3	2
7.	23CS11C	Problem Solving Techniques	ESC	3	0	2	0	5	4
8.	23EE13C	Fundamentals of Electrical and Electronics Engineering	ESC	3	0	2	0	5	4
Practical Courses									
9.	23GN02C	Innovation through Design Thinking	EEC	0	0	0	4	4	2
			TOTAL	**18**	**2**	**6**	**4**	**30**	**25**

SEMESTER – III

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23GN04C	Aptitude Excellence	EEC	0	0	2	0	2	1
2.	23MC02C	Environmental Science and Engineering	MC	2	0	0	0	2	0
3.	23ME31C	Engineering Thermodynamics	ESC	3	1	0	0	4	4
4.	23ME32C	Statistics and Numerical Methods	BSC	3	1	0	0	4	4
Integrated Courses									
5.	23ME33C	Basic Manufacturing Processes	PCC	3	0	2	0	5	4
6.	23ME34C	Fluid Mechanics and Hydraulic Machines	PCC	2	1	2	0	5	4
7.	23ME35C	Materials Engineering	PCC	2	0	2	0	4	3
8.	23ME36C	Kinematics of Machinery	PCC	3	0	0	2	5	4
Practical Courses									
9.	23GN03C	Intellectual Property Rights Study	EEC	0	0	0	4	4	2
			TOTAL	**18**	**3**	**8**	**6**	**35**	**26**

SEMESTER – IV

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23GN06C	Project Management and Finance	HSMC	2	0	0	0	2	2
2.	E1	Open Elective – Science Stream	OEC	3	0	0	0	3	3
3.	E2	Open Elective Course – I	OEC	3	0	0	0	3	3
4.	23MC01C	Constitution of India	MC	2	0	0	0	2	0
Integrated Courses									
5.	23ME41C	Machining Processes	PCC	3	0	2	0	5	4
6.	23ME42C	Thermal Engineering	PCC	3	0	2	0	5	4
7.	23ME43C	Strength of Materials	PCC	3	0	2	0	5	4
8.	23ME44C	Machine Drawing	PCC	1	0	2	0	3	2
Practical Courses									
9.	23ME45C	System Modeling Projects	EEC	0	0	2	2	4	2
			TOTAL	**20**	**0**	**10**	**2**	**32**	**24**

SEMESTER – V

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23ME51C	Mechatronics and Robotics Engineering	PCC	3	0	0	0	3	3
2.	E3	Program Elective Course - I	PEC	3	0	0	0	3	3
3.	E4	Program Elective Course - II	PEC	3	0	0	0	3	3
Integrated Courses									
4.	23ME52C	Heat and Mass Transfer	PCC	2	1	2	0	5	4
5.	23ME53C	Dynamics of Machinery	PCC	2	1	2	0	5	4
6.	23ME54C	Computer Aided Design and Manufacturing	PCC	3	0	2	0	5	4
Practical Courses									
7.	23ME55C	IoT Laboratory	PCC	0	0	2	0	2	1
8.	23ME56C	Simulation using Modern tools	EEC	0	0	2	2	4	2
			TOTAL	**16**	**2**	**10**	**2**	**30**	**24**

SEMESTER – VI

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23ME61C	Design for Manufacturing and Assembly	PCC	3	0	0	0	3	3
2.	23ME62C	Industrial Engineering	PCC	3	0	0	0	3	3
3.	E5	Program Elective Course - III	PEC	3	0	0	0	3	3
4.	E6	Open Elective Course - II	OEC	3	0	0	0	3	3
Integrated Courses									
5.	23ME63C	Engineering Metrology and Measurements	PCC	2	0	2	0	4	3
6.	23ME64C	Machine Elements and System Design	PCC	3	1	0	2	6	5
7.	23ME65C	Computer Aided Analysis	PCC	3	0	2	0	5	4
Practical Courses									
8.	23ME66C	Product Development Practice	EEC	0	0	0	4	4	2
			TOTAL	**20**	**1**	**4**	**6**	**31**	**26**

SEMESTER – VII

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	E7	Open Elective Course - III	OEC	3	0	0	0	3	3
Integrated Courses									
2.	E8	Program Elective Course - IV	PEC	3	0	0	0	3	3
3.	E9	Program Elective Course - V	PEC	3	0	0	0	3	3
4.	E10	Program Elective Course - VI	PEC	3	0	0	0	3	3
Practical Courses									
5.	23ME71C	Mini Project	EEC	0	0	0	6	6	3
6.	23ME72C	Internship	EEC	0	0	0	0	0	2
			TOTAL	**12**	**0**	**0**	**6**	**18**	**17**

SEMESTER – VIII

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Practical Course									
1.	23ME81C	Capstone Project/Industry Practice	EEC	0	0	0	12	12	6
			TOTAL	**0**	**0**	**0**	**12**	**12**	**6**

TOTAL CREDITS: 167

PROGRAMME ELECTIVE COURSES (PEC)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
THERMAL ENGINEERING MODULE								
1.	PEC	23ME01E	Power Plant Engineering	3	0	0	0	3
2.	PEC	23ME02E	Renewable Energy Sources	3	0	0	0	3
3.	PEC	23ME03E	Solar Photovoltaic Energy Conversion	3	0	0	0	3
4.	PEC	23ME04E	Cogeneration and Waste Heat Recovery	3	0	0	0	3
5.	PEC	23ME05E	Energy Efficient Buildings	3	0	0	0	3
6.	PEC	23ME06E	Energy Conservation in Industries	3	0	0	0	3
7.	PEC	23ME07E	Thermal Management of Batteries and Fuel Cells	3	0	0	0	3
8.	PEC	23ME08E	Hybrid and Electric Vehicles	3	0	0	0	3
DESIGN ENGINEERING MODULE								
9.	PEC	23ME20E	Product Design and Development Strategies	3	0	0	0	3
10.	PEC	23ME21E	Hydraulics and Pneumatics	3	0	0	0	3
11.	PEC	23ME22E	Industrial Robotics	3	0	0	0	3
12.	PEC	23ME23E	Advanced Modeling Techniques	2	0	2	0	3
13.	PEC	23ME24E	Product Life Cycle Management	3	0	0	0	3
14.	PEC	23ME25E	Mechanics of Robots	3	0	0	0	3
15.	PEC	23ME26E	Piping Design Engineering	2	0	2	0	3
16.	PEC	23ME27E	Vehicle Systems Design	3	0	0	0	3
17.	PEC	23ME28E	Drone Technology	3	0	0	0	3
MANUFACTURING ENGINEERING MODULE								
18.	PEC	23ME31E	Artificial Intelligence in Manufacturing	3	0	0	0	3
19.	PEC	23ME32E	Non-Destructive Evaluation	3	0	0	0	3
20.	PEC	23ME33E	Advanced Machining Processes	3	0	0	0	3
21.	PEC	23ME34E	Advanced Engineering Materials	3	0	0	0	3
22.	PEC	23ME35E	Additive Manufacturing	3	0	0	0	3
23.	PEC	23ME36E	Automated Guided Vehicles	3	0	0	0	3
24.	PEC	23ME37E	Computer Integrated Manufacturing	3	0	0	0	3
25.	PEC	23ME38E	Artificial Intelligence in Materials Engineering	3	0	0	0	3
26.	PEC	23ME39E	Intelligent Manufacturing Systems	3	0	0	0	3
INDUSTRIAL ENGINEERING MODULE								
16.	PEC	23ME40E	Operations Research	3	0	0	0	3
17.	PEC	23ME41E	Principles of Management	3	0	0	0	3
18.	PEC	23ME42E	Total Quality Management	3	0	0	0	3
19.	PEC	23ME43E	Marketing Management	3	0	0	0	3
20.	PEC	23ME44E	Supply Chain and Logistic Management	3	0	0	0	3
21.	PEC	23ME45E	Industrial Safety Engineering	3	0	0	0	3
22.	PEC	23ME46E	Industry 4.0	3	0	0	0	3

ONE CREDIT COURSES (OCC)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
1.	PEC	23ME01L	Design of Experiments	1	0	0	0	1
2.	PEC	23ME02L	Carbon Capture	1	0	0	0	1
3.	PEC	23ME03L	Energy Audit and Management	1	0	0	0	1
4.	PEC	23ME04L	Functional Materials for Energy Conversion	1	0	0	0	1
5.	PEC	23ME05L	Industrial Drawing Reading with Geometric Dimensioning and Tolerancing	1	0	0	0	1
6.	PEC	23ME06L	Structuring a Startup	1	0	0	0	1
7.	PEC	23ME07L	Design for Environment	1	0	0	0	1
8.	PEC	23ME08L	Codes and Standards for Welding	1	0	0	0	1

OPEN ELECTIVE COURSES (MECHANICAL STREAM)
(Open Elective courses of other discipline offered by Mechanical Engineering)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
1.	OEC	23ID01E	Energy Engineering	3	0	0	0	3
2.	OEC	23ID02E	3D Design and Manufacturing	2	0	2	0	3
3.	OEC	23ID03E	Entrepreneurship Development	3	0	0	0	3
4.	OEC	23ID04E	Financial Management for Engineers	3	0	0	0	3

ELECTIVE COURSES (SCIENCE STREAM)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
MATHEMATICS								
1.	OEC	23SH01E	Linear Algebra, Mathematical Logic and Set Theory	2	1	0	0	3
2.	OEC	23SH02E	Linear Structures and Transformations	2	1	0	0	3
3.	OEC	23SH03E	Number Theory	2	1	0	0	3
4.	OEC	23SH04E	Numerical Analysis	2	1	0	0	3
5.	OEC	23SH05E	Optimization Techniques	2	1	0	0	3
6.	OEC	23SH06E	Principles of Discrete Mathematics	2	1	0	0	3
7.	OEC	23SH07E	Random Processes and Queuing Theory	2	1	0	0	3
8.	OEC	23SH08E	Statistical Techniques and Numerical Methods	2	1	0	0	3
9.	OEC	23SH09E	Transforms, Mathematical Logic and Set Theory	2	1	0	0	3
PHYSICS								
10	OEC	23SH10E	Fundamentals of Laser Technology	3	0	0	0	3
11	OEC	23SH11E	Nanomaterials for Engineers	3	0	0	0	3

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
12	OEC	23SH12E	Photonics	3	0	0	0	3
CHEMISTRY								
13	OEC	23SH13E	Biology for Computing	3	0	0	0	3
14	OEC	23SH14E	Biology for Engineers	3	0	0	0	3
15	OEC	23SH15E	Polymer Science and Technology	3	0	0	0	3
16	OEC	23SH16E	Sensors for Engineering Applications	3	0	0	0	3

Regulation 2023 - VERTICALS FOR HONOURS DEGREE / HONOURS DEGREE WITH SPECIALIZATION / MINOR DEGREE						
Department of Mechanical Engineering						
PROFESSIONAL ELECTIVE COURSES VERTICALS						
Sl No.	**Vertical 1**	**Vertical 2**	**Vertical 3**	**Vertical 4**	**Vertical 5**	**Vertical 6**
	CLEAN AND GREEN TECHNOLOGY	***MODERN MOBILITY SYSTEMS***	***ROBOTICS AND AUTOMATION***	***PRODUCT & PROCESS DEVELOPMENT***	***MATERIAS AND MODERN MANUFACTURING ENGINEERING***	***INDUSTRIAL MANAGEMENT***
1	Renewable Energy Sources	Automobile Engineering	Industrial Robotics	Product Design and Development Strategies	Advanced Engineering Materials	Principles of Management
2	Solar Photovoltaic Energy Conversion	Vehicle Systems Design	Mechanics of Robots	Product Life Cycle Management	Advanced Machining Processes	Total Quality Management
3	Cogeneration and Waste Heat Recovery	Fundamentals of Digital Electronics	Electrical Drives and Control	Advanced Engineering Materials	Quality Control of Welded Structures	Operations Research
4	Energy Conservation in Industries	Automotive Electronics	Control of Robotic Systems	Computer Graphics and Virtual Reality	Non-Destructive Evaluation	Marketing Management
5	Energy Storage Systems	Hybrid Electrical Vehicles	Mechatronics	Advanced Modeling Techniques	Additive Manufacturing	Production Planning and Control
6	Energy Efficient Buildings	Thermal Management of Batteries and Fuel Cells	Hydraulics and Pneumatics	Modelling and Simulation	Lean Manufacturing	Process Planning and Cost Estimation
7	Fuel Cells and Hydrogen Energy	Automotive Materials Components Design and Testing	MEMS Devices – Design and Fabrication	Piping Design Engineering	Machine Tool Control	Engineering Economics and Cost Analysis
8	Hybrid and Electrical Vehicles	Automated Guided Vehicles	Industry 4.0		Computer Integrated Manufacturing	Financial Management for Engineers
9						Industrial Safety Engineering

23SH11C	தமிழர் மரபு (HERITAGE OF TAMILS)	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	1	0	0	0	1

COURSE OUTCOMES

இப்பாடம் முடிந்ததும் மாணவர்களிடம் வளரும் திறன்

CO1:தமிழ் மொழியின் இலக்கிய வளம், ஓவிய, சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப்புறக் கலை மற்றும் வீரவிளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன்

CO2:தமிழர்களின் திணைசார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன்

Upon the successful completion of the course, the student will be able to

Theory Component

CO1:Know and explain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

CO2: Know and explain about Tamils Thinai concepts, contribution of Tamils in Indian National Movements and Indian Culture

CO1:தமிழ் மொழியின் இலக்கிய வளம்,ஓவிய,சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப் புறக்கலை மற்றும் வீரவிளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:9**

இந்தியமொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி–தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை–சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமணபௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு - நடுகல் முதல் நவீன சிற்பங்கள் வரை–ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள்,பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரி முனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம்,பறை,வீணை,யாழ்,நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு - தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

CO1: Know and explain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

Language Families in India - Dravidian Languages – Tamil as a Classical Language – ClassicalLiterature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature- Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land- Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modernliterature in Tamil - Contribution of Bharathiyar and Bharathidhasan - Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple carmaking - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari,Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role ofTemples in Social and Economic Life of Tamils - Therukoothu, Karagattam, VilluPattu, KaniyanKoothu, Oyillattam, Leather puppetry, Silambattam,Valari, Tiger dance - Sports and Games of Tamils.

CO2:தமிழர்களின் திணை சார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:6**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு–சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறைமுகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி கடல் கடந்த நாடுகளில் சோழர்களின் வெற்றி - இந்திய விடுதலைப் போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு–கல்வெட்டுகள், கையெழுத்துப் படிகள் - தமிழ்ப் புத்தகங்களின் அச்சுவரலாறு.

CO2: Know andexplain about Tamils Thinaiconcepts, contribution of Tamils in Indian National Movements and Indian Culture

Flora and Fauna of Tamils &Aham and Puram Concept from Tholkappiyam and Sangam Literature -Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports ofSangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas - Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the otherparts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems ofMedicine – Inscriptions & Manuscripts – Print History of Tamil Books.

REFERENCES:

1. தமிழகவரலாறு–மக்களும் பண்பாடும் - கே.கே.பிள்ளை (வெளியீடு:தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)
2. கணினித் தமிழ் - முனைவர்.இல.சுந்தரம் (விகடன் பிரசுரம்)
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரீகம் (தொல்லியல் துறைவெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரீகம். (தொல்லியல் துறைவெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

L: 15; TOTAL: 15 PERIODS

23SH12C	**MATHEMATICAL FOUNDATIONS FOR ENGINEERS**	**L**	**T**	**P**	**E**	**C**
	(Common to all B.E. / B.Tech. Degree Programmes)	**3**	**1**	**0**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Interpretthe nature of quadratic form by orthogonal transformation.
CO2: Identify the maxima and minima of functions.
CO3: Solve ordinary differential equations.
CO4: Find the solution of partial differential equations.
CO5: Evaluate integrals of multivariate calculus.

Soft skill Component

CO6: Develop communication, problem solving and interpersonal skills

CO1: Interpret the nature of quadratic form by orthogonal transformation. **L:9;**

Characteristic equation – Eigen values and Eigen vectors of a real matrix – Properties of Eigen values and Eigen vectors – Diagonalisation of a matrix by orthogonal transformation – Quadratic forms – Reduction of quadratic form to canonical form by orthogonal transformation and its nature; Cayley – Hamilton theorem (excluding proof) - Application: Stretching of a elastic membrane. **T:3**

CO2: Identify the maxima and minima of functions. **L:9;**

Functions of two variables: Limit, continuity and partial derivatives; Total derivative, Jacobian, Taylor series- Application:Linearization of Non-Linear systems using Taylor Series - Maxima and minima - Method of Lagrange multipliers. **T:3**

CO3: Solve ordinary differential equations. **L:9;**

Solutions of first order ordinary differential equations - Equations solvable for ‘p’, equations solvable for ‘y’, equations solvable for ‘x’ - Solutions of higher order linear differential equations with constant coefficients – Cauchy’s and Legendre’s linear equations - Method of variation of parameters – Solution of simultaneous linear differential equation. Application RCL – circuit and Mass Spring System. **T:3**

CO4: Find the solution of partial differential equations. **L:9;**

Formation of partial differential equations – Solutions of standard types of first order partial differential equations - Lagrange’s linear equations - Solutions of homogeneous and Non homogeneous linear partial differential equations of second and higher order with constant coefficient – Application - Shallow wave equations of first order PDE. **T:3**

CO5: Evaluate integrals of multivariate calculus **L:9;**

Double integration – Cartesian and polar coordinates - Change of order of integration - Change of variables - Cartesian to polar coordinates - Area as double integral - Triple integration - Cartesian and polar coordinates – Change of Variables- Cartesian to spherical and cylindrical coordinates. Application – Moments and centers of mass. **T:3**

TEXT BOOKS:

1. Grewal.B.S., Higher Engineering Mathematics, Khanna Publications, 44th Edition, 2021.
2. James E. Gentle, Matrix Algebra, Springer International Publishing, 2nd Edition, 2017
3. ShankerRao.G., Linear Albebra, WileyIndia, 1stEdition ,2017

REFERENCES:

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications Private Limited, 10th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India, 10th Edition, 2017.
3. Kenneth B. Howell, Ordinary Differential Equations, CRC Press, 2020.
4. James Strewart, Daniel Clegg, Saleem Watson, Essential Calculus Early Trancendentals, Cengage Learning, 9th Edition, 2021.
5. Nanda Kumar A.K, P.S.Datti: Raju.K. George, Ordinary Differential Equations, Cambridge University press, 2017.

L: 45; T: 15; TOTAL: 60 PERIODS

23SH13C	**INTRODUCTION TO ENGINEERING**	**L**	**T**	**P**	**E**	**C**
	(Common to all B.E. / B.Tech. Degree Programmes)	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Articulate the importance of Engineering and its role in society through OBE framework
CO2: Identify and describe academic pathways towards career settlement

CO1: Articulate the importance of Engineering and its role in society through OBE framework **L:9**

Engineering – An introduction, Classification of different Engineering Disciplines, Role of Engineers in Society. Graduate Attributes (GA), Program Specific Criteria (PSC)- Program Educational Objectives (PEO), Program Outcomes (PO), Course Outcomes (CO), Choice Based Credit System (CBCS), course categories, teaching and learning process, active and passive learning, project / problem based learning, different assessments process.

CO2: Identify and describe academic pathways towards career settlement **L:6**

Curriculum, cafeteria curriculum and self learning big picture of the Program and the significance of each course in the undergraduate Engineering Program, Discuss the different career paths for an engineering graduate. Career objective, competency requirement.

Case study: Each student has to interact with alumni mentors/seniors/faculty members/surf the internet and present a career path that inspires him/her at the end of the course

REFERENCES:

1. Quamrul H. MazumderIntroduction to Engineering, An Assessment and Problem Solving Approach, CRC Press, 1st Edition, 2016.
2. Saeed Moaveni, "Engineering Fundamentals an Introduction to Engineering", Cengage Learning, USA, 4th Edition, 2011.

L: 15; TOTAL: 15 PERIODS

23GN01C	**APTITUDE ESSENTIALS**	**L**	**T**	**P**	**E**	**C**
	(Common to all B.E. / B.Tech. Degree Programmes)	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES:

Upon the completion of the course the students will be able to

CO1: Recall the fundamentals in quantitative techniques and solve Number series problems quickly
CO2: Develop problem solving skills on Numbers and enhance arithmetic ability
CO3: Infer appropriate comparison and distribution methods using ratio and to form equations
CO4: Improve quantitative skills and solve problems on percentages and profit loss
CO5: Calculate data interpretation and data sufficiency in quantitative aptitude

CO1: Recall the fundamentals in quantitative techniques and solve Number series problems quickly **L : 3**

Numeric series – Finding missing numbers – Odd number out series - Letter series – Symbol series - Alphanumeric series

CO2: Develop problem solving skills on Numbers and enhance arithmetic ability **L : 3**

Number Types - HCF & LCM – Square root- Cubic root - divisibility criteria- Unit digit calculation- Prime factors

CO3: Infer appropriate comparison and distribution methods using ratio and to form equations **L : 3**

Ratio & Proportion: Comparison of Ratios - Variations: Direct and indirect proportionAges: Present Age, Past Age & Future calculation

CO4: Improve quantitative skills and solve problems on percentage and profit loss **L : 3**

Concept of Percentage – Percentage calculation - Calculation of Percentage on Population Results on Depreciation. Profit and Loss –Percentage of Profit and Loss – Discount

CO5: Calculate data interpretation and data sufficiency in quantitative aptitude **L : 3**

Data Interpretation – Pie Chart – Bar Chart – Table Chart. Data Sufficiency in Logical Reasoning: Numbers, Ratio, Ages, Percentage and Profit Loss

REFERENCES:

1. Dr.R.Aggarwal, "Quantitative Aptitude", S Chand Publishing, Revised Edition 2017
2. R.V.Praveen, "Quantitative Aptitude and Reasoning", 3rd Edition, Eastern Economy Edition, PHI Learning 2016.

Video Materials

Profit Loss

https://youtu.be/PpVO7I8dx6U

https://youtu.be/_cW7_BUDYcw

Number series

https://youtu.be/_4ZJFkFE2XU

https://youtu.be/83nJmniFmNk

Numbers

https://youtu.be/81pwuMJ8OIU

https://youtu.be/VT_N9cacgl4

Square root and Cube root

https://youtu.be/nJSqsaT0AgU

https://youtu.be/_HyhwS8P9KY

Problems on Ages

https://youtu.be/6PCTRVmu-ek

https://youtu.be/eAl3BvO_Ipw

Data Interpretation

https://youtu.be/s99rda8e0vc

L: 15; TOTAL: 15 PERIODS

23SH14C	TECHNICAL ENGLISH	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	1	0	2	0	2

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Apply the fundamental grammar rules in writing

CO2: Utilizing phonetic transcription for pronunciation

Practical Component

CO3: Apply the basic language skills in various aspects of communication

CO4: Utilize technical terms and phrases in specific contexts

CO5: Develop the pronunciation skill through various language components

CO6: Distinguish different writing forms and interpret text through divergent thinking

CO7:Develop effective reports with grammatical and language components

Soft skill Component

CO8: Develop communication, team spirit, creativity and time management

CO1: Apply the fundamental grammar rules in writing **L:13; P:26**

Parts of Speech - Word Formation using Prefix and Suffix - Sentence formation (Kinds of Sentences) - Tenses (Present, Past & Future tense) – Concord

CO3: Apply the basic language skills in various aspects of communication

Diary Writing - Greeting and Self Introduction

CO4: Utilize technical terms and phrases in specific contexts

Technical terms and extended definition - Essay Writing (Argumentative Essay and Analytical Essay) - Situational phrases & Conversation - Formal Letter Writing (Permission & Requisition letters)

CO6: Distinguish different writing forms and interpret text through divergent thinking

Picture Description, Introduction to Reading Techniques (Skimming, scanning, inferring, predicting, Reading and Reviewing a book (Sci – Fi), E Mail Writing

CO7:Develop effective reports with grammatical and language components
Listening and responding to general information (Business context) - Report Writing (Types, Structure, and Stages of report writing) - Checklist

CO2: Utilizing phonetic transcription for pronunciation **L:2;**

Phonetics (Vowels & Consonants) **P:4**

CO5: Develop the pronunciation skill through various language components

Word Transformation from one form to another - Letter Writing (Informal) - Listening and responding to general information (General context)

TEXT BOOKS:

1. Paul V. Anderson, Technical Communication: A Reader - Centered Approach, Cengage Learning, 9th Edition, 2017.
2. RavindraNath Tiwari, Technical English-II, Shashwat Publication, 1st Edition, 2020.
3. Stephen D. Krashen, Principles and Practice in Second LanguageAcquisition. Pergamon, 1987.
4. Lester Kaufman and Jane Straus, The Blue Book of Grammar and Punctuation: An Easy-to Use Guide with Clear Rules, Real-World Examples, and Reproducible Quizzes, Wiley, 2021.
5. Wells H. G., The Time Machine, Penguin Classics, 2012.

REFERENCES:

1. Michael McCarthy, English Grammar: The Basics, Taylor & Francis, 2021.
2. Peter Lucantoni and LydiaKellas, Cambridge IGCSE(TM) English as a Second Language Workbook, Cambridge University Press, 6th Edition, 2022.

L: 15; P: 30; TOTAL: 45 PERIODS

23SH15C	ENGINEERING PHYSICS	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	2	0	2	0	3

COURSE OUTCOMES:

Upon the successful completion of the course, the student will be able to

Theory Components:

CO1: Identify the structural properties of crystalline materials
CO2: Comprehend and apply the concepts of centre of mass and elasticity
CO3: Explain thermodynamic parameters and fundamental laws and their application in various processes
CO4: Illustrate the applications of different lasers and optical fibers
CO5: Interpret the quantum concepts, to illustrate the quantization of energy, and computation

Practical Components:

CO6: Compare the mechanical properties of the materials due to bending and torsion
CO7: Analyze thermal conductivity of different bad conducting materials
CO8: Explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect

Soft skill Component:

CO9: Develop the team spirit and communication skill through group activities

CO1: Identify the structural properties of crystalline materials **L:10**

Crystalline and amorphous materials - unit cell - primitive cell - crystal systems, Bravais lattices - Miller indices – interplanar distance – Characteristics of SC, BCC, FCC, HCP structures - Bragg's law - X-ray diffraction and its applications - Synthesis of crystalline materials

CO2: Comprehend and apply the concepts of centre of mass and elasticity **L:6;P:10**

CO6: Compare the mechanical properties of the materials due to bendingand torsion

Multi-particle dynamics - Introduction - Center of mass (CM) – CM of continuous bodies - Introduction to rigid bodies - translation - rotation – moment of inertia – theorems of moment of inertia – Torsional pendulum.

Elasticity – Stress - strain diagram and its applications - Moduli of elasticity and its relation - bending of beams - Bending moment – cantilever - theory and experiment - Uniform bending - theory and experiment – Non Uniformbending - I-shaped girders

CO3: Explain thermodynamic parameters and fundamental laws and themapplication in various processes **L:6;P:8**

CO7: Analyse thermal conductivity of different bad conducting materials.

Laws of thermodynamics –Thermo dynamical processes – Introduction to heat transfer – conduction - convection and radiation – thermal conductivity of good conductor –Radial flow of heat - Spherical shell method and cylindrical shell method – Thermal conductivity of poor conductor - Lee's disc method– Applications - heat exchangers - refrigerators and ovens

CO4: Illustrate the applications of different lasers and optical fibers **L:6;P:6**

CO8: Explore the light-matter interaction by the phenomenonofInterference and diffraction and photoelectric effect

Lasers: Interaction of light with matter - Einstein coefficients and their relations – characteristics of laser - components of laser – Lasing action – Pumping methods – Types of Laser - Nd-YAG laser -semiconductor laser- Applications.

Fiber optics: principle and classification of optical fibers – propagation of light in optical fiber - Numerical aperture and Acceptance angle – losses associated with optical fibers (Qualitative) – Fiber optic communication system - Applications - Displacement and pressure sensors – Endoscopy.

CO5: Interpret the quantum concepts, to illustrate the quantization of energy, and computation **L:6;P:2**

CO8: Explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect

Planck's radiation law - de-Broglie hypothesis – Matter waves - Heisenberg's uncertainty principle – elementary proof – applications – Schrödinger's time-dependent and time-independent wave equation – physical significance of wave function – Introduction to quantum tunneling - applications - particle in a one-dimensional box – tunneling microscope – quantum confinement in 0D, 1D, 2D systems - quantum computation

TEXT BOOKS:

1. AvadhanuluM. N., KshirsagarP.G and Arun MurthyT.V.S, A Text book of Engineering Physics, S.Chand& Co, 11th Edition, 2018.
2. Kleppner D and Kolenkow R. An Introduction to Mechanics. McGraw Hill Education (Indian Edition), 2017.
3. Kenneth S Krane, Modern Physics, Wiley, 4th Edition, 2021.

REFERENCES:

1. WolfsonR., Essential University Physics, Volume 1 & 2, Pearson Education, 2ndIndian Edition, 2009.
2. Hitendra K. Malik, A.K. Singh, Engineering Physics, McGraw Hill Education, 2nd Edition, 2017.
3. Kyungwon An, Fundamentals of Laser Physics, World Scientific Publishing Company, 2023
4. HallidayD, Resnick RandWalker J, Principles of Physics, Wiley, 12th Edition, 2021.

L: 30; P: 30; TOTAL: 60 PERIODS

23SH16C	ENGINEERING CHEMISTRY	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	2	0	2	0	3

COURSE OUTCOMES:

Upon the successful completion of the course, the student will be able to

Theory Component:

CO1: Explain the suitable water treatment technologies for domestic and industrial applications

CO2: Apply the knowledge of corrosion to solve the industrial problems

CO3: Describe the preparation, properties and their applications of smart materials in various sectors

CO4: Describe the basic components and performance analysis of batteries

CO5: Predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques

Practical Component:

CO6: Estimate the amount of Ca^{2+}/ Mg^{2+}, alkalinity and Chloride ion present in the water sample.

CO7: Quantify the amount of acid and metal ion in the given samples by different analytical techniques

Soft skill Component:

CO8: Develop interpersonal, work ethics and communications skills for career settlement

CO1: Explain the suitable water treatment technologies for domestic and industrial applications **L:6; P:12**

CO6: Estimate the amount of Ca^{2+}/ Mg^{2+}, alkalinity and Chloride ion present in the water sample.

Introduction, sources and impurities in water, potable water specifications (as per WHO and BIS) - hardness-types-estimation of $Ca^{2+}$and Mg^{2+} ion in water by EDTA method. Alkalinity-types-determination of alkalinity of water -chronic daily intake - incremental life time risk - hazard quotient, hazard index, contamination factor - determination of chloride ion in water using Argentometric method-municipal water treatment- physical methods and chemical methods. Disinfection-internal conditioning - calgon and carbonate conditioning. Desalination-types-Reverse Osmosis (RO) process- Forward osmosis (FO) - electro dialysis

- demineralization.

CO2: Apply the knowledge of corrosion to solve the industrial problems. **L:6;**

CO7: Quantify the amount of acid and metal ion in the given samples by different analytical techniques **P:6**

Corrosion – mechanism of dry and wet corrosion-forms of corrosion– galvanic corrosion and differential aeration corrosion, crevice corrosion, pitting corrosion, microbial corrosion-stress corrosion, intergranular corrosion - determination of rate of corrosion by weight loss method.

Protection: cathodic protection, surface coatings, corrosion inhibitors. Corrosion of industrial components: corrosion and its control in power industries, automotive industries, chemical processing industries and marine industries.

CO3: Describe the preparation, properties and their applications of smart materials in various sectors **L:6**

Polymers: introduction - classification - functional polymers: electroluminescence polymer, biodegradable polymers, fire retardant polymer, thermo responsive polymer - piezo, ferro and pyroelectric polymer - nanocomposites: introduction, synthesis, properties & applications- synthesis of nanocomposites using sol -gel process

CO4: Describe the basic components and performance analysis of batteries **L:6**

Introduction - components - operation principle - Lead acid – Nickel metal hydride batteries- Lithium ions batteries: Lithium polymer battery, Lithium sulphur battery - fabrication and performance evaluation- safety issues - battery management system - recycling of lithium batteries.

CO5: Predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques **L:6; P:12**

CO7: Quantify the amount of acid and metal ion in the given samples by different analytical techniques.

Spectroscopy methods: Beer-Lambert's law and its limitations– UV-visible spectroscopy and IR spectroscopy – principle - instrumentation– applications. Estimation of copper. Electro analytical methods: potentiometric titration - Estimation of Fe^{2+} ion by potentiotometric method. Conductometric method- estimation of HCl by conductometric titration- pH metric method-Estimation of HCl by pH metric titration- applications. Thermal analytical methods: Thermal Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA)- Thermo Mechanical Analysis (TMA) –principle - instrumentation - Thermo gravimetric analysis of $CuSO_4.5H_2O$- applications.

TEXT BOOKS:

1. Jain P.C. and Jain M, Engineering Chemistry, DhanpatRai Publishing Company, New Delhi, 17th Edition, 2021.
2. Dara S.S and UmareS.S, A Text Book of Engineering Chemistry, S.Chand& Company Limited, 20th Edition, 2018.
3. Agarwal S, Engineering Chemistry, Cambridge Publishing Company, 2ndEdition, 2019

REFERENCES:

1. Benjamin M. M, Water Chemistry, Waveland Press, 2nd Edition, 2019.
2. Cicek V, Corrosion Engineering, Springer Publishing, 1st Edition, 2021.
3. Shahinpoor. M, Fundamentals of Smart Materials, Publisher: Royal Society of Chemistry, 1st Edition, 2020.
4. Berg H, Bernhardsson S, and Johansson P, Electric Vehicle Batteries: Moving from Research towards Innovation, Publisher: Springer, 1st Edition, 2019.

5. Crouch S, Skoog D, Holler F, Principles of Instrumental Analysis, 2017.

L: 30; P: 30; TOTAL: 60 PERIODS

23CS11C	PROBLEM SOLVING TECHNIQUES	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	3	0	2	0	4

COURSE OUTCOMES:

Upon the successful completion of the course, the student will be able to

Theory Component:

CO1: Apply fundamentals of problem-solving techniques to develop simple algorithms for arithmetic and logical problems

CO2: Apply fundamental, sequential, conditional logic statements and arrays for solving basic problems

CO3: Implement modular programming concept using user defined functions

CO4: Inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions

CO5: Develop file processing application programs

Practical Component:

CO6: develop programs for simple algorithms using sequential and Control structures

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.

CO8: develop application programs using structures and files concept.

CO1: Apply fundamentals of problemsolving techniques to develop simple algorithms for arithmetic and logical problems **L:6**

Overview of programming: Problem Solving in Everyday Life, Types of Problem, Computer-based problem solving, Algorithms - Building blocks of algorithms (statements, control flow, functions) - Notation (pseudo code, flow chart) – Problem solving aspect – Top down design – Implementation of algorithms – Program Verification – Efficiency of algorithms – Analysis of algorithm.

CO2: Apply fundamental, sequential, conditional logic statements and arrays for solving basic problems **L:12; P:10**

Data Types - Constants – Variables - Keywords – Operators– Problem Solving using fundamental algorithms. Control Statements: Branching and Looping - Algorithms Using Selection and Repetition - Summation of a set of numbers, Reversing Digits of an Integer - Implementation of fundamental algorithms and factoring methods - Array Techniques - Array order reversal, Array Counting, Finding maximum and the minimum value in a set

CO6: Develop programs for simple algorithms using sequential and Control structures

Solve problems using control statements (Decision making and Looping)

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Problem solving based on Array Handling(1D and 2D, Multi-dimensional arrays, traversal, rotation) - Solve problems to handle strings

CO3: Implement modular programming concept using user defined functions **L:10;**

Modular Programming approach: Modularization and recursion - Bubble Sort, Selection Sort, Linear Search, Binary Search, Implementation of sorting and searching **P:8**

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Solve problems by using modular approach (Functions and Recursion)

CO4: Inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions **L:12; P:10**

Pointer Concept – add numbers using call by reference – finding maximum number from list of numbers - permutations of a given string using pointers – Implementation of function returns a pointer;

Structures &Union - finding the largest element of an array using Dynamic Memory Allocation – Implementation of Student database in structure using Dynamic Memory Allocation;

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Build efficient solutions to manage memory efficiently through Pointers.

CO8: Develop application programs using structures and files concept.

Develop applications using Structures

CO5: Develop file processing application programs **L:5;**

File Handling: Files - Introduction, Types of file processing: Sequential access, Random access – Implementation of word count, copy file, Voter's age validation, Marks range validation **P:2**

CO8: Develop application programs using structures and files concept.

Develop applications using Files

TEXT BOOKS:

1. Maureen Sprankle and Jim Hubbard, Problem Solving and Programming Concepts, Prentice Hall, 9th Edition, 2012.
2. R.G Dromey, How to solve it by Compute, Pearson education, Delhi, 2nd Edition, 2021.

REFERENCES:

1. Behrouz A. Forouzan, Richard F.Gilberg, P.GoldaJeyasheeli, G.Priyanka, S.T.Veena , Problem solving Using C A Structured Programming Approach, Volume I & II, 1st Edition, Cengage Publication, 2022
2. Karl Beecher, Computational Thinking: A Beginner's Guide to Problem Solving and Programming, BCS Learning & Development Limited, 1st Edition, 2017.
3. Byron S. Gottfried, Jitendar Kumar Chhabra, Programming with C, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2018.
4. Kernighan B.W., Ritchie D.M., C Programming Language (ANSI C), Prentice Hall of India Private Limited., New Delhi, 2nd Edition, 2010.
5. PradipDey and Manas Ghosh, Programming in C, Oxford University Press, New Delhi, 2018.
6. Yashavant P. Kanetkar, Let Us C, BPB Publications,16th Edition, 2020
7. H. M.Deitel, P. J. Deitel, C How to Program, Pearson Education., New Delhi, 7th Edition, 2016.

L: 45; P: 30; TOTAL: 75 PERIODS

23ME11C	ENGINEERING GRAPHICS	L	T	P	E	C
	(Common to MECH, CIVIL, AIDS, EEE, IT)	**2**	**0**	**4**	**0**	**4**

COURSE OUTCOMES:

Upon the successful completion of the course, the student will be able to

CO1: Construct the Engineering Curves and Perform Freehand Sketching.

CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina

CO3: Draw the Projections of Simple Solids in Different Positions.

CO4: Visualize the Sectional Views and Surface of Various Solids.

CO5: Draw the Isometric and Perspective Projections of Various Solids.

CO1: Construct the Engineering Curves and Perform Freehand Sketching. **L:6; P:12**

Principles of Engineering Graphics – significance. Usage of Drawing Instruments. Lettering and dimensioning exercise Construction of ellipse, parabola and hyperbola using eccentricity method– Construction of cycloids, Epi and Hypo-cycloids. Orthographic views of simple components by Free hand drawing - Transferring measurement from the given object to the free hand sketches.

CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina **L:6; P:12**

Principle of orthographic projections – Conventions - First angle and third angle projections. Projections of points placed in all quadrants – projections of straight lines – inclined to both reference planes - determination of true length and inclinations. Projections of regular polygonal surfaces and circular lamina inclined to both reference planes.

CO3: Draw the Projections of Simple Solids in Different Positions. **L:6; P:12**

Projections of simple solids like prisms, pyramids, cylinder and cone - axis inclined to one reference plane - change of position method.

CO4: Visualize the Sectional Views and Surface of Various Solids. **L:6; P:12**

Sectioning of simple solids – Axis perpendicular to horizontal plane- Drawing sectional views with true shape of the section. Development of lateral surfaces of truncated solids – Prisms, pyramids, cylinder and cone.

CO5: Draw the Isometric and Perspective Projections of Various Solids. **L:6; P:12**

Principles of isometric projection – Isometric scale – Isometric projections of simple solids like prism, pyramid, cone and cylinder – Combination of solids. Perspective projections of simple solids by visual-ray method

TEXT BOOKS:

1. Bhatt N.D, “Engineering Drawing”, 54th Edition, Charotar Publishing House, 2023.
2. Shah M.B and Rana B.C, “Engineering Drawing”, Pearson Education, 2nd Edition, 2009.

REFERENCES:

1. Natrajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2009.
2. Agrawal B. & Agrawal C.M., “Engineering Graphics”, TMH Publication,2nd Edition, 2013
3. Narayana K.L. &Kannaiah P, “Text book on Engineering Drawing”, Scitech Publishers, 2011.
4. Gopalakrishna K.R, “Engineering Drawing”, Subhas Publications, 32nd Edition, 2017.

L: 30; P: 60; TOTAL: 90 PERIODS

23SH21C	**தமிழரும் தொழில்நுட்பமும் (TAMILS AND TECHNOLOGY)**	**L**	**T**	**P**	**E**	**C**
		1	**0**	**0**	**0**	**1**

(Common to all B.E. / B.Tech. Degree Programmes)

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: தமிழர்களின் நெசவு மற்றும் பானைத் தொழில் நுட்பம், வடிவமைப்பு மற்றும் தொழில்நுட்பம், உற்பத்தித் தொழில்நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன்.

CO2:தமிழர்களின் வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில்நுட்பம்,அறிவியல் தமிழ் மற்றும் கணினித் தொழில்நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன்.

Upon the successful completion of the course, the student will be able to

CO1: Know and explain about Tamils weaving and Pottery technology, Design and construction Technology and Manufacturing Technology.

CO2: Know and explain about Tamils Agriculture and irrigation technology, Scientific Tamil and Tamil computing

CO1:தமிழர்களின் நெசவு மற்றும் பானைத் தொழில்நுட்பம் , வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம் மற்றும் உற்பத்தித் தொழில்நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:9**

சங்ககாலத்தில் நெசவுத்தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிகப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்- சங்ககாலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்ககாலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு–சங்ககாலத்தில் கட்டுமானபொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும் கோவில்களும் – மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாடு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக்கலை- கப்பல் கட்டும்கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்குமணிகள் – எலும்புத் துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

.

CO1: Know and explain about weaving and ceramic technology, design and construction technology, manufacturing technology

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW)– Graffiti on Potteries- Designing and Structural construction House & Designs in household materials duringSangam Age - Building materials and Hero stones of Sangam age — Details of Stage Constructions in Silappathikaram- Sculptures and Temples of Mamallapuram- Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- ThirumalaiNayakarMahal - Chetti Nadu Houses, Indo –Saracenic architecture at Madras during British Period- Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting, steel -Copper and gold Coins as source of history - Minting of Coins — Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences – Gemstone types described in Silappathikaram.

CO2: தமிழர்களின் வேளாண்மை, நீர்ப்பாசனத் தொழில்நுட்பம், அறிவியல் தமிழ் மற்றும் கணினித் தமிழ் பற்றிய அறிவு மற்றும் விளக்கும் திறன். L:6

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக்கு முழித்தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்- அறிவியல் தமிழின் வளர்ச்சி – கணினித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ்மென் பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின்நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

CO2: Know And Explain About Agriculture Technology, Irrigation Technology, Scientific Tamil & Tamil Computing

Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing – Knowledge of Sea - Fisheries — Pearl - Conche diving - Ancient Knowledge of Ocean – Knowledge Specific Society- Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books –Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries– Sorkuvai Project.

REFERENCE BOOKS:

1. தமிழகவரலாறு–மக்களும் பண்பாடும் - கே. கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம் (விகடன் பிரசுரம்)
3. கீழடி–வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை–ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils(Dr.K.K.Pillay)A joint publication of TNTB & ESC and RMRL
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi-Sangam City Civilization on the banks of river Vaigai (JointlyPublishedby:Department of Archaeology &Tamil Nadu, Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to TamilNadu (Dr.K.K.Pillay) (Published by: The Author)

L: 15; TOTAL: 15 PERIODS

23GN05C	**PROFESSIONAL ETHICS AND HUMAN VALUES**	**L**	**T**	**P**	**E**	**C**
	(Common to all B.E. / B.Tech. Degree Programmes)	**2**	**0**	**0**	**0**	**2**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Recognize and practice the core human values and theories related to ethical behavior.

CO2: Analyze the engineering ethical breach from past study.

CO3: Distinguish and apply safety, responsibility and rights in workplaces.

CO1: Recognize and practice the core human values and theories related to ethical behavior **L: 10**

Moral dilemmas and moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and controversy –Case studies: Vigil mechanism, Whistle blowing - Protected disclosures - Personal ethics, work ethics and human values - Governing Regulation.

CO2: Analyze the engineering ethical breach from past study **L: 10**

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law - Case study: The challenger disaster

CO3: Distinguish and apply safety, responsibility and rights in workplaces **L: 10**

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - Collegiality and loyalty - respect for authority – confidentiality; Collective bargaining, Conflicts of interest - Case study; Occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination. Case studies: The Three-mile Island and Chernobyl disaster

TEXT BOOK

1. Mike W Martin and Roland Schinzinger, "Ethics in Engineering", McGraw Hill, New York,5th Edition, 2022

REFERENCES

1. BehnamTaebi, "Ethics and Engineering: An Introduction", Cambridge University Press, 2021
2. AjeshFaizal, Aswathy S U, Roy V I, "Professional Ethics in Engineering: an Industry Perspective", Noor Publishing, 2021
3. R.S.Naagarazan, "A Textbook on Professional Ethics and Human Values", New age International Pvt. Ltd; 3rdEdition, 2022
4. Dr.P.Elamurugan, "Professional Ethics in Engineering", Notion Press, 2021

L:30; TOTAL:30 PERIODS

23ME21C	**FOURIER SERIES, COMPLEX ANALYSIS AND CALCULUS**	**L**	**T**	**P**	**E**	**C**
		3	**1**	**0**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Perform Fourier series expansion of the functions.
CO2: Calculate the Fourier series solution of Wave and Heat equation.
CO3: Interpret analytic function in transformations.
CO4: Evaluate complex integration over contour.
CO5: Analyze the concepts related to vector field.

CO 1: Perform Fourier series expansion of functions

Dirichlet's conditions – General Fourier series – Half range series – Complex form of Fourier series – Parseval's identity – Harmonic analysis – Identification of frequencies. **L:9; T:3**

CO2: Calculate Fourier series solution of Wave and Heat equation

Fundamentals of Fourier series - Half range Fourier series - Classification of Partial Differential Equations - Fourier series solutions of one dimensional wave equation - One dimensional heat equation - Steady state solution of two dimensional heat equation (Insulated edges excluded). **L:9; T:3**

CO3: Interpret analytic function in transformations

Analytic functions - Necessary and Sufficient conditions (excluding proofs) - Harmonic and orthogonal properties of analytic functions - Harmonic conjugate - Construction of analytic functions- fluid flow problems-Conformal mapping: w= z+c, cz, 1/z and bilinear transformation. **L:9; T:3**

CO4: Evaluate complex integration over contour

Statement and applications of Cauchy's integral theorem and Cauchy's integral formula (excluding proofs) – Taylor's and Laurent's expansions - Singular points - Residues- Residue theorem (excluding proof) - Application of residue theorem to evaluate real integrals - Unit circle and semi - circular contour (excluding poles on boundaries). **L:9; T:3**

CO5: Analyze the concepts of calculus in vector fields

Differentiation of vectors: Gradient, Divergence, Curl and Directional derivatives – Line, Surface and Volume Integrals - Statement of Green's, Gauss divergence and Stokes' theorem - Simple applications involving rectangular parallelepiped and cubes. **L:9; T:3**

TEXT BOOKS:

1. Grewal.B.S., Higher Engineering Mathematics, 44th Edition, Khanna Publications, Delhi, 2021.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

REFERENCE BOOKS:

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, 10th Edition,Laxmi Publications Private Limited, 2016.
2. Jain.R.K. and Iyengar.S.R.K., Advanced Engineering Mathematics, 5thEdition, Narosa Publishing House Private Limited, 2016
3. Ramana B.V, Higher Engineering Mathematics, Tata Mc-Graw Hill Publishing Company, New Delhi, 2017.
4. Michael D.Greenberg, Advanced Engineering Mathematics, 2ndEdition, Pearson Education, 2021.

L: 45; T: 15; TOTAL: 60 PERIODS

23ME22C	**MATERIALS SCIENCE**	**L**	**T**	**P**	**E**	**C**
		2	**0**	**0**	**0**	**2**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Describe the preparation, properties, and applications of glass, ceramics and nanomaterials.
CO2: Qualitatively analyze different materials based on their magnetic properties and explain the applications of magnetic materials in various sectors.
CO3: Interpret the properties of the various solar materials and their role in the energy production.

CO1: Describe the preparation, properties, and applications of glass, ceramics and nanomaterials.

Glass: Introduction - classifications - manufacturing process – commercial and Industrial applications. Glass durability: controlling factors, Improvement of durability, durability measurements, and mechanism of reactions of solutions with glass surfaces. Effect of temperature and composition on the physical properties. Colours in glasses: role of transition metal ions in glass manufacturing - application of redox reactions. Decolorization and refining of glasses, methods of testing of glass quality. **L:18**

Engineering Ceramics: Introduction - Classification – Preparation, properties and applications of Boron carbide, Silicon carbide, Nitrides: Boron, Silicon and aluminium nitrides. Refractories: Introduction - types; acidic, basic and neutral refractories. properties, manufacturing process and applications.

Nanomaterials: Introduction - size dependence of properties –classification. Synthesis; laser ablation method and hydrothermal methods. Characterization techniques: Scanning and Transmission Electron Microscopy – Principle-Instrumentation (Block diagramme only).

CO2: Qualitatively analyze different materials based on their magnetic properties and explain the applications of magnetic materials in various sectors. **L:6**

Magnetic materials: Introduction - types - Soft, hard and Ferrite magnetic materials: properties, and applications. Applications of magnetic materials in spintronics, magnetic information storage, magneto resistance in thin film structures, sensors, and memory elements in computers.

CO3: Interpret the properties of the various solar materials and their role in the energy production. **L:6**

Solar collector materials – Glazing materials – Absorber materials - Insulation materials - Reflecting materials – Phase change materials. Photovoltaic materials: Direct and indirect band-gap materials. Solar grade silicon: Mono and multi crystalline silicon solar cells. CIGS – Dye sensitised solar cells-Pervoskite solar cells

REFERENCES:

1. William J Callister, Introduction to Materials Science and Engineering, John Wiley & Sons, Inc. 12th Edition, Reprint 2021.
2. Vijayamohanan K Pillai, Meera Parthasarathy, Functional Materials: A Chemist's Perspective,Universities Press, 2013.
3. Smith, Foundations for material science and engineering McGraw-Hill, 4th Edition, 2019.
4. Master, IES, Basics of material science & engineering, 7thEdition,Ies Master Publication, 2022.
5. David Kingery.W, Introduction to Ceramics, Wiley & Sons, 2013.
6. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, NewYork, Jui Sheng Hsieh, Solar Energy Engineering, PrenticeHall, 2017.
7. Barry Carter.C, Grant Norton. M., Ceramic Materials: Science and Engineering, Springer Verlag New York Inc., 5th Edition 2021.

L: 30; TOTAL: 30 PERIODS

23ME23C	**ENGINEERING MECHANICS**	**L**	**T**	**P**	**E**	**C**
		3	**1**	**0**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Apply laws of mechanics to analyze the system of forces acting on particles and rigid bodies.
CO2: Evaluate the reactions in supports and perform force analysis on structures.
CO3: Compute the centroid and moment of inertia of lamina.
CO4: Apply the concepts of dry friction and compute the frictional forces for bodies in contact
CO5: Apply the fundamental principles of kinematics and kinetics of particles

CO1 Apply laws of mechanics to analyze the system of forces acting on particles and rigid bodies. L:9; T:3

Particles: Forces on a particle, Laws of Mechanics - transmissibility, resultant of two forces and severalconcurrent forces - resolution of a force, equilibrium of a particle, free body diagram, force in space - equilibrium ofaparticlein space; Rigid Bodies:Moment of a force – Varignon's theorem – Force Couple System –Reduction of system of forces into one force and couple – Equilibrium of rigid bodies in 2D.

Experimentation – Solving of forces in equilibrium of particles using pulley-hanging mass setup

CO2 Evaluate the reactions in supports and perform force analysis on structures. L:9; T:3

Types of supports, Types of Loading and determination of reactions. Structures: Simple trusses: Assumptions and Analysis of Plane Truss - Method of joints, method of sections, joints underspecial loading conditions, Failure of Joints, Analysis of frames.

Demonstration – Estimation of support reactions using a simply supported beam setup

CO3 Compute the centroid and moment of inertia of lamina. L:9; T:3

Centroids of areas, composite areas, Pappus and Guldinus theorems - determination ofmoment of inertia of plane figures, Parallel and perpendicular axis theorem - radius of gyration - polar moment of inertia

Demonstration – Centre of gravity of composite lamina, Significance of area moment of inertia in deflection of simply supported beams

CO4 Apply the concepts of dry friction and compute the frictional forces for bodies in contact L:9; T:3

Role of frictional force – Types of friction – Limiting friction – coefficientof static and kinetic friction - angle of friction – Coulomb's law of friction – Angle of Repose – Cone of friction – Problems in ladder friction, belt friction and wedge friction.

Experimentation – Estimate the coefficient of static and kinetic friction for various surfaces

CO5 Apply the fundamental principles of kinematics and kinetics of particles L:9; T:3

Kinematics: Rectilinear Motion – Uniform and Variable acceleration – Motion of particle under gravity – Relative motion. Curvilinearmotion; Kinetics: Newton's Second Law of motion – D'Alembertz Principle, Work energy principle. Impulse-Momentum principle –Motion of singular body and connected bodies.

Demonstration – Kinetics of connected bodies using pulley-mass system

TEXT BOOKS

1. Hibbeler RC, "Engineering Mechanics: Statics & Dynamics", Pearson India EducationServices Private Limited, 14th Edition, 2018.
2. Irving H Shames and G.KrishnaMohana Rao, "Engineering Mechanics-Statics and Dynamics", Pearson Education, 4th Edition, 2016.
3. Timoshenko, DH Young, J V Rao, S Pati, "Engineering Mechanics", Mcgraw Hill Education Pvt. Ltd., 5th Edition, 2013.

REFERENCES

1. Beer FP, Mazurek DF, Sanghi S, Eisenberg ER, Johnston ER and Cornwell PJ, "Vector Mechanics for Engineers: Statics and Dynamics", Tata McGraw Hill EducationPrivate Limited, 12th Edition, 2019.
2. Meriam J.L and Kraig L.G, "Engineering Mechanics-Statics and Dynamics", John Wiley & sons, New York, 9th Edition, 2021.
3. N.H.Dubey, "Engineering Mechanics – Statics and Dynamics", Tata McGraw-HillPublishing Company, New Delhi, 2017.
4. Rajasekaran S and Sankarasubramanian G, "Fundamentals of EngineeringMechanics", Vikas Publishing House Private Limited, 3rd Edition, 2017.
5. Bansal RK, "A Textbook ofEngineering Mechanics", Laxmi Publications (P) Ltd., 8th Edition New Delhi, 2017.
6. Nelson A, "Engineering Mechanics-Statics and Dynamics", Tata McGraw-HillPublishing Company, New Delhi, 1st Edition 2019.

L:45; T:15; TOTAL:60 PERIODS

23SH22C	PROFESSIONAL ENGLISH	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	2	0	2	0	2

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Extend the primary language skills to develop critical thinking

CO2: Build the secondary language skillsfor professional competence

Practical Component

CO3: Apply the vital sub-functions of listening in particular context

CO4: Take part in propagating ideas through effective oral communication

CO5: Inferring information using various reading techniques

CO6: Construct professional content via distinct methods of writing

Soft skill Component

CO7: Develop interpersonal, communicational and behavioral attributes

CO1:Extend the primary language skills to develop critical thinking

CO3: Apply the vital sub-functions of listening in particular contextL:6,P:16

CO4: Take part in propagating ideas through effective oral communication

If Conditionals – Standard Abbreviations –Types of Listening (Comprehensive, Informational, Critical Listening) –One Word Substitution, Components of Speaking

Listening for Specific Information –Listening to Speech (Oxford Union Society) – Listening to Science Talks or Theories

Product Description – Chart Description – Process Description – Group Discussion (Uses – Structure – Strategies – Team Work – Positive & Negative Body Languages – Samples – Demo)

CO2: Build the secondary language skills for professional competence **L:5;**
CO5: Inferring information using various reading techniques **P:18**
CO6: Construct professional content via distinct methods of writing

Synonyms – Intensive and Extensive Reading –Error Spotting (Based on Concord, Pronoun, Articles & Adverb Placement)– Writing Style (Persuasive, Expository & Descriptive)

Newspaper Reading – Reading Comprehension (Fiction &NonFiction)

Business Letters for Quotations and Clarification, Placing Orders and Making Complaints – Proposal Writing – Job Application Letter & Resume Preparation – Paragraph Writing – Content Writing

TEXT BOOKS

1. Lucantoni,Peter& Lydia Kellas. "English as a Second Language Workbook", 6th Edition, Cambridge University Press, 2022.
2. Twain, Mark. "The Adventures of Tom Sawyer", 1st Edition, Pegasus, 2012.
3. Clear, James. "Atomic Habits", 1st Edition, Dreamliners, 2022.
4. Garcia, Hector &FrancescMiralles. Ikigai: The Japanese Secret to a long and Happy Life. 1stEdition, Tuttle Publishing, 2021.
5. Elbow, Peter, "Writing with Power", 2nd Edition, Oxford University Press, 1998.

REFERENCES

1. Butterfield, Jeff. "Soft Skills for Everyone", 2nd Edition, Cengage, 2020
2. Raman, Meenashi&Sangeetha Sharma. Professional English, 1st Edition, Oxford University Press, 2018

L: 11; P: 34; TOTAL: 45 PERIODS

23CS11C	PROBLEM SOLVING TECHNIQUES	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	3	0	2	0	4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theroy Component

CO1: Apply fundamentals of problemsolving techniques to develop simple algorithms for arithmetic and logical problems

CO2: Apply fundamental, sequential, conditional logic statements and arrays for solving basic problems

CO3: Implement modular programming concept using user defined functions

CO4: Inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions

CO5: Develop file processing application programs

Practical Component

CO6: Develop programs for simple algorithms using sequential and Control structures

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

CO8: Develop application programs using structures and files concept.

CO1: Apply fundamentals of problem solving techniques to develop simple algorithms for arithmetic and logical problems **L:6**

Overview of programming: Problem Solving in Everyday Life, Types of Problem, Computer-based problem solving, Algorithms - Building blocks of algorithms (statements, control flow, functions) - Notation (pseudo code, flow chart) – Problem solving aspect – Top down design – Implementation of algorithms – Program Verification – Efficiency of algorithms – Analysis of algorithm.

CO2: Apply fundamental, sequential, conditional logic statements and arrays for solving basic problems **L:12, P:10**

Data Types - Constants – Variables - Keywords – Operators– Problem Solving using fundamental algorithms. Control Statements: Branching and Looping - Algorithms Using Selection and Repetition - Summation of a set of numbers, Reversing Digits of an Integer - Implementation of fundamental algorithms and factoring methods - Array Techniques - Array order reversal, Array Counting, Finding maximum and the minimum value in a set

CO6: Develop programs for simple algorithms using sequential and Control structures

Solve problems using control statements (Decision making and Looping)

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Problem solving based on Array Handling(1D and 2D, Multi-dimensional arrays, traversal, rotation) - Solve problems to handle strings

CO3: Implement modular programming concept using user defined functions **L:10, P:8**

Modular Programming approach: Modularization and recursion - Bubble Sort, Selection Sort, Linear Search, Binary Search, Implementation of sorting and searching

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Solve problems by using modular approach (Functions and Recursion)

CO4: Inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions **L:12, P:10**

Pointer Concept – add numbers using call by reference – finding maximum number from list of numbers - permutations of a given string using pointers – Implementation of function returns a pointer;

Structures & Union - finding the largest element of an array using Dynamic Memory Allocation – Implementation of Student database in structure using Dynamic Memory Allocation;

CO7: Inscribe programs using arrays, functions and pointers to work with multiple data items.

Build efficient solutions to manage memory efficiently through Pointers.

CO8: Develop application programs using structures and files concept.

Develop applications using Structures

CO5: Develop file processing application programs **L:5, P:2**

File Handling: Files - Introduction, Types of file processing: Sequential access, Random access – Implementation of word count, copy file, Voter's age validation, Marks range validation

CO8: Develop application programs using structures and files concept.

Develop applications using Files

TEXT BOOKS:

1. Maureen Sprankle and Jim Hubbard, Problem Solving and Programming Concepts, Prentice Hall, 9th Edition, 2012.
2. R.G Dromey, How to solve it by Compute, Pearson education, Delhi, 2nd Edition, 2021.

REFERENCES:

1. Behrouz A. Forouzan, Richard F.Gilberg, P.GoldaJeyasheeli, G.Priyanka, S.T.Veena , Problem solving Using C A Structured Programming Approach, Volume I & II, 1st Edition, Cengage Publication, 2022
2. Karl Beecher, Computational Thinking: A Beginner's Guide to Problem Solving and Programming, BCS Learning & Development Limited, 1st Edition, 2017.
3. Byron S. Gottfried, Jitendar Kumar Chhabra, Programming with C, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2018.
4. Kernighan B.W., Ritchie D.M., C Programming Language (ANSI C), Prentice Hall of India Private Limited, New Delhi, 2nd Edition, 2010.
5. PradipDey and Manas Ghosh, Programming in C, Oxford University Press, New Delhi, 2018.
6. Yashavant P. Kanetkar, Let Us C, BPB Publications,16th Edition, 2020
7. H. M.Deitel, P. J. Deitel, C How to Program, Pearson Education., New Delhi, 7th Edition, 2016.

L: 45; P: 30; TOTAL: 75 PERIODS

23EE13C	FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	E	C
		3	0	2	0	4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Demonstrate the characteristic parameters of DC and AC circuits.

CO2: Explain the working of AC and DC machines.

CO3: Describe the analog and digital instruments for monitoring and control.

CO4: Demonstrate the operation of electronic and digital devices for applications.

CO5: Infer the purpose of wiring and safety.

Practical Component

CO6: Analyze basic electric circuits and characteristics of electrical machines.

CO7: Demonstrate the functionality of instruments and characteristics of electronics devices.

CO8: Perform residential wiring and measure earth resistance.

CO1: Demonstrate the characteristic parameters of DC and AC circuits. **L:9, P:6**

Sources - Passive Elements – Electrical Quantities: Voltage, Current, Power and Energy – DC circuits: Ohms Law – Kirchhoff's Laws – Mesh analysis - AC Circuits:

Waveforms, RMS, Peak, real power, reactive power and apparent power, power factor.

CO6: Analyze basic electric circuits and characteristics of electrical machines

1. Verification of Ohms Law and Kirchhoff law.
2. Measurement of AC signal parameter (Peak-Peak, RMS, Period and Frequency)

CO2: Explain the working of AC and DC machines. **L:9, P:8**

Construction, Types of DC motors – Working Principles – Need for Starters - AC Motors: Construction and Working of Single Phase and Three Phase Induction Motor– Servomotor -Stepper motor.

CO6: Analyze basic electric circuits and characteristics of electrical machines.

1. Analyse the characteristics of DC Shunt Motor and DC series motor
2. Load test on single phase and three phase induction motor

CO3: Describe the analog and digital instruments for monitoring and control. **L:9, P:2**

Analog instruments: Functional Elements, Principles: PMMC, MI, And Electrodynamometer wattmeter – Digital voltmeter – energy meter - multimeter – DSO –Multifunction meter.

CO7: Demonstrate the functionality of instruments and characteristics of electronics devices.

1. Calibration of single-phase energy meter using wattmeter

CO4: Demonstrate the operation of electronic and digital devices for applications. **L:9, P:6**

Characteristics and applications: Diode – Rectifiers, Zener Diode – Regulators, BJT - LEDs – Photo Diodes, Opto-Isolators- Binary Number System – Logic Gates: Basic gates, Universal gates – Boolean Algebra –ADC and DAC.

CO7: Demonstrate the functionality of instruments and characteristics of electronics devices.

1. Experimental Verification of PN Junction diode as rectifiers.
2. Experimental Verification of Zener Diode as Voltage Regulators.
3. Verify the truth table of logic gates.

CO5: Infer the purpose of wiring and safety. **L:9, P:8**

Diagrams & Symbols used in basic Electrical wiring -Electric shock -Protection: PPE, Switches, Plug and Socket, Fuse, MCB, ELCB, MCCB and Earthing- Wiring & installations- Inverters – UPS- Energy Consumptions –Electrical safety and standards– Schematic Electrical Layout for building.

CO8: Perform residential wiring and measure earth resistance.

1. Measurement of Earth Resistance using Electrical Equipment.
2. Residential house wiring, Staircase wiring and selection of fuse.

TEXT BOOKS:

1. D.P. Kothari and I J Nagrath, “Basic Electrical and Electronics Engineering”, Tata McGraw Hill, 4th Edition, 2019.
2. R.K.Rajput, “Basic Electrical and Electronics Engineering”, University Science Press, 2017.

REFERENCES:

1. Lionel Warnes, "Electrical and electronics engineering: Principles and practice, Palgrave Macmillan publication, 3rdEdition, 2003.
2. D.C. Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, Revision 1stEdition, 2011.
3. David Bell, "Electronic Devices and Circuits", Oxford university press, 5thEdition, 2008.
4. Mohamed A. El-Sharkawi, "Electric Safety Practice and Standards", Taylor & Francis, 2013.

L: 45; P: 30; TOTAL: 75 PERIODS

		L	T	P	E	C
23GN02C	**INNOVATION THROUGH DESIGN THINKING** (Common to all B.E. / B.Tech. Degree Programmes)	**0**	**0**	**0**	**4**	**2**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Experiential Component

CO1:Analyse the impact of design thinking process.

CO2: Practice design thinking process through real world problems.

Soft skill Component

CO3: Present survey conclusions on selected real-world problems.

CO1: Analyse the impact of design thinking process **E:30**

Design thinking process: history and phases -Ideation tools: brainstorming, mind mapping, scrambler method, six thinking hats -case studies.

CO2: Practice design thinking process through real world problems **E:30**

Real world problem selection-Practicing the preliminary stages of design thinking process - work presentation.

TEXT BOOKS

1. Falk Uebernickel, Li Jiang, Walter Brenner, Britta Pukall, Therese Naef, "Design Thinking: The Handbook", WS Professional, 2020
2. PavanSoni, "Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem solving", Penguin Random House, 2020

REFERENCES

1. Michael Lewrick, "The Design Thinking Playbook", Wiley, 2019
2. Kathryn Christopher, "Design Thinking in Engineering", Kendall Hunt Publishing Company,2019
3. Robert Curedale, "Design Thinking Process & Methods", Design Community College Inc, 5thEdition, 2019
4. David Lee, "Design Thinking in the Classroom", Ulysses Press, 2018
5. Jimmy Jain, "Design Thinking for Startups", Notion Press, 2018
6. Monika Hestad Silvia Rigoni Anders Grnli, "The Little Booklet on Design Thinking: AnIntroduction", Zaccheus Entertainment, 2ndEdition, 2017
7. Scott Swan, Michael G.Luchs and Abbie Griffin, "Design Thinking: New ProductDevelopment Essentials", Wiley-Blackwell, 2016

8. D.M. ArvindMallik, "Design Thinking for Educators", Notion Press, 2019

E:60; TOTAL:60 PERIODS

23GN04C	APTITUDE EXCELLENCE	L	T	P	E	C
		0	0	2	0	1

COURSE OUTCOMES

Upon the completion of the course the students will be able to

CO1: Infer appropriate methods to simplify computation

CO2: Develop problem solving skills on Time and Work and enhance arithmetic ability

CO3: Interpret fundamentals in quantitative techniques and solve problems quickly

CO4: Improve quantitative skills and solve problems on permutation and Combination

CO5: Acquire the knowledge of Cognitive ability and solve puzzles effectively

CO1: Infer appropriate methods to simplify computation

Simplification: Nested Series simplification(fraction) -BODMAS rule –Viraculum (or Bar) rule – Modulus of a real number –Multiplication shortcuts-Comparing Fractions-Data Sufficiency **P:6**

CO2: Develop problem solving skills on Time and Work and enhance arithmetic ability

Time and Work: Work Done - Days from Work: - Ratio – Efficiency –Work and wages - Data Sufficiency **P:6**

CO3: Interpret fundamentals in quantitative techniques and solve problems quickly

Time Speed Distance: Body moving in the same direction- Body moving in the opposite direction-Average speed- Meeting point- Data Sufficiency **P:6**

CO4: Improve quantitative skills and solve problems on permutation and Combination

Probability Permutation Combination: Fundamental Counting Principle – Computing Permutation – Circular Permutation – ComputingCombinations- Data Sufficiency **P:6**

CO5: Acquire the knowledge of Cognitive ability and solve puzzles effectively

Abstract reasoning: Mirror and water image – Figure Matrix –Pattern Completion – Logical puzzles –Dot situation - Ranking ordering.**Cognitive ability:** Blood Relation - Direction Sense Test-Data Sufficiency **P:6**

REFERENCE BOOKS

1. R.V.Praveen, "Quantitative Aptitude and Reasoning", 3rdEdition , Eastern Economy Edition, PHI Learning 2016
2. Arun Sharma," Quantitative Aptitude for CAT", McGraw Hill Edge, 10th Edition 2022
3. Dr.R.Aggarwal, "Quantitative Aptitude", S Chand Publishing, Revised Edition 2017

P:30; TOTAL: 30 PERIODS

23ME31C	ENGINEERING THERMODYNAMICS	L	T	P	E	C
		3	1	0	0	4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1:Apply concepts of energy conversion to analyze open and closed systems
CO2: Arrive benchmark performances of heat engines and refrigerator / heat pump and compute entropy changes
CO3:Apply exergy balance to evaluate the second law efficiency of closed systems and control volumes at steady state
CO4:Estimate properties of ideal gases, real gases and pure substances
CO5: Derive and use the various thermodynamic relation for different systems

CO1 Apply concepts of energy conversion to analyze open and closed systems **L:9, T:3**

Introduction - system and their behavior - Properties of the system - Thermodynamic Equilibrium - Zeroth law of thermodynamics - temperature scale - mechanical concept of energy - Heat and Work - Quasi static process - First law of Thermodynamics - Mass and Energy Analysis: Closed system and open system - Transient systems - Applications.

CO2 Arrive benchmark performances of heat engine, refrigerator and heat pump and compute entropy changes **L:9, T:3**

Introduction- Heat engine, heat pump and Refrigerator - Second Law of Thermodynamics - Carnot Cycle - Carnot theorem and its corollaries - Absolute Temperature scale - Irreversible and Reversible Processes - Clausius Inequality.

Entropy: Principle of increase of entropy - Tds relations - Entropy balance for closed systems - Entropy rate balance for control volumes at steady state.

CO3 Apply exergy balance to evaluate the second law efficiency of closed systems and control volumes at steady state **L:9, T:3**

Exergy of a system - Closed system exergy balance - Exergy rate balance for control volumes at steady state - First and second law efficiency - Case studies.

CO4 Estimate properties of ideal gases, real gases and pure substances **L:9, T:3**

Ideal gas equation of state – Compressibility factor – Vander Waals equation of state for real gases –Ideal Gas Mixtures–Properties of Ideal Gas mixture.

Pure Substances– phases of pure substances – property diagrams – Property tables – evaluation of properties of pure substance for different applications- Simple applications.

CO5 Derive and use the various thermodynamic relation for different systems **L:9, T:3**

Thermodynamics Relations - Gibbs and Helmholtz Functions, Maxwell Relations, specific heat ratio, Joule Kelvin effect, ClausiusClapeyron equation - Multi component system.

TEXT BOOKS

1. YunusA.Cengel, “Thermodynamics - An Engineering Approach”, McGraw Hill publications, 9th Edition, 2019.
2. Mahesh M Rathore, “Thermal Engineering”, McGraw Hill publications, 2010.

REFERENCES

1. Claus Borgnakke, Richard E. Sonntag, “Fundamentals of Thermodynamics”, John Wiley & Sons, 10th Edition, 2020
2. KalliatT.Valsaraj, “Principles of Environmental Thermodynamics and Kinetics”, CRC press, 4th Edition, 2020.

3. P.K.Nag, "Engineering Thermodynamics", McGraw-Hill publications, 6th Edition, 2017
4. R.K. Rajput, "Thermal Engineering", Laxmi Publications, 10th Edition, 2017
5. De Didier Fontaine, "Principles of classical Thermodynamics: Applied to Material Science", World Scientific Publications, 2022
6. Moran, Shapiro,Boettner, Bailey, "Principles of Engineering Thermodynamics", Wiley publications, 8th Edition, 2015.

L:45; T:15; TOTAL:60 PERIODS

23MC02C	ENVIRONMENTAL SCIENCE AND ENGINEERING	L	T	P	C
		2	0	0	--

COURSE OUTCOMES:

Upon the successful completion of the course, the student will be able to

CO1: Explain the structure and functions of an ecosystem and the importance of biodiversity.

CO2: Interpret the causes, effects of air and water pollution.

CO3: Comprehend the causes, impacts and management of e-waste and municipal waste.

CO4: Apply the knowledge of sustainability practices in the environment.

CO1: Explain the structure and functions of an ecosystem and the importance of biodiversity. **L:6**

Introduction to Environment**,** scope and importance of environment – need for public awareness. Eco-system: structure and function. Biodiversity: Introduction - types – values 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 - Biodiversity index calculation (Simpson and Shannon diversity Index, Sorenson coefficient)

CO2: Interpret the causes, effects of air and water pollution. **L:6**

Air pollution - Classification of air pollutants – sources – Effects - Measurements: dust monitor – gas analyzer, particle size analyzer. Water pollution – Classification – health hazards – sampling and analysis of water. Waste water treatment – different industrial effluents and their treatment – Measurement: BOD and COD – atomic absorption spectrometer. Case study (Okhla sewage water treatment plant)

CO3: Comprehend the causes, impacts and management of e-waste and municipal waste. **L:12**

Integrated Waste Management: Introduction – Generation and types of solid waste – Swachh Bharat Mission – Solid waste management: collection, transportation, segregation and processing – Disposal: landfill – biochemical processes and energy recovery - Municipal solid waste management rules 2016.

e-Waste Management: Introduction – Composition - Types – Generation – Environmental and health hazards of e-waste – Recycling - Recovery of metals: pyrometallurgical, hydrometallurgical, and biometallurgical process – e-waste management and handling rules 2016 – e-waste management companies in India.

CO4: Apply the knowledge of sustainability practices in the environment. L:6

Sustainability and Management**:** Introduction - concept, needs and challenges – economic and social aspects of sustainability – unsustainability to sustainability – millennium development goals and protocols – Sustainable Development Goals-targets, indicators and intervention areas – Climate change – Global, Regional and local environmental issues and possible solutions – case studies. Concept of Carbon Credit – Carbon Footprint – Environmental management in industry – A case study – Zero waste and R concept – Circular economy – ISO 14000 Series – Material Life cycle assessment.

L:30; TOTAL: 30 PERIODS

TEXT BOOKS:

1. Miller. G.T and Spoolman.S, 'Environmental Science', 16th Edition, Brooks/Cole Publishing Co., 2018.
2. Peavy. H.S, Rowe. D.R and Tchobanoglous. G, 'Environmental Engineering', 2nd Edition, McGraw Hill Education, 2020.
3. Benny Joseph, 'Environmental Engineering', Tata-Mc-Graw Hill, New Delhi, 2016.
4. Gilbert M.Masters, 'Introduction to Environmental Science and Engineering', 2nd Edition, Pearson Education, 2016.

REFERENCE BOOKS:

1. Kaushik. A and Kaushik. C.P, 'Environmental Science and Engineering', 6th Edition, New Age International Publishers, 2018.
2. Weller. K, 'Environmental Science and Biological Engineering', 1st Edition, WIT Press, 2015.

23ME32C	**STATISTICS AND NUMERICAL METHODS**	**L**	**T**	**P**	**E**	**C**
		3	**1**	**0**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Calculate the various measures of dispersion.

CO2: Apply the principles of hypothesis testing in small and large samples.

CO3: Analyze the variances in design of experiments.

CO4: Apply numerical techniques to solve algebraic equation and calculate derivatives andintegrals.

CO5: Compute numerical solution of differential equations.

CO1: Calculate the various measures of dispersion

Central tendencies - Mean, median, mode - Measures of Dispersion: Mean deviation, and Quartile Deviation - Carry out performance study on measures of central tendencies: Case Study through software– Moments–Skewness–Kurtosis-Correlation and Regression. **L:9, T:3**

CO2: Apply the principles of hypothesis testing in small and large samples L:9,

Sampling distributions - Estimation of parameters - Statistical hypothesis – Central limit **T:3**

theorem - Large sample tests based on Normal distribution for single mean and difference of means - Confidence interval for mean - Chi-square distribution- Contingency table for independent of attributes – Goodness of fit.

CO3: Analyze the variances in design of experiments

Tests based on t and F distributions for mean, variance and proportion - ANOVA - One way and two way classifications - Completely randomized design – Randomizedblock design – Latin square design – 2^2 factorial design. **L:9, T:3**

CO4: Apply numerical techniques to solve algebraic equation and calculate derivatives and integrals

Solution of Algebraic and transcendental linear equations - Newton - Raphson Method- Solution of simultaneous equations – Gauss Elimination method – Gauss Jacobi's method- Gauss Seidel method – Interpolation – Lagrange's Method - Numerical Differentiation – Newton's forward difference and backward difference formula – Numerical integration - Single integration using Trapezoidal and Simpson's 1/3 rd and 3/8 th rules. **L:9, T:3**

CO5: Compute numerical solution of differential equations

Taylor's Series Method – Euler's Method – RungeKutta fourth order Method – Predictor - corrector Methods – Milne's Method - Solution of one dimensional heat equation by explicit and implicit methods - Two dimensional Laplace and Poisson equations – Liebman's iteration Process.- Determine numerical solution of ordinary differential equations and partial differential equations: Activity through software. **L:9, T:3**

L: 45; T:15; TOTAL: 60 PERIODS

TEXT BOOKS:

1. Richard A. Johnson, Irwin Miller, John Freund, Miller & Freund's, Probability and Statistics for Engineers, 9thEdition, Pearson Education Limited, Global Edition, 2017.
2. Grewal, B.S., Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB, 10thEdition, Khanna Publishers, New Delhi, 2014.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdition, Wiley India, 2017.

REFERENCES:

1. R.E. Walpole, R.H. Myers, S.L. Myers, and K Ye, Probability and Statistics for Engineers and Scientists, Pearson Education, Asia, 9th Edition, 2016.
2. M.R.Spiegel, J.Schiller and R.A. Srinivasan, Schaum Outlines, Probability and Statistics, Tata McGraw Hill Edition, 2017.
3. Chapra, S.C and Canale, R.P. Numerical Methods for Engineers, 7th Edition, Tata McGraw Hill, New Delhi, 2016.

		L	T	P	E	C
23ME33C	**BASIC MANUFACTURING PROCESSES**	**3**	**0**	**2**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1:Select appropriate casting method for an industrial component and design the Gating and

riser systems

CO2:Identify the suitable metal joining process for an application

CO3: Select thesuitable metal forming process for making an industrial component and evaluate the load Requirement in forming processes

CO4:Analyze various polymer processing methods and identify suitable fabrication method for polymer product

CO5: Demonstrate the need and process of additive manufacturing

Practical Component

CO6: Demonstrate the green sand and stir casting process and prepare green sand mould for an industrial component

CO7: Practice arc welding for making simple weld joints

CO8: Prepare simple components using forging techniques and sheet metal Process

CO9:Generate prototype for the real time component using 3D printing

CO1 Select appropriate casting method for an industrial component and design the Gating and riser systems. **L:9**

CO6 Demonstrate the green sand casting and stir casting process and prepare green sand mould for an industrial component. **P:8**

Sand casting- Moulding sand: types, properties and testing methods- Patterns: materials and allowances – Core making process - Solidification in casting-Riser and gating design– Fettling and Finishing Process - *Preparation of green sand mould using solid and split pattern in Laboratory.*

Working principle of special casting processes – *Demonstration of the stir casting process in Laboratory* -Recent developments in casting– Casting defects.

CO2 Identify the suitable metal joining process for an application. **L:9**

CO7 Practice arc welding for making simple weld joints. **P:8**

Fusion and solid-state welding processes–*Practicing with TIG and Electric arc welding for making simple weld joints in laboratory* –Brazing, soldering and adhesive bonding processes–Recent developments in welding-*Demonstration of the Automatic Welding in Laboratory - Construction and working principle*–Weld defects.

CO3 Select the suitable metal forming process for making an industrial component and evaluate the load Requirement in forming processes. **L:9**

CO8 Prepare simple components using forging techniques and sheet metal Process. **P:8**

Hot working and cold working of metals – forging, rolling, drawing and extrusion processes- principles and applications- Sheet metal forming processes- principles and applications-Load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes - *Preparation of simple objects through hot forging and simple sheet metal parts in laboratory*-Recent developments in forming.

CO4 **Analyze various polymer processing methods and identify suitable fabrication method for polymer product** **L:9**

Types of plastics- plastic processing techniques: Blow moulding, Injection moulding (screw and plunger type machines), Rotational moulding, Transfer moulding and compression moulding- Recycling and Eco-friendly Processing-Recent developments and Industrial applications.

CO5 **Demonstrate the need and process of additive manufacturing** **L:9**

CO9 **Generate prototype for the real time component using 3D printing** **P:6**

Need and Development of additive manufacturing systems- Classification of additive manufacturing processes - Benefits – Applications - Generation of prototype for the given real time product using 3D printing in laboratory.

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. HajraChoudhury, "Elements of Workshop Technology, Vol.I Manufacturing Processes", Media Promotors Private Limited, Mumbai, 15th Reprint, 2016.
2. S.Gowri, P.Hariharan and A.SureshBabu, "Manufacturing Technology I", Pearson Education, 2017.

REFERENCES

1. Mikell P Groover, "Fundamentals of Modern Manufacturing", John Wiley & Sons, 7thEdition, 2019.
2. Rajput R.K, "A text book of Manufacturing Technology", Lakshmi Publications, 2016.
3. P.N.Rao, "Manufacturing Technology", 2ndEdition, Tata McGraw-Hill Publishing Limited, 2015.
4. P.C.Sharma, "A Text book of Production Technology", 11thEdition, S.Chand and Company, 2013.
5. Begman, "Manufacturing Process", 8thEdition, John Wiley & Sons, 2018.
6. Larry Jeffus, "Welding and Metal Fabrication", Cengage Learning, 2012.
7. SeropeKalpajian, Steven R.Schmid, "Manufacturing Engineering andTechnology", Pearson Education, Inc., 2ndIndian Reprint, 2018.

		L	T	P	E	C
23ME34C	**FLUID MECHANICS AND HYDRAULIC MACHINES**	**2**	**1**	**2**	**0**	**4**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Demonstrate the fundamental properties of fluids and applications of Bernoulli's Equation
CO2: Apply dimensional analysis techniques and dimensionless parameters in fluid Mechanics
CO3: Determine flow rates and head losses in laminar and turbulent flows
CO4: Apply principles of fluid mechanics to design and select hydraulics turbines
CO5: Apply principles of fluid mechanics to design and select pumps

Practical Component

CO6: Apply Bernoulli's equations to determine the flowrate using various flow measuring

devices

CO7: Determine frictional and minor head losses in flow through pipes

CO8: Evaluate the performance of different types of turbines

CO9: Evaluate the performance of different types of pumps

CO1 Demonstrate the fundamental properties of fluids and applications of Bernoulli's Equation **L:9**

CO6 Apply Bernoulli‘s equations to determine the flowrate using various flow measuring devices **P:12**

Units and dimensions- Properties of fluids- mass density, specific weight, specific volume, Specific gravity, viscosity, compressibility, vapor pressure, surface tension and capillarity. Flowcharacteristics – concept of control volume - application of continuity equation, energy equation and momentum equation – E*xperimental determination of Coefficient of Discharge (Cd) – Venturimeter – Orificemeter – Rotameter*

CO2 Apply dimensional analysis techniques and dimensionless parameters in fluid Mechanics **L:9**

Dimension and units - dimensionless parameters - Buckingham‘s π theorem - Models andsimilitude - Applications of dimensionless parameters, scaling factors and law.

CO3 Determine flow rates and head losses in laminar and turbulent flows **L:9**

CO7 Determine frictional and minor head losses in flow through pipes **P:6**

Boundary layer concepts – Flow over Cylinders- Laminar flow though circular conduits and circular annuli -Darcy-Weisbach's equation - Flow through pipes in series and in parallel, friction factor –Moody diagram- Losses in pipes.

Experimental Evaluation of Friction Coefficient – Frictional Loss – Coefficients of pipe fittings – Minor Losses – Bend – Elbow – Sudden expansion - Sudden Contraction

CO4 Apply principles of fluid mechanics to design and select hydraulics turbines **L:9**

CO8 Evaluate the performance of different types of turbines **P:6**

Hydro turbines: definition and classifications - working principles - velocity triangles – workdone - specific speed - efficiencies - performance curves*with experimental verification.*

CO5 Apply principles of fluid mechanics to design and select pumps **L:9**

CO9 Evaluate the performance of different types of pumps **P:6**

Pump: Classification and working principles - Centrifugal pump velocity triangles, specific speed, efficiency and performance curves*with experimental verification* - Reciprocating pump: slip, discharge, work done - cavitation.

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. YunusA. Cengel and John M. Cimbala, “Fluid Mechanics: Fundamentals and Applications”, McGraw-HillLtd, New Delhi, 4th Edition, 2017.
2. Bansal R.K, “Fluid Mechanics and Hydraulics Machines”, Laxmipublications (P) Ltd, New Delhi, 10th Edition, 2019.

REFERENCES:

1. Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics", John Wiley & Sons, 10th Edition, 2021.
2. White FM, "Fluid Mechanics", Tata McGraw-Hill, New Delhi, 8th Edition, 2017.
3. Streeter VL and Wylie EB, "Fluid Mechanics", McGraw-Hill Ltd, Asia, 8th Edition, 2017
4. Modi P.N and Seth S.M, "Hydraulics and Fluid Mechanics Including Hydraulics Machines", Standard Book House, 22nd Edition, 2019
5. Kumar KL, "Engineering Fluid Mechanics", Eurasia Publishing House Private Limited, 15th Edition, New Delhi, 2016.
6. Shiv Kumar, "Fluid Mechanics & Fluid Machines: Basic Concepts & Principles", Ane Books Pvt. Ltd., New Delhi, 3rd Edition, 2018
7. Fluid Mechanics, IIT Kharagpur, Prof. Suman Chakraborty, https://nptel.ac.in/courses/112105171

23ME35C **MATERIALS ENGINEERING**

L	T	P	E	C
2	0	2	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Demonstratethe structure and properties of materials referring suitable phase diagrams.

CO2: Choose appropriate heat-treatment techniques to impart desired properties in materials / alloys.

CO3: Identify the suitable ferrous and non-ferrous alloys for engineering applications.

CO4: Select suitable polymers, ceramics and composites for specific engineering applications.

CO5: Demonstrate different damage mechanisms and testing of metals.

Practical Component

CO6: Prepare the specimens and characterize the microstructures of different ferrous and non-ferrous metals.

CO7: Evaluate the effect of heat treatment on properties of steel.

CO8: Measure the hardness of ferrous and non-ferrous materials

CO1 Demonstrate the structure and properties of materials referring suitable phase diagrams. L:6

Constitution of alloys–Solid solutions, substitutional and interstitial–phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron–Iron carbide phase diagram. Classification of Steel and cast Iron - microstructure, properties and application. Study of metallurgical microscope and sample preparation.

CO2 Choose appropriate heattreatment techniques to impart desired properties in materials / alloys. L:6

CO6 Prepare the specimens and characterize the microstructures of different ferrous and non-ferrous metals. P:12

CO7 Evaluate the effect of heat treatment on properties of steel. P:8

Definition– Introduction to furnace, Full annealing, stress relief, recrystallisation and

spheroidising–normalising, hardening and Tempering of steel. Isothermal transformation diagrams–cooling curves superimposed on I.T. Diagram -Continuous Cooling Transformation (CCT) diagram- Austempering, Martempering –hardening methods-case hardening, carburizing, Nitriding, cyaniding, carbonitriding–Flame and Induction hardening–Vacuum and Plasma hardening - Thermo-mechanical treatments-elementary ideas on sintering.

Preparation and study of the microstructure of low carbon steel, mild steel, high speed steel and stainless steel. Evaluate the effect of heat treatment on properties of steel. Measurement of hardness of various heat treated and untreated plain carbon steels.

CO3 Identify the suitable ferrous and non-ferrous alloys for engineering applications **L:6**

Effect of alloying additions on steel (Mn, Si, Cr, Mo, V, Ti& W) -α and β stabilizers – stainless and tool steels–HSLA, Maraging steels–Cast Iron-Grey, white, malleable, spheroidal–alloy cast irons, Copper and copper alloys–Brass, Bronze and Cupronickel–Aluminum and its alloys - Al-Cu–precipitation strengthening treatment– Titanium alloys, Mg-alloys, Ni-based super alloys –Properties and Applications.

CO4 Select suitable polymers, ceramics and composites for specific engineering applications. **L:6**

Polymers–types of polymer, commodity and engineering polymers–Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, PETG, Polymers–Urea and Phenol formaldehydes)-Engineering Ceramics–Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON–Composites-Classifications-Metal Matrix and FRP-Applications of Composites.

CO5 Demonstrate different damage mechanisms and testing of metals **L:6**

CO8 Measure the hardness of ferrous and non-ferrous materials **P:10**

Mechanisms of plastic deformation, slip and twinning–Types of fracture–Testing of materials under tension, compression and shear loads–Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Micro and Nano-hardness tests, Impact test Izod and Charpy, fatigue and creep failure mechanisms.

Perform Brinnell hardness test on metals, Perform Rockwell hardness test on metals.

L:30; P:30; TOTAL:60 PERIODS

TEXT BOOKS

1. Avner, S.H., “Introduction to Physical Metallurgy”, McGraw Hill Education; 2nd Edition, 2017.
2. Williams D Callister, “Material Science and Engineering” Wiley India Private Limited, 10th Edition, 2020.

REFERENCES

1. Raghavan.V, “Materials Science and Engineering”, Prentice Hall of India Pvt. Ltd., 6thEdition, 2015.
2. Kenneth G.Budinski and Michael K. Budinski, “Engineering Materials”, Prentice Hall of India Private Limited, 9thIndian Reprint, 2016.
3. Upadhyay.G.S. and Anish Upadhyay, “Materials Science and Engineering”, Viva Books Pvt. Ltd., New Delhi, 2015.
4. U.C.Jindal: Material Science and Metallurgy, "Engineering Materials and Metallurgy", 1st Edition, Dorling Kindersley, 2012.

23ME36C	KINEMATICS OF MACHINERY	L	T	P	E	C
		3	0	0	2	4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Demonstrate the fundamental concepts of the simple mechanisms.
CO2: Determine velocity and acceleration of any point on a link in simple mechanisms.
CO3: Draw the cam profile for different types of follower and motion requirements.
CO4: Apply gear and gear train fundamentals to select suitable components for specific applications.
CO5: Apply friction concepts to design clutches and brakes.

Experiential Component

CO6: Design a mechanism for a specific engineering application.
CO7: Analyse and validate the mechanisms through kinematic principles.
CO8: Implement theoretical designs into tangible prototypes.
CO9: Collaborate and communicate effectively as a member of a team for proficient problem-solving.

CO1 Demonstrate the fundamental concepts of the simple mechanisms **L:9**

Definitions – Link, Kinematic pair, Kinematic chain, Mechanism and Machine – Degrees of Freedom – Mobility – Kutzbach criterion (Gruebler‘s equation) – Grashoff‘s law-Kinematic inversions of four-bar chain and single slider crank chain.
Description of common mechanisms – Quick return mechanisms, Double slider mechanism, pantograph, straight line generators (Peaucellier and Watt mechanisms).

CO6 Design a mechanism for a specific engineering application. **L:10**

Identification of an application,selection and design of suitable mechanism for the application.

CO2 Determine velocity and acceleration of any point on a link in simple mechanisms **L:9**

Analysis of velocity and acceleration in simple mechanisms – Graphical Methods forrelative velocity and acceleration polygons –Coriolis acceleration.

CO3 Draw the cam profile for different types of followers and motion requirements **L:9**

Introduction – Terminology, Classifications, Types of follower motion – Uniform velocityMotion,Simple Harmonic Motion, Uniform Acceleration and Retardation Motion andCycloidal Motion. Graphical layouts of cam profile – Knife edge follower, Roller and flatfaced follower.

CO4 Apply gear and gear train fundamentals to select suitable components for specific applications. **L:9**

Types of Gears – Spur gear terminology and definitions – Law of toothed gearing – Involute and cycloidal gear profiles- Contact ratio – Interference and undercutting. Gear trains – Simple, compound and Epicyclic gear trains–speed calculation.

CO5 Apply friction concepts to design clutches and brakes. **L:9**

Dry friction, Friction clutch – single and multi-plateclutch. Brakes – Single and Double Block brakes. Conditions for self-locking and self energizing.

CO7 Analyse and validate the mechanisms through kinematic principles. **E:10**

Performing kinematic analysisof Mechanism.

CO8 Implement theoretical designs into tangible prototypes. **E:10**

Developing a prototype, and testing.

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. Rattan SS, "Theory of Machines", Tata McGraw Hill Publishers, New Delhi, 2017.
2. Robert L Norton, "Design of Machinery", McGraw Hill Higher Education, 5th Edition, 2013.

REFERENCES

1. Uicker J.J, Pennock G.R and Shigley J.E, "Theory of Machines and Mechanisms", Oxford University Press, 5th Edition, 2017.
2. Ambekar A.G, "Mechanism and Machine Theory", Prentice Hall of India, New Delhi, 1st Edition, 2011.

23GN03C	INTELLECTUAL PROPERTY RIGHTS STUDY	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	0	0	0	4	2

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Experiential Component

CO1: Survey and practice the basic elements of existing patents.

CO2: Investigate and present the state of art technologies through effectual IP search.

Soft Skill Component

CO3: Presentpatent survey conclusions

CO1 Survey and practice basic elements of existing patents **E:30**

Basic elements of IPR – claims – infringements – Patent examination and Report - Case studies: patent survey.

CO2 Investigate and present the state of art technologies through effectual IP search **E:30**

Importance of IP search-factors to be considered for effective IP search-Hands-on Practice.

E:60 TOTAL:60 PERIODS

REFERENCES

1. D.P. Mittal, "Indian Patents Law and Procedure", Taxman Publication, 2002
2. B.L. Wadera, "Patents, trademarks, copyright, Designs and Geographical Judications", 2010
3. P. Narayanan, "Intellectual Property Law", Eastern Law House, 2022
4. N.S.Gopalakrishnan&T.G.Agitha, "Principles of Intellectual Property", Eastern Book Company, Lucknow, 2009.

23GN06C	PROJECT MANAGEMENT AND FINANCE	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	2	0	0	0	2

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Select and formulate projects

CO2: Estimate the project cost and make an investment decision

CO3: Apply the scheduling and resource allocation techniques to control and monitor the project

CO1 Select and formulate projects **L:10**

Project – Concepts –Project Life Cycle – Project constraints- Generation and Screening of Project Ideas - Project identification – Preliminary Analysis, Market, Technical, Financial, Economic and Ecological - Pre- Feasibility Report and its Clearance, Project Estimates and Techno-Economic Feasibility Report, Detailed Project Report – Different Project Clearances required.

CO2 Estimate the project cost and make an investment decision **L:10**

Project Evaluation under certainty –Capital budgeting techniques; Methodology for project evaluation – Social Cost Benefit Analysis, Commercial or National Profitability, social or national profitability.

CO3 Apply the scheduling and resource allocation techniques to control and monitor the project **L:10**

Developing a Project Plan - Developing the Project Network – Constructing a Project Network (Problems) – PERT – CPM – Crashing of Project Network (Problems - Case Study) – Resource Leveling and Resource Allocation – Steps in Project Appraisal Process – Project Control Process – Control Issues – Project Audits – the Project Audit Process – project closure – team, team member and project manager evaluations.

L:30; TOTAL:30 PERIODS

TEXT BOOKS

1. Clifford Gray, Erik Larson and Gautam Desai, "Project Management: The Managerial Process", Tata McGraw Hill, 8th Edition, 2021
2. Prasanna Chandra, "Projects, Planning, Analysis, Selection, Financing, Implementation and Review", Tata Mc-GrawHill, 2023

REFERENCES

1. M Y Khan, P K Jain , "Management Accounting", McGraw Hill, 8th Edition, 2021
2. KantiSwarup, P.K.Gupta and Man Mohan, "Operations Research", S. Chand & Sons, 2019
3. Sudhakar, G P, "Project management: the managerial aspects", New Century Pub, 5th Edition, 2020.
4. Gopalakrishnan P and Ramamoorthy V.E., "Textbook of Project Management", Trinity Press, 2022
5. Dr. K.L. Gupta, "Management Accounting", SahityaBhawan Publications, 2022
6. Prem Kumar Gupta, Dr.D.S.Hira, "Problems in Operation Research (Principles & Solutions)", Kindle Edition, 2018
7. Project Management for Managers, IIT Roorkee, Prof. Mukesh Kumar Barua, https://nptel.ac.in/courses/110107081

23ME41C MACHINING PROCESSES

L	T	P	E	C
3	0	2	0	4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Infer the forces and heat generated in metal cutting operation and explain their effects on tool wear and surface finish

CO2: Demonstrate different types of lathe and drilling machines and their respective operations

CO3: Analyze the different flat, profile, and gear machining processes and identify the suitable

machining process for the product with locating principles

CO4: Select suitable finishing process to achieve good surface finish for an industrial component

CO5: Demonstratetheadvancements in the machining process and the environmental-friendly machining process

Practical Component

CO6: Evaluate the cutting forces, temperature and surface finish in cylindrical machining operations

CO7: Analyze and optimize process parameters for cylindrical surface machining and hole making operations

CO8: Select and perform appropriate machining operations to produce flat, profiled and gear components

CO1 Infer the forces and heat generated in metal cutting operation and explain their effects on tool wear and surface finish **L:9**

CO6 Evaluate the cutting forces, temperature and surface finish in cylindrical machining operations **P:10**

Metal cutting: mechanics, tools- geometry, nomenclature and signature, Mechanism of chip formation – Merchant circle diagram, Forces and temperature in metal cutting, Tool life – Machinability and surface finish, cutting tool materials and cutting fluids, Tool wear.
Cutting force and Temperature measurement in Lathe machining operations, surface finish measurement using surface roughness tester.

CO2 Demonstrate different types of lathe and drilling machines and their respective operations **L:9**

CO7 Analyze and optimize process parameters for cylindrical surface machining and pocketing operations **P:10**

Cylindrical Surface Machining: operations, process parameters. Machining time calculations. Drilling Machines - process parameters, Design considerations for drilling operations, Machining time calculations.
selection of optimum machining conditions for MRR and Surface finish criteria, and manufacture the product as per the drawing

CO3 Analyze the different flat, profile, and gear machining processes and identify the suitable machining process for the product with locating principles **L:9**

CO8 Select and perform appropriate machining operations to produce flat, profiled and gear components **P:10**

Flat and Profile Machining: Milling operations – Milling machines: process parameters. Planing and shaping machines -operations. Gear machining processes-gear hobbing and gear shaping. Tooling: Jigs and fixtures, principles of location and clamping.
create simple Prismatic parts, generate gear profile

CO4 Select suitable finishing process to achieve good surface finish for an industrial component **L:9**

Finishing Processes: Theory of grinding process – Fundamentals of abrasives – Grinding wheels- Grinding operations and machines. Super finishing processes, micro finishing - honing, lapping, nano-finishing

CO5 Demonstrate the advancements in the machining process and the environmental-friendly machining process **L:9**

Unconventional methods: Mechanical, electro-chemical, chemical, Thermal, Optimizing Machining Processes for Reduced Environmental Impacts, Recent trends in machining process.

L:45; P:30; TOTAL:75 PERIOD

TEXT BOOKS

1. P.N. Rao, "Manufacturing Technology: Metal Cutting and Machine Tools", McGraw Hill Education, 4th Edition, 2018.

REFERENCES

1. S.K.Hajra Choudhury, Nirjhar Roy, "Elements of Workshop Technology: Machine Tools", Media Promoters & Publishers Pvt. Ltd, 2010.
2. Amitabha Ghosh, Asok Kumar Mallik, "Manufacturing Science", OAFF0 Publisher, 2nd Edition, 2010.
3. P.C.Sharma, "A Textbook of Production Technology (Manufacturing Processes)", S. Chand & Company Pvt. Ltd 8th Edition, 2014.
4. Serope Kalpakjian, Steven R.Schmid, "Manufacturing Engineering and Technology", Pearson Education, 7th Edition, 2018.
5. Mikell P. Groover, "Fundamentals of Modern Manufacturing-Materials, Processes, and Systems", John Wiley & Sons Inc. publisher, 7th Edition, 2019.
6. K.C. Jain, A.K. Chitale, "Textbook of Production Engineering", PHI Learning Pvt.Ltd., 2014
7. Geoffrey Boothroyd and Winston. A. Knight, "Fundamentals of Machining and Machine Tools", CRC Press, 3rd Edition, 2005
8. Advanced Machining Processes, IIT Guwahati, Prof. Manas Das, https://nptel.ac.in/courses/112103202
9. Advanced Machining Processes, IIT Kanpur, Prof. Vijay K. Jain, https://nptel.ac.in/courses/112104028

23ME42C **THERMAL ENGINEERING**

L	T	P	E	C
3	0	2	0	4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Apply thermodynamic concepts to different air standard cycles and calculate the efficiency of IC engines and gas turbines.
CO2: Analyze the performance of vapour power cycles.
CO3: Determine the performance of steam nozzles and turbines.
CO4: Calculate the performance of refrigeration system and demonstrate different psychrometric processes
CO5: Evaluate the performance parameters of an air compressor

Practical Component

CO6: Investigate the performance characteristics of IC engines and draw the valve and port timing diagrams
CO7: Determine the performance of refrigerator and air-conditioning units
CO8: Conduct performance study on air compressors

CO1 Apply thermodynamic concepts to different air standard cycles and calculate **L:9**

the efficiency of IC engines and gas turbines.

CO6 Investigate the performance characteristics of IC engines and draw the valve and port timing diagrams **P:8**

Otto cycle, Diesel cycle, Dual cycle, Brayton (Joule) cycle- Air standard efficiency and mean effective pressure calculations.

I.C Engines –classification and working- Valve Timing and Port timing diagrams - Performance and Heat Balance of I.C. Engines.

Performance and heat balance test, Morse test, Retardation test, Viscosity measurement, Construction of Valve timing and port timing diagrams

CO2 Analyze the performance of vapour power cycles **L:9**

Simple Rankine cycle, Reheat Rankine cycle, Regenerative Rankine Cycle - Performance calculations. Concept of cogeneration.

Requirements of boiler; Types: Water tube, fire tube, fluidized bed boilers;Boiler performance: Direct and indirect heat balance.

CO3 Determine the performance of steam nozzles and turbines **L:9**

Steam Nozzles - Effect of friction, critical pressure ratio, supersaturated flow

Steam Turbines - Impulse and Reaction Types, Components, Working principle, Velocity diagrams and Performance calculations, Compounding and Governing

CO4 Calculate the performance of refrigeration system and demonstrate different psychrometric processes **L:9**

CO7 Determine the performance of refrigerator and air-conditioning units **P:6**

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

Psychrometric properties, Psychrometric processes- heating, cooling, humidification dehumidification, Cooling towers – concept and types

Refrigeration and Air conditioning systems, Cooling Tower - Performance Tests

CO5 Evaluate the performance parameters of an air compressor **L:9**

CO8 Conduct performance study on air compressor **P:6**

Reciprocating Compressor - working principle, Performance study - with and without clearance. Multistage air compressor with Intercooling. Rotary compressors - Working principle, Comparison of Rotary compressors with reciprocating air compressors

Rotary & Reciprocating Compressor - Performance Tests

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOK

1. Rajput RK, "Thermal Engineering", 10th Edition, Laxmi Publications, Ltd., 2018

REFERENCE

1. Kothandaraman.C.P.,Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering",5th Edition," DhanpatRai&Sons , 2016
2. Yunus A Cengel and Michael a Boles, "Thermodynamics - An Engineering Approach", 8thEdition, Tata McGraw-Hill Education, 2015.
3. T.D.Eastop and Mc-Conkey, "Applied Thermodynamics for Engineering Technologists" 5th Edition, Pearson Education Ltd, 2009.
4. Mahesh M Rathore, "Thermal Engineering", Tata McGraw-Hill, New Delhi, 2010.
5. S.M Yahya, "Turbines, Compressors and Fans", 4th Edition, Tata McGraw-Hill Education, 2010

6. Arora C P, "Refrigeration and Air-conditioning", Tata McGraw Hill, 2017.
7. John B. Heywood, "Internal Combustion Engine Fundamentals", 2nd Edition, McGraw-Hill Education, USA, 2018.
8. https://nptel.ac.in/courses/112103316

23ME43C	STRENGTH OF MATERIALS	L	T	P	E	C
		3	0	2	0	4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Analyze stresses, strains, and deformations of structural members subjected to axial load
CO2: Apply Mohr's circle to determine stresses on inclined planes and analyze stresses in thin cylinders
CO3: Analyze the structural members subjected to bending and shear loads.
CO4: Apply theories of failure and analyze the stability of the column
CO5: Determine the twist and shear stresses of the shaft and springs under torsional load

Practical Component

CO6: Analyze materials under tensile and shear forces to evaluate mechanical properties
CO7: Evaluate and compare the structural behavior and load-bearing capacity of steel and timber beam
CO8: Evaluate the strength and resilience of materials through impact tests to make engineering decisions
CO9: Evaluate mild steel rod behavior under torsional stress
CO10: Analyze the load-deflection relationship to determine the spring's stiffness and ascertain its physical properties

CO1 Analyze stresses, strains, and deformations of structural members subjected to axial load **L:9**

CO6 Analyze materials under tensile and shear forces to evaluate mechanical properties **P:6**

Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress-strain diagram for brittle and ductile materials, True stress and strain, Factor of safety, Calculation of stresses in straight, Stepped, and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.

Mechanical properties of steel specimen-Tension test of mild steel specimen- Single and double Shear test of metal specimens -ASTM Standards.

CO2 Apply Mohr's circle to determine stresses on inclined planes and analyze stresses in thin cylinders **L:9**

Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear stress, Mohr circle for plane stress conditions.

Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains

CO3 Analyze the structural members subjected to bending and shear loads. **L:9**

CO7 Evaluate and compare the structural behavior and load-bearing capacity of steel and timber beam **P:6**

Type of beams, Loads and reactions, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads and uniformly distributed loads.
Slope and deflection of cantilever beam and simply supported beams - Mecaulay's Method
Load-bearing capacity of steel and timber beams under bending stress- Modulus of Elasticity of the materials

CO4 Apply theories of failure and analyze the stability of the column L:9
CO8 Evaluate the strength and resilience of materials through impact tests to make engineering decisions P:6

Theories of Failure:Maximum Principal stress theory, Maximum shear stress theory, maximum-distortion-energy theory
Buckling of columns: Buckling and stability, Critical load, Euler buckling load- the effect of end conditions on column buckling.

Energy Absorbing Characteristics of Metal Materials- Charpy and Izod impact test- failure patterns and failure surface- ASTM Standards

CO5 Determine the twist and shear stresses of the shaft and springs under torsional load L:9
CO9 Evaluate mild steel rod behavior under torsional stress P:6
CO10 Analyze the load-deflection relationship to determine the spring's stiffness and ascertain its physical properties P:6

Torsion formulation stresses and deformation in circular and hollow shafts – Steppedshafts– Deflection in shafts fixed at both ends – Stress and defection in open and closed coilhelical springs.
Torsion test on mild steel rod-Modulus of rigidity
Helical Springs: Close coiled helical spring and Open coiled helical spring-Load Vs Deflection Relationship Analysis

L:45; P:30; TOTAL:75 PERIODS

TEXTBOOKS

1. Hibbeler RC, "Mechanics of Materials", 11th Edition, Prentice Hall, 2022.

REFERENCES

1. Popov EP, "Engineering Mechanics of Solids", 2nd Edition, Prentice-Hall of India, New Delhi, 2015.
2. Ferdinand Beer, E. Johnston, John DeWolf, "Mechanics of Materials", 7th Edition, McGraw-Hill Education, 2014
3. Bansal R.K, "Strength of Materials", 6thEdition, Laxmi Publications,2018
4. Timoshenko SP, "Elements of Strength of Materials", Tata McGraw-Hill, New Delhi, 2004.
5. Irving Granet, "Strength of Materials for Engineering Technology", 2nd Edition, Reston Publishing Company, 1980
6. Rajput, "Strength of Materials", S. Chand Publishing, 2018
7. Rattan SS, "Strength of Materials", 3rd Edition, McGraw Hill Education, 2017
8. NPTEL Online course, Strength of Materials IITKGPByProf.Sriman Kumar Bhattacharyya, IIT Kharagpur

23ME44C **MACHINE DRAWING**

L	T	P	E	C
1	0	2	0	2

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Use the Indian standards for the preparation of machine drawing and blueprint reading.

Practical Component

CO2: Draw the assembled view of the mechanical products from the given part drawing.

CO3: Draw the part drawing of the mechanical products from the given assembly drawing.

CO4: Prepare assembly drawing of mechanical components with codes, standards, and symbols

CO1 Use the Indian standards for the preparation of machine drawing and blueprint reading. L:15

Introduction: Bureau of Indian Standards (BIS) for drawing practice–drawing sheets, Symbols and conventional representation – Different materials, springs, gears and other machine elements, surface roughness, weld symbols and its dimensioning, thread, bolt, nuts, screws, keys.

Dimensioning and tolerancing - Fundamental deviation and Fits - Hole and Shaft basis system - Blueprint reading – Interpretation of information from the given production drawing

CO2 Draw the assembled view of the mechanical products from the given part drawing. (Manual & Using CAD Packages) P:10

Assembly drawing: Preparation of assembly drawing from the given part drawings of Screw jack, Swivel bearing and Drilling Jig and Prepare report.

Preparation of assembly drawing from the given part drawings of Screw jack, Swivel bearing and Drilling Jig

CO3 Draw the part drawing of the mechanical products from the given assembly drawing. (Manual & Using CAD Packages) P:10

Preparation of part drawing from the given assembly drawings of Steam Stop valve and Machine vice *Preparation of part drawing from the given assembly drawings.*

CO4 Prepare assembly drawing of mechanical components with codes, standards, and symbols (Manual &CAD Packages) P:10

Preparation of detailed drawings of assembly or part drawing of IC engine piston, Die set and milling fixture.

Preparation of detailed drawings of assembly or part drawing

L:15; P:30; TOTAL:45 PERIODS

TEXT BOOKS

1. K.R.Gopalakrishna, "Machine Drawing", 23rdEdition, Subhas Publications, Bangalore, 2017.
2. K.L. Narayana, P.Kannaiah and K. Venkata Reddy, "Machine Drawing", 6thEdition, New Age International Publishers, New Delhi, 2019.

REFERENCES

1. ThamosP.Olivo and Dr.C.ThamosOlivo, "Basic Blueprint Reading and Sketching", 9th Edition, Industrial Press Inc, New York, 2010.

2. PS. Gill, "A Textbook of Machine Drawing", 18th Edition Reprint, S. K. Kataria& Sons. New Delhi. 2013.
3. RK. Dhawan, "A Textbook of Machine Drawing", 1st Edition, Sultan Chand and Sons, New Delhi, 2015.
4. N. D. Bhat, V M Panchal "Machine Drawing" – Charotar Publication House – 2014
5. BIS recommendation for school practices: SP46:2003
6. Sp46 codes - https://law.resource.org/pub/in/bis/S01/is.sp.46.2003.pdf

Note : End semesterexaminationwillbeconducted as practicalexaminationonly.

		L	T	P	E	C
23ME45C	**SYSTEM MODELING PROJECTS**	**0**	**0**	**2**	**2**	**2**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Practical component:

CO1: Apply basic mathematics, science, and engineering concepts to develop models for systems or products across various domains.

Experiential component:

CO2: Develop and analyze models using fundamental principles to solve real-life problems.

Soft skill component:

CO3: Develop the ability to work collaboratively in teams to model and simulate systems while effectively communicating technical results using suitable tools and techniques.

COURSE OVERVIEW

This course is designed to equip students with the skills to develop and analyze mathematical models for various systems across different domains. It focuses on applying fundamental principles of mathematics, science, and engineering to represent and predict the behaviour of these systems. Through hands-on experience, students will learn to create robust models that address real-world challenges, ranging from system optimization to problem-solving in practical applications. The course emphasizes integrating theoretical concepts with practical solutions, preparing students to design efficient and effective models while promoting technical excellence and professional growth.

P:30; E:30; TOTAL:60 PERIODS

		L	T	P	E	C
23ME51C	**MECHATRONICS AND ROBOTICS ENGINEERING**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the fundamentals of mechatronics systems and its applications
CO2: Demonstrate the types, configuration, components, and specifications of robots
CO3: Identify the appropriate sensor for a particular Mechatronic/Robot system.
CO4: Demonstrate the functional applications of various drive and control systems
CO5: Construct the mechatronics blocks for automation and robotics system blocks from the

real-time case studies

CO1 Demonstrate the fundamentals of mechatronics systems and its applications **L:9**

Mechanical System-Definition-Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modelling, Analysis and Simulation, Man-Machine Interface. Case study on the application of Mechatronics system in Automation and Robotics, Process Automation, Manufacturing, Product design and testing.

CO2 Demonstrate the types, configuration, components, and specifications of robots **L:9**

An overview of Robotics – classification by coordinate and control systems. Components of Industrial Robotics- Basic terminology- End effectors-types, Mechanical grippers, and other grippers- Specifications - Robot selection- Present and future applications.

CO3 Identify the appropriate sensor for a particular mechatronic/robot system **L:9**

Sensor and transducer- classification - characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, and temperature sensor sensors. Optical encoder, tactile and proximity, ultrasonic transducers, Optoelectronics sensor, gyroscope sensors. Micro-sensors and MEMS. Selection of sensors.

CO4 Demonstrate the functional applications of various drive and control systems **L:9**

Hydraulic and Pneumatic drives, Electrical Actuators such as servo and Stepper motors, Drive circuits, and open and closed loop controls. Proportional (P), Proportional and integral (PI) and Proportional, integral and Derivative (PID) control systems.

CO5 Construct the mechatronics blocks for automation and robotics system blocks from the real-time case studies **L:9**

Smart automation systems (e.g., driverless cars, domestic/warehouse mobile robots, intelligent transportation systems, robotic construction machines, Car parking barriers, Motion and temperature control of washing machine, Autofocus camera, 3D printer, etc.). Smart irrigation systems, Pick and place robots, Arc welding robots and Drone systems.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 7th Edition, Pearson Education, 2019.
2. Indri, Marina and Oboe, Roberto, Mechatronics and Robotics: New Trends and Challenges, CRC Press, 1stEdition, 2022.

REFERENCES

1. NitaigourPremchandMahalik, Mechatronics - Principles, Concepts and Applications, Tata McGraw-Hill Pub. Co. Ltd., New Delhi, 2006.
2. Rafael C. Gonzales, Richard. E. Woods, “Digital Image Processing, 4th Edition, Pearson Education”, 2018.
3. Kevin M. Lynch and Frank C. Park, “Modern Robotics: Mechanics, Planning and

Control", 1st Edition, Cambridge University Press, 2017.
4. Bruno Siciliano and Oussama Khatib, "Handbook of Robotics", SpringerVerlag, 2016.
5. Harry H. Poole, "Fundamentals of Robotics Engineering", Springer, 2012.
6. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd Edition, Wiley Publishers, 2010.
7. Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.

23ME52C	**HEAT AND MASS TRANSFER**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**2**	**0**	**4**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Apply the governing equations for steady and unsteady state heat conduction
CO2: Solve the problems involving forced and freeconvection heat transfer
CO3: Estimate the heat transfer in the systems involving radiation heat transfer
CO4: Design a simple heat exchanger and evaluate its performance
CO5: Apply the principles of diffusion and convective mass transfer for simple applications

Practical Component

CO6: Evaluate the thermal conductivity of single and composite materials using different experimental techniques
CO7: Analyze experimentally the natural and forced convection heat transfer
CO8: Analyse the two-phase heat transfer of boiling and condensation and investigate the performance of parallel and counter flow heat exchangers
CO9:Determine Stefan Boltzmann's constant and emissivity of grey surface experimentally
CO10: Investigate the performance of the cooling tower experimentally

CO1 Apply the governing equations for steady and unsteady state heat conduction **L:7 T:3**

CO6 Evaluate the thermal conductivity of single and composite materials using different experimental techniques **P:10**

General differential equation of heat conduction in various coordinate systems – One dimensional heat conduction for steady and unsteady state conditions – Conduction with heat generation - Extended surfaces - Case studies.

Experiments on determination of thermal conductivity of single and composite materials.

CO2 Solve the problems involving forced and free convection heat transfer **L:6 T:3**

CO7 Analyze experimentally the forced and free convection heat transfer **P:6**

Basic concepts - Boundary layer concept - Forced convection - External and internal flow - Free convection - External flow - Dimensional analysis - Applications.

Experiments on convective heat transfer: Forced convection & Natural convection inside a tube.

CO3 Estimate the heat transfer in the systems involving radiation heat **L:6**

	transfer	**T:3**
CO8	**Determine Stefan Boltzmann's constant and emissivity of grey surface experimentally**	**P:4**

Laws of radiation - Black body radiation - Grey body radiation - Shape factor algebra - Electrical analogy - Radiation shields - Introduction to gas radiation - Solar radiation - Concept and applications.

Experimental verification of Stefan Boltzmann constant and determination of emissivity of grey surface

CO4	**Design a simple heat exchanger and evaluate its performance**	**L:6**
		T:3
CO9	**Analyse the two-phase heat transfer of boiling and condensation and investigate the performance of parallel and counter flow heat exchangers**	**P:6**

Pool and flow boiling - Nusselt theory of condensation - Heat exchangers - Types and working principle - Simple heat exchanger design - Fouling factors - Introduction to compact heat exchanger

Experiments on Boiling and Condensation

Experiments on performance of heat exchangers: Parallel and Counter flow

CO5	**Apply the principles of diffusion and convective mass transfer for simple applications**	**L:5**
		T:3
CO10	**Investigate the performance of the cooling tower experimentally**	**P:4**

Basic concepts - Diffusion mass transfer - Steady state molecular diffusion – Convective mass transfer - Application of mass transfer: Cooling tower - Performance characteristics.

Experimental study on performance of cooling tower

L:30; T:15; P:30; TOTAL:75 PERIODS

Note: (Use of HMT data book and steam tables are permitted in the end semester examination)

TEXT BOOKS

1. Frank P Incropera and David P DeWitt, Fundamentals of Heat and Mass Transfer,John Wiley and Sons, 8th Edition, 2018.
2. Yunus A Cengel and Afshin Ghajar, Heat and Mass Transfer: Fundamentals andApplications, McGraw-Hill Education, 6th Edition, 2019.

REFERENCES

1. Nag P K, Heat Transfer, Tata McGraw-Hill, New Delhi, 3rd Edition, 2011.
2. Sachdeva R C, Fundamentals of Engineering Heat and Mass Transfer, New AgeInternational, 5th Edition, 2017.
3. Holman JP, Heat and Mass Transfer, McGraw-Hill Education, 10th Edition, 2011.
4. Ozisik MN, Heat Transfer‖, McGraw-Hill Book Co., 1994.
5. Kothandaraman CP, Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2019.
6. John H. Lienhard V, John H. Lienhard IV, A Heat Transfer Textbook, 5thEdition, Cambridge MA: Phlogiston Press, 2024.

7. R Yadav, - Heat and Mass Transfer, Central Publishing House, 5th Edition, Allahabad, 2004.
8. NPTEL Lecture notes: https://nptel.ac.in/courses/112/108/112108149/
9. NPTEL videos: https://nptel.ac.in/courses/112/101/112101097/

23ME53C	DYNAMICS OF MACHINERY	L	T	P	E	C
		2	1	2	0	4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Analyze dynamic forces in a reciprocating engine and predict the mass and radius of gyration of the flywheel using a turning moment diagram

CO2: Evaluate the balancing condition of the reciprocating and rotating system

CO3: Determine the natural frequencies of longitudinal and torsional vibrations and identify the critical speed for rotating systems

CO4: Determine the amplitude of the forced vibration and force transmissibility

CO5: Analyze the performance of speed control and stability control mechanisms.

Practical Component

CO6:Conduct experiments to calculate the mass moment of inertia of the connecting rod and flywheel

CO7: Investigate the balancing condition of the rotating and reciprocating masses and analyze the vibrations before and after the balancing process

CO8:Conduct experiments to predict and validate the natural frequencies of longitudinal, transverse, and torsional vibratory systems

CO9: Investigate and diagnose the fault condition of the rotating systems

CO10:Conduct experiments to evaluate the performance of speed control and stability control mechanisms

CO1 **Analyze dynamic forces in a reciprocating engine and predict the mass and radius of gyration of the flywheel using a turning moment diagram** **L:9**

CO6 **Conduct experiments to calculate the mass moment of inertia of the connecting rod and flywheel** **P:6**

Introduction - Inertia force and inertia torque - D Alembert‘s principle - Dynamic force analysis in reciprocating engines - Gas forces - Inertia effect of connecting rod – Bearing loads - Crankshaft torque - Turning moment diagrams - Flywheels - Flywheels of punching presses

Moment of inertia - Flywheel and connecting rod - Dynamically equivalent system

CO2 **Evaluate the balancing condition of the reciprocating and rotating system** **L:9**

CO7 **Investigate the balancing condition of the rotating and reciprocating masses and analyze the vibrations before and after the balancing process** **P:6**

Static and dynamic balancing - Balancing of rotating masses - Balancing of single-cylinder engine - Balancing of Multi-cylinder inline engines - Partial balancing of

reciprocating masses.

Balancing of Rotating masses and reciprocating masses

CO3	**Determine the natural frequencies of longitudinal and torsional vibrations and identify the critical speed for rotating systems**	**L:9**
CO8	**Conduct experiments to predict and validate the natural frequencies of longitudinal, transverse, and torsional vibratory systems**	**P:6**

Basic features of vibratory systems - Degrees of freedom - Single degree of freedom - Free vibration - Equations of motion - Natural frequency - Types of damping – Damped free vibration - Whirling of shafts -Torsional systems; Natural frequency of two and three

rotor systems.

Natural frequency- longitudinal vibration- transverse vibration-torsional vibration- Critical speed of the rotating system

CO4	**Determine the amplitude of the forced vibration and force transmissibility**	**L:9**
CO9	**Investigate and diagnose the fault condition of the rotating systems**	**P:6**

Response of one-degree-of-freedom systems to periodic forcing - Harmonic disturbances - Disturbance caused by unbalance - Support motion - Transmissibility – Vibration isolation

Vibration measurement- accelerometer- vibration analyzer-Time and frequency domain analysis- Machine Tool Vibration-Fault diagnosis of rotating machinery

CO5	**Analyze the performance of speed control and stability control mechanisms.**	**L:9**
CO10	**Conduct experiments to evaluate the performance of speed control and stability control mechanisms**	**P:6**

Governors - Types - Centrifugal governors - Watt, Porter and Proell - Spring loaded governors - Hartnell and Hartung governors - Characteristics - Effect of friction - Controlling force curves.

Gyroscopes - Gyroscopic forces and torques - Gyroscopic stabilization – Gyroscopic effects in automobiles, ships and aeroplanes

Governors - Sensitivity and effort - Gyroscope -precession- Gyroscopic couple

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. Rattan SS, Theory of Machines, 5th Edition, McGraw Hill Education India Pvt. Ltd, New Delhi, 2023.
2. Thomas Bevan, Theory of Machines‖, 3rd Edition, Pearson India, 2016.

REFERENCES

1. Uicker JJ, Pennock GR and Shigley JE, Theory of Machines and Mechanisms, 4th Edition, Oxford University Press, New Delhi, 2014.
2. Ballaney P L, Theory of Machines and Mechanisms, 25th Edition, Khanna Publishers, New Delhi, 2005.
3. Ambedkar AG, Mechanism and Machine Theory, PHI Learning, New Delhi, 2009.
4. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw-Hill,2017.

		L	T	P	E	C
23ME54C	**COMPUTER AIDED DESIGN AND MANUFACTURING**	**3**	**0**	**2**	**0**	**4**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the architecture of CAD systems and apply foundational concepts of computer graphics

CO2: Create and manipulate geometric models using curves, surfaces and solids

CO3: Apply standard CAD practices in engineering design and to understand the need for integration of CAD and CAM

CO4: Develop and apply manual CNC programming for machining and turning centres

CO5: Demonstrate the advancements in computer aided manufacturing

Practical Component

CO6: Draft 2D objects using CAD software

CO7: Create geometric part models, assemblies, and automated drawings of mechanical components

CO8: Develop a prototype using 3D printing

CO9: Perform simple operations in CNC Lathe and Milling machines

CO1 Demonstrate the architecture of CAD systems and apply foundational concepts of computer graphics **L:9**

CO6 Draft 2D objects using CAD software **P:6**

Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- Computer graphics – coordinate systems- 2D and 3D transformations- homogeneous Coordinates-Line and circle drawing-sketching and sketch planes; Modeling aids and tools.

Introduction to CAD software, Sketching, Dimensioning, 2D Drafting.

CO2 Create and manipulating geometric models using curves, surfaces and solids **L:9**

CO7 Apply surface and solid modeling techniques to create basic engineering components **P:12**

Curves Modeling: Analytical and synthetic curves, curve manipulations. Surface Modeling: Surface representation and surface analysis, analytical and synthetic surfaces, surface manipulations, NURBS. Solid Modeling: Geometry and topology, solid entities, solid representation, fundamental of solid modeling, boundary representation, constructive solid geometry, sweeps, solid manipulations, Parametric and feature-based modeling.

Create simple components using surface modeling, 3D modeling of machine components, assembly, and Drafting

CO3 Apply standard CAD practices in engineering design and to understand the need for integration of CAD and CAM **L:9**

CO8 Develop a prototype using 3D printing **P:6**

Introduction to reverse engineering and 3D scanning, Converting scanned data to usable CAD models, Graphics and computing standards- Data exchange standards- IGES-STEP –communication standards- Introduction to generative design principles and workflows, Artificial Intelligence in design automation and optimization, Case studies on AI applications in product design, process planning techniques – Total approach to product development, Design guidelines for 3D printing and additive manufacturing.

Image conversion using 3D scanner, Design and development of new product using 3D printing

CO4 Develop and apply manual CNC programming for machining and turning centres **L:9**

Fundamentals of Numerical control – CNC technology – CNC hardware basics- CNC Tooling and machine tools- Control systems – CNC Programming – Manual programming – Machining and Turning Centre Programming - Computer assisted part programming – APT language structure and commands.

CO5 Demonstrate the advancements in computer aided manufacturing **L:9**
CO9 Perform simple operations in CNC Lathe and Milling machines **P:6**

Overview of CAM software and its role in CNC programming, Toolpath generation, optimization, and machining strategies, machining simulation, Digital Twin and Smart Manufacturing, Introduction to IoT and Data analytics in Manufacturing

Numerical Control (NC) code generation using CAM software for milling and turning operations

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. Groover, M. P., CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education, 2008

REFERENCES

1. AlavalaChennakesava R, CAD/CAM: Concepts and Applications, Prentice Hall India Learning Private Limited, 2008.
2. Zeid, I., Mastering CAD/CAM, Tata McGraw Hill., 2007
3. Chris McMahon and Jimmie Browne, CAD/CAM Principles, Practice andManufacturing Management, Pearson Education Asia, 2001.
4. P.N.Rao, CAD/CAM Principles and Applications, Tata McGraw-Hill Publication Co. New Delhi, 2006.
5. Lalit Narayan, K., Mallikarjuna Rao, K., Sarcar, M.M.M, Computer-Aided Design and Manufacturing, Prentice Hall India Learning Private Limited, 2008.
6. P.Radhakrishnan, S.Subramanyan, V.Raju, CAD/CAM/CIM, New Age International Publishers, 2008.
7. Rajesh Kumar Dhanaraj, Ali Kashif Bashir, Vani Rajasekar, Balamurugan Balusamy, Pooja Malik, Digital Twin for Smart Manufacturing, Academic Press, ISBN: 9780323992053,2023,

23ME55C	**IoT LABORATORY**	**L**	**T**	**P**	**E**	**C**
		0	**0**	**2**	**0**	**1**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Practical Component

CO1: Design and implement programs to automate the control of devices, utilizing real-time input from various sensors.

CO2: Demonstrate the ability to interface Bluetooth, manage cloud data and create a UDP/TCP server for real-time communication.

The following are the initial study experiments, designed to familiarize students with IoT components and basic interfacing:

1. Identify and examine IoT components like sensors and actuators, along with software platforms for device management and data analysis.

2. Familiarize with Arduino/Raspberry Pi and perform necessary software installations.

CO1 Design and implement programs to automate the control of devices, utilizing real-time input from various sensors **P:15**

1. Implement an interface for a push button or digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program that turns on an LED when the push button is pressed or when the sensor detects an object.
2. Demonstrate the interface of a DHT11 sensor with Arduino/Raspberry Pi and write a program that prints temperature and humidity readings.
3. Write a program to interface a motor using a relay with Arduino/Raspberry Pi, turning on the motor when the push button is pressed.
4. Write a program to display a warning message if fire is detected using flame sensor

CO2 Demonstrate the ability to interface Bluetooth, manage cloud data and create a UDP/TCP server for real-time communication **P:15**

1. Implement an interface for Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to a smartphone using Bluetooth.
2. Write a program on Arduino/Raspberry Pi to upload & retrieve temperature and humidity data to cloud.
1. To install MySQL database on Raspberry Pi and perform basic SQL queries.
2. Write a program to create UDP/TCP server on Arduino/Raspberry Pi and respond with humidity data to UDP/TCP client when requested.

Software Requirements

- Arduino IDE software
- Python3.x
- Cloud Platform: Thingspeak/ThingWorx/SAP Leonardo IoT/Oracle IoT Cloud
- Database Software: MySQL for Raspberry Pi

Hardware Requirements

- Arduino
- Raspberry Pi
- Basic electronic components

REFERENCES

1. Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things: Principles and Paradigms, 1st Edition, Morgan Kaufmann, 2016.
2. John C. Shovic, Raspberry Pi IoT Projects, Packt Publishing,1st Edition, 2016.
3. Russell S. Hunter, Building the Internet of Things: Implement New Business Models for Connected Products and Services, Wiley, 1st Edition, 2017.
4. Richard Blum, Python Programming for Raspberry Pi, Sams Teach Yourself in 24 Hours, Sams Publishing, 1st Edition, 2016.
5. David Hanes, Gonzalo Salgueiro, Maciej Kranz, and Karim Vellani, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, 1st Edition, 2017.
6. M.S.K.A.H. Ali, Data Science for the Internet of Things, Springer, 1st Edition, 2019.

P:30; TOTAL:30 PERIODS

23ME56C	SIMULATION USING MODERN TOOLS	L	T	P	E	C
		0	0	2	2	2

COURSE OUTCOMES (COS)

Upon completion of this course, students will be able to:

Practical Component:

CO1: Simulate and analyze simple systems to identify appropriate parameters.

Experiential Component:

CO2: Simulate and analyze real-world systems to identify appropriate parameters.

Softskill Component:

CO3: Communicate effectively and work collaboratively as a team to develop projects and present simulation findings

CO1 Simulate and analyze simple systems to identify appropriate parameters. **P:30**

Develop mathematical models for various engineering applications, including optimization of shaft diameter for minimum induced stress under applied loads, selection of helical spring parameters for reduced stress and deflection, development and implementation of a user-defined function for clutch design, simulation and thermal performance analysis of fins to enhance heat transfer, and optimization of pipeline diameter and flow velocity for achieving maximum fluid discharge.

CO2 Simulate and analyze real-world systems to identify appropriate parameters. **E:30**

Students are expected to identify and select a real-world mechanical system and create a mathematical model that accurately represents its behavior. They implement the model using computational tools such as MATLAB, run simulations to observe the system's response under various conditions, and critically analyze the results, evaluating the system's performance against predefined criteria.

Example:

1. Analysis and Design for Vibration Control in Vehicle Suspension Systems
2. Analysis and Design of Braking Systems for Heavy-Duty Industrial Equipment
3. Analysis of Thermal Performance and Design of Heat Exchangers

REFERENCES

1. Dukkipati, R. V. MATLAB: An Introduction with Applications. New Age International Publications, 2010.
2. Pratap, Rudra. Getting Started with MATLAB. Oxford University Press, 2019.
3. Gilat, Amos. MATLAB: An Introduction with Applications. Wiley Editorial Team, 2023.
4. Marghitu, Dan B., Ghaednia, Hamid, & Zhao, Jing. Mechanical Simulation with MATLAB. Springer, 2021.

P:30; E:30; TOTAL:60 PERIODS

23ME61C DESIGN FOR MANUFACTURE AND ASSEMBLY

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the general principles of manufacturability.

CO2: Design components suitable for casting, welding, sheet metal and injection molding with focus on manufacturability.

CO3: Apply design features to improve machinability, economy, assembly, and manufacturing efficiency.

CO4: Apply DFA principles to minimize part count and reduce assembly complexity, enhancing product manufacturability and efficiency.

CO5: Use the concept and importance of Geometric Dimensioning and Tolerancing (GD&T) in engineering design and manufacturing.

CO1 Demonstrate the general principles of manufacturability **L:9**

DFMA: History, Concepts and fundamentals– Application of DFMA - Challenges in implementation - General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability- Feature tolerances - Geometric tolerances - Assembly limits -Datum features - Tolerance stacks.

CO2 Design components suitable for casting, welding, sheet metal and injection molding with focus on manufacturability. **L:9**

Design of castings based on parting line considerations, minimizing core requirements, designing cast members using weldments, design of weldments, design of sheet metal components, design of injection molding parts – Case Studies.

CO3 Apply design features to improve machinability, economy, assembly, and manufacturing efficiency. **L:9**

Review and selection of Manufacturing Processes - Design features to facilitate machining Machining processes - Turned parts – Drilled parts – Milled, planned, shaped and slotted parts– Ground parts. Bulk deformation processes- Design consideration for Metal extruded parts – Impact/Cold extruded parts – Stamped parts – Forged parts, Doweling procedures - simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability - Design for accessibility.

CO4 Apply DFA principles to minimize part count and reduce assembly **L:9**

complexity, enhancing product manufacturability and efficiency.

Introduction to Assembly: The assembly process - Characteristics and applications - DFA methodology - Economic significance of assembly - General taxonomies of assembly operation and systems - Minimize Part Count - Standardization and Minimize Part Variety - Assembling a product - Design for Assembly: Introduction - Design consideration - Design for Fasteners - DFA analysis - DFA index - Design for Automated Assembly Computer Application software for DFA.

CO5 **Use the concept and importance of Geometric Dimensioning and Tolerancing (GD&T) in engineering design and manufacturing.** **L:9**

Geometric Dimensioning & Tolerance (GD&T) – Form tolerancing: straightness, flatness, circularity, cylindricity – Profile tolerancing: profile of a line, and surface – Orientation tolerancing: angularity, perpendicularity, parallelism – Location tolerancing: position, concentricity, symmetry – runout tolerancing: circular and total – Supplementary symbols - Indian Standards (IS) for GD&T - ASME Y14.5 codes.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. G.Boothroyd, P.Dewhurst & W. Knight, Product Design for Manufacture and Assembly, 3rd Edition, CRC Press, 2011.

REFERENCES

1. Harry Peck, Designing for manufacture, Pitman, 1973.
2. Kevin Otto and Kristin Wood, Product Design. Pearson Publication, (4thImpression) 2009.
3. Bralla, Design for Manufacture handbook, McGraw hill, 1999.
4. Fixel, J. Design for the Environment McGraw Hill., 2011.
5. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.
6. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 2001.
7. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
8. Boothroyd, G, Marcel Dekker, "Design for Assembly Automation and Product Design", New York, 1980.
9. https://onlinecourses.nptel.ac.in/noc19_me48/preview
10. https://www.udemy.com/course/manufacturing-process-selection-and-design-for-manufacturing

23ME62C **INDUSTRIAL ENGINEERING**

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Demonstrate the various production planning methodologies and layout design.
CO2: Use production control tools like dispatching, routing, and Gantt charts for monitoring production.
CO3: Demonstrate the use of micro and micromotion studies in industrial engineering applications.
CO4: Apply the inventory management techniques and suitable material handling equipment.

CO5: Apply the concept of value engineering and plant maintenance.

CO1 Demonstrate the various production planning methodologies and layout design **L:9**

Industrial Engineering- Concept, History and development, Applications, Roles of Industrial engineer- Production management, Industrial engineering versus production management, operations management- Production System Analysis, input output model, Productivity, Factors affecting productivity- Plant layout, Criteria for good layout, Types of layout, Flow pattern, Work station design.

CO2 Use production control tools like dispatching, routing, and Gantt charts for monitoring production. **L:9**

Introduction to process planning - Definition, Procedure, Process selection, Machine capacity, process sheet, process analysis. Group technology –classification and coding system. Production planning, loading, scheduling. Production control-dispatching, routing - progress control bar, curve, Gantt chart, route and schedule chart.

CO3 Demonstrate the use of micro and micromotion studies in industrial engineering applications. **L:9**

Work study -Definition, Need, Advantages, method study and work measurement, Process chart symbols, outline process chart, flow process chart, multiple activity chart, flow diagram, string diagram, operation analysis, principles of motion economy, Therbligs, SIMO chart, stopwatch procedure, micro & micromotion study, ergonomics - applications of ergonomic principles in the shop floor work benches seating arrangement, Industrial physiology.

CO4 Apply the inventory management techniques and suitable material handling equipment **L:9**

Inventory control, classification, management, objectives, functions. Economic order quantity, Economic batch quantity, inventory models, ABC analysis, Material Requirement Planning (MRP I), Manufacturing Resource Planning (MRP II), Operating cycle, lean manufacturing, KANBAN technique, Supply chain management-Material Handling Functions, Principles, Engineering and economic factors, Material handling equipment selection, maintenance, types.

CO5 Apply the concept of value engineering and plant maintenance. **L:9**

System concept-system analysis, systems engineering, techniques and applications. Value analysis - Aim, technique, procedure, advantages, value engineering, value control, types of values. Plant maintenance - objectives, importance, maintenance engineer duties, functions and responsibilities. Types- breakdown, scheduled, preventive and predictive- Plant maintenance schedule, Condition monitoring.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Martand T. Telsang, Industrial Engineering and Production Management, S Chand Publishers, 2018.
2. Ravi Shankar, Industrial Engineering and Management, Galgotia Publications Pvt. Ltd., New Delhi, 2012.

REFERENCES

1. Jan Dul, Bernard Weerdmeester, Ergonomics for Beginners: A quick Reference Guide, CRC Press, Taylor and Francis group, 2008.
2. Lee J.Krajewski, Larry P. Ritzman, Foundations of Operations Management, Addison Wesley, 2015.
3. Panneerselvam R., Production and operations management, Heritage Publishers, 2012.
4. Khanna O.P., Industrial Engineering and management, Dhanpat Rai Publications, 2012.
5. https://onlinecourses.nptel.ac.in/noc22_me04/preview
6. https://www.udemy.com/course/industrial-engineering-fundamentals-laurence-gartside/?utm_source

23ME63C	ENGINEERING METROLOGY AND MEASUREMENTS	L	T	P	E	C
		2	0	2	0	4

COURSE OUTCOMES

Upon the completion of this course the students will be able to

Theory Component:

CO1: Demonstrate the concepts of measurements.
CO2: Demonstrate the principles of linear and angular measurement tools.
CO3: Apply gear and form measurement techniques in practical industrial scenarios.
CO4: Demonstrate the procedure for conducting computer aided inspection.
CO5: Use various measuring techniques of power, flow and temperature.

Practical Component:

CO6: Execute calibration techniques for standard metrological instruments in accordance with ISO/ASTM standards.
CO7: Evaluate the performance of different types of linear instruments, comparators and angular instruments.
CO8: Evaluate key parameters of screw threads and gears using form measurement instruments.
CO9: Apply non-contact measurement techniques for the specific inspection.
CO10: Use LVDT, Thermocouple, and strain gauge systems and acquire experimental data under varying input conditions.

CO1 Demonstrate the concepts of measurements L:6

CO6 Execute calibration techniques for standard metrological instruments in accordance with ISO/ASTM standards P:6

Introduction to Metrology – Need – Elements – Work piece, Measuring Instruments – Persons – Environment – Their effect on precision and accuracy, static and dynamic response – Errors; Errors in measurements, error percentage – Uncertainty in measurements – Types – Control – Calibration – terminology, Types of standards.

Experimental demonstration and evaluation of Accuracy, Precision and calibration of metrological instruments using slip gauges.

CO2 Demonstrate the principles of linear and angular measurement tools L:6

CO7 Evaluate the performance of different types of linear instruments, comparators and angular instruments. P:8

Linear measuring instruments – Evolution – Types – Classification – limits, fits and tolerances, Limit gauges –Terminology – Procedure – Gauge design – Taylor's principle, Design of Go and No-Go gauges - Concepts of interchangeability and selective assembly – Comparators. Angular measuring instruments – Types – Bevel protractor, clinometers, angle gauges, spirit levels, sine bar – Angle alignment telescope.

Experimental Evaluation of tolerance of part using linear measuring instruments, Electrical & Mechanical Comparators, Angular Measurement using Sine bar and Bevel protractor.

CO3 Apply screw, gear and form measurement techniques in practical industrial scenarios. L:6

CO8 Evaluate key parameters of gears using form measurement instruments. P:6

Screw threads measurements - tool maker's microscope- Gear measurement – Gear tooth terminology, measurement of gear elements, constant chord and base tangent methods, Surface finish measurement, - Autocollimator – Straightness - Flatness measurement - roundness measurement- Cylindricity - Profilometer – Applications and case study.

Measurements Screw Thread dimensions using tool makers microscope - Gear tooth dimensions using a gear tooth vernier and optical profile projector and measurement of roundness measurement & cylindricity using V Block.

CO4 Demonstrate the procedure for conducting computer aided inspection / advances in metrology L:6

CO9 Apply non-contact measurement techniques for the specific inspection. P:4

CMM – Basic concepts, Types – Constructional features – Probes – Accessories – Software – Applications.

Basic concept of lasers – Laser interferometers – Types - LASER alignment telescope - laser scanner– Measurement capabilities - CNC machine calibration - Applications – Machine vision system: Basic concepts – Element – Applications.

Determine the straightness and flatness of a surface table using an autocollimator.

CO5 Use various measuring techniques of power, flow and temperature. L:6

CO10 Use LVDT, Thermocouple, and strain gauge systems and acquire experimental data under varying input conditions. P:6

Measurement of force, torque, power - Mechanical, pneumatic, hydraulic and electrical type - Flow measurement: Venturi meter, orifice meter, rotameter, pitot tube, ultrasonic flow measurements – Temperature: Bi-metallic strip, thermocouples, electrical resistance thermometer, infrared thermometer.

Temperature measurement using Thermocouple. Displacement using LVDT. Strain measurement of Cantilever beam using strain gauge.

L:30; P:30; TOTAL:60 PERIODS

TEXT BOOKS

1. Gupta. I.C., "Engineering Metrology", Dhanpatrai Publications, 2018.
2. Jain R.K. "Engineering Metrology", Khanna Publishers, 2009.

REFERENCES

1. Beckwith, Marangoni, Lienhard, "Mechanical Measurements", Pearson Education, 2014.
2. Raghavendra, Krishnamurthy "Engineering Metrology & Measurements", Oxford Univ. Press, 2013.
3. Donald Peckman, "Industrial Instrumentation", Wiley Eastern, 2004.
4. Alan S. Morris, "The essence of Measurement", Prentice Hall of India 1996.
5. Charles Reginald Shotbolt, "Metrology for Engineers", 5th Edition, Cengage Learning EMEA, 1990.
6. Holman J P, "Experimental methods for engineers" New York: McGraw-Hill, 1993
7. https://onlinecourses.nptel.ac.in/noc24_me99/preview
8. https://www.udemy.com/course/metrology/?utm_source=&couponCode=IND21PM

23ME64C	MACHINE ELEMENTS AND SYSTEM DESIGN	L	T	P	E	C
		3	1	0	2	5

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory component:

CO1: Design and analyze the shafts under various loading conditions.

CO2: Design mechanical couplings and bearings for given conditions.

CO3: Design springs and suitable joints under specified loading conditions.

CO4: Design and selection of Transmission elements.

CO5: Design gear drives and multi-speed gearboxes.

Experiential component:

CO6: Select and study a real-life machine component or system for a specific application.

CO7: Apply design principles to perform calculations and estimate design parameters.

CO8: Evaluate and compare calculated design parameters with real-world component specifications

Soft skill:

CO9: Collaborate effectively as a team member to analyze and present the project findings through a comprehensive technical report.

CO1 Design and analyze the shafts under various loading conditions. L:9, T:3

CO6 Select and study a real-life machine component or system for a specific application. E:6

Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers - Stress concentration - Fatigue life - Design for variable loading - Design of shafts based on strength.

Identification of a mechanical component or system used in a practical application - Analyze the functional role, operating environment, and design considerations - Usage of Design data book.

CO2 Design mechanical couplings and bearings for given conditions. L:9, T:3

Design - Rigid and Flexible Couplings - Hydrodynamic bearings - Static and dynamic load capacity – Selection of rolling contact bearings.

CO3 Design springs and suitable joints under specified loading conditions. L:9, T:3

CO7 Apply design principles to perform calculations and estimate design parameters. E:14

Springs – Helical and leaf springs – Design under static loading, Bolted Joints - Tightening torque - Simple and eccentrically loaded joints, Welded Joints – Types and strength analysis under axial, shear, and bending loads. (Tightening torque)

Performing design calculations using relevant formulas and design procedures for stresses, loads, material selection, safety factors, etc.

CO4 Design and selection of Transmission elements. L:9, T:3

Belt Drives – Types and design of flat and V-belt drives. Design - Transmission chains and sprockets.

CO5 Design gear drives and multi-speed gearboxes. L:9, T:3

CO8 Evaluate and compare calculated design parameters with real-world component specifications. E:10

Design of straight tooth spur & helical gears based on strength – Simple and compound Gear boxes – Multi-speed design, ray diagrams, kinematic arrangement.

Analyzing the calculated values with the real-world component's dimensions and specifications to validate design decisions.

TEXT BOOKS

1. Bhandari V. B., Design of Machine Elements, Tata McGraw Hill Education (India) Private Limited, New Delhi, 5th Edition, 2020.
2. Norton, R.L., Machine Design: An Integrated Approach, 6th Edition, Published by Pearson, 2021.

REFERENCES

1. Budynas, R.G. and Nisbett, J.K., Shigley_s Mechanical Engineering Design, 11th Edition, Tata McGraw Hill Education, 2020.
2. Schmid, S. R., Hamrock, B. J., and Jacobson, B. O., Fundamentals of Machine Elements, CRC Press, 3rd Edition, 2014.
3. R. S. Khurmi and J. K. Gupta, A Textbook of Machine Design, S Chand Publishing, New Delhi, 25th Edition, 2020.
4. Kamlesh Purohit and Sharma C. S., Design of Machine Elements, Prentice-Hall of India Private Limited, New Delhi, 3rd Edition, 2005.
5. Wentzell, Timothy H., Machine Design, Delmar Cengage Learning, U.S.A, 1st Edition, 2003.
6. Design of Machine Elements - I https://archive.nptel.ac.in/courses/112/105/112105124/
7. Machine design - II https://archive.nptel.ac.in/courses/112/106/112106137/

L: 45; T:15; E 30; TOTAL:90 HOURS

		L	T	P	E	C
23ME65C	**COMPUTER AIDED ANALYSIS**	**3**	**0**	**2**	**0**	**4**

COURSE OUTCOMES

Upon the completion of this course, the students will be able to

Theory Component:

CO1: Implement one-dimensional finite element models for solving structural problems involving bar, truss, and beam elements.

CO2: Apply two-dimensional finite elements to solve structural problems under plane stress and plane strain conditions.

CO3: Apply axisymmetric formulation and isoparametric elements to solve structural problems.

CO4: Solve heat transfer problems using appropriate finite element formulations.

CO5: Solve dynamic problems using appropriate finite element formulations.

Practical Component:

CO6: Perform 1D static stress analysis on bars, beams, and trusses using simulation tools.

CO7: Analyze stress and deformation in mechanical components under various static loading conditions.

CO8: Perform heat transfer analysis to evaluate the thermal behaviour of mechanical components.

CO9: Conduct modal and harmonic analysis to evaluate the dynamic behaviour of mechanical components.

CO1 Implement one-dimensional finite element models for solving structural problems involving bar, truss, and beam elements. **L:9**

CO6 Perform 1D static stress analysis on bars, beams, and trusses using simulation tools. **P:8**

Introduction to Finite Element Modeling, Coordinate Systems –Linear Bar Element, Truss, and Beam Elements – Interpolation Functions – Derivation of Element Matrices – Structural Problems.

Stress and Deformation under Axial and Bending loads - Stress analysis with self-weight - Analytical vs simulation results.

CO2 Apply two-dimensional finite elements to solve structural problems under plane stress and plane strain conditions. **L:9**

CO7 Analyze stress and deformation in mechanical components under various static loading conditions. **P:14**

Constant Strain Triangular (CST) Element – Shape Functions – Element Matrices and Vectors – Plane Stress and Plane Strain – Stress Calculations – Temperature Effects – Applications to Solid Mechanics Problems.

Static structural analysis of machine parts - Parametric study on stress variation - Analysis of pressure-loaded structures - Use of constraints, loads, and meshing in simulation

CO3 Apply axisymmetric formulation and isoparametric elements to solve structural problems. **L:9**

Axisymmetric Formulation – Shape Functions – Element Matrices and Vectors – Stress Calculations – Temperature Effects – Applications to Cylinders Under Internal Pressure.

Natural Coordinate Systems – Isoparametric Elements – Interpolation Functions and Element Matrices – Applications to Structural Problems.

CO4 Solve heat transfer problems using appropriate finite element formulations. **L:9**

CO8 Perform heat transfer analysis to evaluate the thermal behaviour of mechanical components. **P:4**

1D Heat Transfer – Element Matrices and Force Vectors – Applications of Bar Elements, 2D Heat Transfer – Element Matrices and Force Vectors – Applications of CST Elements.

Steady-state heat transfer analysis - Thermal stress due to temperature gradients.

CO5 Solve dynamic problems using appropriate finite element formulations. **L:9**

CO9 Conduct modal and harmonic analysis to evaluate the dynamic behaviour of mechanical components. **P:4**

Longitudinal Vibration of Bars and Beams – Lumped and Consistent Mass Matrices, Eigenvalue Analysis – Natural Frequencies and Mode Shapes.

Modal analysis - Harmonic response - Mode shapes and amplitude.

L:45; P:30; TOTAL:75 PERIODS

TEXT BOOKS

1. T. R. Chandrupatla and A. D. Belegundu, "Introduction to Finite Elements in Engineering", Pearson, 2021.
2. Seshu P, "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi, 2013.

REFERENCES

1. Rao, S.S., The Finite Element Method in Engineering, 6thEd., Elsevier Butterworth Heinemann, 2017.
2. Bathe, K.J., "Finite Element Procedures", PHI Learning, New Delhi, 2014.
3. David V Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw-Hill Edition, 2017.
4. Reddy J N, "An Introduction to the Finite Element Method", McGraw-Hill International Editions, 2018.
5. Nitin S. Gokhale, "Practical Finite Element Analysis", Finite to Infinite publishers, 2025.
6. https://nptel.ac.in/courses/112104193
7. https://archive.nptel.ac.in/courses/112/106/112106135/

23ME66C PRODUCT DEVELOPMENT PRACTICE

L	T	P	E	C
0	0	0	4	2

COURSE OUTCOMES

Upon the completion of this course the students will be able to

Experiential Component:

CO1: Identify and analyze real-world problems.

CO2: Apply forward engineering to develop innovative solutions.

Soft skill Component:

CO3: Demonstrate the functionality of the developed product through prototypes and validate its commercial and patenting potential.

CO1 Identify and analyze real-world problems. E: 25

- Empathy-driven customer need identification
- Problem definition and market analysis
- Study of existing solutions and reverse engineering analysis
- Deriving specifications and functional gaps
- Conceptual design based on gaps and feasibility

CO2 Apply forward engineering to develop innovative solutions. E:35

- Concept refinement and solution detailing
- Rough model and Working model Prototype development (hardware/software)
- Technical, financial, and IP (intellectual property) feasibility study
- Cost estimation and business model canvas
- Prototype demonstration and product documentation

E:60; TOTAL:60 PERIODS

REFERENCES

1. Avinash K. Chitale, R. C. Gupta, Product Design and Manufacturing, PHI Learning Pvt. Ltd., 7th Edition, 2022
2. Anil Mital, Aashi Mital, Anoop Desai, Anand Subramanian, Product Development: A Structured Approach to Consumer Product Development, Design, and Manufacture, Elsevier, 2nd Edition, 2014
3. George E. Dieter, Engineering Design, McGraw-Hill Education, 5th edition, 2012.
4. Prithwiraj Nath, New Product Development, Oxford University Press India, 1st Edition,

2014
5. Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, Product Design and Development, McGraw Hill Education, 7th Edition, 2020
6. Idris Mootee, Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, Wiley, 1st Edition, 2013
7. Jeff Gothelf, Josh Seiden, Lean UX: Designing Great Products with Agile Teams, O'Reilly Media, 3rd Edition, 2021.

23ME71C	MINI PROJECT	L	T	P	E	C
		0	0	0	6	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Experiential component:

CO1: Identify and define an engineering problem through need analysis, systematic literature review and feasibility study.

CO2: Develop an appropriate methodology, preliminary design/model, and project plan with required resources and timelines.

Soft skill component:

CO3: Communicate project ideas effectively through structured documentation, teamwork, and technical presentations.

Course content:

Selection of topic/problem based on relevance to industry / society / research, literature review – survey of existing solutions – research papers, identification of gaps, defining the problem clearly. Objectives of the project & scope.

Project Planning, Methodology, Block diagrams, Flow diagrams, Algorithm design, Resource identification, Basic simulation and prototype (if applicable), Life cycle costing.

Structured documentation and Presentation

E:90; TOTAL: 90 PERIODS

23ME72C	INTERNSHIP	L	T	P	E	C
		0	0	0	0	2

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Experiential Component:

CO1: Gain practical knowledge through internship in real-world industries, research organizations and institutes.

Softskill Component:

CO2: Document and communicate internship learnings effectively through technical report and presentation.

DURATION:

The students have to undergo practical industrial training for minimum of four week in recognized industrial establishments as per Regulations 2023.

A. Student shall undergo internship after getting prior permission from the head of the department

B. A report should be submitted after the successful completion of internship with the following content:

1. Profile of the Industry/Research Institute,
2. Product/Research Area,
3. Organization Structure,
4. Facility/Plant/Research Layout,
5. Processes/Machines/Equipment/Devices,
6. Personnel Welfare Schemes,
7. Details of the Training Undergone,
8. Projects Undertaken During the Training (if any), and
9. Learning Points.

23ME81C CAPSTONE PROJECT/INDUSTRYPRACTICE

L	T	P	E	C
0	0	0	12	6

CAPSTONE PROJECT

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Experiential component:

CO1: Identify, analyze, and define a significant engineering problem using based on need assessment, literature survey and domain knowledge.

CO2: Apply appropriate engineering methods, design principles, tools, and modern software to develop and implement a solution or prototype with sustainability considerations.

CO3: Conduct experiments, analyze data, evaluate results, and interpret findings with integrity and ethics.

Soft skill component:

CO4: Prepare comprehensive project documentation and effectively present technical results in reputed conferences / journals

Course Content

Domain Analysis, Problem Identification, Literature Review / Market survey, Methodology, Design and Implementation, Experimental Work / Simulation / Analytical studies / Optimization / Testing, Project Management - Life cycle costing, Documentation & Presentation.

E:180; TOTAL: 180 PERIODS

INDUSTRY PRACTICE

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Participate in the training / projects in industries during his or her internship at industry.

CO2: Describe the use of advanced tools and techniques encountered during the internship.

CO3: Interact with industrial personnel and follow engineering practices and discipline prescribed in industry.

CO4: Prepare professional work reports and presentations.

B.E. – MECHANICAL ENGINEERING

PROGRAMME ELECTIVE COURSES

23ME01E **POWER PLANT ENGINEERING**

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the working of various components of thermal power plant and estimate the performance of steam boilers

CO2: Demonstrate the functions of different components of nuclear and hydel power plants

CO3: Demonstrate the working principles of diesel and gas turbine power plants

CO4: Demonstrate the basics and working of renewable based power plants

CO5:Estimate the economy of power plants and recognize the environmental and regulatory issues related to various power plants

CO1 Demonstrate the working of various components of thermal power plant and estimate the performance of steam boilers **L:9**

Layout - Fuel and ash handling, Combustion Equipment for burning coal, Mechanical Stokers. Pulveriser, Electrostatic Precipitator, Draught, condenser and Cooling Towers -Steam Boilers - High pressure and Super Critical Boilers - Fluidized Bed Boilers -Performance of boiler - Environmental effects.

CO2 Demonstrate the functions of different components of nuclear and hydel power plants **L:9**

Nuclear Energy - Fission, Fusion Reaction, Types of Reactors, Waste disposal and safety nuclear waste transportation norms - Hydel Power plant - Layout - Essential Elements, Selection of turbines, governing of Turbines.

CO3 Demonstrate the working principles of diesel and gas turbine power plants **L:9**

Layout - Types of diesel plants, components, Selection of Engine type, applications – Gasturbine Power plant - Layout - Gas turbine material - open and closed cycles - reheating -Regeneration and inter cooling - combined cycle.

CO4 Demonstrate the basics and working of renewable based power plants **L:9**

Solar Energy- Conversion Techniques, Applications. Wind energy- Potential, Conversion Techniques and its features. Biomass: sources, characterization, conversion methods. Construction and working of MHD - Geo thermal - OTEC - Tidal Power Plants.

CO5 Estimate the economy of power plants and recognize the environmental and regulatory issues related to various power plants **L:9**

Cost of Electric Energy - Fixed and operating costs - Energy rates - Types tariffs -Economics of Load sharing - comparison of various power plants - Emission from various power plants -Environmental affects and its remedies - Environmental regulatory and norms for power plant.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Arora SC and Domkundwar S, “A Course in Power Plant Engineering”, Dhanpat Rai, Eighth Edition 2016.
2. EI-Wakil MM, “Power Plant Technology”, Tata McGraw-Hill, 2010.

REFERENCES

1. Sharma SC and Nagpal, "A Text Book of Power Plant Engineering", Jain publication,16th Edition, 2015.
2. Nag PK, "Power Plant Engineering", Tata McGraw- Hill, 4th Edition, 2017.
3. Ramalingam KK, "Power Plant Engineering", Scitech Publications, 2015.
4. Rai GD, "Introduction to Power Plant technology", Khanna Publishers, 11th Reprint Edition, 2013.
5. Indian boiler regulations (IBR) Act, 2005.
6. NPTEL Course: https://nptel.ac.in/courses/112107291

23ME02E	RENEWABLE ENERGY SOURCES	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the physics of solar radiation, different solar collectors and energy storage

CO2: Illustrate the fundamentals of solar PV systems and uses in other solar energy systems

CO3: Demonstratethe concepts of extraction of wind energy

CO4: Interpret the concepts of various bio-energy conversion techniques

CO5: Demonstrate the other available forms of renewable energy sources

CO1 Demonstrate the physics of solar radiation, different solar collectors and energy storage L:9

Energy scenario – Introduction – Energy resources and its Types – Energy Parameters - Principles of renewable energy – Solar radiation – Measurements of solar radiation and sunshine – Solar Collectors – Flat plate collectors – Parabolic Concentrators – Linear Fresnel Lens Collector – Paraboloidal Dish Collector – Central Tower Receiver Collector - Solar energy storage – Sensible and Latent Heat Storage with applications.

CO2 Illustrate the fundamentals of solar PV systems and uses in other solar energy systems L:9

Fundamentals of solar photovoltaic systems – Solar cells Module, Panel and Array and its Characteristics - Sustainability of solar cell materials and recycling – Solar PV applications – Solar Pond, Solar water heater, Solar Distillation, Solar Refrigeration and Cooling System, Solar Thermal Power Plants.

CO3 Demonstrate the concepts of extraction of wind energy L:9

Introduction – Wind Sources and its potentials - Wind data and energy estimation – Betz limit – Site selection for wind farms - Basic components of wind energy conversion system – Types of Wind mills – HAWT, VAWT, Savonius Rotor and Darrieus Rotor – Wind Energy Storage – Environmental impacts and Applications

CO4 Interpret the concepts of various bio-energy conversion techniques L:9

Introduction - Biomass resources – Biogas – Aerobic and anaerobic Processes - Classification of Biogas plants – Application of Biogas in IC Engine – Biomass Conversion Technologies – Biomass Gasification – Biomass Gasifier and its types - Energy Recovery from Urban Waste by Landfill Reactors – Pyrolysis and Digestors – Size and Location of Biogas plant – Problems and Constraints in the use of Biogas.

CO5 Demonstrate the other available forms of renewable energy sources L:9

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. Ocean Energy: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics. Direct Energy Conversion: Need for DEC, Carnot cycle, limitations, principles of DEC.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Rai G.D. Non-Conventional Energy Sources‖, Khanna Publishers, 2013.
2. Twidell&Wier, Renewable Energy Resources‖, CRC Press (Taylor & Francis), 2011.

REFERENCES

1. Tiwari and Ghosal, Renewable energy resources‖, Narosa Publishing House, Re-print 2015.
2. Ramesh R & Kumar K.U, Renewable Energy Technologies‖, Narosa Publishing House, Re-print 2018.
3. Solanki, Chetan Singh. Renewable Energy Technologies: A Practical Guide for Beginners‖, 2nd Edition, P.H.I, New Delhi, 2013.
4. Kothari D.P, Singhal., K.C., Renewable energy sources and emerging technologies, 2nd Edition, P.H.I, New Delhi, 2015.
5. B H Khan, Non-Conventional Energy Resources, 3rd Edition, McGraw Hill Education India Private Limited, 2017.
6. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Third Edition, Oxford University Press, 2013.
7. G.S.Sawhney, "Non Conventional Energy Resources", Asoke K Ghosh PHI Learning private Limited, New Delhi 2011.

23ME03E SOLAR PHOTOVOLTAIC ENERGY CONVERSION

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the fundamentals of solar cells and principles of solar radiation measurement

CO2: Demonstrate the principles, materials, and fabrication techniques of various existing and emerging solar PV technologies

CO3: Use the suitable techniques and process for PV module fabrication and assembly

CO4: Design and analyze on–grid and off-grid PV systems

CO5: Predict the PV system performance and accomplish cost benefit analysis of PV installations

CO1: Demonstrate the fundamentals of solar cells and principles of solar radiation measurement **L:9**

Semiconductor fundamentals - PN Junction, doping, carrier motion & recombination. Photovoltaic effect, Solar cells – design characteristics, parameters influencing performance, losses in solar cells, Solar radiation measurement and predictions - standard test conditions, Measuring instruments– pyranometer, pyrheliometer.

CO2: Demonstrate the principles, materials, and fabrication techniques of various existing and emerging solar PV technologies **L:9**

Mono and poly – crystalline cells, Si wafer, Ingots and sheets production, process flow of commercial Si cell technology. Thin film solar cells – A-Si, CIS/CdTe/CIGS - deposition techniques – Evaporation, Sputtering - Physical vapour deposition (PVD), Chemical vapour deposition (CVD) – Plasma enhanced CVD, Emerging technologies – Multi-junction cells, Dye sensitized cells, Perovskite cells.

CO3: Use the suitable techniques and process for PV module fabrication and assembly **L:9**

Solar PV module - Optical loss minimization - Anti reflective coating, Surface texturing, Surface passivation, Metal contacts. PV module fabrication: Number of cells in a module, blocking and byepass diode, packing density, Hot spots, Solar simulator: I-V measurement, Standard PV module parameters, Solar PV arrays – modules in series and parallel.

CO4: Design and analyze on–grid and off-grid PV systems **L:9**

Balance of system – DC-DC converters – Inverters – Maximum power point tracking – On-Grid PV system – Net Metering, Off-Grid stand-alone PV system – System sizing – Charge controller – Storage Batteries, Design & analysis – Performance monitoring – Field visit.

CO5: Predict the PV system performance and accomplish cost benefit analysis of PV installations **L:9**

PV systems – Maintenance – Troubleshooting of system components, Performance prediction and optimization – PVsyst – PV Performance Modeling - Energy yield - Performance Ratio - Capacity Factor - System Losses, Economic indicators: Simple payback, Life cycle costing.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Chetan Singh Solanki “Solar Photovoltaics Fundamentals, Technologies and Applications”, 3rd Edition, Prentice Hall of India, 2019.

REFERENCES

1. Chetan Singh Solanki “Solar Photovoltaic Technologies and Systems – A manual for Technicians, Trainers and Engineers”, Prentice Hall of India, 2023.
2. Robert Foster Majid Ghassemi, Alma Cota “Solar Energy – Renewable Energy and the Environment”, CRC Press, 2016
3. James P. Dunlop “Photovoltaic Systems”, 2nd Edition, American Technical Publishers, 2015
4. A. Goetzberger, V.U. Hoffmann “Photovoltaic Solar Energy Generation”, Springer-Verlag Berlin, Heidelberg, 2015.
5. www.pveducation.org

6. https://www.pvsyst.com/pdf-tutorials/
7. https://onlinecourses.nptel.ac.in/noc25_ph34/preview

23ME04E	**COGENERATION AND WASTE HEAT RECOVERY**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the concepts of cogeneration
CO2: Analyze the applications and techno economics of cogeneration systems
CO3: Demonstrate the concepts of waste heat recovery and its sources
CO4: Select a proper heat recovery system to enhance the performance
CO5: Implement the economic analysis of cogeneration and waste heat recovery systems

CO1 Demonstrate the concepts of cogeneration L:9

Introduction to cogeneration - Heat to Power ratio - Technical Parameters and Performance indices of Cogeneration system - Cogeneration with Steam Turbine Cycle and Gas Turbine Cycle - Integrated Gasification Combined Cycle (IGCC) - Other Cogeneration Technologies: Steam turbine topping systems and heat recovery from engine exhaust - Case studies.

CO2 Analyze the applications and techno economics of cogeneration systems. L:9

Cogeneration Application in various industries like Cement - Sugar Mill - Paper Mill - Applications of Cogeneration in utility sector – building sector – rural sector - Utility and cogeneration plant interconnection issues - Impacts of cogeneration plants – Fuel, electricity and environment.

CO3 Demonstrate the concepts of waste heat recovery and its sources L:9

Waste Heat Sources – Selection criteria for waste heat recovery technologies – Special Heat Exchangers for Waste Heat Recovery – Classifications and design Considerations – Heat pipes & Vapor Chambers - Heat Recovery Steam Generator (HRSG) - Regenerative & Recuperative burners - Economizer - Direct & Indirect contact condensation recovery - Hurdles in the Waste Heat Recovery Process.

CO4 Select a proper heat recovery system to enhance the performance L:9

Direct conversion technologies – Thermoelectric Generators, Thermionic conversion, Thermo-PV, MHD - Heat Recovery from Incinerators, Energy Storage Techniques - Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage - Thermal storage (Sensible & Latent), Chemical Energy Storage

CO5 Implement the economic analysis of cogeneration and waste heat recovery systems L:9

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for Cogeneration.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. R.Kehlhofer, B. Rukes, F. Hannemann, F. Stirnimann, ―Combined-cycle Gas & Steam Turbine Power Plants, PennWell Books, 3rd Edition, 2009.

REFERENCES

1. B.F.Kolanowski, ―Small-scale cogeneration handbook, River Publishers, 5th Edition, 2022.
2. M.P. Boyce, ―Handbook for cogeneration and combined cycle power plants, ASME Press, 2nd Edition, 2010.
3. A.Thumann, D. Paul Mehta, ―Handbook of energy engineering, The Fairmont Press, Inc, 7th Edition, 2013.
4. Steve Doty, Wayne C. Turner, ―Energy management handbook, The Fairmont Press, Inc., 9th Edition, 2018.
5. https://nptel.ac.in/courses/112105221
6. Pradeep K. Sinha - Energy Efficiency in Thermal Utilities, Bureau of Energy Efficiency, Fourth Edition, 2015.

23ME05E	ENERGY EFFICIENT BUILDINGS	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO 1: Demonstrate conventional and energy efficient buildings versatile with energy conservation building codes
CO 2: Design an energy efficient landscape system
CO 3: Examine different solutions for HVAC in buildings
CO 4: Analyze the heat transmission in buildings
CO 5: Implement integration of renewable energy in buildings

CO1 Demonstrate conventional and energy efficient buildings versatile with energy conservation building codes **L:9**

Conventional versus energy efficient buildings–Understanding building Energy use – Energy efficiency potential in buildings -IAQ requirement analysis – Future building design aspects – critical of resources and needs of modern living – Building assessment and green building processes – Materials for energy efficiency-Energy conservation building codes.

CO2 Design an energy efficient landscape system **L:9**

Energy efficient landscape design – Micro climates – various methods – Shading, water bodies –Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, insulation, Design methods and tools.

CO3 Examine different solutions for HVAC in buildings **L:9**

Natural Ventilation, Passive cooling and heating: Thermal mass effects – Application of wind, water and earth for cooling, evaporative cooling, radiant cooling, shading, paints and cavity walls for cooling; roof radiation traps, Earth air tunnel – Building Management system and Building Automation - Hybrid methods – energy conservation measures, thermal storage integration in buildings.

CO4 Analyze the heat transmission in buildings **L:9**

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; heat transfer due to ventilation / infiltration, internal heat transfer; solar temperature; decrement factor; phase lag. Design of day lighting; Different methods of estimation of thermal loads; Computer packages for carrying out thermal design of buildings and predicting performance. Thermal load estimation: Heat balance method. Degree day method for seasonal energy consumption.

CO5 Implement integration of renewable energy in buildings L:9

Solar absorption cooling and Solar vapor compression cooling for buildings – Solar water heating systems in buildings – Small wind turbines, standalone PV, Hybrid systems for residential buildings with economics.Case studies and simple design of energy efficient buildings.

L45; TOTAL:45 PERIODS

TEXT BOOKS

1. Krieder. J, and Rabi. A., Heating and cooling of buildings: design for efficiency, McGraw Hill, New Delhi, 2nd Edition 2010.
2. Charles. J. Kibert, Sustainable Construction: Green Building Design and Deliver, John Wiley& Sons, 2016.

REFERENCES

1. ASHRAE Handbook—Fundamentals, 2021.
2. Duffie, A and Beckmann, W. A., Solar Engineering of Thermal Processes, John Wiley, 1991.
3. R.Velraj, 'Sensible heat Storage for solar heating and cooling systems' in the book titled "Advances in Solar Heating and Cooling – Pages 399 - 428 Elsevier Publication, 2016.
4. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
5. Ursala Eicker, "Solar Technologies for buildings, Wiley Publications, 2003. 3 Guide book for national certification examination for energy managers and energy auditors (downloaded from www.energymanagertraining.com)
6. Michael Bauer, Peter Mosle and Michael Schwarz, Green Building - Guidebook for Sustainable Architecture, 2009.
7. https://nptel.ac.in/courses/105102175 - Energy Efficiency, Acoustics and day lighting in Building.
8. https://nptel.ac.in/courses/103103206, Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems.
9. Energy Conservation Building Codes 2017; Bureau of Energy Efficiency.

23ME06E ENERGY CONSERVATION IN INDUSTRIES

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Explore energy resources, conservation opportunities, and basic energy auditing principles and practices.

CO2: Demonstrate energy accounting, financial analysis techniques, and key mechanisms for effective energy management.

CO3: Analyze billing parameters, power quality factors, and energy efficiency practices in electrical systems.

CO4: Analyze the thermal systems in industries for energy efficiency

CO5: Identify performance evaluation methods and energy-saving opportunities in major industrial utilities.

CO1 Explore energy resources, conservation opportunities, and basic energy auditing principles and practices. L:9

Energy Resources Availability in Tamil Nadu, India and World - Energy consumption pattern – Energy conservation potential in various Industries - EC Act 2003 - ISO 50001Energy management

Energy Auditing: Types, classifications, deliverables, barriers – Benchmarking - Roles & Responsibility of Energy Managers and Auditors – Basic Instruments for Energy Auditing

CO2 Demonstrate energy accounting, financial analysis techniques, and key mechanisms for effective energy management. **L:9**

Energy Accounting and Balancing – Depreciation - Financial Analysis Techniques:Discount Rate, Payback Period, Internal Rate of Return, Net Present Value– CUSUM Technique – ESCO–Carbon Trading- Renewable Energy Certification – CDM

CO3 Analyzebilling parameters, power quality factors, and energy efficiency practices in electrical systems. **L:9**

Analysis on billing Parameters accounted by TANGEDCO for HT and LT supply - Transformers - Power Factor – Harmonics - Electric Motors : Motor Efficiency Computation, Energy Efficient Motors - Encon in Illumination systems

CO4 Analyze the thermal systems in industries for energy efficiency **L:9**

Stoichiometry - Efficiency Computation and Encon Measures in Boilers, Furnaces, Heat Exchangers and Thermic Fluid Heaters - Steam Traps - Cogeneration – Waste heat recovery.

CO5 Identify performance evaluation methods and energy-saving opportunities in major industrial utilities **L:9**

Performance evaluation and energy saving avenues in major industrial utilities: Pumps – Fans – Blowers - Compressed Air Systems - Refrigeration and Air Conditioning Systems - Cooling Towers - D.G. sets.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Energy Manager Training Manual (4 Volumes) available at https://beeindia.gov.in/content/energy-auditors, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2017.

REFERENCES

1. Witte L.C., Schmidt P.S. and Brown D.R., "Industrial Energy Management and Utilization",2nd Edition, Hemisphere Publ., Washington, Reprint 2023.
2. Steve Doty, Wayne C. Turner "Energy Management Handbook", 7th Edition, the FairmontPress, Inc., 2013.Callaghan P.W., "Design and Management for Energy Conservation", Pergamum Press, Oxford, 2012.
3. Murphy W.R. and McKay G., "Energy Management", 4th Edition Butterworth's, London, 2009.
4. Dale R Patrick, Stephen W Fardo, "Energy Conservation Guidebook", 2nd Edition, CRC Press, 2017.
5. Amlan Chakrabarti, "Energy Engineering and Management", 2nd Edition, PHI Learning Pvt Ltd., 2018.
6. Frank Kreith, D. Yogi Goswami, "Energy Management and Conservation Handbook", CRC Press, 2008.

23ME07E	THERMAL MANAGEMENT OF BATTERIES AND FUEL CELLS	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Apply the principles of lithium-ion cell chemistry to select suitable battery formats for electric vehicle applications.

CO2: Apply the different battery cooling methods to recommend suitable systems for electric vehicle applications.

CO3: Analyze the impact of thermal management on battery lifespan, efficiency and safety in electric vehicles.

CO4: Apply the operating principles of various fuel cells to examine their performance in electric vehicle applications

CO5: Analyze the concept of sizing and fuel economy to evaluate trade-offs between BEV and FCEV**.**

CO1 Applythe principles of lithium-ion cell chemistry to select suitable battery formats for electric vehicle applications. **L:9**

Li-ion Batteries - chemistry, different formats, operating areas, efficiency, ageing. Battery Management System- Configuration, Characteristics. Battery Model S - 18650 Cell specifications, P85 Battery Pack mechanical structure, Texas Instruments BMS. Supercapacitors Vs batteries. Diamond battery concepts.

CO2 Applythe different battery cooling methods to recommend suitable systems for electric vehicle applications. **L:9**

Thermal Management Systems- impact, Types- Air, Liquid, Direct refrigerant, Heat pipe, Thermo-Electric, Phase Change Material Cooling methods. Solid-liquid PCM Types- Organic, Inorganic, Eutectics. PCM Thermal Properties and applications. Battery Model-S Battery Module- bonding techniques, thermal management.

CO3 Analyzethe impact of thermal management on battery lifespan, efficiency and safety in electric vehicles. **L:9**

EV Battery Cooling - challenges and solutions. Heat Exchanger Design and Optimization Model for EV Batteries using PCMs- system set up, selection of PCMs. Chevrolet Volt Model Battery Thermal Management System- Case study. Modelling Liquid Cooling of a Li-Ion Battery Pack Multiphysics- simulation concepts.

CO4 Apply the operating principles of various fuel cells to examine their performance in electric vehicle applications. L:9

Fuel Cells- operating principle, hydrogen-air fuel cell system characteristics, other fuel cell technologies, polarization curves, applications. Fuel cell thermal management- basic model, energy balance, governing equations, characteristic curve, sizing, cooling methods, advantages, restrictions.

CO5 Analyze the concept of sizing and fuel economy to evaluate trade-offs between BEV and FCEV. L:9

Fuel cell system- balance of plant- components required. Fuel cell power plant sizing problems- Fuel Cell Electric Vehicle Fuel Economy Calculations-Battery EVs Vs Fuel Cell EVs. Toyota Mirai FCV- Operating principle, High pressure hydrogen tank, Boost convertor, Ni-MH Battery, Internal circulation system, Hydrogen refueling- Case studies.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Ibrahim Dinçer, Halil S. Hamut, and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems'', Wiley, 2017.
2. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles-Fundamentals, Theory, and Design'', CRC Press, 3rd Edition, 2018.

REFERENCES

1. Jiuchun Jiang and Caiping Zhang, "Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles'', Wiley, 2015.
2. John G. Hayes and G. Abas Goodarzi, "Electric Powertrain", Wiley, 2018
3. Davide Andrea, "Battery Management Systems for Large Lithium-Ion Battery Packs" ARTECH House, 2010.
4. "Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
5. T. Yomi Obidi, "Thermal Management in Automotive applications", 2015, SAE International.
6. Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw- Hill
7. NPTEL: Battery Pack Design and Development: Fundamentals, Prof. Atriya Biswas and Dr Kaushal Kumar Jha, IIT Madras.

23ME08E	HYBRID AND ELECTRIC VEHICLES	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO 1: Demonstrate architecture and operation principles of hybrid and electric vehicles.
CO 2: Identify suitable propulsion system components for EV/HEV applications.
CO 3: Select and evaluate appropriate energy storage systems for specific applications.
CO 4: Estimate and size the key components of the drivetrain of hybrid and electric vehicles.
CO 5: Demonstrate and compare energy management strategies used in EV/HEV platforms.

CO1 Demonstrate architecture and operation principles of hybrid and electric vehicles. **9**

History and evolution of hybrid and electric vehicles. Social, environmental, and economic impact. Vehicle performance basics and power source characterization. Hybrid and electric drivetrains: architecture and topologies. Power flow control in hybrid and electric drivetrains. Fuel efficiency analysis and impact of modern drivetrains on energy systems.

CO2 Identify suitable propulsion system components for EV/HEV applications. **9**

Electric components used in EV/HEV powertrains. Configuration and control of various electric motor drives:DC Motor Drives, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motor Drives.Power electronics in propulsion systems. Drive system efficiency and performance considerations.

CO3 Select and evaluate appropriate energy storage systems for specific applications. **9**

Energy storage requirements for EVs and HEVs.Battery systems: types, characteristics, modeling, and performance analysis. Fuel cell technology: working principles and system integration. Supercapacitors and high-power storage systems. Hybridization of energy storage devices for optimized efficiency.

CO4 Estimate and size the key components of the drivetrain of hybrid and electric vehicles. **9**

Principles of matching the electric motor with internal combustion engines for electric and hybrid vehicles. Sizing propulsion motors and power electronics. Energy storage selection criteria (power/energy trade-offs). Supporting subsystems and vehicle communication networks - Controller Area Network (CAN), Battery Management System (BMS), Energy Management System (EMS).

CO5 Demonstrate and compare energy management strategies used in EV/HEV platforms. **9**

Objectives and functions of energy management in EVs and HEVs. Classification and comparison of different strategies: Rule-Based, Optimization-Based, Soft Computing / Artificial Intelligence-Based. Implementation challenges and case studies. Design approach for HEV and BEV platforms.

L45; TOTAL:45 PERIODS

TEXT BOOKS

1. Electric and Hybrid Vehicles: Design Fundamentals – Iqbal Husain, 2nd Edition, CRC Press, 2011.

REFERENCES

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design – Mehrdad Ehsani, Yimin Gao, Sebastian E. Gay, Ali Emadi, 2nd Edition, CRC Press, 2009.
2. Electric Vehicle Technology Explained – James Larminie & John Lowry, 2nd Edition, Wiley, 2012.
3. Battery Management Systems for Large Lithium-Ion Battery Packs – Davide Andrea, 1st Edition, Artech House, 2010.
4. Automotive Electrical and Electronic Systems – Tom Denton, 5th Edition, Routledge, 2017.
5. Vehicle Dynamics: Theory and Application – Reza N. Jazar, 3rd Edition, Springer, 2017.
6. Standards and Regulations – AIS & CMVR (India), ISO 26262 (2018), IEC 61851 (2017), UNECE Regulations for Evs.
7. NPTEL: Introduction to Hybrid and Electric Vehicles, Prof. S. Majhi, Dr. Praveen Kumar, IIT Guwahati, https://nptel.ac.in/courses/108103009

23ME20E	**PRODUCT DESIGN AND DEVELOPMENT STRATEGIES**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the basic principles of generic development process and need analysis

CO2: Demonstrate the process of concept selection for new product design and

development

CO3: Analyze the various aspects in detail design
CO4: Demonstrate the principles of design validation and prototyping techniques
CO5: Interpret the concepts of economics principles and project management practices

CO1 Demonstrate the basic principles of generic development process and need analysis **L:9**

Introduction - A Generic Development Process - Concurrent Engineering Principles-Field and Market analysis - Data collection techniques - Analysis of Data, PESTEL analysis - Identifying Customer Needs - House of Quality for Specifications - Establishing Target Specifications - Setting the Final Specifications.

CO2 Demonstrate the process of concept selection for new product design and development **L:9**

Concept generation activities - Pugh concept selection method: Concept screening; Concept scoring - Concept testing - Value Analysis.

CO3 Analyze the various aspects in detail design **L:9**

Architecture of Product - Sizing of Parts - Selection of materials using Bubble chart - Selection of Manufacturing Processes - Design for Manufacturing - Design for Assembly - Design for Ergonomics - Importance of Tolerances - Detail Design and Bill of Materials.

CO4 Demonstrate the principles of design validation and prototyping techniques **L:9**

Prototyping techniques - Additive Manufacturing - Virtual Prototyping using FEA - Topology, Shape and Size Optimization - Generative Design.

CO5 Interpret the concepts of economics principles and project management practices **L:9**

Product Development Economics: Economic Analysis Process - Managing Projects: Protecting intellectual property - Patents, Trade mark and copy right.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. George E.Dieter, Linda C.Schmidt, - Engineering Design, McGraw-Hill InternationalEdition, 6th Edition, 2022.
2. Karl T Ulrich, Steven D Eppinger, Maria C Yang, - Product Design and Development,7th Edition, Tata McGraw-Hill Education, 2020.

REFERENCES

1. Kevin Otto, Kristin Wood, Product Design, Indian Reprint, Pearson Education, 2007.
2. Clive L.Dym, Patrick Little, Engineering Design: A Project-based Introduction, 4th Edition, John Wiley & Sons, 2013.
3. S.P. Jain & K.L. Narang, ―Advanced Cost Accounting, Kalyani Publishers, 2017.
4. NPTEL course link: https://onlinecourses.nptel.ac.in/noc24_me81

23ME21E HYDRAULICS AND PNEUMATICS L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the components in fluid power systems and their applications
CO2: Select suitable fluid power actuator for the stated fluid operated system
CO3: Interpret functions of different control components and use them in circuit design
CO4: Design and develop the fluid power circuit for any specific applications
CO5: Design the relay and ladder logic diagram for the given application

CO1 Demonstrate the components in fluid power systems and their applications **L:9**

Introduction to Fluid power systems - Types, Advantages and Applications. Properties of hydraulic fluids - General types of fluids - Basics of Hydraulics system – fluid power symbols - Applications of Pascal's Law. Sources of Hydraulic Power - Pumping theory - Pump classification - Construction and working of Gear, Vane and Piston pumps – Pump performance. Pneumatic components - Compressors - Filter, Regulator, and Lubricator (FRL) unit.

CO2 Select suitable fluid power actuator for the stated fluid operated system **L:9**

Fluid Power Actuators- Linear actuators - Single acting, Double acting, special cylinders like tandem, Rod less, Telescopic. Cushioning mechanism in linear actuators. Rotary actuators - Gear, Vane and Piston motors. Pneumatic actuators.

CO3 Interpret functions of different control components and use them in circuit design **L:9**

Types of control components - Direction control valves - Shuttle valve - check valve - pressure control valve - counterbalance valves - pressure reducing valve - sequence valve. Flow control valves - fixed and adjustable, solenoid valves, relays - Methods of actuation. Accumulators and Intensifiers - types - working principle - sizing of accumulators - pressure intensifier - applications.

CO4 Design and develop the fluid power circuit for any specific applications **L:9**

Fluid Power Circuit Design, Circuits for acceleration and deceleration, synchronizing circuit, regenerative circuits, Pump unloading circuit, sequencing circuits, Speed control circuits, accumulator circuits, hydro-pneumatic circuits, fail-safe circuits, sequential circuit design for simple applications using cascade method.

CO5 Design the relay and ladder logic diagram for the given application **L:9**

Servo systems - Hydro mechanical servo systems, Electro-hydraulic servo systems and proportional valves. Electrical control of pneumatic and hydraulic circuits-use of relays, Introduction to PLC - ladder logic - Ladder diagram using internal relay, timers, and counters - applications of PLC in fluid power control - case studies on simple pneumatic systems.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Anthony Esposito, Fluid Power with Applications, 7th Edition, Pearson Education New Delhi, 2018.
2. James L Johnson, Introduction to Fluid Power, S.Chand (G/L) & Company Ltd, 2002.

REFERENCES

1. Andrew Parr, Hydraulics and Pneumatics, Jaico Publishing House, 2013.
2. John S Cundiff, Fluid Power Circuits and Controls - Fundamentals & Applications, CRC Press, 2019.
3. Majumdar SR, Pneumatic Systems - Principles and Maintenance, Tata McGraw Hill, 2017.
4. Majumdar SR, Oil Hydraulic Systems - Principles and Maintenance, Tata McGraw Hill, 2017.
5. Illango S and Soundararajan V, Introduction to Hydraulics and Pneumatics Prentice Hall of India, 2012.
6. William Bolton, Pneumatic & Hydraulic Systems, Butterworth-Heinemann Ltd, 2017.
7. https://nptel.ac.in/courses/112/106/112106300/
8. https://nptel.ac.in/courses/112105046

23ME22E **INDUSTRIAL ROBOTICS**

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the basics of robots and safety standards and economics of robots
CO2: Demonstrate the configuration of the robot and perform the simple forward and inverse kinematics of Manipulator movements.
CO3: Select suitable sensors for the robot and summarize of robot's machine vision system.
CO4: Write simple robot programs to move the robot on a specific route sequence
CO5: Explore industrial applications of robots

CO1 Demonstrate the basics of robots and safety standards and economics of robots **L:9**

Definition, Laws of a robot, Classification of Robot – Industrial Robot & Service Robot, Anatomy, Spatial coordinates, Geometric configurations and work envelope, Machine Intelligence, Criteria for robot selection, Safety standards for Industrial Robot, Economic justification.

CO2 Demonstrate the configuration of the robot and perform the simple forward and inverse kinematics of Manipulator movements. **L:9**

Basic control system concepts - control system analysis - robot actuation and feedback, Manipulators - Coordinate transformation - Brief of Robot dynamics. Types of end effectors - Grippers - Tools as end effectors.

Introduction to manipulator kinematics, Homogeneous transformations and robot kinematics, Denavit- Hartenberg (D-H) representation, Concept of forward and inverse kinematics.

CO3 Select suitable sensors for the robot and summarize of robot's machine vision system **L:9**

Mechanical control by stops and cams, Solenoids, Relays; Internal Sensors, potentiometers, resolvers and encoders; External sensing: Simple touch sensing, strain sensing, tactile sensing, acoustic sensing, magnetic sensing, capacitive sensing, laser sensing- Camera- applications.

Introduction to Machine vision - Sensing and digitizing - Image processing and analysis.

CO4 Write simple robot programs to move the robot on a specific route sequence **L:9**

Introduction, On-line programming: Manual input, Lead through -programming, Teach pendant programming, Off-line programming language, Simulation, Introduction to ROS Concept.

Control systems- Open and closed loop control system, Control system concepts, Linear control schemes, PID control system, Types of motion control, drives and control, Planning of trajectories, Human-Robot Collaboration.

CO5 Explores industrial applications of robots **L:9**

Robot Applications-Material handling, Machine loading and unloading, Assembly, Inspection, Welding, Spray painting, Medical Industry, Influence of robots in industry 4.0 CIM - Hostile and remote environments Future of Robotics.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, Industrial Robotics: Technology, Programming and Applications, 2nd Edition, Tata McGraw Hill, 2012.
2. Mark R. Miller - Robots and Robotics‖ McGraw Hill International Edition, 2018.

REFERENCE

1. Nicholas Odrey, Mitchell Weiss, Mikell Groover, Roger N. Nagel, Ashish Dutta, - Industrial Robotics: Technology, Programming and Applications‖ McGraw Hill Education; 2nd Edition, 2017.
2. S K. Saha - Introduction to Robotics‖ 2nd Edition, 2014.
3. Ashitava Ghosal, ―Robotics fundamental concepts and Analysis, Oxford University Press, 2006.

23ME23E ADVANCED MODELING TECHNIQUES

L	T	P	E	C
2	0	2	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Apply the principles and concepts of Geometric modeling, solid modeling and assembly
CO2: Apply advanced modeling and computational tools for complex mechanical part.
CO3: Produce detailed exploded assembly views with Bill of Materials
CO4: Execute weldment and sheet metal CAD drawings for mechanical engineering applications in the current industrial practice
CO5: Demonstratethe fundamentals of GD &T

CO1 Apply the principles and concepts of Geometric modeling, solid modeling and assembly **12**

Planes and Axis - 2D Sketch - Line, Rectangle, arcs, relations, Constrained sketch. Part modeling - Extrude, Revolve, Sweep, Loft, Rib, Fillet, Chamfer, Shells, Mirroring, Patterns, drafts, custom properties.

Assembly constraints - Mates, Smart mates, Interference, Collision, Dynamic clearance, Exploding assembly.

CO2 Apply advanced modeling and computational tools for complex mechanical part **12**

3D Sketch - Parabola, conic, splines, derived sketches. Advanced part modeling - Flex, Bending, Twisting, Tapering & Stretching, Splitting, Multi body, Configurations. Assembly - Flexible sub assembly, Path, Linear coupler, Gear, Cam, Screw, Limit and Hinge mates, Assembly Configurations.

CO3 Produce detailed exploded assembly views with Bill of Materials **12**

Different views - Model, projection, section, detail, broken, exploded. Dimensions - ordinate, driving, baseline, annotations, balloons, Bill of materials, tables, Tolerances. Animations -walkthrough videos, Photo view, Rendering

CO4 Execute weldment and sheet metal CAD drawings for mechanical engineering applications in the current industrial practice **12**

Weldment - Structural Members, Trim, Extend, Gusset end caps, Weld beads, Cut List, Sub-weldment, Custom profiles. Sheet Metal - Cone, Cylinder, Lofts, Base Flange, Edge Flange, Swept flange, Mitre flange, sketched bend, Jog, Hem. Surfacing - Spline, boundary surface, knit.

CO5 Demonstrate the fundamentals of GD &T **12**

Engineering drawing and tolerance - Limits, fits and Tolerance - Tolerance symbols and terms - rules and concepts of GD&T - significance of GD&T - MMC, LMC - datum - Form - Orientation - profile - Runout

L:30; P:30; TOTAL:60 PERIODS

Note: The End Semester Examination will be conducted in Computer Aided Design Laboratory

REFERENCES

1. Ibrahim Zeid, CAD/CAM, Theory and Practice‖, Tata Mc Graw Hill, 2010
2. Donald Hearn, Computer Graphics, Pearson Education Ltd, 2nd Edition, 2011.
3. Matt Lombard, Mastering Solidworks, 2018.
4. Alex Krulikowsi, Fundamentals of Geometric Dimensioning and Tolerancing, 2nd Edition, Delmar publications, 2012.
5. Standards for dimensioning and tolerancing - ASME Y 14.5, 2009
6. James D Meadows, GD&T Application, analysis and Measurements, ASME Press, 2009.

23ME24E	**PRODUCT LIFE CYCLE MANAGEMENT**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Demonstrate the various strategies of PLM and Product Data Management.
CO2: Demonstrate the decomposition of product design and model simulation.
CO3: Demonstrate the strategies for sustainable product design and lifecycle management.
CO4: Use the technological forecasting and the tools in the innovation.
CO5: Execute the virtual product development and model analysis

CO1 Demonstrate the various strategies of PLM and Product Data Management **L:9**

Introduction to PLM, Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM. Product Data Management, implementation of PDM systems. PLM software tools and PDM data security concepts.

CO2 Demonstrate the decomposition of product design and model simulation **L:9**

Engineering design, organization and decomposition in product design, product design process, systematic evolution in product design, concurrent engineering. Simulation tools and techniques used in product design and design validation.

CO3 Demonstrate strategies for sustainable product design and lifecycle management **L:9**

Principles of sustainable product design, eco-design strategies, life cycle assessment (LCA), circular economy models, sustainability metrics in product lifecycle management, and case studies of eco-friendly product innovation.

CO4 Use the technological forecasting and the tools in the innovation **L:9**

Technological change, methods of technology forecasting, relevance trees, methods and tools in the innovation process according to the situation. Alignment of forecasting with Competitive benchmarking.

CO5 Execute the virtual product development and model analysis **L:9**

Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, Augmented Reality (AR) and Virtual Reality (VR) in new product development, digital mock-up, model building, model analysis, production (process) planning, and product data technology.

L:45; P: 0; TOTAL:45 PERIODS

TEXT BOOKS

1. John Stark, Product Lifecycle Management: 21st Century Paradigm for Product Realization, 4th Edition, Springer, 2021,
2. Shojiro Fukuda, Product Lifecycle Management for a Global Market: Evolving Product Lifecycle Management (PLM) with New Technologies, 1st edition,Springer2018.
3. Dr. Samir Dani, Design for Life Cycle, Palgrave Macmillan, 2022.

REFERENCES

1. UthayanElangovan, Product Lifecycle Management (PLM): A Digital Journey Using Industrial Internet of Things (IIoT), 1st Edition, CRC Press, Part of Taylor & Francis Group, 2020.
2. Fabio Giudice, Guido La Rosa, Product Design for the environment-A life cycle approach, Taylor & Francis. 2006.

23ME25E	**MECHANICS OF ROBOTS**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the fundamentals of robotics, configuration, components, and its applications
CO2: Demonstrate the robot's mechanical end effectors and gripper actuation mechanisms
CO3: Apply coordinate transformations to map position and orientation coordinates from the end effector to the robot base.
CO4: Demonstrate concepts of robot dynamics
CO5: Demonstrate the various drives and control systems of robots

CO1 Demonstrate the fundamentals of robotics, configuration, components, and its applications **L:9**

Robot - Definition, Classification – Anatomy, Spatial coordinates, Geometric configurations -workspace – accuracy and resolution –repeatability of the robot. Mechanical actuation mechanisms – compliance-end-effecter design- legged robots- multi-fingered hands; Autonomous, agile Robots and Cobots - Industry 5.0- Case studies.

CO2 Demonstrate the robot's mechanical end effectors and gripper actuation mechanisms **L:9**

Robot end effectors & Grippers: Introduction- types & classification- Design of robot's Mechanical linkage and gripper mechanisms for pick and place, welding, external and internal gripping- gripper force analysis- design of special purpose grippers- Case studies

CO3 Apply coordinate transformations to map position and orientation coordinates from the end effector to the robot base. **L:9**

Link description, reference frame assignment, Denavit-Hartenberg (D-H) approach, D-H parameters, position representation, homogeneous transformation matrix, forward kinematics, and an introduction to inverse kinematics using geometric methods.

CO4 Demonstrate concepts of robot dynamics **L:9**

Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution, Newton's equation, Euler's equation, Iterative Newton–Euler's dynamic Formulation, closed dynamics, concept of Lagrangian formulation of manipulator dynamics.

CO5 Demonstrate the various drives and control systems of robots **L:9**

Hydraulic and Pneumatic drives, Electrical Actuators such as servo and Stepper motors, Drive circuits, and open and closed loop controls. Proportional (P), Proportional and integral (PI), and Proportional, integral and Derivative (PID) control systems.

L: 45; TOTAL:45 PERIODS

TEXT BOOKS

1. S. K. Saha, Introduction to Robotics. 3rd Edition, McGraw Hill Education India, 2024. ISBN-13: 978-9355326461
2. John J. Craig, Introduction to Robotics: Mechanics and Control. 4th Edition, Pearson, 2022, ISBN-13: 9780137848744

REFERENCES

1. Dilip Kumar Pratihar, Fundamentals of Robotics, 1st Edition, Narosa Publishing House, New Delhi, reprinted 2019, ISBN-13: 978-81-8487-577-5.
2. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar Robot Modeling and Control. 2nd Edition, Wiley, 2020. ISBN-13: 978-1119523994

3. Reza N. Jazar, Theory of Applied Robotics: Kinematics, Dynamics, and Control. 3rd Edition, Springer International Publishing, 2022. ISBN-13: 978-3-030-93219-0
4. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, and Nicholas G. Odrey, Industrial Robotics, Tata McGraw Hill Education India, 2008.

NPTEL Online resources

1. Robotics by Prof. Dilip Kumar Pratihar - IIT Kharagpur
2. Robotics by Prof. D.K. Pratihar - IIT Kharagpur

23ME26E	PIPING ENGINEERING	L	T	P	E	C
		2	0	2	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Apply the fundamental principles for designing piping and its components
CO2: Demonstrate the working principle of piping components and design of pipes for various piping codes and standards.
CO3: Analyze the stresses induced in the pipes under static loading condition.
CO4: Design pipes and pipe support structures considering weld reinforcement and stress intensifications.
CO5: Predict the behaviour of pipes mathematically under dynamic conditions.

Practical Component

CO6: Draft isometric piping drawings manually
CO7: Validate the thickness calculations of pipes with codes and standards using software
CO8: Generate pipe stress analysis report
CO9: Generate pipe stress analysis report for the various pipe loading conditions

CO1 Apply the fundamental principles for designing piping and its components. L:6
CO6 Draft isometric piping drawings manually. P:6

Engineering drawing fundamentals - Piping drawings - P and ID - Plot Plan - Layout - Mechanical Design fundamentals - Pipes subjected to Thermal, mechanical and dynamic behaviours.

Preparation of piping drawings 2D views, Isometric drawing

CO2 Demonstrate the working principle of piping components and design of pipes for various piping codes and standards L:6
CO7 Validate the thickness calculations of pipes with codes and standards using software P:8

Introduction to piping - Piping Components - Pipe, Fittings, Flanges, Gaskets and Bolting - Valves - Isolation, Regulation, Non-return and Special purpose. Piping Materials - Piping Codes and Standards - Pipe Sizing, Diameter and Pressure drop calculations.

Thickness calculation and validation using codes and standards.

CO3 Analyze the stresses induced in the pipes under static loading conditions. L:6
CO8 Generate pipe stress analysis report P:8

Piping Supports - Restraints and hangers - Variable and Constant load spring hangers - selection design methodologies - Stress analysis introduction - Method of analysis - Static Stress analysis exercises - Piping Flexibility - Code Stress requirement.
Simulation of pipe stress analysis for routing.

CO4 Design pipes and pipe support structures considering weld reinforcement and stress intensifications. L:6

Welding reinforcement calculations - Nozzle design - Stress intensification at elbows, tees and branch - Structure basics - Piping supporting structure modeling.

CO5 Predict the behaviour of pipes mathematically under dynamic conditions. L:6

CO9 Generate pipe stress analysis report for the various pipe loading conditions P:8

Wind and Seismic analysis - Damping - Lumped Mass - Steady state vibration and harmonic analysis - Time history Analysis.
Simulating pipe stress analysis for dynamic conditions

L:30; P:30; TOTAL:60 PERIODS

TEXT BOOKS

1. Mohinder L Nayyar, "Piping Handbook", McGraw Hill Handbook, 7thEdition, 2022.
2. George A Antaki, ―Piping and Pipeline Engineering: Design, Construction, Maintenance Integrity and Repair, CRC Press, 2003.

REFERENCES

1. Power and Process Piping Standards‖ ASME B 31.1 & B 31.3, 2012.
2. Kellogg M W, ―Design of Piping Systems, John Wiley & Sons, 2019.
3. Liang-Chuan Peng and Tsen-Loong Peng, ―Pipe Stress Engineering, ASME Press, New York, 2009.

23ME27E VEHICLE SYSTEMS DESIGN

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO 1: Analyze aerodynamic forces and apply drag-reduction methods to improve vehicle performance and safety.

CO 2: Apply ergonomic and comfort design principles to enhance occupant comfort and noise–vibration performance.

CO 3: Analyze chassis and suspension parameters to ensure ride comfort and handling stability.

CO 4: Compare transmission and braking systems of conventional and electric vehicles to assess their suitability.

CO 5: Evaluate structural failures and crashworthiness using test data and simulations to improve design durability and safety.

CO 1 **Analyze aerodynamic forces and apply drag-reduction methods to improve vehicle performance and safety.** 9

Aerodynamics - Aerodynamic forces - Drag - Drag reduction - Stability and cross-winds - Noise - Under hood ventilation - Cabin ventilation - Wind tunnel testing - Computational fluid dynamics. Recent trends in automotive safety systems - Safety regulations and testing.

CO 2 **Apply ergonomic and comfort design principles to enhance occupant comfort and noise–vibration performance.** 9

Occupant accommodation - Ergonomics - Eight fundamental fallacies - Ergonomics methods and tools. Vibration control - Fundamentals of acoustics - Human response to sound - Sound measurement - Automotive noise criteria - noise sources - control techniques and Standards.

CO 3 **Analyze chassis and suspension parameters to ensure ride comfort and handling stability.** 9

Load case, introduction - Chassis types, Structural analysis - Vehicle suspension - Factors affecting design - Mobility of suspension mechanisms - Kinematic analysis - Anti-squat/Anti- dive geometries- Roll centre analysis- Force analysis.

CO 4 **Compare transmission and braking systems of conventional and electric vehicles to assess their suitability.** 9

Engine and motor characteristics – Vehicle power requirement – Manual, automatic, and CVT transmissions – Transmission in electric vehicles. Basics of braking – Brake proportioning and adhesion – Braking systems in electric vehicles – Regenerative and brake-by-wire systems – Comparative study.

CO 5 **Evaluate structural failures and crashworthiness using test data and simulations to improve design durability and safety.** 9

Aspects of failures - endurance and durability - Testing and failure prediction - automotive failures and injury analysis - Crashworthiness - Vehicle impacts: general dynamics - crush characteristics - Structural collapse.

L:45; TOTAL:45 PERIODS

TEXT BOOK

1. Happian-Smith, J. An Introduction to Modern Vehicle Design. Reed Educational and Professional Publishing Ltd., 2012.

REFERENCES

1. Khajepour, A.; Fallah, S.; Goodarzi, A. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach. Wiley, 2014.
2. Bhise, V.D. Ergonomics in the Automotive Design Process. CRC Press, 2015.
3. Malen, D.E. Fundamentals of Automobile Body Structure Design. SAE International, 2011.
4. Orbye, J.P.N. Car Design: Structure and Architecture. Tab Books, 2011.
5. Gillespie, T.D. Fundamentals of Vehicle Dynamics. SAE International, 2020.
6. Morello, L. et al. The Automotive Body: Volume II – System Design. Springer, New York, 2011.
7. Prof. C. S. Shankar Ram, Fundamentals of Automotive Systems, IIT Madras, https://onlinecourses.nptel.ac.in/noc21_de02/preview

8. Prof. Sougata Karmakar, Ergonomics In Automotive Design, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc19_de01/preview
9. Pof. Ashok Jhunjhunwala, Prof. Kaushal Jha, Prof. L Kannan, Prof. Prabhjot Kaur, Fundamentals of Electric vehicles: Technology & Economics, IIT Madras, https://onlinecourses.nptel.ac.in/noc20_ee99/preview

23ME28E DRONE TECHNOLOGY

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Apply the fundamental principles and classifications of drones to real-world scenarios.

CO2: Implement design, fabrication, and programming techniques to develop functional drone systems.

CO3: Demonstrate the operation and control of small drones in simulated or controlled environments.

CO4: Employ suitable drone technologies for specific commercial and industrial applications.

CO5: Apply knowledge of safety guidelines, regulations, and emerging drone technologies.

CO1 Apply the fundamental principles and classifications of drones to real-world scenarios. **L:9**

Introduction to drone technology – Terminology – History of drones – Types of current-generation drones based on propulsion – Impact of drone technology on business – Entrepreneurship and drone-based opportunities – Applications and employability scope.

CO2 Implement design, fabrication, and programming techniques to develop functional drone systems. **L:9**

Classification of UAVs – Overview of main drone components – Technical characteristics and functions – Assembling procedures – Energy sources, Payload calculation, and Autonomy levels – Drone configurations – Drone programming methods – Program installation and execution – Multi-rotor stabilization – Flight modes – Wi-Fi connectivity.

CO3 Demonstrate the operation and control of small drones in simulated or controlled environments. **L:9**

Concept of operation for drones – Flight modes and control systems – Operating small drones in controlled environments – Flight operation management – Onboard sensors and storage – Data transmission – Linked mobile devices and applications for drone operation.

CO4 Employ suitable drone technologies for specific commercial and industrial applications. **L:9**

Selection of drones based on applications – Drones in insurance and logistics – Use of drones in mail and parcel delivery – Drones in agriculture – Drones in inspection of power transmission lines – Drones in filmmaking, photography, and photogrammetry imaging.

CO5 Apply knowledge of safety guidelines, regulations, and emerging drone technologies. **L:9**

Drone safety and risk management – Guidelines for safe operation – Aviation regulations and drone licensing – Miniaturization and advanced materials – Increasing autonomy and artificial intelligence in drones – Drone swarms and future developments

L:45; TOTAL:45 PERIODS

REFERENCES

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby, "Make: Getting Started with Drones ", Maker Media, Inc,
3. John Baichtal, "Building Your Own Drones: A Beginner's Guide to Drones, UAVs, and ROVs", Que Publishing, 2016.
4. Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.
5. Prof. Suresh Sundaram, Drone Systems and Control, IISc Bangalore - https://nptel.ac.in/courses/101108661

23ME31E	ARTIFICIAL INTELLIGENCE IN MANUFACTURING	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Implement Artificial Intelligence techniques to solve computational problems.
CO2: Use AI and optimization algorithms to improve process parameters in manufacturing.
CO3: Apply AI techniques for process monitoring, predictive maintenance, and quality.
CO4: Apply AI methods for production planning, scheduling, and supply chain optimization.
CO5: Implement AI-based automation, robotics, and human-robot collaboration.

CO1 Implement Artificial Intelligence techniques to solve computational problems **L:9**

Components of Artificial Intelligence, Data Processing and Preprocessing, Regression Methods: Multi-layer Perceptron, Support Vector Regression, Classification Methods: Support Vector Machine (SVM), k-Nearest Neighbors (k-NN).
Deep Learning: Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Long Short-Term Memory Networks (LSTM), Generative Adversarial Networks (GAN)

CO2 Use AI and optimization algorithms to improve process parameters in manufacturing. **L:9**

Introduction to process modeling and optimization, Machine learning for machining and additive manufacturing optimization.
Optimization Algorithms: Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Fitness Evaluation.

CO3 Apply AI techniques for process monitoring, predictive maintenance, and quality. **L:9**

AI-driven process monitoring and control using real-time data streams. Predictive maintenance: Condition monitoring, data collection, predictive models. Quality control and inspection: AI for defect detection, computer vision applications.

CO4 Apply AI methods for production planning, scheduling, and supply chain optimization. L:9

AI for production planning and scheduling: ERP, JIT, AI-generated schedules, Digital Twins, Supply chain management: Demand forecasting, inventory management, Industry 4.0 applications.

CO5 Implement AI-based automation, robotics, and human-robot collaboration. L:9

Manufacturing equipment design and selection, machine programming, workstation orchestration, Machine perception, automation, and robotics in industrial processes, Human-robot collaboration and multimodal robot control.

L:45; TOTAL:45 PERIODS

REFERENCES

1. N. M. Anoop Krishnan, Hariprasad Kodamana, Ravinder Bhattoo, Machine Learning for Materials Discovery: Numerical Recipes and Practical Applications, Springer International Publishing, 2023
2. George Chryssolouris, Kosmas Alexopoulos, Zoi Arkouli, A Perspective on Artificial Intelligence in Manufacturing, Springer International Publishing, 2022
3. John Soldatos, Artificial Intelligence in Manufacturing, Springer International Publishing, 2023
4. Lilian Ashioya, Artificial Intelligence in Manufacturing, Bibliotex Publications, 2024

		L	T	P	E	C
23ME32E	**NON-DESTRUCTIVE EVALUATION**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Identify the various NDT processes for practical application

CO2: Use liquid penetrant and magnetic particle test for identifying defects

CO3: Demonstrate ultrasonic testing of casting, weld, forgings and Acoustic Emission

CO4: Identify the defects in welded, forged and cast components using radiographic testing.

CO5: Apply NDT methods and relevant standards in power, nuclear, and aerospace industries.

CO1 Identify the various NDT processes for practical application L:9

Introduction non-destructive testing -visual examination-different visual examination aids - selection of NDT processes – detection of manufacturing defects.

CO2 Use liquid penetrant and magnetic particle test for identifying defects. L:9

Physical principle – procedure – penetrant testing materials and methods – sensitivity – advantages and limitations. Physics of magnetism - magnetization techniques – equipment and accessories – demagnetization- advantages and limitations.

CO3 Demonstrate ultrasonic testing of casting, weld, forgings and Acoustic Emission L:9

Fundamentals of ultrasonic waves – inspection methods - equipment - calibration of testing equipment - advantages and limitations. Acoustic Emission Technique – Principle, AE

parameters, Applications

CO4 Identify the defects in welded, forged and cast components using radiographic testing. L:9

Geometric exposure principle – radiation sources – radiography techniques – radiation safety - radiographic film processing – radiographic image quality - Interpretation and evaluation of radiographs- advantages and limitations - Computed Radiography, Computed Tomography

CO5 Apply NDT methods and relevant standards in power, nuclear, and aerospace industries. L:9

Application of NDT in power plants - application of NDT in Nuclear industries - Application of NDT in aerospace industries - Codes and standards for the above applications

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu, Practical Non-Destructive Testing, Narosa Publishing House, 2009.
2. Parmer R.S, Welding Engineering and Technology, 2nd Edition, Khanna publishers, Delhi, 2010.

REFERENCES

1. ASM Metals Handbook Vol. 17 – Nondestructive Evaluation and Quality Control, published by ASM, USA
2. R Halmshaw, Introduction to the Non-Destructive Testing of Welded Joints, 2nd Edition, Woodhead Publishing, 1997.
3. www.nde-ed.org.
4. NPTEL Course - PROF. RANJIT BAURI,Theory and Practice of Non-Destructive Testing, IIT Madras.

23ME33E ADVANCED MACHINING PROCESSES

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the various unconventional machining processes
CO2: Analyze the applications and process parameters of various mechanical energy based unconventional machining processes
CO3: Analyze the influence of EDM process parameters on MRR and surface finish
CO4: Demonstrate the different chemical energy-based machining processes
CO5:Demonstratethevarious high energy density machining processes and its applications

CO1 Demonstrate the various unconventional machining processes L:9

Technological and commercial need, Advantages over conventional machining, classification, performance constraints, selection of UCMP, hybrid processes. Ultrasonic Machining (USM): Process description - equipment's - mechanics of

cutting - hammering and throwing model - typical problems - factors affecting material removal rate - dimensional accuracy and surface quality – applications, recent developments.

CO2 Analyze the applications and process parameters of various mechanical energy based unconventional machining processes **L:9**

Introduction - description - equipment - nozzles - material removal rate - typical problems - parametric analysis - process capabilities and applications of Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) processes.

CO3 Analyze the influence of EDM process parameters on MRR and surface finish **L:9**

Introduction - mechanism of material removal - description - electrodes - dielectric fluids - different types of flushing - material removal rate - process characteristics and applications – Wire- µ-Electric Discharge Machining (Wire- µ-EDM): Equipments - process variables - process capabilities and applications in die making.

CO4 Demonstrate the different chemical energy-based machining processes **L:9**

Electro Chemical Machining (ECM): Principle of electrolysis - theory of ECM - description of the equipment - electrodes - modeling of material removal rate - accuracy and surface finish - advantages and limitations - various applications - Electro Chemical Grinding - Electro Chemical Deburring - Chemical etching process and its applications.

CO5 Demonstrate the various high energy density machining processes and its applications **L:9**

Electron Beam Machining (EBM): Principle - equipments - vacuum system - process parameters - characteristics and applications - Laser Beam Machining (LBM): Types of lasers - characteristics - material removal mechanism - process characteristics - applications - three-dimensional machining and advantages - Plasma Arc Machining (PAM): Generation of plasma - elements - torch design types and its characteristics - effect of process parameters - applications.

L:45; P:0; TOTAL:45 PERIODS

TEXT BOOKS

1. Hassan Abdel, Gawad El-Hofy, "Advanced Machining Processes: Non Traditional and Hybrid Machining Process", 1st Edition, McGraw Hill, New York, 2005.
2. Jain V K, "Advanced Machining Processes", 1st Edition, Allied Publishers Pvt. Ltd., London, 2017.

REFERENCES

1. James Brown, "Advanced Machining Technology Hand Book", 1st Edition, Mc-Graw Hill, New Delhi, 1998.
2. Benedict G.F, "Advanced Manufacturing Processes", 2nd Edition, Jain V.K, New Delhi, 2016.
3. Pandey P.C, "Advanced Methods of Machining", 2nd Edition, Chapman and Hill, New

York, 2011.
4. Jain V K, "Modern Machining Processes", 1st Edition, Tata McGraw Hill, New Delhi, 1981.
5. NPTEL Course: https://nptel.ac.in/courses/112103202
6. NPTEL Course: https://nptel.ac.in/courses/112105212

23ME34E	ADVANCED ENGINEERING MATERIALS	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1:Use the properties, fabrication techniques, and applications of metal matrix composites in engineering.

CO2: Implement the knowledge in polymer matrix composites and its processing methods.

CO3: Comprehend the ceramic matrix composite and its processing routes.

CO4: Demonstrate the fundamental principles, characteristics, and engineering applications of metamaterials and quasicrystals.

CO5: Demonstrate the classifications, properties, and applications of advanced smart materials, nanomaterials, and metal alloys for innovative engineering solutions.

CO1 Usethe properties, fabrication techniques, and applications of metal matrix composites in engineering. **L:9**

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume fraction – rule of mixtures. Manufacturing methods of MMC – powder metallurgy process - diffusion bonding – stir casting – Squeeze casting - applications of MMC

CO2 Implement the knowledge in polymer matrix composites and its processing methods. **L:9**

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – ravings –woven fabrics – non woven random mats – various types of fibres. PMC Manufacturing methods - hand lay-up processes – compression moulding – injection moulding - resin transfer moulding – Pultrusion – Filament winding. Laminates-Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. - applications of PMC.

CO3 Comprehend the ceramic matrix composite and its processing routes **L:9**

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics - need for CMC – ceramic matrix - various types of ceramic matrix composites-oxide ceramics – non-oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing). Applications of CMC.

CO4 Demonstrate the fundamental principles, characteristics, and engineering applications of metamaterials and quasicrystals. **L:9**

Metamaterials: Advantages over other materials, Types and synthesis, General Theory on Artificial Metamaterials, Experiments and Applications of Metamaterials.
Quasicrystals: Structures and symmetries, Fundamental concepts, Quasicrystallography, Production, Defects, Elastic and Plastic Properties, Mechanical Properties, Magnetic Properties, Recent Developments, Applications.

CO5 Demonstrate the classifications, properties, and applications of advanced smart materials, nanomaterials, and metal alloys for innovative engineering solutions. **L:9**

Smart materials: classification, piezo electric materials, Rheological materials, smart gels, chromic materials, thermos responsive materials, magneto strictive materials, electro strictive materials, nanotechnology materials synthesis, properties, carbon nanotechnology tubes and applications.

TOTAL:45 PERIODS

TEXT BOOKS

1. Krishan K. Chawla, ―Composite Materials: Engineering and Science‖, 3rd Edition, Springer, 2013.
2. Nader Engheta, Richard W Ziolkowski, Metamaterials: Physics and Engineering Explorations, Wiley-IEEE Press, 2006.
3. J.B. Suck, M. Schreiber, P. Häussler, Quasicrystals: An Introduction to Structure, Physical Properties and Applications, Springer-Verlag Berlin Heidelberg publications, 1st ed., 2002.

REFERENCES

1. Gary S. Was, Fundamentals of Radiation Materials Science: Metals and Alloys, Springer International Publication, 2017.
2. Prof. Mohsen Shahinpoor, Fundamentals of Smart Materials, Royal Society of Chemistry: Cambridge, 2020.
3. Mallick, P K, Fiber-reinforced composites: Materials, manufacturing and Design‖, Third Edition, CRC press, 2007
4. John Cuppoletti, Metal, ceramic and polymeric composites for various uses‖, In tech, 2011.
5. Takeo Fujiwara, Yasushi Ishii, Quasicrystals, Elsevier Science publications, 1st ed., Vol. 3, 2007.
6. Adel zakiel-sonbati, Thermoplastic-composite materials‖, 2012.

NPTEL SOURCES

1. https://youtu.be/JBMVZpRD-Zk
2. https://youtu.be/ns8TSBk2wDI
3. https://archive.nptel.ac.in/courses/112/104/112104229/
4. https://www.youtube.com/watch?v=_Q9k_umhIB8
5. https://www.youtube.com/watch?v=lmr4kETnwi0
6. https://www.youtube.com/watch?v=_KdWxyWHsqk

23ME35E	**ADDITIVE MANUFACTURING**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the development of Additive Manufacturing (AM) technology and its expansion into various industries and business opportunities.

CO2: Demonstrate the vat polymerization and material extrusion processes and its applications.

CO3: Demonstrate the binder jetting, material jetting and laminated object manufacturing processes.

CO4: Demonstrate the process and applications of powder bed fusion and direct energy deposition.

CO5: Apply the concepts of AM technology into the final product

CO1 Demonstrate the development of Additive Manufacturing (AM) technology and its expansion into various industries and business opportunities. **L:9**

Rapid Prototyping and Tooling - Overview, Need and Development of Additive Manufacturing (AM) Technology - AM Process Chain- Classification – Benefits. Applications: Building Printing, Bio Printing, Food Printing, Printing Electronics - Business Opportunities and Future Directions, Buy to Fly (BTF) ratio.

CO2 Demonstrate the vat polymerization and material extrusion processes and its applications. **L:9**

Photo polymerization: Stereolithography Apparatus (SLA), Digital Light Processing (DLP), Extrusion Based System – Fused Deposition Modeling (FDM) - Process - Materials – Applications, Benefits and Limitations.

Demonstration of FDM and DLP Techniques.

CO3 Demonstrate the binder jetting, material jetting and laminated object manufacturing processes. **L:9**

Binder Jetting: Three-Dimensional Printing, Material Jetting: Multi-jet Modeling, Sheet Lamination Process: Laminated Object Manufacturing (LOM) - Basic Principle, Materials, Application and Limitation, Acceptance Criteria - Evaluation of printed parts based on dimensional accuracy, surface finish, mechanical integrity, and process-specific tolerances.

CO4 Demonstrate the process and applications of powder bed fusion and direct energy deposition. **L:9**

Powder bed fusion processes: Electron beam melting, selective laser melting, selective laser sintering, binder jetting process for metals – Process - Advantages and Applications. Directed energy deposition processes (DED): Arc based technology, Laser-based and electron beam-based DED processes, process parameters, materials and microstructures.

CO5 Apply the concepts of AM technology into the final product **L:9**

Concepts and Objectives- AM Unique Capabilities: Part Consolidation-Topology Optimization- Generative Design - Lightweight Structure - DFAM for Part Quality Improvement. Data Processing - CAD Model Preparation -Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation-Customized Design and Fabrication for Medical Applications, Organ printing (Bio Ink) - Case

Studies.

L45; TOTAL:45 PERIODS

TEXT BOOKS

1. Ian Gibson, David W.Rosen and Brent Stucker ―Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd edition, Springer., United States, 2021.
2. Andreas Gebhardt and Jan-Steffen Hötter Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser publications, United States, 2016.

REFERENCES

1. Amit Bandyopadhyay and Susmita Bose, Additive Manufacturing, 1st Edition, CRC Press., United States, 2015.
2. C.P Paul, A.N Junoop - Additive Manufacturing: Principles, Technologies and Applications, McGrawHill, 2021.
3. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2000.
4. Milan Brandt, Laser Additive Manufacturing: Materials, Design, Technologies, and Applications, Woodhead Publishing., United Kingdom, 2016.

NPTEL Online resources

1. https://archive.nptel.ac.in/courses/112/103/112103306/
2. https://nptel.ac.in/courses/112104312

23ME36E AUTOMATED GUIDED VEHICLES

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the evolution and operational use of AGVS.

CO2: Interpret the industrial applications of AGVS and their effectiveness.

CO3: Implement suitable technological standards of AGVS to fulfill customer requirements.

CO4: Apply the design concepts of Automated Storage and Retrieval Systems (AS/RS) for material handling solutions.

CO5: Analyze the requirements of AGVS to address future industrial challenges.

CO1 Demonstrate the evolution and operational use of AGVS. L:9

Introduction to AGV – Evolution of AGV – Vehicle guidance technology – Vehicle management and safety – Benefits of AGVs – Important issues for AGVS – Navigation.

CO2 Interpret the industrial applications of AGVS and their effectiveness. L:9

Flow line organization and the focus on series production – Warehousing and commissioning – Industry-related aspects and examples – Paper manufacturing and processing – Steel making industry.

CO3 Implement suitable technological standards of AGVS to fulfill customer requirements. L:9

Navigation and safety – AGVS guidance control – AGV categories: towing vehicles, unit load

carriers, pallet trucks, forklift trucks, light-load transporters, assembly-line vehicles – AGVS environment.

CO4 Apply the design concepts of Automated Storage and Retrieval Systems (AS/RS) for material handling solutions **L:9**

Definition of AS/RS – Functions of AS/RS – Components and terminology – Types – Design of AS/RS – AGV interfacing with other subsystems – Conventional storage methods and equipment.

CO5 Analyze the requirements of AGVS to address future industrial challenges. **L:9**

Drive Safe: Integration of navigation and safety – Automated togetherness: Acting intelligently – Energy mix: Modern energy management – Market development – Case studies.

L:45; TOTAL:45 PERIODS

REFERENCES

1. Günter Ullrich & Thomas Albrecht, Automated Guided Vehicle Systems: A Guide – With Practical Applications, 2nd / Revised Edition (2023).
2. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition (2019).
3. T. Muller, Automated Guided Vehicle Systems: No. 2, International Conference Proceedings, 1st Edition, IFS Ltd., 1983.
4. Prof. Asokan T, Prof. Santhakumar Mohan, Wheeled Mobile Robots, IIT Madras - https://onlinecourses.nptel.ac.in/noc21_me44/preview

		L	T	P	E	C
23ME37E	**COMPUTER INTEGRATED MANUFACTURING**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the basic concepts of computer integrated manufacturing system

CO2: Apply logical steps of process planning and resource planning tools to solve basic production scheduling and inventory control problems.

CO3: Execute Group Technology concepts to classify parts and form part families using coding systems.

CO4: Demonstrate the concepts of FMS, AGV and AS/RS system.

CO5: Apply optimal, adaptive, and sequence control methods using PLC/SCADA in process applications.

CO1 Demonstrate the basic concepts of computer integrated manufacturing system **L:9**

Introduction to CIM – Evolution of CIM – CIM wheel and cycle – Production concepts and mathematical models – Simple problems in production models – CIM hardware and software – Major elements of CIM system – Three-step process for implementation of CIM – Computers in CIM – Computer networks for manufacturing – The future automated factory – Management of CIM – safety aspects of CIM– advances in CIM.

CO2 Apply logical steps of process planning and resource planning tools to solve basic production scheduling and inventory control problems. **L:9**

Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- ControlSystems-Shop Floor Control-Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) – Simple Problems.

CO3 Execute Group Technology concepts to classify parts and form part families using coding systems. **L:9**

Group Technology (GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method – Arranging Machines in a GT cell – Hollier Method – Simple Problems

CO4 Demonstrate the concepts of FMS, AGV and AS/RS system **L:9**

Types of Flexibility – FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety. Storage system performance – storage location strategies – Conventional storage methods and equipment – Automated storage/Retrieval system and Carousel storage system.

CO5 Apply optimal, adaptive, and sequence control methods using PLC/SCADA in process applications. **L:9**

Introduction to process model formulation – linear feedback control systems – Optimal control – Adaptive control –Sequence control and PLC & SCADA. Computer process control – Computer process interface – Interface hardware – Computer process monitoring – Direct digital control and Supervisory computer control – Overview of Automatic identification methods – Bar code technology –Automatic data capture technologies - Quality management (SPC) and automated inspection.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Mikell.P.Groover, **—** Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India, 2016.
2. Radhakrishnan P, Subramanyan S. and Raju V., **—**CAD/CAM/CIM, New Age International (P) Ltd, New Delhi, 2023.

REFERENCES

1. Gideon Halevi and Roland Weill, Principles of Process Planning – A Logical Approach, Chapman and Hall, London, 2012.
2. Kant Vajpayee S, Principles of Computer Integrated Manufacturing, Prentice Hall India, 1995.
3. Rao. P, N Tewari &T.K. Kundra, Computer Aided Manufacturing, Tata McGraw Hill Publishing Company, 2000.

4. NPTEL Course - Computer Integrated Manufacturing by Prof. J. Ramkumar, Prof. Amandeep Singh, IT Kanpur.

		L	T	P	E	C
23ME38E	**ARTIFICIAL INTELLIGENCE IN MATERIALS ENGINEERING**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Apply the basic concepts of Artificial Intelligence data preprocessing techniques for problem-solving.

CO2: Implement suitable machine learning methods for prediction and classification tasks.

CO3: Use clustering, dimensionality reduction, and deep learning methods to analyze and model data.

CO4: Apply AI techniques for material property prediction and discovery.

CO5: Apply AI methodologies for material simulation and behaviour prediction.

CO1 Apply the basic concepts of Artificial Intelligence data preprocessing techniques for problem-solving. **L:9**

Components of Artificial Intelligence, Data Visualization and Extracting Statistics from Data, Outlier Detection and Data Imputation, Data Augmentation Techniques, Error Measures and Similarity Measures.

CO2 Implement suitable machine learning methods for prediction and classification tasks. **L:9**

Introduction to Machine Learning, Regression Methods: Gradient Descent, Locally Weighted Linear Regression, Random Forest Regression, Multi-layer Perceptron, Support Vector Regression. Classification Methods: Decision Trees, Random Forest Classifier, Support Vector Machine (SVM), k-Nearest Neighbors (k-NN)

CO3 Use clustering, dimensionality reduction, and deep learning methods to analyze and model data. **L:9**

Clustering: K-Means, Gaussian Mixture Model, Dimensionality Reduction: Principal Component Analysis (PCA), t-Distributed Stochastic Neighbor Embedding (t-SNE), Model Refinement: Hyperparameter Optimization. Deep Learning: Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Long Short-Term Memory Networks (LSTM), Generative Adversarial Networks (GAN)

CO4 Apply AI techniques for material property prediction and discovery. **L:9**

Data-driven Materials Property Prediction: Dataset preparation and cleaning, Feature engineering and selection, Model development for property prediction, Hyperparameter optimization

AI-based Material Discovery: Surrogate model-based optimization, Material selection charts, Generative models for new material design, Reinforcement learning for optimizing atomic structures

CO5 Apply AI methodologies for material simulation and behaviour prediction. **L:9**

Material Simulation: Predictive modeling of material behavior, Linking process parameters and composition to material properties.

Image-Based Predictions: Structure–property-performance prediction, Predicting ionic conductivity, stress-strain behavior, and crack formation.
Case studies demonstrating AI-assisted simulation and predictions in materials engineering

L:45; TOTAL:45 PERIODS

REFERENCES

1. N. M. Anoop Krishnan, Hariprasad Kodamana, Ravinder Bhattoo, Machine Learning for Materials Discovery: Numerical Recipes and Practical Applications, Springer International Publishing, 2023
2. Stefan Sandfeld, Materials Data Science: Introduction to Data Mining, Machine Learning, and Data-Driven Predictions for Materials Science and Engineering, Springer International Publishing, 2024
3. Keith T. Butler, Felipe Oviedo, Pieremanuele Canepa, Machine Learning in Materials Science, ACS Publications, 2022.
4. Dr. Krishanu Biswas,Artificial Intelligence and Machine Learning in Materials Engineering, Indian Institute of Technology Kanpur, https://onlinecourses.nptel.ac.in/noc24_ce107/preview

23ME39E INTELLIGENT MANUFACTURING SYSTEMS

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to
CO1: Demonstrate automation types and AI-based intelligent manufacturing systems
CO2: Apply expert systems for automated process planning and equipment selection
CO3: Develop knowledge based systems for various applications of manufacturing
CO4: Demonstrate the intelligent systems and its troubleshooting methods
CO5: Investigate and deploy Artificial Intelligence for future smart manufacturing factories

CO1 Demonstrate automation types and AI-based intelligent manufacturing systems **L:9**

Components of manufacturing – Soft and Hard Automation – Flexible Manufacturing Cell – Flexible handling methods -Basic concepts of Artificial intelligence and expert systems – Intelligent System Components -System architecture and Data flow – System Operations.

CO2 Apply expert systems for automated process planning and equipment selection **L:9**

Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

CO3 Develop knowledge based systems for various applications of manufacturing **L:9**

Knowledge based systems-knowledge representation– knowledge acquisition and optimization-Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly

CO4 Demonstrate the intelligent systems and its troubleshooting methods L:9

Knowledge based system for material selection–Intelligent process planning system. Intelligent system for equipment selection-Intelligent system for project management& factory monitoring. Scheduling in manufacturing–scheduling the shop floor–Diagnosis & trouble Shooting.

CO5 Investigate and deploy Artificial Intelligence for future smart manufacturing factories L:9

The role of Artificial Intelligence in the factory of the future Features of Experts systems - applications in manufacturing planning and control – Intelligent systems. – Dark factories: concept, architecture, benefits and challenges. Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Andrew Kussiak, “Intelligent Manufacturing Systems”, Prentice Hall, 1990.

REFERENCES

1. Rich,E., “Artificial Intelligence”, McGraw Hill, 1986.
2. Simons, G.L, “Introducing Artificial Intelligence”, NCC Pub, 1990.
3. Kenneth R.Baker, “Introduction to sequencing and scheduling”, John Wiley & Sons, New York, 2009.
4. Richard W. Conway, William Maxwell and Louis W. Miller, “Theory of Scheduling”, Dover Publications, 2003.
5. NPTEL: Prof. Pradip Kumar Ray,Automation in Production Systems and Management IIT Kharagpur

23ME40E **OPERATIONS RESEARCH**

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Develop a model and render an optimal solution during the given circumstances
CO2: Analyze the challenges in the transportation and production problems and furnish a rational solution to maximize the benefits
CO3: Determine the purchase/ manufacturing policies to manage the inventory control and meet the customer demands
CO4: Explore the avenues for better customer service using the different queue discipline
CO5: Determine the nature of the project/ failure and offer methodical assistance towards decision making

CO1 Develop a model and render an optimal solution during the given circumstances L:9

OR-Definition - Phases - models, LP problem formulation – Graphical solution, GLPP, Standard and Canonical forms of LPP- simplex methods- Big M, Two phase methods,

Alternate optimal solutions, Duality in LP and Revised Simplex method.

CO2 Analyze the challenges in the transportation and production problems and furnish a rational solution to maximize the benefits **L:9**

Transportation problems- Basic feasible solution, Optimal solution By MODI method, Balanced and Unbalanced TP, Degeneracy, Production problems. Assignment problems – Hungarian method - Traveling salesman problems - Scheduling and Sequencing models- Johnson algorithm, n job 2 machines, n job 3 machines and n job m machines.

CO3 Determine the purchase/ manufacturing policies to manage the safety stocks and meet the customer demands. **L:9**

Types of inventory- Inventory cost - EOQ - Deterministic inventory problems – Purchase and Production models with and without shortages-EOQ with price breaks – Stochastic inventory problems - Multi product problems - Systems of inventory control (P and Q Systems)-Determination of buffer stock and re-order levels -Selective inventory control techniques (ABC, VED, SDE, etc.)

CO4 Explore the avenues for better customer service using the different queue discipline **L:9**

Queuing system - Characteristics - symbols - Poisson process and exponential distribution –Single server queuing models - Multiserver queuing models, Simulation Monte Carlo technique- Inventory & Queuing problems.

CO5 Determine the nature of the project/ failure and offer methodical assistance towards decision making **L:9**

Project management: Network logic – Ford-Fulkerson's rule - AON diagram - CPM and PERT techniques, Critical path and float calculations. Replacement models -types of failures – Gradual failures: - replacement of items: with and without change in money values, sudden failures- individual and group replacement policies.

L45; TOTAL:45 PERIODS

TEXT BOOKS

1. Wayne.L.Winston,"Operations research applications and algorithms",4th Edition,Cengage learning, 2011.
2. Hamdy A Taha, "Operations research an introduction", 10th Edition, PHI/Pearson education, 2017.

REFERENCES

1. Srinivasan G, "Operations research principles and applications", 3rd edition, PHI, 2017,
2. Pannerselvam R, "Operations research", 2nd edition, PHI, 2009.
3. Ravindran, Phillips and Solberg, "Operations research principles and practice", 2nd edition, Wiley India, 2007.
4. Sharma J K, "Operations research theory and applications",5th edition, Trinity Press,2013.
5. Prem Kumar Gupta and D.S.Hira, "Problems in Operations Research",S.Chand& Co., 2009.
6. http://digimat.in/nptel/courses/video/112106134/L01.html
7. https://archive.nptel.ac.in/courses/111/107/111107128/

23ME41E	**PRINCIPLES OF MANAGEMENT**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the development of management thoughts and different types of Business Organization.

CO2: Use the process of planning and decision making in an industrial situation.

CO3: Apply the suitable selection process for a particular job description.

CO4: Demonstrate the different motivational techniques and leadership skills in the organization.

CO5: Apply the various controlling techniques and tools in the organization.

CO1 Demonstrate the development of management thoughts and different types of Business Organization. **L:9**

Definition of Management – Science or Art – Manager Vs Entrepreneur- types of managers managerial roles and skills – Evolution of Management –Scientific, human relations, system and contingency approaches- Case study – Types of Business organization- Sole proprietorship, partnership, company-public and private sector enterprises- Organization culture and Environment – Current trends and issues in Management.

CO2 Use the process of planning and decision making in an industrial situation. **L:9**

Nature and purpose of planning – Planning process – Types of planning – Objectives – Setting objectives – Case study - Policies – Planning premises – Strategic Management – Planning Tools and Techniques – Decision making steps and process.

CO3 Apply the suitable selection process for a particular job description. **L:9**

Nature and purpose – Formal and informal organization – Organization chart – Organization structure – Types – Line and staff authority – Departmentalization – delegation of authority – Centralization and decentralization – Job Design - Human Resource Management – HR Planning, Recruitment, selection, Training and Development, Performance Management, Career planning and management – Case study

CO4 Demonstrate the different motivational techniques and leadership skills in the organization. **L:9**

Foundations of individual and group behaviour– Motivation – Motivation theories – Motivational techniques – Job satisfaction – Job enrichment – Leadership – types and theories of leadership – Case study - Communication – Process of communication – Barrier in communication – Effective communication – Communication and IT.

CO5 Apply the various controlling techniques and tools in the organization. **L:9**

System and process of controlling – Budgetary and non - Budgetary control techniques – Use of computers and IT in Management control – Case study – Productivity problems and management – Control and performance – Direct and preventive control – Reporting.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Harold Koontz & Heinz Weihrich, Essentials of Management – An International Perspective, Tata Mcgraw Hill, 11th Edition, 2020.
2. Callie Daum, Principles of Management Essentials, Vibrant Publishers; 3rd edition, 2023.
3. P.C Tripathi, P.N Reddy, Principles of Management, McGraw Hill Education, 7th Edition, 2021.

REFERENCES

1. Stephen P. Robbins and Mary Coulter, Management, Prentice Hall of India, 15th Edition, 2021.
2. Charles W.L Hill, Steven L McShane, Principles of Management, Mcgraw Hill Education, Special Indian Edition, 2017.

23ME42E **TOTAL QUALITY MANAGEMENT** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the fundamental principles of TQM, quality management philosophies and its Framework.

CO2: Demonstrate the need of customer expectations, employee involvement and Supplier partnership.

CO3: Applythe TQM tools and Techniques to improve the product and process Quality.

CO4: Analysis of the quality of the product through appropriate tools and techniques.

CO5: Demonstratethe ISO 9001, Environmental Management Standards and ISO 14001 certification process.

CO1 Demonstrate the fundamental principles of TQM, quality management philosophies and its Framework. **L:9**

Introduction - Need, evolution and definition of quality - Dimensions of manufacturing and service quality - Basic concepts, definition and framework of TQM - Contributions of Deming, Juran and Crosby - Barriers to TQM - Case Studies in TQM

CO2 Demonstrate the need of customer expectations, employee involvement and Supplier partnership. **L:9**

Leadership - Strategic quality planning, Quality statements - Customer focus, orientation, satisfaction, complaints and retention - Employee involvement - Motivation, Team and Teamwork, Recognition and Reward, Performance appraisal - Supplier partnership - Partnering, Supplier selection, Supplier Rating - Continuous process improvement – PDSA cycle, 5s, Poka-yoke and Kaizen.

CO3 Apply the TQM tools and Techniques to improve the product and process Quality. **L:9**

Quality circles - Quality Function Deployment (QFD) - Taguchi quality loss function – TPM - Concepts, improvement needs - Statistical Quality Tools, Quality cost, types and its analysis techniques - Performance measures.

CO4 Analysis of the quality of the product through appropriate tools and techniques. **L:9**

Seven traditional tools of quality - New management tools – Lean and Six-sigma principles, applications to manufacturing, service sector including IT - Benchmarking - Reason to benchmark, Benchmarking process, Business Process Reengineering (BPR) - FMEA - Stages and types - Criteria for getting Quality awards.

CO5 Demonstrate the ISO 9001, Environmental Management Standards and ISO 14001 certification process. **L:9**

Need for ISO 9000 - ISO 9000-2000 Quality System - QS 9000 - ISO 14000 - ISO/TS 16949 - ISO 17025 - Elements, Documentation, Quality auditing - Concepts, Requirements and Benefits - IATF and BIS standards.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Dale H Bester filed, Total Quality Management, Pearson Education Asia, 5th Edition, Indian Reprint 2018.
2. Sunil Sharma, - Total Quality Management: Concepts, Strategy and Implementation for Operational Excellence, Sage Publications Pvt. Ltd, 2018.

REFERENCES

1. James R Evans and William M Lindsay, The Management and Control of Quality, 8th Edition, Cengage Learning, 2010.
2. Oakland J S, TQM - Text with Cases‖, Butterworth - Heinemann Ltd., Oxford, 3rd Edition, 2012 (e version).
3. Suganthi L and Anand Samuel, Total Quality Management, Prentice Hall (India) Pvt. Ltd., 2006.
4. Janakiraman. B and Gopal R.K., "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.
5. Subburaj. R., "Total Quality Management"- Tata McGraw Hill Education, 2017

ONLINE COURSES

1. https://www.udemy.com/course/total-quality-management-certification
2. https://onlinecourses.nptel.ac.in/noc20_mg34/preview
3. https://www.coursera.org/learn/six-sigma-principles
4. https://www.academyeurope.org/courses/engineering-technology/total-quality-management-tqm/

23ME43E	**MARKETING MANAGEMENT**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstratethe fundamental marketing concepts and their relevance to engineering and technology sectors

CO2: Analyze market opportunities, consumer behavior, and segmentation strategies

CO3: Apply marketing mix strategies to engineering products and services

CO4: Use the digital marketing tools and technology-driven marketing approaches for effective market engagement

CO5: Develop a marketing strategy for an engineering-based product or service

CO1 Demonstrate the fundamental marketing concepts and their relevance to engineering and technology sectors **L:9**

Definition, scope, and importance of marketing - Marketing vs. selling – Marketing environment and trends - Consumer and industrial markets – Characteristics and differences - Market segmentation, targeting, and positioning (STP) - Case studies on engineering and technology market segmentation

CO2 Analyze market opportunities, consumer behavior, and segmentation strategies. **L:9**

Consumer behavior – Buying decision process - Factors influencing consumer behavior – Psychological, social, and cultural aspects - Basics of market research – Types and techniques - Data collection methods and tools for marketing analysis - Case studies on technology adoption and consumer preferences

CO3 Apply marketing mix strategies to engineering products and services **L:9**

Introduction to marketing mix strategies (4Ps) - Product strategy – Types of products, product life cycle, and new product development - Pricing strategy – Pricing methods, factors affecting pricing decisions - Place (Distribution) strategy – Supply chain management, distribution channels - Promotion strategy – Advertising, personal selling, sales promotion, public relations - Integrated marketing communications – Case studies from engineering sectors

CO4 Use the digital marketing tools and technology-driven marketing approaches for effective market engagement **L:9**

Introduction to digital marketing – Importance and key components - Social media marketing and content marketing - Search engine optimization (SEO) and search engine marketing (SEM) - Branding strategies for engineering firms and technology startups - Case studies on successful branding in engineering and technology companies

CO5 Develop a marketing strategy for an engineering-based product or service **L:9**

Business-to-business (B2B) and Business-to-consumer (B2C) marketing - Sustainable marketing and green marketing - Role of artificial intelligence and automation in marketing - Ethical issues in marketing and legal aspects - Project presentations and discussions on innovative marketing strategies

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Philip Kotler, Kevin Lane Keller, and Alexander Chernev – Marketing Management, 17th Edition, Pearson, 2024.
2. Michael Levy and Barton A. Weitz – Retailing Management, 10th Edition, McGraw Hill, 2023.
3. Simon Kingsnorth, Digital Marketing Strategy: An Integrated Approach to Online Marketing, Kogan Page Publishers, 2019.

REFERENCES

1. Alexander Chernev – Strategic Marketing Management, 10th Edition, Cerebellum Press, 2023.
2. Rajan Nair N, Varma M.M, Marketing Management, 2nd Edition, S.Chand& Sons, New Delhi, 2005.

23ME44E	SUPPLY CHAIN AND LOGISTICS MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Use fundamental supply chain concepts to improve material and information flow.

CO2: Implement logistics management functions to ensure efficient movement and distribution of goods.

CO3: Utilize network design principles to develop efficient distribution strategies.

CO4: Employ inventory management techniques for effective production and sales forecasting.

CO5: Use current practices and tools to address issues in supply chain and logistics.

CO1 Use fundamental supply chain concepts to improve material and information flow. **L:9**

Role of Logistics and Supply chain Management: Scope and Importance - Evolution of Supply Chain – Supply chain strategy - Enablers/ Drivers of Supply Chain Performance - Supply Chain relationships - Green supply chain management.

CO2 Implement logistics management functions to ensure efficient movement and distribution of goods. **L:9**

Functions, objectives and solution - Customer Service - Warehousing and Material Storage - Material Handling - Transportation and Packaging – 3PL and 4PL- Global Logistics - Reverse Logistics; Reasons, Activities and issues.

CO3 Utilize network design principles to develop efficient distribution strategies. **L:9**

Distribution Network Design – Role, Factors Influencing and Options - Value Additions - Models for Facility Location and Capacity allocation - Impact of uncertainty on Network Design - Network Design decisions using Decision trees.

CO4 Employ inventory management techniques for effective production and sales forecasting. **L:9**

Sourcing – Make Vs. buy decision - Creating World Class Supply base - World Wide Sourcing Inventory Management – managing cycle inventory - Value of information - Bullwhip effect - Coordination in supply chain - Analyzing impact of supply chain redesign on the inventory.

CO5 Use current practices and tools to address issues in supply chain and logistics. **L:9**

E-Business – Framework and Role of Supply Chain in e- business and B2b practices - Supply Chain IT Framework - E-Supply Chains - E – Logistics – eSRM – eLRM – eSCM - Agile Supply Chains - Reverse Logistics - Global Logistics – SAP, AI in SCM, Blockchain technology in SCM - Real time examples.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Bowersox Donald J, Logistical Management – The Integrated Supply Chain Process" Tata McGraw Hill, July 2017.
2. Chopra S and Meindl P, "Supply Chain Management: Strategy, Planning, and Operation", Pearson, 2018.

REFERENCES

1. Donald J. Bowersox, David J. Closs and M. Bixby Cooper, "Supply Chain Logistics Management", Tata McGraw Hill, Sixth edition, 2012.
2. Altekar Rahul V, Supply Chain Management-Concept and Cases, Prentice Hall India, 2005.
3. Joel D. Wisner, G. Keong Leong, Keah-Choon Tan, "Principles of Supply Chain Management- A Balanced Approach", South-Western, Cengage Learning, fifth edition, 2019.
4. Narayan Rangarj, G. Raghuram, Mandyam M. Srinivasan, "Supply Chain Management for Competitive Advantage – Concepts and Cases", Tata McGraw Hill, 2009.
5. R.P. Mohanty and S.G. Deshmukh, "Supply Chain Management", Biztantra, 2005.
6. NPTEL: Prof. Vikas Thakur, Logistics & Supply Chain Management, IIT Kharagpur
7. https://www.udemy.com/course/certification-in-supply-chain-management/
8. https://www.coursera.org/specializations/supply-chain-management

23ME45E INDUSTRIAL SAFETY ENGINEERING

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the concept of accidents and their prevention.
CO2: Use ergonomics to design the work system to avoid accidents.
CO3: Analyze various industrial hazards and their control measures.
CO4: Select the appropriate fire extinguishing systems for various classes of fire.
CO5: Apply various safety management techniques to promote safety practices.

CO1 Demonstrate the concept of accidents and their prevention. L:9

Concept of an Accident, reportable and non-reportable accidents, reporting to statutory authorities. Principles of accident prevention - accident investigation and analysis – Unsafe act and unsafe condition - Domino sequence - cost of accidents - role of safety officer - safety supervisor - safety committee - Factories act and rules related to safety.

CO2 Use ergonomics to design the work system to avoid accidents. L:9

Introduction to ergonomics and its area of application in the work system. Anatomy, Posture

and body mechanics - low back pain, risk factors for musculoskeletal disorders in the work place - behavioral aspects of posture - effectiveness. Individual differences, Factors contributing to personality, fitting the man to the job. Motivation -job satisfaction - Emotion and frustration. Attitudes - determination of attitudes- changing attitudes.

CO3 Analyze various industrial hazards and their control measures. L:9

Physical hazards-Noise, heat, vibration, ionizing and non-ionizing radiations and effects. Chemical hazards-dusts, fumes, mist, vapor, fog, gases, types, concentration, exposure Vs dose, TLV. HAZOP studies - Mechanical hazards, Safety in materials handling - ladder, forklift scaffold. Hazards prevention - Administrative control methods, Engineering control methods- use of personal protective equipment.

CO4 Select the appropriate fire extinguishing systems for various classes of fire. L:9

Fire triangle-principles of fire extinguishing - various classes of fire - A, B, C, D types of fire extinguishers - Industrial fire protection systems. Sprinklers - Fire hydrants - Alarm and detection systems - other suppression systems - CO_2 system, foam system and DCP system.

CO5 Apply various safety management techniques to promote safety practices. L:9

Incident Recall Technique, Disaster Control, Job Safety Analysis, safety survey, safety inspection, safety Audit. Safety training, seminars, conferences, competitions - method of promoting safe practice - creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign - Domestic Safety and Training.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. L M Deshmukh, Industrial Safety Management‖, Tata McGraw-Hill Education, 2010.
2. Charles D. Reese, Occupational Health and Safety Management: A Practical Approach, CRC Press, 2018.

REFERENCES

1. Edward Ghali, V. S. Sastri, M. Elboujdaini, ―Corrosion Prevention and Protection: Practical Solutions‖, John Wiley & Sons, 2007.
2. J Maiti, Pradip Kumar Ray, Industrial Safety Management: 21st Century Perspectives of Asia, Springer, 2017.
3. R. Keith Mobley, Maintenance Fundamentals, Elsevier, 2011.
4. W. E. Vesely, F. F. Goldberg, Fault Tree Handbook, Create space Independent Pub, 2014.
5. NPTEL: Prod. J.Maiti, Industrial Safety Engineering https://nptel.ac.in/courses/110105094

23ME46E **INDUSTRY 4.0**

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Explore the basic concepts of Industry 4.0 and smart manufacturing.

CO2: Develop dataset in the context of Industry 4.0 enabled manufacturing to optimize manufacturing processes.

CO3: Use the Machine Learning techniques to improve manufacturing processes.

CO4: Interpret the fundamental concepts and applications of Cyber-Physical Systems

CO5: Identify key performance patterns of manufacturing processes using digital twins.

CO1: Explore the basic concepts of Industry 4.0 and smart manufacturing. **L:9**

1st, 2nd, 3rd, and 4th Industrial Revolutions; Industry 4.0 in Manufacturing; Major components of Smart Manufacturing – Industrial IoT sensors, Big data, Artificial Intelligence, Networking and cybersecurity, Robotics, Additive Manufacturing. Industry 4.0 Design principles, Benefits of Smart Manufacturing.

CO2: Develop dataset in the context of Industry 4.0 enabled manufacturing to optimize manufacturing processes. **L:9**

Concept and characteristics of big data, Data sharing and collaboration, Structured data, and relational databases, Unstructured data, Four levels of data analytics, Lifecycle of Big data in Manufacturing.

CO3: Use the Machine Learning techniques to improve manufacturing processes. **L:9**

Introduction to Machine Learning, The Machine Learning Process, Advantages and Disadvantages of ML, ML for sustainable manufacturing, ML to improve manufacturing, Challenges in implementing ML in manufacturing, Case studies of ML in manufacturing.

CO4: Interpret the fundamental concepts and applications of Cyber-Physical Systems **L:9**

Introduction to Cyber-Physical Systems (CPS), Concept and Characteristics of CPS, Architecture of CPS- Components, Data science and technology for CPS, Classification of CPS in the context of I4.0, Application of CPS in Manufacturing

CO5: Identify key performance patterns of manufacturing processes using digital twins. **L:9**

Background and concept of Digital Twin, Digital Twin, and related concepts, Value of digital twin, Applications of Digital Twin, Digital Twin modeling and key technologies, Digital Twin driven smart manufacturing, Case studies – Equipment energy consumption management, Machining process improvement, Prognostics, and health management

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Tyagi, Amit Kumar; Tiwari, Shrikant; Ahmad, Sayed Sayeed – Industry 4.0, Smart Manufacturing, and Industrial Engineering: Challenges and Opportunities – 1st Edition – Routledge – 2024
2. Ustundag, Alp; Cevikcan, Emre – Industry 4.0: Managing the Digital Transformation – 1st Edition – Springer – 2018.

REFERENCES

1. Gilchrist, Alasdair – Industry 4.0: The Industrial Internet of Things – 1st Edition – Apress – 2016
2. Hassanien, Aboul Ella; Chatterjee, Jyotir Moy; Jain, Vishal (eds) – Artificial Intelligence and Industry 4.0 – 1st Edition – Academic Press – 2022.
3. Social Innovation in Industry 4.0 (NPTEL Course), Prof. Janakranjan Ramkumar and Prof. Amandeep Singh Oberoi, IIT Kanpur.
4. Introduction to Industry 4.0 and Industrial Internet of Things (NPTEL Course), Prof. Sudip Misra, IIT Kharagpur.

B.E. – MECHANICAL ENGINEERING

OPEN ELECTIVE COURSES

23ID01E	**ENERGY ENGINEERING**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Demonstrate the operation of solar thermal and solar photovoltaic systems.
CO2: Demonstrate the operation of wind energy system.
CO3: Use the concepts of various bio-energy conversion techniques for power generation.
CO4: Illustrate the concepts of other conventional and nonconventional power plants.
CO5: Demonstrate the concepts of hydrogen and fuel cell technology

CO1 Demonstrate the operation of solar thermal and solar photovoltaic systems **L:9**

Sun - Earth Geometry, solar radiation, Solar Collectors - Application of solar thermal systems. Direct Electricity Conversion - Types of Solar cell - Solar Photovoltaic system and types.

CO2 Demonstrate the operation of wind energy system **L:9**

Wind energy potential, Principle of wind energy conversion; Basic components, types and their constructional features; design considerations: wind data and site selection.

CO3 Use the concepts of various bio-energy conversion techniques for power generation. **L:9**

Biomass: sources, characterization, principles of energy transfer technologies. Biogas: Feedstock, types of Biogas plant - parameters affecting biogas production.

CO4 Illustrate the concepts of other conventional and nonconventional power plants **L:9**

Layout of Hydel - thermal - Nuclear - Gas turbine - Diesel - MHD - Geo thermal - OTEC - Tidal Power Plants

CO5 Demonstrate the concepts of hydrogen and fuel cell technology **L:9**

Energy carrier: Types - Hydrogen: generation, storage, transport and utilization – thermal energy storage: Principle and utilization - Fuel cells: Technologies, types and applications.

L:45; TOTAL:45 PERIODS

REFERENCES

1. Soteris Kalogirou, “Solar Energy Engineering: Processes and Systems”, Academic Press, 2014.
2. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K, 3rd Edition, 2012.
3. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 2nd Edition, 2006.
4. Hart A B and Womack, G J, “Fuel Cells: Theory & Applications”, Prentice Hall, 1997
5. EI-Wakil M M, “Power Plant Technology”, Tata McGraw-Hill, 2010.
6. Khandelwal K C and Mahdi S S, “Biogas Technology - A Practical Handbook”, Tata McGraw Hill, 1986.
7. Duffie J A and Beckman W A, “Solar Engineering of Thermal Processes”, Wiley, 4th

Edition, 2013.
8. Chetan Singh Solanki, "Solar Photovoltaics Fundamentals, Technologies and Applications", Prentice Hall of India, 3rd Edition, 2015.

23ID02E	3D DESIGN AND MANUFACTURING	L	T	P	E	C
		2	0	2	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory component:

CO1: Demonstrate key additive manufacturing (AM) techniques and their industrial applications.

CO2: Use the concepts of 3D Modeling and scanning techniques for designing and preparing models used in 3D printing and reverse engineering applications.

CO3: Demonstrate the operation and influence of fabrication parameters on print quality in FDM

CO4: Demonstrate the operation and influence of fabrication parameters on print quality in DLP

Practical component:

CO5: Practice 3D scanning and operate dual extruder FDM to fabricate solid models

CO6: Operate DLP to fabricate solid models.

CO1 Demonstrate key additive manufacturing (AM) techniques and their industrial applications. **L:9**

Overview and Importance of AM in Modern Industry-Commercially Popular AM Techniques: FDM, SLA, DLP, SLS-Benefits and Limitations of AM-Applications across Disciplines: Medical, Aerospace, Automotive, Electronics, Civil Engineering, AI, and Data Science-Future Trends and Business Opportunities in AM.

CO2 Use the concepts of 3D Modeling and scanning techniques for designing and preparing models used in 3D printing and reverse engineering applications. **L:10**

Basics of 3D CAD Modelling. Model Preparation: Creating Simple to Complex Models for 3D Printing using any modelling software. Model Optimization: Ensuring Structural Integrity and Printability- Introduction to 3D Scanning: Tools, Techniques, and Applications. 3D Scanning for Reverse Engineering: Capturing Real-World Geometries for Digital Redesign. Reengineering with 3D Scanned Models: Integration into New Product Development. Design for additive manufacturing (DFAM)

CO3 Demonstrate the operation and influence of fabrication parameters on print quality in FDM **L:5**

CO5 Practice 3D scanning and operate dual extruder FDM to fabricate solid models **P:20**

Introduction to Fused Deposition Modeling (FDM)- Dual Extruder Operation: Multi-Material and Multi-Colour Printing.

Operating the Dual Extruder FDM Machine-Troubleshooting Common FDM Issues and

Maintenance.

CO4 Demonstrate the operation and influence of fabrication parameters on print quality in DLP **L:6**

CO6 Operate DLP to fabricate solid models. **P:10**

Introduction to Digital Light Processing (DLP)-Material Selection for DLP: Photopolymer Resins. Maintenance and Safety Protocols for Resin Handling-Applications of DLP in Precision and Detailed Manufacturing

Operating the DLP Machine for High-Resolution Printing.

L:30; P:30; TOTAL:60 PERIODS

TEXT BOOKS

1. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing forPrototyping and Manufacturing", Hanser publications, United States, 2015.
2. Ian Gibson, David W.Rosen and Brent Stucker "Additive ManufacturingTechnologies: Rapid Prototyping to Direct Digital Manufacturing", 2nd Edition,Springer, United States, 2015.

REFERENCES

1. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition,CRC Press., United States, 2015.
2. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping,Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011.
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer,United States, 2006.
4. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: Atool box for prototype development", CRC Press., United States, 2011.
5. Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies,and Applications", Woodhead Publishing., United Kingdom, 2016.

23ID03E	ENTREPRENEURSHIP DEVELOPMENT	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the completion of this course the students will be able to

Theory Component:

CO1: Demonstrate the types of entrepreneurship and factors influencing growth

CO2: Explore achievement motivation theories and principles for developing entrepreneurship

CO3: Choose the right business ownership for starting a company

CO4: Demonstrate the accounting process, finance and their significance sources

CO5: Demonstrate the sickness in small business and growth strategies for small scale enterprises

CO1 Demonstrate the types of entrepreneurship and factors influencing growth **L:9**

Entrepreneur – Characteristics – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur – Role of Entrepreneurship in Economic Development –

Factors Affecting Entrepreneurial Growth – Economic, Non-Economic, Government Actions.

CO2 **Explore achievement motivation theories and principles for developing entrepreneurship** **L:9**

Entrepreneurial Motivation: Theories and Factors, Achievement Motivation – Entrepreneurial Competencies – Entrepreneurship Development Programs – Need, Objectives – Business Game, Thematic Apperception Test, Self Rating, Stress management.

CO3 **Choose the right business ownership for starting a company** **L:9**

Small Enterprises – Definition, Characteristics, Project Identification and selection – Project Formulation: Significance, content, formulation of project report – Project Appraisal: Concept and method – Ownership Structures: Selection & Pattern.

CO4 **Demonstrate the accounting process, finance and their significance sources** **L:9**

Finance: Need, Sources, Capital Structure, Term Loans – Accounting: Need, Objectives, Process, Journal, Ledger, Trial Balance, Final Accounts – Working Capital Management: Significance, Assessment, Factors, Sources, Management.

CO5 **Demonstrate the sickness in small business and growth strategies for small scale enterprises** **L:9**

Sickness in small Business: Concept, Signals, Symptoms, Magnitude, Causes and Consequences, Corrective Measures – Government Policy for Small Scale Enterprises – Growth Strategies in Small Scale Enterprise – Institutional Support to Entrepreneurs: Need and Support – Taxation Benefits to Small Scale Industry: Need, Depreciation, Rehabilitation, Investment.

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. S.S.Khanka, Entrepreneurial Development, S.Chand& Co. Ltd., 4th revised edition, 2023.
2. Kuratko & Hodgetts, Entrepreneurship – Theory, process and practices, Thomson learning 12th Edition, 2024
3. Vasant Desai, The Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, 6th Edition, 2022.

REFERENCES

1. Poornima M. Charantimath., Entrepreneurship Development and Small Business Enterprises, Pearson, 3rd Edition, 2018.
2. Robert D. Hisrich and Peters M P, Entrepreneurship 12th Edition, Tata McGraw-Hill, 2024.
3. Rajeev Roy, Entrepreneurship, Oxford University Press, 3rd Edition, 2021.
4. https://onlinecourses.swayam2.ac.in/ini25_cm03/preview
5. https://onlinecourses.nptel.ac.in/noc25_mg81/preview
6. https://onlinecourses.swayam2.ac.in/cec25_cm16/preview
7. https://onlinecourses.swayam2.ac.in/cec25_mg23/preview

23ID04E FINANCIAL MANAGEMENT FOR ENGINEERS

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Demonstrate the fundamental accounting principles and financial statements

CO2: Analyze financial statements using key financial ratios and engineering cost concepts

CO3: Apply cost accounting techniques for effective cost control and decision-making in engineering projects

CO4: Evaluate project feasibility using capital budgeting and financial planning methods

CO5: Demonstrate knowledge of accounting applications in engineering industries and entrepreneurial ventures

CO1 Demonstrate the fundamental accounting principles and financial statements **L:9**

Basics of accounting - Concepts of double-entry system and accounting equations - Journal entries, ledger posting, and trial balance preparation - Preparation of financial statements - Accounting standards and regulatory framework

CO2 Analyze financial statements using key financial ratios and engineering cost concepts **L:9**

Introduction to financial statement analysis – Purpose & scope - Ratio analysis – Liquidity, profitability, solvency, and efficiency ratios - Case studies on financial analysis in engineering firms

CO3 Apply cost accounting techniques for effective cost control and decision-making in engineering projects **L:9**

Introduction to cost accounting - Elements of cost - Cost classification – Fixed, variable, and semi-variable costs - Cost-volume-profit (CVP) analysis and breakeven point - Marginal costing and its applications in engineering projects.

CO4 Evaluate project feasibility using capital budgeting techniques and financial planning methods **L:9**

Capital budgeting techniques – Payback period, Discounted Payback period, NPV, IRR, ARR - Depreciation - Working capital management – Importance and techniques - Sources of finance – Equity, debt, venture capital, and government grants - Financial risk management in engineering projects - Engineering economic decision-making – Case studies

CO5 Demonstrate knowledge of accounting applications in engineering industries and entrepreneurial ventures **L:9**

Cost estimation in manufacturing and engineering projects - Financial planning for startups and new ventures - Taxation, and GST implications - Ethical issues in financial decision-making and corporate governance - Case studies in engineering financial management

L:45; TOTAL:45 PERIODS

TEXT BOOKS

1. Easton, Halsey, McAnally, "Financial & Managerial Accounting for MBAs", Cambridge Business Publisher, 6th Edition, 2021.
2. Dr. Dinesh D Harsolekar; CA (Dr.) Pinky Agarwal, "Accounting for Management", Taxmann Publications Private Limited, 2022.
3. Dr. J. Made Gowda, Inchara P. M. Gowda, "Accounting For Managers" Himalaya Publishing House, 2024.

REFERENCES

1. K Maheshwari, Dr S N Maheshwari, "A Textbook of Accounting for Management", Vikas Publishing House, 2022.
2. Prasanna Chandra, "Projects, Planning, Analysis, Selection, Financing, Implementation and Review", Tata Mc-Graw Hill, 2023.

B.E. – MECHANICAL ENGINEERING

ONE CREDIT ELECTIVE COURSES

23ME01L	**DESIGN OF EXPERIMENTS**	**L**	**T**	**P**	**E**	**C**
		1	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Design, conduct, and analyze experiments using statistical techniques and modeling tools to solve practical engineering problems

CO1 Design, conduct, and analyze experiments using statistical techniques and modeling tools to solve practical engineering problems L:15

Introduction to Experimental Design-Principles and Planning of Experiments-Two-Factor Experiments and Interaction Effects -Factorial Designs and Advanced Concepts-Modelling and Software Implementation-Response Surface Method-Taguchi Method-Case Studies and Applications

L15; TOTAL:15 PERIODS

TEXT BOOKS

1. Douglas C. Montgomery, Design and Analysis of Experiments, willey, 2020

REFERENCES

1. Jiju Antony, Design of Experiments for Engineers and Scientists, Elsevier, 2023.
2. Gary W. Oehlert, A First Course in Design and Analysis of Experiments, University of Minnesota, 2010
3. Design and Analysis of Experiments, SWAYAM
4. Experimentation for Improvement, COURSERA

23ME02L	**CARBON CAPTURE**	**L**	**T**	**P**	**E**	**C**
		1	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Analyze the carbon storage options, challenges and opportunities in carbon capture.

CO1 Analyze the challenges and opportunities in carbon capture and storage. L:15

Introduction to Carbon Capture: Overview of climate change and the role of carbon capture, Types of carbon capture technologies - Pre-Combustion Carbon Capture: Principles and applications of pre-combustion carbon capture, Technologies and challenges - Post-Combustion Carbon Capture: Principles and applications of post-combustion carbon capture, Technologies and challenges - Oxyfuel Combustion Carbon Capture: Principles and applications of oxyfuel combustion carbon capture, Technologies and challenges - Carbon Capture and Storage (CCS): Overview of CCS systems, Challenges and opportunities - Carbon Utilization: Overview of carbon utilization technologies, Applications and challenges – Carbon credits

L:15; TOTAL:15 PERIODS

REFERENCES

1. “Carbon Capture and Storage" Report of Intergovernmental Panel on Climate Change (IPCC)

2. Jennifer Wilcox – Carbon Capture, Springer, 2012
3. Howard J. Herzog - Carbon Capture, MIT Press, 2018.
4. Malti Goel, M Sudhakar and R V Shahi - Carbon Capture, Storage, and Utilization – Report of TERI, 2018
5. Research papers on carbon capture technologies
6. Industry reports and case studies on carbon capture

23ME03L	ENERGY AUDIT AND MANAGEMENT	L	T	P	E	C
		1	0	0	0	1

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Apply the methodology to carry out energy audit and management of electrical and thermal systems.

CO1 Apply the methodologies to carry out energy audit and management of equipment and processes. **L:15**

Basics of Energy Audit: Types, Methodology, and Instruments – Role of Energy Manager and Energy Auditor - Energy Audit in Electrical Systems: Motors, Lighting, HVAC. Energy Audit in Thermal Systems: Boilers, Furnaces, Insulation - Energy Efficiency Measures and Technologies - Economic Analysis of Energy Conservation Projects: Payback, ROI, NPV - Energy Performance Indexes, Benchmarking - Energy Conservation Act and Roles of BEE, PAT Scheme - Case Studies – Hands on Experience.

L:15; TOTAL:15 PERIODS

REFERENCES

1. Bureau of Energy Efficiency Books, Volumes I - IV
2. B. L. Singhal, Amit L. Nehete, Energy Audit and Management, TechKnowledge Publications, 2023.
3. L. Ashok Kumar, Gokul Ganesan, Energy Audit and Management - Concept, Methodologies, Procedures, and Case Studies, CRC Press, 2022.
4. NPTEL Course on Basic Principles of Energy Management & Energy Audit

23ME04L	FUNCTIONAL MATERIALS FOR ENERGY CONVERSION	L	T	P	E	C
		1	0	0	0	1

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Select the suitable functional materials for energy conversion and storage

CO1 Select the suitable functional materials for energy conversion and storage **L:15**

Procedure for functional material development. Review of materials developed/available. Need for functional materials, synthesis methods, energy application. Design philosophy of functional materials, Nanostructures and Advanced Materials for solar energy conversion, fuel cell and energy storage.

L:15; TOTAL:15 PERIODS

TEXT BOOKS

1. David Munoz-Rojas, Xavier Moya, ―Materials for Sustainable Energy Applications: Conversion, Storage, Transmission, and Consumption‖, Pan Stanford Publishing, 2016.

REFERENCES

1. Kilner J A, Skinner S J, Irvine S J C, Edwards P P, Functional Materials for Sustainable Energy Applications‖, Woodhead Publishing Limited, 2012.

		L	T	P	E	C
23ME05L	**INDUSTRIAL DRAWING READING WITH GEOMETRIC DIMENSIONING AND TOLERANCING**	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO1: Use the limits, fits and tolerance in component drawing

CO1 Use the limits, fits and tolerance in component drawing **L:15**

Industrial Drawing reading – First and third angle projection – free hand sketches – BIS SP46 - Engineering drawing and tolerance – Limits, fits and Tolerance – Tolerance symbols and terms – rules and concepts of GD&T - use of GD&T – MMC, LMC – datum – Form – Orientation – profile – Runout

L:15; TOTAL:15 PERIODS

TEXT BOOK

1. Alex Krulikowsi, Fundamentals of Geometric Dimensioning and Tolerancing, 2nd Edition, Delmar publications, 2012.

REFERENCES

1. Standards for dimensioning and tolerancing - ASME Y 14.5, 2009.
2. James D Meadows, GD&T Application, analysis and Measurements, ASME Press 2009.

		L	T	P	E	C
23ME06L	**STRUCTURING A STARTUP**	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon the completion of this course the students will be able to

Theory Component:

CO1: Identify real world problems, create innovative solutions, and establish a startup within the Indian entrepreneurial and regulatory framework.

CO1 **Identify real world problems, create innovative solutions, and establish a startup within the Indian entrepreneurial and regulatory framework.** **L:15**

Introduction to Startup Entrepreneurship: Definitions: Entrepreneur, Startup, Innovation- Traits of a Startup Entrepreneur, Overview of Indian Startup Ecosystem and Government Support Schemes. **Problem Identification and Ideation:** Understanding and identifying real-world problems - Ideation techniques: brainstorming, design thinking basics- Case studies of engineering startups born from real-world problems. **From Idea to Innovation to Startup:** Innovation funnel: from idea to Minimum Viable Product (MVP)- Product-market fit and validation techniques- Basics of Intellectual Property Rights (IPR) in the startup context. **Structuring a Startup in India:** Business entity types: Proprietorship, Partnership, LLP, Private Ltd- Legal procedures for startup registration- Overview of regulatory compliance, taxation, and funding sources.

L:15; TOTAL:15 PERIODS

TEXT BOOKS

1. S. S. Khanka, "Entrepreneurship Development", S. Chand Publishing, 2023
2. Anjan Raichaudhuri, "Startup and New Venture Management", Oxford University Press India, 2022
3. Eric Ries, "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses", Crown Business Publishers, 2024

REFERENCES

1. Bill Aulet, "Disciplined Entrepreneurship: 24 Steps to a Successful Startup", Wiley publishers, 2023
2. https://onlinecourses.swayam2.ac.in/ini25_cm03/preview
3. https://onlinecourses.nptel.ac.in/noc25_mg81/preview
4. https://onlinecourses.swayam2.ac.in/cec25_cm16/preview
5. https://onlinecourses.swayam2.ac.in/cec25_mg23/preview

23ME07L DESIGN FOR ENVIRONMENT

L	T	P	E	C
1	0	0	0	1

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO: Explore the concepts to design various components for the environmental concern

CO	**Explore the concepts to design various components for the environmental concern**	**15**

Introduction - Environmental objectives - Global issues - Regional and local issues - Basic DFE methods - Design guide lines - application. Lifecycle assessment - Basic method - AT&T's environmentally responsible product assessment - Weighted sum assessment method - Lifecycle assessment method - Techniques to reduce environmental impact - Design to minimize material usage - Design for disassembly - Design for recyclability - Design for manufacture - Design for energy efficiency - Design to regulations and standards.ESG (Environmental, Social, and Governance) - EIA (Environmental Impact Assessment)

L15; TOTAL:15 PERIODS

REFERENCES

1. Fixel, J. Design for the Environment McGraw Hill., 2011.

2. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.

		L	T	P	E	C
23ME08L	**CODES AND STANDARDS FOR WELDING**	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO: Apply pressure vessel, piping, and tank design codes for safe industrial design.

CO **Apply pressure vessel, piping, and tank design codes for safe industrial design.** **15**

Codes, standards -Types of codes - Code making bodies - Codes of Materials - Code of Weld symbols - Pressure vessel design codes ASME Sec VIII - Piping codes ASME B31.1 & ASME B31.3 -Tank design. As per API 650 - Indian standard wind and seismic code - Manufacturing as per ASME Sec VIII - Manufacturing as per AWS D1.1 -Welding Procedure Qualification, Welder Qualification - Inspection As per ASME Sec viii - Inspection As per AWS D1.1- Welding defects ISO 5817 - Mechanical testing as per, IS, ASTM - Casting inspection as per ASME 16.34 - ISO9001, ISO 3834 Quality Management System in Welding Operation.

L15; TOTAL:15 PERIODS

REFERENCES

1. IS 2062, AWS A5.1, ASTM A 36, IS 814
2. ASME SEC VIII ASME B 3.1, ASME B 31,3, API 650
3. ASME SEC VIII, AWS D1.1ASME B 31.1, 31.3
4. ASME Sec viii, As per AWS D1.1, ISO 5817, ASTM A 370, ASME B 16.34, IS 1608 -1
5. ISO 9001, ISO 3834 , ISO IEC 17025

23SH01E	LINEAR ALGEBRA, MATHEMATICAL LOGIC AND SET THEORY	L	T	P	E	C
		2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Analyze concepts of vector spaces.

CO2: Measure the similarity between different datasets using Inner product spaces.

CO3: Decompose the matrix for computational convenience.

CO4: Illustrate the validity of the arguments.

CO5**:** Analyze the concepts of Sets, Relations and Functions.

CO1: Analyze concepts of vector spaces **L:6 T:3**

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions.

CO2: Measure the similarity between different datasets using Inner product spaces **L:6 T:3**

Linear transformation - Null spaces and ranges – Rank Nullity theorem - Matrix representation of a linear transformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process**.**

CO3: Decompose the matrix for computational convenience **L:6 T:3**

Generalized eigenvector - QR decomposition- generalized inverse - Singular value decomposition and applications – Pseudo Inverse.

CO4: Illustrate the validity of the arguments. **L:6 T:3**

Propositional Logic – Equivalences and Implications – Normal forms – Predicate Calculus and Quantifiers - Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency.

CO5: Analyze the concepts of Sets, Relations and Functions **L:6 T:3**

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Partial Ordering Relation - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions.

TEXT BOOKS

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
2. Bernard Kolman and David Hill, "Elementary Linear Algebra with Application" Pearson India, 9th Edition, 2019.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

REFERENCE BOOKS

1. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi,2017.
2. Friedberg, A.H., I nsel,A.J.and Spence, L., Elementary Linear Algebra, a matrix approach, 2nd Edition pearson Publication.
3. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.
4. Seymour Lipschutz Marc Lipson., "Linear Algebra" Schaum's Out lines series, 6th Edition, McGraw – Hill Education, 2018.

L : 30; T :15; TOTAL : 45 PERIODS

23SH02E	**LINEAR STRUCTURES AND TRANSFORMATIONS**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Solve the linear system of equations.

CO2: Determine the dimension of vector spaces.

CO3: Find the orthonormal vectors using Inner product spaces.

CO4: Illustrate Jordan canonical form on a finite dimensional vector space.

CO5:Decompose the matrix using Generalized Eigen vectors for computation.

CO 1: Solve the linear system of equations **L:6**

General system of linear equations – Matrices– Echelon form of matrix- Solving linear systems- Consistency of a system of linear equations -LU factorization. **T:3**

CO2: Determine the dimension of vector spaces

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:6 T:3**

CO3: Find the orthonormal vectors using Inner product spaces

Linear transformation - Null spaces and ranges – Rank Nullity Theorem - Matrix representation of a lineartransformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process. **L:6 T:3**

CO4: Illustrate Jordan canonical form on a finite dimensional vector space

Generalized eigenvector- Chains- Canonical basis the minimum polynomial- - Algebraic and Geometric multiplicity of Eigen Values - Similar matrices-Modal matrix-Jordan canonical form. **L:6 T:3**

CO5: Decompose the matrix using Generalized Eigen vectors for computation

Eigen-values using QR transformations – Generalized Inverse Eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse **L:6 T:3**

TEXT BOOKS

1. Bernard Kolman and David Hill, “Elementary Linear Algebra with Application” Pearson India, 9th Edition 2019.
2. Seymour Lipschutz Marc Lipson., “Linear Algebra” Schaum’s Out lines series, Six edition, McGraw – Hill Education, 2018.

REFERENCE BOOKS

1. Friedberg, A.H., I nsel,A.J.and Spence, L., Elementary Linear Algebra, A Matrix Approach, 2nd Edition, Pearson 2019.
2. Jim Defranza. Daniel Gagiardi “Introduction to Linear Algebra with Applications” Waveland PrLnk, 2015.
3. Eggar.Goodaire“Linear Algebra Pure & Applied”, World Scientific, New Delhi, first edition, 2015.
4. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.

L: 30; T :15; TOTAL: 45 PERIODS

23SH03E	**NUMBER THEORY**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Acquire the concepts of theory of numbers. (CDL 1)

CO2: Apply the fundamental propositions to interpret solutions of congruence. (CDL 1)

CO3: Find the primitive roots for the congruence. (CDL 1)

CO4: Analyze the inter-relation between arithmetical functions. (CDL 1)

CO5: Determine quadratic residues of congruence. (CDL 1)

CO1: Acquire the concepts of theory of numbers

Introduction – Divisibility- Greatest common divisor - Prime numbers - The fundamental theorem of arithmetic - The series of reciprocals of the primes - The Euclidean algorithm(without Proof) - The greatest common divisor of more than two numbers. **L:6 T:3**

CO2: Apply the fundamental propositions to interpret solutions of congruence

Congruence - Linear congruence - Euler-Fermat theorem - Polynomial congruence modulo p – Wilson's Theorem **L:6 T:3**

CO3: Analyze the inter-relation between arithmetical functions.

The Mobius function μ(n) – The Euler Totient function φ(n)– A relation connecting φ and μ – A product formula for φ(n) – properties of φ(n) –Multiplicative functions– completely multiplicative function. **L:6 T:3**

CO4: Determine quadratic residues of congruence

Quadratic Residues – Legendre's symbol and its properties – Evaluation of (-1|p) and (2|p) – Gauss lemma – The Quadratic Reciprocity law – Applications – The Jacobi symbol. **L:6 T:3**

CO5:Implement the concepts of congruence in cryptography

Chinese remainder theorem - Applications of Chinese remainder theorem - Cryptography and its application – RSA algorithm and Rabin Cryptosystem. **L:6 T:3**

TEXT BOOKS

1. Tom M.Apostol, "Introduction to Analytic Number Theory", Springer International Edition, Narosa Publishing House, New Delhi, 2013.
2. G.A.Jones&J.M.Jones, "Elementary Number Theory", Springer publications, 2012.

REFERENCE BOOKS

1. David M.Burton, "Elementary Number Theory", McGraw Hill, 7th Edition,2023
2. Joseph H.Silverman, "A Friendly Introduction to Number Theory", Pearson Education, 4th Edition, 2019.
3. Titu Andreesu, Gabriel Dospinescu, Oleg MushKarov, Number Theory: concepts and problems, Springer Science & Business Media, 2017.
4. S B Malik , "Basic Number Theory", S Chand publications, 2nd Edition, 2018

L : 30; T :15; TOTAL : 45 PERIODS

23SH04E	**NUMERICAL ANALYSIS**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Solve algebraic and transcendental equations using numerical methods. (CDL 1)

CO2: Interpolate and approximate the polynomial of data. (CDL 1)

CO3: Perform numerical differentiation and integration. (CDL 1)

CO4: Find numerical solution of ordinary differential equation. (CDL 1)

CO5:Classify and find numerical solution of partial differential equations. (CDL 1)

CO 1: Solve algebraic and transcendental equations using numerical methods

Solutions of Algebraic linear equations Newton - Raphson Method, Fixed Point Iteration method - Solutions of algebraic simultaneous linear equations - Gauss Elimination –Gauss Seidel Methods. **L:6 T:3**

CO 2: Interpolate and approximate the polynomial of data

Curve Fitting – Method of Least Squares – Fitting a Straight Line – Fitting a Second-Degree Parabola - Finite differences - Newton's Forward & Backward Difference Formulae - Central Differences - Stirling's Formula - Lagrange's Formula. **L:6 T:3**

CO 3: Perform numerical differentiation and integration

Derivatives using forward and backward difference Formulae - Trapezoidal rule - Simpson's rules - Double integration using Trapezoidal and Simpson's rules. **L:6 T:3**

CO 4: Find numerical solution of ordinary differential equation

Taylor's Series Method - Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods - Milne's Method - Finite difference for solving ordinary differential equation. **L:6 T:3**

CO 5: Classify and find numerical solution of partial differential equations

Classification of Partial Differential Equations of second order - Finite difference solution of one dimensional heat equation by explicit and implicit methods (Crank Nichelson and Bender Schmidth methods) - One dimensional wave equation and two dimensional Laplace and Poisson equations. **L:6 T:3**

TEXT BOOKS

1. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.
2. M.K.Jain, S.R.K.Iyengar, R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, J. Wiley and Sons, 2023.

REFERENCE BOOKS

1. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGrawHill, New Delhi, 2021.
2. Saumyen Guha, Rajesh Srivastava "Numerical Methods: For Engineering and Science", Oxford University Press, New Delhi, 1st Edition with third impression, 2015.
3. K.SankaraRao , "Numerical Methods For Scientists And Engineers", 5th Edition, New age International Publisher, 2018
4. Dr Chaitanya Kumar, Dr Harinderjit Kaur Chawla, Dr Indarpal Singh "A Textbook on Numerical Methods and Analysis" Sultan Chand and SonsPublisher, 2024

L: 30; T:15; TOTAL: 45 PERIODS

23SH05E	**OPTIMIZATION TECHNIQUES**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Find optimum solution of linear programming problem.

CO2: Determine the optimum schedule for assignment and transportation problems.

CO3: Acquire decision making in Pure and Mixed Strategies.

CO4: Analyze the network for optimal schedule.

CO5: Compute optimum solution of non-linear programming.

CO1: Find optimum solution of linear programming problem

Linear Programming Problem – Mathematical Formulation of Linear Programming Problems (LPP) – Graphical Solution Method - Canonical and Standard Forms of LPP - Simplex Method - Linear Programming using Artificial Variables - Two Phase Method. **L:6 T:3**

CO2: Acquire decision making in Pure and Mixed Strategies

Basic Terms in Game Theory - Two-Person Zero-Sum Games - Maximin-Minimax Principal - Games without Saddle Points - Mixed Strategies-Pure and Mixed Strategies with Saddle Point- Mixed Strategy Problems by Arithmetic Method- Graphic Solution of $2 \times n$ and $m \times 2$ Games. **L:6 T:3**

CO3: Analyze the network for optimal schedule

Development of Network Analysis - Network Analysis and Rules of Network Construction - Critical Path Method (CPM) - Programme Evaluation and Review Technique (PERT). **L:6 T:3**

CO4: Compute optimum solution of non – linear programming

Formulating a Non-Linear Programming Problem – Constrained Optimization with equality Constraints- Graphical Solution – Kuhn- Tucker Conditions with Non negative constraints- Quadratic Programming – Wolfe's modified Simplex method. **L:6 T:3**

CO5: Solve non-linear constrained optimization

Optimization using Gradient Descent – Constrained optimization - Lagrange Multipliers - Convex optimization - Non linear Constrained Optimization. **L:6 T:3**

TEXT BOOKS

1. KantiSwarup, Gupta P.K and Man Mohan, Operations Research: Introduction to management Science, Sultan Chand &Sons, 20th Revised Edition, 2022.
2. Hamdy A Taha, Operations Research - An Introduction, 10th Edition, Pearson Education, 2019.

REFERENCE BOOKS

1. Sharma JK., Operations Research, Trinity, New Delhi, 6th Edition, 2017.
2. Sundaresan.V, Ganapathy Subramanian. K.S. and Ganesan.K, Resource Management Techniques, A.R. Publications, 11th Edition, 2017.
3. Gupta P K, Mohan Man, Problems in Operations Research, Sultan Chand & Sons, 2014
4. V K Kapoor, Operations Research , Concept problems & solutions, Sultan Chand & Sons, 2017

L: 30; T:15; TOTAL: 45 PERIODS

23SH06E	**PRINCIPLES OF DISCRETE MATHEMATICS**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Illustrate the validity of the arguments. (CDL 1)
CO2: Analyze the concepts of Sets, Relations and Functions. (CDL 1)
CO3: Perform the principles of counting and solve recurrence relations. (CDL 1)
CO4: Interpret the basic concepts of graphs. (CDL 1)
CO5: Compute minimum Spanning Trees and shortest route for the graph. (CDL 1)

CO1: Illustrate the validity of the arguments.

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

CO2: Analyze the concepts of Sets, Relations and Functions

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions. **L:6 T:3**

CO3: Perform the principles of counting and solve recurrence relations.

Mathematical induction - Strong induction and well ordering -The basics of counting – The pigeonhole principle - Recurrence relations – Solving linear recurrence relations – Generating functions - Inclusion and exclusion principle. **L:6 T:3**

CO4: Interpret the basic concepts of graphs

Graphs and their properties - Special types of graphs – Matrix representation of graphs and graph isomorphism- Euler and Hamiltonian graphs. **L:6 T:3**

CO5: Compute minimum Spanning Trees and shortest route for the graph

Trees – Some properties of Trees – Pendant vertices in a Tree – Distance and centers in a Tree – Rooted and Binary Trees - Spanning Trees- minimum spanning tree–Prim's algorithm. **L:6 T:3**

TEXT BOOKS

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, first Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2020.
3. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, 1st Edition, Dover Publications Inc., 2016.

REFERENCE BOOKS

1. Ralph.P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson Education Asia, Delhi, 2019.
2. Bondy, J.A., Murty.U.S.R., Graph Theory with applications, North Holland publication, 2008.
3. K.Balakrishnan, Schaum's Outline of Graph Theory, Tata Mc Graw-Hill Pub, 2020.
4. Richard J.J, Introduction to Graph Theory, 1st Edition, Parker Pub. Company, 2017.

L: 30; T :15; TOTAL: 45 PERIODS

23SH07E	RANDOM PROCESSES AND QUEUEING THEORY	L	T	P	E	C
		2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Interpret the basic characteristic features of Random processes.

CO2: Encapsulate the time averages of uncertain events.

CO3: Evaluate spectral densities of functions.

CO4: Analyze the characteristics of Markovian queues.

CO5**:**Apply the concepts of queuing theory in networks.

CO1: Interpret the basic characteristic features of Random processes **L:6 T:3**

Classification - Stationary process - Markov process - Markov chains - Transition probabilities.

CO2: Encapsulate the time averages of uncertain events **L:6 T:3**

Counting Process - Ergodic process - Poisson Process - Renewal Processes - Gaussian process.

CO3: Evaluate spectral densities of functions **L:6 T:3**

Auto correlation - Cross correlation – Power spectral density–Cross spectral density-Properties–Wiener – Khintchine theorem (without proof).

CO4: Analyze the characteristics of Markovian queues **L:6 T:3**

Markovian models – Birth and Death Queuing models- Steady state results: Single and multiple server queuing models- queues with finite waiting rooms- Finite source models- Little's Formula.

CO5: Apply the concepts of queuing theory in networks **L:6 T:3**

M/G/1 queue- Pollaczek- Khintchine formula, series queues- open and closed networks.

TEXT BOOKS

1. Oliver C. Ibe, "Fundamentals of Applied Probability and Random processes", Academic Press, 2nd Edition, 2014.
2. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes, Tata McGraw-Hill Education, 3rdEdition, 2017.
3. John F Shortle, James M Thompson, Donald Gross and Carl M Harris, "Fundamentals of Queueing Theory", Wiley and Sons Publication Limited, 5thEdition, 2018.

REFERENCE BOOKS

1. Miller.S.L and Childers, S.L, Probability and Random Processes with applications to Signal Processing and Communications, Elsevier Inc., 2nd Edition, 2012.
2. Peyton. Z. Peebles Jr., Probability Random Variables and Random Signal Principles, 4th Edition, Tata McGraw-Hill Publishers, New Delhi, 2017.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

L: 30; T:15; TOTAL: 45 PERIODS

		L	T	P	E	C
23SH08E	**STATISTICAL TECHNIQUES AND NUMERICAL METHODS**	**2**	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Calculate the various measures of dispersion.
CO2: Apply the principles of hypothesis testing in small and large samples.
CO3: Analyze the variances in design of experiments.
CO4: Find solution of linear equations and to perform differentiation and integration numerically.
CO5: Compute numerical solution of differential equations.

CO1: Calculate the various measures of dispersion

Central tendencies - Mean, median, mode - Measures of Dispersion –Mean deviation, and Quartile deviation–Moments– Skewness –Kurtosis - Correlation and Regression. **L:6 T:3**

CO2: Apply the principles of hypothesis testing in small and large samples

Sampling distributions - Statistical hypothesis - Large sample testsbased on Normal distribution for single mean and difference of means -Tests based on t, and F distributions - Chi-square -Contingency table for independent of attributes – Goodness of fit. **L:6 T:3**

CO3: Analyze the variances in design of experiments

One way and two way classifications - Completely randomized design – Randomized block design – Latin square design – 2^2 factorial design. **L:6 T:3**

CO4: Find solution of linear equations and to perform differentiation and integrationnumerically

Solution of algebraic and transcendental linear equations - Newton - Raphson Method- Solution of simultaneous equations – Gauss Elimination method – Gauss Seidel method – Interpolation – Lagrange's Method - Numerical Differentiation – Newton's forward difference and backward difference formula – Numerical integration - Single integration using Trapezoidal and Simpson's 1/3 rd and 3/8 th rules. **L:6 T:3**

CO5: Compute numerical solution of differential equations

Taylor's Series Method – Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods – Milne's Method - Solution of one dimensional heat equation by explicit and implicit methods(Crank Nichelson and Bender Schmidth methods) - Two dimensional Laplace and Poisson equations. **L:6 T:3**

TEXT BOOKS

1. Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education Private Ltd., 2018.
2. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ &MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.

REFERENCE BOOKS

1. Dharmaraja Selvamuthu, Dipayan Das, Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control, Springer Verleg Singapore Pvt. Ltd., 2018.
2. S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand & Sons, Delhi, 2014.

3. M.K.Jain, S.R.K.Iyengar,R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
4. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGraw - Hill, New Delhi, 2021.

L: 30; T:15; TOTAL: 45 PERIODS

23SH09E	**TRANSFORMS, MATHEMATICAL LOGIC AND SET THEORY**	**L**	**T**	**P**	**E**	**C**
		2	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

Theory Components:

CO1: Apply Laplace transform to solve ordinary differential equations.
CO2: Compute the Fourier transforms of various functions.
CO3: Solve difference equations using Z-Transform.
CO4: Illustrate the validity of the arguments.
CO5**:**Analyze the concepts of Sets, Relations and Functions.

CO 1: Apply Laplace transform to solve ordinary differential equations

Definition of Laplace transform and its inverse – Transforms of elementary functions – Properties – Transforms of periodic functions – Initial and final value theorems – Convolution theorem. - solutions of linear ordinary differential equations with constant coefficients. **L:6 T:3**

CO2: Compute the Fourier transforms of various functions

Fourier Integral theorem (without proof)–Fourier transform pair–Fourier Sine and Cosine transforms–Properties–Transforms of simple functions–Convolution theorem –Parseval's theorem. **L:6 T:3**

CO3: Solve difference equations using Z-Transform

Z– transform –Elementary properties – Inverse Z–transform – Convolution theorem- Initial and final value theorem – Formation of difference equations –Solutions of difference equations using Z–transform. **L:6 T:3**

CO4: Illustrate the validity of the arguments.

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

CO5: Analyze the concepts of Sets, Relations and Functions

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions **L:6 T:3**

TEXT BOOKS

1. Grewal.B.S. "Higher Engineering Mathematics", 44th Edition, Khanna Publications, Delhi, 2021.
2. Kenneth H.Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

REFERENCE BOOKS

1. Ramana B.V, "Higher Engineering Mathematics", Tata Mc-Graw Hill Education, New Delhi, 2017.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2017.
3. J K Goyal, K.P.Gupta, Laplace and Fourier Transforms, Pragati Prakashan, 2016

L: 30; T :15; TOTAL: 45 PERIODS

23SH10E	**FUNDAMENTALS OF LASER TECHNOLOGY**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Explain the fundamentals of lasers

CO2: Demonstrate the laser surface modification process

CO3: Describe the laser machining processes

CO4: Identify the laser measurement and testing process

CO5: Organizethe advanced applications and safety measures of laser

CO1: Explain the fundamentals of lasers

Characteristics of laser -laser principle- population inversion-line broadening mechanisms-Q switching - threshold condition for laser-three-level and four-level systems-conditions for continuous wave (CW) and pulsed laser action- pumping schemes-classification of lasers:Er:YAG - carbon dioxide lasers - argon laser - X-Ray lasers - fiber lasers - Raman lasers. **L:9**

CO2: Demonstrate the laser surface modification process

Laser surface heat treatment: process parameters - advantages and disadvantages of laser surface treatment; laser surface melting - laser direct metal deposition: processing parameters - methods for applying the coating material- laser alloying and cladding - advantages and disadvantages -laser physical vapor deposition - laser shock peening: analysis - advantages and disadvantages **L:9**

CO3: Describe the laser machining processes

Laser welding parameters: beam power, spot diameter and traverse speed; welding efficiency; mechanism of laser welding: conduction mode welding, keyhole welding; laser cutting – process characteristics-fusion cutting, sublimation cutting, photochemical ablation;laser drilling –single pulse drilling-percussion drilling, trepanning applications - laser marking - dot matrix marking, engraving, image micro machining -lasers for marking – application **L:9**

CO4: Identify the laser measurement and testing process

Laser for measurement - distance -length-velocity-acceleration-current-voltage-atmospheric effect-laser application in spatial frequency filtering. **L:9**

Holography: basic principle - methods - Holographic interferometry and applications-holography for non – destructive testing – holographic components

CO5: Organizethe advanced applications and safety measures of laser

Laser advanced application in defence-laser weapons-industry for material handling: ASRS and AGV- medicine -laser activated therapy - photodynamic therapy, laser angioplasty, lasers in surgery - photocoagulation, photodisruption and photoablation - laser scanning confocal microscopy - Laser safety - danger - safety limits for eye and skin - class four safety arrangements - electric hazards- chemical hazards - fume hazards - explosion hazards - safety guidelines **L:9**

TEXTBOOKS:

1. William M. Steen, "Laser Material Processing", Springer Verlag, 2010
2. K.Thyagarajan, AjoyK.Ghatak, "Lasers, Theory and Applications", Springer,2nd Edition, 2011.
3. Chunlei Guo, Subhash Chandra SinghHandbook of Laser Technology and Applications Lasers Applications: Materials Processing and Spectroscopy, 2nd Edition, (Vol.3), 2021

REFERENCES:

1. Uday Shanker Dixit, Shrikrishna N. Joshi, J. Paulo Davim, "Application of Lasers in Manufacturing" Springer Singapore, 1stEdition, 2019
2. Stephan Wieneke and Christoph Gerhard, "Lasers in Medical Diagnosis and Therapy Basics, applications and future prospects" IOP Publishing Ltd, 2018
3. AK Katiyar, CK Pandey and Manisha Bajpai, "Fundamentals of Laser Systems and Applications", Wiley, 2017.

L :45; TOTAL: 45 PERIODS

23SH11E	**NANOMATERIALS FOR ENGINEERS**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Explain the fundamentals of nanomaterials
CO2: Interpret the different properties of nanomaterials
CO3: Demonstrate the synthesis of nanomaterials
CO4: Illustrate the characterization of nanomaterials
CO5: Organize the applications of nanomaterials

CO1: Explain the fundamentals of nanomaterials

Introduction to nanomaterials - size effect - specific surface area - surface to volume ratio - quantum confinement effects - morphology - density - melting point - wettability - classification based on the dimension - nanoparticles - nanowires - nanoclusters - nanotubes - quantum wells - metal based nanomaterials - nanocomposites - carbon nanotubes - nanosized metals - alloys - semiconductors – ceramics **L:9**

CO2: Interpret the different properties of nanomaterials

Mechanical behavior- comparison of bulk and nano materials - elastic and plastic deformation - tensile strength - superplasticity -hardness - nano hardness -influence of porosity - grain size – thermodynamics of nanoparticles- heat capacity – phase transformation of nanoparticles- electrical and optical properties: electrical conductivity in nano tubes, nano rods and nanocomposites - photoconductivity of nanorods - electroluminiscesnce in nanoparticles- magnetic properties: magnetic hysteresis - superparamagnetism **L:9**

CO3: Demonstrate the synthesis of nanomaterials

Bottom-up and top-down approach - inert gas condensation - plasma arc technique - ion sputtering - ball milling - molecular beam epitaxy - chemical vapour deposition - method - electrodeposition - ultrasonication - microemulsions method - solvothermal synthesis - microwave assisted synthesis. **L:9**

CO4: Illustrate the characterization of nanomaterials

X-ray diffraction - energy dispersive spectrum - atomic force microscopy - high resolution transmission electron microscopy - Raman spectroscopy - x-ray photoelectron spectroscopy - electrochemcial characterization measurements - cyclic voltammetry - linear sweep voltametry - Brunauer-Emmett-Teller - surface area analysis - nanoindentation - determination of nano hardness. **L:9**

CO5: Organize the applications of nanomaterials

Functional graphene - carbon nanotube - polymer composite applications in defence and aerospace - nanomaterials for solar cells - nanoscale catalysts for energy and automobile industries - rechargeable batteries based on nanomaterials - nanomaterials for electrodes and wearable electronics - nano based coating and paints - nanosensors -gas sensors - bio sensors - nano electro mechanical systems **L:9**

TEXTBOOKS:

1. Charles P Poole, Frank J Ownes, Introduction to Nanoscience and Nanotechnology, An Indian Adaption, Wiley, 2020
2. Hornyak, G.Louis, Tibbals, H.F., Dutta, Joydeep, Fundamentals of Nanotechnology, CRC Press, 1st Edition, 2018
3. Dieter Vollath, Nanomaterials an introduction to synthesis, properties and applications, Wiley, 2nd Edition, 2013

REFERENCES:

1. Narendra Kumar, Sunita Kumbhat, Essentials in Nanoscience and Nanotechnology, Wiley, 1st Edition, 2016
2. G. Cao,Ying Wang, Nanostructures and nanomaterials: Synthesis, properties and applications, Imperial College Press, 2nd Edition, 2011
3. B.S. Murty , P. Shankar , Baldev Raj , B B Rath , James Murday, Textbook of Nanoscience and Nanotechnology, Springer, 1st Edition, 2013

L: 45; TOTAL: 45 PERIODS

23SH12E	**PHOTONICS**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: Explain the basics of photonics
CO2: Demonstrate the properties of photonic crystal
CO3: Outline the basics of bio photonics
CO4: Interpret the quantum confinement in photonic materials
CO5: Organize the applications of photonic materials

CO1: Explain the basics of photonics

Wave phenomena – interference, diffraction-photon properties - energy, flux, statistics-Interaction of photons with atoms-optical amplification-three and four level system -EDFA-semiconductor light sources-detectors-light manipulation - birefringence - Faraday's rotation - interaction of light with RF and acoustic waves - Raman-Nath diffraction experiment. **L:9**

CO2: Demonstrate the properties of photonic crystal

Electromagnetic theory of light-electromagnetic properties of material- polarization of light; Reflection and refraction- Fresnel equations; absorption, dispersion, and scattering of electromagnetic waves -Bragg grating; 1D photonic crystals -photonic band structure-real and reciprocal lattices; 2D and 3D photonic crystals-emerging applications of photonic crystals - 1D Bragg grating - periodic dielectric wave guide - 2D photonic crystal slab and fibre. **L:9**

CO3:Outline the basics of bio photonics

Fundamentals of light and matter-basics of light-matter interactions in molecules, cells and tissues -lasers for biophotonics -bioimaging: principles and applications-transmission microscopy, Kohler illumination-optical biosensors-light activated therapy: photo thermal and photo dynamic therapy- tissue engineering with light- optical tweezers, scissors and traps - bio nanophotonics applications - bio chip - DNA micro-arrays - gene chip - lab on chip. **L:9**

CO4: Interpret the quantum confinement in photonic materials

Quantum confined materials: quantum wells, quantum wires, quantum dots, quantum rings, manifestations of quantum confinement, optical properties, quantum confined stark effect, dielectric confinement effect. **L:9**

Nanoplasmonics: optical response of metals, plasmons, optical properties of metal nanoparticles, size dependent absorption and scattering, coupled nanoparticles - metal-dielectric core-shell nanoparticles - local electromagnetic fields in metal nanoparticles.

CO5: Organize the applications of photonic materials

Excitation energy transfer – device operation: nanophotonic AND gate - nanophotonic OR gate – interconnection with photonic devices - metamaterials concept; super lens, hyperbolic metamaterials and application in high-resolution imaging: hyper lens - tunable photonic metamaterials based devices - electro-optical metamaterials - phase-change metamaterials - metamaterials in solar energy harvesting - perfect absorbers and thermal emitter **L:9**

TEXTBOOKS:

1. Bahaa E. A. Saleh, Malvin Carl Teich, Fundamentals of Photonics, 3rdEdition, Wiley,2019.
2. Brian Culshaw, Introducing Photonics, Cambridge University Press, 2020.
3. Gerd Keiser, Biophotonics: Concepts to Applications, second edition, Springer Nature Singapore Pvt. Ltd 2022.

REFERENCES:

1. Joseph W. Haus, Fundamentals and Applications of Nanophotonics, Woodhead Publishing, 2016.
2. W.Cai and V.Shalaev, Optical Metamaterials: Fundamentals and Applications, 2ndEdition, Springer, 2024.
3. P PYupapin, K Srinuanjan, S Kamoldilok, Devices, Circuits and Systems: Nanophotonics, Pan Stanford Publishing, 2013.

4. Paulo Ribeiro, Maria Raposo, "Optics, Photonics and Laser Technology", Springer International publishing, 1st Edition, 2018

L: 45; TOTAL: 45 PERIODS

23SH13E	**BIOLOGY FOR COMPUTING**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successful completion of the course the students will be able to

CO1: Describe the structure, interaction and applications of biomolecules
CO2: Interpret the structure and functions of the gene and protein using the bioinformatics data
CO3: Simulate the behavior of simple biological models using computational softwares
CO4: Identify and design molecules for new drug development by computational methods

CO1: Describe the structure, interaction and applications of biomolecules L:9

Biomolecules-I

Introduction – monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Enzymes: enzymatic action via Lock and key – Enzyme therapy - immune response monitoring – molecular modification – encapsulation. Agarose gel electrophoresis: SDS, PAGE and 2D – Molecular interactions: covalent and non-covalent interactions, antigen – antibody interactions. Methods to measure the interactions: UV-visible and single crystal X-ray diffraction.

Biomolecules -II L:9

Chromosome structure and function – chromosome abnormalities – chromosome dynamics – nuclear architecture. DNA transcription, replication and segregation. DNA finger printing. Pedigree analysis. Identifying human disease genes (functional cloning versus positional cloning; mutation screening). Human genome project: introduction – steps – salient features. Hap map project – salient features.

CO2: Interpret the structure and functions of the gene and protein using the bioinformatics data L:9

Bioinformatics: introduction – biological databases – types. DNA databases – EMBL, gene bank, DDBJ. Protein databases: Swiss Prot/TrEMBL, PIR. Sequence motif databases - Pfam, PROSITE, Protein structure databases, protein data Bank – SCOP, CATH, and KEGG. Sequence analysis – methods of sequencing: sangar method, maxama - gilbert method and edman degradation method, NGS methods of sequencing.Basic local alignment search tool (BLAST) – types – determining the identity of an organism from its r DNA gene nucleotide sequence. Softwares for handling the databases –ChemDiff.

CO3: Simulate the behavior of simple biological models using computational softwares L:9

Quantum mechanics: influence of physics on theoretical chemistry. Semi empirical methods – slater determinants – Hartree – Fock equation. Semi empirical models - Ab-initio calculations: Thermodynamic functions – koopmans's theorem – isodesmic reactions, Density functional theory for larger molecules. Introduction to Gaussian and ADF :Geometry optimization, frequency calculation, location of transition state, intrinsic reaction co-ordinates, molecular orbitals and population analysis, natural bond orbital analysis, calculation of equilibrium constants and rate constants. Introduction to GROMACS: GROMACS input files, simulations of liquid water, water methanol mixtures, S-peptide and free energy of salvation. Introduction to SCILAB- Scilab programming: Curve fitting, integral transforms and introduction to molecular dynamics. Execution of programs for

liquid argon.

CO4: Identify and design molecules for new drug development by computational methods **L:9**

Drug design: General approach to discovery of new drugs – lead modification – calculation of the various drug likeness rules like Lipinski's rule, MDDR - like rule, Veber rule, Ghose filter, BBB rule, CMC-50 like rule and Quantitative estimate of drug-likeness (QED) using DruLiTo and Swiss ADMEsoftware. Pharmacokinetic properties of drug using Osiris and Molinspiration software. Structure-based drug designing approaches - target identification and validation - physiochemical principles of drug action – drug stereo chemistry – drug action - 3D database – computer aided drug design. Identification of the suitable target using Pharmmapper - Molecular docking programs using Autovinasoftwares and visualization tools - Preparation of protein and ligand using ADT and pymol-generation of paper publication-quality images and data analysis-protein-protein docking-Protein DNA docking

TEXT BOOKS

1. Shawn T. O'Neil, A Primer for Computational Biology, Oregon State Campus, Corvallis, USA, 2019.
2. Frank Jensen, Introduction to Computational Chemistry, 3rd Edition, Wiley publishing LLC. USA, 2016
3. Philly Charles, Genes, Genomes, Genetics and Chromosomes, Nottinghamshire, England, 2020.

REFERENCE BOOKS

1. Ariel Fernández Stigliano, Biomolecular Interfaces: Interactions, Functions and Drug Design, 1st Edition, Springer International Publishing AG, London, 2016.
2. S.C. Rastogi, P.Rastogi, N.Mendiratta, Bioinformatics: Methods and Applications - Genomics, Proteomics and Drug Discovery, 5th Edition, PHI Learning Pvt. Ltd., Delhi, 2022.
3. Robert A. Copeland, Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis, 3rdEdition, Wiley-Blackwell, New York, 2023.

L: 45; TOTAL: 45 PERIODS

23SH14E	**BIOLOGY FOR ENGINEERS**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successful completion of the course the students will be able to

CO1: Understanding of bio design principles to create novel devices and structures and cell biology

CO2: Explain the structure and stability of biomolecules

CO3: Describe the principle, components and applications of various instruments for medical diagnosis

CO4: Interpret the major bio-energetic pathways

CO5: Explain the properties characterization and application of various biomaterials

CO1: Understand the basic principles of biology to create novel devices **L:9**

Cell - prokaryotic and eukaryotic cells - plant cell and animal cell - structural and function of Mitochondria - Chloroplast - Lysosomes - Golgi bodies - Nucleus. Cell cycle: mitosis and meiosis. Bioinspired devices: GPS, aircrafts, swim suits, bullet train, super hydrophobic and self-cleaning surfaces.

CO2: Explain the structure and stability of biomolecules **L:9**

Introduction - monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Molecular interactions: covalent and non-covalent interactions – methods of quantification and determination: UV – visible, CD, and SPR.

Enzymes - classification - specific activity - enzyme activity - chemical nature of enzymes. Protein and non-protein nature of enzymes. Metalloenzymes and metal activated enzymes. Industrial applications of enzymes: biosensors and bio bleaching.

CO3: Describe the principle and applications of various instruments for medical diagnosis **L:9**

Basic concepts of instrumentation: static and dynamic characteristics, design criteria, instrumentation, amplifiers. Biopotential electrodes: fundamentals - body surface electrodes - microelectrodes - Principle, components and applications of microscope: light and electron microscope. Electrocardiograph, glucometer, CT, magnetic resonance imaging, ultrasonic imaging. Artificial Intelligence for disease diagnosis.

CO4: Interpret the major bio-energetic pathways **L:9**

Thermodynamics in biological systems - exothermic and endothermic versus endergonic and exergonic reactions - concept of K_{eq} and its relation to standard free energy - spontaneity - ATP as an energy currency. Glucose synthesis from CO_2 + H_2O (photosynthesis) – decomposition of glucose (Glycolysis and Krebs cycle). Energy yielding and energy consuming reactions. Concept of energy charge. Regulation of glycogenesis - measurement of blood glucose level.

CO5: Explain the properties, characterization, and applications of various biomaterials. **L:9**

Biomaterials: introduction - types: alloys, polymers. Composites - properties: biocompatibility, elasticity, immune compatibility, resorbability, cytotoxicity, hemocompatibility and biodegradability. Physicochemical characterization: XRD and SEM. Applications: tissue engineering, heart valves, dental and orthopaedic implants.

TEXT BOOKS

1. Y.Nelson, L.David, Lehninger, “Principles of Biochemistry”, International Edition. New York, 7th Edition, 2017.
2. Nagata, Kazuhiro, Real-Time Analysis of Biological Interactions, Springer, Japan, 3rd Edition, 2015.
3. I. Bertini, H.B Gray, Bioinorganic Chemistry, University Science Book, California, 4thEdition, 2014.

REFERENCE BOOKS:

1. P.N.Bartlett, Bioelectrochemistry: Fundamentals, Experimental Techniques and Applications, 2nd Edition, John Wiley & Sons, New Delhi, 2014.
2. Ratner and Hoffmann, Biomaterial Science: An Introduction to Materials in Medicine, 2nd Edition, Elsevier Academic Press, London, 2015.
3. Lesile Cromwell, “Bio-medical instrumentation and measurement”, Prentice Hall of India, New Delhi, 2nd Edition, Reprint, 2017.

L: 45; TOTAL: 45 PERIODS

23SH15E	**POLYMER SCIENCE AND TECHNOLOGY**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

CO1: Acquire knowledge on structure - property relationship of polymers

CO2: Identify the suitable polymerization techniques for the large scale synthesis of polymers

CO3: Explain the basic principles of various polymer processing techniques and their applications

CO4: Interpret the chemical, thermal, electrical, and mechanical properties of the polymers

CO5: Familiar with plastics waste disposal, value addition, associated environmental issues and legislation

CO1: Acquire knowledge on structure - property relationship of polymers **L: 9**

Basic concepts of polymerization - polydispersity - conformation and configuration of macromolecules - stereo isomerism and tacticity in polymers - geometrical isomerism. Structure - property relationship -molecular force and chemical bonding in polymers - effect of polymerization on PDI. General rules for polymer solubility - crystallinity and orientation in polymers. Polymer chain flexibility: concept - factors deciding polymer flexibility - amorphous and crystalline polymers - crystallinity in polymers - factors affecting crystallinity - properties affected by crystallinity of polymers. Glass transition temperature and crystalline melting points. Factors affecting glass transition temperature.

CO2: Identify the suitable polymerization techniques for the large scale synthesis of polymers **L:9**

Basic aspects of polymer synthesis - bulk, solution and suspension polymerization (styrene and MMA) - emulsion polymerization (vinyl acetate, styrene) - preparation of phenolic and epoxy resins. Modern techniques in polymerization: metathesis polymerization - controlled polymerization methods, viz., nitroxide mediated polymerization (NMD), atom transfer radical polymerization (ATRP), group transfer polymerization (GTP), and reversible addition fragmentation termination (RAFT).

CO3: Explain the basic principles of various polymer processing techniques and their applications **L:9**

Plastics technology: raw materials - additives for compounding (fillers, plasticizers and softeners, lubricants, promoters, anti-aging additives, flame retarders, colorants, blowing agents, UV stabilizers,) - requirements and functions of additives. Pre-compounding operations: mixing, drum blenders, ribbon blenders, mixing rolls, internal mixers, mixing extruders, blenders for making organosol and plastisol, granulators, pelletizers.

Advanced fabrication techniques: RTM, RIM, filament winding, BMC/SMC. Post-forming and finishing, machining, welding and design of polymers products. Selections of polymers, additives, mold design. Analysis of defects in moulded products. Processing of reinforced thermoplastics and thermosets: manual processing methods and semi-automatic processing methods. Rubber processing: internal mixer and open mill.

CO4: Interpret the chemical, thermal, electrical, and mechanical properties of polymers **L:9**

Physical testing: density, mechanical behaviour, MFI, and water/solvent adsorption.

Chemical testing: ignition - pyrolysis - solvent extraction - elemental analysis. Thermal analysis: vicat softening point - dynamic mechanical thermal analysis. Morphological analysis: atomic force microscopy and chemical force microscopy. Spectroscopic analysis: IR peaks assigned for rubber. Study of hydrogenation, halogention, evidence for cyclization and formation of ionomers. Analysis of carbon filled rubber - Case studies.

CO5: Familiar with plastics waste disposal, value addition, associated environmental issues and legislation **L-9**

Polymer waste: sources, collection, segregation, and identification by simple techniques. Life cycle assessment, risk factor analysis. Plastics waste management techniques: chemical recycling, thermal conversion technologies, microbial, microwave, and ultrasonic. Use of plastics waste for value addition. Plastics waste management rule - environmental issues.

TEXT BOOKS

1. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Edition, McGraw Hill Education, 2017.
2. Richard A Petherick, Polymer Science and Technology for Engineers and Scientists, Whittles Publishing, 2010.
3. Michael L. Berins, SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. 1st Edition, Springer New York, 2012
4. Vishu Shah, Handbook of Plastics Testing Technology,2nd Revised edition, Wiley–Blackwell, 1998**.**

REFERENCES

1. Gowarikar V R, Polymer science, 5th Edition, New Age International Private Limited, 2023
2. Fred W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley & Sons, 2007
3. Nayak S.K, Text Book on Fundamentals of Plastics Testing, Springer (I) Private Limited, 2020
4. J S Anand, Recycling & Plastics Waste Management, Central Institute of Plastics Engineering and Technology, 1997.
5. Korschwitz J, Polymer Characterization and Analysis, John Wiley and Sons, 1990.

L: 45; TOTAL: 45 PERIODS

23SH16E	**SENSORS FOR ENGINEERING APPLICATIONS**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

CO1: Gain knowledge on basic concepts of sensors and Transducer.

CO2: Know about the thermal and motion sensors for various applications.

CO3: Enumerate the principles and applications of optical and magnetic sensors and transducers used in various field.

CO4: Explain the construction, working principle and applications of electrochemical and electric sensors.

CO5: Design the sensors for environmental monitoring

CO1: Gain knowledge on basic concepts of sensors and Transducer. **L: 9**

Introduction – Historical development of sensors – Human body as a sensor system –

sensors and transducers. Principle and classification of sensor. Sensor characteristics – sensor properties – various transducers – piezoelectric effect – pyroelectric effect – seebeck effect and peltier effect. Advantages and limitations of Sensors.

CO2: Know about the thermal and motion sensors for various applications. **L:9**

Thermal sensors: introduction – types - primary sensor: gas thermometer and He low temperature thermometer. Secondary sensor: Resistance thermometer and NQR thermometer. Temperature sensing technologies: IC sensor, resistive temperature detectors, thermocouples and thermistor.

Motion sensors: Introduction and principle. Types: Infra red and microwave. Specialized motion sensor: proximity and ranging sensor. Motion Sensors in everyday life: The role of motion sensors in home security.

CO3: Enumerate the principles and applications of optical and magnetic sensors and transducers used in various field **L:9**

Magnetic sensors: Introduction – principle and applications: magnetic field sensors and magneto-resistive Sensors, hall effect sensors.

Optical sensors: light intensity – wavelength and color – light dependent resistors, photodiode, photo transistor, CCD, CMOS sensors. Pulse oximeter, portable pulse oximeter, wearable pulse oximeter; wearable capnometer for monitoring of expired.

CO4: Explain the construction, working principle and applications of electrochemical and electric sensors **L-9**

Electrochemical sensors: Introduction - fundamental concepts – chemiresistors. Conductometric sensor: amperometric sensor - potentiometric sensors - impendence sensors.

Electric sensors: Introduction- conventional volt and ammeters, high current sensors, (current transformers), high voltage sensors, High power sensors. Real time applications: Glucose Monitoring

Devices, GlucoWatch G2 Biographer, GlucoTrackTM; Pulse oximeter, Portable Pulse Oximeter, wearable pulse oximeter.

CO5: Design the sensors for environmental monitoring **L-9**

Environmental Sensor: Introduction - environmental quantities**:** time, moisture acidity/alkalinity, wind-chill, radioactive count rate. Surveying and security. Sensors for environmental monitoring. Smoke and fire detector. Pressure sensor in emission testing, pollution devices, and wind management systems.

TEXT BOOKS

1. Jacob Fraden, Handbook of Modern Sensors: Physics, Design and Applications, 5th edition, Springer Nature, New Delhi, 2016
2. D. Patranabis, Sensors and Transducers, 2nd Edition, PHI Learning Private Limited, New Delhi, 2013.
3. John Veteline, Aravind Raghu, Introduction to sensors, CRC press, New Delhi,2011.
4. S Nihtianov, A. Luque Smart Sensors and MEMS, 2nd Edition, Woodhead Publishing Limited, New Delhi,2018.

5. Edward Sazonov and Michael R. Neuman, Wearable Sensors - Fundamentals, Implementation and Applications, Elsevier publishing company, Amsterdam, Netherland,2014.

REFERENCE BOOKS

1. Shantanu Bhattacharya,A K Agarwal, NripenChanda, Ashok Pandey and Ashis Kumar Sen Environmental, Chemical and Medical Sensors, Springer Verlag, Singapore,2018 .
2. Krzysztof Iniewski, Optical, Acoustic, Magnetic, and Mechanical Sensor Technologies, 1st Edition, CRC Press, New Delhi, 2017.

L: 45; TOTAL: 45 PERIODS