



Sri

SAI RAM

INSTITUTE OF TECHNOLOGY

An Autonomous Institution

West Tambaram, Chennai - 44

www.sairamit.edu.in

Approved by AICTE, New Delhi
Affiliated to Anna University



DEPARTMENT OF
MECHANICAL ENGINEERING

REGULATIONS
2020

Academic Year 2020-21 onwards

AUTONOMOUS
CURRICULUM AND

SYLLABUS

I - VIII

SEMESTERS

SRI SAIRAM INSTITUTE OF TECHNOLOGY



VISION

To be identified as a “Centre of Excellence” with high standards of Knowledge Dissemination and Research opportunities and to transform the students to imbibe qualities of technical expertise of international standards and high levels of ethical values, who in turn shall contribute to the advancement of society and human kind.



MISSION

We shall dedicate and commit ourselves to attain and maintain excellence in Technical Education through commitment and continuous improvement of infrastructure and equipment and provide an inspiring environment for Learning, Research and Innovation for our students to transform them into complete human beings with ethical and social values.



QUALITY POLICY

We at Sri Sai Ram Institute of Technology are committed to build a better nation through Quality Education with team spirit. Our students are enabled to excel in all values of Life and become Good Citizens. We continually improve the System, Infrastructure and Services to satisfy the Students, Parents, Industry and Society.

DEPARTMENT OF MECHANICAL ENGINEERING



VISION

Establish the department with high quality education and to create opportunities for research and development in the field of Mechanical engineering and to create innovative, entrepreneurial and successful mechanical engineers together with human values, and ethically strong to serve the society.



MISSION

The Department imparts high quality technical knowledge and provides research environment with well-established and continuously improving infrastructure and laboratories, to keep up with the development across the globe, while training the students successfully to establish themselves in the society through the social and ethical learning.

AUTONOMOUS CURRICULUM AND SYLLABI

Regulations 2020

SEMESTER I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20BSMA101	Engineering Mathematics-I	3	1	0	4	4
2	20HSEN101	Technical English-I	3	0	0	3	3
3	20BSPH101	Engineering Physics	3	0	0	3	3
4	20BSCY101	Engineering Chemistry	3	0	0	3	3
5	20ESCS101	Problem solving and Programming in C	3	0	0	3	3
6	20ESGE101	Engineering Graphics	1	2	0	3	3
PRACTICAL							
7	20BSPL101	Physics and Chemistry Lab	0	0	3	3	1.5
8	20ESPL101	Programming in C lab	0	0	3	3	1.5
VALUE ADDITIONS - I							
9	20TPHS101	Skill Enhancement	0	0	2	2	1
10	20HSMG101	Personal Values	2	0	0	2	0
TOTAL						29	23

SEMESTER II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20BSMA201	Engineering Mathematics-II	3	1	0	4	4
2	20HSEN201	Technical English-II	3	0	0	3	3
3	20ESIT201	Python Programming with Lab	3	0	2	5	4
4	20BSCY201	Environmental Science and Engineering	3	0	0	3	3
5	20ESEE201	Electrical Technology with Lab	3	0	2	5	4
6	20BSPH202	Physics of Materials	3	0	0	3	3
PRACTICAL							
7	20ESGE201	Engineering Practices Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - II							
8	20TPHS201	Skill Enhancement	0	0	2	2	1
9	20HSMG201	Interpersonal Values	2	0	0	2	0
TOTAL						31	23.5

SEMESTER III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20ESCE201	Engineering Mechanics	3	0	0	3	3
2	20MEPC301	Manufacturing Processes	3	0	0	3	3
3	20MEPC302	Engineering Thermodynamics	3	1	0	4	4
4	20MEPC303	Engineering Metallurgy	3	0	0	3	3
5	20BSMA303	Partial Differential Equations and Probability Theory	3	1	0	4	4
6	20CEPC306	Fluid Mechanics and Machinery	3	0	0	3	3
PRACTICAL							
7	20MEPL301	Manufacturing Processes Laboratory	0	0	3	3	1.5
8	20MEPL302	Computer Aided Drafting Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - III							
9	20METE301	Live-in Lab I	0	0	2	2	1
10	20METP301	Skill Enhancement	0	0	2	2	1
TOTAL						27	25

SEMESTER IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20MEPC401	Measurement and Control Systems	3	0	0	3	3
2	20MEPC402	Metrology, Measurements and Computer Aided Inspection	3	0	0	3	3
3	20MEPC403	Computer Aided Design and Manufacturing	3	0	0	3	3
4	20MEPC404	Applied Thermal Sciences	3	0	0	3	3
5	20BSMA403	Statistics and Numerical Methods	3	1	0	4	4
6	20CEPC405	Strength of Materials	3	0	0	3	3
PRACTICAL							
7	20MEPL401	Metrology and Measurements Laboratory	0	0	3	3	1.5
8	20CEPL403	Strength of Materials and Fluid Mechanics & Machinery Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - IV							
9	20METE401	Live-in Lab II	0	0	2	2	1
10	20METP401	Skill Enhancement	0	0	2	2	1
TOTAL						29	24

SEMESTER V

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20MEPC501	Automotive Systems	3	0	0	3	3
2	20MEPC502	Robotics	3	0	0	3	3
3	20MEPC503	Theory of Machines	3	0	0	3	3
4	20MEPC504	Design of Machine Elements	3	1	0	4	4
5	20XXELXXX	Professional Elective-I	3	0	0	3	3
PRACTICAL							
6	20MEPL501	3D Modeling and Computer Aided Manufacturing Laboratory	0	0	3	3	1.5
7	20MEPL502	Kinematics and Dynamics Laboratory	0	0	3	3	1.5
8	20HSPL501	Communication and Soft Skills Laboratory	0	0	2	2	1
9	20METE501	Live-in Lab III	0	0	4	4	2
VALUE ADDITIONS - V							
10	20METP501	Skill Enhancement	0	0	2	2	1
TOTAL						30	23

SEMESTER VI

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20MEPC601	Design of Transmission Systems	3	0	0	3	3
2	20MEPC602	Heat Transfer	3	0	0	3	3
3	20MEPC603	Mechatronics	3	0	0	3	3
4	20XXELXXX	Professional Elective-II	3	0	0	3	3
5	20XXOEXXX	Open Elective-I	3	0	0	3	3
PRACTICAL							
6	20MEPL601	Thermal Science Laboratory	0	0	3	3	1.5
7	20MEPL602	Mechatronics and Robotics Laboratory	0	0	3	3	1.5
8	20MEPJ601	Innovative Design and Fabrication Project	0	0	2	2	1
VALUE ADDITIONS - VI							
9	20METP601	Skill Enhancement	0	0	2	2	1
10	20MGMC301	Constitution of India	2	0	0	2	0
TOTAL						27	20

SEMESTER VII

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20HSMG601	Principles of Engineering Management	3	0	0	3	3
2	20MEPC701	Finite Element Analysis	3	0	0	3	3
3	20MEPW701	3D Printing and Sustainable Design with Lab	3	0	2	5	4
4	20XXELXXX	Professional Elective-III	3	0	0	3	3
5	20XXOEXXX	Open Elective-II	3	0	0	3	3
PRACTICAL							
6	20MEPL701	Computer Aided Simulation and Analysis Laboratory	0	0	3	3	1.5
7	20MEPJ701	Project Phase-I	0	0	4	4	2
VALUE ADDITIONS - VII							
8	20METP701	Skill Enhancement	0	0	2	2	1
TOTAL						26	20.5

SEMESTER VIII

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	20XXELXXX	Professional Elective - IV	3	0	0	3	3
PRACTICAL							
2	20MEPJ801	Project Phase - II	0	0	8	8	4
TOTAL						11	7

CREDIT DISTRIBUTION

Category	BS	ES	HS	EL	PC+PL	PW	OE	TE	PJ	TP	IS	MC	TOTAL
Credit	29.5	10	20	12	66.5	4	6	4	7	7	3	Y	169
Percentage	17.46	5.92	11.83	7.10	39.35	2.37	3.55	2.37	4.14	4.14	1.78	-	100

*IS-Internship

PROFESSIONAL ELECTIVES - I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	20MEEL501	Gas Dynamics and Jet Propulsion	3	0	0	3	3
2	20MEEL502	Power Plant Technology	3	0	0	3	3
3	20MEEL503	Alternative Fuels	3	0	0	3	3
4	20MEEL504	Thermal Environmental Engineering	3	0	0	3	3
5	20MEEL505	Environmental & Energy Management	3	0	0	3	3
6	20MEEL506	Applied Hydraulics and Pneumatics	3	0	0	3	3
7	20MEEL507	Robot Kinematics And Dynamics	3	0	0	3	3
8	20MEEL508	Mechanical Behaviour of Materials	3	0	0	3	3
9	20MEEL509	Product Design and Development	3	0	0	3	3
10	20MEEL510	Non Traditional Machining Techniques	3	0	0	3	3
11	20MEEL511	Material Joining Techniques	3	0	0	3	3
12	20MEEL512	Precision Manufacturing	3	0	0	3	3
13	20MEEL513	Metal Additive Manufacturing Processes	3	0	0	3	3
14	20MEEL514	Process Planning and Cost Estimation	3	0	0	3	3
15	20MEEL515	Industrial Engineering	3	0	0	3	3
16	20MGEL801	Intellectual Property Rights	3	0	0	3	3
17	20HSMG301	Professional Ethics and Values	3	0	0	3	3

PROFESSIONAL ELECTIVES - II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	20MEEL601	Renewable Energy Sources	3	0	0	3	3
2	20MEEL602	Turbo Machines	3	0	0	3	3
3	20MEEL603	Design of Pressure Vessels and Piping	3	0	0	3	3
4	20MEEL604	Energy Efficiency and Sustainability	3	0	0	3	3
5	20MEEL605	Energy Conservation in Industries	3	0	0	3	3
6	20MEEL606	IOT for Mechanical & Manufacturing Industry	3	0	0	3	3
7	20MEEL607	Programming for Robotics	3	0	0	3	3
8	20MEEL608	Automotive Infotonics	3	0	0	3	3
9	20MEEL609	Product Life Cycle Management	3	0	0	3	3
10	20MEEL610	Micro Electro Mechanical Systems (MEMS)	3	0	0	3	3
11	20MEEL611	Non Destructive Testing and Evaluation	3	0	0	3	3
12	20MEEL612	Materials Characterization	3	0	0	3	3
13	20MEEL613	Green Manufacturing Systems and Strategies	3	0	0	3	3
14	20MEEL614	Lean and Agile Manufacturing	3	0	0	3	3
15	20MEEL615	Logistics & Supply Chain Management	3	0	0	3	3
16	20MGEL601	Total Quality Management	3	0	0	3	3

PROFESSIONAL ELECTIVES - III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	20MEEL701	Computational Fluid Dynamics	3	0	0	3	3
2	20MEEL702	Refrigeration, Air Conditioning and Cryogenic Systems	3	0	0	3	3
3	20MEEL703	Biogas Engineering	3	0	0	3	3
4	20MEEL704	Energy Conservation and Waste Heat Recovery	3	0	0	3	3
5	20MEEL705	Hybrid Vehicles	3	0	0	3	3
6	20MEEL706	Computer Integrated Manufacturing Systems	3	0	0	3	3
7	20MEEL707	Industrial Robotics And Material Handling Systems	3	0	0	3	3
8	20MEEL708	Artificial Intelligence for Robotics	3	0	0	3	3
9	20MEEL709	Design for Manufacturing	3	0	0	3	3
10	20MEEL710	Virtual Prototyping	3	0	0	3	3
11	20MEEL711	Tool Design	3	0	0	3	3
12	20MEEL712	Composite Materials and Mechanics	3	0	0	3	3
13	20MEEL713	Wear, Corrosion and Surface Protection of Materials	3	0	0	3	3
14	20MEEL714	Project Planning and Management	3	0	0	3	3
15	20MEEL715	Six Sigma Quality	3	0	0	3	3
16	20MGEL701	Economics for Engineers	3	0	0	3	3
17	20HSMG601	Statistical Quality Control and Reliability Engineering	3	0	0	3	3

PROFESSIONAL ELECTIVES - IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	20MEEL801	Advanced Internal Combustion Engines	3	0	0	3	3
2	20MEEL802	Microrobotics	3	0	0	3	3
3	20MEEL803	Smart Manufacturing	3	0	0	3	3
4	20MEEL804	Polymer Materials and their Processing	3	0	0	3	3
5	20MEEL805	Industrial Safety and Maintenance Engineering	3	0	0	3	3
6	20MEEL806	Theory of Vibrations and Noise Control	3	0	0	3	3
7	20MEEL807	Systems Engineering	3	0	0	3	3
8	20MEEL808	Machine Vision Systems & Imaging Techniques	3	0	0	3	3
9	20MEEL809	Fatigue Design & Analysis	3	0	0	3	3
10	20MGEL703	Entrepreneurship Development	3	0	0	3	3

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

- PEO1** To promote successful career in engineering and technological organizations and in other industries with the emphasis in the fields of Design, Engineering, Manufacturing, Service and R&D.
- PEO2** To prepare students for higher studies and research in institutes of national importance and developed countries by providing strong fundamentals in basic sciences and applying them in engineering.
- PEO3** Entrepreneurial skill and self-employment in the program adopted.
- PEO4** Working with ethical values in diverse culture and adherence to Indian culture without compromise in the profession is promoted.
- PEO5** Institutional program prepares for total development of personality encouraging cultural events, sports, social activities etc.

PROGRAM SPECIFIC OUTCOMES (PSOs)

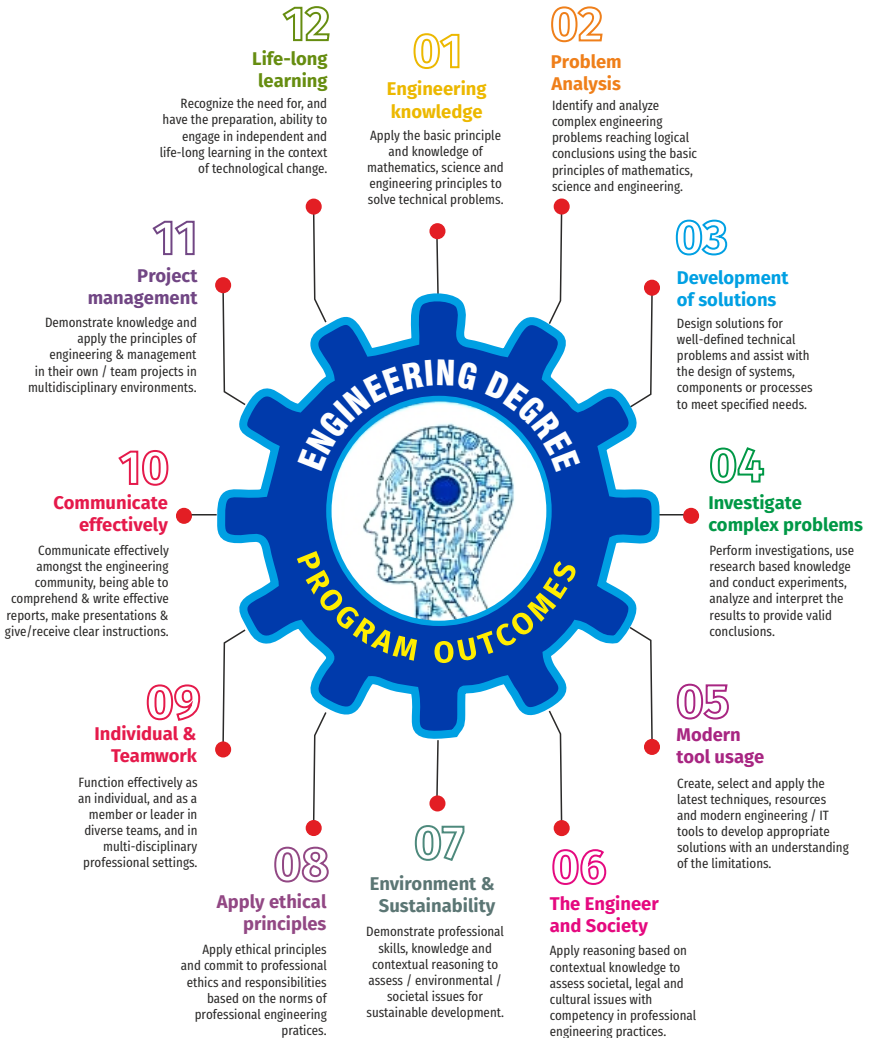
- PSO1** To impart sound fundamental of basic sciences viz. mathematics, physics, chemistry so as to apply them for engineering problem analysis, and prepare students for higher education and research in the chosen field.
- PSO2** To achieve ability to gather and synthesis engineering data with basic knowledge of engineering and prepare students for successful career in industry, while generating thirst for knowledge and lifelong learning.

COMPONENTS OF THE CURRICULUM (COC)

Course Component	Curriculum Content (% of total number of credits of the program)	Total number of contact hours	Total Number of credits
Basic Sciences(BS)	17.46	31	29.5
Engineering Sciences(ES)	11.83	25	20
Humanities and Social Sciences (HS)	5.92	12	10
Professional Electives(EL)	7.10	12	12
Program Core+Program Lab (PC+PL)	39.35	80	66.5
Program theory with Lab (PW)	2.37	5	4
Open Electives (OE)	3.55	6	6
Talent Enhancement (TE)	2.37	8	4
Project (PJ)	4.14	14	7
Training & Placement (TP)	4.14	14	7
Internships/Seminars (IS)	1.78	-	3
Mandatory Courses (MC)	NA	06	NA
Total number of Credits		213	169

PROGRAMME OUTCOMES(POs)

PROGRAM OUTCOME REPRESENTS THE KNOWLEDGE, SKILLS AND ATTITUDES THAT THE STUDENTS WOULD BE EXPECTED TO HAVE AT THE END OF THE 4 YEAR ENGINEERING DEGREE PROGRAM



SEMESTER - I

20BSMA101 SDG NO. 4	ENGINEERING MATHEMATICS-I	L	T	P	C
		3	1	0	4

OBJECTIVES:

The intent of the course is

- To understand and gain the knowledge of matrix algebra.
- To introduce the concepts of limits, continuity, derivatives and maxima and Minima
- To acquaint the concept of improper integrals and the properties of definite integrals.
- To provide understanding of double integration, triple integration and their application.
- To introduce the concept of sequence and series and impart the knowledge of Fourier series.

UNIT I MATRICES**12**

Symmetric, skew symmetric and orthogonal matrices; Eigenvalues and Eigenvectors of a real matrix – Characteristic equation – Properties of Eigenvalues and Eigenvectors – Cayley-Hamilton theorem (excluding proof) – Diagonalization of a Quadratic form using orthogonal transformation - Nature of Quadratic forms.

UNIT II DIFFERENTIAL CALCULUS**12**

Limits, continuity, Differentiation rules - Maxima and Minima of functions of one variable, partial derivatives (first and second order – basic problems), Taylor's series for functions of two variables, Jacobian, Maxima & Minima of functions of several variables, saddle points; Method of Lagrange multipliers.

UNIT III INTEGRAL CALCULUS**12**

Evaluation of definite integrals - Techniques of Integration-Substitution rule - Integration by parts, Integration of rational functions by partial fraction, Integration of irrational functions. Applications of definite integrals to evaluate surface area of revolution and volume of revolution. Evaluation of improper integrals.

UNIT IV MULTIPLE INTEGRALS**12**

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of solids – Change of variables in double and triple integrals.

UNIT V SEQUENCES AND SERIES**12**

Introduction to sequences and series – power series – Taylor's series – series for exponential, trigonometric, logarithmic, hyperbolic functions – Fourier series – Half range Sine and Cosine series – Parseval's theorem.

TOTAL: 60 PERIODS**TEXTBOOKS:**

1. James Stewart, "Calculus: Early Transcendentals", Cengage Learning, 7th Edition, New Delhi, 2015.
2. B. V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 11th Reprint, 2010.

REFERENCES:

1. G.B. Thomas and R.L. Finney, "Calculus and Analytic Geometry", 9th Edition, Pearson, Reprint, 2002.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2006.
3. T. Veerarajan, "Engineering Mathematics for first year", Tata McGraw-Hill, New Delhi, 2008.
4. N.P. Bali and Manish Goyal, "A text-book of Engineering Mathematics", Laxmi Publications, Reprint, 2008.
5. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 40th Edition, 2014.

WEB REFERENCES:

1. <https://math.mit.edu/~gs/linearalgebra/ila0601.pdf>
2. <http://ocw.mit.edu/ans7870/18/18.013a/textbook/HTML/chapter30/>
3. <https://ocw.mit.edu/courses/mathematics/18-02sc-multivariable-calculus-fall-2010/2.-partial-derivatives/>
4. <http://ocw.mit.edu/ans7870/18/18.013a/textbook/HTML/chapter31/>

ONLINE RESOURCES:

1. <https://www.khanacademy.org/math/linear-algebra/alternate-bases/eigen-everything/v/linear-algebra-introduction-to-eigenvalues-and-eigenvectors>
2. <https://www.khanacademy.org/math/differential-calculus>

OUTCOMES:**Upon completion of the course, the student should be able to**

1. Diagonalize the matrix using orthogonal transformation and apply Cayley Hamilton Theorem to find the inverse and integral powers of a square matrix. (K3)
2. Evaluate the limit, examine the continuity and use derivatives to find extreme values of a function. (K3)
3. Evaluate definite and improper integrals using techniques of integration. (K3)
4. Apply double and triple integrals to find the area of a region and the volume of a surface. (K3)
5. Compute infinite series expansion of a function. (K3)

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	-	-	-	-	-	-	1
CO2	3	3	2	1	1	-	-	-	-	-	-	1
CO3	3	3	2	1	1	-	-	-	-	-	-	1
CO4	3	3	2	1	1	-	-	-	-	-	-	1
CO5	3	3	2	1	1	-	-	-	-	-	-	1

SEMESTER - I

20HSEN101 SDG NO. 4	TECHNICAL ENGLISH - I	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To develop the basic LSRW skills of the students
- To encourage the learners to adapt to listening techniques
- To help learners develop their communication skills and converse fluently in real contexts
- To help learners develop general and technical vocabulary through reading and writing tasks
- To improve the language proficiency for better understanding of core subjects

UNIT I INTRODUCTION**9**

Listening – short texts – formal and informal conversations - **Speaking** – basics in speaking – speaking on given topics & situations – recording speeches and strategies to improve - **Reading** – critical reading – finding key information in a given text – shifting facts from opinions - **Writing** – free writing on any given topic – autobiographical writing - **Language Development** – tenses – voices- word formation: prefixes and suffixes – parts of speech – developing hints

UNIT II READING AND LANGUAGE DEVELOPMENT**9**

Listening - long texts - TED talks - extensive speech on current affairs and discussions - **Speaking** – describing a simple process – asking and answering questions - **Reading** comprehension – skimming / scanning / predicting & analytical reading – question & answers – objective and descriptive answers – identifying synonyms and antonyms - process description - **Writing** instructions – **Language Development** – writing definitions – compound words.

UNIT III SPEAKING AND INTERPRETATION SKILLS**9**

Listening - dialogues & conversations - **Speaking** – role plays – asking about routine actions and expressing opinions - **Reading** longer texts & making a critical analysis of the given text - **Writing** – types of paragraph and writing essays – rearrangement of jumbled sentences - writing recommendations - **Language Development** – use of sequence words - cause & effect expressions - sentences expressing purpose - picture based and newspaper based activities – single word substitutes

UNIT IV VOCABULARY BUILDING AND WRITING SKILLS**9**

Listening - debates and discussions – practicing multiple tasks – self introduction – **Speaking** about friends/places/hobbies - **Reading** - Making inference from the reading passage – Predicting the content of the reading passage - **Writing** – informal letters/e-mails - **Language Development** - synonyms & antonyms - conditionals – if, unless, in case, when and others – framing questions.

UNIT V LANGUAGE DEVELOPMENT AND TECHNICAL WRITING**9**

Listening - popular speeches and presentations - **Speaking** - impromptu speeches & debates - **Reading** - articles – magazines/newspapers **Writing** – essay writing on technical topics - channel conversion – bar diagram/ graph – picture interpretation - process description - **Language Development** – modal verbs - fixed / semi-fixed expressions – collocations

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Board of Editors. Using English: A Coursebook for Undergraduate Engineers and Technologists. Orient Blackswan Limited, Hyderabad: 2015.
2. Dhanavel, S.P. English and Communication Skills for Students of Science and Engineering. Orient Blackswan, Chennai, 2011.

REFERENCES:

1. Anderson, Paul V. Technical Communication: A Reader – Centered Approach. Cengage, New Delhi, 2008.
2. Smith-Worthington, Darlene & Sue Jefferson. Technical Writing for Success. Cengage, Mason, USA, 2007.
3. Grussendorf, Marion, English for Presentations, Oxford University Press, Oxford, 2007.
4. Chauhan, Gajendra Singh and et.al. Technical Communication (Latest Revised Edition). Cengage Learning India Pvt. Limited, 2018.

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc19_hs31/preview
2. <http://engineeringvidelectures.com/course/696>

ONLINE RESOURCES:

1. <https://www.pearson.com/english/catalogue/business-english/technical-english.html>
2. <https://www.cambridgeenglish.org/learning-english/free-resources/>

OUTCOMES:**Upon completion of the course, the student should be able to**

1. Express and explain short texts on different topics with key information applying suitable vocabulary (K2)
2. Interpret and dramatize fluently in informal and formal contexts (K2)
3. Choose and apply the right syntax in comprehending diversified general and technical articles (K3)
4. Analyze and write technical concepts in simple and lucid style (K3)
5. Construct informal letters and e-mails thoughtfully (K2)
6. Demonstrate technical concepts and summaries in correct grammar and vocabulary (K2)

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	1	-	2	3	1	1
CO2	-	-	-	-	-	-	-	1	2	3	2	1
CO3	-	-	-	-	-	-	-	-	1	3	3	2
CO4	-	2	-	-	-	-	-	1	2	3	1	1
CO5	-	-	-	-	-	-	-	2	-	3	2	1
CO6	-	-	-	-	-	-	3	-	-	3	2	1

SEMESTER - I

20BSPH101 SDG NO. 4	ENGINEERING PHYSICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To educate and enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology

UNIT I CRYSTAL PHYSICS**9**

Single crystalline, Polycrystalline and Amorphous materials - single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal - Miller indices - Interplanar distance - Powder diffraction method - Debye Scherer formula - Calculation of number of atoms per unit cell - Atomic radius - Coordination number - packing factor for SC, BCC, FCC and HCP structures - Polymorphism and allotropy - Diamond and Graphite structure (qualitative) - Growth of single crystals: Solution and Melt growth Techniques.

UNIT II PROPERTIES OF MATTER**9**

Elasticity - Stress - strain diagram and its uses - Poisson's ratio - Relationship between three moduli of elasticity (qualitative) - Factors affecting elastic modulus and tensile strength - Twisting couple - shaft - Torsion pendulum: theory and experiment - bending of beams - bending moment - cantilever: theory and experiment - uniform and non-uniform bending: theory and experiment - I-shaped girders - stress due to bending in beams.

UNIT III QUANTUM PHYSICS**9**

Black body radiation - Planck's theory (derivation) - Compton effect: theory - wave particle duality - electron diffraction - progressive waves - wave equation - concept of wave function and its physical significance - Schrödinger's wave equation - Time independent and Time dependent equations - particle in a box (one dimensional motion) - Tunneling (qualitative) - scanning tunneling microscope.

UNIT IV LASERS AND FIBER OPTICS**9**

Lasers: population of energy levels, Einstein's A and B coefficients derivation - pumping methods - resonant cavity, optical amplification (qualitative) - three level and four level laser - CO₂ laser - Semiconductor lasers: Homojunction and Heterojunction.

Fiber optics: Principle, Numerical aperture and Acceptance angle - Types of optical fibers (material, refractive index, mode) - Losses associated with optical fibers - Fiber Optical Communication system (Block diagram) - Fiber optic sensors: pressure and displacement.

UNIT V THERMAL PHYSICS**9**

Transfer of heat energy - thermal expansion of solids and liquids - bimetallic strips - thermal conduction, convection and radiation - heat conduction in solids (qualitative) - thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) - thermal insulation - applications: heat exchangers, refrigerators and solar water heaters.

TOTAL : 45 PERIODS**TEXT BOOKS:**

1. D.K. Bhattachary & T.Poonam, "Engineering Physics". Oxford University Press, 2015.
2. R.K. Gaur & S.L. Gupta, "Engineering Physics". Dhanpat Rai Publishers, 2012.
3. B.K. Pandey & S.Chaturvedi, "Engineering Physics", Cengage Learning India, 2017.
4. V. Rajendran, "Engineering Physics", Mc Graw Hill Publications Ltd. New Delhi, 2014.
5. M.N. Avadhanulu & P.G. Kshirshagar, "A textbook of Engineering Physics", S. Chand & Co Ltd. 2016.

REFERENCES:

1. D. Halliday, . Resnick & J. Walker, "Principles of Physics", Wiley, 2015.

2. R.A. Serway, & J.W. Jewett, "Physics for Scientists and Engineers", Cengage Learning, 2010.
3. N.K. Verma, "Physics for Engineers", PHI Learning Private Limited, 2014.
4. P.A. Tipler & G. Mosca "Physics for Scientists and Engineers", W.H. Freeman, 2020.
5. Brijlal and Subramanyam, "Properties of Matter", S. Chand Publishing, 2018.
6. Shatendra Sharma & Jyotsna Sharma, "Engineering Physics", Pearson, 2018.

OUTCOMES :

Upon completion of the course, the student should be able to

1. To understand the crystal systems and elastic properties of Materials (K2)
2. To distinguish different crystal structures and heat conduction in conductor and insulators (K4)
3. To explain powder diffraction method-deformation of materials in response to action load, quantum mechanics to understand wave particle dualism (K2)
4. To apply quantum theory to set up one dimensional Schrodinger's wave equation and applications to a matter wave system and principle of laser action (K3)
5. To analyze bending of beams, types of optical fiber and modes of heat transfer (K4)
6. To discuss light propagation in optical fibers and transfer of heat energy in different measures and its applications (K2)

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	-	-	-	-	-	-	-	1
CO2	3	2	3	3	-	-	2	-	-	-	-	3
CO3	3	3	3	2	-	-	3	-	-	-	-	2
CO4	3	3	3	3	-	-	-	-	-	-	-	3
CO5	3	3	3	3	-	-	3	-	-	-	-	3
CO6	3	3	3	3	-	-	3	-	-	-	-	3

SEMESTER - I

20BSCY101 SDG NO. 4,6&7	ENGINEERING CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the students conversant with boiler feed water requirements, related problems and water treatment techniques
- To illustrate the principles of electrochemical reactions, redox reactions in corrosion of materials and methods for corrosion prevention and protection of materials
- To categorize types of fuels, calorific value calculations, manufacture of solid, liquid and gaseous fuels
- To demonstrate the principles and generation of energy in batteries, nuclear reactors, solar cells, windmills and fuel cells
- To recognize the applications of polymers, composites and nano-materials in various fields

UNIT I WATER TECHNOLOGY AND SURFACE CHEMISTRY 9

Water Technology : Introduction – Hard water and Soft water. Hardness of water – types – expression of hardness (numerical problems). Boiler troubles – scale and sludge, priming and foaming, caustic embrittlement and boiler corrosion. Treatment of boiler feed water – Internal treatment (carbonate, phosphate, calgon, colloidal and sodium aluminate conditioning). External treatment – Ion exchange process, Zeolite process – Domestic water treatment (break point chlorination) – Desalination of brackish water – Reverse Osmosis.

Surface Chemistry: Adsorption – types – adsorption of gases on solids – adsorption of solutes from solution – applications of adsorption – role of adsorbents in catalysis and pollution abatement.

UNIT II ELECTROCHEMISTRY AND CORROSION 9

Electrochemistry: Cells – types (electrochemical and electrolytic cell) Redox reaction – single electrode potential (oxidation potential and reduction potential) – measurement and applications – Nernst equation (derivation and problems) – electrochemical series and its significance.

Corrosion: Causes, factors and types – chemical and electrochemical corrosion (galvanic, differential aeration). Corrosion control – material selection and design aspects, cathodic protection methods (sacrificial anodic and impressed current cathodic method) and corrosion inhibitors. Paints: Constituents and its functions. Electroplating of Copper and electroless plating of Nickel.

UNIT III FUELS AND COMBUSTION

9

Fuels: Introduction – classification of fuels – Coal – analysis of coal (proximate and ultimate). Carbonization – manufacture of metallurgical coke (Otto Hoffmann method) – Petroleum – manufacture of synthetic petrol (Bergius process). Knocking – octane number and cetane number – Gaseous fuels – Compressed natural gas (CNG), Liquefied petroleum gases (LPG). Biofuels – Gobar gas and Biodiesel.

Combustion of Fuels: Introduction – calorific value – higher and lower calorific values- theoretical calculation of calorific value – flue gas analysis (ORSAT Method).

UNIT IV ENERGY SOURCES AND STORAGE DEVICES

9

Energy sources: Nuclear fission – nuclear fusion – differences between nuclear fission and fusion – nuclear chain reactions – nuclear energy – light water nuclear power plant – breeder reactor – solar energy conversion – solar cells – wind energy.

Storage devices: Batteries – types of batteries – primary battery (dry cell) secondary battery (lead acid battery, lithium-ion-battery), fuel cells – H₂ -O₂ fuel cell and super capacitors.

UNIT V POLYMERS AND NANOMATERIALS

9

Polymers: Classification – types of polymerization – mechanism (Free radical polymerization) – Engineering polymers: Nylon-6, Nylon-6,6, Teflon, Kevlar and PEEK – preparation, properties and uses – Plastic and its types – Conducting polymers – types and applications. Composites – definition, types, polymer matrix composites – FRP.

Nanomaterials: Introduction – Nanoparticles, Nanoclusters, Nanorods, Nanotubes (CNT: SWNT and MWNT) and Nanowires – Properties (surface to volume ratio, melting point, optical and electrical), Synthesis (precipitation, thermolysis, hydrothermal, electrodeposition, chemical vapour deposition, laser ablation, sol-gel process) and Applications.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. S. S. Dara and S. S. Umare, "A Textbook of Engineering Chemistry", S. Chand & Company LTD, New Delhi, 2015.
2. P. C. Jain and Monika Jain, "Engineering Chemistry" Dhanpat Rai Publishing Company (P) LTD, New Delhi, 2015.
3. S. Vairam, P. Kalyani and Suba Ramesh, "Engineering Chemistry", Wiley India PVT, LTD, New Delhi, 2013.
4. Ravikrishnan A, 'Engineering Chemistry', Sri Krishna Hitech Publishing Company Pvt. Ltd, New Edition 2021.

REFERENCES:

1. Friedrich Emich, "Engineering Chemistry", Scientific International PVT, LTD, New Delhi, 2014.
2. Prasanta Rath, "Engineering Chemistry", Cengage Learning India PVT, LTD, Delhi, 2015.
3. Shikha Agarwal, "Engineering Chemistry-Fundamentals and Applications", Cambridge University Press, Delhi, 2015.

OUTCOMES

Upon completion of the course, the student should be able to

1. Identify the origin of water resources and develop innovative methods to produce soft water for industrial use and potable water at cheaper cost and recognize the basic design of adsorption systems and its industrial applications. (K2)
2. Recognize the basic concepts of electrochemistry and apply the principles of electrochemistry to corrosion process and the applications of protective coatings to overcome the corrosion. (K2)
3. Disseminating the importance of chemistry of fuels and combustion to enhance the fuel efficiency. (K2)
4. Acquire the basics of non-conventional sources of energy and illustrate the principles and the reaction mechanism of batteries and fuel cells. (K2)
5. Explain the synthesis and applications of polymers, composites and nano-materials. (K2)

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	1	2	-	-	-	-	1
CO2	3	2	3	2	2	1	2	-	-	-	-	3
CO3	3	2	3	2	-	1	2	-	-	-	-	1
CO4	3	2	3	2	-	1	2	-	-	-	1	3
CO5	3	2	3	1	2	1	1	-	-	-	1	3

SEMESTER - I

20ESCS101 SDG NO. 4&9	PROBLEM SOLVING AND PROGRAMMING IN C	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand about the programming language
- To develop C Programs using basic Programming Constructs, Loops Arrays and Strings
- To develop applications in C using Functions , Pointers and Structures
- To perform I/O operations and File Handling in C

UNIT I INTRODUCTION TO PROGRAMMING AND ALGORITHMS FOR PROBLEM SOLVING

10

The Basic Model of Computation, Programming Paradigms- Program Development Life Cycle - Algorithm –Pseudo Code – Flow Chart - Programming Languages - Compilation - Linking and Loading - Testing and Debugging - Documentation - Control Structures – Algorithmic Problem Solving- Problems Based on Sequential, Decision Making - Branching and Iteration.

UNIT II BASICS OF C PROGRAMMING

8

Structure of C program - C programming: Data Types – Storage Classes - Constants – Enumeration Constants - Keywords – Operators: Precedence and Associativity - Expressions – Input / Output Statements - Assignment Statements – Decision making Statements - Switch Statement - Looping Statements – Pre-Processor Directives - Compilation Process

UNIT III ARRAYS AND STRINGS

9

Introduction to Arrays: Declaration, Initialization – One Dimensional Array – Example Program: Computing Mean, Median and Mode - Two Dimensional Arrays – Example Program: Matrix Operations (Addition, Scaling, Determinant and Transpose) - String Operations: Length, Compare, Concatenate - Copy – Selection Sort - Linear and Binary Search.

UNIT IV FUNCTIONS AND POINTERS

9

Introduction to Functions: Function Prototype, Function Definition, Function Call, Built-in Functions (String Functions, Math Functions) – Recursion – Example Program: Computation of Sine Series - Scientific Calculator using Built-in Functions - Binary Search using Recursive Functions – Pointers – Pointer Operators – Pointer Arithmetic – Arrays and Pointers –

Array of Pointers – Example Program: Sorting of Names – Parameter Passing: Pass by Value - Pass by Reference – Example Program: Swapping of Two Numbers using Pass by Reference.

UNIT V STRUCTURES and FILE PROCESSING

9

Structure - Nested Structures – Pointer and Structures – Array of Structures – Example Program using Structures and Pointers – Self Referential Structures – Dynamic Memory Allocation - Singly Linked List – Typedef.

Files – Types of File Processing: Sequential Access, Random Access – Sequential Access File - Example Program: Finding Average of Numbers stored in Sequential Access File - Random Access File - Example Program: Transaction Processing Using Random Access Files – Command Line Arguments.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Reema Thareja, “Programming in C”, Oxford University Press, Second Edition, 2016.
2. Kernighan, B.W and Ritchie, D.M, “The C Programming language”, Second Edition, Pearson Education, 2012.

REFERENCES:

1. Paul Deitel and Harvey Deitel, “C How to Program”, Seventh edition, Pearson Publication.
2. Jeri R. Hanly & Elliot B. Koffman, “Problem Solving and Program Design in C”, Pearson Education, 2013.
3. Pradip Dey, Manas Ghosh, “Fundamentals of Computing and Programming in C”, First Edition, Oxford University Press, 2009.
4. Anita Goel and Ajay Mittal, “Computer Fundamentals and Programming in C”, Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011.
5. Byron S. Gottfried, "Schaum's Outline of Theory and Problems of Programming with C", McGraw-Hill Education, 1996.
6. Kanetkar Y, “Let us C”, BPB Publications, 2007.
7. Hanly J R & Koffman E.B, “Problem Solving and Programme design in C”, Pearson Education, 2009.

WEB REFERENCES:

1. <https://www.learn-c.org/>
2. <https://codeforwin.org/>
3. <https://www.cprogramming.com/>

ONLINE RESOURCES:

1. https://www.linuxtopia.org/online_books/programming_books/gnu_c_programming_tutorial
2. <https://nptel.ac.in/courses/106105171>
3. https://swayam.gov.in/nd1_noc19_cs42/preview

OUTCOMES:

Upon completion of the course, the student should be able to

1. Develop efficient algorithms for solving a problem. (K2)
2. Use the various constructs in C to develop simple applications. (K3)
3. Design and Implement applications using Array & Strings. (K3)
4. Develop applications using Functions and Pointers. (K6)
5. Design and Develop applications using Structures. (K3)
6. Design and Develop applications using Files. (K4)

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	3	3	3	3	2	1	1	-	2	2	-	3	2	3
C02	3	3	3	3	2	-	1	1	2	2	3	3	2	3
C03	3	3	3	3	2	1	1	1	2	-	3	-	3	2
C04	3	3	3	3	2	1	-	1	2	2	3	3	1	2
C05	3	3	3	3	2	1	1	1	2	2	3	3	2	1
C06	3	3	3	3	2	1	1	1	2	2	3	3	3	2

SEMESTER - I

20ESGE101 SDG NO. 4,6,7, 9, 12,14 &15	ENGINEERING GRAPHICS	L	T	P	C
		1	2	0	3

OBJECTIVES:

- To develop in students, graphic skills for communication of concepts, ideas and design of engineering products
- To visualize the job in three dimensions
- To have a clear conception and appreciation of the shape, size, proportion and design
- To expose the student community to existing national standards related to technical drawings

CONCEPTS AND CONVENTIONS (Not for Examination)**3**

Importance of graphics in engineering applications – Use of drafting instruments – BIS conventions and specifications – Size, layout and folding of drawing sheets – Lettering and dimensioning- Projection of Points

UNIT I PLANE CURVES AND FREEHAND SKETCHING**6+9**

Basic Geometrical constructions, Curves used in engineering practices: Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Construction of cycloid on Horizontal Surfaces – construction of involutes of circle for one complete revolution – Drawing of tangents and normal to the above curves.

Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects – Layout of views- Freehand sketching of multiple views from pictorial views of objects.

UNIT II PROJECTION OF LINES AND PLANE SURFACE**6+9**

Orthographic projection- principles-Principal planes- Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method- Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

UNIT III PROJECTION OF SOLIDS**6+9**

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method.

UNIT IV PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES**6+9**

Sectioning of prisms, pyramids, cylinder and cone in simple vertical position when the cutting plane is inclined to one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of simple and truncated solids in vertical position – Prisms, pyramids cylinder and cone.

UNIT V ISOMETRIC AND PERSPECTIVE PROJECTIONS**6+9**

Principles of isometric projection – isometric scale –Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinder, cone- Perspective projection of simple solids-Prisms, pyramids and cylinder by visual ray method.

TOTAL: 78 PERIODS

TEXT BOOKS:

1. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International (P) Limited, 2008.
2. T. Jeyapooan, "Engineering Graphics using AUTOCAD", Vikas Publishing House Pvt Ltd, 7th Edition.

REFERENCES:

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
3. Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
5. Luzzader, Warren.J. and Duff, John M., "Fundamentals of Engineering Drawing with an introduction to Interactive Computer Graphics for Design and Production, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2005.
6. N S Parthasarathy and Vela Murali, "Engineering Graphics", Oxford University, Press, New Delhi, 2015.
7. Shah M.B., and Rana B.C., "Engineering Drawing", Pearson, 2nd Edition, 2009.

WEB REFERENCES:

1. <https://nptel.ac.in/courses/112/103/112103019/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/105/104/105104148/>

PUBLICATION OF BUREAU OF INDIAN STANDARDS:

1. IS10711 – 2001: Technical products Documentation – Size and lay out of drawing sheets.
2. IS9609 (Parts 0 & 1) – 2001: Technical products Documentation – Lettering.
3. IS10714 (Part 20) – 2001 & SP 46 – 2003: Lines for technical drawings.
4. IS11669 – 1986 & SP 46 – 2003: Dimensioning of Technical Drawings.
5. IS15021 (Parts 1 to 4) – 2001: Technical drawings – Projection Methods

OUTCOMES:**Upon completion of the course, the student should be able to**

1. Relate thoughts and ideas graphically in a neat fashion and ability to perform sketching of engineering curves used in engineering practices, multiple views of objects. (K1)
2. Understand the concepts of orthographic projections for basic geometrical constructions. (K2)
3. Acquire the knowledge of orthographic projection in three dimensional object. (K2)
4. Develop knowledge about Sectioning and apply interior shapes of solids. (K3)
5. Analyze the concepts of design in developing various 3 dimensional projections. (K4)
6. Build a strong foundation to analyze the design in various dimensions. (K4)

CO - PO , PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	-	-	-	-	-	2	2	-	2	2	2
C02	3	2	2	-	-	-	-	-	2	2	-	2	2	2
C03	3	2	2	-	-	-	-	-	2	2	-	2	2	2
C04	3	2	2	-	-	-	-	-	2	2	-	2	2	2
C05	3	2	2	-	-	-	-	-	2	2	-	2	2	2
C06	3	2	2	-	-	-	-	-	2	2	-	2	2	2

SEMESTER - I

20BSPL101 SDG NO. 4	PHYSICS AND CHEMISTRY LABORATORY	L	T	P	C
		0	0	3	1.5

PHYSICS LABORATORY**OBJECTIVES:**

- To acquaint the students with practical knowledge of physics principles in various fields such as optics, thermal physics and properties of matter for developing basic experimental skills
- To make the student to acquire practical skills in the determination of water quality parameters through volumetric and instrumental analysis

LIST OF EXPERIMENTS (Any 5 Experiments)

1. Determination of Young's modulus by non-uniform bending method.
2. Determination of rigidity modulus –Torsion pendulum.
3. Determination of velocity of sound and compressibility of liquid – Ultrasonic Interferometer.
4. (a) Determination of wavelength and particle size using Laser.
(b) Determination of acceptance angle in an optical fiber.
5. Determination of thermal conductivity of a bad conductor – Lee's Disc method.
6. Determination of specific resistance of a given coil of wire – Carey Foster's bridge.
7. Determination of wavelength of mercury spectrum – spectrometer grating.
8. Determination of band gap of a semiconductor.
9. Determination of Hall coefficient by Hall Effect experiment.
10. Determination of solar cell characteristics.

**LAB REQUIREMENTS FOR A BATCH OF 30 STUDENTS /
6 (max.) STUDENTS PER EXPERIMENT**

- | | |
|--|-----------|
| 1. Young's modulus by non-uniform bending method-
experimental set-up | – 12 sets |
| 2. Rigidity modulus - Torsion pendulum experimental
set-up | – 12 sets |
| 3. Ultrasonic Interferometer to determine velocity of sound
and compressibility of liquid | – 6 sets |
| 4. (a) Experimental set-up to find the wavelength of light,
and to find particle size using Laser | – 6 sets |
| (b) Experimental set-up to find acceptance angle in an
optical fiber | – 6 sets |
| 5. Lee's disc method- experimental set up to find thermal
conductivity of a bad conductor | – 6 sets |
| 6. Experimental set-up to find specific resistance of a coil
of wire-Carey Foster's Bridge | – 6 sets |
| 7. Experimental set-up to find the wavelength of mercury
spectrum-spectrometer grating | – 6 sets |
| 8. Experimental set-up to find the band gap of a semiconductor | – 12 sets |
| 9. Experimental set-up to find the Hall coefficient by
Hall Effect Experiment | – 6 sets |
| 10. Experimental set-up to study characteristics of solar cells | – 6 sets |

TEXTBOOKS:

1. J.D. Wilson & C.A. Hernandez Hall "Physics Laboratory Experiments" Houghton Mifflin Company, New York, 2010.
2. M.N. Srinivasan, S. Balasubramanian & R. Ranganathan, "Practical Physics", S. Chand & Sons educational publications, New Delhi, 2011.
3. R. Sasikumar, "Practical Physics", PHI Learning Pvt. Ltd., New Delhi, 2011.

CHEMISTRY LABORATORY**(Any five experiments to be conducted)****OBJECTIVES:**

- To acquaint the students with practical knowledge of the basic concepts of chemistry, the student faces during the course of their study in the industry and engineering field
- To make the student to acquire practical skills in the determination of water quality parameters through volumetric and instrumental analysis
- To understand and develop experimental skills for building technical competence

LIST OF EXPERIMENTS (Any five experiments to be conducted)

1. Estimation of HCl using Na_2CO_3 as primary standard and Determination of alkalinity in water samples.
2. Determination of total, temporary & permanent hardness of water by EDTA method.
3. Determination of DO content of water sample by Winkler's method.
4. Determination of chloride content of water sample by argentometric method.
5. Determination of strength of given hydrochloric acid using pH meter.
6. Conductometric titration of strong acid vs strong base.
7. Estimation of iron content of the given solution using potentiometer.
8. Estimation of iron content of the water sample using spectrophotometer (1, 10-Phenanthroline / thiocyanate method).
9. Estimation of sodium and potassium present in water using flame photometers.
10. Determination of molecular weights of polymers using Ostwald's Viscometer.

**LAB REQUIREMENTS FOR A BATCH OF 30 STUDENTS /
6 (MAX.) STUDENTS PER EXPERIMENT.**

- | | |
|---|----------|
| 1. Estimation of HCl using Na_2CO_3 as primary standard and Determination of alkalinity in water sample | - 6 sets |
| 2. Determination of total, temporary & permanent hardness of water by EDTA method | - 6 sets |
| 3. Determination of DO content of water sample by Winkler's method | - 6sets |
| 4. Determination of chloride content of water sample by argentometric method | - 6 sets |
| 5. Determination of strength of given hydrochloric acid using pH meter | - 6 sets |
| 6. Conductometric titration of strong acid vs strong base | - 6 sets |
| 7. Estimation of iron content of the given solution using potentiometer | - 6 sets |
| 8. Estimation of iron content of the water sample using spectrophotometer (1,10- Phenanthroline / thiocyanate method) | - 2 sets |
| 9. Estimation of sodium and potassium present in water using flame photometer | - 2 sets |
| 10. Determination of molecular weights of polymer using Ostwald's Viscometer. | - 6 sets |

TOTAL: 30 PERIODS

TEXTBOOKS:

1. Vogel's Textbook of Quantitative Chemical Analysis (8th edition, 2014).

OUTCOMES:

Upon completion of the course, the student should be able to

1. Apply the principles of thermal physics and properties of matter to evaluate the properties of materials and to determine the physical properties of liquid using ultrasonic interferometer. (K1)
2. Understand measurement technique and usage of new instruments in optics for real time application in engineering. (K2)
3. Apply the knowledge of semiconductor materials to evaluate the band gap and Hall coefficient of materials and to study the characteristics of solar cell for engineering solutions. (K3)
4. Interpret quantitative chemical analysis to generate experimental skills in building technical competence. (K3)
5. Analyze the quality of water for domestic and industrial purpose. (K3)

6. Standardize the solutions using volumetric titrations, conductivity, pH, redox potential and optical density measurements. (K3)

CO- PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	3	3	2	2	1	1	3
CO2	3	3	3	3	3	3	3	2	2	2	2	3
CO3	3	3	3	3	3	3	3	2	1	1	2	3
CO4	3	2	3	3	1	1	2	2	2	2	3	2
CO5	3	2	3	3	1	1	2	2	2	2	3	2
CO6	3	2	3	3	1	1	2	2	2	2	3	2

SEMESTER - I

20ESPL101 SDG NO. 4&9	PROGRAMMING IN C LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To develop programs in C using basic Programming Constructs
- To develop applications in C using Arrays and Strings
- To design and implement applications in C using Functions, Structures
- To develop applications in C using Files

LIST OF EXPERIMENTS

1. Write a program using I/O statements and expressions.
2. Write programs using decision-making constructs.
3. Write a program to find whether the given year is leap year or not? (Hint: not every centurion year is a leap. For example 1700, 1800 and 1900 is not a leap year)
4. Write a program to perform the Calculator operations, namely, addition, subtraction, multiplication, division and square of a number.

5. Write a program to check whether a given number is Armstrong number or not?
6. Write a program to check whether a given number is odd or even?
7. Write a program to find the factorial of a given number.
8. Write a program to find out the average of 4 integers.
9. Write a program to display array elements using two dimensional arrays.
10. Write a program to perform swapping using function.
11. Write a program to display all prime numbers between two intervals using functions.
12. Write a program to reverse a sentence using recursion.
13. Write a program to get the largest element of an array using the function.
14. Write a program to concatenate two string.
15. Write a program to find the length of String.
16. Write a program to find the frequency of a character in a string.
17. Write a program to store Student Information in Structure and Display it.
18. The annual examination is conducted for 10 students for five subjects. Write a program to read the data and determine the following:
 - (a) Total marks obtained by each student.
 - (b) The highest marks in each subject and the marks of the student who secured it.
 - (c) The student who obtained the highest total marks.
19. Insert, update, delete and append telephone details of an individual or a company into a telephone directory using random access file.
20. Count the number of account holders whose balance is less than the minimum balance using sequential access file.

TOTAL: 45 PERIODS

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

Standalone desktops with C compiler	30 Nos.
(or)	
Server with C compiler supporting 30 terminals or more.	

OUTCOMES:

Upon completion of the course, the student should be able to

1. Solve some simple problems leading to specific applications. (K3)
2. Demonstrate C programming development environment, compiling, debugging, linking and executing a program. (K3)
3. Develop C programs for simple applications making use of basic constructs, arrays and strings. (K4)

4. Develop C programs involving functions and recursion. (K4)
5. Develop C programs involving pointers, and structures. (K6)
6. Design applications using sequential and random access file. (K4)

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	1	1	2	2	3	3	2	3
CO2	3	3	3	3	2	1	-	1	2	2	3	3	1	3
CO3	3	3	-	3	2	-	1	1	-	2	-	3	3	2
CO4	3	3	3	3	2	1	1	1	2	2	3	3	1	3
CO5	3	3	3	-	2	-	1	-	2	2	3	-	2	1
CO6	3	3	3	3	2	1	1	1	2	-	3	3	3	2

SEMESTER - I

20TPHS101 SDG NO. 4&5	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To enrich social network ethics
- To develop and enhance browsing culture
- To understand the concepts of networking
- To promote self professionalism
- To acquire knowledge about various digital identification procedures

UNIT I SOCIAL NETWORK ETIQUETTES**6**

Introduction to social network – Social Networking Etiquettes - Pros and Cons - Usage of Facebook, Instagram, WhatsApp , Telegram, Youtube, Evolution of Android and IOS, Introduction to LinkedIn & Benefits. (Practicals – Official Mail id- LinkedIn Id Creation, LinkedIn Profile Building , Facebook Id and Creation and Modifying the existing FB ID)

UNIT II BROWSING CULTURE**6**

Introduction to browsing – Search Engines-Google - Bing -Yahoo!-AOL -MSN -DuckDuckGo ,browsers, phishing – Cookies - URL – https:// extensions , browsing history, Incognito mode-VPN – Pros and Cons – Book mark.

UNIT III NETWORKING**6**

Basics of networking - LAN, MAN, WAN, Introduction to network topologies, Protocols , IP Commands (Command line prompt), Define online compiler and editor (Practicals – Find Your System IP, Ping Command, Firewall Fortinet, Basic DOS Commands)

UNIT IV PROFESSIONALISM**6**

Dress Code, Body Language, Appropriate Attire ,Communication Skills, Interview preparation – Introducing yourself - How to greet Superiors, Importance of Eye Contact During conversation.

UNIT V DIGITAL IDENTIFICATION**6**

Introduction to NAD - Importance of Aadhar, PAN Card, Passport, Bank Account, Bar Code, QR scan, Payment Gateway (Gpay, Phone Pe, UPI, BHIM, Paytm), Mobile Banking (Practicals - NAD registration Step by Step, Linking bank account with netbanking, Register for payment gateway).

TOTAL : 30 PERIODS**WEB REFERENCES :****Unit I: Social Network Etiquettes:**

1. <https://sproutsocial.com/glossary/social-media-etiquette/>
2. <https://www.shrm.org/resourcesandtools/tools-and-samples/hr-qa/pages/socialnetworkingsitespolicy.aspx>
3. <https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02711/full>
4. <https://medium.com/@sirajea/11-reasons-why-you-should-use-telegram-instead-of-whatsapp-ab0f80bfa79>
5. <https://buffer.com/library/how-to-use-instagram/>
6. <https://www.webwise.ie/parents/what-is-youtube/>
7. <https://www.androidauthority.com/history-android-os-name-789433/>
8. <https://www.mindtools.com/pages/article/linkedin.htm>

Unit II: Browsing Culture:

1. <https://sites.google.com/site/bethanycollegeofteacheredn/unit--ict-connecting-with-world/national-policy-on-information-and-communication-technology-ict/accessing-the-web-introduction-to-the-browser-browsing-web>
2. <https://www.wordstream.com/articles/internet-search-engines-history>
3. <https://www.malwarebytes.com/phishing/>
4. <https://www.adpushup.com/blog/types-of-cookies/>

5. <https://www.eff.org/https-everywhere>
6. [https://www.sciencedirect.com/topics/computer-science/browsing-history\](https://www.sciencedirect.com/topics/computer-science/browsing-history)
7. <https://www.vpnmentor.com/blog/pros-cons-vpn/>
8. <https://www.tech-wonders.com/2016/10/use-hush-private-bookmarking-extension-chrome.html>

Unit III: Networking

1. <https://www.guru99.com/types-of-computer-network.html>
2. <https://www.studytonight.com/computer-networks/network-topology-types>
3. <https://www.cloudflare.com/learning/network-layer/what-is-a-protocol/>
4. <https://www.howtogeek.com/168896/10-useful-windows-commands-you-should-know/>
5. <https://paiza.io/en>

Unit IV : Professionalism

1. <https://career.vt.edu/develop/professionalism.html>
2. <https://englishlabs.in/importance-dress-code/>
3. <https://www.proschoolonline.com/blog/importance-of-body-language-in-day-to-day-life>
4. <https://www.thespruce.com/etiquette-of-proper-attire-1216800>
5. <https://shirleytaylor.com/why-are-communication-skills-important/>
6. <https://www.triad-eng.com/interview-tips-for-engineers/>
7. <https://www.indeed.co.in/career-advice/interviewing/interview-question-tell-me-about-yourself>
8. <https://toggl.com/track/business-etiquette-rules/>

Unit V: Digital Identification

1. <https://nad.ndml.in/nad-presentation.html>
2. <https://www.turtlemint.com/aadhaar-card-benefits/>
3. <https://www.bankbazaar.com/pan-card/uses-of-pan-card.html>
4. <https://www.passportindex.org/passport.php>
5. <https://consumer.westchestergov.com/financial-education/money-management/benefits-of-a-bank-account>
6. https://en.wikipedia.org/wiki/QR_code

7. <https://www.investopedia.com/terms/p/payment-gateway.asp>
8. <https://www.paisabazaar.com/banking/mobile-banking/>

OUTCOMES:

Upon completion of the course, the student should be able to

1. Learn and apply social network ethics. (K3)
2. Understand the browsing culture. (K2)
3. Analyze the networking concepts. (K4)
4. Develop self professionalism. (K3)
5. Gain hands-on experience in various digital identification procedures. (K2)
6. Analyse and apply the different digital payment gateway methods. (K4)

CO- PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	3	2	-	3	2	3	-	2
CO2	-	-	-	-	3	2	-	3	2	3	-	2
CO3	-	-	-	-	3	2	-	-	1	3	-	2
CO4	-	-	-	-	3	2	-	3	3	3	-	2
CO5	-	-	-	-	3	2	-	-	2	3	-	2
CO6	-	-	-	-	3	2	-	-	2	3	-	2

SEMESTER - I

20HSMG101 SDG NO. 4&5	PERSONAL VALUES	L	T	P	C
		2	0	0	0

OBJECTIVES:

- Values through Practical activities

UNIT I SELF CONCEPT**6**

Understanding self Concept – Identify Yourself – Who am I – an individual, engineer, citizen – Attitude – Measuring Behaviour – Change of Behaviour – Personality – Characteristics in personal, professional life.

UNIT II INDIVIDUAL VALUES**6**

Personal Values – Attributes – Courage – Creativity, Honesty, Perfection, Simplicity, Responsibility – Measuring personal values

UNIT III MORAL VALUES**6**

Moral – Understanding right and wrong – Positive thoughts – Respect to others – Doing good to society.

UNIT IV PHYSICAL AND MENTAL WELL-BEING**6**

Health – Physical fitness – Mental vigour – Diet management – Yoga – Meditation – Peaceful life – Happiness in life

UNIT V DECISION MAKING**6**

Goal Setting – Decision making skill – Overcome of Barriers – Success – Mental strength and weakness

TOTAL: 30 PERIODS**Note:**

Each topic in all the above units will be supplemented by practice exercises and classroom activities and projects.

REFERENCE BOOKS:

1. Barun K. Mitra, "Personality Development and Soft Skills", Oxford University Press, 2016.
2. B.N.Ghosh, "Managing Soft Skills for Personality Development" McGraw Hill India, 2012.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Become an individual in knowing the self. (K4)
2. Acquire and express Personal Values, Spiritual values and fitness. (K4)
3. Practice simple physical exercise and breathing techniques. (K2)
4. Practice Yoga asana which will enhance the quality of life. (K1)
5. Practice Meditation and get benefitted. (K1)
6. Understanding moral values and need of physical fitness. (K2)

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Co1	-	-	-	-	-	2	2	3	3	1	1	1
CO2	-	-	-	-	-	2	2	3	3	1	1	1
CO3	-	-	-	-	-	2	2	3	3	1	1	1
CO4	-	-	-	-	-	2	2	3	3	1	1	1
CO5	-	-	-	-	-	2	2	3	3	1	1	1
CO6	-	-	-	-	-	2	2	3	3	1	1	1

SEMESTER - II

20BSMA201 SDG NO. 4	ENGINEERING MATHEMATICS - II	L	T	P	C
		3	1	0	4

OBJECTIVES:

- The objective of this course is to familiarize the prospective engineers with techniques in Vector Calculus, Ordinary differential equations, Complex variables and Laplace transforms. It aims to equip the students to deal with advanced levels of Mathematics and applications that would be essential for their disciplines.

UNIT I VECTOR CALCULUS

12

Gradient and Directional derivatives - Divergence and Curl- Vector identities - Irrotational and Solenoidal vector fields - Line integral over a plane curve - Surface integral - Volume integral – Gauss divergence, Green's and Stoke's theorems - Verification and application in evaluating line, Surface and volume integrals.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS

12

Second and higher order linear differential equations with constant coefficients - Method of variation of parameters - Homogeneous equation of Euler's and Legendre's types - System of simultaneous linear differential equations with constant coefficients.

UNIT III COMPLEX DIFFERENTIATION

12

Analytic functions- Necessary and sufficient conditions for analyticity in cartesian and polar coordinates (without proof) - Properties - Harmonic conjugate - construction of analytic functions- Conformal mapping - Mapping by functions $w = z+a, w=az, w=1/z, w=z^2$ - Bilinear transformation.

UNIT IV COMPLEX INTEGRATION

12

Contour integrals, Cauchy- Goursat theorem (without proof) - Cauchy Integral formula (without proof) - Taylor's series - Zeroes of Analytic functions - Singularities - Laurent's Series - Residues – Cauchy Residue theorem (without proof) – Application of Residue theorem for evaluation of real integrals – use of circular contour and semicircular contour (without poles on real axis).

UNIT V LAPLACE TRANSFORM

12

Existence conditions – Transforms of elementary functions – Transform of Unit step function and Unit impulse function – Basic properties – Shifting theorems – Transforms of derivatives and integrals – Initial and Final value

theorems – Convolution theorem – Transform of Periodic functions – Application of solution of linear second order ordinary differential equations with constant coefficients.

TEXT BOOKS:

1. Erwin Kreyszig, Advance Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill Publishing Company, New Delhi, 2008.

REFERENCES:

1. Dass, H.K., and Er. Rajnish Verma, “Higher Engineering Mathematics”, S.Chand Private Ltd., 2011.
2. Glyn James, “Advanced Modern Engineering Mathematics”, 3rd Edition, Pearson Education, 2010.
3. Peter V.O'Neil, “Advanced Engineering Mathematics”, 7th Edition, Cengage learning, 2012.
4. E.A.Coddinton, “An Introduction to Ordinary Differential Equations”, Prentice Hall India, 1995.
5. B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publishers, 40th Edition, 2014.
6. N.P.Bali and Manish Goyal, “A text Book of Engineering Mathematics”, Laxmi Publications, Reprint 2008.

WEB COURSES:

1. <https://nptel.ac.in/courses/122107036/>
2. <https://nptel.ac.in/courses/111105134/>
3. <https://ocw.mit.edu/courses/mathematics/18-04-complex-variables-with-applications-spring-2018/>
4. <https://ocw.mit.edu/courses/mathematics/18-02-multivariable-calculus-fall-2007/>
5. <https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/lecture-notes/>

ONLINE RESOURCES:

1. <https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/video-lectures/lecture-1-introduction/>
2. <http://www.nptelvideos.com/course.php?id=90>

COURSE OUTCOMES:

Upon completion of the course, the student should be able to

1. Compute the derivatives of scalar and vector point functions. Use vector point function to establish a relation between line, surface and volume integrals. (K3)
2. Solve ordinary differential equations of second and higher order with constant coefficients, variable coefficients and simultaneous linear differential equations. (K3)
3. Construct an analytic function and apply the properties of analytic functions to check for harmonic and orthogonal functions and find the images of circle and straight lines under the standard transformations. (K3)
4. Use Cauchy's integral theorem, formula and Cauchy's Residue theorem to evaluate complex and real integrals, find the Taylor's and Laurent's series expansion. (K3)
5. Apply Laplace and inverse Laplace Transforms to solve the Linear ordinary differential equations with constant coefficients. (K3)

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	-	-	-	-	-	-	-	1
CO2	3	3	2	1	-	-	-	-	-	-	-	1
CO3	3	3	2	1	-	-	-	-	-	-	-	1
CO4	3	3	2	1	-	-	-	-	-	-	-	1
CO5	3	3	2	1	-	-	-	-	-	-	-	1

SEMESTER - II

20HSEN201 SDG NO. 4	TECHNICAL ENGLISH - II	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To strengthen the listening skills for comprehending and critically analyzing passages
- To enhance students' ability with multiple strategies and skills for making technical presentations
- To participate in group discussions for developing group attitude
- To develop skills for preparing effective job application
- To write effective technical reports

UNIT I LANGUAGE DEVELOPMENT

9

Listening – Listening conversations involving two participants – multiple participants – **Speaking** – conversation methods in real life occurrences using expressions of different emotions and imperative usages – **Reading** passages and short stories - **Writing** – preparation of checklist – extended definition – **Language Development** – tenses - subject - verb agreement

UNIT II VOCABULARY BUILDING

9

Listening – listening formal and informal conversation and participative exercises – **Speaking** - creating greetings/wishes/excuses and thanks – **Reading** – articles/novels-**Writing** summary of articles and concise writing identifying new words – homonyms, homophones, homographs – one-word substitutions – easily confused words - creating SMS and using emoticons - sharing information in social media. **Language Development** - reported speeches – regular and irregular verbs - idioms & phrases

UNIT III WRITING TECHNICAL REPORTS

9

Listening – listening conversation – effective use of words and their sound aspects, stress, intonation & pronunciation – **Speaking** - practicing telephonic conversations – observing and responding. **Reading** – regular columns of newspapers/magazines - **Writing** – reports – feasibility, accident, survey and progress - preparation of agenda and minutes – **Language Development** - using connectives – discourse markers

UNIT IV TECHNICAL WRITING

9

Listening – Model debates & documentaries - **Speaking** – expressing agreement/disagreement, assertiveness in expressing opinions – **Reading**

biographies/autobiographies – **Writing** – note-making – formal letters – inviting guests – acceptance/declining letters - **Language Development** – degrees of comparison - numerical adjectives – embedded sentences

UNIT V GROUP DISCUSSION AND JOB APPLICATION

9

Listening – Listening - classroom lectures – recommending suggestions & solutions – **Speaking** – participating in group discussion – learning GD strategies – **Reading** – journal articles - Writing – Job application – cover letter - résumé preparation – **Language Development** – purpose statement – editing – verbal analogies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Board of editors. Fluency in English: A Course book for Engineering and Technology. Orient Blackswan, Hyderabad 2016.
2. Ashraf Rizvi. M, Effective Technical Communication. 2nd ed. McGraw Hill, New Delhi, 2018.

REFERENCES

1. Bailey, Stephen. Academic Writing: A Practical Guide for Students. Routledge, New York, 2011.
2. Raman, Meenakshi and Sharma, Sangeetha. Technical Communication Principles and Practice. Oxford University Press, New Delhi, 2014.
3. Muralikrishnan & Mishra Sunitha, Communication skills for Engineers 2nd ed. Pearson, Tamilnadu, India 2011. P. Kiranmai and Rajeevan, Geetha. Basic Communication Skills, Foundation Books, New Delhi, 2013.
4. Suresh Kumar, E. Engineering English. Orient Blackswan, Hyderabad, 2015
5. Richards, Jack C. Interchange Students' Book – 2. Cambridge University Press, New Delhi, 2015.

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc20_hs21/preview
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/109106122/lec1.pdf
3. <https://freevideolectures.com/course/3250/introduction-to-film-studies/10>

ONLINE RESOURCES

1. <https://www.ef.com/wwen/english-resources/>

2. https://www.smilesforlearning.org/gclid=EAIaIQobChMI49DF9bnd6AIVSY6PCh1d_gV9EAAAYASAAEgIBPvD_BwE.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Define technical terms with the correct use of grammar (K1)
2. Identify new words, phrases, idioms and summarize articles/ write ups effectively (K2)
3. Pronounce words correctly, speak fluently and share opinions and suggestions effectively in conversations, debates and discussions (K3)
4. Construct reports convincingly and write official letters emphatically (K3)
5. Communicate confidently while speaking and writing by employing language strategies (K2)
6. Adapt group behavior, execute their role as a contributing team member and prepare winning job applications (K3)

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	-	-	-	-	-	-	-	-	2	3	1	2
C02	-	2	-	-	-	-	-	-	2	3	1	1
C03	-	-	-	1	-	-	-	2	2	3	1	1
C04	-	-	-	-	-	2	-	3	2	3	2	2
C05	-	-	-	-	-	-	-	-	2	3	2	2
C06	-	-	-	-	-	-	-	2	2	3	1	2

SEMESTER - II

20ESIT201 SDG NO. 4	PYTHON PROGRAMMING WITH LABORATORY	L	T	P	C
		3	0	2	4

OBJECTIVES:

- To Develop Python Programs with Conditionals and Loops
- To Use Python Data Structures – Lists, Tuples, Dictionaries, Sets
- To Define Python Functions and Work with Modules and Packages
- To Work with Python Classes, Objects and Handling Exceptions

UNIT I BASICS OF PYTHON PROGRAMMING**9**

Python Interpreter and Interactive Mode - Features – History of Python – Literals – Variables and Identifiers – Data Types – Input Operation – Comments – Reserved Words – Indentation – Operators and Expressions – Operator Precedence– Operations on Strings – Other Data types – Type Conversion - Illustrative Programs: Use of various Operators, Evaluation of expressions, String Operations.

UNIT II DECISION CONTROL STATEMENTS**9**

Conditionals: Boolean Values and Operators, Conditional (if) - Alternative (if-else) - Chained Conditional (if-elif-else) - Iteration: state - while - for - break - continue - pass - Illustrative Programs: Exchange the Values of Two Variables - Circulate the values of N Variables - Distance Between Two Points - Square Root - GCD - Exponentiation - Sum and Array of Numbers.

UNIT III STRING, LISTS, TUPLES, DICTIONARIES, SETS**9**

Strings: String Slices - Immutability - String functions and methods - String Module - Lists: List Operations - List Slices - List methods - List Loop - Mutability - Aliasing - Cloning lists - List Parameters - Tuples: Tuple Assignment - Tuple as return value - Dictionaries: Operations and Methods - Advanced List Processing - List Comprehension - Sets: Creating Sets – Operations and Methods – Set Comprehension - Illustrative programs: Linear Search - Binary Search - Selection Sort - Insertion Sort - Merge Sort - Histogram.

UNIT IV FUNCTIONS, MODULES AND PACKAGES**9**

Functions - Function Definition and Use - Flow of Execution - Parameters and Arguments - Fruitful Functions: Return values - Parameters - Local and Global Scope - Function Composition - Recursion - Modules – from-import Statement – Name of Module – Making your own modules - Packages - Standard Library Modules – globals(), locals() and reload() - Illustrative programs: Fibonacci Series using functions - Arithmetic Operations using Module - Area of different shapes using Packages.

UNIT V CLASSES, OBJECTS AND EXCEPTION HANDLING**9**

Classes and Objects – Defining Classes – Creating Objects – Data Abstraction and Hiding through Classes - init() method – Class Variables and Object Variables – Introduction to Errors and Exception Handling – Handling Exceptions – Multiple Except Blocks – else Clause – Raising Exceptions – Built-in and User-defined Exceptions – Finally Block.

LIST OF EXPERIMENTS

1. Write a Python program to perform
 - a. Linear Search
 - b. Binary Search
2. Write a Python program to perform Selection Sort.
3. Write a Python program to sort the given numbers using Insertion Sort.
4. Write a Python program to do sorting using Merge sort.
5. Write a Python program to find first n prime numbers.
6. Write a Python program to Multiply two matrices.
7. Write a Python program to create Student class and instantiate its Object.
8. Write a Python License verification process using Exception handling.

TOTAL: 60 PERIODS**TEXT BOOKS:**

1. ReemaThareja, "Python Programming Using Problem Solving Approach", Oxford University Press 2018.
2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd edition, Updated for Python 3, O'Reilly Publishers, 2016.

REFERENCES:

1. Guido van Rossum and Fred L. Drake Jr, "An Introduction to Python" Revised and updated for Python 3.2, Network Theory Ltd., 2011.
2. John V Guttag, "Introduction to Computation and Programming Using Python", Revised and expanded Edition, MIT Press, 2013.
3. Robert Sedgewick, Kevin Wayne, Robert Dondero, "Introduction to Programming in Python: An Inter-Disciplinary Approach", Pearson India Education Services Pvt. Ltd., 2016.
4. Timothy A. Budd, "Exploring Python", Mc-Graw Hill Education (India) Private Ltd., 2015.
5. Kenneth A. Lambert, "Fundamentals of Python: First Programs", CENGAGE Learning, 2012.
6. Charles Dierbach, "Introduction to Computer Science using Python: A Computational Problem-Solving Focus", Wiley India Edition, 2013.
7. Paul Gries, Jennifer Campbell and Jason Montojo, "Practical Programming: An Introduction to Computer Science using Python 3", Second edition, Pragmatic Programmers, LLC, 2013.

WEB REFERENCES:

1. <http://greenteapress.com/wp/think-python/>
2. www.docs.python.org
3. <https://nptel.ac.in/courses/106/106/106106182/>

OUTCOMES:

Upon completion of the course, the student should be able to

1. Describe the syntax, semantics and control flow statements of Python programming. (K2)
2. Implement simple programs using control structures in Python. (K3)
3. Explain the methods to create and manipulate strings, lists, dictionaries, tuples and sets. (K2)
4. Articulate the concepts of functions, modules and packages in Python. (K2)
5. Implement simple programs using Python Data types and functions. (K3)
6. Apply the concepts of Exception handling, classes and objects. (K3)

CO - PO, MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	2	1	2	-	-	-	1	-	3	3
CO2	1	2	3	3	3	2	1	1	1	1	1	3
CO3	-	1	3	3	2	1	-	-	-	-	1	3
CO4	1	2	3	3	2	-	-	-	-	-	1	3
CO5	2	3	3	3	3	1	1	2	2	1	2	3
CO6	2	3	3	3	3	1	1	2	2	1	2	3

SEMESTER - II

20BSCY201 SDG NO. 1-17	ENVIRONMENTAL SCIENCE AND ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the nature and facts about environment
- To find and implement scientific, technological, economic and political solutions to environmental problems
- To study the interrelationship between living organism and environment
- To provide the importance of environment by assessing its impact on the human world; envision the surrounding environment, its functions and its value
- To study the integrated themes and biodiversity, natural resources, pollution control and waste management.

UNIT I ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY**9**

Definition, scope and importance of environment – need for public awareness – Ecosystem: concept of an ecosystem – structure and functions of an ecosystem – Biotic and abiotic components – Biogeochemical cycle (C, N & P) – energy flow in the ecosystem – food chains, food webs and ecological pyramids – ecological succession - keystone species. Introduction to biodiversity definition: genetic, species and ecosystem diversity – values of biodiversity – IUCN Red list species classification - endemic, endangered, rare, vulnerable, extinct and exotic species – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity – man-wildlife conflicts. Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity. Field study of Terrestrial (Forest, Grassland, Desert) and Aquatic ecosystem (Pond, Lake, River, Estuary and Marine)

UNIT II ENVIRONMENTAL POLLUTION**9**

Definition – causes, effects and control measures of: Air pollution, Water pollution, Soil pollution Marine pollution, Noise pollution, Thermal pollution and Nuclear pollution – solid waste management: causes, effects and control measures of municipal solid wastes (MSW) – role of an individual in prevention of pollution – Case studies related to environmental pollution. Disaster management: floods, earthquake, cyclone and landslides – nuclear holocaust – Case studies.

UNIT III NATURAL RESOURCES**9**

Forest resources: Use and over – exploitation, deforestation – Land resources: land degradation, man induced landslides, soil erosion and desertification – Water resources: Use and over- utilization of surface and groundwater – dams-benefits and problems, conflicts over water – Mineral resources: Environmental effects of extracting and using mineral resources – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture – fertilizer – pesticide problems, water logging and salinity. Energy resources: Renewable energy (Solar energy, Wind energy, Tidal energy, Geothermal energy, OTE, Biomass energy) and non renewable energy (Coal, Petroleum, Nuclear energy) sources. – role of an individual in conservation of natural resources. Case studies – timber extraction, mining, dams and their effects on forests and tribal people.

UNIT IV SOCIAL ISSUES AND THE ENVIRONMENT**10**

Atmospheric Chemistry - Composition and structure of atmosphere. Climate change - greenhouse effect- role of greenhouse gases on global warming. Chemical and photochemical reactions in the atmosphere - Formation of

smog, PAN, acid rain (causes, effect and control measures). Oxygen and ozone chemistry - Ozone layer depletion (causes, effect and control measures). environmental ethics: Issues and possible solutions – Green chemistry - 12 principles of green chemistry.

Urbanisation - Urban problems related to energy - Water conservation: rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns - case studies. Environment Legislations and Laws : Environment (protection) act – 1986. Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act – Wildlife protection act – Forest conservation act. Biomedical Waste(Management and Handling rules):1998 and amendments- scheme of labelling of environmentally friendly products (Ecomark) - Issues involved in enforcement of environmental legislation - central and state pollution control boards, role of non-governmental organization – Public awareness - Environmental Impact Assessment (EIA).

UNIT V HUMAN POPULATION AND THE ENVIRONMENT

8

Population growth, variation among nations – population explosion – family welfare programme – women and child welfare environment and human health – HIV / AIDS – Role of Information Technology in environment and Human health – Case studies – human rights – value education – Sustainable Development – Need for sustainable development – concept - 17 SDG goals – 8 Millennium Development Goals(MDG).

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2006.
2. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education, 2004.
3. Ravikrishnan A, 'Environmental Science and Engineering', Sri Krishna Hitech Publishing Company Pvt. Ltd, Revised Edition 2020.

REFERENCES:

1. Dharmendra S. Sengar, "Environmental law", Prentice hall of India Pvt Ltd, New Delhi, 2007.
2. Erach Bharucha, "Textbook of Environmental Studies", Universities Press(I) Pvt Ltd., Hydrabad, 2015.
3. G. Tyler Miller and Scott E. Spoolman, "Environmental Science", Cengage Learning India Pvt. Ltd., Delhi, 2014.
4. Rajagopalan. R, "Environmental Studies-From Crisis to Cure", Oxford University Press, 2005.

OUTCOMES:

Upon successful completion of this course, student should be able to

1. Explain the different components of environment, structure and function of an ecosystem, importance of biodiversity and its conservation. (K1)
2. Aware about problems of environmental pollution, its impact on human and ecosystem, control measures and basic concepts in Disaster Management. (K2)
3. Disseminate the need for the natural resources and its application to meet the modern requirements and the necessity of its conservation. (K2)
4. Illustrate the various aspects of atmospheric chemistry with a focus on climate change and recognize the principles of green chemistry. Describe suitable scientific, technological solutions and Protection Acts to eradicate social and environmental issues. (K2)
5. Recognize the need for population control measures and the environmental based value education concepts to achieve the Sustainable Development Goals. (K2)

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	-	-	-	1	2	-	1	1	-	2
CO2	2	2	2	-	2	2	3	1	2	2	-	2
CO3	1	1	1	1	-	1	1	-	1	2	-	1
CO4	2	2	2	1	2	1	1	-	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1

SEMESTER - II

20ESEE201 SDG NO. 4 & 9	ELECTRICAL TECHNOLOGY WITH LABORATORY	L	T	P	C
		3	0	2	4

OBJECTIVES:

- To impart knowledge on Electric circuit laws.
- To impart the Construction and working principles of Electrical Machines.
- To introduce about the Electrical drives and its applications.

UNIT I ELECTRICAL CIRCUITS**9**

Basic Circuit Components - Ohms Law - Kirchoff's Law – Steady State Solution of DC Circuits - Nodal Analysis, Mesh Analysis - Thevinin's Theorem - Norton's

Theorem - Maximum Power Transfer Theorem - Linearity and Superposition Theorem - Introduction to AC Circuits – Single Phase and Three - Phase Circuits - Power and Power Factor

UNIT II TRANSFORMER & DC MACHINE **9**

Construction – Principle of Operation – EMF Equation of Transformer – DC Machine – Construction and Working – Types of DC Motor – Principle and Operations – Types of DC Motor – Torque Equation.

UNIT III AC MACHINES **9**

Construction and Principles of Operation of; Synchronous Machines -Three Phase and Single Phase Induction Motors – Torque Equation - Characteristics of Three Phase and Single Phase Induction Motor.

UNIT IV STARTING METHODS & ELECTRICAL BRAKING **9**

Need for Starters - Types of DC Motor Starters – Typical Control Circuits for Shunt and Series Motors - Three Phase Squirrel Cage and Slip Ring Induction Motors – Electrical Braking.

UNIT V ELECTRICAL DRIVES **9**

Basic Elements – Types of Electric Drives – Factors Influencing the Choice of Electrical Drives – Heating and Cooling Curves – Loading Conditions and Classes of Duty - Applications.

LIST OF EXPERIMENTS: **15**

1. Verification of Circuit Laws
2. Verification of Network Theorems
3. Load test on DC Shunt motor
4. Load test on DC Series motor
5. Speed control of DC shunt motor (Armature, Field control)
6. Load test on single phase transformer
7. Load test on three phase squirrel cage Induction motor

TOTAL : 60 PERIODS

TEXT BOOKS:

1. A. E. Fitzgerald, Kingsely Jr Charles, D. Umans Stephen, “Electric Machinery”, Tata McGraw Hill, Sixth Edition, 2003.
2. B. L. Theraja, “A Textbook of Electrical Technology”, (vol. I), Chand and Company Ltd., New Delhi, 2005.
3. V. K. Mehta, “Basic Electrical Engineering”, S. Chand and Company Ltd., New Delhi, 2008.

REFERENCES:

1. William H. Hayt & Jack E. Kemmerly, "Engineering Circuit Analysis", McGraw-Hill Book Company Inc., 2006.
2. Theodore Wildi, "Electrical Machines, Drives, and Power Systems", Pearson Education, 5th Edition, 2002.
3. B.R. Gupta, 'Fundamental of Electric Machines' New age International Publishers, 3rd Edition, Reprint 2015.
4. S.K. Bhattacharya, "Electrical Machines", Mc Graw -Hill Education, New Delhi, 3rd Edition, 2009.

WEB RESOURCES:

1. <https://www.springerprofessional.de/en/electrical-machines-and-drives/15402586?tocPage=1>
2. https://www.academia.edu/37967928/a-textbook_of_electrical_technology_volume_II_ac_and_dc_machines_BL.Theraja.pdf_BUKU_BL.THERAJA_VOL_II

ONLINE RESOURCES:

1. https://swayam.gov.in/nd1_noc19_ee69/preview
2. <https://nptel.ac.in/courses/108102146/>
3. <https://www.coursera.org/lecture/motors-circuits-design/1-course-introduction-EP7KP>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Understand electric circuits and apply circuit theorems. (K2)
2. Apply the knowledge of electric circuits for engineering application. (K3)
3. Understand the working principles of various electrical machines. (K2)
4. Choose the electrical machines for different applications. (K3)
5. Analyze the performance of electrical machines and electrical circuits in practical. (K4)
6. Build the knowledge to select the starters and braking for electrical machines. (K2)

CO- PO,PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	2	2	-	-	-	-	-	-	-	3	3
C02	3	3	2	2	1	1	1	-	-	-	-	1	3	3
C03	3	2	1	2	1	1	-	-	-	-	1	-	2	3
C04	3	2	2	1	-	1	1	-	-	-	1	1	2	3
C05	3	3	2	1	1	-	-	-	-	-	-	-	3	3
C06	3	2	1	1	1	-	-	-	-	-	1	-	3	3

SEMESTER - II

20BSPH202 SDG NO. 4	PHYSICS OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the formation of alloy and phase diagrams
- To interpret the properties of ferrous alloys and its uses
- To familiarize the mechanical properties of materials
- To expose the magnetic, dielectric and superconducting materials properties and application
- To explicate the properties and applications of advanced materials

UNIT I ALLOY FORMATION AND PHASE DIAGRAMS**9**

Types of alloys - Solid solutions - Hume Rothery's rules - the phase rule - single component system - one-component system of iron - binary phase diagrams - isomorphous systems - the Tie-line rule - Lever rule - application to isomorphous system - eutectic phase diagram - peritectic phase diagram - other invariant reactions - free energy composition curves for binary systems - micro structural change during cooling

UNIT II FERROUS ALLOYS**9**

The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - diffusion in solids - Fick's laws - phase transformations - T-T-T-diagram for eutectoid steel - pearlite, bainite and martensite transformations - tempering of martensite.

UNIT III MECHANICAL PROPERTIES**9**

Tensile test - plastic deformation mechanisms - slip and twinning - role of dislocations in slip - strengthening methods - strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening - creep resistance - creep curves - mechanisms of creep - creep-resistant materials - fracture - the Griffith criterion - critical stress intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Brinell hardness - Vickers microhardness.

UNIT IV MAGNETIC, DIELECTRIC AND SUPERCONDUCTING MATERIALS**9**

Ferromagnetism - domain theory - types of energy - hysteresis - hard and soft magnetic materials - ferrites - dielectric materials - types of polarization - Langevin-Debye equation - frequency effects on polarization - dielectric breakdown - Insulating materials - Ferroelectric materials - superconducting materials - properties - applications.

UNIT V ADVANCED MATERIALS**9**

Metallic glasses: types, glass forming ability of alloys, melt spinning process, applications - shape memory alloys: phases, shape memory effect, pseudoelastic effect, NiTi alloy, applications - Advanced ceramics - applications - composites: classification, role of matrix and reinforcement - nanomaterials: preparation (bottom up and top down approaches), properties and applications - carbon nanotubes: types.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. W.F.Smith , J. Hashemi , & R.J.Prakash, "Materials Science and Engineering", Tata McGraw Hill Education Pvt. Ltd., 2014.
2. R.Balasubramaniam, "Callister's Materials Science and Engineering", Wiley India Pvt. Ltd., 2014.
3. V.Raghavan, "Physical Metallurgy: Principles and Practice", PHI Learning, 2015.
4. William D. Callister Jr, David G.Rethwisch, "Callister's Materials Science and Engineering", 10th edition, Global edition, John Wiley & Sons, 2019.
5. Donald R Askeland, Wedelin J Wright, "Essentials of Materials Science and Engineering", Cengage Learning India Private Ltd., 2018.

REFERENCES

1. George Dieter, "Mechanical Metallurgy", McGraw Hill, 2013.
2. James F. Shackelford, "Introduction to Materials Science for Engineers", 8th edition, 8th edition, Pearson, 2015.

3. O.P.Kanna, "Materials science and Metallurgy", Dhanpat Raj Publications, 2nd edition, 2014.
4. Susan Troiler –Mckinstry and Robert E. Newnham, "Materials Engineering: Bonding, Structure, Structure – property relationship" Cambridge University press, 2018.
5. A.Daniel, Brandt, J.C.Warner, "Metallurgy Fundamentals: Ferro and Non Ferrous" 6th edition, Good Heart Wilcox, 2019.

OUTCOMES:

Upon completion of the course, the students should be able to

1. Understand the concept of formation of alloys and invariant phase reactions related to unary and binary system (K2)
2. Demonstrate the practical exposure on microstructure, phase transformation, effect of alloying elements in ferrous alloys and their applications (K2)
3. Explain the phase transformation TTT diagram, various testing procedures for understanding the properties of materials and strengthening methods (K2)
4. Understand the basic knowledge of ferromagnetic and ferrimagnetic materials (K2)
5. Gain knowledge on dielectric, super conducting, composite, ceramic materials, metallic glasses, shape memory alloys, nanomaterials and their properties (K2).
6. Apply the suitable superconducting, ceramic, nano, composite materials and shape memory alloys for specific engineering applications (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	3	-	2	-	-	-	-	1
CO2	3	3	2	-	3	-	2	-	-	-	-	2
CO3	3	3	2	-	3	-	2	-	-	-	-	2
CO4	3	3	2	-	3	-	2	-	-	-	-	2
CO5	3	3	2	-	3	-	2	-	-	-	-	2
CO6	3	3	2	-	3	-	2	-	-	-	-	1

SEMESTER - II

20ESGE201 SDG NO. 4,9,12	ENGINEERING PRACTICES LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To provide exposure to the students with hands on experience on various basic engineering practices in Electrical and Electronics Engineering, Civil and Mechanical Engineering

ELECTRICAL ENGINEERING PRACTICE

1. Residential house wiring using switches, fuse, indicator, lamp and energy meter.
2. Fluorescent lamp wiring.
3. Stair case wiring.
4. Measurement of electrical quantities – voltage, current, power & power factor in RLC circuit.
5. Measurement of energy using single phase energy meter.
6. Measurement of resistance to earth of electrical equipment.

ELECTRONICS ENGINEERING PRACTICE

1. Study of Electronic components and equipments – Resistor, colour coding measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2. Study of logic gates AND, OR, EX-OR and NOT.
3. Generation of Clock Signal.
4. Soldering practice – Components, Devices and Circuits – Using general purpose PCB.
5. Measurement of ripple factor of HWR and FWR.

CIVIL ENGINEERING PRACTICE**Buildings:**

Study of plumbing and carpentry components of residential and industrial buildings, safety aspects.

Plumbing Works:

1. Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, elbows in household fittings.
2. Study of pipe connections requirements for pumps and turbines.

3. Preparation of plumbing line sketches for water supply and sewage works.
4. Hands-on-exercise: Basic pipe connections – Mixed pipe material connection – Pipe connections with different joining components.
5. Demonstration of plumbing requirements of high-rise buildings.

Carpentry using Power Tools only:

1. Study of the joints in roofs, doors, windows and furniture.
2. Hands-on-exercise: Wood work, joints by sawing, planing and cutting.

MECHANICAL ENGINEERING PRACTICE**Welding:**

1. Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
2. Gas welding practice.

Basic Machining:

1. Simple Turning and Taper turning.
2. Drilling Practice.

Sheet Metal Work:

1. Forming & Bending.
2. Model making – Trays and funnels.
3. Different type of joints.

Machine assembly practice:

1. Study of centrifugal pump.
2. Study of air conditioner.

Demonstration on:

1. Smithy operations, upsetting, swaging, setting down and bending.
Example – Exercise – Production of hexagonal headed bolt.
2. Foundry operations like mould preparation for gear and step cone pulley.
3. Fitting – Exercises – Preparation of square fitting and V – fitting models.

Total : 45 PERIODS

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS**1. Electrical**

1	Assorted electrical components for house wiring	15 Sets
2	Electrical measuring instruments	10 Sets
3	Study purpose items: Iron box, fan and regulator, emergency lamp	1 Each
4	Megger (250V/500V)	1 No
5	Power Tools: Range Finder	2 Nos
	Digital Live-wire detector	2 Nos

2. Electronics

1	Soldering guns	10 Nos
2	Assorted electronic components for making circuits	50 Nos
3	Small PCBs	10 Nos
4	Multimeters	10 Nos

3. Civil

1	Assorted components for plumbing consisting of metallic pipes, plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings.	15 Sets
2	Carpentry vice (fitted to work bench)	15 Nos
3	Standard woodworking tools	15 Sets
4	Models of industrial trusses, door joints, furniture joints	5 each
5	Power Tools: Rotary Hammer	2 Nos
	Demolition Hammer	2 Nos
	Circular Saw	2 Nos
	Planer	2 Nos
	Hand Drilling Machine	2 Nos
	Jigsaw	2 Nos

4. Mechanical

1	Arc welding transformer with cables and holders	5 Nos
2	Welding booth with exhaust facility	5 Nos
3	Welding accessories like welding shield, chipping hammer, wire brush, etc	5 Sets
4	Oxygen and acetylene gas cylinders, blow pipe and other welding outfit.	2 Nos

5	Centre lathe	2 Nos
6	Hearth furnace, anvil and smithy tools	2 Sets
7	Moulding table, foundry tools	2 Sets
8	Power Tool: Angle Grinder	2 Nos
9	Study-purpose items: centrifugal pump, air-conditioner	1 each

OUTCOMES:

Upon completion of the course, the students should be able to

1. Elaborate on the components, gates, soldering practices. Calculate electrical parameters such as voltage, current, resistance and power. (K1)
2. Design and implement Rectifier and Timer circuits (K2)
3. Measure the electrical energy by single phase and three phase energy meters. (K2)
4. Prepare the carpentry and plumbing joints. (K2)
5. Perform different types of welding joints and sheet metal works (K2)
6. Perform different machining operations in lathe and drilling. (K2)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	-	-	1	1	1	1
CO2	3	2	1	1	2	1	-	-	1	1	1	1
CO3	2	2	1	1	1	1	-	-	1	1	1	1
CO4	1	1	1	-	-	2	-	-	1	1	1	2
CO5	2	1	1	-	-	1	1	1	1	1	1	2
CO6	2	1	1	-	-	1	-	1	1	1	1	2

SEMESTER - II

20TPHS201 SDG NO. 4&5	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To understand the nuances in resume building
- To explore various virtual meeting tools
- To gain knowledge about online certification courses
- To develop knowledge in Google Suite products
- To enhance presentation skills

UNIT I RESUME BUILDING**6**

Your Strength, Projects, Internship, Paper Presentation, uploading your coding in github, Introduction to HackerRank, HackerEarth virtual online assessment (Auto Proctored) (Practicals - Construct a resume, Register for a online Mock Assessment / Contest)

UNIT II VIRTUAL MEETINGS**6**

Basic Etiquette of virtual meeting – Introduction to Skype - Zoom - Webex - Google Meet - Gotowebinar - Jio meet – Screen Share - Jamboard - Feedback polling - Chatbox

(Practicals - Accept and Register for a mock class to attend - How to host a meeting).

UNIT III ONLINE LEARNING**6**

Online Certification - Coursera – Udemy – Edx – Cisco – Online Practice Platforms - SkillRack – Myslate - FACEprep - BYTS - aptimithra - Contest Registrations - TCS Campus Commune - HackwithInfy, InfyTQ - Virtusa NurualHack - Mindtree Osmosis – Online assessment - AMCAT-PGPA.

(Practicals - Campus Commune Registration , Coursera registration - Mock Registration (KAAR Technologies as sample).

UNIT IV GOOGLE SUITE**8**

Define google suite - Benefits of google suite - Google Search - Sheet - Docs - Forms - Calender - Drive - Slide - Translate - Duo - Earch - Maps - Hangouts- Sites - Books - Blogger

(Practicals – Create google sheets and share - Create google Forms and share, Create Google Slide and share , Google drive creation and share (Knowledge of Rights), Create poll and share.

UNIT V PRESENTATION SKILLS

4

Email Writing – Group Discussion - Power Point Presentation

(Practicals- Create a self SWOT Analysis report. A PowerPoint Slide Preparation)

TOTAL : 30 PERIODS**WEB REFERENCES :****Unit I: Resume Building:**

1. <https://zety.com/blog/resume-tips>
2. <https://resumegenius.com/blog/resume-help/how-to-write-a-resume>
3. <https://www.hackerearth.com/recruit/>
4. <https://www.hackerrank.com/about-us>

Unit – II:Virtual Meetings

1. <https://www.claphamschool.org/our-community/blog/online-learning-etiquette-guide-14-principles-to-guide-students>
2. https://online.hbs.edu/blog/post/virtual-interview-tips?c1=GAW_SE_NW&source=IN_GEN_DSA&cr2=search__-__nw__-__in__-__dsa__-__general&kw=dsa__-__general&cr5=459341920955&cr7=c&gclid=Cj0KCQjw8fr7BRDSARIsAK0Qqr4dRRbboL3kltrwDsr7hm8oIHtN5dfjD3NIFZULuzNwEXxhjpNFQ2caApn5EALw_wcB
3. <https://hygger.io/blog/top-10-best-group-meeting-apps-business/>
4. <https://www.zdnet.com/article/best-video-conferencing-software-and-services-for-business/>

Unit – III:Online Learning

1. <https://www.coursera.org/browse>
2. <https://support.udemy.com/hc/en-us/articles/229603868-Certificate-of-Completion>
3. <https://www.edx.org/course/how-to-learn-online>
4. <https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html>
5. <https://campuscommune.tcs.com/en-in/intro>
6. <https://www.freshersnow.com/tcs-campus-commune-registration/>
7. <https://www.infosys.com/careers/hackwithinfy.html>
8. <https://www.mindtree.com/blog/osmosis-2013-my-experiences>
9. <https://www.myamcat.com/knowning-amcat>
10. <https://www.admitkard.com/blog/2020/02/06/amcat/>

Unit IV: Google Suite

1. <https://www.inmotionhosting.com/blog/what-is-g-suite-and-why-should-i-consider-using-it/>
2. https://en.wikipedia.org/wiki/G_Suite
3. <https://blog.hubspot.com/marketing/google-suite>
4. <https://kinsta.com/blog/g-suite/>

Unit V: Presentation Skills

1. <https://www.mindtools.com/CommSkil/EmailCommunication.htm>
2. <https://www.grammarly.com/blog/email-writing-tips/>
3. <https://business.tutsplus.com/articles/how-to-write-a-formal-email--cms-29793>
4. <https://www.softwaretestinghelp.com/how-to-crack-the-gd/>
5. <https://www.mbauniverse.com/group-discussion/tips>
6. <https://slidemodel.com/23-powerpoint-presentation-tips-creating-engaging-interactive-presentations/>
7. <https://business.tutsplus.com/articles/37-effective-powerpoint-presentation-tips--cms-25421>
8. <https://blog.prezi.com/9-tips-on-how-to-make-a-presentation-a-success/>
9. <http://www.garreynolds.com/preso-tips/design/>

OUTCOMES:**On completion of this course, the student should be able to**

1. Construct a suitable resume and registration procedure for online mock assessments. (K1)
2. Handle various virtual meeting tools. (K3)
3. Acquire exposure about online certification courses. (K4)
4. Get involved and work in a collaborative manner. (K2)
5. Gain knowledge in various presentation methodologies. (K1)
6. Apply knowledge to practice Google suite features and SWOT analysis. (K3)

CO – PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	3	2	-	3	2	3	-	2
CO2	-	-	-	-	3	2	-	3	2	3	-	2
CO3	-	-	-	-	3	2	-	-	1	3	-	2
CO4	-	-	-	-	3	2	-	3	3	3	-	2
CO5	-	-	-	-	3	2	-	-	2	3	-	2
CO6	-	-	-	-	3	2	-	-	2	3	-	2

SEMESTER - II

20HSMG201 SDG NO. 4 & 5	INTERPERSONAL VALUES	L	T	P	C
		2	0	0	0

OBJECTIVES:

- Values through Practical activities

UNIT I INTERPERSONAL VALUES**6**

Interpersonal Relationships and Values – Importance and Barriers – Building and maintain relationships – Mutual understanding – Respect to others.

UNIT II EFFECTIVE COMMUNICATION**6**

Communication skills –Importance and Barriers - Impressive formation and management – Public speaking

UNIT III GROUP DYNAMICS**6**

Group formation –Teamwork – Identify others attitude and behaviour – Formation of relationship – Personal and professional.

UNIT IV MUTUAL RELATIONSHIP**6**

Building mutual understanding and cooperation – Enhancing decision making skills – Problem solving skills – Comparative Appraisal – Interpersonal needs.

UNIT V POSITIVE ATTITUDE**6**

Fostering trust and cooperation – Developing and maintain positive attitude – Improving socialization – Development of security and comfort.

TOTAL: 30 PERIODS

Note: Each topic in all the above units will be supplemented by practice exercises and classroom activities and projects.

REFERENCE BOOKS:

1. Barun K. Mitra, "Personality Development and Soft Skills", Oxford University Press, 2016.
2. B.N.Ghosh, "Managing Soft Skills for Personality Development", McGraw Hill India, 2012.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Develop a healthy relationship & harmony with others. (K1)
2. Practice respecting every human being. (K3)
3. Practice to eradicate negative temperaments. (K3)
4. Acquire Respect, Honesty, Empathy, Forgiveness and Equality. (K4)
5. Manage the cognitive abilities of an Individual. (K5)
6. Understanding the importance of public speaking and teamwork. (K2)

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	2	3	3	1	1	1
CO2	-	-	-	-	-	2	2	3	3	1	1	1
CO3	-	-	-	-	-	2	2	3	3	1	1	1
CO4	-	-	-	-	-	2	2	3	3	1	1	1
CO5	-	-	-	-	-	2	2	3	3	1	1	1
CO6	-	-	-	-	-	2	2	3	3	1	1	1

SEMESTER - III

20ESCE201 SDG NO. 4, 9, 12	ENGINEERING MECHANICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To predict the effect of force and motion in the course of carrying out the design functions of engineering

UNIT I STATICS OF PARTICLES**10**

Introduction – Units And Dimensions – Laws of Mechanics – Newton's Laws- lam'i's Theorem- Parallelogram, Triangular Law and Polygon Law of Forces- principle of Transmissibility - Vectorial Representation of Forces – Fundamental Vector Operations of Forces – Free Body Diagram - Equilibrium of a Particle in 2 D – Forces in Space – Equilibrium of a Particle in Space – Equivalent Systems of Forces.

UNIT II EQUILIBRIUM OF RIGID BODIES**10**

Moments And Couples - Vectorial Representation – Scalar Components of a Moment – Varignon's Theorem- Moment of a Force About a Point and About an Axis- Single Equivalent Force - Types of Supports – Action and Reaction Forces – Types of Equilibrium - Equilibrium of Rigid Bodies in Two and Three Dimensions.

UNIT III FRICTION**7**

Friction Force – Types of Friction - Laws of Coulomb Friction – Simple Contact Friction - Two Bodies in Contact - Wedge Friction, Ladder Friction - Rolling Resistance.

UNIT IV PROPERTIES OF SURFACES AND SOLIDS**9**

Centroids and Centre of Mass and Volume – Simple and Composite Areas and Solids - Theorems of Pappus - Area Moments of Inertia of Composite Areas – Parallel Axis Theorem and Perpendicular Axis Theorem – Polar Moment of Inertia - Radius of Gyration - Product of Inertia - Principal Moments of Inertia of Plane Areas and Composite Areas – Principal Axes of Inertia - Mass Moment of Inertia – Prismatic, Cylindrical and Spherical Solids from First Principle.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES**9**

Displacement, Velocity and Acceleration – Relative Motion - Curvilinear Motion - Newton's Laws of Motion – D' Alembert's Principle, Work Energy

Principle - Impulse and Momentum – Impact of Elastic Bodies. Rigid Body Motion - Translation and Rotation – General Plane Motion of Simple Rigid Bodies such as Cylinder, Disc / Wheel and Sphere.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. F.P. Beer and Johnston Jr. E.R., “Vector Mechanics for Engineers (In SI Units): Statics and Dynamics”, 8th Edition, Tata McGraw-Hill Publishing company, New Delhi, 2004.
2. N.H Dubey, “Engineering Mechanics – Statics and Dynamics”, McGraw Hill Education (India) Pvt Ltd.

REFERENCES:

1. S.S. Bhavikatti and K.G. Rajashekarappa, “Engineering Mechanics”, New Age International (P) Limited Publishers, 1998.
2. R.C. Hibbeler and Ashok Gupta, “Engineering Mechanics: Statics and Dynamics”, 11th Edition, Pearson Education 2010.
3. Irving H. Shames and Krishna MohanaRao. G., “Engineering Mechanics – Statics and Dynamics”, 4th Edition, Pearson Education 2006.
4. J.L Meriam and L.G. Kraige, “ Engineering Mechanics- Statics - Volume 1, Dynamics- Volume 2”, Third Edition, John Wiley & Sons, 1993.
5. Dr. N. Kottiswaran, “Engineering Mechanics (statics and Dynamics)”, Sri Balaji Publications, Erode.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105164/>
2. <https://nptel.ac.in/courses/112/103/112103109/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106286/>
2. <https://nptel.ac.in/courses/112/103/112103108/>
3. <https://nptel.ac.in/courses/112/106/112106180/>
4. <https://www.coursera.org/learn/engineering-mechanics-statics>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Apply the Fundamental concepts of Mechanics and operation of forces to solve equilibrium of particles in 2D and 3D (K3)
2. Apply Varignon’s theorem to equilibrium of rigid bodies in 2D & 3D (K3)

3. Apply coulombs law of friction to calculate contact friction, wedge friction, ladder friction and rolling resistance. (K3)
4. Calculate the centroid, centre of mass, volume and area of simple, composite solids using Theorem of Pappus. (K2)
5. Calculate the moment of inertia, product of inertia, radius of gyration of plane & composite areas and mass moment of inertia of prismatic, cylindrical and spherical solids (K2)
6. Determine relative and curvilinear motion using equations of motion and impulse, momentum, impact of elastic bodies, general plane motion of rigid bodies.(K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	-	1	-	-	-	-	-	-	-	-	1	1
C02	3	2	-	1	-	-	-	-	-	-	-	-	1	1
C03	3	2	-	1	-	-	-	-	-	-	-	-	1	1
C04	2	1	-	1	-	-	-	-	-	-	-	-	1	1
C05	2	1	-	1	-	-	-	-	-	-	-	-	1	1
C06	3	2	-	1	-	-	-	-	-	-	-	-	1	1

SEMESTER - III

20MEPC301 SDG NO. : 4,9,12,13	MANUFACTURING PROCESSES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the concepts of basic manufacturing processes and fabrication techniques, such as metal casting, metal joining, metal forming and welding
- To understand the working of standard machine tools such as lathe, shaping and allied machines, milling, drilling and allied machines, grinding and allied machines and broaching
- To transform Raw Material into a Finished Product using various Manufacturing Processes
- To identify appropriate Manufacturing process for producing a component in a least expensive possible way

UNIT I METAL CASTING AND WELDING**9**

Sand Casting Mould – Type Of Patterns - Pattern Materials – Pattern Allowances – Moulding Sand Properties and Testing – Cores – Types and Applications – Moulding Machines– Types and Applications – Special Casting Techniques; Melting Furnaces : Blast and Cupola Furnaces; Defects in Casting Welding: Operating Principle, Basic Equipment, Merits and Applications of: Fusion Welding Processes: Gas Welding - Types – Flame Characteristics; Manual Metal Arc Welding – Gas Tungsten Arc Welding- Gas Metal Arc Welding – Submerged Arc Welding – Electro Slag Welding, Friction Stir Welding, Plasma, Laser Welding; Operating Principle and Applications of: Resistance Welding - Brazing and Soldering; Weld Defects: Types, Causes And Cure.

UNIT II METAL FORMING PROCESSES**9**

Hot Working and Cold Working of Metals – Forging Processes – Open, Impression and Closed Die Forging – Forging Operations. Rolling of Metals– Types of Rolling – Flat Strip Rolling – Shape Rolling Operations – Defects in Rolled Parts. Principle of Rod and Wire Drawing – Tube Drawing – Principles of Extrusion – Types – Hot and Cold Extrusion. Sheet Metal Characteristics – Shearing, Bending and Drawing Operations – Stretch Forming Operations – Formability of Sheet Metal – Test Methods

UNIT III THEORY OF METAL CUTTING AND TURNING MACHINES**9**

Mechanism of Metal Cutting, Cutting Forces, Merchant's Circle, Cutting Tool Nomenclature, Types of Chips, Tool Materials and Cutting Fluids, Taylor's Equation, Machining Variables, Machinability, Problems on Metal Cutting- Centre Lathe, Constructional Features, Specification, Operations – Taper Turning Methods, Thread Cutting Methods, Special Attachments, Machining Time and Power Estimation. Capstan and Turret Lathes - Tool Layout – Automatic Lathes: Semi Automatic – Single Spindle : Swiss Type, Automatic Screw Type – Multi Spindle.

UNIT IV SHAPER, PLANER, SLOTTER, DRILLING, MILLING AND GEAR CUTTING MACHINES**9**

Shaper, Planer, Slotter - Types of Operations and Mechanisms. Drilling, Tapping, Reaming and Boring, Milling Operations - Types of Milling Cutter and Nomenclature. Gear Cutting – Forming and Generation Principle and Construction of Gear Milling, Hobbing and Gear Shaping Processes – Finishing of Gears.

UNIT V ABRASIVE PROCESSES AND BROACHING**9**

Abrasive Processes: Grinding Wheel – Specifications and Selection, Types of Grinding Process– Cylindrical Grinding, Surface Grinding, Centreless Grinding

and Internal Grinding - Typical Applications Concepts of Surface Integrity, Broaching Machines: Broach Construction – Push, Pull, Surface and Continuous Broaching Machines and Applications - Lapping and Honing Processes.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Hajra Chouldhary S.K and Hajra Choudhury. AK., "Elements of workshop Technology", volume I and II, Media promoters and Publishers Private Limited, Mumbai, 2008
2. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2013.

REFERENCES:

1. Paul Degarmo E, Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice – Hall of India, 1997.
2. Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 4th Edition, TMH-2013
3. Roy. A. Lindberg, "Processes and Materials of Manufacture", PHI / Pearson education, 2006
4. Sharma, P.C., "A Text book of production Technology", S.Chand and Co. Ltd., 2014.
5. Rao. P.N "Manufacturing Technology - Metal Cutting and Machine Tools", 3rd Edition, Tata McGraw-Hill, New Delhi, 2013.
6. Winston.A.Knight, Geoffrey Boothroyd, "Fundamentals of Metal Machining and Machine Tools" CRC Press, 3rd Edition
7. A.Bhattacharya, "Metal Cutting : Theory And Practice" New Central Book Agency, 1984

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107144/>
2. <https://nptel.ac.in/courses/112/105/112105127/>
3. <https://nptel.ac.in/courses/112/107/112107084/>
4. <https://nptel.ac.in/courses/112/106/112106153/>
5. <https://nptel.ac.in/courses/112/107/112107090/>
6. <http://web.mit.edu/2.810/www/files/lectures/lec5-machining-2018.pdf>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107145/>
2. <https://nptel.ac.in/courses/112/105/112105126/>

3. <https://nptel.ac.in/courses/112/104/112104195/>
4. <https://nptel.ac.in/courses/112/107/112107219/>
5. <https://nptel.ac.in/courses/112/107/112107083/>
6. <https://nptel.ac.in/courses/112/107/112107215/>
7. <https://nptel.ac.in/courses/112/107/112107250/>
8. <https://nptel.ac.in/courses/112/104/112104290/>
9. <https://nptel.ac.in/courses/112/103/112103248/>
10. <https://nptel.ac.in/courses/112/103/112103250/>
11. <https://nptel.ac.in/courses/112/107/112107089/>
12. <https://nptel.ac.in/courses/113/106/113106087/>
13. <https://www.mooc-list.com/course/fundamentals-manufacturing-processes-edx>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Students able to know the capability of selecting suitable manufacturing processes to manufacture the products optimally. (K2)
2. Obtain fundamental knowledge and able to know the method of operations in manufacturing processes. (K2)
3. Understand the knowledge about the various tools, equipment, and machinery required for basic manufacturing processes. (K2)
4. Understand the requirements to achieve Best quality manufacturing methods for various industrial engineering needs. (K2)
5. Students can able to apply the different metal removing, finishing and super finishing and for component production.(K2)
6. Understand the application, advantages and limitations of various manufacturing processes Introduce to recent emerging areas in primary manufacturing process.(K2)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	1	0	0	0	0	0	0	0	0	0	0	1	1
C02	1	1	0	0	0	0	0	0	0	0	0	0	2	2
C03	1	1	0	0	0	0	0	0	0	0	0	0	2	2
C04	1	0	0	0	0	0	0	0	0	0	0	0	1	1
C05	2	1	0	0	0	0	0	0	0	0	0	0	1	1
C06	1	0	0	0	0	0	0	0	0	0	0	0	1	1

SEMESTER - III

20MEPC302 SDG NO. 4,7, 12,15	ENGINEERING THERMODYNAMICS	L	T	P	C
		3	1	0	4

(Use of Standard and approved Steam Table, Mollier Chart, Compressibility Chart and Psychrometric Chart are permitted)

OBJECTIVES:

- Enable students to analyze and evaluate various thermodynamic cycles used for energy production - work and heat within the natural limits of conversion
- To enable student to understand the concepts of system, entropy and availability.
- To impart the concepts of ideal, real gases and the various gas relations associated with it.
- To make student understand about the concepts of Gas mixtures and psychrometry.

UNIT I BASIC CONCEPTS AND FIRST LAW

9

Basic concepts - concept of continuum, comparison of microscopic and macroscopic approach - Path and point functions - Intensive and extensive properties. System and their types. Thermodynamic Equilibrium State, path and process - Quasi-static, reversible and irreversible processes - Heat and work transfer, definition and comparison, sign convention. Displacement work and other modes of work, p-V diagram - Zeroth law of thermodynamics - concept of temperature and thermal equilibrium - relationship between temperature scales - new temperature scales - First law of thermodynamics - application to closed and open systems - steady and unsteady flow processes.

UNIT II SECOND LAW AND AVAILABILITY ANALYSIS

9

Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump - Statements of second law and its corollaries - Carnot cycle, Reversed Carnot cycle, Performance. Clausius inequality - Concept of entropy, T-s diagram, T-ds Equations, entropy change for - pure substance, ideal gases - different processes, principle of increase in entropy - Space applications of II Law - High and low grade energy - Available and non-available energy of a source and finite body - Energy and irreversibility - Expressions for the energy of a closed system and open systems - Energy balance and entropy generation - Irreversibility.

UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

9

Formation of steam and its thermodynamic properties: p-v, p-T, T-v, T-s, h-s diagrams, p-v-T surface - Use of Steam Table and Mollier Chart - Determination of dryness fraction - Application of I and II law for pure substances - Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles, Economiser, pre heater, Binary and Combined cycles.

UNIT IV IDEAL, REAL GASES AND THERMODYNAMIC RELATIONS

9

Properties of Ideal gas - Ideal and real gas comparison- Equations of state for ideal and real gases Reduced properties - Compressibility factor - Principle of Corresponding states – Generalised Compressibility Chart and its use- Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule-Thomson Coefficient, Clausius Clapeyron equation, Phase Change Processes. Simple Calculations.

UNIT V GAS MIXTURES AND PSYCHROMETRY

9

Mole and Mass fraction, Dalton's and Amagat's Law - Properties of gas mixture – Molar mass, gas constant, density, change in internal energy, enthalpy, entropy and Gibbs function - Psychrometric properties, Psychrometric charts - Property calculations of air vapour mixtures by using chart and expressions - Psychrometric process – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing - Simple Applications

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R.K.Rajput, "A Text Book Of Engineering Thermodynamics", Fifth Edition, 2017.
2. Yunus A. Cengel & Michael A. Boles, "Thermodynamics", 8th edition 2015.

REFERENCES :

1. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.
2. Borgnakke & Sonntag, "Fundamental of Thermodynamics", 8th Edition , 2016.
3. Chattopadhyay, P, "Engineering Thermodynamics", Oxford University Press, 2016.
4. Michael J. Moran, Howard N. Shapiro, "Fundamentals of Engineering Thermodynamics", 8th Edition.
5. Nag.P.K., "Engineering Thermodynamics", 5th Edition, Tata McGraw-Hill, New Delhi, 2013

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104113/>
2. <https://nptel.ac.in/courses/112/108/112108148/>
3. <https://www.mcgoodwin.net/pages/thermodynamics.pdf>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/102/112102255/>
2. <https://nptel.ac.in/courses/112/105/112105123/>
3. <https://nptel.ac.in/courses/101/104/101104063/>
4. <https://nptel.ac.in/courses/101/104/101104067/>
5. <https://nptel.ac.in/courses/112/105/112105220/>
6. <https://nptel.ac.in/courses/112/105/112105266/>
7. <https://nptel.ac.in/courses/112/103/112103275/>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Describe the various thermodynamics systems and its associated laws (K1)
2. State and apply the laws of thermodynamics for various thermal systems (K2)
3. Illustrate the concept of available and unavailable energies for different thermodynamic systems (K3)
4. Identify the suitable thermodynamic cycle for power developing and cooling systems (K3)
5. Derive the thermodynamic relations for real and ideal gases and gas mixtures (K3)
6. Make use of Thermodynamic charts and tables to obtain the properties for various processes (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	-	-	-	-	-	2	-	-	-	1	3	3
CO3	3	3	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	3	-	-	-	-	-	-	-	-	-	1	3	3
CO5	3	3	-	-	-	-	-	-	-	-	-	-	3	2
CO6	3	3	-	-	-	-	-	2	-	-	-	-	3	3

SEMESTER - III

20MEPC303 SDG NO. 4,8,9,12	ENGINEERING METALLURGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic structure and the phase diagrams
- To impart knowledge on the various heat treatment processes and strengthening mechanisms.
- To study and test various metallic and non-metallic materials
- To identify and select suitable materials for various engineering applications

UNIT I ALLOYS AND PHASE DIAGRAMS 9

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram. Classification of steel and cast Iron - microstructure, properties and application.

UNIT II HEAT TREATMENT AND STRENGTHENING MECHANISMS 9

Definition- Full annealing, stress relief, recrystallisation and spheroidising – normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - Austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening.

Strengthening Mechanisms: Cold working, Grain size control, precipitation strengthening, dispersion strengthening, particulate and fiber strengthening, texture strengthening.

UNIT III FERROUS AND NON FERROUS METALS 9

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

UNIT IV NON METALLIC MATERIALS 9

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, 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

UNIT V MECHANICAL METALLURGY AND TESTING OF MATERIALS 9

Plastic Deformation: Dislocations and Deformations by Slip, Twinning, Stacking faults. Dislocation Theory. Fracture: Types, Griffith's theory of brittle fracture. Testing of Materials - Tension, Torsion, Shear, Delamination, Hardness, Impact, fatigue and Creep Testing of materials according to ASTM Standards.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Avner, S.H., "Introduction to Physical Metallurgy", McGraw Hill Book Company, 1997.
2. Williams D Callister, "Material Science and Engineering", Wiley India Pvt Ltd, Revised Indian Edition 2014.

REFERENCES:

1. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 2010.
2. R.K. Rajput, "Engineering Materials and Metallurgy", S. Chand & Co
3. Raghavan, V., "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd., 2015.
4. U.C. Jindal : Material Science and Metallurgy, "Engineering Materials and Metallurgy", First Edition, Dorling Kindersley, 2012
5. Upadhyay. G.S. and Anish Upadhyay, "Materials Science and Engineering", Viva Books Pvt. Ltd., New Delhi, 2006

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/108/112108150/>
2. <https://nptel.ac.in/courses/113/106/113106032/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/122/102/122102008/>
2. <https://nptel.ac.in/courses/113/102/113102080/>
3. <https://nptel.ac.in/courses/113/104/113104074/>
4. <https://nptel.ac.in/courses/112/104/112104219/>

5. <https://nptel.ac.in/courses/113/105/113105028/>
6. <https://nptel.ac.in/courses/113/106/113106075/>
7. <https://nptel.ac.in/courses/112/104/112104220/>

OUTCOMES:

Upon completion of the course, the students should be able to:

1. Impart knowledge in basics of materials and its characteristics. [K2]
2. Interpret the phase diagram by identifying appropriate transformation process. [K2]
3. Restate in preparing specimens for material testing as per standards. [K2]
4. Identify the effect of secondary processes in material properties. [K3]
5. Apply the secondary processes and its effects on microstructure of different materials. [K3]
6. Analyze the characteristics of materials for industrial applications. [K4]

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	1	-	-	-	-	-	-	-	2	3	3
C02	3	2	3	1	-	2	2	-	-	-	-	2	3	3
C03	2	-	2	-	-	2	2	1	-	-	-	3	3	3
C04	2	-	2	-	-	2	3	1	-	-	-	3	3	3
C05	3	2	1	2	-	2	-	2	-	-	-	2	3	3
C06	3	3	2	2	-	2	-	1	-	-	-	3	3	3

SEMESTER - III

20BSMA303	PARTIAL DIFFERENTIAL EQUATIONS AND PROBABILITY THEORY	L	T	P	C
SDG NO. 4		3	1	0	4

OBJECTIVES:

- To introduce the basic concepts of PDE for solving standard partial differential equations.
- To acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
- To introduce Fourier Transform techniques for applications in engineering problems.
- To provide necessary basic concepts in probability theory and random variables.
- To understand the basic concepts of probability, one dimensional and two-dimensional random variables. Introduce some standard distributions applicable to engineering which can describe real life phenomenon.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS

12

Formation of partial differential equations – Singular integrals – Solutions of standard types of first order partial differential equations – Lagrange's linear equation – Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT II APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

12

Classification of Partial Differential Equations – Method of separation of variables – Fourier Series Solutions of one-dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction.

UNIT III FOURIER TRANSFORMS

12

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT IV PROBABILITY AND RANDOM VARIABLES

12

Probability – Axioms of probability – Conditional probability – Baye's theorem – Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

UNIT V TWO – DIMENSIONAL RANDOM VARIABLES**12**

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

TOTAL: 60 PERIODS**TEXT BOOKS:**

1. Grewal. B.S., "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers, Delhi, 2012.
2. Veerarajan. T., "Transforms and Partial Differential Equations", Tata Mc-Graw Hill Education Pvt. Ltd., New Delhi, Third print, 2016.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 8th Edition, Wiley India, 2007.
2. Trivedi K.S., "Probability and Statistics with Reliability, Queueing and Computer Science Applications", John Wiley and Sons, 2nd Edition, 2002.
3. Ray Wylie. C and Barrett L.C, "Advanced Engineering Mathematics" Tata Mc Graw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012
4. Ramana B.V., "Higher Engineering Mathematics", Tata Mc Graw Hill Publishing Company Limited, NewDelhi, 2008.
5. Yates R.D. and Goodman D. J., "Probability and Stochastic Processes", Wiley India Pvt. Ltd., Bangalore, 2nd Edition, 2012.
6. Ibe O.C., "Fundamentals of Applied Probability and Random Processes", Elsevier, 1st Indian Reprint, 2007.
7. Veerarajan T., "Probability, Statistics and Random Processes", Tata McGraw Hill Education Pvt. Ltd., New Delhi, Third print, 2016.
8. Narayanan S., Manicavachagom Pillay T.K. and Ramanaiah G., "Advanced Mathematics for Engineering Students" Vol. II & III, S.Viswanathan Publishers Pvt. Ltd. 1998.

WEB RESOURCES:

1. <https://ocw.mit.edu/courses/mathematics/18-600-probability-and-random-variables-fall-2019/lecture-notes/index.htm>
2. <https://nptel.ac.in/courses/122103012/>

ONLINE RESOURCES:

1. <https://youtu.be/vEt3eqihm80>
2. <https://www.youtube.com/watch?v=bjybXMwWjjc>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Solve first, higher order linear and nonlinear partial differential equations with constant coefficients and find the variable separable solution of partial differential equations. (K3)
2. Find the Fourier series solution of one-dimensional wave equation, one dimensional and two-dimensional heat equations. (K3)
3. Compute the Fourier and Inverse Fourier Transform, Sine and Cosine Transform of simple functions. (K3)
4. Calculate the probability, conditional probability and statistical averages of one dimensional discrete and continuous random variables and corresponding probability distributions. (K3)
5. Find the relation between two-dimensional random variables and their transformations. (K3)

CO- PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	-	-	-	-	-	-	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1
CO3	3	3	3	2	-	-	-	-	-	-	-	1
CO4	3	3	3	2	-	-	-	-	-	-	-	1
CO5	3	3	3	2	-	-	-	-	-	-	-	1

SEMESTER - III

20CEPC306 SDG NO. 4,6,9,14	FLUID MECHANICS AND MACHINERY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the properties of fluids, measurement of pressure, types of flow and basic equations of motion.
- To apply conservation laws, boundary layer theory and various losses.
- To understand the basic concepts of Dimensional Analysis and similitude.
- To study various types of pumps, turbines.

UNIT I FLUID PROPERTIES AND PRESSURE MEASUREMENTS 9

Units and Dimensions – Fluid Properties – Density, Specific Gravity, Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus – Pascal’s Law – Pressure Measurements – Manometers - Simple- Differential and Inverted U Tube Manometers

UNIT II FLUID KINEMATICS AND DYNAMICS 9

Fluid Kinematics - Lagrangian and Eulerian Descriptions - Types of Fluid Flow – Control Volume – Continuity Equation– Velocity and Acceleration - Energy Equation – Euler and Bernoulli’s Equations and its Applications- Orifice Meter, Venturimeter and Pitot Tube – Momentum Equation – Moment of Momentum Equation.

UNIT III FLOW THROUGH PIPES AND BOUNDARY LAYER CONCEPT 9

Laminar Flow Through Circular Pipes-major and Minor Losses - Hagen Poissuille Equation - Turbulent Flow- Darcy Weisbach Equation – Chezy’s Formula.

Boundary Layer Theory - Definition - Types - Displacement, Energy and Momentum Thickness.

UNIT IV DIMENSIONAL ANALYSIS AND MOMENTUM PRINCIPLE 9

Dimensional Analysis - Need and Methods of Dimensional Analysis - Dimensional Homogeneity- Rayleigh Method and Buckingham π Theorems - Applications - Similitude - Types - Prototype and Model – Model Testing and Analysis.

UNIT V HYDRAULIC PUMPS AND TURBINES 9

Impact of Jet – Force Exerted by a Jet on Normal, Inclined and Curved Surfaces- Angular Momentum Principle - Construction of Velocity Diagrams.

Classification of Turbines - Construction, Working and Design of Pelton Wheel, Kaplan and Francis Turbines - Head, Losses, Work Done and Efficiency - Specific Speed - Operating Characteristics. Introduction to Draft Tube.

Classification of Pumps - Centrifugal Pump - Working Principle - Discharge, Work Done and Efficiencies - Operating Characteristics. Reciprocating Pump - Working Principle - Performance Calculation.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dr.R.K.Bansal, (2000), "Fluid Mechanics and Hydraulic Machines", Laxmi Publication (P) Ltd., New Delhi.
2. P.N.Modi and S.M.Seth (1999), "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Naisarak, Delhi.

REFERENCES

1. Vijay Gupta and S.K.Gupta, (1999), "Fluid Mechanics and Applications", New-Age International Ltd.
2. D.S. Kumar,(2004), "Fluid Mechanics and Fluid Power Engineering", Katson Publishing House, Delhi.
3. V.L. Streeter, (2001), "Fluid Mechanics", McGraw Hill Book Co.
4. R.K. Rajput, "Fluid Mechanics and Hydraulic Machines", S.Chand & Company Ltd, 2010.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104118/>
2. <https://nptel.ac.in/courses/112/104/112104117/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105171/>
2. <https://nptel.ac.in/courses/105/101/105101082/>
3. <https://nptel.ac.in/courses/112/105/112105183/>
4. <https://nptel.ac.in/courses/112/105/112105206/>
5. <https://nptel.ac.in/courses/112/105/112105269/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Interpret the values and relationships of fluid properties, principles of continuity, momentum and energy as applied to fluid motions. (K2)
2. Compare and contrast the different types of flows in a fluid motion. (K2)
3. Understand the applications of hydro machines in industries. (K2)
4. Illustrate and Interpret a suitable hydro machines in relation to given situation in hydro power plants. (K2)

5. Develop a range of analytical fluid flow and evaluation techniques using fluid mechanics principles. (K3)
6. Apply dimensional analysis to predict physical parameters that impact the effectiveness. (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	1	-	-	-	1	-	3	3	3
CO2	3	3	2	2	1	1	-	-	-	2	-	3	3	3
CO3	3	3	3	2	1	1	-	-	-	1	-	3	3	3
CO4	3	3	3	2	1	1	-	-	-	1	-	3	3	3
CO5	3	3	3	2	1	1	-	-	-	1	-	3	3	3
CO6	3	3	3	2	1	1	-	-	-	1	-	3	3	3

SEMESTER - III

20MEPL301 SDG NO. 4,9,12,13	MANUFACTURING PROCESS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To operate arc welding and gas welding equipments
- To prepare moulds in foundry
- To Study and practice the various operations that can be performed in lathe, shaper, drilling, milling and special purpose machines etc.
- To equip the student with practical knowledge required in the core industries

LIST OF EXPERIMENTS

1. Fabrication of simple structural shapes using Gas Metal Arc Welding
2. Joining of plates and pipes using Gas Metal Arc Welding/ Arc Welding /Submerged arc welding
3. Preparation of green sand moulds
4. Manufacturing of simple sheet metal components using shearing and bending operations.
5. Manufacturing of sheet metal components using metal spinning on a lathe

6. Taper Turning
7. External Thread cutting
8. Internal Thread Cutting
9. Eccentric Turning
10. Knurling
11. Square Head Shaping
12. Hexagonal Head Shaping
13. Contour milling using vertical milling machine
14. Spur gear cutting in milling machine
15. Helical Gear Cutting in milling machine
16. Gear generation in hobbing machine
17. Gear generation in gear shaping machine
18. Plain Surface grinding
19. Cylindrical grinding
20. Tool angle grinding with tool and Cutter Grinder
21. Measurement of cutting forces in Milling / Turning Process

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

1	Arc welding transformer with cables and holders	2 Nos
2	Oxygen and acetylene gas cylinders, blow pipe and other welding outfit	1 No.
3	Moulding table, Moulding equipments	2 Nos
4	Sheet metal forming tools and equipments	2 Nos
5	Centre Lathes	7 Nos.
6	Horizontal Milling Machine	1 No.
7	Vertical Milling Machine	1 No.
8	Shaper	1 No.
9	Surface Grinding Machine	1 No.
10	Cylindrical Grinding Machine	1 No.
11	Radial Drilling Machine	1 No.
12	Lathe Tool Dynamometer	1 No.
13	Milling Tool Dynamometer	1 No.
14	Gear Hobbing Machine	1 No.
15.	Gear Shaper	1 No.
16	Tool Cutter and Grinder	1 No.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Join two metals using arc welding. (K2)
2. Use sheet metal fabrication tools and make simple tray and funnel.(K2)
3. Use different moulding tools, patterns and prepare sand moulds.(K2)
4. Make the workpiece as per given shape and size using Lathe, Milling, Drilling and Special Purpose Machines.(K2)
5. Use different machine tools to manufacture gears and finishing operations(K2)
6. Develop simplified Manufacturing Processes with the aim of reduction of cost and scrap(K2)

CO – PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO2	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO3	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO4	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO5	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO6	2	2	2	-	-	-	-	-	2	-	-	2	2	2

SEMESTER - III

20MEPL302 SDG NO. 4, 8, 9,12	COMPUTER AIDED DRAFTING LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To comprehend the absolute, relative and polar coordinate systems
- To learn the procedure to Create, edit, annotate and plot drawings using basic AutoCAD commands
- To Visualize and graphically reproduce complex layouts in drafting and design areas
- To calculate part features using math skills

LIST OF EXERCISES USING SOFTWARE CAPABLE OF DRAFTING AND MODELLING

1. Creation of simple figures like polygon and general multi-line figures.
2. Drawing of a Title Block with necessary text and projection symbol.
3. Drawing of curves like parabola, spiral, involute using Bspline or cubic spline.
4. Drawing of front view and top view of simple solids like prism, pyramid, cylinder, cone, etc, and dimensioning.
5. Drawing front view, top view and side view of objects from the given pictorial views.
6. Drawing of a plan of residential building (Two bed rooms house.)
7. Drawing of a simple steel truss.
8. Drawing sectional views of prism, pyramid, cylinder, cone, etc,
9. Drawing isometric projection of simple objects.
10. Creation of 3-D models of simple objects and obtaining 2-D multi-view drawings from 3-D model.

Note: Plotting of drawings must be made for each exercise and attached to the records written by students.

LIST OF EQUIPMENTS:

1. Pentium IV computer or better hardware, with suitable graphics facility.
2. Licensed software for Drafting and Modelling. – 30 Licenses
3. Laser Printer or Plotter to print / plot drawings.

OUTCOMES:

Upon completion of the course, the students should be able to

1. Comprehend the absolute, relative and polar coordinate systems. (K1)
2. Create, edit, annotate and plot drawings using basic AutoCAD commands. (K1)
3. Visualize and graphically reproduce complex layouts in drafting and design areas. (K2)
4. Create 3D Models and Plotting of Simple objects. (K2)
5. Create graphical models by creating basic solid primitives. (K3)
6. Generate bill of materials in assembly. (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	1	-	2	-	-	-	1	2	1	2	2	2
CO2	2	-	3	-	3	-	-	-	1	2	1	2	2	2
CO3	2	-	3	-	3	-	-	-	1	2	1	2	2	2
CO4	3	1	3	2	3	-	-	-	1	2	1	2	2	2
CO5	2	1	3	-	2	-	-	-	1	2	1	2	2	2
CO6	2	1	2	-	2	-	-	-	1	2	1	2	2	2

SEMESTER - III

20METE301 SDG NO. 4,11,15	LIVE-IN-LAB - I	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students face reviews and viva voce examination.

GUIDELINES TO BE FOLLOWED:

The student individually works on a specific topic may be selected from published data or from the creative ideas approved by project supervisor who is familiar in the area of interest (Design/ Manufacturing/ Thermal/Mechatronics) and head of the department. The selected topic may be analytical or experimental. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners. The student would apply the knowledge gained from theoretical and practical courses, so as to give confidence to the students to be creative, well planned, organized, coordinated in their Live-in Lab Project-II.

The progress of the project is reviewed and evaluated with a minimum of three reviews with the guidance of Project Coordinator. The review committee may be constituted by the Head of the Department. The student must submit a

project report at the end of the semester for evaluation.

EVALUATION: Project work evaluation is based on Regulations of Credit system of Autonomous Regulatory Body.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. List the problems and conduct literature survey to identify the gap and come up with an application oriented research problem in the specific domain.(K1)
2. Understand the project characteristics and explore necessary tools and components needed at various stages of the project(K2)
3. Design and validate the proposed system using simulation.(K3)
4. Develop the Prototype of the proposed system by adapting Industrial safety standards and best financial management practices(K5)
5. Analyze the obtained results and prepare a technical report.(K4)
6. Evaluate the project and go for journals and patents publication.(K5)

CO- PO & PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	2	2	2	2	2	3	2	2	3	3	3
C02	3	3	3	2	3	3	2	2	3	3	3	3	3	3
C03	3	3	3	2	3	3	2	2	3	3	3	3	3	3
C04	2	2	2	1	2	1	1	1	3	2	3	3	3	2
C05	2	2	2	1	2	1	1	1	3	2	3	3	3	2
C06	2	2	2	1	2	1	1	1	3	2	3	3	3	2

SEMESTER - III

20METP301 SDG NO. 4	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	1

APTITUDE & COGNITIVE SKILLS – PHASE 1**COURSE OBJECTIVE:**

- To educate and enrich the students on quantitative ability, reasoning ability, and verbal ability.

UNIT I QUANTITATIVE ABILITY – I 6

Problems on Trains - Time and Distance - Height and Distance - Time and Work.

UNIT II QUANTITATIVE ABILITY – II 6

Problems on Ages - Alligation or Mixture - Chain Rule - Simple Interest - Simple Equation - Theory Of Equation.

UNIT III REASONING ABILITY – I 6

Analytical Reasoning - Pipes and Cistern - Logical Problems - Logical Games - Logical Deduction - Data Sufficiency - Arithmetic Reasoning.

UNIT IV VERBAL ABILITY – I 6

Idioms & Phrases - Synonyms - Antonyms - Classification.

UNIT V CREATIVITY ABILITY – I 6

Venn Diagrams, Cube and Cuboids, Dice, Cubes and Dice, Figure Matrix

TOTAL : 30 PERIODS

REFERENCES:

- 1) R. S. Agarwal, "Quantitative Aptitude for Competitive Exams"
- 2) Sarvesh Verma, "Quantum CAT"
- 3) R. S. Agarwal, "A Modern Approach to Logical Reasoning"
- 4) Arun sharma, "Verbal Ability and Reading Comprehension"

PROBLEM SOLVING USING C PROGRAMMING AND GEOMETRIC DIMENSIONING AND TOLERANCES – PHASE 2**COURSE OBJECTIVE:**

- To provide exposure to problem-solving through programming.
- To train the student to the basic concepts of the C-programming language.
- To provide exposure to problem-solving through programming.
- The course aims to provide exposure to problem-solving through programming. It aims to train the student to the basic concepts of the C-programming language. This course involves a lab component which is designed to give the student hands-on experience with the concepts.
- Understand the basics to define the geometry for part and assemblies. Understand the geometrical requirements of the drawings.

UNIT I INTRODUCTION TO PRINCIPLES OF PROGRAMMING 6

Introduction to Programming - Programing Domain : Artificial Intelligence- Systems Programming - Assembly Level Languages - Problem solving using Algorithms and Flowcharts.

UNIT II INTRODUCTION TO C PROGRAMMING 6

Features of C and its Basic Structure - Simple C programs - Constants - Integer Constants - Real Constants - Character Constants - String Constants Floating-point Numbers - The type cast Operator - Interactive Programming.

Operators Expressions and Control statement - The goto statement - The if statement - The if-else statement - Nesting of if statements - The conditional expression - The break statement and continue statement.

UNIT III ARRAYS, STRINGS AND POINTERS 6

Arrays - Multidimensional Arrays - Strings, Basics of Pointers - Pointer Arithmetic - Similarities between Pointers and One-dimensional Arrays Structures - Unions And Functions - Basics of Structures - Arrays of Structures - Pointers to Structures - Function Basics - Function Prototypes and Passing Parameters - Structures and Functions Recursion.

UNIT IV BASICS OF GEOMETRY TERMINOLOGY 6

Basics of Geometric Dimensioning and Tolerances – Terminology & basic tools - Symbols of Geometric Dimensioning and Tolerances.

UNIT V MREPRESENTATION OF GD & T**6**

Adding GD&T to drawing/Design – Datum - Tolerances – Form, Orientation, profile.

TOTAL : 30 PERIODS**REFERENCES:**

1. Balagurusamy, “Programming in ANSI C”, Tata McGraw-Hill Education, 2008.
2. Stephen G. Kochan, “Programming in C” (3rd Edition), Sams, 2004.
3. Stephen G. Kochan, “Programming in C”, III Edition, Pearson Education.
4. Geometric Dimensioning and Tolerancing by P.S.Gill, S.K. Kataria & sons, edition 2013.
5. Fundamentals of Geometric Dimensioning and Tolerancing by Alex krulikowski, 2012, 3rd edition, Delmar cengage learning publications.

ONLINE RESOURCES

1. <https://www.coursera.org/learn/introduction-cad-cam-practical-cnc-machining>
2. <https://nptel.ac.in/courses/112/105/112105211/>

WEB RESOURCES

1. <https://www.steckermachine.com/blog/g-code-and-m-code-programming>
2. <http://www.helmancnc.com/cnc-programming-for-beginners-a-simple-cnc-programming-example/>

COURSE OUTCOMES :

Upon completion of this course, the students should be able to:

1. Analyze their quantitative ability. (K4)
2. Understand the ability of arithmetic reasoning along with creative thinking and problem solving skills. (K2)
3. Create their verbal ability through vocabulary building and grammar. (K6)
4. Evaluate the situations to analyse the computational methods in order to identify and abstract the programming task involved. (K5)
5. Understanding the basics of geometric dimensioning and tolerance. (K2)
6. Identify the symbols of GD&T. (K1)

CO- PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	-	-	-	-	3	2	-	3	2	3	-	2	-	-
C02	-	-	-	-	3	2	-	3	2	3	-	2	-	-
C03	-	-	-	-	3	2	-	-	1	3	-	2	-	-
C04	-	-	-	-	3	2	-	3	3	3	-	2	2	2
C05	-	-	-	-	3	2	-	-	2	3	-	2	2	2
C06	-	-	-	-	3	2	-	-	2	3	-	2	2	2

SEMESTER - IV

20MEPC401 SDG NO. 4,8,9,12,16	MEASUREMENTS AND CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of measurement technology
- To understand the concept of mathematical modeling using block diagram and signal flow graph techniques
- To study time response and frequency response of closed loop control systems
- To learn operating principle of mechanical sensors and transducers used to measure mechanical parameters
- To familiarize with the principle of various temperature and pressure measurement techniques

UNIT I INTRODUCTION**9**

Static and dynamic characteristics of measurement systems - standards and calibration - error and uncertainty analysis-statistical analysis of data-and curve fitting

UNIT II SYSTEMS AND REPRESENTATION**9**

Basic elements in control systems: – Open and closed loop systems – Electrical analogy of mechanical systems – Transfer function – AC and DC servomotors – Block diagram reduction techniques – Signal flow graphs.

UNIT III TIME AND FREQUENCY RESPONSE**9**

Time response: – Time domain specifications – Types of test input -I and II order system response – Error coefficients – Generalized error series – Steady state error – Correlation between frequency domain and time domain specifications- Frequency response: – Bode plot – Polar plot – Determination of closed loop response from open loop response

UNIT IV MECHANICAL MEASUREMENTS**9**

Measurement of displacement-Resistive-Inductive-Capacitive Methods Velocity Measurement-Contact type and Non-contact type Acceleration measurement-Potentiometric type-LVDT type-Piezoelectric type – Force measurement-Hydraulic-Pneumatic-Strain gauge-Magnetostrictive Load Cell Measurement of Torque-Inline rotating-Inline stationary-Proximity type.

UNIT V MEASUREMENT OF TEMPERATURE AND PRESSURE**9**

Temperature measurement-Bimetallic thermometer-Filled system thermometer-Resistance temperature detector-Thermistor-Thermocouple-Radiation fundamentals-Pyrometers Pressure measurement-Pressure fundamentals-Manometer and its types-Elastic and Electrical pressure transducers-Vacuum pressure measurement-McLeod gauge-Thermal conductivity gauge-Pressure gauge calibration-Dead weight tester

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw-Hill, 2009.
2. Sawhney A K and Puneet Sawhney, "A Course in Mechanical Measurements and Instrumentation and Control", 12th edition, Dhanpat Rai & Co, New Delhi, 2013.
3. Nagarath, I.J. and Gopal, M., "Control Systems Engineering", New Age International Publishers, 2017.
4. Benjamin C. Kuo, "Automatic Control Systems", Wiley, 2014.

REFERENCES:

1. Patranabis. D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2010.
2. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.
3. Richard Zurawski, "Industrial Communication Technology Handbook" 2nd edition, CRC Press, 2015.
4. Katsuhiko Ogata, "Modern Control Engineering", Pearson, 2015

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc19_ee41/preview
2. <http://www.nptelvideos.in/2012/11/industrial-instrumentation.html>
3. <https://nptel.ac.in/content/storage2/courses/112103174/pdf/mod2.pdf>
4. <https://nptel.ac.in/courses/107106081>

ONLINE RESOURCES:

1. <https://instrumentationtools.com/tag/sensors-and-transducers-nptelpdf/>

2. <https://electronics-tutorials.ws/io/io>
3. <https://freevidelectures.com/course/2337/control-engineering>
4. <https://instrumentationtools.com/tag/sensors-and-transducers-nptelpdf/>
5. <https://electronics-tutorials.ws/io/io>

OUTCOMES

Upon the Completion of the course, the student will be able to

1. Explain various characteristics, standards, calibration and types of errors in measurement systems. (K3)
2. Develop mathematical models for different types of system by using block diagram and signal flow graph. (K3)
3. Determine the time response specifications along with error coefficients for closed loop control system. (K3)
4. Determine frequency response specifications along with determination of closed loop response from open loop response for typical control systems. (K3)
5. Illustrate the working principle and applications of different types of Mechanical sensors and transducers. (K2)
6. Illustrate the working principle and applications of different types of instruments for measurement of temperature and pressure. (K2)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	1	1	-	-	-	-	-	-	-	-	-	-
C02	3	3	-	2	-	-	-	-	-	-	-	-	-	-
C03	3	3	1	2	-	-	-	-	-	-	-	1	-	-
C04	3	3	1	2	-	-	-	-	-	-	-	1	-	-
C05	3	2	1	-	-	-	-	-	-	-	-	1	1	-
C06	3	2	2	-	-	-	-	-	-	-	-	1	1	-

SEMESTER - IV

20MEPC402 SDG NO. 4,8,9, 12,16	METROLOGY, MEASUREMENTS AND COMPUTER AIDED INSPECTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge on various Metrological equipments available to measure the dimension of the components.
- To provide knowledge on the correct procedure to be adopted to measure the dimension of the components.
- To measure recessed areas those are difficult to measure using optical systems.
- To improve the quality of the product, increase the productivity in the inspection process and reduce the lead times in manufacturing

UNIT I BASICS OF MEASUREMENT AND LINEAR MEASUREMENT 9

Definition of metrology-needs, elements and methods of measurement. Accuracy and Precision, Basic definitions in Measurements. Generalized measurement system - static characteristics of instruments - factors considered in selection of instruments - Errors - classification - sources of error. Calibration – uncertainty. General cares and rules in measurement, Standards and its types.

Linear Measuring Instruments: Evolution – Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, Slip Gauge- classification and calibration. Comparators- mechanical, electrical, optical and pneumatic.

UNIT II ANGULAR, SURFACE MEASUREMENTS AND GAUGES 9

Angular Measuring Instruments: Types – Bevel protractor, Spirit level, Clinometers, Angle gauges, Sine bar – Angle alignment telescope – Autocollimator – applications, Angle dekkor. Principles and methods of straightness measurement – Flatness measurement – Surface finish measurement. Limit gauges – gauge design – terminology – procedure – concepts of interchangeability and selective assembly.

UNIT III FORM AND MECHANICAL PARAMETER MEASUREMENTS 9

Thread measurement, Gear measurement, Roundness measurement – Position sensors: Potentiometer, LVDT, Proximity sensors - types. Temperature sensors: Bimetallic strip, Thermocouples, Liquid in glass thermometer, Resistance temperature detector, Thermocouples and Thermopiles, Thermistor, Optical pyrometer. Force, Torque, Power measurement - Mechanical, Pneumatic, Hydraulic and Electrical type.

UNIT IV CO-ORDINATE MEASURING MACHINE AND LASER METROLOGY

9

CMM: Need, Types and applications - Manual CMMs, CNC CMMs, Multi-sensor CMMs, Portable CMMs, CMM software, Modes of operation-Types of probes

LASER METROLOGY: Interferometry, applications of Interferometry, methods of Interferometry, Michelson's Interferometer, ACLI- N.P.L flatness Interferometer, Zeiss interferometer, Twyman-Green interferometer, sources of errors, corrections to be made, laser spectroscopy, laser holography, machine tool alignment

UNIT V MACHINE VISION SYSTEM

9

Machine Vision: Image sensing and acquisition, types of cameras and their principles, machine vision lightings, designing a machine vision system- lens design, choice of camera and illumination, laser vision system, software for image processing.

Industrial Applications: Machine vision in industry automation, dimensional measurement, identification of flaws and defects, pattern recognition applications, sorting and counting, study of surface finish, tool wear measurement, robot guidance, safety monitoring.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gupta. I.C., "Engineering Metrology", Dhanpatrai Publications, 2005.
2. Jain R.K. "Engineering Metrology", Khanna Publishers, 2009.

REFERENCES

1. Alan S. Morris, "The essence of Measurement", Prentice Hall of India 1996.
2. Beckwith, Marangoni, Lienhard, "Mechanical Measurements", Pearson Education, 2014.
3. Charles Reginald Shotbolt, "Metrology for Engineers", 5th edition, Cengage Learning EMEA, 1990.
4. Davies E R, "Computer and Machine Vision: Theory, Algorithms, Practicalities", Academic Press, 2012.
5. Bhabatosh Chanda and Dutta Majumder D, "Digital Image Processing and Analysis", PHI Learning Pvt. Ltd., 2011.
6. Raghavendra and Krishnamurthy "Engineering Metrology & Measurements", Oxford Univ. Press, 2013.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106139/>
2. <https://www.matweb.com>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106138/>
2. <https://nptel.ac.in/courses/112/106/112106179/>
3. <https://nptel.ac.in/courses/112/104/112104250/>
4. <https://nptel.ac.in/courses/112/103/112103261/>
5. <https://nptel.ac.in/courses/112/106/112106140/>
6. <https://nptel.ac.in/courses/112/107/112107242/>
7. <https://nptel.ac.in/courses/112/107/112107259/>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Describe the concepts of measurements to apply in various metrological instruments used in engineering applications.(K2)
2. Outline the principles of different measurement tools to interpret the results.(K2)
3. Illustrate the concepts of advanced measuring techniques in metrology.(K2)
4. Exhibit the different profile parameter measurements used for industrial components.(K2)
5. Make use of basic metrological knowledge for solving engineering problems.(K3)
6. Apply relevant measuring principles to measure mechanical parameters in industrial applications.(K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	2	-	-	-	-	-	1	-	-	-	-	2	2
C02	2	2	-	-	-	-	-	1	-	-	-	-	2	2
C03	2	2	-	-	-	-	-	1	-	-	-	-	2	2
C04	2	2	-	-	-	-	-	1	-	-	-	-	2	2
C05	3	3	-	-	-	-	-	2	-	-	-	-	3	3
C06	3	3	-	-	-	-	-	2	-	-	-	-	3	3

SEMESTER - IV

20MEPC403 SDG NO. 4,8,9,12	COMPUTER AIDED DESIGN AND MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the usage of computers in designing mechanical components
- To introduce the student to the basic tools of computer-aided design (CAD) and computer-aided manufacturing (CAM)
- To expose the student to contemporary computer design tools
- To prepare the student to be an effective user of a CAD/CAM system
- To understand the concepts of CNC and Part Programming

UNIT I INTRODUCTION**9**

Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- computer graphics – coordinate systems- 2D and 3D transformations homogeneous co-ordinates - Line drawing -Clipping- viewing transformation-Introduction to CAD and CAM – Manufacturing planning, Manufacturing control.

UNIT II GEOMETRIC MODELING**9**

Representation of curves- Hermite curve- Bezier curve- B-Spline curves- rational curves. Techniques for surface modeling – surface patch- Coons and Bicubic patches- Bezier and B-Spline surfaces. Solid modeling techniques- CSG and B-rep

UNIT III VISUAL REALISM AND ASSEMBLY OF PARTS**9**

Hidden – Line – Surface - Solid removal algorithms – shading – colouring – computer animation - Assembly modeling.

UNIT IV CAD STANDARDS**9**

Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - communication standards.

UNIT V FUNDAMENTAL OF CNC AND PART PROGRAMMING**9**

Introduction to NC systems and CNC - Machine axis and Co-ordinate system- CNC machine tools. Principle of operation - Construction features including structure- Drives and CNC controllers-2D and 3D machining on CNC- Introduction of Part Programming, types - Manual part programming on Lathe

and Milling machines using G codes and M codes- Cutting Cycles, Loops, Sub program and Macros.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ibrahim Zeid, "Mastering CAD CAM", Tata McGraw-Hill Publishing Co. 2007
2. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.

REFERENCES

1. Chris McMahan and Jimmie Browne, "CAD/CAM Principles", "Practice and Manufacturing management " Second Edition, Pearson Education, 1999.
2. Donald Hearn and M. Pauline Baker, "Computer Graphics". Prentice Hall, Inc, 1992.
3. Foley, Wan Dam, Feiner and Hughes, "Computer graphics principles & practice", Pearson Education -2003.
4. William M Neumann and Robert F.Sproul, "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
5. Radhakrishnan P, Subramanyan S and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/102/112102102/>
2. <https://nptel.ac.in/courses/112/102/112102103/>
3. <http://nitc.ac.in/index.php?url=users/view/270/12/3>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104031/>
2. <https://nptel.ac.in/courses/112/102/112102101/>
3. <https://nptel.ac.in/courses/112/105/112105211/>
4. <https://nptel.ac.in/courses/112/104/112104252/>
5. <http://guides.lib.ua.edu>

OUTCOMES:

Upon completion of the course, the students should be able to

- 1 Explain the elements involved in computer aided design and manufacturing of 2D and 3D systems.(K1)
- 2 Model the design and manufacturing process using different techniques viz. Bezier curve and B-spline curve.(K2)

- 3 Enhance and create the various features of surface and solid modeling.(K2)
- 4 Convert CAD documents effectively among CAD Software.(K1)
- 5 Convert the assembled model into a visually realistic model.(K2)
- 6 Explain the construction, working features , Coordinate systems for NC , CNC lathe and milling machines and to develop part programs using codes and Macros.(K1)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	1	-	-	-	-	-	-	-	-	-	3	3
C02	3	3	1	-	-	-	-	-	-	-	-	-	3	3
C03	3	2	1	-	-	-	-	-	-	-	-	-	2	2
C04	3	3	1	-	-	-	-	-	-	-	-	-	3	3
C05	3	2	1	-	-	-	-	-	-	-	-	-	3	3
C06	3	3	1	-	-	-	-	-	-	-	-	-	3	3

SEMESTER - IV

20MEPC404 SDG NO. 4,7,9,13	APPLIED THERMAL SCIENCES				L	T	P	C
					3	0	0	3

(Use of Standard and approved Steam Table, Mollier Chart, Compressibility Chart and Psychrometric Chart are permitted)

OBJECTIVES:

- To apply the concepts, laws and methodologies of thermodynamics in the analysis of gas power cycles
- To apply the thermodynamic concepts to steam nozzles and turbines
- To apply the concepts of thermodynamics to air compressor
- To apply the thermodynamic concepts into various thermal application like IC engines, steam turbines, compressor and refrigeration & air conditioning systems

UNIT I GAS POWER CYCLES**9**

Gas cycles : Air standard cycles- Otto cycle, Diesel cycle, Dual cycle and Brayton cycle – efficiency, mean effective pressure.

UNIT II STEAM NOZZLES AND STEAM TURBINES**9**

Steam Nozzles: Types, exit velocity, critical pressure ratio, effect of friction, throat and exit area calculations.

Steam Turbines: Types, Impulse and reaction principles, Velocity diagrams, Work done and efficiency - optimal operating conditions. Multi-staging, compounding and governing.

UNIT III AIR COMPRESSOR**9**

Reciprocating Air compressor: Classification and comparison, working principle, single stage compressor - work done, volumetric efficiency, multi stage compressor - minimum power requirement, performance calculation.

Rotary Air Compressor: Working principle of Rotary compressors, comparison

UNIT IV INTERNAL COMBUSTION ENGINES AND COMBUSTION**9**

IC Engines: Classification - Petrol and Diesel engines, 2 stroke and 4 stroke, valve timing and port timing diagrams, Accessories- Fuel supply and ignition system, Cooling system, lubrication system, performance calculation of IC engines.

Combustion: Desirable properties and qualities of fuels. Air-fuel ratio calculation – lean and rich mixtures. Combustion in SI and CI Engines – Knocking – phenomena and control.

UNIT V REFRIGERATION, PSYCHROMETRY AND AIR-CONDITIONING**9**

Refrigeration: Vapour compression refrigeration cycle, Effect of superheat and sub-cooling, Performance calculations, working principle of air cycle, vapour absorption system, and thermoelectric refrigeration.

Psychrometry: Psychrometric properties and processes. Air-conditioning systems: concept of RSHF, GSHF and ESHF, Cooling load calculations. Components of air conditioning systems and working principle of summer and winter air conditioning.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Kothandaraman. C.P., Domkundwar. S, Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, Dhanpat Rai & sons, 2016.
2. Rajput. R. K., "Thermal Engineering", S. Chand Publishers, 2017.

REFERENCES

1. Arora C.P., "Refrigeration and Air Conditioning," Tata McGraw-Hill Publishers 2008.

2. Ganesan V., "Internal Combustion Engines", Third Edition, Tata Mcgraw-Hill 2012.
3. Ramalingam K.K., "Thermal Engineering", SCITECH Publications (India) Pvt. Ltd., 2009.
4. Rudramoorthy R., "Thermal Engineering", Tata McGraw-Hill, New Delhi, 2003.
5. Sarkar B.K., "Thermal Engineering", Tata McGraw-Hill Publishers, 2007.
6. Nag P.K., "Basic and Applied Thermodynamics", Tata McGraw-Hill, New Delhi, 1st edition, 2002.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106133/>
2. <https://nptel.ac.in/courses/112/105/112105129/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107216/>
2. <https://nptel.ac.in/courses/112/107/112107291/>
3. <https://nptel.ac.in/courses/112/103/112103277/>
4. <https://nptel.ac.in/courses/112/103/112103275/>
5. <https://nptel.ac.in/courses/112/107/112107208/>
6. <https://nptel.ac.in/courses/112/105/112105128/>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Select suitable thermal systems for various thermal applications (K1)
2. Recognize and discuss the principles of turbo machines for enabling a sustainable society. (K2)
3. Identify and examine the problems associated to different thermal systems (K3)
4. Calculate the performance of power developing and refrigerating systems (K3)
5. Compute the performance of turbo machines and various thermal components. (K3)
6. Apply thermodynamic concepts, laws and methodologies to different power and cooling systems (K3)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	-	-	-	-	-	-	-	-	-	2	3	3
C02	3	3	-	-	-	-	-	-	-	-	-	-	3	2
C03	3	3	-	-	-	-	-	-	-	-	-	-	3	2
C04	3	3	-	-	-	-	-	-	-	-	-	-	3	2
C05	3	3	-	-	-	-	-	-	-	-	-	-	3	2
C06	3	3	-	-	-	-	-	-	-	-	-	1	3	3

SEMESTER - IV

20BSMA403 SDG NO. 4	STATISTICS AND NUMERICAL METHODS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To identify small, large samples and apply testing of hypothesis
- To acquaint the knowledge of testing of hypothesis for small and large samples which plays an important role in real life problems
- To introduce the basic concepts of solving algebraic and transcendental equations
- To introduce the numerical techniques of interpolation in various intervals and numerical techniques of differentiation and integration which plays an important role in engineering and technology disciplines
- To introduce the knowledge of various techniques and methods of solving ordinary differential equations

UNIT I TESTING OF HYPOTHESIS**12**

Sampling distributions - Estimation of parameters - Statistical hypothesis - Large sample tests based on Normal distribution for single mean and difference of means - Tests based on t, Chi-square and F-distributions for mean, variance and proportion - Contingency table (test for independence) - Goodness of fit.

UNIT II DESIGN OF EXPERIMENTS**12**

One way and two way classifications - Completely randomized design - Randomized block design - Latin square design - 2^2 factorial design.

UNIT III SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEMS 12

Solution of algebraic and transcendental equations - Fixed point iteration method - Newton Raphson method - Solution of linear system of equations - Gauss elimination method - Pivoting - Gauss Jordan method - Iterative methods of Gauss Jacobi and Gauss Seidel - Eigenvalues of a matrix by Power method and Jacobi's method for symmetric matrices.

UNIT IV INTERPOLATION, NUMERICAL DIFFERENTIATION AND NUMERICAL INTEGRATION 12

Lagrange's and Newton's divided difference interpolations - Newton's forward and backward difference interpolation - Approximation of derivatives using interpolation polynomials - Numerical single and double integrations using Trapezoidal and Simpson's 1/3 rules.

UNIT V NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 12

Single step methods : Taylor's series method - Euler's method - Modified Euler's method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods : Milne's and Adams - Bashforth predictor corrector methods for solving first order equations. Solution of two dimensional Laplace's and Poisson's equations on rectangular domain - One dimensional heat flow equation by Crank Nicholson method - One dimensional wave equation by explicit method.

TOTAL: 60 PERIODS**TEXT BOOKS:**

1. Grewal. B.S. and Grewal. J.S., "Numerical Methods in Engineering and Science", 10th Edition, Khanna Publishers, New Delhi, 2015.
2. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.

REFERENCES

1. Burden, R.L and Faires, J.D, "Numerical Analysis", 9th Edition, Cengage Learning, 2016.
2. Devore. J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, 8th Edition, 2014.
3. Gerald. C.F. and Wheatley. P.O. "Applied Numerical Analysis" Pearson Education, Asia, New Delhi, 2006.
4. Spiegel. M.R., Schiller. J. and Srinivasan. R.A., "Schaum's Outlines on Probability and Statistics", Tata McGraw Hill Edition, 2004.
5. Walpole. R.E., Myers. R.H., Myers. S.L. and Ye. K., "Probability and Statistics for Engineers and Scientists", 8th Edition, Pearson Education, Asia, 2007.

WEB RESOURCES:

1. <https://www.classcentral.com/course/swayam-numerical-analysis-17709>
2. <https://online-learning.harvard.edu/course/statistics-and-r?delta=1>

ONLINE RESOURCES:

1. <https://freevideolectures.com/course/3057/numerical-methods-and-computation>
2. <https://nptel.ac.in/courses/111107105/>
3. <https://www.maths.unsw.edu.au/courses/math2089-numerical-methods-and-statistics>

OUTCOMES:

Upon completion of the course, the student should be able to

1. Apply statistical techniques for testing of hypothesis of small and large samples. (K3)
2. Perform Analysis of Variance (ANOVA) in the Design of Experiments. (K3)
3. Provide numerical solution for Algebraic equations, Transcendental equations and Eigen value problems. (K3)
4. Apply Numerical techniques to interpolate data and find Numerical Differentiation and Integration. (K3)
5. Solve Ordinary and Partial Differential equations using numerical techniques. (K3)

CO- PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	-	-	-	-	-	-	1
CO2	3	3	2	1	1	-	-	-	-	-	-	1
CO3	3	3	2	1	1	-	-	-	-	-	-	1
CO4	3	3	2	1	1	-	-	-	-	-	-	1
CO5	3	3	2	1	1	-	-	-	-	-	-	1

SEMESTER - IV

20CEPC405 SDG NO. 4, 9	STRENGTH OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of stress and strain
- To determine the principal stresses and deformation in cylindrical and spherical shells
- To determine stresses and deformation in circular shafts and helical spring due to torsion
- To study the concept of shearing force and bending moment due to external loads in beams and their effect on stress distribution
- To compute slopes and deflections in determinate beams by various methods

UNIT I STRESS, STRAIN & DEFORMATIONS OF SOLIDS 9

Definition of Stress and Strain – Tension, Compression and Shear Stresses. Stress-Strain relationship and Hooke's law. Deformation of simple and compound bars – Thermal stresses – Elastic constants and their relations

UNIT II ANALYSIS OF STATE OF STRESS AND CYLINDRICAL AND SPHERICAL SHELLS (THIN AND THICK) 9

Stresses on inclined planes – principal stresses and principal planes – Mohr's circle of stress. Stresses and deformation in thin and thick cylinders due to internal pressure. Stresses and deformation in thin and thick spherical shells subjected to internal pressure. Lamé's theorem.

UNIT III TORSION AND SPRINGS 9

Torsion Equation - Deformation in solid and hollow shafts – Stepped shafts–shafts fixed at the both ends- Stresses & deflection in open and closed coil helical springs with axial load – Stresses and deflection in carriage springs.

UNIT IV STRESSES IN BEAMS 9

Beams – types, Transverse loading on beams – Shear force and bending moment in beams – Cantilevers – Simply supported beams and over – hanging beams. Theory of simple bending–bending stress distribution- Shear stress distribution.

UNIT V DEFLECTION OF BEAMS & COLUMNS

Computation of slopes and deflections in beams - Double Integration method – Macaulay's method – Area moment method - Euler Equation and Rankine Formula for buckling of columns.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ferdinand P. Beer and E. Russell Johnston Jr, "Mechanics of Materials", 7th Edition in S.I. Units, McGraw Hill Education (India) Pvt. Ltd., 2017.
2. Bansal, R.K., "A Text Book of Strength of Materials", Laxmi Publications (P) Ltd. New Delhi, 2018.

REFERENCES

1. Rajput, R.K., "Strength of Materials", S. Chand Publications, 2018.
2. Jindal U.C., "Strength of Materials", 2nd Edition, Pearson India Education, 2018.
3. Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2016.
4. Hibbeler, R.C., "Mechanics of Materials", Pearson India Education, 2017.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106141/>
2. <https://nptel.ac.in/courses/112/107/112107146/>
3. <https://nptel.ac.in/courses/105/102/105102090/>
4. <http://ocw.mit.edu/courses/mechanical-engineering>
5. <http://nitc.ac.in/index.php?url=users/view/270/12/3>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107147/>
2. <https://nptel.ac.in/courses/105/105/105105108/>
3. <https://nptel.ac.in/courses/105/106/105106116/>
4. <https://nptel.ac.in/courses/105/104/105104160/>
5. <https://nptel.ac.in/courses/105/106/105106172/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Interpret the concepts and principles of stress and strain and perform calculations, related to the strength of structured and mechanical components (K3).

2. Analyse members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.(K3)
3. Predict the internal stresses developed in structural and mechanical components.(K3)
4. Demonstrate an understanding of the relationships between loads, member forces and deformations and material stresses and strains (K3)
5. Demonstrate an understanding of the assumptions and limitations of the structural mechanics theory.(K3)
6. Apply structural mechanics of deformable bodies to solve engineering problems (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	1	-	-	1	1	-	-	-	-	1	2	2
C02	3	2	1	-	-	1	1	-	-	-	-	1	2	2
C03	3	2	1	-	-	1	1	-	-	-	-	1	2	2
C04	3	2	1	-	-	1	1	-	-	-	-	1	2	2
C05	3	2	1	-	-	1	1	-	-	-	-	1	2	2
C06	3	2	1	-	-	1	1	-	-	-	-	1	2	2

SEMESTER - IV

20MEPL401 SDG NO. 4,7,12	METROLOGY AND MEASUREMENTS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To measure various parameters accurately using different measuring instruments for Quality Inspection in Industries
- To identify and classify different measuring tools and explain accuracy and precision
- To conduct, analyse, interpret, and present measurement data from measurements experiments
- To identify sources of variability, error, and uncertainties

LIST OF EXPERIMENTS

1. Calibration and use of measuring instruments – vernier caliper, micrometer, vernier height gauge – using gauge blocks
2. Calibration and use of measuring instruments – depth micrometer, bore gauge, telescopic gauge
3. Measurement of linear dimensions using Comparators
4. Measurement of angles using bevel protractor and sine bar
5. Measurement of screw thread parameters – Screw thread Micrometers and Three wire method (floating carriage micrometer)
6. Measurement of gear parameters – gear tooth vernier caliper
7. Measurement of features in a prismatic component using Coordinate Measuring Machine
8. Programming of CNC Coordinate Measuring Machines for repeated measurements of identical components
9. Non-contact (optical) measurement using toolmaker's microscope / profile projector.
10. Measurement of surface finish in components manufactured by various processes (turning, milling, grinding, etc.,) using stylus based instruments.
11. Machine tool metrology – Level tests using precision level, Testing of straightness of a machine tool guide way using autocollimator.
12. Measurement of force, torque and temperature

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

1	Micrometer and dial gauges	5
2	Vernier Caliper	5
3	Vernier Height Gauge	2
4	Vernier depth Gauge	2
5	Slip Gauge Set	2
6	Gear Tooth Vernier	2
7	Sine Bar	2
8	Floating Carriage Micrometer	1
9	Profile Projector / Tool Makers Microscope	1
10	Parallel / counter flow heat exchanger apparatus	1
11	Mechanical / Electrical / Pneumatic Comparator	1
12	Autocollimator	1
13	Temperature Measuring Setup	1
14	Force Measuring Setup	1
15	Torque Measuring Setup	1

16 Coordinate measuring machine	1
17 Surface finish measuring equipment	1
18 Bore gauge	1
19 Telescope gauge	1

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Discuss the various parameters like length, height, angle, displacement, flatness, etc.(K2)
2. Interpret the various linear and angular measurements using measurants like comparator, sine bar, floating carriage micrometer etc.(K2)
3. Inspect various profiles of small mechanical components using light illumination devices.(K2)
4. Develop the knowledge on measuring various physical and dynamic properties like Tolerance, force and temperature using LVDT, Load cell and Thermocouples.(K3)
5. Formulate some unknown quantity or parameter of engineering interest(K3)
6. Relate the surface quality of a given specimen which is important in all kind of manufacturing.(K3)

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	-	-	-	-	-	-	-	-	-	2	2	2
C02	3	2	-	-	-	-	-	-	-	-	-	2	2	2
C03	3	2	-	-	-	-	-	-	-	-	-	2	2	2
C04	3	2	-	-	-	-	-	-	-	-	-	2	2	2
C05	3	2	-	-	-	-	-	-	-	-	-	2	2	2
C06	3	2	-	-	-	-	-	-	-	-	-	2	2	2

SEMESTER - IV

20CEPL403 SDG NO. 4,9	STRENGTH OF MATERIALS AND FLUID MECHANICS & MACHINERY LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To supplement the theoretical knowledge gained in Mechanics of Solids and Fluid Mechanics with practical testing for determining the strength of materials under externally applied loads
- To enable the students to have a clear understanding of the Design for strength and stiffness and losses in pipe flow
- To understand the flow measurements.
- To analyse the Performance of various Pumps and Turbines

LIST OF EXPERIMENTS :

1. Tension test on a mild steel rod
2. Double shear test on Mild steel and Aluminium rods
3. Torsion test on mild steel rod
4. Impact test on metal specimen
5. Hardness test on metals - Brinnell and Rockwell Hardness Number
6. Deflection test on beams
7. Compression test on helical springs
8. Strain Measurement using Rosette strain gauge
9. Effect of hardening- Improvement in hardness and impact resistance of steels.

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

S.No	NAME OF THE EQUIPMENT	QTY
1	Universal Tensile Testing machine with double shear attachment – 40 Ton Capacity	1
2	Torsion Testing Machine (60 NM Capacity)	1
3	Impact Testing Machine (300 J Capacity)	1
4	Brinell Hardness Testing Machine	1
5	Rockwell Hardness Testing Machine	1
6	Spring Testing Machine for tensile and compressive loads (2500 N)	1

FLUID MECHANICS AND MACHINERY LABORATORY**LIST OF EXPERIMENTS**

1. Determination of the Coefficient of discharge of given Orifice meter.

2. Determination of the Coefficient of discharge of given Venturi meter.
3. Determination of friction factor for a given set of pipes.
4. Conducting experiments and drawing the characteristic curves of centrifugal pump/submersible pump.
5. Conducting experiments and drawing the characteristic curves of reciprocating pump.
6. Conducting experiments and drawing the characteristic curves of Gear pump.
7. Conducting experiments and drawing the characteristic curves of Pelton wheel, Francis and Kaplan Turbine.

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

1	Bernoulli's Apparatus.	1 No.
2	Orifice meter setup	1 No.
3	Venturi meter setup	1 No.
4	Rotameter setup	1 No.
5	Pipe Flow analysis setup	1 No.
6	Centrifugal pump/submersible pump setup	1 No.
7	Reciprocating pump setup	1 No.
8	Gear pump setup	1 No.
9	Pelton wheel Turbine setup	1 No.
10	Francis turbine setup	1 No.
11	Kaplan turbine setup	1 No.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Explain and perform different destructive testing's such as Tension test, Shear test, Impact test, Hardness test to estimate the strength under externally applied loads with due consideration to safety. (K2)
2. Estimate and compare the elastic constants such as Young's modulus and Rigidity modulus of the given specimen through Deflection testing and spring testing with standard values. (K2)
3. Compare the structures and hardness of Unhardened and Hardened specimen through microscopic examinations. (K2)
4. Measure the flow rate of fluid using different flow measuring devices and calculate the friction loss and other minor losses in a pipe flow. (K2)
5. Predict the basic performance characteristics of hydraulic Pumps. (K2)
6. Predict the basic performance characteristics of hydraulic Turbines. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	-	-	1	1	-	-	-	-	1	1	2
CO2	2	2	1	-	-	1	1	-	-	-	-	1	1	2
CO3	2	2	1	-	-	1	1	-	-	-	-	1	1	2
CO4	2	2	1	-	-	1	1	-	-	-	-	1	1	2
CO5	2	2	1	-	-	1	1	-	-	-	-	1	1	2
CO6	2	2	1	-	-	1	1	-	-	-	-	1	1	2

SEMESTER - IV

20METE401 SDG NO.4,6,7,8,9, 11,12,13, 17	LIVE-IN-LAB - II	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same
- To train the students face reviews and viva voce examination

COURSE METHODOLOGY

- The student should continue the Live-in Lab Project-I on the selected topic under the same supervisor selected in Live-in Lab Project-I. The student has to complete design part and design evaluation of the selected project in Live-in Lab Project-I. At the end of the semester, the progress of the project is reviewed and evaluated with a minimum of three reviews with the guidance of Project Coordinator. The students will be evaluated through project report and the viva-voce examination by the panel of members. The review committee may be constituted by the Head of the Department. The student must submit a detailed project report at the end of the semester for evaluation.

EVALUATION: Project work evaluation is based on Regulations of Credit system of Autonomous Regulatory Body.

Note: All the three evaluations are mandatory for course completion and for awarding the final grade

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Conduct literature survey to identify the gap and an application oriented research problem in the specific domain(K4)
2. Design and validate the proposed system using simulation(K6)
3. Prototype the proposed system(K5)
4. Analyze the obtained results and prepare a technical report(K4)
5. Publish the work in journals and apply for the patents.(K3)
6. Prepare for industrial environment and real time work(K3)

CO- PO & PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	2	2	2	3	2	2	3	3	3
CO2	3	3	3	2	3	3	2	2	3	3	3	3	3	3
CO3	2	2	2	1	2	1	1	1	3	2	3	3	3	2
CO4	2	2	2	1	2	1	1	1	3	2	3	3	3	2
CO5	2	2	2	1	2	1	1	1	3	2	3	3	3	2
CO6	2	2	2	2	3	2	2	2	2	2	3	3	3	3

SEMESTER - IV

20METP401 SDG NO. 4	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	1

PROBLEM SOLVING SKILLS – PHASE 1**COURSE OBJECTIVE:**

- Improve their quantitative ability.
- Improve their reasoning ability.
- Enhance their verbal ability through vocabulary building and grammar
- Equip with creative thinking and problem solving skills

UNIT I QUANTITATIVE ABILITY – III**6**

Compound Interest - Profit and Loss - Partnership - Percentage - Set Theory

UNIT II QUANTITATIVE ABILITY – IV**6**

True Discount - Ratio and Proportion - Simplification - Problems on H.C.F and L.C.M

UNIT III REASONING ABILITY – II**6**

Course of Action - Cause and Effect - Statement and Conclusion - Statement and Argument - Data Sufficiency (DS) - Statement and Assumption - Making Assumptions.

UNIT IV VERBAL ABILITY – II**6**

Change of Voice - Change of Speech - Letter and Symbol Series - Essential Part - Verbal Reasoning - Analyzing Arguments.

UNIT V CREATIVITY ABILITY – II**6**

Seating Arrangement - Direction Sense Test - Character Puzzles - Missing Letters Puzzles - Mirror & Water Images.

TOTAL : 30 PERIODS**REFERENCES:**

- 1) R. S. Agarwal, “Quantitative Aptitude for Competitive Exams”
- 2) Sarvesh Verma, “Quantum CAT”
- 3) R. S. Agarwal, “A Modern Approach to Logical Reasoning”
- 4) Arun sharma, “Verbal Ability and Reading Comprehension”

ADVANCED C PROGRAMMING AND CNC PROGRAMMING - PHASE 2**COURSE OBJECTIVE:**

- To improve C programming skills with understanding of code organization and functional hierarchical decomposition with using complex data types.
- The course is oriented to those who want to advance structured and procedural programming understating and to improve C programming skills. The major objective is to provide students with understanding of code organization and functional hierarchical decomposition with using complex data types.
- To educate and enrich the students on the programming aspect of CNC machines.

UNIT I INTRODUCTION TO RECURSION AND GROWTH FUNCTIONS 6

Introduction to Recursion - Recurrence Relation - Deriving time complexity and space complexity using recurrence relation Polynomial Equations -

Compare growth functions - Nth Fibonacci Number - Exponent Function - Taylor Series - Tower of Hanoi.

UNIT II STORAGE CLASSES, THE PREPROCESSOR AND DYNAMIC MEMORY ALLOCATION

6

Storage Classes and Visibility - Automatic or local variables - Global variables - Macro Definition and Substitution - Conditional Compilation - Dynamic Memory Allocation - Allocating Memory with malloc and calloc Allocating Memory with calloc - Freeing Memory - The Concept of linked list - Inserting a node by using Recursive Programs - Deleting the Specified Node in a Singly Linked List.

UNIT III FILE MANAGEMENT AND BIT MANIPULATION

6

Defining and Opening a file - Closing Files - Input/output Operations on Files - Predefined Streams - Error Handling during I/O Operations - Random Access to Files - Command Line Arguments - The hexadecimal number system - C bitwise operators - How to generate all the possible subsets of a set - Tricks with Bits - Applications of bit operations.

UNIT IV INTRODUCTION

6

Introduction to NC and CNC machine – types – constructional details.

UNIT V BASICS OF PROGRAMMING

6

Basics of part programming – G codes and M codes – Programming and Machining of a component.

TOTAL : 30 PERIODS

REFERENCES:

1. R. G. Dromey, "How to Solve It By Computer", Pearson, 1982
2. A.R. Bradley, "Programming for Engineers", Springer, 2011
3. Kernighan and Ritchie, "The C Programming Language", (2nd ed.) Prentice Hall, 1988
4. CNC Programming by Dr. S. K. Sinha
5. CNC Programming Handbook (3rd edition) by Peter Smid
6. CNC Trade Secrets by James Harvery

COURSE OUTCOMES :

Upon completion of this course, the students should be able to:

1. Analyze their quantitative ability. (K4)
2. Understand the ability of arithmetic reasoning along with creative thinking and problem solving skills. (K2)
3. Create their verbal ability through vocabulary building and grammar. (K6)
4. Evaluate code organization and functional hierarchical decomposition with complex data types. (K5)
5. Understand to improve C programming skills to apply advance structured and procedural programming. (K2)
6. Write a part program for a given product drawing and demonstrate the program by using a CNC Machine. (K2)

CO- PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	-	-	-	-	3	2	-	3	2	3	-	2	-	-
C02	-	-	-	-	3	2	-	3	2	3	-	2	-	-
C03	-	-	-	-	3	2	-	-	1	3	-	2	-	-
C04	-	-	-	-	3	2	-	3	3	3	-	2	2	2
C05	-	-	-	-	3	2	-	-	2	3	-	2	2	2
C06	-	-	-	-	3	2	-	-	2	3	-	2	2	2

SEMESTER - V

20 MEPC501 SDG NO. 4,7,8,9,12,13	AUTOMOTIVE SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the construction and working principle of various parts of an automobile.
- To identify the systems and sub-systems of a typical automobile
- To analyse Steering, Suspension, Braking systems, Power transmission system and its components
- To have the practice for assembling and dismantling of engine parts and transmission system.

UNIT I VEHICLE STRUCTURE AND ENGINES**9**

Types of automobiles, vehicle construction and different layouts, chassis, frame and body, vehicle aerodynamics (various resistances and moments involved), IC engines –components-functions and materials, variable valve timing (VVT).

UNIT II ENGINE AUXILIARY SYSTEMS**9**

Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and Common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS).

UNIT III TRANSMISSION SYSTEMS**9**

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Overdrive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

UNIT IV STEERING, BRAKES AND SUSPENSION SYSTEMS**9**

Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control.

UNIT V ALTERNATIVE ENERGY SOURCES**9**

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with alternate fuels - Electric and Hybrid vehicles, Fuel Cells.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Jain K.K. and Asthana .R.B, “Automobile Engineering” Tata McGraw Hill Publishers, NewDelhi, 2002.
2. Kirpal Singh, “Automobile Engineering”, Vol 1 & 2, Seventh Edition, Standard Publishers, NewDelhi, 13th Edition 2014.

REFERENCES

1. Ganesan V. “Internal Combustion Engines”, Third Edition, Tata McGraw-Hill, 2012.
2. Heinz Heisler, “Advanced Engine Technology,” SAE International Publications USA, 1998.
3. Joseph Heitner, “Automotive Mechanics,” Second Edition, East-West Press, 1999.
4. Martin W, Stockel and Martin T Stockle , “Automotive Mechanics Fundamentals,” The Goodheart - Will Cox Company Inc, USA, 1978.
5. Newton, Steeds and Garet, “Motor Vehicles”, Butterworth Publishers, 1989.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104033/>
2. <https://nptel.ac.in/courses/103/105/103105110/>
3. <https://ocw.mit.edu/courses/mechanical-engineering/2-61-internal-combustion-engines-spring-2017/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/107/106/107106088/>
2. <https://nptel.ac.in/courses/112/103/112103262/>

OUTCOMES:

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

1. Understand the construction and working principle of various parts of an automobile. (K3)

2. Identify various systems and sub-systems such as injection and ignition system. (K2)
3. Study power train system of automobile. (K3)
4. Analyse Steering, Suspension, Braking systems and its components. (K3)
5. Predict alternative fuels and energy sources in automobile. (K2)
6. Study of emission and control systems of automobile. (K2)

CO – PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	1	-	-	-	-	2	1	2
CO2	3	2	-	-	-	-	1	-	-	-	-	2	1	2
CO3	3	2	-	-	-	-	1	-	-	-	-	2	1	2
CO4	3	2	-	-	-	-	1	-	-	-	-	2	1	2
CO5	3	2	-	-	-	-	1	-	-	-	-	2	1	2
CO6	3	2	-	-	-	-	1	-	-	-	-	2	1	2

SEMESTER - V

20MEPC502 SDG NO. 4, 8,9,12	ROBOTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the functions of the basic components of a Robot.
- To study the use of various types of End of Effectors and Sensors
- To impart knowledge in Robot Kinematics and Programming
- To learn Robot safety issues and economics.

UNIT I FUNDAMENTALS OF ROBOT**9**

Robot - Definition - Robot Anatomy - Co ordinate Systems, Work Envelope Types and Classification- Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load- Robot Parts and their Functions-Need for Robots-Different Applications.

UNIT II ROBOT DRIVE SYSTEMS AND END EFFECTORS**9**

Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, Applications and Comparison of all these Drives, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

UNIT III SENSORS AND MACHINE VISION**9**

Requirements of a sensor; Principles and Applications of the following types of sensors- Position sensors - Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors Triangulations Principles, Structured, Lighting Approach, Time of Flight, Range Finders, Laser Range Meters, Touch Sensors, binary Sensors., Analog Sensors, Wrist Sensors, Compliance Sensors, Slip Sensors, Camera, Frame Grabber, Sensing and Digitizing Image Data- Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Applications- Inspection, Identification, Visual Servoing and Navigation.

UNIT IV ROBOT KINEMATICS AND ROBOT PROGRAMMING**9**

Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Lead through Programming, Robot programming Languages-VAL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs.

UNIT V APPLICATION OF ROBOTS**9**

RGV, AGV; Implementation of Robots in Industries-Variou Steps; Safety Considerations for Robot Operations - Economic Analysis of Robots.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Groover M.P., "Industrial Robotics -Technology Programming and Applications", McGraw Hill, 2012.
2. Klafter R.D., Chmielewski T.A and Negin M., "Robotic Engineering - An Integrated Approach", Prentice Hall, 2003

REFERENCES

1. Craig J.J., "Introduction to Robotics Mechanics and Control", Pearson Education, 2008.
2. Deb S.R., "Robotics Technology and Flexible Automation" Tata McGraw Hill Book Co., 2013.
3. Fu.K.S.,Gonzalaz R.C. and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co., 1987.
4. Janakiraman P.A., "Robotics and Image Processing", Tata McGraw Hill, 1995. 5. Koren Y, "Robotics for Engineers", Mc Graw Hill Book Co., 1992.

WEB RESOURCES:

1. <https://robots.ieee.org>.<https://www.robotic.org>
2. <https://nptel.ac.in/courses/112/101/112101098/>
3. <https://nptel.ac.in/courses/112/108/112108093/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/101/112101099/>
2. <https://nptel.ac.in/courses/112/105/112105236/>
3. <https://nptel.ac.in/courses/112/105/112105249/>
4. <https://nptel.ac.in/courses/112/107/112107289/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Explain the concepts of industrial robots, classification, specifications and coordinate systems. (K1)
2. Illustrate the different types of robot drive systems as well as robot end effectors. (K1)
3. Apply the different sensors and image processing techniques in robotics to improve the ability of robots. (K2)
4. Develop robotic programs for different tasks and familiarize with the kinematics motions of robot. (K2)
5. Examine the implementation of robots in various industrial sectors and interpolate the economic analysis of robots. (K2)
6. Gain an overview about sensory control and automation of robot. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	-	1	-	-	-	-	-	-	-	-	2	3	3
C02	2	-	1	-	-	-	-	-	-	-	-	2	3	3
C03	3	1	2	-	-	-	-	-	-	2	-	2	3	3
C04	3	2	2	-	-	2	-	-	-	2	-	2	3	3
C05	1	-	1	-	-	-	-	-	-	-	-	2	3	3
C06	3	-	2	-	-	-	-	-	-	-	-	2	3	3

SEMESTER - V

20MEPC503 SDG NO. 4, 9,12	THEORY OF MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the principles in the formation of mechanisms and their kinematics.
- To learn the basic concepts of toothed gearing and kinematics of gear trains.
- To analyze the forces and torque acting on simple mechanical systems and balancing them.
- To understand the concepts of vibration.
- To study the effect of friction in different machine elements and principles in mechanisms used for speed control and stability control

UNIT 1 BASICS OF MECHANISMS AND KINEMATICS**9**

Classification of mechanisms – Basic kinematic concepts and definitions – Degree of Freedom, Mobility (Definitions only) – Kutzbach criterion, Gruebler's criterion – Grashof's Law – Kinematic inversions of four-bar chain and slider crank chains – Mechanical advantage – Transmission Angle (Definitions only) Displacement, Velocity and Acceleration analysis of simple mechanisms – Graphical Relative Velocity method–Velocity and Acceleration polygons.

UNIT II GEARS AND KINEMATICS OF CAM**9**

Types of Gears - Law of toothed gearing – Spur Gear terminology - Involute and Cycloidal tooth profiles – Contact ratio – Interference and undercutting -

Gear trains – Speed ratio, train value – Parallel axis gear trains.

Classification of cams and followers – Terminology and definitions – Displacement diagrams – Uniform velocity, parabolic, simple harmonic and cycloidal motions- Layout of plate cam profiles - Pressure angle and undercutting

UNIT III FORCE ANALYSIS AND BALANCING OF FORCES

9

D'Alembert's principle – Dynamic force Analysis in reciprocating engines – Flywheels in punching presses - Static and dynamic balancing- Graphical Method- Balancing of rotating masses – Balancing of masses rotating in same and different planes - Balancing of single cylinder and Multi-cylinder inline Engines.

UNIT IV FREE AND FORCED VIBRATIONS

9

Basic features of vibratory systems – Free vibration– Equations of motion – Natural frequency – Dunkerley's method - Free Damped vibration– Types of Damping – Critical speed of shafts – Torsional vibration – Two rotor systems Forced, Damped Vibration - periodic Harmonic forcing –Disturbance caused by unbalance–Transmissibility – Vibration isolation.

UNIT V FRICTION ELEMENTS AND CONTROL MECHANISMS

9

Friction in screw threads – Screw Jack – Pivot and Collar Bearings – Belt drives Governors – Centrifugal governors – Gravity controlled governors -- Gyroscopic forces and couples – Gyroscopic effects in Aeroplanes, Ships and Stability of two wheeler and four wheeler drives.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", 3rd Edition, Oxford University Press, 2009.
2. Rattan, S.S., "Theory of Machines", 5th Edition, Tata McGraw-Hill, 2019.
3. Khurmi, R.S., "Theory of Machines", 14th Edition, S Chand Publications, 2020.

REFERENCES:

1. Thomas Bevan, "Theory of Machines", 3rd Edition, CBS Publishers and Distributors, 2005.
2. Cleghorn. W. L, "Mechanisms of Machines", Oxford University Press, 2005
3. Robert L. Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill, 2009.

4. Allen S. Hall Jr., "Kinematics and Linkage Design", Prentice Hall, 1961
5. Ghosh. A and Mallick, A.K., "Theory of Mechanisms and Machines", Affiliated East-West Pvt. Ltd., New Delhi, 1988.
6. V.P.Singh, "Mechanical Vibrations", Dhanpat Rai & Co (p) Ltd., New Delhi, 2015.
7. Rao.J.S. and Duggipati.R.V. "Mechanisms and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.
8. V.Ramamurthi, "Mechanics of Machines", Narosa Publishing House, 2002.

WEB REFERENCES:

1. <http://www.mekanizmalar.com>
2. <http://www.mechanisms.com>
3. <http://dynref.engr.illinois.edu>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104121/>
2. <https://nptel.ac.in/courses/112/105/112105268/>
3. <https://nptel.ac.in/courses/112/104/112104114/>

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Understand basic principles in the formation of simple mechanisms and its kinematics (K2)
2. Describe various gear types , terminology , Cam and follower mechanisms (K2)
3. Describe various gear types , terminology , Cam and follower mechanisms (K2)
4. Summarize the concepts and equations on various types of vibrating systems (K2)
5. Analyze the friction effect in different machine elements and principles in speed and stability control mechanisms (K4)
6. Examine the various mechanisms ,effect of friction on different machine elements and speed and stability control devices . (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	2	-	-	-	-	2	3	2
CO2	2	2	2	-	-	1	2	-	-	-	-	2	3	2
CO3	3	3	2	1	-	2	1	-	-	-	-	3	3	2
CO4	3	3	2	-	2	1	2	-	-	-	-	2	2	2
CO5	2	3	2	-	1	1	2	-	-	-	-	3	2	2
CO6	3	3	2	-	-	2	2	-	-	-	-	2	2	2

SEMESTER - V

20MEPC504 SDG NO. 4,9,11,12	DESIGN OF MACHINE ELEMENTS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To familiarize the various steps involved in the Design Process.
- To understand the principles involved in evaluating the shape and dimensions of a component to satisfy functional and strength requirements.
- To design machine components for static, impact and fatigue strength.
- To design fasteners, shafts, joints, couplings, keys, threaded fasteners riveted joints, welded joints and power screws.

UNIT I FUNDAMENTALS OF MACHINE DESIGN**12**

Phases of design process – Factors influencing machine design – Selection of materials – Factor of Safety-Preferred numbers – Limits, Fits and tolerances – Normal, Bending, Shear and Combined stresses – Calculation of Principle Stresses for various load combinations - Eccentric loading – Curved beams – Stress Concentration factors - Impact stress due to Axial, Bending and Torsional loads - Theories of Failure –Endurance limit, S-N Diagram, Notch sensitivity, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading.

UNIT II SHAFTS AND COUPLINGS**12**

Introduction – Design of shafts under combined loads – Critical speed – Design of keys, keyways and splines – Design of rigid and flexible couplings.

UNIT III PERMANENT AND TEMPORARY JOINTS**12**

Rivet types, rivet materials, failures of riveted joints, Joint Efficiency, Boiler Joints, Lozenge Joints, Riveted Brackets, eccentrically loaded joints. Types of welded joints, Strength of butt and fillet welds, welded brackets with transverse and parallel fillet welds, eccentrically loaded welded joints.

Design of Cotter and Knuckle joints. Threaded fasteners – Bolted joints including eccentric loading

UNIT IV ENERGY STORING ELEMENTS AND I.C ENGINE COMPONENTS**12**

Types of springs, spring materials, stresses in helical coil springs of circular cross sections. Concentric springs; springs under fluctuating loads. Leaf Springs: Stresses in leaf springs, equalized stresses, nipping of leaf springs. Introduction to Belleville springs.

Flywheels considering stresses in rims and arms for engines. Design of Connecting Rod.

UNIT V BEARINGS**12**

Journal bearings – bearing materials, properties and mechanisms of lubrication, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design.

Roller and Ball bearings - Types and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep groove ball bearings - selection of bearings subjected to cyclic loads and speeds; probability of survival.

TOTAL: 60 PERIODS**TEXT BOOKS:**

1. Richard G. Budynas, and J. Keith Nisbett, “Shigley's Mechanical Engineering Design”, McGraw- Hill Education, 10th Edition, 2015.
2. V. Bhandari, “Design of Machine Elements”, 4th edition, Tata McGraw Hill, 2017.

REFERENCES

1. Robert L. Norton “Machine Design – An integrated approach”, Pearson Education, 5th edition 2018.
2. Spotts M.F, Shoup T.E “Design of Machine Elements”, Pearson Education, 8th edition, 2019.

3. P.C. Gope, "Machine Design – Fundamental and Application", PHI learning private ltd, New Delhi, 2012.
4. Robert C. Juvinall and Kurt M. Marshek, "Machine Component Design", Wiley India.
5. Jindal U.C. "Machine Design", Pearson Education, 1st Edition 2010.

WEB RESOURCES:

1. http://library.iiti.ac.in/?page_id=1477
2. <https://www.machinedesignonline.com/>,
3. <https://library.stanford.edu/guides/mechanical-engineering>
4. <https://www.classcentral.com/course/machine-design1-7404>
5. <http://thegateacademy.com/subject-pack/machine-design>,
6. <https://freevideolectures.com/subject/mechanical>
7. <https://nptel.ac.in/courses/112/105/112105125/>
8. <https://nptel.ac.in/courses/112/106/112106137/>
9. <http://nitc.ac.in/index.php?url=users/view/270/12/3>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105124/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Acquaint with design standards, material selection and static stress in the design of machine components. (K3)
2. Apply the concept of variable stress and theories of failures in the design of machine components. (K3)
3. Determine the dimensions of torque transmitting elements. (K3)
4. Calculate the dimensions of mechanical joints like knuckle, cotter, bolted, riveted and welded joints. (K3)
5. Calculate the dimensions of springs and flywheel. (K3)
6. Predict the size of hydrodynamic and antifriction bearings. (K3)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C02	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C03	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C04	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C05	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C06	3	3	2	-	-	1	1	-	-	-	-	1	2	2

SEMESTER - V

20MEPL501 SDG NO. 4,8,9,12	3D MODELING AND COMPUTER AIDED MANUFACTURING LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To draw part and Assembly Diagrams of dimensional Components.
- To gain practical experience in handling 3D modeling software systems.
- To understand the concepts G and M codes and manual part programming.
- To understand the applications of various CNC machines and to expose students to modern CNC application machines.

DRAWING STANDARDS:

Code of practice for Engineering Drawing, BIS specifications – Welding symbols, riveted joints, keys, fasteners – Reference to hand book for the selection of standard components like bolts, nuts, screws, keys etc.

LIST OF EXERCISES (CAD)

Introduction of 3D Modelling software (Solid Works / Fusion 360). Creation of 3D assembly model of following machine elements using 3D Modeling software:

1. Knuckle Joint
2. Flange Coupling
3. Plummer Block
4. Screw Jack
5. Lathe Tailstock
6. Universal Joint

LIST OF EXERCISES (CAM)

1. Develop CNC Program for simple Facing operation with its tool simulation.
2. Develop CNC Program for Step turning operation with its tool simulation.
3. Develop CNC Program for Tapper turning operation with its tool simulation.
4. Develop CNC Program for Multiple Facing and turning operation along with its tool simulation.
5. Develop CNC Program for Grooving and threading operation along with its tool simulation.
6. Develop CNC Program for Boring operation along with its tool simulation.
7. Develop a manual CNC Program for Contour milling with simulation.
8. Develop CNC Program for Profile milling operation.
9. Develop CNC Program for Profile milling and circular pocket operation with simulation.
10. Develop CNC Program for profile milling and drilling operations using CAM Package.
11. Develop CNC Program for mirroring operations using CAM Package.

LIST OF EXERCISES (CMM)

1. Real Time Inspection of various machine Elements like Shafts, Bolts, springs, Bearings, etc.
2. Inspecting components like Brackets, Connecting Rod, Governor, Flywheel, etc. and model them using any Modelling Software.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

1. Pentium IV computer or better hardware, with suitable graphics facility.
2. Licensed software for Drafting and Modeling. – 30 Licenses
3. CNC Lathe and Milling Machines
4. Co-ordinate Measuring Machine (CMM)

TOTAL: 45 PERIODS**OUTCOMES:****Upon completion of the course, the students should be able to**

1. Create 3D model for the various components using modelling software. (K3)
2. Generate part programming on CNC lathe and CNC milling machine for given design. (K3)
3. Inspect various machine elements using CMM. (K3)

CO- PO,PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	3	1	2	1	-	-	2	2	1	2	2	2
C02	3	3	3	1	2	1	-	-	2	2	1	2	2	2
C03	3	3	3	1	2	1	-	-	2	2	1	2	2	2

SEMESTER - V

20MEPL502 SDG NO. 4,9,12	KINEMATICS AND DYNAMICS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To supplement the principles learnt in kinematics and Dynamics of Machinery.
- To gain practical knowledge about various mechanisms & their applications in machineries.
- To understand how certain measuring devices are used for dynamic testing.
- To understand Machine Kinematics and Dynamics.

LIST OF EXPERIMENTS

1. a) Study of gear parameters.
b) Experimental study of velocity ratios of simple, compound, Epicyclic and differential gear trains
2. a) Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double rocker, Oscillating cylinder Mechanisms
b) Kinematics of single and double universal joints.
3. a) Determination of Mass moment of inertia of Fly wheel and Axle system.
b) Determination of Mass Moment of Inertia of Axis-Symmetric bodies using Turn Table apparatus.
c) Determination of Mass Moment of Inertia using bifilar suspension and compound pendulum.
4. Motorized gyroscope – Study of gyroscopic effect and couple.
5. Governor - Determination of range sensitivity, effort etc., for Watt, Porter, Proell, and Hartnell Governors.
6. Cams – Cam profile drawing, Motion curves and study of jump phenomenon
7. a) Single degree of freedom Spring Mass System – Determination of

- natural frequency and verification of Laws of springs – Damping coefficient determination
- b) Multi degree freedom suspension system – Determination of influence coefficient.
 8. a) Determination of torsional natural frequency of single and Double Rotor systems.-. Undamped and Damped Natural frequencies
b) Vibration Absorber – Tuned vibration absorber.
 9. Vibration of Equivalent Spring mass system – Undamped and damped vibration.
 10. Whirling of shafts – Determination of critical speeds of shafts with concentrated loads.
 11. a) Balancing of rotating masses. (b) Balancing of reciprocating masses.
 12. a) Transverse vibration of Free-Free beam – with and without concentrated masses.
b) Forced Vibration of Cantilever beam – Mode shapes and natural frequencies.
 - 13 Determination of transmissibility ratio using vibrating table

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

1	Cam follower setup	1 No.
2	Motorized gyroscope	1 No.
3	Governor apparatus - Watt, Porter, Proell and Hartnell governors	1 No.
4	Whirling of shaft apparatus	1 No.
5	Dynamic balancing machine.	1 No.
6	Two rotor vibration setup	1 No.
7	Spring mass vibration system	1 No.
8	Torsional Vibration of single rotor system setup	1 No.
9	Gear Models	1 No.
10	Kinematic Models to study various mechanisms	1 No.
11	Turn table apparatus	1 No.
12	Transverse vibration setup of a cantilever	1 No.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Explain gear parameters, kinematics of mechanisms, gyroscopic effect and working of lab equipment. (K3)
2. Study the governor effect and range sensitivity and perform balancing of rotating and reciprocating masses. (K3)

3. Determine mass moment of inertia of mechanical elements, critical speed of shafts and natural frequency, damping coefficient and torsional frequency. (K3)

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	-	-	1	1	-	1	2	-	1	3	2
C02	3	2	2	-	-	1	1	-	1	2	-	1	3	2
C03	3	2	2	-	-	1	1	-	1	2	-	1	3	2

SEMESTER - V

20HSPL501 SDG NO. 4, 8	COMMUNICATION AND SOFT SKILLS LAB	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To develop effective communication and presentation skills
- To enhance the employability and career skills of the learners
- To enable the learners for preparing job application and e-portfolio
- To make the learners use soft skills efficiently
- To develop their confidence and help them in attending interviews successfully

UNIT I LISTENING AND SPEAKING SKILLS**6**

Conversational skills participate in formal and informal talks – general, – group discussion – time management – group dynamics – GD strategies - making effective presentations - listening/watching interviews conversations, documentaries - listening to lectures, discussions from social media – improving articulation.

UNIT II ADVANCED READING AND WRITING SKILLS**6**

Reading different genres of texts - writing job applications – cover letter – résumé – emails – memos - writing abstracts – summaries – interpreting visual texts - e-portfolio.

UNIT III SKILLS FOR COMPETITIVE EXAMS**6**

Reading passages for competitive exams – language focus exercise – building vocabulary tasks - FAQs related to competitive exams – current affairs -

improving global reading skills – elaborating ideas – summarizing – understanding arguments – identifying opinion/attitude and making inferences - critical reading.

UNIT IV SOFT SKILLS

6

Motivation – emotional intelligence – managing changes – stress management – leadership traits – team work – career planning – intercultural communication – creative and critical thinking

UNIT V INTERVIEW SKILLS

6

Different types of interview – personal interview – panel interview – telephone/online interview - interview etiquette - answering questions – offering information – mock interviews – FAQs related to job interviews

TOTAL: 30 PERIODS

REFERENCES:

1. Business English Certificate Materials, Cambridge University Press.
2. Comfort, Jeremy, et al. Speaking Effectively: Developing Speaking Skills for Business English. Cambridge University Press, Cambridge, 2011.
3. International English Language Testing System Practice Tests, Cambridge University Press.
4. Personality Development (CD-ROM), Times Multimedia, Mumbai.

WEB REFERENCES:

1. <https://nptel.ac.in/courses/109/107/109107121/>
2. https://swayam.gov.in/nd1_noc19_hs33/preview
3. <https://ict.iitk.ac.in/courses/enhancing-soft-skills-and-personality/>

ONLINE RESOURCES:

1. <https://www.britishcouncil.my/english/courses-adults/learning-tips/importance-of-soft-skills>
2. <https://www.skillsoft.com/content-solutions/business-skills-training/soft-skills-training/>

OUTCOMES:

Upon completion of the course learners should be able to

1. Demonstrate a better understanding of the communication process by articulating effectively(K2)
2. Exhibit soft skills & technical skills and construct e-portfolio effectively(K3)
3. Apply critical thinking abilities and perform well in group discussions(K2)
4. Adapt the skills towards grooming as a professional continuously(K2)

5. Identify different types of personal interview skills through mock interviews and practices(K2)
6. Execute the employability and career skills in their chosen profession(K3)

CO - PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	1	2	1	1	-	-	-	-	-	-	2	3	1
C02	3	1	2	3	3	-	-	-	-	-	-	2	3	-
C03	3	1	2	3	3	-	-	-	-	-	-	2	3	1
C04	3	11	2	3	3	-	-	-	-	-	-	2	3	1
C05	3	3	3	3	3	-	-	-	-	-	-	2	3	1
C06	3	1	3	3	3	-	-	-	-	-	-	2	3	1

SEMESTER - V

20METE501 SDG NO.4,6,7,8, 9,11,12,13,17	LIVE-IN-LAB - III	L	T	P	C
		0	0	3	1

OBJECTIVES:

- To provide opportunities for the students, exposure to the Industrial environment and real time work.
- To enable hands-on experience in the electronics hardware/Software domain
- To enable development of skill set for designing and realizing prototype electronic systems/simulation model

COURSE METHODOLOGY

- This initiative is designed to inculcate ethical principles of research and to get involved in a life-long learning process for the students.
- The project work must involve engineering design with realistic constraints. It must also include appropriate elements of the following: Engineering standards, design analysis, modeling, simulation, experimentation, prototyping, fabrication, correlation of data, and software development.
- Project can be individual work or a group project, with a maximum of 3 students. In case of group project, the individual project report of each student should specify the individual's contribution to the group project

- On completion of the project, the student shall submit a detailed project report. The project should be reviewed and the report shall be evaluated and the students shall appear for a viva-voce oral examination on the project approved by the Coordinator and the project guide.

EVALUATION

- First evaluation (Immediately after first internal examination) : 20 marks
- Second evaluation (Immediately after second internal examination): 30 marks
- Final evaluation (Last week of the semester) : 50 marks

Note: All the three evaluations are mandatory for course completion and for awarding the final grade

TOTAL: 30 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to:

- 1 Perform literature survey to identify the gap and an application oriented research problem in the specific domain (K2)
- 2 Design and validate the proposed system using simulation (K3)
- 3 Implement the proposed system (K3)
- 4 Examine the obtained results and prepare a technical report (K4)
- 5 Publish the work in journals and apply for the patents. (K3)
- 6 Prepare for industrial environment and real time work (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	2	2	2	2	2	3	2	2	3	3	3
C02	3	3	3	2	3	3	2	2	3	3	3	3	3	3
C03	2	2	2	1	2	1	1	1	3	2	3	3	3	2
C04	2	2	2	1	2	1	1	1	3	2	3	3	3	2
C05	2	2	2	1	2	1	1	1	3	2	3	3	3	2
C06	2	2	2	2	3	2	2	2	2	2	3	3	3	3

SEMESTER - V

20METP501	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	2

APTITUDE & COGNITIVE SKILLS – PHASE - 1

AIM

- To educate and enrich the students on quantitative ability, reasoning ability and verbal ability.

COURSE OBJECTIVES

To enable students to,

- Enhance their quantitative ability.
- Enhance their reasoning ability
- Enhance their verbal ability.
- Equip with creative thinking and problem solving skills

UNIT I QUANTITATIVE ABILITY – V 10

Square Root and Cube Root, Logarithm, Volume and Surface Area, Permutation and Combination

UNIT II Quantitative Ability – VI 10

Probability, Averages, Area, Odd Man Out, Crypt Arithmetic, Flowcharts

UNIT III REASONING ABILITY – III 8

Data Interpretation Table Charts, Data Interpretation Bar Charts, Blood Relationship, Puzzles

UNIT IV VERBAL ABILITY – III 10

Spellings, Selecting Words, Spotting Errors, Ordering of Words, Logical Sequence of Words

Unit V CREATIVITY ABILITY – III 7

Logical Puzzles, Playing Cards Puzzles, Clock Puzzles, Number Puzzles, Sudoku

REFERENCES

- Quantitative Aptitude for Competitive Exams by R. S. Agarwal
- Quantum CAT by Sarvesh Verma

3. A Modern Approach to Logical Reasoning by R. S. Agarwal
4. Verbal Ability and Reading Comprehension by Arun Sharma

PYTHON PROGRAMME AND APPLICATION OF PARAMETRIC MODELLING – PHASE - 2

OBJECTIVES

The course is designed to provide Strong knowledge of Python. Python programming is intended for software engineers, system analysts, program managers and user support personnel who wish to learn the Python programming language.

UNIT I INTRODUCTION, DATATYPES AND STRINGS, LIST & TUPLES: 10

DataTypes - Integer , Float , Boolean , String , List , Tuple , Dictionary and Sets. String - Concatenation and Replication, isalnum functions, Slicing Operation sorted() , reversed() , min() , max() , index() and count() function, packing and unpacking of data in a tuple

UNIT II DICTIONARY AND SETS and HANDLING 10

Dictionary - del Keyword, Sets - Frozen sets, Internal working of sets, add() , union() , intersection() and difference() method, symmetric_difference, clear() method, Operators in sets, Higher Order Functions - map , filter , reduce and lambda function, Random Library

UNIT III EXCEPTIONAL HANDLING, REGULAR EXPRESSIONS AND OBJECT ORIENTED PROGRAMMING 10

Exception Handling - All Error Categories, try , except , finally blocks, Raising an exception, Regular Expression, Object Oriented Programming - Types of Inheritance, Data encapsulation and Abstraction, Polymorphism, Method OverRiding, Operator overloading, operator overRiding,

UNIT IV PARAMETRIC MODELLING 8

Introduction to parametric modelling - wireframe modelling - analytical curves - synthetic curves - surface modeling - Introduction to catia software for surface modelling.

UNIT V VEHICLE DYNAMICS

7

Introduction to vehicle dynamics - suspension and steering kinematics -
Introduction to adams software for vehicle dynamics.

TOTAL : 45 PERIODS

REFERENCES:

1. Python-(Mark Lutz)
2. Python Training guide (BPB Publications)
3. <https://www.pdfdrive.com/catia-books.html>
4. <https://core.ac.uk/download/pdf/128709302.pdf>
5. https://www.mscsoftware.com/sites/default/files/Book_Adams-Tutorial-ex17-w.pdf

OUTCOMES:

Upon completion of this course, the students should be able to:

1. Explain basic principles of Python programming language. (K2)
2. Implement object oriented concepts. (K3)
3. Implement database and GUI applications. (K3)
4. Apply the knowledge of parametric modeling using 3D Modelling software. (K4)
5. Gain practical knowledge using adams software for multibody vehicle dynamics. (K4)
6. Implementing Analytical skills for Design Applications. (K4)

CO- PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	2	-	-	-	-	-	-	-	-	-	-	-
C02	3	-	2	-	-	-	-	-	-	-	-	-	-	-
C03	3	2	2	2	-	-	-	-	-	-	-	-	-	-
C04	1	2	1	-	1	-	-	-	1	1	1	1	2	2
C05	1	2	1	1	2	-	-	-	1	1	-	1	2	2
C06	1	2	1	2	2	-	-	-	1	1	-	1	2	2

SEMESTER - VI

20MEEL601 SDG NO. 4,9,12	DESIGN OF TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

(Use of PSG Design Data Book is permitted)

OBJECTIVES:

- To understand the basics of Transmission elements involved in a Mechanical Power Transmission Components.
- To Design and analyze various forces acting on the Mechanical Power Transmission Components using suitable techniques, Codes and Standards.
- To Select Transmission Elements like Belts, Chain drives, Rope Drives, Pulleys, Gears, Clutches and Brakes from the manufactures Catalogue.
- To learn to use standard data and catalogues.

UNIT I DESIGN OF FLEXIBLE DRIVES

9

Design of Flat belts and pulleys - Selection of V belts and pulleys – Selection of hoisting wire ropes and pulleys – Design of Transmission chains and sprockets.

UNIT II DESIGN OF SPUR AND HELICAL GEAR DRIVES

9

Speed ratios and number of teeth-Force analysis -Tooth stresses - Dynamic effects – Fatigue strength- Factor of safety - Gear materials – Design of straight tooth spur & helical gears based on strength and wear considerations – Pressure angle in the normal and transverse plane- Equivalent number of teeth.

UNIT III DESIGN OF BEVEL AND WORM GEAR DRIVES

9

Straight bevel gear- Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears.

Worm Gear-Terminology, Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair.

UNIT IV DESIGN OF GEAR BOX

9

Geometric progression - Standard step ratio - Ray diagram, kinematic layout - Design of sliding mesh gear box - Design of multi speed gear box for machine tool applications - Constant mesh gear box - Speed reducer unit – Variable speed gear box.

UNIT V DESIGN OF CLUTCHES AND BRAKES

Design of plate clutches - cone and centrifugal clutches - internal expanding rim clutches- Electromagnetic clutches.

Design of Band and Block brakes - external shoe brakes – Internal expanding shoe brake.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bhandari V, “Design of Machine Elements”, 5th Edition, Tata McGraw-Hill Book Co, 2010.
2. Prabhu. T.J., “Design of Transmission Elements”, 5th Edition, Mani Offset, Chennai, 2000.

REFERENCES

1. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett “Mechanical Engineering Design”, 10th Edition, Tata McGraw-Hill, 2008.
2. Robert L. Norton “Machine Design – An integrated approach”, Pearson Education, 5th edition 2018.
3. Spotts M.F, Shoup T.E “Design of Machine Elements”, Pearson Education, 8th edition, 2019.
4. P.C. Gope, “Machine Design – Fundamental and Application”, PHI learning private ltd, New Delhi, 2012.
5. Robert C. Juvinall and Kurt M. Marshek, “Machine Component Design”, Wiley India.
6. Jindal U.C. “Machine Design”, Pearson Education, 1st Edition 2010.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105125/>
2. <https://nptel.ac.in/courses/112/106/112106137/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105124/>

OUTCOMES:

Upon completion of the course, the students should be able to:

- 1 Determine the design parameters for flexible power transmission elements, using Design Standards. (K3)
- 2 Determine the design parameters of parallel axis Gears, using Design Standards. (K3)
- 3 Determine the design parameters of Non-parallel axis Gears, using Design Standards. (K3)

- 4 Compute the dimensions of a multi-speed gear box for machine tool and automotive applications using Design Standards. (K3)
- 5 Predict the dimensions of clutches (K3)
- 6 Calculate the braking torque and dimensions of a mechanical brake. (K3)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	1	1	-	-	-	-	1	2	2
CO2	3	2	2	-	-	1	1	-	-	-	-	1	2	2
CO3	3	2	2	-	-	1	1	-	-	-	-	1	2	2
CO4	3	2	2	-	-	1	1	-	-	-	-	1	2	2
CO5	3	2	2	-	-	1	1	-	-	-	-	1	2	2
CO6	3	2	2	-	-	1	1	-	-	-	-	1	2	2

SEMESTER - VI

20MEPC602 SDG NO. 4,9,11, 12,13,15	HEAT TRANSFER	L	T	P	C
		3	0	0	3

(Use of standard HMT data book is permitted)

OBJECTIVES:

- To understand the mechanisms of heat transfer under steady and transient conditions during conduction and heat transfer through extended surfaces.
- To understand the mechanisms of heat transfer under free and forced convection and radiation.
- To impart the knowledge on boiling and condensation.
- To learn the thermal analysis and sizing of heat exchangers.

UNIT I CONDUCTION**9**

General differential equation of Heat Conduction– Cartesian and Polar Coordinates – One dimensional steady state heat conduction -- plane and composite systems – Conduction with internal heat generation – Extended surfaces – Unsteady heat conduction – Lumped analysis – Semi infinite and infinite solids –Use of Heisler’s charts.

UNIT II RADIATION 9

Black body radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation shields. Radiation through gases.

UNIT III CONVECTION 9

Free and Forced Convection - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over plates and cylinders and Internal flow through tubes.

UNIT IV BOILING AND CONDENSATION 9

Nusselt's theory of condensation - Regimes of pool boiling and flow boiling. Correlations in boiling and condensation.

UNIT V HEAT EXCHANGERS 9

Heat Exchanger Types - Overall Heat Transfer Coefficient –Fouling Factors - Analysis – LMTD method - NTU method. Applications and analysis of heat exchangers

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 2019.
2. R.C. Sachdeva R.C. "Fundamentals of Engineering Heat and Mass Transfer", New Age International publishers, 2017.

REFERENCES

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 1998.
2. Venkateshan. S.P., "Heat Transfer", Ane Books, New Delhi, 2004.
3. Ghoshdastidar, P.S., "Heat Transfer", Oxford, 2004,
4. Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002
5. Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000
6. Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.
7. Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
8. Yadav, R., "Heat and Mass Transfer", Central Publishing House, 1995.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/108/112108149/>
2. <https://nptel.ac.in/courses/112/104/112104159/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/101/112101097/>
2. <https://nptel.ac.in/courses/112/107/112107211/>
3. <https://nptel.ac.in/courses/112/108/112108246/>
4. <https://nptel.ac.in/courses/112/107/112107256/>
5. <https://nptel.ac.in/courses/112/105/112105248/>

OUTCOMES:

Upon completion of the course, the students should be able to:

- 1 Calculate heat transfer and temperature distribution in steady and transient conduction. [K3]
- 2 Analyze radiation heat exchange between bodies and surfaces in solid and participating media. [K3]
- 3 Interpret heat transfer in convection among engineering systems. [K3]
- 4 Calculate basic boiling and condensation heat transfer. [K2]
- 5 Design heat exchangers for various modes of heat transfer. [K4]
- 6 Design and Analyze heat transfer in thermal systems [K4]

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	1	1	2
CO2	3	2	1	2	1	-	-	-	-	-	-	1	1	2
CO3	3	2	1	1	1	-	-	-	-	-	-	1	1	2
CO4	3	2	1	1	-	-	-	-	-	-	-	1	1	2
CO5	3	2	3	2	1	-	-	1	-	-	-	1	1	2
CO6	3	2	1	1	-	-	-	-	-	-	-	1	1	1

SEMESTER - VI

20MEPC603 SDG NO. 4,9,11,12	MECHATRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the interdisciplinary applications of Electronics, Electrical, Mechanical and Computer systems for the control of mechanical and electronic systems
- To understand the architecture and operation of typical microprocessors and microcontrollers
- To understand the concept of PLC system and its programming
- To understand the key actuation elements and mechatronics system design

UNIT I INTRODUCTION 9

Introduction to Mechatronics – Systems – Concepts of Mechatronics approach – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and dynamic Characteristics of Sensor; Potentiometers – LVDT – Capacitance sensors – Strain gauges – Eddy current sensor – Hall effect sensor – Temperature sensors – Light sensors

UNIT II MICROPROCESSOR AND MICROCONTROLLER 9

Introduction – Architecture of 8085 – Pin Configuration – Addressing Modes – Instruction set, Timing diagram of 8085 – Concepts of 8051 microcontroller – Block diagram

UNIT III PROGRAMMABLE PERIPHERAL INTERFACE 9

Introduction – Architecture of 8255, Keyboard interfacing, LED display –interfacing, ADC and DAC interface, Temperature Control – Stepper Motor Control – Traffic Control interface.

UNIT IV PROGRAMMABLE LOGIC CONTROLLER 9

Introduction – Basic structure – Input and output processing – Programming – Mnemonics – Timers, counters and internal relays – Data handling – Selection of PLC.

UNIT V ACTUATORS AND MECHATRONICS SYSTEM DESIGN 9

Types of Stepper and Servo motors – Construction – Working Principle – Advantages and Disadvantages. Design process-stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics

systems – Pick and place Robot – Engine Management system – Automatic car park barrier

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bolton .W,“Mechatronics” ,Pearson Education Limited, 5th Edition, 2011.
2. Devadas Shetty, Richard A. Kolk, “Mechatronics System Design”, CENGAGE Learning, 2nd International student edition, 2010.

REFERENCES

1. Mazidi. M.A and Mazidi .M.J., MCKinlay.R.D, “The 8051 Microcontroller and Embedded Systems Using Assembly and C”, Pearson India, 2nd Edition, 2008.
2. Patranabis D., “Sensor and Actuators”, Prentice Hall of India Pvt Ltd., 2nd edition 2005.
3. John P. Bentley., “Principle of Measurement systems”, Pearson Prentice Hall, Fourth edition, 2005

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/103/112103174/>
2. <https://nptel.ac.in/courses/108/105/108105063/>
3. <https://nptel.ac.in/courses/112/102/112102011/>
4. <https://nptel.ac.in/courses/106/108/106108100/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/108/105/108105062/>
2. <https://nptel.ac.in/courses/108/105/108105088/>
3. <https://nptel.ac.in/courses/112/104/112104288/>
4. <https://nptel.ac.in/courses/108/108/108108147/>
5. <https://nptel.ac.in/courses/108/107/108107029/>
6. <https://nptel.ac.in/courses/108/105/108105102/>

OUTCOMES:

Upon completion of the course, the students should be able to:

1. Discuss the interdisciplinary applications of Electronics, Electrical, Mechanical and Computer Systems for the Control of Mechanical, Electronic Systems and sensor technology. (K2)

2. Discuss the architecture of 8085 Microprocessor and 8051 Microcontroller, Pin Diagram, Addressing Modes of Microprocessor and Microcontroller. (K2)
3. Interpret the Programmable Peripheral Interface, Architecture of 8255 PPI, and various device interfacing (K2)
4. Explain the architecture, programming and application of programmable logic controllers to problems and challenges in the areas of Mechatronic engineering. (K2)
5. Discuss the Stepper and Servo motors Construction, Working Principle and applications in mechatronics design. (K2)
6. Apply various Actuators and Mechatronics system design using the knowledge and skills acquired through the course and also from the given case studies (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	1	-	1	1	-	1	-	-	2	2	3
C02	3	3	2	1	-	1	1	-	1	-	-	2	2	3
C03	3	3	2	1	-	1	1	-	1	-	-	2	2	3
C04	3	3	2	3	-	1	1	-	1	-	-	2	2	3
C05	3	3	2	2	-	1	1	-	1	-	-	2	2	3
C06	3	3	2	2	-	1	1	-	1	-	-	2	2	3

SEMESTER - VI

20MEPL601 SDG NO. 4,9,11, 12,13,15	THERMAL SCIENCES LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To study the value timing-port timing diagram and performance of IC Engines
- To study the characteristics of fuels/Lubricates used in IC Engines
- To study the Performance of steam generator/ turbine
- To study the heat transfer phenomena predict the relevant coefficient using implementation
- To study the performance of refrigeration cycle / components

LIST OF EXPERIMENTS**ENGINE LAB:**

1. Valve Timing and Port Timing diagrams.
2. Actual p-v diagrams of IC engines.
3. Performance Test on 4 – stroke Diesel Engine.
4. Heat Balance Test on 4 – stroke Diesel Engine.
5. Morse Test on Multi-cylinder Petrol Engine.
6. Retardation Test on a Diesel Engine.
7. Determination of Flash Point and Fire Point of various fuels / lubricants.

STEAM LAB:

1. Study on Steam Generators and Turbines.
2. Performance and Energy Balance Test on a Steam Generator.
3. Performance and Energy Balance Test on Steam Turbine.

HEAT TRANSFER LAB:

1. Thermal conductivity measurement using guarded plate apparatus.
2. Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.
3. Determination of heat transfer coefficient under natural convection from a vertical cylinder.
4. Determination of heat transfer coefficient under forced convection from a tube.
5. Determination of Thermal conductivity of composite wall.
6. Determination of Thermal conductivity of insulating powder.
7. Heat transfer from pin-fin apparatus (natural & forced convection modes)
8. Determination of Stefan – Boltzmann constant.
9. Determination of emissivity of a grey surface.
10. Effectiveness of Parallel / counter flow heat exchanger.

REFRIGERATION AND AIR CONDITIONING LAB:

1. Determination of COP of a refrigeration system
2. Experiments on Psychrometric processes
3. Performance test on a reciprocating air compressor
4. Performance test in a HC Refrigeration system
5. Performance test in a fluidized bed cooling tower

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

1	I.C Engine – 2 stroke and 4 stroke model	1 No.
2	Apparatus for Flash and Fire Point	1 No.
3	4-stroke Diesel Engine with Mechanical Loading	1 No.
4	4-stroke Diesel Engine with Electrical Loading	1 No.
5	4-stroke Diesel Engine with Hydraulic Loading	1 No.
6	Multi-cylinder Petrol Engine	1 No.
7	Single cylinder Petrol Engine	1 No.
8	Steam Boiler with turbine setup	1 No.
9	Guarded plate apparatus	1 No.
10	Lagged pipe apparatus	1 No.
11	Natural convection-vertical cylinder apparatus	1 No.
12	Forced convection inside tube apparatus	1 No.
13	Composite wall apparatus	1 No.
14	Thermal conductivity of insulating powder apparatus	1 No.
15	Pin-fin apparatus	1 No.
16	Stefan-Boltzmann apparatus	1 No.
17	Emissivity measurement apparatus	1 No.
18	Parallel/counter flow heat exchanger apparatus	1 No.
19	Single/two stage reciprocating air compressor	1 No.
20	Refrigeration test rig	1 No.
21	Air conditioning test rig	1 No.

TOTAL: 45 PERIODS**OUTCOMES:****Upon completion of the course, the students should be able to**

1. Perform experiments on IC Engines, steam turbines and study their performance. (K3)
2. Perform the test on heat exchanger apparatus and evaluate relevant heat transfer coefficient. (K3)
3. Perform the experiment on air compressor, refrigerator and air conditioner test rig and evaluate its performance. (K3)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	2	-	-	-	-	1	3	3
CO2	3	3	3	-	-	-	-	-	-	-	-	1	3	2
CO3	3	3	3	-	-	-	2	-	-	-	-	2	3	2

SEMESTER - VI

20MEPL602 SDG NO. 4,7,9,11,12,	MECHATRONICS AND ROBOTICS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To know Microprocessor programming.
- To design, model and analyse basic Electrical, Hydraulic & Pneumatic Systems
- To introduce different types of robotics and demonstrate them to identify different parts and components.
- To write Robot programming for simple operations.

STUDY

1. Forward and Inverse kinematics to control hand movements.
2. Study and selection of Gripper.

LIST OF EXPERIMENTS

1. Assembly language programming of 8085 – Addition – Subtraction – Multiplication – Division – Sorting – Code conversion.
2. Stepper motor interface.
3. Study of various types of transducers.
4. Modeling and analysis of basic hydraulic, pneumatic and electrical circuits using the software.
5. Study of PLC, Design and Development of Color Sorting Conveyor system, Pick and place conveyor system using sensors and PLC.
6. Study of image processing techniques and its application in Robotics.
7. Implementation of trajectory planning algorithm for straight line motion and Curved line using PID based control of two axis robot.
8. Robot programming and simulation for pick and place using SCARA Robot
9. Robot programming and simulation for Drilling and Welding based operation.
10. Robot programming and simulation for packaging systems.
11. Robot programming and simulation for collaborative Robotics Systems.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No	NAME OF THE EQUIPMENT	QTY
1	Basic Pneumatic Trainer Kit with manual and electrical controls/ PLC Control each	1
2	Basic Hydraulic Trainer Kit	1
3	Hydraulics and Pneumatics Systems Simulation Software	10
4	8051 - Microcontroller kit with stepper motor and drive circuit sets	2
5	Image processing system with hardware & software	1
TOTAL: 45 PERIODS		

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Demonstrate the functioning of hydraulic and pneumatic control systems with the help of PLC and microcontrollers. (K1)
2. Introduce different types of robotics and demonstrate them to identify different parts and components. (K2)
3. Write Robot programming for simple operations and automate a system. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	-	3	2	-	-	-	-	-	2	3	3
CO2	1	-	2	1	3	2	3	1	3	2	3	3	3	2
CO3	1	1	-	3	3	1	1	1	2	2	2	3	2	2

SEMESTER - VI

20MEPJ601 SDG NO. 4, 6, 7, 8, 9, 11, 12, 13, 17	INNOVATIVE DESIGN AND FABRICATION PROJECT	L	T	P	C
		0	0	2	1

OBJECTIVES:

- The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them

GUIDELINES TO BE FOLLOWED:

The students may be grouped into 2 to 4 and work under a project supervisor. The device/ system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

OUTCOMES:

Upon completion of the course, the students should be able to:

1. Conceptualize the societal needs and acquire design ability. (K3)
2. Manufacture the component/equipment to meet the specific needs of the society with appropriate consideration for public health, safety and environmental context for sustainable development. (K4)
3. Demonstrate the working of model fabricated by them and write a detailed report on project. (K3)

CO - PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	2	3	3	3	3	3	3	3	3
CO2	2	2	3	1	3	3	3	3	3	3	3	3	3	3
CO3	3	1	-	-	3	-	2	3	3	3	1	3	3	3

SEMESTER - VI

20ECTP601 SDG NO. 4,11,15	SKILL ENHANCEMENT	L	T	P	C
		0	0	2	1

APTITUDE & COGNITIVE SKILLS - PHASE 1

OBJECTIVES:

- Enhance their quantitative ability.
- Enhance their reasoning ability
- Enhance their verbal ability.

UNIT I QUANTITATIVE ABILITY - VII

6 Hours

Races And Games, Boats and Streams, Surds and Indices, Pipes and Cistern, Alligations And Mixtures

UNIT II QUANTITATIVE ABILITY - VIII

6 Hours

Numbers, Problems on Numbers, Pick Wrong Number, Missing Number, Areas, Shapes, Perimeter.

UNIT III REASONING ABILITY - IV

6 Hours

Data Interpretation Pie Charts, Data Interpretation Line Charts, Data Sufficiency (DS), Data Arrangements, LR - Arrangements, LR - Ranking.

UNIT IV VERBAL ABILITY - IV

6 HOURS

Sentence Correction, Sentence Improvement, Completing Statements, Sentence Formation, Paragraph Formation.

UNIT V CREATIVITY ABILITY - IV

6 Hours

Dot Situation, Rule Detection, Embedded Images, Grouping Of Images, Image Analysis.

TOTAL : 30 PERIODS

REFERENCES

- Quantitative Aptitude for Competitive Exams by R. S. Agarwal
- Quantum CAT by Sarvesh Verma
- A Modern Approach to Logical Reasoning by R. S. Agarwal
- Verbal Ability and Reading Comprehension by Arun Sharma

PROBLEM SOLVING USING BASIC DATA STRUCTURES - MATLAB AND SIMULINK - PHASE – II

COURSE OBJECTIVES

To enable students to

- Analyze simple algorithms and data structures.
- Design of computer algorithms, as well as analysis of sophisticated algorithms.
- Familiar with the CST Studio Suite interface
- Perform basic tasks in terms of modeling, setup of simulation, and analyzing pre and post processing results.

UNIT I LINKED LIST & STACK, QUEUE & HEAP 10

Linked List - Doubly Linked List Traversal, Circular Linked List, Structure, Node creation, Traversal Stack, Stack –Time Complexities of the Operations, Infix to Postfix/Prefix Conversation, Histogram Problem, Implementation - Using Array, Using Linked List, Queue Implementation - Queue using Stack

UNIT II BINARY TREE AND HASHING 10

Binary Tree - Types of Binary Tree, Balanced Tree, Degenerate or pathological Tree, Binary Search Tree, Inorder , Preorder , PostOrder and LevelOrder Traversal, Hashing, Linear Probing for Collision Handling, Union and Intersection of two Linked Lists

UNIT III TREES AND GRAPH 10

AVL Tree -Right-Left Imbalance, Left and Right Rotation, - Red Black Tree, Rules of coloring Left and Right Rotation, Graph terminology –Representation of graphs –Path matrix –Graph Traversal –BFS (breadth first search) –DFS (depth first search) –Minimum spanning Tree –Kruskal's Algorithm & Prim's Algorithm –Warshall's algorithm (shortest path algorithm).

UNIT IV SIMULINK 8

Basics of matlab programming - simulink - computer programming - application of simulink for automotive field.

UNIT V MATLAB 7

Simulation software in matlab - Experimentation with matlab - scripting - plotting - Applications.

TOTAL : 45 PERIODS

REFERENCES:

1. Weiss, Mark. A. (2012), Data structures and algorithm analysis in Java. 3 edition. Harlow, Essex : Pearson (632 p).
2. Zobel, Justin (2014), Writing for Computer Science. 3 edition. Springer Verlag London Ltd (270 p).

WEBSITE LINKS

1. <http://users.isr.ist.utl.pt/~alex/micd0506/simulink.pdf>
2. <https://in.mathworks.com/products/simulink.html>

COURSE OUTCOMES

Upon completion of this course, the students should be able to:

1. Data abstraction and information hiding. (K2)
2. linear data structures and their applications in problem solving and programming. (K2)
3. Nonlinear data structures and their applications in problem solving and programming. (K3)
4. Internal and external sort and search techniques. (K2)
5. Implementing statistical analysis using matlab and simulink software. (K3)
6. Applying Simulink Tool for Design and Analysis. (K4)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	2	-	-	-	-	-	-	-	-	-	-	-
C02	3	-	2	-	-	-	-	-	-	-	-	-	-	-
C03	3	2	2	2	-	-	-	-	-	-	-	-	-	-
C04	1	1	-	2	2	-	-	-	-	1	-	1	2	2
C05	-	2	1	2	1	-	-	-	-	-	-	1	2	2
C06	1	2	1	-	2	-	-	-	-	-	1	1	2	2

SEMESTER - VI

20MGMC301 SDG NO. 4	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

OBJECTIVES:

At the end of the course, the student is expected to

- To know about Indian constitution
- To know about central government functionalities in India
- To know about state government functionalities in India
- To know about Constitution function
- To Know about Constitutional remedies

UNIT I INTRODUCTION

6

Historical Background – Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties

UNIT II STRUCTURE AND FUNCTION OF CENTRAL GOVERNMENT

6

Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India.

UNIT III STRUCTURE AND FUNCTION OF STATE GOVERNMENT

6

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

UNIT IV CONSTITUTION FUNCTIONS

6

Indian Federal System – Centre – State Relations – President's Rule – Constitutional Amendments – Constitutional Functionaries.

UNIT V CONSTITUTIONAL REMEDIES

6

Enforcement of fundamental rights - Power of parliament to modify the rights the conferred by this part in their application to forces.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Durga Das Basu, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.

- R.C. Agarwal, (1997) "Indian Political System", S. Chand and Company, New Delhi.
- M.V. Pyle (2019) , "An Introduction to The Constitution of India, 5/e", Vikas Publishing, New Delhi.
- P.M. Bakshi, (2018) , "Constitution of India", Universal Law Publishing, New Delhi.

REFERENCES:

- Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.
- U.R.Gahai, "Indian Political System", New Academic Publishing House, Jalandhar.

OUTCOMES:

Upon completion of the course, the student should be able to

- Explain the Constitution and Fundamental rights of citizens (K2)
- Discuss the structure, hierarchy and functions of Central Government (K2)
- Explain the functions of Supreme Court and Judiciary Systems in the state (K2)
- Discuss the structure, hierarchy and functions of State Government (K2)
- Recall the Centre-State relationship, constitutional amendments and functionaries (K1)
- Discuss the remedies and rights available to India Citizens (K2)

CO – PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	-	-	-	-	-	1	1	-	-	-	-	-
C02	-	-	-	-	-	1	1	-	-	-	-	-
C03	-	-	-	-	-	1	1	-	-	-	-	-
C04	-	-	-	-	-	1	1	-	-	-	-	-
C05	-	-	-	-	-	2	1	3	-	-	-	-
C06	-	-	-	-	-	2	1	2	3	-	-	-

SEMESTER - VII

20HSMG601 SDG NO. 4,8,9,10,12	PRINCIPLES OF ENGINEERING MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

At the end of the course, the student is expected to

- To enable the students to study the evolution of Management, to study the functions and principles of management and to learn the application of the principles in an organization

UNIT I INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS 9

Management – Science or Art – Manager Vs Entrepreneur – types of managers – Engineers as Managers. Evolution of Management – Scientific, human relations, system and contingency approaches – Types of Business organization – Sole proprietorship, partnership, company-public and private sector enterprises – Organization culture and Environment – Current issues and future trends in Management; Industry 4.0 – Engineering management in modern business.

UNIT II PLANNING 9

Planning, Technology Planning - Nature and purpose of planning – planning process – types of planning – objectives – setting objectives – policies – Planning premises – MBO – process - Principles and functions of engineering management – Planning Tools and Techniques – Decision making steps and process.

UNIT III ORGANISING 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.

UNIT IV DIRECTING AND CONTROLLING 9

Foundations of individual and group behaviour – Motivation – theories and techniques – Leadership – Level 5 leadership - theories – Leadership as a determinant of Engineering management - Communication – process and barriers – effective communication – Communication and IT - System and process of controlling – budgetary and non-budgetary control techniques.

UNIT V INNOVATION AND TECHNOLOGY MANAGEMENT**9**

Innovation management of Product and Services, Role of R & D in Entrepreneurship, Breakthrough Innovation, Disruptive Innovation – Modern approaches in Engineering management – Green management, Lean management, Managing diversity. IPR – Principles of Ethics for Engineering Managers.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Tripathy.P.C and Reddy.P.N, “Principles of Management”, Tata McGraw Hill, 1999.

REFERENCES:

1. Stephen P. Robbins and Mary Coulter, “Management”, Prentice Hall (India) Pvt. Ltd., 10th Edition, 2009.
2. JAF Stoner, Freeman R.E and Daniel R Gilbert, “Management”, Pearson Education, 6th Edition, 2004.
3. Stephen A. Robbins and David A. Decenzo and Mary Coulter, “Fundamentals of Management”, Pearson Education, 7th Edition, 2011.
4. Robert Kreitner and Mamata Mohapatra, “Management”, Biztantra, 2008.
5. Harold Koontz and Heinz Weihrich, “Essentials of Management”, Tata McGraw Hill, 1998.

WEB RESOURCES:

1. <https://www.managementstudyguide.com/organization-management.htm>
2. <https://nptel.ac.in/courses/110/105/110105034/>
3. <https://courses.lumenlearning.com/boundless-management/chapter/principles-of-management/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/110/105/110105033/>

OUTCOMES:

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

1. Get a clear idea on the practical implications of the management concepts in engineering with emphasis on the need for innovation in every sphere.
2. Manage functions like planning on international aspect of management.
3. Understand basic knowledge about organizing, staffing on international aspect of management.
4. Understand the concepts and principles of management viz., Directing, and Controlling in the changing business scenario.

5. Get through knowledge on the Efficient and Effective management of Men, Money and Technology towards developing the industrial system.

CO – PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	2	3	3	1	1	1
CO2	-	-	-	-	-	2	2	3	3	1	1	1
CO3	-	-	-	-	-	2	2	3	3	1	1	1
CO4	-	-	-	-	-	2	2	3	3	1	1	1
CO5	-	-	-	-	-	2	2	3	3	1	1	1

SEMESTER - VII

20MEPC701 SDG NO. 4, 9, 12	FINITE ELEMENT ANALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of mathematical modelling and engineering fundamentals for solving complex engineering problems
- To analyze one and two dimensional elements
- To analyze the heat transfer and vibration in simple and complex geometries
- To understand the concepts of iso-parametric and higher order elements

UNIT I INTRODUCTION

9

Basic Concepts – History, Relevance and Scope of Finite Element Methods - FEM Procedure - Natural and Essential boundary conditions - Concepts of Potential Energy - Rayleigh Ritz – Weighted Residual Method- Gaussian Elimination Methods – Solved Problems.

UNIT II ONE-DIMENSIONAL ELEMENTS

9

Coordinate Systems -Global, Local and Natural - Shape function, Finite element formulation - Stiffness Matrix, Load Vector, Boundary Condition and Assembly of Global Equation, Temperature Effects for 1D bar, Truss and Beam Element – Solved Problems.

UNIT III TWO-DIMENSIONAL ELEMENTS**9**

Shape function for linear triangular element-Finite element formulation-Constant Strain Triangular (CST) element -Plane Stress, Plane Strain conditions – Axisymmetric Elements formulation – Solved Problems

UNIT IV HEAT TRANSFER AND VIBRATION**9**

Shape function for 1D and 2D Triangular Element - Stiffness Matrix, Load vector and Assembly of Global Equation - Heat Conduction, Convection and Internal heat Generation for Linear element - Longitudinal and Transverse Vibrations for Bar and Beam Elements.

UNIT V HIGHER ORDER AND ISOPARAMETRIC ELEMENT**9**

Higher order Elements, Serendipity elements, Shape function formulation - Isoparametric, Sub parametric, Super parametric Elements, Iso parametric Transformation, Jacobian formulation and Stress Strain relations for Isoparametric elements. Gaussian Quadrature. Introduction to CFD

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. J.N.Reddy, “An Introduction to the Finite Element Method” Third Edition, McGraw-Hill Mechanical Engineering, Reprint, 2015.
2. Singuresu S. Rao, “Finite Element method in Engineering”, Fourth edition, Elsevier Science & Technology Books, Reprint 2015.

REFERENCES

1. Tirupathi R. Chandrupatla, Ashok D. Belagundu, “Introduction to Finite Elements in Engineering”, Third Edition, Reprint, Prentice Hall, 2012.
2. R. D. Cook, D. S. Malkus, and M. E. Plesha, “Concepts and Applications of Finite Element Analysis”, Third Edition, John Wiley and Sons, New York, Reprint 2010.
3. O. C. Zienkiewicz and R. L. Taylor, “The Finite Element Method: Volume 1 The Basis”, 5th Edition, Butterworth-Heinemann, Oxford. Reprint 2011.
4. Daryl L. Logan A, “First Course in the Finite Element Method”, Fourth Edition, Cengage Learning, 2007. 5. K. J. Bathe, “Finite Element Procedures”, Second Edition, Prentice-Hall Inc., Englewood Cliffs, New Jersey, Reprint 2012.
5. S. Bhavikati, “Finite Element Analysis”, New Age International Publishers, 2015.
6. David V. Hutton, “Fundamentals of Finite Element Analysis”, Tata McGraw Hill Publishing Company Pvt. Ltd., New Delhi, 2005.

WEB RESOURCES:

1. <https://www.simscale.com/blog/2016/11/learn-finite-element-analysis-fea/>
2. <https://nptel.ac.in/courses/112/104/112104116/>
3. <https://nptel.ac.in/courses/105/105/105105041/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104193/>
2. <https://nptel.ac.in/courses/112/104/112104205/>
3. <https://nptel.ac.in/courses/105/106/105106051/>
4. <https://nptel.ac.in/courses/112/106/112106135/>
5. <https://nptel.ac.in/courses/112/104/112104115/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Illustrate the element properties based on boundary conditions for solving various field problems. (K3)
2. Elucidate 1D and 2D elements in scalar and vector variable conditions. (K3)
3. Identify concepts of matrix solution techniques in various Engineering field problems. (K3)
4. Predict approximate solutions using mathematical modeling through Governing Equations. (K3)
5. Decide various numerical techniques for given domain. (K3)
6. Develop models for structural members and interpret its results. (K3)

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	2	-	-	-	-	-	-	-	2	3	2
C02	3	3	2	2	-	-	-	-	-	-	-	2	3	2
C03	3	3	2	2	-	-	-	-	-	-	-	2	3	2
C04	3	3	2	2	-	-	-	-	-	-	-	2	3	2
C05	3	3	2	2	-	-	-	-	-	-	-	2	3	2
C06	3	3	2	2	2	-	-	-	-	-	-	2	3	2

SEMESTER - VII

20MEPW701 SDG NO. 4,8,9, 12,13,15	3D PRINTING AND SUSTAINABLE DESIGN WITH LAB	L	T	P	C
		3	0	2	4

OBJECTIVES:

- To introduce the development of 3D Printing for various business opportunities and applications
- To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using 3D Printing
- To study the Design approaches, methods and tools for Sustainability
- To gain practical experience in handling 3D modelling software systems and 3D Print the components

UNIT I INTRODUCTION TO 3D PRINTING AND ITS APPLICATIONS 9

Overview – Need - Development of 3D Printing Technology, 3D Printing process chain - Impact of 3D Printing on Product Development - Virtual Prototyping- Rapid Tooling – Rapid Prototyping to 3D Printing -Classification of Additive Manufacturing (AM) processes Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain, Use of 3D Printing for Disaster Management, 3D Printing applications in Industry 4.0

UNIT II DIGITALIZATION AND TOOLING 9

Digitization techniques: Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies, Design for Additive Manufacturing for Part Quality Improvement
Rapid Tooling: Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling

UNIT III VARIOUS 3D PRINTING TECHNIQUES 9

Stereolithography Apparatus (SLA), Solid Ground Curing (SGC), Digital Light Processing (DLP), Fused deposition Modeling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Sintering (SLS), Indirect and Direct SLS, Laser Engineered Net Shaping (LENS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM), Binder Jetting, Material Jetting- Working Principles, details of processes variables, products, materials, advantages,

limitations and applications-Case studies. Hybrid Additive Manufacturing techniques, Wire Arc Additive Manufacturing.

UNIT IV SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT 9

Sustainability and Sustainable Development – Definitions, Pathway, Systems Approach to Design, Evolution of sustainability within Design, Diverse Approaches to Design for Sustainability, Product Life Cycle Design and Assessment Techniques, Productivity and Sustainability

UNIT V SUSTAINABLE PRODUCT-SERVICE SYSTEM AND SUSTAINABLE MANUFACTURING 9

Sustainable Product-Service System Design-Definition & Examples, Khadi Movement as a precursor to PSS thinking, Sustainable Product-Service System: Design, Transition Paths, Strategy, Challenges, Methods and Tools, Sufficiency Economy Philosophy applied to Sustainable PSS Thinking, Value Creation by Sustainable Manufacturing - Global Value Creation – Modeling, Cleaner Production, Remanufacturing, Demanufacturing, Opportunities of Sustainable Manufacturing in Industry 4.0

LIST OF EXPERIMENTS 15

3D PRINTING

After designing the Mechanical Component, the student will manufacture the same using 3D printing Technology

1. Generate NC code for a simple component using appropriate slicing software
2. RPT the given design with 3D printer using PLA
3. RPT the given design with 3D printer using ABS

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

1. Pentium IV computer or better hardware, with suitable graphics facility.
2. Licensed software for Drafting and Modeling. – 30 Licenses
3. Laser Printer or Plotter to print / plot drawings.
4. 3D Printer

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Pham D T and Dimov S S, “Rapid Manufacturing”, Verlag, 2001
2. J. Paulo Davim, “Sustainable Manufacturing”, John Wiley & Sons, 2013.

REFERENCES

1. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.
2. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN: 9783446425521.
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, United States, 2006, ISBN: 978-1-4614-9842-1.
4. Peter P. Rogers, Kazi F. Jalal and John A. Boyd, An Introduction to Sustainable Development, Glen Educational Foundation, 2008.
5. Sustainable Manufacturing: Shaping Global Value Creation, edited by Gunther Seliger, Springer Science & Business Media, 2012.

WEB RESOURCES:

1. <https://www.sculpteo.com/en/3d-printing/3d-printing-technologies/>
2. <https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/>
3. <https://3dprinting.com/what-is-3d-printing/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/107/103/107103081/>
2. <https://nptel.ac.in/courses/112/104/112104225/>
3. <https://nptel.ac.in/courses/112/104/112104265/>
4. <https://www.coursera.org/learn/3d-printing-revolution>
5. <https://www.coursera.org/learn/3d-printing-software>
6. <https://www.coursera.org/learn/3d-print-hardware>
7. <https://www.coursera.org/learn/3d-printing-applications>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Enrich knowledge on 3D Printing approach, basic terminology and its applications in industry.
2. Access specific resources needed to 3D print an object; includes CAD software.
3. Learn about various 3D printing techniques and its working principles.
4. Gain knowledge on sustainability, sustainable development and Product life cycle design.

5. Understand about Sustainable product, service system and sustainable manufacturing.

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	2	0	-	-	-	1	1	2	-	1	3	2
C02	1	1	3	1	3	-	1	1	2	3	-	2	3	3
C03	1	1	3	1	3	-	1	1	2	3	-	2	3	3
C04	1	0	1	0	1	-	3	1	2	2	-	2	2	2
C05	1	0	1	0	1	-	3	1	2	2	-	2	2	2

SEMESTER - VII

20MEPL701 SDG NO. 4, 9, 12	COMPUTER AIDED ANALYSIS AND SIMULATION LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To develop the student's skills in proper modeling, meshing, and setting up material properties, loads, and constraints for computer simulation and analysis
- To give exposure to software tools needed to analyze engineering problems
- To expose the students to different applications of simulation and analysis tools
- To provide the analysis skills to interpret and draw conclusion the results of computer analysis

LIST OF EXERCISES

1. Analysis of bar element under axial loads and thermal loads.
2. Analysis of truss structure.
3. Analysis of beams with point load, UDL, UVL, plotting shear force and bending moment diagrams.
4. Analysis of a Plate with various Boundary conditions.
5. Stress analysis of an Axi-symmetric component.
6. Modal Analysis of Beam and Plate Elements.
7. Harmonic Analysis of Beam and Plate Elements.

8. Analysis of Column with Buckling Loads.
9. Steady state heat transfer analysis of composite wall.
10. Vibration analysis of spring-mass systems.
11. Coupled field analysis of a solid object.
12. Fluid flow analysis on circular pipe.
13. Analysis of Joints and Springs.
14. Case Study - Structural/Thermal Analysis.
15. Case Study – Fluid Analysis.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS:

1. Pentium IV computer or better hardware, with suitable graphics facility.
2. Licensed Analysis software – 20 Licenses
3. LASER Printer

ONLINE REFERENCES:

1. <https://studentcommunity.ansys.com/>
2. https://www.mathworks.com/academia.html?s_tid=gn_acad
3. <https://sites.ualberta.ca/~wmoussa/AnsysTutorial/>
4. <https://www.mathworks.com/academia/tah-portal/university-of-alberta-1088131.html>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Analyze and simulate the static solid and structural mechanics problems using FEA software.
2. Understand heat transfer and dynamic analysis.
3. Analyze and simulate fluid flow on pipes.
4. Model, analyse and simulate any problem irrespective of its shape and dimension.

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	-	2	2	-	-	1	-	-	2	3	2
CO2	2	3	2	-	2	2	-	-	2	-	-	2	3	2
CO3	1	1	1	-	2	2	-	-	2	-	-	2	3	2
CO4	3	3	3	-	2	2	1	-	2	-	-	3	3	2

SEMESTER - VII

20MEPJ701 SDG NO. 4, 6,7, 8, 9,11,12,13, 17	PROJECT PHASE - I	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To train the Students for Project Work Phase-II
- To improve the student research and development activities
- To identify industrial problem and solve them
- To develop good written and oral communication skills and leadership skills
- To train the students in preparing the project reports and to face reviews
- To develop the ability to solve a specific Industrial problem
- To accelerate the learning process

GUIDELINES TO BE FOLLOWED:

Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work. Each Group of students are required to select their area of interest either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.

Seminar:

Each student, under the guidance of a Faculty, is required to

1. Present the seminar on the selected project orally and/or through power point slides.
2. Answer the queries and involve in discussion.
3. Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

TOTAL: 60 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to

1. Undertake problem identification, formulation and solution.
2. Communicate with engineers and the community at large in written and oral forms.
3. Demonstrate the knowledge, skills and attitudes of a professional engineer.

CO- PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Co1	3	3	2	2	2	2	2	2	3	2	2	3	3	3
CO2	3	3	3	2	3	3	2	2	3	3	3	3	3	3
CO3	2	2	2	1	2	1	1	1	3	2	3	3	3	2

SEMESTER - VIII

20MEPJ801 SDG NO. 4,6,7, 8, 9,11,12,13,17	PROJECT PHASE-II	L	T	P	C
		0	0	8	4

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students face reviews and viva voce examination.

GUIDELINES TO BE FOLLOWED:

The students may be grouped into 3 to 4 and work under a project supervisor (faculty member) for preparing a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department. The Project Work Phase-II will have the following Sequence:

I. Problem Identification

1. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
2. List of possible solutions including alternatives and constraints
3. Cost benefit analysis
4. Time Line of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]**III. A presentation including the following:**

1. Implementation Phase (Hardware / Software / both)
2. Testing and Validation of the developed system
3. Learning in the Project

IV. Consolidated report preparation**TOTAL: 120 PERIODS****OUTCOMES :****Upon completion of the course, the students should be able to**

1. Comprehend an industrial or real life problem and identify right/ real issue with solution.
2. Complete the necessary studies and review the literature, design a setup of equipment, complete the analysis.
3. Write a project report based on the findings.

CO- PO & PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Co1	3	3	2	2	2	2	2	2	3	2	2	3	3	3
CO2	3	3	3	2	3	3	2	2	3	3	3	3	3	3
CO3	2	2	2	1	2	1	1	1	3	2	3	3	3	2

PROFESSIONAL ELECTIVES - I

20MEEL501 SDG NO. 4, 8,9	GAS DYNAMICS AND JET PROPULSION	L	T	P	C
		3	0	0	3

(Use of Standard Gas Tables is permitted)

OBJECTIVES:

- To understand the basic difference between incompressible and compressible flow.
- To understand the phenomenon of shock waves and its effect on flow.
- To gain some basic knowledge about jet propulsion and Rocket Propulsion.
- To develop documentation, test specifications and procedures for various Jet engines & Rocket engines and motivated to life-long learning to update latest technologies in Jet propulsion & rocket propulsion.

UNIT I BASIC CONCEPTS AND IS ENTROPIC FLOW 9

Steady State Energy Equation, Adiabatic Energy Equation for compressible fluid flow – Stagnation properties and derivations, stagnation state. Mach number, Critical Mach number, Mach wave and Mach cone – Effect of Mach number on compressibility. Bernoulli equation, Sonic velocity.

UNIT II FLOW THROUGH VARIABLE AREA DUCT 9

Isentropic flow through variable ducts – Flow properties, mass flow rate, maximum mass flow rate, Nozzle and Diffusers – Use of Gas tables.

UNIT III FLOW THROUGH CONSTANT AREA DUCT 9

Flows through constant area duct with heat transfer (Rayleigh flow) and Friction (Fanno flow) – and isothermal flow- long pipe , variation of flow properties – Use of tables and charts

UNIT IV NORMAL AND OBLIQUE SHOCKS 9

Governing equations – Variation of flow parameters across normal and oblique shocks – Prandtl – Meyer relations for Normal Shock – Use of table and charts – Applications.

UNIT V JET AND SPACE PROPULSION 9

Gas turbine power plant- theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Jet engine - types : turbojet, turbofan and turbo prop engines. Ram jet and SCRAM jet engines. Pulse jet engine.

Types of rocket engines – Propellants-feeding systems – Ignition and

combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Anderson, J.D., “Modern Compressible flow”, McGraw Hill, 4th Edition, 2021.
2. S.M. Yahya, fundamentals of Compressible Flow, New Age International (P) Limited New Delhi, 6th Edition, 2018.

REFERENCES

1. P. Hill and C. Peterson, Mechanics and Thermodynamics of Propulsion, Addison – Wesley Publishing Company, 2nd Edition, 2009.
2. N.J. Zucrow, Aircraft and Missile Propulsion, vol.1 & II, John Wiley, 1975.
3. N.J. Zucrow, Principles of Jet Propulsion and Gas Turbines, John Wiley, New York, 1970.
4. G.P. Sutton, Rocket Propulsion Elements, John Wiley, 1986, New York.
5. A.H. Shapiro, Dynamics and Thermodynamics of Compressible fluid Flow, John Wiley, New York, 1977.
6. V. Ganesan, Gas Turbines, Tata McGraw Hill Publishing Co., New Delhi, 2004.
7. Pr. S.L. Somasundaram, Gas Dynamics and Jet Propulsions, New Age International Publishers, 1996.
8. V. Babu, Fundamentals of Gas Dynamics, Springer; 2nd Edition, 2021.

WEB RESOURCES:

1. <https://www3.nd.edu/~powers/ame.30332/notes.pdf>
2. <https://encyclopedia2.thefreedictionary.com/Gas+Dynamics>
3. <https://my.mech.utah.edu/~pardyjak/me3700/IntroCompFlow.pdf>
4. http://mae-nas.eng.usu.edu/MAE_6530_Web/ New_Course/ Section4/Section4.1.pdf

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/103/112103021/>
2. <https://nptel.ac.in/courses/101/106/101106040/>
3. <https://nptel.ac.in/courses/112/106/112106196/>
4. <https://nptel.ac.in/courses/112/106/112106166/>
5. <https://nptel.ac.in/courses/101/106/101106044/>
6. <https://nptel.ac.in/courses/112/106/112106056/>
7. <https://nptel.ac.in/courses/112/105/112105182/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Understand the basic concept of incompressible and compressible flow. (K2)
2. Analyse flow through variable area duct in subsonic and supersonic conditions. (K3)
3. Understand the phenomenon of shock waves and its effects. (K3)
4. Apply the concept of compressible flow in constant area ducts systems. (K3)
5. Know the fundamentals and performance of jet and aircraft propulsion. (K2)
6. To gain basic knowledge and performance of jet and aircraft propulsion. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	1	-	-	-	-	-	-	-	-	2	2	2
C02	3	3	1	-	-	-	-	-	-	-	-	2	2	2
C03	3	3	1	-	-	-	-	-	-	-	-	2	2	2
C04	3	3	1	-	-	-	-	-	-	-	-	2	2	2
C05	3	3	1	-	-	-	-	-	-	-	-	2	2	2
C06	3	3	1	-	-	-	-	-	-	-	-	2	2	2

PROFESSIONAL ELECTIVES - I

20MEEL502 SDG NO. 4,7,12,15	POWER PLANT TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce and familiarize the students with different aspects of coal based power plant.
- To apply the concepts of Brayton cycle to Gas Turbine power plants and also to understand the method of power production in Diesel engine power plant.
- To assimilate the knowledge of Nuclear Power production to the students.
- To impart the knowledge of various methods of harnessing power from renewable resources to expose the students about the significance of safety and environmental issues.

UNIT I COAL BASED THERMAL POWER PLANTS**9**

Rankine cycle - improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.

UNIT II DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS**9**

Otto, Diesel, Dual & Brayton Cycle - Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.

UNIT III NUCLEAR POWER PLANTS**9**

Basics of nuclear engineering, Layout and subsystems of Nuclear power plants, Working of nuclear reactors: Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for nuclear power plants.

UNIT IV POWER FROM RENEWABLE ENERGY**9**

Hydro Electric Power Plants – Classification, Typical Layout and associated components including turbines. Principle, construction and working of wind, tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.

UNIT V ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS**9**

Power tariff types, Load distribution parameters, Load curve, Comparison of site selection criteria, relative merits and demerits, Capital and operating cost of different power plants. Pollution control technologies including waste disposal options for coal and nuclear power plants.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Nag. P.K., "Power Plant Engineering", Third Edition, Tata McGraw – Hill Publishing Company Ltd., 2008
2. R.K.Rajput, "A text book of Power Plant Engineering", Fifth Edition

REFERENCES

1. El-Wakil. M.M., "Power Plant Technology", Tata McGraw – Hill Publishing

Company Ltd.,2010.

2. Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.
3. Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, "Power Plant Engineering", Second Edition, Standard Handbook of McGraw – Hill, 1998.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105050/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107291/>
2. <https://nptel.ac.in/courses/112/103/112103277/>
3. <https://nptel.ac.in/courses/112/103/112103243/>
4. <https://nptel.ac.in/courses/112/107/112107216/>
5. <https://nptel.ac.in/courses/109/101/109101171/>
6. <https://nptel.ac.in/courses/103/107/103107157/>
7. <https://nptel.ac.in/courses/109/106/109106161/>
8. <https://nptel.ac.in/courses/121/106/121106014/>
9. <https://nptel.ac.in/courses/112/105/112105221/>
10. <https://nptel.ac.in/courses/112/105/112105051/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. understand the features and operation of Thermal Power Plants. [K2]
2. describe the various systems of Diesel, gas and combined cycle Power Plants. [K3]
3. explain the features and working of different types of nuclear power plants. [K3]
4. understand the different renewable energy power plants. [K2]
5. understand the commercial aspects of power generation and power plant design market. [K3].
6. narrate the pollution and environmental issues associated with various types of power plants. [K2]

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	-	-	-	1	1	-	-	-	-	1	1	2
C02	3	2	-	-	-	1	1	-	-	-	-	1	1	2
C03	3	2	-	-	-	1	2	-	-	-	-	1	1	2
C04	3	2	-	-	-	1	1	-	-	-	-	1	1	2
C05	3	2	-	-	-	1	1	-	-	-	-	1	1	2
C06	3	2	-	-	-	1	2	-	-	-	-	1	1	2

PROFESSIONAL ELECTIVES - I

20MEEL503 SDG NO. 3,4,7, 8,9, 11,12,13,15	ALTERNATE FUELS				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To acquire complete knowledge on availability of possible alternate fuels and their properties to use as fuel in CI and SI engines
- To protect against Global Warming
- To provide opportunities for local energy generation
- To increase the productivity of cleaner fuels

UNIT I NEED FOR ALTERNATE FUELS**9**

An introduction to hydrocarbon fuels, estimate of petroleum reserve and availability, Petroleum refining process, Physio-chemical characteristics of fuels, fuel additives, Need for alternative fuels, applications, types, study of availability, manufacture, storage, handling and dispensing, safety aspects.

UNIT II COMBUSTION, ENGINE PERFORMANCES AND EMISSION**9**

Principle of combustion-Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels - equivalence ratio - fixed bed and fluid bed combustion - fuel and ash handling systems - steam cost comparison with conventional fuels - Engine performance parameters, operating variables that affect SI and CI engine performance, efficiency and emissions, Emission formation in SI and CI engines - UBHC, NO_x, CO, CO₂, particulate emissions, aldehydes, SO_x - Emission effects on health and environment, emission norms- driving cycles - NDIR analyser - Flame Ionisation Detector; Chemiluminescence NO_x analyzer, Gas Chromatograph.

UNIT III GASIFICATION, PYROLYSIS CARBONISATION AND CFC 9

Chemistry of gasification - types – comparison – application – performance evaluation – economics – dual fuelling in IC engines – 100 % gas engines– engine characteristics on gas mode – gas cooling and cleaning systems - pyrolysis - classification- process governing parameters – typical yield rates. carbonization techniques – merits of carbonized fuels.

Catalytic Converter: Types-substrates requirements, properties, thermal and mechanical durability, strength, types, wash coat – design aspects.

Catalysts & Catalyst Deactivation: Catalyst materials – selection– properties – surface area, pore size, pore size distribution, pore structure, pore volume – poisoning – selective and non selective, reactions, sintering – alloying – catalysts wear – chemical and thermal mechanisms- carbon deposits and mechanical factors.

UNIT IV TYPES OF ALTERNATIVE FUELS 9

Alcohol fuels - ethanol & methanol, vegetable oils, fuel composition, fuel induction techniques, blending and fumigation of fuels, applications to engines. LPG and LNG, CNG, producer gas, components, mixtures and kits, fuel supply system, hydrogen combustion characteristics, safety aspects and system development, HCNG, fuel cells, introduction to synthetic fuels: GTL, BTL Production methods of biogas, naturalgas and LPG. properties studies –CO₂ and H₂S scrubbing in biogas – modification required to use in SI and CI Engines- performance and emission characteristics of biogas, NG and LPG in SI and CI engines.

UNIT V BIOFUELS 9

History of usage of straight vegetable oil(SVO) as fuel - biodiesel production from oil seeds, waste oils and algae - process and chemistry - biodiesel health effects / emissions / performance – production of alcoholic fuels (methanol and ethanol) from biomass – engine- oxygenated fuels, biodiesel formulation techniques, transesterification, application in diesel engines, DME (Dimethyl ether), DEE (Diethyl ether), properties, fuel injection consideration. Biomass: generation, characterization, use as energy source, Biogas: aerobic and anaerobic bio-conversion processes, microbial reactions, purification, properties of biogas (composition and calorific value), Storage and enrichment.

FUTURE OF BIOFUELS: Advanced biofuels: the widening portfolio of

alternatives to ethanol; biobutanol and ABE; bacterial production of C3–C7 alcohols and related compounds; glycerol; the Mix Alco process; biohydrogen; microbial fuel cells: environmental impacts of biofuel production-CASE STUDIES

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ayhan Demirbas, “Biodiesel A Realistic Fuel Alternative for Diesel Engines”, Springer-Verlag London Limited 2008, ISBN-13: 9781846289941

REFERENCES:

1. John Heywood “Internal Combustion Engine Fundamentals” 2017
2. Bechtold, Richard. L., “Alternate Fuels – Transportation Fuels for Today and Tomorrow”, Society of Automotive Engineers (SAE) – 2002.
3. “Alcohols as Motor Fuels”, SAE, 2012
4. Watson, E.B., “Alternative fuels for the combustion engine”, ASME, 2011.
5. Eriksson S. and Prior.M, “The briquetting of Agricultural wastes for fuel”, FAO Energy and Environment paper, 1990.
6. Khandelwal K.C., Mahdi S.S., “Biogas Technology – A Practical Handbook”, Tata McGraw Hill, 1986.
7. Mahaeswari R.C., “Bio Energy for Rural Energisation”, Concepts Publication, 1997.
8. David M Mousdale, “Introduction to Biofuels”, CRC Press, 2010.
9. Bhojvaid P P, “Biofuels – towards a greener and secure energy future”, TERI, 2006.

WEB RESOURCES:

1. <https://afdc.energy.gov/fuels/>
2. <https://www.energy.gov/eere/bioenergy/biofuels-basics>
3. <https://www.studentenergy.org/topics/biofuels>
4. <https://www.teriin.org/>

ONLINE RESOURCES:

1. <https://www.edx.org/course/from-fossil-resources-to-biomass-a-chemistry-persp>
2. <https://www.edx.org/course/catalytic-conversions-for-biobased-chemicals-and-p>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Identify the needs of alternate fuels. (K2)
2. Compare the performance and combustion characteristics of IC engines.(K3)
3. Describe the types of gasification system and its merits.(K2)
4. Explain the types and functions of catalytic fuel converter.(K2)
5. Differentiate the various types of alternate fuels.(K2)
6. Analyze the various methods of production of biofuels and its storage.(K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	1	2	-	-	-	-	1	3	2
C02	3	2	-	-	-	2	2	-	-	-	-	-	3	2
C03	3	-	-	-	-	-	1	-	-	-	-	-	3	2
C04	3	-	-	-	-	-	3	-	-	-	-	2	3	2
C05	3	-	-	-	-	1	1	-	-	-	-	2	3	3
C06	3	-	-	-	-	1	1	-	-	-	-	2	3	3

PROFESSIONAL ELECTIVES - I

20MEEL504 SDG NO: 3, 7, 8, 12	THERMAL ENVIRONMENTAL ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Apply principles of thermodynamics, heat transfer and fluid mechanics in designing and simulating air-conditioning systems.
- Apply heat transfer principles in estimating the thermal loads of buildings.
- Estimate the load calculations of buildings.
- Comparative study of different air conditioning & refrigerants equipment and systems.
- Analyse the energy performance of buildings.

UNIT-I INTRODUCTION**9**

Introduction to Heating, Ventilating, Air Conditioning, and Refrigeration. Review of Thermodynamics, Fluid Mechanics, and Heat Transfer. Applications of Air Conditioning and Refrigeration.

UNIT-II HEAT GAINS THROUGH BUILDING ENVELOPES**6**

Solar Heat Gain, Fenestration and Shading Coefficient, Thermal Performance of Building Envelopes, The Overall Thermal Transmittance Value, Green-Mark Incentive Scheme.

UNIT-III COOLING LOAD CALCULATIONS**12**

Manual and computerized methods of load estimation – Air-conditioning design calculations: Sensible and latent loads. Room load ratio line. Supply air quantity. Cooling capacity.

UNIT-IV AIR-CONDITIONING SYSTEMS**9**

All-air, all-water, Air-water, Heat pump and solar assisted systems – Air-conditioning plants, equipment and systems: Vapour Compression Refrigeration. Chillers – Cooling and dehumidifying coils, Cooling towers, district cooling

UNIT-V ENERGY ESTIMATION AND PERFORMANCE ANALYSIS**9**

Energy Estimation and Energy Performance analysis: Computer-aided energy estimation – Energy performance measurement and analysis.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Thomas H. Kuehn, James W. Ramsey, James L. Threlkeld, "Thermal Environmental Engineering", Published by Pearson 3rd Edition, 1998.
2. Stoecker, W.F. and Jones, J.W., "Refrigeration and Air Conditioning", McGraw-Hill Book Company, 2nd Edition, 1983.

REFERENCES

1. ASHRAE Handbook of Fundamentals. Kreider, J.F., Curtiss, P.S. and Rabl, A., "Heating and Cooling of Buildings", McGraw-Hill Inc., 2002.
2. 2011 ASHRAE Handbook - Heating, Ventilating, and Air-Conditioning Applications (SI Edition)

OUTCOMES:

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

1. Illustrate the fundamental principles and applications of Thermal system in buildings. (K2)
2. Present applications of different Air conditioning & refrigeration systems. (K2)
3. Calculate cooling load for air conditioning system in buildings. (K3)
4. Calculate Thermal performance of buildings. (K3)

5. Analyse the refrigeration and air conditioning system performance in buildings.(K3)
6. Analyse the energy estimation & performance of buildings(K3)

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	-	1	-	-	-	-	1	2	3
C02	3	-	-	-	-	1	-	-	-	-	-	-	2	3
C03	2	2	1	-	-	2	-	-	-	-	1	-	2	3
C04	2	2	1	-	-	2	-	-	-	-	1	-	2	3
C05	2	2	2	-	-	2	-	-	-	-	1	-	2	3
C06	2	2	2	-	-	2	-	-	-	-	1	-	2	3

PROFESSIONAL ELECTIVES - I

20MEEL505 SDG NO: 3, 7, 8, 12	ENVIRONMENTAL AND ENERGY MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the principle of working and the components of different non-conventional sources of energy and their utilization.
- To get an exposure on the power plants working with non-conventional energy
- To understand what constitutes the environment, what are precious resources in the environment, how to conserve these resources.
- What is the role of a human being in maintaining a clean environment and useful environment for the future generations
- Understand and analyse the energy data of industries

UNIT I ENERGY AND ENVIRONMENT**9**

Primary energy sources - world energy resources-Indian energy scenario-energy cycle of the earth - environmental aspects of energy utilisation, CO₂ emissions and Global warming-renewable energy resources and their importance. Potential impacts of harnessing the different renewable energy resources

UNIT II POWER FROM RENEWABLE ENERGY**9**

Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.

UNIT III ENVIRONMENTAL POLLUTION**9**

Definition – causes, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards – solid waste management: causes, effects and control measures of municipal solid wastes – role of an individual in prevention of pollution – pollution case studies – disaster management: floods, earthquake, cyclone and landslides.

UNIT IV SOCIAL ISSUES AND THE ENVIRONMENT**9**

From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization environmental ethics: Issues and possible solutions – climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. – Wasteland reclamation – consumerism and waste products.

UNIT V ENERGY MANAGEMENT AND CONSERVATION**9**

Energy - Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization –Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Instruments for energy auditing.

TOTAL : 45 HOURS**TEXT BOOK:**

1. Rai G.D, “Non conventional Energy sources” (2011) Khanna Publishers, New Delhi.
2. Benny Joseph, ‘Environmental Science and Engineering’, Tata McGraw-Hill, NewDelhi, (2017).
3. Turner. W.C., “Energy Management Handbook: 8th Edition Volume II”, Wiley, New York, 2013.
4. Murphy. W.R. and G. Mc KAY, “Energy Management”, Butterworths, London 1987

REFERENCES:

1. Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.

2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.

OUTCOMES:

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

1. Understand the principle of working and the components of different non-conventional sources of energy and their utilization.(K2)
2. Identify the appropriate power plants working with non-conventional energy.(K2)
3. Interpret the environment and the precious resources in the environment.(K3)
4. Analyse the role of a human being in maintaining a clean environment and useful environment for the future generations.(K2)
5. Understand and analyse the energy data of industries.(K3)
6. Acquire the basic knowledge of commercial aspects of energy conservation and energy auditing.(K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	1	-	-	-	-	1	-	-	-	-	-	3	3
C02	3	1	-	-	-	-	2	-	-	-	-	-	3	3
C03	2	2	-	-	-	-	2	-	-	-	-	-	3	3
C04	2	3	-	-	-	2	2	-	-	-	-	-	3	3
C05	2	2	-	-	-	-	2	-	-	-	-	-	3	3
C06	2	3	-	-	-	-	2	-	-	-	-	-	3	3

PROFESSIONAL ELECTIVES - I

20MEEL506 SDG NO. 4, 8,9,11,12	APPLIED HYDRAULICS AND PNEUMATICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamental principles, design and operation of hydraulic and pneumatic machines
- To identify the components, component functions, and maintenance procedures of hydraulic and pneumatic systems
- To study their application in recent automation revolution
- To describe a method of transmitting power from one place to another through the use of a liquid or a gas

UNIT I FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS 9

Introduction to Fluid Power: Advantages and Applications- Fluid power systems – Types of fluids- Properties of fluids and selection. Basics of Hydraulics – Pascal's Law- Principles of flow.

Sources of Hydraulic Power: Classification of Pumps- Construction, Working, Design, Advantages, Disadvantages, Performance. Linear, Rotary-Fixed and Variable displacement pumps.

UNIT II HYDRAULIC CIRCUITS AND CONTROL COMPONENTS 9

Hydraulic Linear Actuators: Cylinders – Types and construction. Fluid Power ANSI Symbol.

Control Components: Direction control, Flow control and Pressure control valves - Types, Construction and Operation - proportional valve- Applications.

UNIT III HYDRAULIC CIRCUITS AND ACCESSORIES 9

Accessories: Accumulator and its types, Intensifier and its types- Applications.

Industrial hydraulic circuits: Regenerative, Pump Unloading, Sequence, Reciprocation, Synchronous, Fail-safe

UNIT IV HYDRAULIC, PNEUMATIC AND ELECTRO PNEUMATIC SYSTEM 9

Hydrostatic transmission, Electro hydraulic circuits, Hydro-Mechanical servo systems.

Compressors- Filter, Regulator, Lubricator, Muffler, Quick Exhaust valves, Pneumatic logic circuits

UNIT V DESIGN OF CIRCUITS AND MAINTENANCE**9**

Sequential circuit design for simple applications using cascade method.

Electro-pneumatic circuits. Selection criteria of pneumatic components – Installation fault finding and maintenance of pneumatic components.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Anthony Esposito.” Fluid Power with Applications”, PHI / Pearson Education, 2005.
2. Srinivasan. R, "Hydraulic and Pneumatic Control", 2nd Edition, Tata McGraw - Hill Education,

REFERENCES

1. Shanmugasundaram. K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006.
2. Majumdar, S. R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGraw Hill, 2001
3. Majumdar, S. R., “Pneumatic Systems – Principles and Maintenance”, Tata McGraw Hill, 2007.
4. Micheal J, Pinches and Ashby, J.G., “Power Hydraulics”, Prentice Hall, 1989.
5. Dudelyt, A Pease and John J Pippenger, “Basic Fluid Power”, Prentice Hall, 1987.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105046/>
2. <http://nitc.ac.in/index.php?url=users/view/270/12/3>
3. <https://www.e4training.com/index.php>
4. <https://www.hydraulicspneumatics.com/learning-resources>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105047/>
2. <https://nptel.ac.in/courses/112/103/112103249/>
3. <https://nptel.ac.in/courses/112/106/112106175/>
4. <https://www.coursera.org/learn/fluid-power>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Explain the basic principles of fluids, pumps and their working.
2. Identify the fluid power symbols, working of hydraulic cylinders and

valves.

3. Describe the Accumulators, Intensifiers and various hydraulic circuits.
4. Summarize the Servo systems, Components of Pneumatics and Logic Circuits
5. Design the Hydraulic and Pneumatic circuits; explain the maintenance procedure of pneumatic systems.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	3	-	-	-	1	1	-	-	-	-	-	1	2	2
C02	2	-	-	-	1	1	-	-	-	-	-	1	2	2
C03	2	-	-	-	1	1	-	-	-	-	-	2	2	2
C04	2	-	-	-	1	1	-	-	-	-	1	2	2	2
C05	2	-	-	-	1	1	-	-	-	-	1	2	2	2
C06	2	-	-	-	-	-	-	-	-	-	-	1	2	2

PROFESSIONAL ELECTIVES - I

20MEEL507 SDG NO. 4,8,9,12	ROBOT KINEMATICS AND DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To analyze and determine the kinematic and dynamic models of robots and control systems design motion and strength
- To analyze, design and implement advanced robotic applications
- To demonstrate various concepts by working out problems and exercises relevant to real time applications involving innovative mechanisms and robotic chains
- To undertake research topics in the field of robot modeling and control

UNIT I INTRODUCTION

9

Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots.

UNIT II DIRECT & INVERSE KINEMATICS

9

Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis,

three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two axis Three axis, Four axis and Five axis robots

UNIT III WORKSPACE ANALYSIS

9

Workspace analysis of Four axis, Five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures

UNIT IV DIFFERENTIAL MOTION AND STATICS

9

The tool Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.

UNIT V DYNAMIC ANALYSIS , FORCES AND TRAJECTORY PLANNING

9

Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot. Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straightline motion.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", PHI Learning, 2009.
2. Niku S B, "Introduction to Robotics, Analysis, Systems, Applications", Prentice Hall, 2001.

REFERENCES

1. John J Craig, "Introduction to Robotics", Pearson, 2009.
2. Deb S R and Deb S, "Robotics Technology and Flexible Automation", Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S K, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd, 2010.

WEB RESOURCES:

1. <https://blog.robotiq.com/how-to-calculate-a-robots-forward-kinematics-in-5-easy-steps>

2. <https://www.sciencedirect.com/topics/engineering/trajectory-planning>
3. https://en.wikibooks.org/wiki/Robotics/Navigation/Trajectory_Planning

ONLINE RESOURCES:

1. <https://h2t.anthropomatik.kit.edu/pdf/Vahrenkamp2016.pdf>
2. <https://www.youtube.com/watch?v=Fd7wjZDoh7g>
3. https://www.youtube.com/watch?v=1U6y_68CjeY

OUTCOMES:

Upon completion of the course, the students should be able to

1. Able to learn the basic structure of robot, its specifications and basics of kinematics.(K1)
2. Analyse forward and inverse kinematics upto five axis robots.(K2)
3. Perform workspace analysis and camera calibration.(K2)
4. Manipulate joint motion and forces.(K2)
5. Perform dynamic analysis and trajectory planning.(K3)
6. Implement basic principles of motion for effective arm movement.(K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	2	2	-	-	-	-	1	-	-	2	2	2
C02	3	3	3	3	-	-	-	-	1	-	-	2	2	2
C03	3	3	3	3	-	-	-	-	1	-	-	2	2	2
C04	3	3	3	3	2	-	-	-	1	-	-	2	2	2
C05	3	3	3	3	2	-	-	-	1	-	-	2	2	2
C06	3	3	3	3	2	-	-	-	1	-	-	2	2	2

PROFESSIONAL ELECTIVES - I

20MEEL508 SDG NO. 4,9,11	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To equip students with a wide ranging knowledge of the response of solid materials to stress
- To build knowledge on structure of materials and its relationship to mechanical properties
- To gain in depth knowledge about dislocation theories of plasticity behavior, various strengthening mechanisms and fracture mechanics
- To learn about failure mechanisms due to fatigue and creep
- To select a Material according to various considerations for a specific application

UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR

9

Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test, bonding and material behaviour, elasticity in metals– Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, polyphase mixture, precipitation, particle, fiber and dispersion strengthening.

UNIT II YIELDING AND PLASTIC DEFORMATION

9

Hydrostatic and deviatoric stress, octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, stress - strain relation in plasticity, plastic deformation of metals and polymers.

Types of fracture, Basic mechanisms of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification. Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, Determination of DBTT. Fracture mechanics-Introduction, Modes of fracture, Stress intensity factor, Fracture toughness and Determination of K_{IC}.

UNIT III BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES

9

Stress intensity factor and fracture toughness – Fatigue, low and high cycle fatigue test Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, crack initiation and propagation mechanisms and Paris law. Safe life, stress-life, strain-life and fail -

safe design approaches., Cumulative damage- Miner law, HCF / LCF, creep-fatigue interactions, micro- mechanisms of fatigue crack initiation and growth, fatigue testing machines- Paris's Equation, Residual life prediction under Fatigue. Macro, Microstructural features of fatigue fracture.

Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep.

UNIT IV SELECTION OF MATERIALS

9

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto: marine, machinery and nuclear applications – Computer aided materials selection.

UNIT V MODERN METALLIC MATERIALS

9

Dual phase steels, High strength low alloy (HSLA) steel, transformation induced plasticity (TRIP) steel, maraging steel, nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dieter, G.E., “Mechanical Metallurgy”, McGraw-Hill, SI Edition, 1995.

REFERENCES:

1. Bhargava A K & Sharma C P, “Mechanical behavior and Testing of materials” PHI learning 2011.
2. Norman E Dowling, “Mechanical Behaviour of Materials, Pearson 2013.
3. Prashant Kumar, “Elements of Fracture Mechanics”, McGraw-Hill, 2009.
4. Shetty M N, Dislocations and mechanical behavior of materials”, PHI learning 2013.
5. William F.Hosford, “Mechanical behaviour of Materials”, Cambridge University press, 2010

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104122/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/113/103/113103072/>
2. <https://nptel.ac.in/courses/112/103/112103278/>
3. <https://nptel.ac.in/courses/113/106/113106088/>
4. <https://nptel.ac.in/courses/112/101/112101095/>

5. <https://nptel.ac.in/courses/113/106/113106075/>
6. <https://www.edx.org/course/mechanical-behavior-of-materials-part-1-linear-ela>
7. <https://www.edx.org/course/mechanical-behavior-of-materials-part-2-stress-tra>
8. <https://www.edx.org/course/mechanical-behavior-of-materials-part-3-time-depen>

OUTCOMES:

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

1. Interpret the mechanical properties and behaviour of materials. (K2)
2. Understand the concept of fracture mechanics (K2)
3. Identify engineering problem in using material testing. (K3)
4. Describe the mechanism of failure with examples. (K2)
5. Select a suitable material for specific application (K3)
6. Identify types of metallic materials available and its applicability. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	1	1	-	-	2	1	-	-	-	-	-	2	2
C02	2	2	1	-	-	2	1	-	-	-	-	-	2	2
C03	2	2	2	1	-	1	1	-	-	-	-	-	2	2
C04	3	2	2	2	-	2	1	-	-	-	-	-	2	2
C05	2	2	2	1	-	1	2	-	-	-	-	-	2	2
C06	1	2	-	-	-	-	-	-	-	-	-	-	2	2

PROFESSIONAL ELECTIVES - I

20MEEL509 SDG NO. 4,9,12	PRODUCT DESIGN AND DEVELOPMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide basic concepts of product design, product features and its architecture
- To gain basic knowledge about the common features of a product
- To develop qualities and characteristics of products
- To design a product that is easily and economically manufactured

UNIT I INTRODUCTION TO PRODUCT DESIGN AND INNOVATION 9

Need for Innovation and design, User Innovation, Introduction to product and Product design. Difference between Product development and product design, Need: Problem Identification, User study by contextual enquiry, Questionnaire study, Interview techniques, Persona and scenario mapping, Product Study and market study, Design Brief

UNIT II CONCEPTS GENERATION AND EVALUATION 9

Importance of Human factors in product design, Physical Ergonomics principles and issues, Ergonomic assessment tool, Cognitive issues in product design, Creative techniques and tools for Concept generation, concept evaluation, Product prototyping model making work flow, tools and techniques for model making and prototyping, introduction to prototype driven innovation, Overview of materials and processes, Evaluation tools and techniques for User- Product interaction

UNIT III PRODUCT ARCHITECTURE 9

Implications, Product change , variety, Component Standardization , Product performance, manufacturability – product development management , Establishing the architecture – creation – clustering – geometric layout development – fundamental and incidental interactions – related system level design issues – secondary systems – architecture of the chunks – creating detailed interface specifications.

UNIT IV INDUSTRIAL DESIGN AND CASE STUDIES 9

Integrate process design – Managing costs, Robust design, Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing processes electronically, Need for industrial design – impact – design process – investigation of industrial design – impact – design process – investigation of customer needs – conceptualization – refinement – management of the industrial design process – technology driven products – user driven products – assessing the quality of industrial design. Case Studies

UNIT V DESIGN FOR MANUFACTURING 9

Design for Manufacturing: Over the wall design, most in influential phase in design, best practices in injection molding and sheet metal working, Design for additive manufacturing, single point and multipoint tools, Design for Assembly: Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method, Do's and don'ts in manual assembly, assembly time estimation, design for robotic assembly considerations. Design for sustainability

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Karl T.Ulrich and Steven D.Eppinger, "Product Design and Development", McGraw-Hill International Edns. 1999.

REFERENCES

1. Kenneth Crow,"Concurrent Engg./Integrated Product Development", DRM Associates,26/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
2. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
3. Staurt Pugh, "Tool Design – Integrated Methods for Successful Product Engineering", Addison Wesley Publishing, New York, NY

WEB RESOURCES:

1. <https://nptel.ac.in/courses/107/104/107104076/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/107/103/107103082/>
2. <https://nptel.ac.in/courses/107/101/107101086/>
3. <https://nptel.ac.in/courses/107/101/107101088/>
4. <https://nptel.ac.in/courses/112/107/112107258/>
5. <https://nptel.ac.in/courses/112/106/112106249/>

OUTCOMES:**Upon completion of the course, the students should be able to**

1. Understand basic concepts of Product Design, Development and Innovation (K1)
2. Generate concepts and selection for the design of a product. (K2)
3. Describe the Product Architecture.(K2)
4. Know the Industrial Design procedure.(K2)
5. Explain the Design for Manufacturing for Product development. (K2)
6. Gain enough knowledge to generate concepts and convert those concepts into ergonomic and aesthetic design (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	-	2	2	2	3	3	1	2	3	3	3	3	1	2
C02	2	2	1	2	2	-	-	1	3	3	3	3	1	2
C03	2	2	3	3	2	1	1	3	2	3	3	3	2	3
C04	2	3	2	3	3	1	-	2	3	3	3	3	2	3
C05	-	2	1	3	2	1	1	1	3	3	3	3	1	3
C06	-	2	1	3	2	1	1	1	3	3	3	3	1	3

PROFESSIONAL ELECTIVES - I

20MEEL510 SDG NO. 4,9,12	NON TRADITIONAL MACHINING			L	T	P	C
	TECHNIQUES			3	0	0	3

OBJECTIVES:

- To learn about various Non-traditional Machining processes, their process parameters and influence on the performance of end components
- To select appropriate machining technique for machining advanced materials
- To select appropriate machining technique for machining components with very tight tolerances
- To update the students with latest technological developments and research trends in the field of Non-traditional Machining.

UNIT I INTRODUCTION AND MECHANICAL ENERGY BASED PROCESSES**9**

Unconventional machining Process – Need – classification – merits, demerits and applications. Abrasive Jet Machining – Water Jet Machining – Abrasive Water Jet Machining - Ultrasonic Machining. (AJM, WJM, AWJM and USM). Working Principles – equipment used – Process parameters – MRR- Applications. Numerical Problems

UNIT II THERMAL AND ELECTRICAL ENERGY BASED PROCESSES**9**

Electric Discharge Machining (EDM) – Wire cut EDM – Working Principle- equipments-Process parameters-Surface Finish and MRR- electrode / Tool – Power and control Circuits-Tool Wear – Dielectric – Flushing -- Applications. Laser beam machining and drilling, Plasma arc machining (PAM), Electron Beam Machining (EBM) and Ion Beam Machining (IBM). Principles –

Equipment – Types - Beam control techniques – Applications. Numerical Problems

**UNIT III CHEMICAL AND ELECTRO-CHEMICAL ENERGY
BASED PROCESSES**

9

Chemical machining - Etchants – Maskant - techniques of applying maskants - Principles of Electro Chemical Machining (ECM) - equipments - Process Parameters, MRR and Surface Finish. Electro Chemical Grinding (ECG) and Electro Chemical Honing (ECH), Electro Stem Drilling (ESD) - Applications. Numerical Problems

UNIT IV ADVANCED FINISHING PROCESSES

9

Abrasive flow machining, chemo-mechanical polishing, magnetic abrasive finishing, magneto rheological finishing, magneto rheological abrasive flow finishing, plasma assisted polishing: their working principles, equipments, effect of process parameters, applications, advantages and limitations- Recent developments in finishing process.

**UNIT V RECENT TRENDS IN NON-TRADITIONAL MACHINING
PROCESSES**

9

Recent developments in non-traditional machining processes, their working principles, equipments, effect of process parameters, applications, advantages and limitations. Comparison of non-traditional machining processes, Bio Machining, Ice Jet Machining, Elastic Emission Machining (EEM), Hybrid Machining Process – Micromachining and Nano machining, Non Traditional Machining in Industry 4.0.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Vijay.K. Jain “Advanced Machining Processes” Allied Publishers Pvt. Ltd., New Delhi, 2009
2. Pandey P.C. and Shan H.S. “Modern Machining Processes” Tata McGraw-Hill, New Delhi, 2017.

REFERENCES

1. Benedict. G.F. “Nontraditional Manufacturing Processes”, Marcel Dekker Inc., New York, 2019.
2. Mc Geough, “Advanced Methods of Machining”, Chapman and Hall, London, 1998.
3. Paul De Garmo, J.T.Black, and Ronald. A.Kohser, “Material and Processes in Manufacturing”, Prentice Hall of India Pvt. Ltd., 8th Edition, New Delhi, 2001.

WEB RESOURCES:

1. <http://nitc.ac.in/index.php?url=users/view/270/12/3>
2. <http://home.iitk.ac.in/~vkjain/micromachining.html>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104028/>
2. <https://nptel.ac.in/courses/112/103/112103202/>
3. <https://nptel.ac.in/courses/112/105/112105212/>
4. <https://nptel.ac.in/courses/112/103/112103250/>
5. <https://nptel.ac.in/courses/112/103/112103264/>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Classify various Mechanical Energy based Non Traditional Machining processes. (K1)
2. Compare various Thermal energy and Electrical energy based Non Traditional Machining processes. (K2)
3. Summarize various chemical and electro-chemical energy based Non Traditional Machining processes. (K1)
4. Explain various Nano Finishing processes. (K2)
5. Gain knowledge about recent trends and developments in Non Traditional Machining (K2)
6. List the merits, demerits and applications of various non-traditional machining process. (K1)

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C02	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C03	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C04	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C05	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C06	2	2	2	2	1	1	-	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - I

20MEEL511 SDG NO. 4,9,11,12	MATERIAL JOINING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study various Materials Joining Process for various Industrial Applications
- To learn the latest techniques and procedures for beginning to advanced welding
- To select appropriate Joining technique for a particular material and thickness
- To build a strong foundation of skill and knowledge in preparation for a successful career in the welding and metal fabrication fields

UNIT I GAS AND ARC WELDING TECHNIQUES 9

Classification of welding processes, Conventional Gas Welding Techniques, Conventional fusion welding processes-Principal heat sources. Physics and Power Sources of the Welding Arc, Filler Materials and Gases for Arc Welding, Selection of Process Control variables. SMAW, SAW, FCAW, MIG, TIG- Their variants and advancements. Welding Consumables and its Advancements.

UNIT II ELECTRICAL RESISTANCE BASED JOINING PROCESSES, BRAZING AND SOLDERING 9

Electrical welding, Resistance welding processes: spot welding, seam welding, projection welding, high- frequency resistance welding, resistance butt welding, flash butt welding, Brazing, Adhesive bonding, Clinching, Self Pierce Riveting, Soldering

UNIT III SOLID STATE JOINING PROCESSES 9

Fundamental principles of solid-state joining processes, ultrasonic welding, ultrasonic spot welding, explosion welding process

Diffusion joining, principles, applications. Diffusion brazing, Diffusion Bonding Metals to Ceramics; Solid-State deposition welding processes. Pressure non-fusion welding processes: cold welding processes, electromagnetic pulse welding, pressure gas welding process, hot pressure welding, forge welding process; Roll bonding

UNIT IV FRICTION BASED JOINING PROCESS 9

Friction Welding Process: Friction welding (FW) process, Process parameters, applications, Spin welding, Rotary drive FW (continuous drive),

Inertia welding, Friction taper stitch welding, Radial FW, Friction plunge welding, Third-body FW. Friction seam welding, Linear and angular FW, Orbital FW, Friction brazing, Friction seam welding and Friction Stud Welding

Friction Stir Welding Process: Fundamentals of Friction Stir Welding (FSW) process; Taxonomy of FSW. Materials used with FSW; Material Changes during Solid-State Joining and Its Impact, environmental and energy benefits, micro FSW, and its applications.

UNIT V OTHER WELDING TECHNIQUES

9

Introduction to Micro joining and Nano joining techniques, High Energy Density Process- LASER, EBM and Plasma Welding, Underwater Welding, Thermit Welding, Atomic Hydrogen Welding, Cold Metal Transfer (CMT) Welding, Magnetically Impelled Arc Butt (MIAB) welding, Electroslag Welding. Narrow gap Welding techniques. Manual Control Techniques- Monitoring-Automated Control Techniques, Welding Automation Techniques, Sustainability in Materials Joining

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Parmer R.S., "Welding Engineering and Technology", 1st Edition, Khanna Publishers, New Delhi, 2008
2. Parmer R.S., "Welding Processes and Technology", Khanna Publishers, New Delhi, 1992.

REFERENCES:

1. Nadkarni S.V. "Modern Arc Welding Technology", Oxford IBH Publishers, 1st Edition, 2005.
2. Schwartz M.M. "Metals Joining Manual". McGraw Hill Books, 1979.
3. Tylecote R.F. "The Solid Phase Welding of Metals". Edward Arnold Publishers Ltd. London.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107090/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/103/112103263/>
2. <https://nptel.ac.in/courses/112/103/112103244/>
3. <https://nptel.ac.in/courses/112/107/112107089/>
4. <https://nptel.ac.in/courses/113/106/113106087/>
5. <https://nptel.ac.in/courses/114/105/114105004/>
6. <https://nptel.ac.in/courses/113/106/113106067/>

7. <https://nptel.ac.in/courses/113/106/113106082/>
8. <https://nptel.ac.in/courses/112/107/112107257/>

OUTCOMES:

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

1. Know various Advancements in Fusion Welding techniques. (K1)
2. Understand various Electric Resistance based Joining process, Brazing and Soldering. (K2)
3. Understand various Solid State Joining Process. (K2)
4. Understand various Friction and Friction Stir Welding Process and their variants. (K2)
5. Gain knowledge about Special Welding techniques, Welding Automation and Control techniques. (K2)
6. List merits, demerits and applications of various metal joining process. (K1)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	2	2	2	1	1	1	-	-	-	-	2	3	2
C02	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C03	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C04	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C05	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C06	2	2	2	2	1	1	-	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - I

20MEEL512 SDG NO. 4,8,9,12	PRECISION MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To focus the design and development of highly accurate components
- To achieve the best synergy between accuracy, precision, and tolerance
- To achieve miniaturization and high packing densities
- To gain knowledge on Micro and Nano Manufacturing practices.

UNIT I ELEMENTS OF PRECISION ENGINEERING**9**

Introduction - Precision, Accuracy & Smoothness - Need - Development of overall machining precision - Classes of achievable machining Accuracy - Precision machining - High precision Machining - Ultra precision Machining - application of precision machining - Materials for tools and machine elements - carbides - ceramic, CBN & diamond - Tool and work material compatibility.

UNIT II PRECISION MACHINE COMPONENTS**9**

Introduction - Guide ways - Drive systems - Spindle drive - preferred numbers - Rolling elements - hydrodynamic & hydrostatic bearings - Hybrid fluid bearings - Aero static and aero dynamic bearings - Hybrid gas bearings - materials for bearings.

UNIT III ERROR CONTROL**9**

Error - Sources - Static stiffness - Variation of the cutting force - total compliance - Different machining methods - Thermal effects - heat source - heat dissipation - Stabilization - decreasing thermal effects - forced vibration on accuracy - clamping & setting errors - Control - errors due to locations - principle of constant location surfaces.

UNIT IV MICRO MANUFACTURING TECHNIQUES**9**

Micro machining processes - Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining, diamond machining - micro engraving - Micro replication techniques - forming - casting - injection moulding - micro embossing - Energy assisted processes - LBM, EBM, FIB, Micro electro discharge machining - photolithography - LIGA process - Silicon micro machining - Wet and dry etching - thin film deposition, Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Advancements in Micromanufacturing

UNIT V NANO TECHNOLOGY AND NANO FABRICATION TECHNIQUES 9

Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws/Sizing effects, Nano materials - safety precautions

Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing, Advancements in Nanomanufacturing.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Venkatesh V.C. and Izman S., "Precision Engineering", Tata McGraw Hill, 2007.

2. Murthy R.L., "Precision Engineering", New Age International, 2009.

REFERENCES:

1. Marc Madou, Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition CRC Press, 2002.
2. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
3. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
4. Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture," McGraw- Hill, 2008.

WEB REFERENCES:

1. <https://sciencedirect.com>
2. <https://link.springer.com>
3. <https://tandfonline.com>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105231/>
2. <https://nptel.ac.in/courses/112/104/112104162/>
3. <https://nptel.ac.in/courses/112/104/112104181/>
4. <https://nptel.ac.in/courses/117/108/102108078/>

OUTCOMES:**Upon completion of the course, the student should be able to:**

1. Understand the basics of Precision Engineering terminologies. (K1)
2. Gain knowledge about mitigating the Errors while Manufacturing. (K1)
3. Design and analyze methods and tools for micro and nano-manufacturing. (K2)
4. Select micro and nano-manufacturing methods and identify key variables to improve quality of Product. (K2)
5. Choose appropriate industrially viable process, equipment and tools for a specific product. (K2)
6. Grasp the advancements in Micro and Nano Manufacturing process. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	3	2	2	-	3	-	2	-	-	3	3	3
C02	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C03	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C04	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C05	3	2	2	3	2	-	3	-	2	-	-	3	3	3
C06	2	2	2	3	2	-	3	-	2	-	-	3	3	3

PROFESSIONAL ELECTIVES - I

20MEEL513 SDG NO. 4,8,9,12	METAL ADDITIVE MANUFACTURING PROCESSES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To develop a comprehensive understanding of fundamental Metal Additive Manufacturing
- To provide students with the latest knowledge and skills for Metal Additive Manufacturing
- To build products regardless of the complexity of the part, and expected to alter the cycle involved in product development
- To apply engineering knowledge, techniques, skills and modern tools to analyse problems in Metal Additive Manufacturing

UNIT I INTRODUCTION TO METAL ADDITIVE MANUFACTURING 9

Introduction to Metal Additive Manufacturing (MAM), Evolution of MAM, Distinction between MAM and Additive Manufacturing (AM), Path Planning Techniques in MAM, Design considerations for MAM

Materials science for MAM: Multifunctional and graded materials in MAM, Role of solidification rate, Evolution of non-equilibrium structure, Microstructural studies, Structure property relationship, Loss of Alloying Elements, Cracking & Delamination, Distortion, Residual Stresses in MAM Components

Post Processing of MAM Parts: Support Material Removal, Surface Texture Methodologies and its Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques, Various Inspection techniques of MAM components

UNIT II BINDER JETTING & SHEET LAMINATION PROCESS 9

Binder Jetting (BJ): BJ process features and parameters effect, Powder Characteristics- Density, Morphology, Powder selection, Powder Rheology, Powder feeding and layer building; Role of Binders, Part consolidation stage in BJ.

Thermal Inkjet 3D Printing: Process physics, Equipment, Inks, Binder formulation, Hybrid binders, AM metal substrates for inkjet-printing of smart devices, Photonic Curing/Sintering, Online droplet monitoring using catadioptric stereo system, Challenges faced

Ultrasonic Consolidation: Equipments, Process Parameters, Interlaminar Bond Interface Quantification, Sonotrode Texture Importance, Plastic Flow and Work Hardening during UAM, Interlaminar Sub-Grain Refinement, Optimal design for additive manufacturing of heterogeneous objects using ultrasonic consolidation

UNIT III POWDER BED FUSION PROCESS 9

Direct Metal LASER Sintering (DMLS): Process, Sintering Mechanism, Scan Speed, Hatch Spacing, Layer Thickness, Hatch Pattern, LASER Spot Size, Laser-equipped RM techniques, Laser engineering net shaping (LENS), Laser-based cell printing techniques, Laser Powder Bed Fusion (LPBF)

Selective LASER Sintering (SLS): Process, Parameters, Equipments, Microstructural modification of additively manufactured metals by electropulsing in SLS components, Advancements in SLS

Selective LASER Melting (SLM): Process characteristics, Processing parameters, Characteristics of the melt pool, Microstructural features and Mechanical properties of SLM-processed metallic parts, In-situ alloying in laser-based additive manufacturing processes, Development of Micro Selective Laser Melting

Electron Beam Melting (EBM): Process cycle, Key Parameters, Material consolidation, Microstructure and in-situ heat treatment, Additional Equipment Necessary, Applications and future prospects.

Comparison of Electron and Laser Beam Melting Systems, Thermal analysis applied to LASER and Electron beam interactions with matter

UNIT IV DIRECT ENERGY DEPOSITION PROCESS**8**

Electron Beam Free form Fabrication: Equipments, Control Methods, Productivity Enhancement, Online Measurement of Deposit Surface, Advances and future scope

Wire-LASER Additive Manufacturing (WLAM): Equipments, Process Parameters

Wire Arc Additive Manufacturing (WAAM): Wire arc additive manufacturing (WAAM) systems: Gas metal arc and Plasma welding based additive manufacturing, Materials processing challenges in WAAM, Classification of primary process selections in WAAM, Classification of ancillary processes in WAAM- Oscillation-based, Wire feeder based oscillations, Workpiece based oscillations.

UNIT V ADVANCES IN METAL ADDITIVE MANUFACTURING**9**

Friction based Additive Manufacturing (FBAM): Classification of existing FBAM technologies on the basis of their working principle-Friction deposition, Friction Surfacing, Friction stir additive manufacturing (FSAM), Additive friction stir (AFS), Friction-forging tubular additive manufacturing (FFTAM).

Metal Hybrid Additive Manufacturing (MHAM) Process: Metal HAM with multiple thermal energy sources, Metal HAM with material removal processes, Metal HAM with forming processes, Physical mechanisms in hybrid additive manufacturing: A process design framework, Additive-Subtractive Manufacturing- Case studies and economics, Hybrid laser Additive manufacturing

Applications of Metal Additive Manufacturing in various sectors: Ship Building, Space, Aerospace, Automotive, Medical, etc.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. LinkanBian, NimaShamsaei and John Usher: "Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties", 1st Edition, CRC Press, 2017
2. Srivatsan.TS and Sudarshan.TS: "Additive manufacturing : innovations, advances, and applications", 1st Edition, CRC Press, 2016
3. Sandeep Rathee, Manu Srivastava, Sachin Maheshwari, T.K. Kundra and Arshad Noor Siddiquee: "Friction Based Additive Manufacturing Technologies: Principles for Building in Solid State, Benefits, Limitations, and Applications", 1st Edition, CRC Press, 2018

REFERENCES:

1. John O. Milewski: "Additive Manufacturing of Metals: From Fundamental

Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry”, 1st Edition, Springer, 2017.

2. Richard Leach and Simone Carmignato: “Precision Metal Additive Manufacturing”, 1st Edition, CRC Press, 2020
3. Leila Ladani: “Additive Manufacturing of Metals: Materials, Processes, Tests, and Standards”, DEStech Publications, 2020
4. K.R. Balasubramanian and V. Senthilkumar: “Additive Manufacturing Applications for Metals and Composites”, 1st Edition, IGI Global, 2020
5. David.J.Fisher: “Additive Manufacturing of Metals”, Materials Research Forum LLC, 2020

WEB REFERENCES:

1. <https://www.metal-am.com/>
2. <https://www.asme.org/learning-development/find-course/design-additive-manufacturing-metals>
3. <https://www.mmsonline.com/zones/additive>
4. <https://additivemanufacturing.com/am-service-provider/>
5. <https://wipro-3d.com/>
6. <https://www.sciencedirect.com/>
7. <https://link.springer.com/>
8. <https://www.tandfonline.com/>

ONLINE RESOURCES:

1. <https://www.coursera.org/lecture/high-throughput/additive-manufacturing-metals-Dxsjj>
2. https://www.coursera.org/learn/additive-technologies-in-metallurgy-mechanical-engineering?trk_location=query-summary-list-link
3. <https://learn-xpro.mit.edu/additive-manufacturing>
4. <https://www.futurelearn.com/courses/general-introduction-to-metal-additive-manufacturing>
5. <https://www.linkedin.com/learning/additive-manufacturing-metal-3d-printing>

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Understand the working principle and process parameters of Metal Additive Manufacturing processes. (K1)
2. Explore the applications of Metal Additive Manufacturing processes in various fields. (K2)
3. Select the suitable material and process for fabricating a given product.

(K2)

4. Apply the knowledge in Material science in Metal Additive Manufacturing. (K2)
5. Understand about the relationships between Metal Additive Manufacturing process phenomena, part accuracy and surface finish. (K1)
6. Gain knowledge in Advancements in Metal Additive Manufacturing process and equipments. (K1)

CO- PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C02	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C03	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C04	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C05	2	2	2	2	1	1	-	-	-	-	-	2	3	2
C06	2	2	2	2	1	1	-	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - I

20MEEL514 SDG NO. 4, 8,9,12	PROCESS PLANNING AND COST ESTIMATION				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To introduce the process planning concepts and to make cost estimation for various products and processes.
- To determine the methods by which a product is to be manufactured economically and competitively
- To prepare a detailed specification which lists the operations, tools, facilities and instructions that describes how to manufacture the product and its parts.
- To prepare the functional requirements of the product, quantity, tools and equipment, and eventually the cost for manufacture.

UNIT I INTRODUCTION TO PROCESS PLANNING**9**

Introduction – methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-Production equipment and tooling selection

UNIT II PROCESS PLANNING ACTIVITIES**9**

Process parameters calculation for various production processes-Selection jigs and fixtures- selection of quality assurance methods - Set of documents for process planning-Economics of process planning- case studies

UNIT III INTRODUCTION TO COST ESTIMATION**9**

Importance of costing and estimation –methods of costing-elements of cost estimation –Types of estimates-Estimating procedure- Estimation of labour cost, material cost- allocation of overhead charges- Calculation of depreciation cost

UNIT IV PRODUCTION COST ESTIMATION**9**

Estimation of Different Types of Jobs - Estimation of Forging jobs, Estimation of Welding Jobs, Estimation of Foundry jobs.

UNIT V MACHINING TIME CALCULATION**9**

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of Machining time for different lathe operations - drilling and boring - milling, shaping and planning - grinding

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Peter Scallan, "Process planning, Design/Manufacture Interface", Elsevier science technology Books, June 2003.
2. M.Adithyan, "Process Planning and Cost Estimation", New Age International Publishers, 2007.

REFERENCES:

1. Ostwalal P.F. and Munez J., "Manufacturing Processes and systems", 9th Edition, John Wiley, 1998.
2. Russell R.S and Tailor B.W, "Operations Management", 4th Edition, PHI, 2003.
3. Chitale A.V. and Gupta R.C., "Product Design and Manufacturing", 2nd Edition, PHI, 2002.

WEB RESOURCES:

1. <http://www.ignou.ac.in/upload/Unit-9-CRC.pdf>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/110/101/110101132/>

OUTCOMES:

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

1. Select the process, equipment and tools for various industrial products.(K2)
2. Prepare process planning activity chart. (K2)
3. Determine the cost of a product by applying the knowledge of basic elements of cost.(K2)
4. Calculate the cost of a product based on the method of manufacturing such as Forging, Welding and Foundry.(K2)
5. Estimate the machining time of a component involving Lathe, Drilling and Boring operations. (K2)
6. Estimate the machining time of a component involving Shaping, Planning, Milling and Grinding operations. (K2)

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	1	1	1	2
CO2	1	1	-	-	-	-	-	-	-	-	1	1	1	2
CO3	2	2	-	-	-	-	-	-	-	-	1	1	1	2
CO4	2	2	-	-	-	-	-	-	-	-	1	1	1	2
CO5	2	2	-	-	-	-	-	-	-	-	1	1	1	2
CO6	2	2	-	-	-	-	-	-	-	-	1	1	1	2

PROFESSIONAL ELECTIVES - I

20MEEL515 SDG NO: 4, 8, 9, 12	INDUSTRIAL ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To establish methods for improving operations and controlling production costs.
- To develop ways of reducing costs.
- To Design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and environments
- To improve efficiency of production processes and simultaneously ensuring worker safety.

UNIT I WORKSYSTEM DESIGN AND WORK STUDY

9

Work Study: Basic Concept, Steps Involved in Work Study, Concept of Work Content, Techniques of Work Study, Human Aspects of Work Study.

Method Study: Basic Concept, Steps Involved in Method Study, Recording Techniques, Operation Process Charts-Examples.

Motion Study: Principles of Motion Economy, Micro-Motion Study, Therbligs, SIMO Charts.

Memo-Motion Study, Cycle graph and Chrono-Cycle Graph, Critical Examination Techniques, Development and Selection of New Method, Installation and Maintenance of Improved Methods.

Work Measurement: Basic Concept, Techniques of Work Measurement, Steps Involved in Time Study, Time Study Equipment, Performance Rating. Performance Rating: Examples, Allowances, Computation of Standard Time, Numerical on Computation of Standard Time, Case Study

UNIT II PLANT LAYOUT AND MATERIAL HANDLING

9

Plant Layout: Factors affecting location decisions, Facilities Requirement-Location and layout-Need for a layout study - Objectives and Features of a good Layout-Factors influencing layout - Classification- product, process, cellular and fixed position layouts

Concepts and Designing for Process layout: CRAFT, ALDEP, CORELAP – Trends in computerized layout, Algorithms and models for Group Technology - ROC and Bond Energy Algorithms.

Line balancing for Product Layout: Objectives, Line balancing techniques – Largest Candidate rule- Kilbridge and Wester method- RPW method-COMSOAL.

Material Handling: Objectives and benefits of Material handling, Relationship between layout and Material handling, Principles of material handling, Unit load concept, Classification of material handling equipments, Equipment selection, Packaging

UNIT III PROJECT PLANNING AND CONCURRENT ENGINEERING 9

Project Management, Concepts and Definitions, Project Management Cycle, Risk associated with Projects Decision, Tree Modeling, Cost Evaluation Techniques in Project Management, GANTT Chart and Precedence Diagrams, PERT, CPM, Project Life Cycles, GERT, Q-GERT, Critical Chain and Theory of Constraints, Activity Network Diagram; Resource requirement, Resource constraints, Crashing of Jobs, Project Control Techniques, Earned Value Project

Concurrent Engineering: Introduction, Components of CE models, Types of CE organizations

UNIT IV PRODUCTION, PLANNING AND CONTROL 9

Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control, Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP)

Scheduling: Types, functions and objectives, Sequencing n jobs on one machine – Schedule using Priority dispatch rules (FCFS, SPT, EDD, LCFS, and Critical Ratio). Sequencing ‘n’ jobs in Flow shop – Johnson, CDS and Palmer Algorithms. Sequencing ‘n’ jobs in Job shop – Two jobs on M machines

UNIT V INVENTORY CONTROL AND FORECASTING TECHNIQUES 9

Inventory Control: Introduction to Inventory and Materials Management, Inventory Problems and Selective Inventory Management, Determination of Economic order quantity and economic lot size, Static and Inventory Problems under Risk and Uncertainty, Two bin system - Ordering cycle system- ABC analysis

Forecasting Techniques: Introduction, Demand patterns, Factors affecting demand, Subjective forecasting methods, Casual forecasting methods, Time series forecasting methods, Routine short term forecasting methods, Selection of forecasting model.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Khanna, O.P: Industrial Engineering and Management, Dhanpat Rai and Sons, 2008.
2. S K Sharma and Savita Sharma : Industrial Engineering and Organization Management,, S K Kataria & Sons, Edition 1, 2011.

3. Martand.T.Telsang: Industrial Engineering and Production Management” S. Chand Publishing, 1999.

REFERENCES:

1. Prasanna Chandra: “Projects: Planning, Analysis, Selection, Financing, Implementation, and Review”, Tata McGraw Hill, 8th Edition
2. Dilip R. Sule: Industrial scheduling – PWS Publishing company, Boston, 1997.
3. James Apple, M, Plant layout and Material Handling, John Wiley, 3rd Edition, 1977.
4. Sundaresh. S. Heragu, Facilities Design, 4th edition, CRC press, 2016.

WEB REFERENCES:

1. <https://nptel.ac.in/courses/112/107/112107142/>
2. <https://nptel.ac.in/courses/112/102/112102107/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107143/>
2. <https://nptel.ac.in/courses/112/107/112107292/>
3. <https://nptel.ac.in/courses/110/105/110105095/>
4. <https://nptel.ac.in/courses/112/102/112102106/>
5. <https://nptel.ac.in/courses/110/104/110104073/>
6. <https://nptel.ac.in/courses/112/107/112107249/>

OUTCOMES:**Upon completion of the course, the student should be able to:**

1. Evaluate the work methods through work measurement. (K3)
2. Identify a suitable layout for a Plant by considering appropriate factors for minimizing the movement of Men, Materials and Floor space thereby maximizing the Utilization Capacity (K4)
3. Initiate, plan, execute, regulate and complete a Project within the set scope, time, quality and budget standards (K3)
4. Understand the various components and functions of Production Planning and Control (K2)
5. Manage Inventory effectively with suitable forecasting techniques. (K2)
6. Improve Productivity in an Organization by implementing various Industrial Engineering and Management concepts. (K3)

CO- PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	3	3	2	2	2	2	2	2	2	2	2	2	2	3
C02	3	3	3	3	3	2	2	2	2	2	3	2	3	3
C03	2	2	2	2	2	2	1	2	2	1	2	2	3	3
C04	2	2	2	2	2	1	1	1	1	1	2	2	2	3
C05	2	2	2	2	2	2	2	2	2	2	2	2	2	3
C06	2	2	2	2	2	2	2	2	2	2	2	2	3	3

PROFESSIONAL ELECTIVES - I

20MGEL801 SDG NO. 4,8,9,12	INTELLECTUAL PROPERTY RIGHTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To get an introductory insight about the IPR in national and international context
- To understand the procedures for IPR, registration and its enforcement.
- To encourage innovation and to provide incentives for innovation by granting protection to inventors that will allow them to recover research and development investments
- To protect inventors or creators of intellectual products with moral and commercial value.

UNIT I INTRODUCTION**9**

Intellectual property: Introduction, Meaning, Nature and significance types of intellectual property, importance of intellectual property rights, Protection of human innovations by IPR such as Patents, Trademarks, Copyright, Industrial Designs Geographical Indications, and Trade Secrets

UNIT II AGREEMENTS AND TREATIES**9**

International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, General agreement on trade and tariff (GATT), Ben convention, Rome convention, Role of WTO and WIPO

UNIT III PATENTS**9**

Concept of Patent – Historical view of Patent system in India and International Scenario, patent searching process, ownership rights and transfer, compulsory licenses, Procedure for filing of patents, Grants of patent, Benchmarks for patentability of inventions, Recent key changes and development

UNIT IV TRADEMARKS AND COPYRIGHTS**9**

Concept of Trademarks and copyrights – Rationale behind the protection- Purpose, function and acquisition, ownership issues, Procedure for Registration, Industrial design and integrated circuits, protection of geographical indications and plant varieties, Recent Trends in copyrights and Trademark., Trade secrets -liability for misappropriations of trade secrets

UNIT V LEGAL ASPECTS AND NEW DEVELOPMENTS**9**

Infringements of patents– Criteria of Infringement – Modes of Infringement- remedies and modification Protection against unfair competition, enforcement of intellectual property rights, Intellectual property audits, New developments of intellectual property, Impact of international instruments relating to the protection of intellectual properties Future of IPR in National and International levels.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. S.V. Satarkar, Intellectual Property Rights and Copy Rights, EssEss Publications, New Delhi, 2002.
2. V. Scople Vinod, Managing Intellectual Property, Prentice Hall of India pvt Ltd, 2012
3. P.Narayanan, Intellectual property rights Eastern law house-2018 3rd Edition (revised and updated)
4. Deborah, E. Bouchoux, Intellectual property right, Cengage learning- 2018 5th Edition

REFERENCES:

1. Sterling, J. L. A., World copyright law, (2008) 3rd Edition, London, Sweet & Maxwell
2. GP Reddy, Intellectual property rights & other laws, Gogia law agency
3. Barrett, Margreth, Intellectual Property, (2009) 3rd Edition, New York Aspen publishers

4. Inventing the Future: An introduction to Patents for small and medium sized Enterprises; WIPO publication
5. Cornish, William Intellectual Property: Patents, Copyright, Trademarks and allied rights, (2010) 7th Edition, London Sweet & Maxwell.
6. Kankanala and Kalyan.C : Indian Patent Law and Practice (2010), India, Oxford University Press

WEB RESOURCES:

1. <https://www.wipo.int/edocs/lexdocs/laws/en/ws/ws020en.pdf>
2. http://caaa.in/Image/34_Hb_on_IPR.pdf
3. <http://www.ipindia.nic.in/patents.htm>
4. <http://www.ipindia.nic.in/trade-marks.htm>
5. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627956/IP-Rights-in-India.pdf
6. <https://economictimes.indiatimes.com/small-biz/resources/startup-handbook/intellectual-property-rights-registration/ articleshow/59126802.cms?from=mdr>

ONLINE RESOURCES:

1. <https://www.coursera.org/learn/introduction-intellectual-property>
2. <https://www.edx.org/course/intellectual-property-law-and-policy-part-1>
3. <https://www.classcentral.com/tag/intellectual-property>
4. https://swayam.gov.in/nd1_noc19_mg58/preview

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the concepts of Intellectual property rights. (K2)
2. Demonstrate the agreements and treaties of Intellectual property rights(K2)
3. Explore needs and avenues for patents (K2)
4. Explore the necessity of Trademarks and Copy rights (K2)
5. Understand the legal context and developments of Intellectual property rights(K2)
6. Understand the systems and procedures for IPR (K2)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	1	-	1	1	1	1	1	-	-	1	2	1
C02	3	1	3	1	2	-	1	1	-	-	-	1	2	1
C03	1	1	2	2	2	-	1	1	-	-	-	1	1	1
C04	2	1	1	2	2	-	1	1	-	-	-	1	1	2
C05	1	1	1	2	2	2	1	1	-	-	-	1	2	2
C06	1	1	1	2	2	2	1	1	2	2	2	1	2	2

PROFESSIONAL ELECTIVES - I

20MGEL501 SDG NO. 4,8,9,12	PROFESSIONAL ETHICS AND VALUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objectives of this course are to provide students of engineering with:

- An understanding of their duties and responsibilities as professionals through gaining knowledge of the philosophies of ethics, professional practice, and world culture
- Basic knowledge to make informed ethical decisions when confronted with problems in the working environment
- Improved awareness of potential ethical issues within an engineering context
- Team skills through working in teams on assignments and in-class assignments
- Subjective analytical skills through investigation and evaluation of ethical problems in engineering settings using accepted tests for moral problem solving
- An understanding of how societal morals vary with culture and its influence on ethical thought and action
- Improved communications skills with regard to ethical and professional issues in engineering
- Know some of the classic cases as well as contemporary issues in engineering ethics

UNIT I HUMAN VALUES & PRINCIPLES FOR HARMONY 9

Morals, Values, and Ethics – Value Education – Human Dignity – Human Rights – Fundamental Duties – Aspirations and Harmony (I, We & Nature) – Gender Bias – Emotional Intelligence – Salovey – Mayer Model – Emotional Competencies – Conscientiousness.

UNIT II ENGINEERING ETHICS AND SOCIAL EXPERIMENTATION 9

History of Ethics – Need of Engineering Ethics – Engineering Ethics – Profession and Professionalism – Self Interest – Moral Autonomy – Utilitarianism – Virtue Theory – Uses of Ethical Theories – Deontology – Types of Inquiry – Kohlberg's Theory – Gilligan's Argument – Heinz's Dilemma – Comparison with Standard Experiments – Learning from the Past – Engineers as Managers – Role of Codes – Codes and Experimental Nature of Engineering.

UNIT III ENGINEERS' RESPONSIBILITIES TOWARDS SAFETY AND RISK 9

The concept of Safety – Safety and Risk – Types of Risks – Voluntary v/s Involuntary Risk – Consequences – Risk Assessment – Accountability – Liability – Reversible Effects – Threshold Levels of Risk – Delayed v/s Immediate Risk – Safety and the Engineer – Designing for Safety – Risk-Benefit Analysis – Accidents.

UNIT IV ENGINEERS' DUTIES AND RIGHTS 9

Concept of Duty – Professional Duties – Collegiality – Professional and Individual Rights – Confidential and Proprietary Information – Conflict of Interest – Ethical egoism – Collective Bargaining – Confidentiality – Gifts and Bribes – Problem solving – Occupational Crimes – Industrial Espionage – Price Fixing – Whistle Blowing.

UNIT V GLOBAL ISSUES 9

Globalization and MNCs – Cross Culture Issues – Business Ethics – Media Ethics – Environmental Ethics – Endangering Lives – Bio Ethics – Computer Ethics – War Ethics – Research Ethics – Intellectual Property Rights.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. M.Govindarajan, S.Natarajan and V.S.SenthilKumar, "Engineering Ethics & Human Values", PHI Learning Pvt. Ltd., 2009.

REFERENCE BOOKS:

1. Sekhar, R.C., "Ethical Choices in Business Response Books", New Delhi, Sage Publications, 1997.

2. Kitson, Alan and Campebell, Robert, "The Ethical Organisation", Great Britain Macmillan Press Ltd., 1996.
3. Pinkus, Rosa Lyun B., Larry J Shulman, Norman Phummon, Harvey Wolfe, "Engineering Ethics", New York, Cambridge Uty, Press, 1997.
4. R. Subramaniam, "Professional Ethics", Oxford Publications, New Delhi.
5. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw-Hill - 2003.
6. Prof.A.R.Aryasri, Dharanikota Suyodhana, "Professional Ethics and Morals" Maruthi Publications.
7. Harris, Pritchard, and Rabins, "Engineering Ethics", Cengage Learning, New Delhi.
8. S. B. Gogate, "Human Values & Professional Ethics", Vikas Publishing House Pvt. Ltd., Noida.
9. A. Alavudeen, R.Kalil Rahman and M. Jayakumaran, "Professional Ethics and Human Values", University Science Press.
10. Prof.D.R.Kiran, "Professional Ethics and Human Values" Tata McGraw-Hill - 2013.
11. Jayshree Suresh and B. S. Raghavan, "Human Values and Professional Ethics", S.Chand Publications.

WEB REFERENCES :

1. Ethos Education provides a concise guide on developing a code of ethics for primary and secondary schools.
2. The Ethics Resource Center has a toolkit available for use. When used for commercial purposes, a nominal license fee is required.
3. Creating A Code Of Ethics for Your Organization, with many suggested books, by Chris MacDonald.
4. The Deloitte Center for Corporate Governance offers a variety of resources for those who are active in governance, including a variety of resources and a set of suggested guidelines for writing a code of ethics or a code of conduct.

ONLINE RESOURCES:

1. <https://www.udemy.com/course/workplace-ethics-and-attitude/>
2. <https://www.udemy.com/course/business-ethics-how-to-create-an-ethical-organization/>
3. [https://nptel.ac.in/courses/110/105/110105097/Ethics in Engineering Practice](https://nptel.ac.in/courses/110/105/110105097/Ethics%20in%20Engineering%20Practice)
4. [https://nptel.ac.in/courses/109/104/109104068/Human Values](https://nptel.ac.in/courses/109/104/109104068/Human%20Values)
5. <https://www.coursera.org/learn/ethics-technology-engineering>

6. <https://www.classcentral.com/course/ethics-technology-engineering-10485>

OUTCOMES:

Upon completion of the course, the students should be able to

1. Improved ability to distinguish between ethical and non-ethical situations.
2. The ability to practice moral judgment in conditions of dilemma.
3. The understanding to relate the code of ethics to social experimentation.
4. The knowledge to apply risk and safety measures in various engineering fields.
5. The broad education necessary to better understand the impact of engineering solutions in a global/societal context.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	2	3	3	3	3	3	1	3
CO2	2	3	2	2	2	3	3	3	3	3	2	3
CO3	3	2	3	2	2	3	3	3	3	3	1	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	2	2	2	2	2	3	3	3	3	3	1	3

PROFESSIONAL ELECTIVES - II

20MEEL601 SDG NO: 4,7,8,9,11, 12,13,14,15	RENEWABLE ENERGY SOURCES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand and analyze the pattern of renewable energy resources.
- To impart the knowledge and value of Solar Energy and Wind Energy.
- To suggest methodologies or technologies for utilization of waste in energy.
- To understand the economics of renewable energy sources, utilization and environmental aspects.

UNIT I NEED FOR RENEWABLE ENERGY

9

World energy usage -reserves for world energy resources. Principles of renewable energy – renewable energy resources and their importance. Conventional and non-conventional fuels. Review of possible renewable energy resources. Scientific principles, technical implications, and social implications. Environmental Aspects of Energy Utilization – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials - Achievements / Applications – Economics of renewable energy systems.

UNIT II SOLAR ENERGY

9

Solar radiation: Extra-terrestrial solar radiation - Measurement and estimation of solar radiation. Solar heating devices. Flat Plate and Concentrating Collectors – Solar direct Thermal Applications – Solar thermal Power Generation - Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications. Recent advancements in solar power generation. Photovoltaic Devices and Systems. Types and usage of photovoltaic systems. Grid connection; system design and RAPS (remote area power supply) applications.

UNIT III WIND ENERGY

9

Basics of Wind Energy. Current and Future Technologies - Benefits and Drawbacks of Wind Energy- Wind Turbine and its components- Loads on the wind turbine. Forces acting on-wind turbines and calculation of wind turbine efficiency. Process of electricity generation and supply to the grid (wind farms). Current and Potential Uses - Issues, Challenges, and Obstacles.

UNIT IV BIOMASS AND BIOENERGY**9**

Biomass resources - Reviews the use of agricultural crops and solid biomass wastes in the production of Alternative fuels. Available Technologies for biomass energy production. Incineration, pyrolysis, gasification and other thermo-chemical processes. Ethanol and biogas production technologies. Recent advancements in Biomass energy production.

UNIT V OTHER RENEWABLE ENERGY RESOURCES**9**

Introduction to Geothermal, Ocean thermal and tidal energies. Working principles of Geothermal, Ocean thermal and tidal power plants. Hydro Energy, Hydrogen Storage - Fuel Cell Systems – Hybrid Systems. Binary cycle power generation. Advantages and drawbacks. Current trends in geothermal, ocean thermal and tidal power technologies.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Rai, G.D. "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2017.
2. Twidell, J.W. & Weir, A., "Renewable Energy Resources", EFN Spon Ltd., UK, 2015.

REFERENCES:

1. B.H. Khan, "Non-Conventional Energy Resources", The McGraw Hill companies, 2017.
2. Tiwari, G.N. "Solar Energy – Fundamentals Design, Modelling and applications", Alpha Science Intl Ltd, 2013.
3. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 2012.
4. Dewulf, J and Herman Van Langenhove, 'Renewables Based Technology: Sustainability Assessment', John Wiley & Sons, Ltd. 2006
5. Neil Schlager and Jayne Weisblatt, Alternative Energy, Thomson Gale sales, 2006

WEB RESOURCES:

1. <https://nptel.ac.in/courses/108/108/108108078/>
2. <https://nptel.ac.in/courses/112/105/112105050/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/108/105/108105058/>
2. <https://nptel.ac.in/courses/112/105/112105051/>
3. <https://nptel.ac.in/courses/103/107/103107125/>

4. <https://nptel.ac.in/courses/102/104/102104057/>
5. <https://nptel.ac.in/courses/121/106/121106014/>
6. <https://nptel.ac.in/courses/103/107/103107157/>
7. <https://nptel.ac.in/courses/109/101/109101171/>

OUTCOMES:

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

1. Know the importance of renewable energy sources utilization and various renewable energy technologies. (K2)
2. Describe the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, power generation, drying, cooking etc.(K3)
3. Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications. (K2)
4. Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications (K3)
5. Acquire the knowledge of wave power, tidal power and geothermal principles and applications. (K2)
6. Know the importance of Renewable sources and harvesting techniques and current trends of development (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	1	2	-	2	-	-	-	1	1	2	3	2
C02	3	3	3	3	1	1	2	-	-	-	2	2	3	2
C03	3	3	3	3	3	2	1	-	1	-	2	2	3	2
C04	3	2	2	-	-	1	2	1	-	-	2	2	2	2
C05	3	2	2	1	-	-	1	-	1	1	2	1	2	2
C06	3	3	2	2	-	-	1	1	1	-	-	1	2	2

PROFESSIONAL ELECTIVES - II

20MEEL602 SDG NO. 4, 9	TURBO MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various systems, principles, operations and applications of different types of turbo machinery components.
- To study the design and analyze the performance characteristics of centrifugal fans and blowers.
- To understand the design of centrifugal and Axial compressor and its performance parameters.
- To enable the students to do performance calculations of different types of axial and radial turbo machines.

UNIT I INTRODUCTION TO TURBO MACHINARIES AND CLASSIFICATIONS 9

Energy transfer between fluid and rotor-classification of fluid machinery, - dimensionless parameters specific speed-applications-stage velocity triangles-work and efficiency.

UNIT II CENTRIFUGAL FANS AND BLOWERS 9

Types- stage and design parameters-flow analysis in impeller blades-volute and diffusers, losses, characteristic curves and selection, fan drives and fan noise.

UNIT III CENTRIFUGAL COMPRESSOR 9

Construction details, impeller flow losses, slip factor, diffuser analysis, losses and performance curves

UNIT IV AXIAL FLOW COMPRESSOR 9

Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done simple stage design problems and performance characteristics.

UNIT V AXIAL AND RADIAL FLOW TURBINES 9

Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, testing and performance characteristics.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Yahya, S.M., Turbines, Compressor and Fans, Tata McGraw Hill Publishing Company, 2011.
2. B.K Venkanna "Fundamentals of Turbo Machinery" PHI learning Pvt Ltd, 2009.

REFERENCES:

1. Bruneck, Fans, Pergamom Press, 1973.
2. Earl Logan, Jr, Hand book of Turbomachinery, Marcel Dekker Inc., 2003.
3. Dixon, S.I., "Fluid Mechanics and Thermodynamics of Turbomachinery", Pergamon Press, 2010.
4. Shepherd, D.G., "Principles of Turbomachinery", Macmillan, 1969.
5. Ganesan, V., "Gas Turbines", Tata McGraw Hill Pub. Co., 2006.
6. Gopalakrishnan .G and Prithvi Raj .D, "A Treatise on Turbo machines", Scitech Publications (India) Pvt. Ltd., 2002.

WEB RESOURCES:

1. <https://cosmolearning.org/courses/turbomachinery-aerodynamics/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106200/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Explain the classifications and applications of turbo machines. (K3)
2. Explain the principles and working of centrifugal fans and blowers. (K3)
3. Explain the construction details and performance of Centrifugal Compressor.(K3)
4. Illustrate velocity diagrams and do performance calculations of axial flow compressor.(K3)
5. Solve performance characteristics of Axial and Radial Flow Turbines.(K3)

6. Identify industrial applications in turbo machinery. (K2)

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	2	2	2	1	-	-	1	2	2	3	2
CO2	3	3	3	3	2	1	1	-	-	-	1	-	3	2
CO3	3	3	3	3	2	2	2	-	1	-	2	1	3	3
CO4	3	3	3	3	2	1	1	-	-	-	1	-	2	2
CO5	3	3	3	3	2	2	2	-	1	1	2	2	3	2
CO6	3	3	3	3	2	2	2	-	1	-	2	1	3	3

PROFESSIONAL ELECTIVES - II

20MEEL603 SDG NO. 9,11	DESIGN OF PRESSURE VESSELS AND PIPING			L	T	P	C
				3	0	0	3

(ASME VIII Code book for pressure vessels may be permitted)

OBJECTIVES:

- To understand the terminology and the applications of stresses in the pressure vessels.
- To apply the Mathematical knowledge gained in the design of pressure vessels and piping
- To carry out the stress analysis in pressure vessels and piping.
- To carry out the buckling and fracture analysis in pressure vessels.

UNIT I INTRODUCTION 9

Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

UNIT II STRESSES IN PRESSURE VESSELS 9

Introduction – Stresses in a circular ring, cylinder –Dilation of pressure vessels, Membrane stress Analysis of Vessel – Cylindrical, spherical and, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

UNIT III DESIGN OF VESSELS 9

Design of Tall cylindrical self-supporting process columns – Supports for short vertical vessels – Stress concentration at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – Pressure Vessel Design.

UNIT IV BUCKLING AND FRACTURE ANALYSIS IN VESSELS**9**

Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

UNIT V PIPING**9**

Introduction – Flow diagram – piping layout and piping stress Analysis.

TOTAL:45 PERIODS**TEXT BOOK:**

1. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers and Distributors, 1987.

REFERENCES:

1. Henry H. Bedner, "Pressure Vessels, Design Hand Book", CBS publishers and Distributors, 1987.
2. Stanley, M. Wales, "Chemical process equipment, selection and Design. Butterworths series in Chemical Engineering", 1988.
3. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997.
4. Sam Kannapan, "Introduction to Pipe Stress Analysis". John Wiley and Sons, 1985.

WEB RESOURCES:

1. <https://www.coursera.org/lecture/mechanics2/module-1-general-analysis-approach-VvZu4>
2. <https://www.youtube.com/watch?v=k1vRtbMfSHA>
3. <https://www.youtube.com/watch?v=erW4HZ5I928>
4. <https://www.youtube.com/watch?v=zZDPTtPWQtc>

ONLINE RESOURCES:

1. <https://nptel.ac.in/content/storage2/courses/103103027/pdf/mod6.pdf>
2. <https://arvengtraining.com/en/all-courses/asme-viii-design-pressure-vessels-online/>

OUTCOMES:

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

1. Interpret the various stresses induced in the pressure vessels. (K2)
2. Comprehend the design consideration of pressure vessels and piping. (K3)
3. Identify the suitable layouts and flow diagrams for the piping systems. (K3)
4. Analyze the various stresses in the pressure vessels and piping systems. (K3)
5. Apply the mathematical fundamentals for the design of pressure vessels and pipes. (K4)
6. Analyze and design pressure vessels and piping. (K4)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	-	-	-	-	2	-	-	3	3
C02	3	-	-	-	-	-	-	-	-	2	-	-	3	3
C03	3	-	-	-	-	-	-	-	-	-	-	-	3	3
C04	3	3	-	-	-	-	-	-	-	-	-	-	3	3
C05	3	3	3	-	-	-	-	-	-	2	-	-	3	3
C06	3	3	3	-	-	-	-	-	-	-	-	-	3	3

PROFESSIONAL ELECTIVES - II

20MEEL604 SDG NO. 7, 9, 12, 15	ENERGY EFFICIENCY AND SUSTAINABILITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To infuse the knowledge of various energy resources
- To understand the global energy requirements
- To impart the significance and need of sustainable energy
- To apply the concepts of energy measurement and auditing

UNIT I CLASSIFICATION OF ENERGY SOURCES**9**

Classification of Energy Sources, Principle fuels for energy conversion: Fossil fuels, Nuclear fuels. Conventional & Renewable Energy Sources: prospecting,

extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, and Nuclear energy etc. Energy Conversion through fission and fusion, Nuclear power generation etc.,

UNIT II GLOBAL ENERGY SCENARIO

9

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Discovery of various energy sources: Energy Sources and Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and projected future demands. Energy Resources: Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar and Other Renewable etc. Depletion of energy sources, its impact on exponential rise in energy consumption, economies of countries and international relations.

UNIT III SUSTAINABLE ENERGY SOURCES

9

Introduction: fundamental concepts of energy conversion and perspectives on energy supply and demand Wind power: primary mechanical design and system aspects, Biomass: resources and thermo chemical conversion, Solar: photovoltaic and solar thermal including concentrating solar power. Hydropower: key components along with large-scale and small-scale systems, Other technologies: energy storage, fuel cells, hydrogen, wave and tidal power, geothermal energy

UNIT IV ENERGY SECURITY AND POLICIES

9

Energy Security, Energy Consumption and its impact on environment and climatic change. International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EU Countries. International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal. Future Energy Options: Sustainable Development, Energy Crisis: Transition from carbon rich and nuclear to carbon free technologies, parameters of transition.

UNIT V ENERGY AUDIT METHODOLOGY AND RECENT TRENDS

9

General Philosophy, need of Energy Audit and Management, EC Act, Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy. Economics of implementation of energy optimization projects, its constraints, barriers and limitations, Financial Analysis: Simple Payback, IRR, NPV, Discounted Cashflow; Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
2. Energy Management Conservation and Audits By Anil Kumar ,Om Prakash, Prashant Singh Chauhan, SamsherGautam1st Edition Copyright Year 2021

REFERENCES:

1. Guide to Energy Management, Sixth Edition, (Seventh Edition available) 2008; Barney L Capehart, Wayne Turner, William J Kennedy, Fairmont Press ISBN 0-88173-605-8
2. Energy and the New Reality: Energy Efficiency and the Demand for Energy Services, 2010; L.D. Danny Harvey, Earthscan ISBN: #978-1-8497-072-5
3. Sustainable Energy Without the Hot Air, David JC MacKay, 2008, UIT
4. Greening Your Home, Sustainable Options for Every System in Your House, 2008; Clayton Bennett, McGraw-Hill Companies ISBN 978-0-07-149909-5

WEB RESOURCES:

1. Free on-line book at the following web site:
<http://www.withouthotair.com/about.html> ISBN#: 978-0-9544529-3-3 (paperback)

ONLINE RESOURCES:

1. Technologies For Clean And Renewable Energy Production
https://onlinecourses.nptel.ac.in/noc20_ch37/preview

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Interpret the various types of energy sources. (K2)
2. Recognize the various sustainable energy resources and the harnessing techniques. (K3)
3. Explain the various energy policies adopted by the nations.(K3)
4. Discuss the various aspects of energy requirements of the world nations. (K2)
5. Analyze the impact of energy consumptions in terms of environment and climate change. (K2)
6. Estimate the energy consumptions and perform energy audit. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	-	-	-	-	-	-	-	3	3
C02	3	-	-	-	-	-	-	-	-	-	-	-	3	3
C03	3	-	-	-	-	-	-	-	-	-	-	-	3	3
C04	3	-	-	-	-	-	3	-	-	-	-	-	3	3
C05	3	-	-	-	-	-	-	-	-	2	3	-	3	3
C06	3	-	-	-	-	-	-	-	-	-	-	-	3	3

PROFESSIONAL ELECTIVES - II

20MEEL605 SDG NO: 3, 7, 9, 12	ENERGY CONSERVATION IN INDUSTRIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Understand the Energy demands and Energy auditing.
- Estimate the Energy conservation in Utilization of Electrical and Thermal utilities.
- Analysis the economics of Thermal and Electrical Utilities.
- Understand the concepts of Thermal and Electrical Utilities.
- Apply the Energy Management in the all the utilities.
- Improve the Efficiency of thermal and Electrical Utilities.

UNIT-I INTRODUCTION**9**

Energy scenario of World, India and TN - Environmental aspects of Energy Generation – Material and Energy balancing - Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Basic instruments for Energy Auditing.

UNIT-II ELECTRICAL SUPPLY SYSTEMS**9**

Electricity Tariff structures – Typical Billing - Demand Side Management - HT and LT supply – Power Factor – Energy conservation in Transformers – Harmonics

UNIT-III ENERGY CONSERVATION IN MAJOR THERMAL UTILITIES 9

Stoichiometry - Combustion principles. Energy conservation in: Boilers - Steam Distribution Systems - Furnaces - Thermic Fluid Heaters - Cooling Towers - D.G. sets. Insulation and Refractories - Waste Heat Recovery Devices.

UNIT-IV ENERGY CONSERVATION IN MAJOR ELECTRICAL UTILITIES 9

Energy conservation in : Motors - Pumps - Fans - Blowers - Compressed Air Systems - Refrigeration and Air Conditioning Systems - Illumination systems

UNIT-V ENERGY MONITORING, TARGETING, LABELLING AND ECONOMICS 9

Elements of Monitoring & Targeting System - CUSUM - Energy / Cost index diagram - Energy Labelling - Energy Economics - Cost of production and Life Cycle Costing - Economic evaluation techniques - Discounting and Non Discounting - ESCO concept - PAT scheme.

TOTAL: 45 hours

TEXT BOOKS:

1. Guide book for National Certification Examination for "Energy Managers and Energy Auditors" (4 Volumes). Available at <http://www.em-ea.org/gbook1.asp>. This website is administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.
2. K. NagabhushanRaju, Industrial Energy Conservation Techniques: (concepts, Applications and Case Studies), Atlantic Publishers &Dist, 2007.

REFERENCES:

1. Abbi Y P, Shashank Jain., Handbook on Energy Audit and Environment Management, TERI Press, 2006.
2. Albert Thumann and Paul Mehta D, "Handbook of Energy Engineering", 7th Edition, The Fairmont Press, 2013.
3. Murphy.W.R. and McKay.G, "Energy Management", Butterworth, London 1982.
4. Paul.W.O'Callaghan, Design and management for energy conservation: A handbook for energy managers, plant engineers, and designers, Pergamon Press, 1981.
5. Steve Doty, Wayne Turner C, Energy Management Handbook 7th Edition, The Fairmont Press, 2009.

OUTCOMES:

1. Understand the Energy demands and Energy auditing. (K2)
2. Estimate the Energy conservation in Utilization of Electrical and Thermal utilities. (K3)
3. Analysis the economics of Thermal and Electrical Utilities. (K3)
4. Understand the concepts of Thermal and Electrical Utilities. (K2)
5. Apply the Energy Management in the all the utilities. (K2)
6. Improve the Efficiency of thermal and Electrical Utilities. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	2	1	1	3	2	-	1	2	1	3	3
C02	3	3	2	2	1	-	-	-	-	-	-	1	3	2
C03	3	3	2	2	1	-	-	-	-	-	-	1	3	2
C04	3	3	2	2	1	-	-	-	-	-	-	1	3	2
C05	3	3	2	2	1	-	1	-	-	-	-	1	3	3
C06	3	3	2	2	1	-	-	-	-	-	-	1	3	3

PROFESSIONAL ELECTIVES - I

20MEEL606 SDG NO. 4,8,9,11,12	IoT FOR MECHANICAL AND MANUFACTURING INDUSTRY				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To enable the interconnection and integration of the physical world and the cyber space
- To introduce some background and related technologies of IoT
- To introduce Digital Manufacturing & Digital twin concepts and their applications in industry.
- To increase value creation in Mechanical and Manufacturing Industries.
- To introduce the potential implications of Industry 4.

UNIT I INTRODUCTION TO DIGITAL MANUFACTURING**9**

Introduction- Digital Manufacturing and Design Operation Mode and Architecture of Digital Manufacturing System, Digital Thread-Components

and Implementation, Advanced Manufacturing Process Analysis, Intelligent Machining, Advanced Manufacturing Enterprise, Cyber Security in Manufacturing, Model Based Systems Engineering.

UNIT II INTERNET OF THINGS (IOT) 9

Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino. Applications, IoT data management requirements, Architecture of IoT, Technological challenges, Industrial Gateways, Basics of Communication requirements, RFID and the Electronic Product Code (EPC) network, The web of things, Issues in implementing IoT.

UNIT III PROGRAMMING FOR IOT 9

Introduction to Python programming, Raspberry Pi. Implementation of IoT with Raspberry Pi, Introduction to SDN for IoT, Data Handling and Analytics, Cloud Computing.

UNIT IV CLOUD AND FOG COMPUTING 9

Cloud Computing, Sensor-Cloud. Fog Computing, Smart Cities and Smart Homes. Connected Vehicles, Smart Grid, Industrial IoT- Case Studies.

UNIT V DIGITAL TWIN AND INDUSTRY 4.0 9

Digital twin - Definition, types of Industry & its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin, Industrial Revolutions, Industry 4.0 – Definition, principles, Application of Industry 4.0 in process & discrete industries, Benefits of Industry 4.0

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Alasdair Gilchrist , "Industry 4.0: The Industrial Internet of Things", Apress, United States, 2017.
2. Christoph Jan Bartodziej, "The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics", Springer Gambler, Germany, 2017.

REFERENCES:

1. Ibrahim Garbie, "Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0", Springer, Switzerland, 2016.
2. Ronald R. Yager and Jordán Pascual Espada, "New Advances in the Internet of Things", Springer, Switzerland, 2018
3. Ulrich Sandler, "The Internet of Things, Industries 4.0 Unleashed", Springer, Germany, 2016
4. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017
5. Andrew Yeh, Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019

WEB RESOURCES:

1. <https://www.internetsociety.org/iot/>
2. <https://event.asme.org/digitaltwin/About/Digital-Twin-Resources>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/106/105/106105166/>
2. <https://nptel.ac.in/courses/106/105/106105195/>
3. <https://www.edx.org/course/industry-40-how-to-revolutionize-your-business>
4. <https://www.coursera.org/specializations/digital-manufacturing-design-technology>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Get introduced to Digital Manufacturing and its components. (K1)
2. Acquire knowledge on Internet of Things. (K1)
3. Get insight about various programming techniques for IoT. (K2)
4. Understand about Cloud and Fog Computing. (K1)
5. Discover the advantages of Industry 4.0 and Digital Twin. (K2)
6. Have a good vision to the future of IOT in Manufacturing Industry. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	-	-	3	1	2	-	-	-	-	2	3	2
C02	1	1	-	-	3	1	2	-	-	-	-	2	3	2
C03	1	1	-	-	3	1	2	-	-	-	-	2	3	2
C04	1	1	-	-	3	1	2	-	-	-	-	2	3	2
C05	1	1	-	-	3	1	2	-	-	-	-	2	3	2
C06	2	1	1	1	3	1	1	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - II

20MEEL607 SDG NO. 8,9	PROGRAMMING FOR ROBOTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To analyze and determine the movement of the robot arm through various controlled paths..
- To analyze, design and implement advanced robotic applications.
- To demonstrate various concepts by working out exercises relevant to real life applications involving innovative mechanisms , robotic programs
- To undertake research topics in the field of robot programming and simulation.

UNIT I: BASICS OF ROBOTICS AND ROBOT SIMULATION**9**

History – Definition – Components – Building a robot – The Robot drive mechanism. Mathematical modelling of the robot - Robot kinematics – Concepts of ROS and Gazebo.

UNIT II: DESIGNING CHEFBOT HARDWARE**9**

Specifications - Block diagram - Working with Robotic Actuators and Wheel Encoders - Interfacing DC geared motor with Tiva C LaunchPad - Interfacing quadrature encoder with Tiva C Launchpad - Working with Dynamixel actuators

UNIT III: WORKING WITH ROBOTIC SENSORS**9**

Working with ultrasonic distance sensors - Working with the IR proximity sensor - Working with Inertial Measurement Unit.

UNIT IV: PYTHON AND ROS**9**

Introduction to OpenCV, OpenNI, and PCL - Programming Kinect with Python using ROS, OpenCV, and OpenNI - Working with Point Clouds using Kinect, ROS, OpenNI, and PCL

UNIT V: INTERFACING IT INTO ROS, USING PYTHON**9**

Building ChefBot hardware - Writing a ROS Python driver for ChefBot - Understanding ChefBot ROS launch files - Working with ChefBot Python nodes and launch files - The Calibration and Testing of ChefBot - The Calibration of Xbox Kinect using ROS - Wheel odometry calibration - Testing of the robot using GUI

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Lentin Joseph, —Learning Robotics using Python, PACKT Publishing, 2015.
2. Aaron Martinez and Enrique Fernandez, —Learning ROS for Robotics Programming, PACKT Publishing, 2013.

REFERENCES:

1. Bill Smart, Brian Gerkey, Morgan Quigley, —Programming Robots with ROS: A Practical Introduction to the Robot Operating System, O'Reilly Publishers, 2015.

WEB RESOURCES:

1. https://subscription.packtpub.com/book/application_development/9781783287536/4/ch04lv1sec23/specifications-of-the-chefbot-hardware
2. <https://hub.packtpub.com/integration-chefbot-hardware-and-interfacing-it-ros-using-python/>
3. <https://hackaday.io/project/8588/instructions>

ONLINE RESOURCES:

1. <https://www.youtube.com/watch?v=96XsJ7xfS8>
2. <https://www.youtube.com/watch?v=9GyOoUkQOJI>
3. https://www.youtube.com/watch?v=SDS79iWW5_Y

OUTCOMES:

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

1. Understand the robot drive modeling and kinematic simulations. (K1)

2. Able to actuate and interface actuator based hardware systems with digital control drives. (K2)
3. Learn about the sensor based control of robots. (K2)
4. Program robotic motions using Python and ROS. (K2)
5. Interface and test robot using ROs and Python. (K3)
6. Program any type of robot movement and any type of application (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	2	2	3	2	1	1	3	1	2	3	1	2
C02	1	2	3	3	3	2	1	1	3	1	2	3	2	3
C03	-	-	2	1	3	1	1	1	2	-	1	2	1	2
C04	1	1	2	2	3	1	1	2	2	1	2	3	1	3
C05	2	1	3	2	3	1	1	1	2	1	2	3	1	3
C06	1	1	2	2	3	3	1	1	2	1	2	3	1	3

PROFESSIONAL ELECTIVES - II

20MEEL608 SDG NO: 4,8,9,12	AUTOMOTIVE INFOTRONICS				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To understand the basics of Automotive Infotronics
- To understand about various assistance systems for driver
- To understand about Telematics and safety systems
- To learn about comfort systems and security systems

UNIT I DRIVER ASSISTANCE SYSTEM

8

Driver information, driver perception, driver convenience, driver monitoring, general vehicle control, longitudinal and lateral control, collision avoidance, vehicle monitoring. Knock sensors, oxygen sensors, crankshaft angular position sensor, temperature sensor, speed sensor, Pressure sensor, Mass air flow sensor, Manifold Absolute Pressure Sensors, crash sensor, Coolant level sensors, Brake fluid level sensors – operation, types, characteristics, advantage and their applications

UNITII TELEMATICS**9**

Global positioning system, geographical information systems, navigation system, architecture, automotive vision system, road recognition, Vision based autonomous road vehicles

UNIT III SAFETY SYSTEMS**10**

Object detection, Collision warning and avoidance system, Active Safety Sensor systems, Passive Sensor Safety system - Side Impact Sensing, front impact sensing system, airbags, seat belt tightening system, forward collision warning systems, child lock, anti lock braking systems, Autonomous Vehicle System, Lane departure warning system, Adaptive headlight system, Day time running lights (DRL), Automatic wiper system, Traffic Sign Identification. Automatic Rain sensing/wiper activation system, drowsy-driver sensing system, Tyre pressure warning system

UNIT-IV COMFORT SYSTEMS**10**

Adaptive cruise control system, Active suspension system, power steering, collapsible and tiltable steering column, power windows, and climate control system, Emergency Electronic braking, MEMS and Microsystems

UNIT-V SECURITY SYSTEMS**8**

Anti theft technologies – mechanical, electromechanical and electronic immobilizers, alarm system, stolen vehicle tracking system, remote keyless entry, smart card system, number plate coding, Bio metric systems, Security systems: Intelligent Vehicle Systems – Unmanned ground vehicles, Vehicle Platooning

TOTAL: 45HOURS**TEXT BOOKS:**

1. William B. Ribben, Understanding Automotive Electronic: An Engineering Perspective (2012), Elsevier Science.
2. Ronald K Jurgen, –Navigation and Intelligent Transportation Systems – Progress in Technology, Automotive Electronics Series. SAE, USA, 1998.
3. Robert Bosch GmbH, "Safety, Comfort and Convenience Systems", Wiley, 2007.

REFERENCES:

1. Robert Bosch, –Automotive Hand Book, SAE, 2000.
2. Hong Cheng, –Autonomous Intelligent Vehicles: Theory, Algorithms, and Implementation, Springer, 2011.

3. Robert Bosch GmbH, "Bosch Automotive Handbook", Bentley Publishers, 2011.
4. LjuboVlacic, Michel Parent and Fumio Harashima, –Intelligent Vehicle Technologies, Butterworth-Heinemann Publications, Oxford, 2001.
5. Bechhold, "Understanding Automotive Electronics", SAE, 1998.
6. Tom Denton, Automobile Electrical and Electronic systems (2013), Routledge, Taylor & Francis Group.
7. Tom Denton, Automobile Mechanical and Electrical Systems (2011), Taylor & Francis Group

ONLINE RESOURCES:

1. <https://www.mercedes-benz.com/en/mercedes-benz/innovation/mercedes-benzintelligentdrive/-Mercedes-Benz-Intelligent-Drive>

OUTCOMES:

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

1. Understand about various peripherals of vehicle assistance systems. (K1)
2. Explain about telematics used in automobiles. (K2)
3. Understand about various safety systems used in automobiles. (K1)
4. Understand about different comfort systems employed in automobiles. (K1)
5. Explain various security systems in automobiles (K2)
6. Describe computer based automotive instrumentation system. (K2)

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	-	-	-	1	2	1	1	2	2	2	2	-	1	1
CO2	-	-	-	1	2	1	1	2	2	2	2	-	1	1
CO3	-	-	-	1	2	1	1	2	2	2	2	-	1	1
CO4	-	-	-	1	2	1	1	2	2	2	2	-	1	1
CO5	-	-	-	1	2	1	1	2	2	2	2	-	1	1
CO6	-	-	-	1	2	1	1	2	2	2	2	-	1	1

PROFESSIONAL ELECTIVES - II

20MEEL609 SDG NO. 4,9,12	PRODUCT LIFECYCLE MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn about increasing product revenues, reducing product-related costs, maximizing the value of the product portfolio
- To maximize the value of current and future products for both customers and shareholders
- To reduce time to market, improve product quality, reduce prototyping costs, identify potential sales opportunities
- To maintain and sustain operational serviceability, and reduce environmental impacts at end-of-life.

UNIT I INTRODUCTION TO PLM

9

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (CPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II PLM/PDM FUNCTIONS AND FEATURES

9

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

UNIT III DETAILS OF MODULES IN A PDM/PLM SOFTWARE

9

Case studies based on top few commercial PLM/PDM tools – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.

UNIT IV ROLE OF PLM IN INDUSTRIES

9

Case studies on PLM selection and implementation (like auto: aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM

implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance

UNIT V BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE

9

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Antti Saaksvuori and Anselmi Immonen, “Product Lifecycle Management”, Springer Publisher, 2008.
2. Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.

REFERENCES:

1. Arie Karniel and Yoram Reich, Managing the Dynamics of New Product Development Processes: A New Product Lifecycle Management Paradigm, Springer, 2011.
2. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.
3. John Stark, “Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question”, Springer Publisher, 2007.
4. John Stark, “Product Lifecycle Management: 21st Century Paradigm for Product Realisation”, Springer Publisher, 2011.
5. Kevin Roebuck, Product Lifecycle Management (PLM): High-impact Strategies - What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors, Emereo, 2011.

WEB RESOURCES:

1. <https://www.coursera.org/lecture/advanced-manufacturing-enterprise/product-life-cycle-management-plm-xk84j>
2. <https://wiki.scn.sap.com/wiki/display/PLM/SAP+PLM+Learning+Material>

ONLINE RESOURCES:

1. <https://www.udemy.com/course/organizing-and-optimizing-your-business-with-plm/>
2. <https://www.udemy.com/course/fundamentals-of-life-cycle-assessment-lca/>
3. <https://www.udemy.com/course/productmanagement101/>
4. <https://www.udemy.com/course/sapdms-document-management-system-training-sap-plm/>
5. <https://www.udemy.com/course/siemens-plm-teamcenter-lifecycle-visualization-mockup/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Explain the history, concepts and terminology of PLM. (K2)
2. Apply the functions and features of PLM/PDM. (K3)
3. Apply different modules offered in commercial PLM/PDM tools. (K3)
4. Implement PLM/PDM approaches for industrial applications. (K3)
5. Integrate PLM/PDM with legacy data bases, CAx& ERP systems. (K3)
6. Ensure the quality and satisfaction in both product and service. (K2)

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	3	2	3	3	3	2	2	3	3	3	3
C02	2	2	3	3	3	3	3	2	2	2	2	2	3	3
C03	2	3	3	2	3	3	3	3	2	2	2	2	3	3
C04	3	3	2	3	3	2	3	3	2	3	3	3	3	3
C05	2	3	3	2	3	2	2	3	2	3	3	3	3	3
C06	2	3	3	2	3	2	2	3	2	3	3	3	3	3

PROFESSIONAL ELECTIVES - II

20MEEL610	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
SDG NO: 4, 8, 9, 12		3	0	0	3

OBJECTIVES:

- To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices
- To educate on the rudiments of Micro fabrication techniques.
- To introduce various sensors and actuators
- To introduce different materials used for MEMS
- To educate on the applications of MEMS to disciplines beyond Electrical and Mechanical engineering.
- To provide insight on various MEMS case studies and its implications.

UNIT I INTRODUCTION TO MEMS

9

Electrostatic sensors Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Micro fabrication - Silicon based MEMS processes – New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection..

UNIT II MICRO SENSORS AND ACTUATORS - I

9

Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors – Thermal Sensing and Actuation

Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph – Applications - Magnetic Actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators-Actuation using Shape Memory Alloys

UNIT III MICRO SENSORS AND ACTUATORS - II

9

Transmission Piezoresistive sensors – Piezoresistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia, Acoustic, Tactile and Flow sensors.

UNIT IV MICRO MACHINING

9

Silicon Anisotropic Etching – Anisotropic Wet Etching – Dry Etching of Silicon – Plasma Etching – Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas Phase Etchants – Case studies - Basic surface micro machining processes –

Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antistriction methods – LIGA Process - Assembly of 3D MEMS – Foundry process.

UNIT V POLYMER AND OPTICAL MEMS

9

Polymers in MEMS– Polyimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon - Application to Acceleration, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2006.
2. Stephen D Senturia, "Microsystem Design", Springer Publication, 2000.

REFERENCES:

1. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.
2. James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher, 2010.
3. Julian w. Gardner, Vijay K. Varadan, Osama O. Awadelkarim, "Micro Sensors MEMS and Smart Devices", John Wiley & Son LTD, 2002
4. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2000
5. NadimMaluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
6. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer 2012.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/103/106/103106075/>
2. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/lecture-notes/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/117/105/117105082/>
2. <https://nptel.ac.in/courses/112/104/112104181/>
3. <https://nptel.ac.in/courses/108/108/108108113/>

OUTCOMES:

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

1. Be introduced to Gain knowledge in basic approaches of Micro ElectroMechanical Systems. ((K1))

2. Be introduced to micro sensors and actuator system. (K1)
3. Be introduced to micro sensors and actuator system for various applications. (K2)
4. Gain knowledge in various micromachining techniques. (K2)
5. Learn new materials, fabrication and its applications Micro ElectroMechanical Systems. (K2)
6. Have a good vision to the future of micro Micro Electro Mechanical Systems. (K2)

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	1	2	1	1	-		-	-	1	2	3	3	2
C02	3	2	2	1	2	-	-	-	-	1	2	3	2	3
C03	3	2	2	1	2	-	-	-	-	1	2	3	3	3
C04	3	1	2	1	2	-	-	-	-	1	2	3	3	2
C05	3	1	1	1	1	-	-	-	-	1	2	3	2	2
C06	2	2	2	1	2	-	1	-	-	1	2	2	2	2

PROFESSIONAL ELECTIVES - II

20MEEL611 SDG NO: 4,8,9,11,12	NON DESTRUCTIVE TESTING AND EVALUATION				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To imbibe the students the basic principles of various NDT techniques, its applications, limitations, codes and standards.
- To equip the students with proper competencies to locate a flaw in various materials, products.
- To make the students to be ready to use NDT techniques for in-situ applications too.
- To inculcate the knowledge of selection of the right NDT technique for a given application

UNIT I INTRODUCTION AND VISUAL INSPECTION METHODS 9

NDT versus Mechanical testing, Need for NDT, Relative merits and limitations, various physical characteristics of materials and their applications in NDT.

Visual Inspection -Unaided, Aided- Borescopes -Videoscopes, Special features in Borescopes, Selection of borescopes, Optical sensors, Microscopes & replication Microscopy Technique and applications, Holography, Case study.

UNIT II LIQUID PENETRANT TESTING AND MAGNETIC PARTICLE TESTING

9

LPT - Principle, types, Procedures, Penetrants and their characteristics, Emulsifiers, Solvent Cleaners / Removers, Developers- properties and their forms, Equipments, Advantages and limitations, Inspection and Interpretation, Applications and case study.

MPT-Principle, Theory of Magnetism, Magnetising current, Magnetisation methods, Magnetic particles, Procedure, Interpretation, Relevant and Non-relevant indications, Residual magnetism, Demagnetisation- need, methods, Advantages and Limitations, Applications, Magnetic Rubber Inspection, Magnetic Printing, Magnetic Painting, Case study.

UNIT III THERMOGRAPHY AND EDDY CURRENT TESTING

9

Thermography – Introduction, Principle, Contact & Non-Contact inspection methods, Active & Passive methods, Liquid Crystal – Concept, example, advantages & limitations. Electromagnetic spectrum, infrared thermography-approaches, IR detectors, Instrumentation and methods and applications, Case study.

Eddy current Testing – Principle, properties of eddy currents, Eddy current sensing elements, probes, Instrumentation, Types of arrangement, Advantages & Limitations, Interpretation of Results& applications, Case study.

UNIT IV ULTRASONIC TESTING AND ACOUSTIC EMISSION TESTING

9

Ultrasonic Testing-Principle, Basic Equipment, Transducers, couplants, Ultrasonic wave, Variables in UT, Transmission and Pulse-echo method, Straight beam and angle beam, A-Scan, B-Scan & C-Scan, Phased Array Ultrasound& Time of Flight Diffraction, Advantages & Limitations, Interpretation of Results& Applications, Case study

Acoustic Emission Technique – Introduction, Types of AE signal, AE wave propagation, Source location, Kaiser effect, AE transducers, Principle, AE parameters, AE instrumentation, Advantages & Limitations, Interpretation of Results, Applications, Case study

UNIT V RADIOGRAPHY AND REMOTE FIELD INSPECTION

9

Introduction, Principle, X-ray Production, Gamma ray sources, tubing materials, X-ray tubing characteristics, Interaction of X-ray with matter, Imaging, Film techniques, Filmless techniques, Types and uses of filters and

screens, Real time radiography, geometric factors, inverse square law, characteristics of film, graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy-Xero-Radiography,

Digital Radiography – Film Digitisation, Direct Radiography & Computed Radiography, Computed Tomography, Gamma ray Radiography, Safety in X-ray and Gamma Ray radiography, Case study. Radiation Safety Measures

RFI: Introduction, Theory-Zones, probes, Instrumentation, Signal Interpretation and Reference Standards

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu “Practical Non-Destructive Testing”, Narosa Publishing House, 2009.
2. Ravi Prakash, “Non-Destructive Testing Techniques”, New Age International Publishers, 1st revised edition, 2010.

REFERENCES:

1. ASM Metals Handbook, “Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2. Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd edition New Jersey, 2005
3. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.
4. G. Gaussorgues, “Infrared Thermography”, Chapman & Hall, University Press, Cambridge, 1994.
5. J Prasad, C G K Nair, “Non-Destructive Test and Evaluation of Materials”, MC Graw Hill Education, Second Edition, 2017.

WEB RESOURCES:

1. https://www.nde-ed.org/index_flash.htm
2. <https://ndtlibrary.asnt.org/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/113/106/113106070/>
2. <https://nptel.ac.in/courses/112/107/112107259/>

OUTCOMES:

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

1. Understand the concepts of various Non-traditional Machining processes with its applications.(K2)
2. Different energy mediums required to remove the materials from the workpiece.(K2)
3. Selection of appropriate machining techniques for machining advanced materials.(K2)
4. Identify the machining techniques for machining components with very high tolerance and accuracy ranges.(K2)
5. Understand the various process parameters involved and their influence on the performance of end components.(K2)
6. Upgrade the students with latest technological developments and research trends in the field of Non-traditional Machining.(K3)

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	-	2	-	1	1	-	-	-	-	-	2	3	2
C02	2	-	2	-	1	1	-	-	-	-	-	2	3	2
C03	2	-	2	-	1	1	-	-	-	-	-	2	3	2
C04	2	-	2	-	1	1	-	-	-	-	-	2	3	2
C05	2	-	2	-	1	1	-	-	-	-	-	2	3	2
C06	2	2	2	-	1	1	-	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - II

20MEEL612 SDG NO. 4,9 &12	MATERIALS CHARACTERIZATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To gain knowledge in microstructure evaluation.
- To determine the Material structure
- To measure Physical and Chemical properties of Materials.
- To acquire skills in the use and selection of advanced experimental techniques for characterization of materials and application of these techniques to solving problems in materials science and engineering.

UNIT I OPTICAL METALLOGRAPHIC TECHNIQUES**9**

Macro Examination -applications, metallurgical microscope - construction and principle of working, specimen preparation, light material interaction – Rayleigh Scattering, Abbes theory; magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources; lenses aberrations and their remedial measures, Principles of microscopy -bright field , dark field, phase-contrast, polarization, differential interference contrast, high temperature microscopy; Quantitative Metallography – Image analysis for grain size distribution and grain/precipitate shape.

UNIT II X-RAY DIFFRACTION TECHNIQUES**9**

Reciprocal lattice, Stereographic projection, X-ray generation, absorption edges, characteristic and continuous spectrum, Bragg's law, Ewald's Sphere, Diffraction methods – Laue, rotating crystal and powder methods. Intensity of diffracted beams –structure factor calculations and other factors. Diffractometer – General features and optics, Counters - Proportional, Scintillating, Geiger counters and semiconductor based.X-Ray Fluorescence Spectrometry

UNIT III ANALYSIS OF X-RAY DIFFRACTION**9**

Line broadening-crystallite size, residual stress; Texture Analysis; Crystal structure determination- indexing -Phase identification- ASTM catalogue of Materials identification, quantitative phase estimation, Phase diagram determination, Precise lattice parameter calculation, Determination of residual stress – double angle diffraction.

UNIT IV ELECTRON MICROSCOPY**9**

Electron specimen interaction; Construction and operation of Transmission electron microscope (TEM) – specimen preparation techniques- Diffraction mode and image mode, Sources of contrast- Selected Area Electron Diffraction, Zone axis, indexing ; Construction, modes of operation and sources of contrast of Scanning electron microscope(SEM), Electron probe micro analysis, Basics of Field ion microscopy (FIB), Scanning Tunneling Microscope (STM) and Atomic Force Microscope(AFM), Scanning Auger Microprobe, Scanning Probe Microscopy.

UNIT V SURFACE ANALYSIS**9**

Electron Spectroscopy for Chemical Analysis, X-ray emission spectroscopy - Energy Dispersive Spectroscopy- Wave Dispersive Spectroscopy- Ultraviolet Photo Electron Spectroscopy (UPS), X ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Electron Energy Analysers, Secondary Ion mass spectrometry, Ion Scattering Spectroscopy - Quadrapole mass

spectrometer ; Surface Structure -Unit meshes of five types of surface nets - diffraction from diperiodic structures - Low Energy Electron Diffraction (LEED)- Reflection High Energy Electron Diffraction (RHEED).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. P. C. Angelo, "Materials Characterization", Cengage Learning, 1st edition, ISBN:9788131530764
2. K. R. Hebbar, Basics of X-Ray Diffraction and its Applications, I.K. International Publishing House Pvt Ltd, (2007)

REFERENCES:

1. B. D. Cullity, Elements of X-ray Diffraction, Prentice Hall, 3rd edition, (2001).
2. A. Mammoli, C. A. Brebbia and A. Klemm, Materials Characterisation, WIT Press, 1st edition, (2011).
3. V. Voort, Metallography: Principle and practice, ASM International, (1999).
4. V. A. Phillips, Modern Metallographic Techniques and their Applications, John Wiley & Sons, 1st edition, (1972).
5. V. T. Cherepin and A. K. Mallic, Experimental Techniques in Physical Metallurgy, Asia Publishing Compny, (1967).

WEB RESOURCES:

1. <https://nptel.ac.in/courses/115/103/115103030/>
2. <https://nanohub.org/resources/27532>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/113/106/113106069/>
2. <https://nptel.ac.in/courses/112/106/112106227/>
3. <https://nptel.ac.in/courses/113/106/113106064/>
4. <https://nptel.ac.in/courses/113/106/113106034/>
5. <https://nptel.ac.in/courses/113/104/113104004/>

OUTCOMES:

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

1. Understand of the techniques of the Metallography and analyze the Microstructure of materials. (K2)
2. Understand the techniques of XRD. (K1)

3. Interpret and analyze the XRD results. (K2)
4. Understand the techniques of electron microscopy and their application. (K2)
5. Understand the techniques of elemental chemical composition and structure of surface. (K1)
6. Understand the uses of various materials characterization techniques. (K1)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	1	-	-	-	-	-	-	-	2	2	2
C02	3	2	2	1	-	-	-	-	-	-	-	2	2	2
C03	3	2	2	1	-	-	-	-	-	-	-	2	2	2
C04	3	2	2	1	-	-	-	-	-	-	-	2	2	2
C05	3	2	2	1	-	-	-	-	-	-	-	2	2	2
C06	2	2	1	2	-	-	-	-	-	-	-	2	2	1

PROFESSIONAL ELECTIVES - II

20MEEL613 SDG NO: 4,8,9,12	GREEN MANUFACTURING STRATEGIES AND SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To conserve energy and natural resources, and to ensure that they have minimal impact on the environment and society.
- To fulfil the needs of the present without compromising the ability of future generations to meet their own needs
- To develop an industrial system that is restorative or regenerative by intention and design
- To reuse natural capital as efficiently as possible
- To find value throughout products’ life cycles.

UNIT I MANUFACTURING STRATEGIES-AN OVERVIEW

9

Output of Manufacturing, Operations Systems, Operations Strategy, Functional Strategy Within Context of a Firm, Functional Dominance within Corporate Strategy, World Class Manufacturing Organization, Ps of

Manufacturing Strategy, Contribution of Skinner and Hayes and Wheelwright, Alternative Paradigm of Manufacturing Strategy, Some Generic Manufacturing Strategies, Green Manufacturing Modeling: Indices, Metrics and Development

UNIT II DEVELOPMENT OF STRATEGIES

9

Developing Manufacturing Strategy: Understanding Markets, Concept of Order Winner and Qualifiers- Basic Characteristics and Specific Dimensions, Methodologies for development of Operations Strategy, Roth and Miller Classification

Total Quality Management and Manufacturing Excellence: Deming's Approach to Quality, Business Excellence Awards, Process Choice-3D View, Product Profiling, World Class Manufacturing- Critical Factors for Achievement.

UNIT III VALUE ENGINEERING

9

Origin of Value Engineering, Meaning of value, Definition of Value Engineering and Value analysis, Difference between Value analysis and Value Engineering, Types of Value, function - Basic and Secondary functions, concept of cost and worth, Creativity in Value Engineering, Seven phases of job plan, FAST Diagram as Value Engineering, Value Engineering vs. Cost cutting, Case Studies in Value Engineering

UNIT IV CIRCULAR MANUFACTURING SYSTEMS

9

Circular economy-Introduction, Thinking in systems, Sustainable Packaging in a Circular Economy, Urgency and challenges with critical raw materials (CRMs), Different collection systems for recycling and remanufacturing/refurbishment, return of product, Product design using better recycling or remanufacturing and refurbishment, Substitution of materials, Business value in a circular economy

UNIT V RECYCLING TECHNIQUES

9

Recycling rate, material recovery facilities – Integrating recycling with landfills – Processing equipments, Recycling of papers, pulp, construction and demolition of debris, house hold wastes, Solid wastes. Recycling of Ferrous and Non Ferrous Metals, Recycling of tyres, batteries, glass beverage bottles, textiles, plastic bottles, rubber materials, Selection of natural friendly materials.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. David A. Dornfeld: Green Manufacturing: Fundamentals and Applications (Green Energy and Technology), Springer; 2012 edition

REFERENCES:

1. Peter Lacy and Jakob Rutqvist: Waste to Wealth: The Circular Economy Advantage, Palgrave Macmillan, 2015
2. David Schönmayr: Automotive Recycling, Plastics, and Sustainability-The Recycling Renaissance, Springer Publications, 2017
3. Mudge, Arthur E: Value Engineering- A systematic approach, McGraw Hill, New York, 2000.

WEB RESOURCES:

1. <https://www.teriin.org/article/green-agenda-converting-waste-wealth>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104225/>
2. <https://nptel.ac.in/courses/110/104/110104119/>
3. <https://nptel.ac.in/courses/112/107/112107282/>
4. <https://www.coursera.org/learn/circular-economy>
5. <https://www.edx.org/course/circular-economy-an-introduction>
6. <https://www.edx.org/course/circular-economy-an-interdisciplinary-approach>
7. <https://www.edx.org/course/sustainable-packaging-in-a-circular-economy>
8. <https://www.edx.org/course/engineering-design-for-a-circular-economy>
9. <https://www.edx.org/course/waste-management-and-critical-raw-materials>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the manufacturing strategies, metrics and its development. (K2)
2. Develop Manufacturing Strategy through basic methodologies of Green manufacturing and also with the concepts of TQM. (K2)
3. Understand the basic concepts, methods, tools, and the operation of Value Engineering. (K2)
4. Identify the strategies for the purpose of satisfying a set of given sustainable green manufacturing requirements. (K3)

5. Understand recycling techniques of various processing industries (K2)
6. Understand generic and green manufacturing modeling (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	1	1	-	-	1	3	1	-	-	-	2	2	2
C02	3	-	1	-	-	2	3	2	-	2	-	2	3	2
C03	3	1	1	1	-	2	3	2	-	1	-	2	2	2
C04	2	2	2	-	-	1	3	2	-	-	-	2	2	2
C05	2	2	-	2	2	1	3	2	-	-	-	2	2	2
C06	2	2	-	2	2	1	3	2	-	-	-	2	2	2

PROFESSIONAL ELECTIVES - II

20MEEL614 SDG NO. 4, 9, 12	LEAN AND AGILE MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the principles of Lean Manufacturing.
- To introduce the tools for cost reduction and profitability.
- To explore the various Visual management techniques and lean practices.
- To know the concepts of Agile Manufacturing and its drivers.

UNIT I LEAN MANUFACTURING PRINCIPLES AND CONCEPTS 9

Definition and objectives of lean manufacturing - Origin -Key principles and implications of lean manufacturing -Toyota Production System- Value creation and waste elimination- tools and techniques applied to eliminate waste- Main kinds of waste- Traditional vs Lean Manufacturing.

UNIT II LEAN MANUFACTURING TOOLS AND METHODOLOGIES 9

5s concepts- Stages of 5s and elimination of waste - Kaizen - Steps of kaizen - Poka Yoke - Desing for Manufacturing and Assembly (DFMA) - Principles - Single Minute Exchange of Die (SMED) - Principles - Design of SMED - Total Productive Maintenance (TPM) - Principles - Pull Production through Kanban - Kanban Circles - Tact time, Cycle time, Target Cycle time.

UNIT III VISUAL MANAGEMENT AND LEAN IMPLEMENTATION 9

Visual Management - Tools for eliminating wastes - Overproduction -

Inventory - Delay - Transportation - Processing - Unnecessary motion - Defective parts - Implementation of Lean practices.

UNIT IV AGILE MANUFACTURING

9

Defintion - Conceptual framework - Characteristics - Generic features - Aggregate Capacity Planning and Production line design / redesign in Agile Manufacturing - Robust Design Approach - Approaches to enhance agility in manufacturing - Role of QFD - Managing people in Agile Organization.

UNIT V MANAGEMENT TECHNOLOGY AND COMPETITIVE DRIVERS OF AGILE MANUFACTURING

9

Management driver - Organizational structure - Employee Status and Involvement - Time Management - Application of multimedia to improve agility in Manufacturing - Agility through technology driver - Competitive driver - Status of Quality and Productivity - Outsourcing - Implementation of Agile Manufacturing.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Devadasan S R, Mohan Sivakumar V, Murugesh R and Shalij P R, "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities", Prentice Hall of India (PHI) Private Limited, New Delhi, India, 2012.
2. M.P.Chowdiah, "Agile Manufacturing: Globalised Customerized Green Products", I.K International Publishing House Pvt Ltd, Recent Edition, 2013.

REFERENCES:

1. Bill Carreira, " Lean Manufacturing That Works ", PHI Learning Private Limited, Recent Special Edition 2018.
2. Dennis P. Hobbs, " Lean Manufacturing Implementation ", 1st edition, J. Ross Publishing 2003.
3. Gopalakrishnan.N, " Simplified Lean Manufacture : Elements, Rules, Tools and Implementation ", PHI Learning Private Limited, 2010.
4. William M Feld, "Lean Manufacturing, Tools, Techniques and How To Use Them", CRC Press, 2000.

WEB RESOURCES:

1. <https://www.newcastlesys.com/the-essentials-of-lean-manufacturing-ebook>
2. <http://www.free-management-ebooks.com/news/lean-six-sigma-methodology/>
3. <https://tulip.co/resources/agile-manufacturing/>
4. <https://www.leanproduction.com>

ONLINE RESOURCES:

1. https://www.youtube.com/watch?v=_n28vUPJzxM
2. https://www.youtube.com/watch?v=7M_uMhxZtC4
3. <https://www.edx.org/course/agile-for-project-control-2>
4. <https://www.edx.org/course/agile-leadership-principles-2>
5. <https://www.edx.org/course/agile-solutions-for-greater-innovation>
6. <https://www.edx.org/course/product-management-with-lean-agile-and-system-desi>
7. <https://www.coursera.org/specializations/agile-development>
8. <https://www.coursera.org/learn/uva-darden-agile-team-management>
9. <https://www.edx.org/course/lean-production>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Demonstrate the lean manufacturing principles and concepts to find and eliminate wastes.(K2)
2. Identify the lean manufacturing tools and their potential applications.(K2)
3. Summarize the usage of Visual management and lean practices.(K2)
4. Demonstrate the Agile Manufacturing concepts and managing people in Agile organization.(K2)
5. Compare the Technology and Competitive drivers of Agile Manufacturing.(K2)
6. Incorporate various Lean and Agile manufacturing principles in to manufacturing systems. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	-	-	-	-	1	-	-	-	1	2	1	3	-
C02	2	2	1	1	1	1	1	-	-	2	2	1	2	1
C03	2	2	2	1	1	1	1	-	-	-	2	1	1	2
C04	2	1	1	1	2	1	-	-	-	1	1	1	-	2
C05	1	-	1	-	-	1	1	-	-	1	2	1	-	2
C06	1	1	1	-	-	-	-	-	-	-	-	-	1	1

PROFESSIONAL ELECTIVES - II

20MEEL615 SDG NO: 4,8,9, 11, 12	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the decision phases in a supply chain
- Learn logistics network design
- Understand supplier integration and mass customization
- Learn the global supply chain and technologies for supply chain management(SCM)

UNIT I INTRODUCTION

9

Definition of logistics and supply chain management, decision phases in a supply chain, objectives of SCM, examples of supply chains, supply chain drivers, supply chain integration, supply chain performance measures.

UNIT II NETWORK DESIGN, COORDINATED PRODUCT AND SUPPLY CHAIN DESIGN

9

LOGISTICS NETWORK DESIGN: Role of distribution in supply chain, distribution network design, factors influencing distribution network design, distribution networks in practice, network design in the supply chain, factors influencing the network design, framework for network design, models for facility location and capacity allocation, Impact of uncertainty on network design.

UNIT III STRATEGIC ALLIANCES

9

Framework for strategic alliance - 3PL and 4PL – retailer-supplier partnerships – distribution integration – procurement and outsourcing – benefits, make/buy decisions, E-Procurement, supplier relationship management – supplier scoring and assessment, supplier selection and contracts – E-Business and the supply chain. Design for logistics- Reverse logistics – Case Studies – Supplier integration for new product development

UNIT IV INVENTORY MANAGEMENT

9

Single warehouse inventory model - cycle inventory – economies of scale to exploit fixed costs, quantity discounts, short term discounting, multi-echelon inventory, managing uncertainty – safety inventory in the supply chain – safety level estimation, impact of supply uncertainty, impact of aggregation, impact

of replenishment policies, managing safety inventory in multi echelon supply chain, managing safety inventory in practice -Value of information - Bullwhip effect, information and supply chain technology.

UNITV CUSTOMER VALUE, GLOBAL SUPPLY CHAIN AND TECHNOLOGIES FOR SCM 9

Customer value – dimensions, strategic pricing, customer value measures, information technology and customer value – customer relationship management. Global supply chains – introduction, driving factors, risks and advantages, issues, regional differences in logistics. Information Technology (IT) - Infrastructure- Interface devices - System architecture - Electronic commerce - IT for supply chain excellence - Service oriented architecture - Radio Frequency Identification (RFID) - Impact of internet.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi Edith, “Designing and Managing the Supply Chain”, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2003.
2. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Prentice Hall India Pvt. Ltd, New Delhi, 2007

REFERENCES:

1. Robert B Handfield and Ernest L Nichols, “Introduction to Supply Chain Management”, Prentice Hall, Inc. New Delhi, 1999.
2. Sahay B S, “Supply Chain Management”, Macmillan Company, 2000.
3. David Brunt and David Taylor, “Manufacturing Operations and Supply Chain Management : The Lean Approach”, Vikas Publishing House, New Delhi, 2001.
4. Hartmud Stadler and Christoph Kilger, “Supply Chain Management and Advanced Planning: Concepts, Models, Software”, Springer-Verlag, 2000.
5. David F Ross, “Introduction to E-Supply Chain Management”, CRC Press, 2003

WEB REFERENCES:

1. <https://www.supplychainmanagement.in/copyright.htm>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/110/106/110106045/>
2. <https://nptel.ac.in/courses/110/108/110108056/>
3. <https://nptel.ac.in/courses/110/107/110107074/>
4. <https://nptel.ac.in/courses/110/105/110105141/>

5. https://www.edx.org/course?search_query=supply+chain+management
6. <https://www.coursera.org/search?query=supply%20chain%20management&>

OUTCOMES:

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

1. Get aware about logistics and SCM objectives, Strategies and decision phases.(K2)
2. Know about the SCM drivers, performance measures, role of Distribution and network designing.(K2)
3. Learn about SCM framework, customization, supplier integration.(K2)
4. Understand E business in SCM, supplier assessment, Inventory management.(K2)
5. Know about the art of customer elicitation and the role of IT, infrastructure, Architecture and Ecommerce inSCM. (K2)
6. Get idea about basic framework, networking, strategic alliances, developing E business solutions and technologies required for Logistics and SCM.(K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	1	2	1	1	2	3	3	2	-	1	2
CO2	-	-	-	1	2	1	1	2	3	3	2	-	1	2
CO3	-	-	-	1	2	1	1	2	3	3	2	-	1	2
CO4	-	-	-	1	2	1	1	2	3	3	2	-	1	2
CO5	-	-	-	1	2	1	1	2	3	3	2	-	1	2
CO6	-	-	-	1	2	1	1	2	3	3	2	-	1	2

PROFESSIONAL ELECTIVES - II

20MGEL601 SDG NO. 4,8,9,12	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts and philosophies of Quality Management
- To know the impact and significance of TQM principles on organizations in recent times

UNIT 1 INTRODUCTION 8

Need and Evolution of Quality, Quality-Definitions, statements and dimensions of product and service quality TQM-concepts, Elements and Framework, Benefits & Obstacles of TQM, TQM-Culture, Strategic Quality Management, Costs of Quality.

UNIT II CONTRIBUTIONS AND APPROACHES TO QUALITY MANAGEMENT 9

Renowned quality gurus- Deming, Juran, Crosby and Ishikawa, Contributions of Taguchi – Loss Function, Signal to Noise Ratio and design of experiments, Kaizen - principles and practices - 5S tools, Poka Yoke-8Discipline Methodology, Just in time, Continuous process improvement - PDCA cycle and 5 why analysis.

UNIT III CUSTOMER FOCUS AND TEAMWORK 8

Identifying Customer Needs, QFD - Process, Building HoQ, Customer Satisfaction Measurement Techniques. Employee Involvement Practices. Individual Participation - Suggestion Systems & Empowerment, Motivation, Leadership, Partnerships - Cross-Functional Teams, Supplier/Customer Partnerships, Problem-Solving Teams - Quality Circles.

UNIT IV STATISTICAL TOOLS & TECHNIQUES 11

SQC - Tools For Data Collection And Analysis – Seven tools(old and new),Statistical Process Control (SPC) – Construction of Control Chart – Variables and Attributes. Process Capability – concepts and measurement. Six Sigma models,Lean six sigma, BPR, TPM, FMEA and Benchmarking.

UNIT V QUALITY SYSTEMS AND STANDARDS 9

Need for ISO 9000- ISO 9001: 2015 quality system-guidelines and clausewise requirements, Quality audits-types and responsibilities, ISO 14001:2004 EMS, ISO / TS 16949:2002, ISO 27001:2005 ISMS, SEI – CMMI and Awards - Demings Prize, MBNQA and criteria.

TEXT BOOKS:

1. Besterfield, "Total Quality Management", 3rd Edition, Pearson India.
2. Shridhara K Bhat, "Total Quality Management", Himalaya Publishing House, 2010.

REFERENCES:

1. Bedi Kanishka, "Quality Management", Oxford University Press.
2. Kiran D.R., "Total Quality Management - Key Concepts and Case Studies", Butterworth - Heinemann, 2016.
3. Poornima M Charantimath, "Total Quality Management", Pearson India, 2017.
4. Sharma DD, "Total Quality Management, Principles, Practice and Cases", Sultan Chand and Sons.
5. Douglas C. Montgomery, "Introduction to Statistical Quality Control", Wiley Student Edition, 4th Edition, Wiley India Pvt Limited, 2008.

MOOC REFERENCES:

1. <https://www.coursera.org/lecture/supply-chain-management/total-quality-management-wLrvy>
2. https://swayam.gov.in/nd1_noc20_mg34/preview
3. <https://www.openlearning.com/courses/total-quality-management/>
4. <https://www.udemy.com/course/tqm-in-academics/>

ONLINE RESOURCES:

1. https://www.unido.org/sites/default/files/2009-04/A_roadmap_to_quality_volume_1_0.pdf
2. <https://www.investopedia.com/terms/t/total-quality-management-tqm.asp>
3. https://www.researchgate.net/publication/237006071_Total_Quality_Management_in_Academic_Libraries_A_Study
4. <https://www.isixsigma.com/methodology/total-quality-management-tqm/introduction-and-implementation-total-quality-management-tqm/>
5. <https://study.com/academy/lesson/five-principles-of-total-quality-management-tqm.html>

OUTCOME:

Upon completion of the course, the student should be able to

1. Understand quality concepts and philosophies of TQM. (K2)
2. Apply TQM principles and concepts of continuous improvement. (K3)
3. Explain the quality tools, management tools and statistical fundamentals

to improve quality. (K2)

- 4 Demonstrate the various TQM tools as a means to improve quality. (K2)
- 5 Illustrate quality tools and procedures for better quality output. (K3)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	1	-	1	-	1	1	-	-	-	1
CO2	3	3	3	2	2	-	1	1	-	-	-	1
CO3	3	3	2	2	2	-	1	1	-	-	-	1
CO4	2	2	3	2	2	-	1	1	-	-	-	1
CO5	3	3	3	2	2	2	1	1	-	-	-	1

PROFESSIONAL ELECTIVES - III

20MEEL701 SDG NO. 4,9,12	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce governing equations of viscous fluidflows
- To introduce numerical modelling and its role in the field of fluid flow and heattransfer
- To enable the students to understand the various discretization methods, solution procedures and turbulencemodelling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speedcomputers.

UNIT I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS 9

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and energy equations –Physical boundary conditions – Time- averaged equations for turbulent flow –Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

UNIT II FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION 9

Derivation of finite difference equations – Simple Methods – General methods for first and second order accuracy – Finite volume formulation for steady state one, and two -dimensional diffusion problems–Parabolic equations – Explicit and implicit schemes – Example problems on elliptic and parabolic equations.

UNIT III FINITE VOLUME METHOD FOR CONVECTION DIFFUSION 9

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes, properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

UNIT IV FLOW FIELD ANALYSIS 9

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and velocity corrections – Pressure correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

UNIT V TURBULENCE MODELS AND MESH GENERATION**9**

Turbulence models, mixing length model, Turbulent Kinetic Energy (K) - Two equation (k- ϵ) models – High and low Reynolds number models – Structured grid generation – Unstructured grid generation – Mesh refinement – Usage of Softwares.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 2017.
2. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd. Second Edition, 2007.

REFERENCES:

1. Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press, 2005.
2. Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
3. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2014.
5. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.

WEB RESOURCES:

1. <https://www.cfd-online.com/Links/education.html>
2. <https://cfd.fossee.in/resources>
3. <https://www.openfoam.com/documentation/tutorial-guide/2-incompressible-flow/2.1-lid-driven-cavity-flow>
4. <https://doc.cfd.direct/notes/cfd-general-principles/>

ONLINE RESOURCES:

1. <https://www.classcentral.com/course/youtube-mechanical-computational-fluid-dynamics-47635/classroom>
2. <https://www.classcentral.com/course/youtube-chemical-computational-fluid-dynamics-47623/classroom>
3. <https://www.coursera.org/lecture/modeling-simulation-natural-processes/computational-fluid-dynamics-overview-jTjAc>
4. <https://www.learncax.com/knowledge-base/blog/how-to-learn-cfd-the-beginners-guide>

5. <https://nptel.ac.in/courses/112105171>

OUTCOMES:

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

1. Identify Governing equations and boundary conditions of fluid dynamics and heat transfer. (K1)
2. Describe the mathematical models for fluid flow and heat transfer problems. (K2)
3. Apply various discretization methods into diffusion problems and convection – diffusion problems. (K3)
4. Demonstrate solution procedures and to solve flow field problems.
5. Outline various turbulence modelling techniques. (K1)
6. Analyze complex problems in the field of fluid flow and heat transfer by using high speed computers. (K3)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	1	1	2	-	-	-	-	-	-	1	3	3
C02	3	3	2	2	2	-	-	-	-	-	-	1	2	2
C03	3	3	3	2	2	-	-	-	-	-	-	1	2	2
C04	3	3	3	2	2	-	-	-	-	-	1	2	2	2
C05	3	3	1	1	2	-	-	-	-	-	1	2	3	2
C06	3	3	3	2	2						1	2	3	3

PROFESSIONAL ELECTIVES - III

20MEEL702 SDG NO. 4, 9, 11, 12, 13, 15	REFRIGERATION, AIR CONDITIONING AND CRYOGENIC SYSTEMS				L	T	P	C
	3	0	0	3				

(Use of Refrigeration Tables and Charts are permitted)

OBJECTIVES:

- To understand the underlying principles of operations in different Refrigeration & Air conditioning systems and components.
- To provide knowledge on design aspects of classical Refrigeration and Air conditioning systems.
- To apply the concepts of refrigeration to various other advanced systems
- To understand the concepts of Cryogenic Systems.

UNIT I INTRODUCTION**9**

Introduction to Refrigeration - Unit of Refrigeration and COP – Ideal cycles- Desirable properties of Refrigerants – Classification - Nomenclature - ODP & GWP

UNIT II VAPOUR COMPRESSION REFRIGERATION SYSTEM**9**

Vapor compression cycle: P-H and T-S diagrams - deviations from theoretical cycle – sub cooling and super heating- effect of condenser and evaporator pressure on COP- multi pressure system - low temperature refrigeration - Cascade systems – problems. Type of compressors, condensers, expansion devices, and evaporators.

UNIT III OTHER REFRIGERATION SYSTEMS**9**

Working principle of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems.

UNIT IV AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION**9**

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort and IAQ principles, effective temperature and chart, calculation of summer and winter air conditioning load; Classifications, layout of plants; Air distribution systems; Filters; Air conditioning systems with controls: Temperature, pressure and humidity sensors, actuators and safety control.

UNIT V INTRODUCTION TO CRYOGENICS**9**

Introduction to Cryogenics and its applications, property of cryogenic fluids, Gas-Liquidification and Refrigeration Systems, Cryocoolers, Cryostat design, Dilution Refrigerator and Adiabatic Demagnetization, safety in cryogenics.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Arora, C.P., "Refrigeration and Air Conditioning", 3rd edition, McGraw Hill, New Delhi, 2010.
2. R.S Khurmi and J.K. Gupta "A text book of Refrigeration and Air conditioning"

REFERENCES:

1. ISHRAE Hand book, Fundamentals, 2010

- Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2007
- Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2009.
- Stoecker, W.F. and Jones J. W., "Refrigeration and Air Conditioning", McGraw Hill, New Delhi, 1986
- Randall F. Barron, "Cryogenics Systems", Second Edition Oxford Univesity Press New York, Clarendon Press, Oxford, 1985.

WEB RESOURCES:

- <https://nptel.ac.in/courses/112/105/112105129/>

ONLINE RESOURCES:

- <https://nptel.ac.in/courses/112/105/112105128/>
- <https://nptel.ac.in/courses/112/107/112107208/>
- <https://nptel.ac.in/courses/112/101/112101004/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

- Explain the basic concepts of refrigeration. (K1)
- Explain the Vapor compression refrigeration systems and to solve problems. (K2)
- Illustrate the various types of refrigeration systems. (K2)
- Apply the concepts of Air conditioning and evaluate load calculations. (K3)
- Explain the concepts of Cryogenics. (K2)
- Acquire the knowledge of various types of refrigeration systems and its applications. (K1)

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	-	-	-	1	-	-	-	-	-	-	3	3
C02	3	2	-	-	-	-	-	-	-	-	-	-	3	3
C03	3	2	2	-	-	1	-	-	-	-	-	-	3	3
C04	3	2	-	-	-	-	-	-	-	-	-	-	3	2
C05	3	1	-	-	-	1	-	-	-	-	-	-	3	3
C06	3	2	-	-	-	1	-	-	-	-	1	1	3	3

PROFESSIONAL ELECTIVES - III

20MEEL703 SDG NO. 7	BIOGAS ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To describe various biogas conversion principles, conversion technologies and the economic viability of biogas utilization.
- To understand the raw materials of biogas production and their characteristics.
- To give exposure in to the types and working of bio-reactors and biogas plants.
- To provide basic knowledge on selection based on end use requirements and scaling of biogas plants.
- To familiarize about the purification, storage, utilization and applications of biogas.

UNIT I INTRODUCTION

8

Bio-Energy. Overview of bio gas technology. Technical status of bio gas technology. Economic viability of bio gas technology. Diffusion status of bio gas technology in developing countries. Bio gas technology scenario in India.

UNIT II MATERIALS FOR BIOMETHANATION AND PRODUCT OF METHANATION

8

Bio mass and its availability. Bio degradability. Raw materials of bio gas production and their characteristics. Conversion principle. Fermented slurry as fertiliser.

UNIT III BIO REACTORS

9

Types of bio - reactors - Constant pressure type reactors, Ganesh model, Pragathi model, Astra model, Jwala bio gas plant, Batch digester, German designs, plastic bag digesters, free fabricated steel/plastic digesters, Tunnel type digester, Large Farm bio gas plants, Anaerobic Contact reactors, Anaerobic Filter reactors.

UNIT IV SELECTION, CONSTRUCTION AND OPERATION OF BIO GAS PLANTS

10

Selection of the digester based on end use requirements. Scaling of bio gas plants. Optimal design-KVIC. Design of fixed Dome type of digesters.

Material estimate of fixed dome plants. Selection and size of bio gas reactors and their specifications. Constructional aspects. Operational problems in bio gas plants methods of improving plant productivity. Measuring and test programs.

UNIT V PURIFICATION, SCRUBBING, STORAGE AND UTILIZATION OF BIOGAS

9

Effect of H₂S on bio gas plant and devices. Determination of H₂S content in biogas. Methods for removing H₂S from bio gas. Desulphurising apparatus. Operation procedure of desulphurization. Scrubbing, storage, transportation. Bio gas utilization. Bio gas burners. Design of biogas burners. Stove models. Lighting mantles. Bio gas using stationary power plants. Mobile power plants.

TOTAL:45 HOURS

TEXTBOOKS:

1. Nijaguna BT, "Bio gas Technology", New Age International Publishers, New Delhi, 2002.
2. Khandelwal KC and Mahdi SS, "Bio gas Technology, Vol.I", Tata Mc Graw Hill, 1986.
3. Frank Stephan, "Bio gas Technology", Fachhochschule Koln Hochschule, Bremerhaven, Germany, 1985.

REFERENCES:

1. Helmut Muche / Harald Zimmerman, "The Purification of Biogas", published by Friedr Vieweg and Sohn, Germany, 1985.
2. Ludwig Sasse, "Bio gas Plants", published by Friedr Vieweg and Sohn, Germany, 1985.
3. Singh JB, Reymond Myles and Anil Dhussa, "Manual on Deenabandhu Bio gas Plant", Tata Mc Graw Hill, 1987.
4. Tata Energy Research Institute, "Fixed Dome Bio gas Plants, A design, Construction and Operation Manual", 1987.

OUTCOMES:

Upon completion of the course, the students should be able to

1. Recognize the concept of Bio gas conversion technologies, bio-reactors, purification, storage, utilization and the applications of bio gas. (K1)
2. Interpret various bio gas technologies, reactor types, storage possibilities and utilization devices. (K2)
3. Apply the principles of bio gas conversion, storage techniques and its utilization methods. (K3)

4. Categorize the raw materials of bio gas production, bio-reactors, storage and utilization devices. (K1)
5. Determine which biomass conversion technology would be more appropriate for the given application. (K2)
6. Justify the selection of appropriate biomass conversion system, storage system and utilization system. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	-	1	-	-	-	-	-	1	-
C02	3	-	-	-	-	-	1	-	-	-	-	-	1	-
C03	3	-	-	-	-	3	2	-	-	-	-	-	2	-
C04	3	3	1	-	-	1	3	-	-	-	-	-	2	1
C05	3	3	2	-	-	2	3	-	-	-	-	-	2	1
C06	3	3	2	-	-		3	-	-	-	-	-	2	1

PROFESSIONAL ELECTIVES - III

20MEEL704 SDG NO. 4,7,8,9, 11,12,13,14,15	ENERGY CONSERVATION AND WASTE HEAT RECOVERY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To conserve energy by waste heat recovery
- To harness the energy stored in waste heat and use it for generation of additional electric power
- To study about various methods of Waste Heat Recovery
- To design better equipment focusing on recovering the energy

**UNIT I INTRODUCTION TO ENERGY CONSERVATION AND
MANAGEMENT****9**

Definition of energy management - Energy conservation schemes - Optimizing steam usage - Waste heat management - Insulation - Optimum selection of pipe size – Energy conservation in space conditioning – Energy and cost indices - Energy diagrams – Energy auditing.

UNIT II THERMODYNAMIC SYSTEMS**9**

Thermodynamic availability analysis – Thermodynamic efficiencies -Available energy and fuel, Thermodynamic Cycles: topping, bottoming and combined cycle - organic rankine cycles – performance indices of cogeneration systems, waste heat recovery – sources and types – concept of tri generation. Configuration and thermodynamic performance – steam turbine cogeneration systems, gas turbine cogeneration systems, reciprocating IC engines cogeneration systems, combined cycles cogeneration systems, advanced cogeneration systems, fuel cell, Stirling engines, Heat Recovery Steam Generators

UNIT III WASTE HEAT RECOVERY SYSTEMS**9**

Thermodynamic cycles for low temperature application, Introduction to Heat Exchangers, Analysis – LMTD and NTU method Analysis of Heat Exchanger-Problem solving, Special Heat Exchangers for Waste Heat Recovery, Systems of Heat Exchanger Network of Heat pipes & Vapor Chambers, Direct conversion technologies – Thermoelectric Generators. Direct conversion technologies – Thermoelectric Generators, Thermionic conversion, Thermo-PV, MHD Heat Pump; Heat Recovery from Incinerators, Sorption Systems
Selection criteria for waste heat recovery systems – Recuperators, Regenerators, Economizers, Thermic fluid heaters, Waste heat boilers – classification, location, service conditions, design considerations.

UNIT IV ENERGY STORAGE TECHNIQUES**9**

Energy Storage Techniques – Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic Storage Energy Storage Techniques – Thermal storage (Sensible & Latent), Battery, Chemical Energy Storage, Fuel cell

UNIT V ECONOMIC ANALYSIS**9**

Investment cost – economic concept – Analysis 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 and waste heat recovery systems.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Energy Management and Conservation , P. Venkataseshaiiah K.V. Sharma, Wiley Publication, January 2020
2. Energy Engineering and Management, AmlanChakrabarti, PHI publishers, second edition January 2019

REFERENCES:

1. Fuel Economy in furnaces and Waste heat recovery-PCRA
2. Heat Recovery Systems by D.A.Reay, E &F.N.Span, London,.
3. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
4. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997

WEB RESOURCES:

1. <https://www.journals.elsevier.com/energy-conversion-and-management>
2. <https://www.energylens.com/articles/energy-management>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112105221>

OUTCOMES:

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

1. Understand about need for Energy Conservation and Management. (K1)
2. Apply concepts of thermodynamics to engineering systems. (K3)
3. Study the different measures for energy conservation. (K2)
4. Study the various applications of energy storage systems. (K2)
5. Develop optimized model for energy planning. (K2)
6. Gain knowledge on Waste Heat Recovery methods and Energy Economical balance study. (K1)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	2	-	-	2	1	-	-	-	2	1	3	3
C02	3	2	1	-	-	2	1	-	-	-	1	-	3	3
C03	3	1	1	-	-	1	1	-	-	-	-	-	3	2
C04	3	1	1	-	-	2	2	-	-	-	1	2	3	3
C05	3	2	2	-	-	1	-	-	-	-	1	1	2	2
C06	2	2	3	-	1	2	1	-	-	2	2	1	2	2

PROFESSIONAL ELECTIVES - III

20MEEL705 SDG NO: 4,7,8,9, 11,12,13,15	HYBRID VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of Electric and Hybrid Vehicles,
- To understand and differentiate the power transmission system of conventional, Electric and Hybrid electric vehicles.
- To understand the Propulsion unit of an E-Vehicle
- To discuss various methods of energy storage and charging technologies
- To initiate Entrepreneurship in the area of E-Vehicles and Hybrid Vehicles.

UNIT I ELECTRIC AND HYBRID VEHICLES 9

Electric vehicle: Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption

Hybrid Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supply.

Hydraulic Hybrid Vehicles: Introduction to Hydraulic Hybrid Vehicles, Hydraulic Hybrid Architectures, Component Sizing & System Simulation

UNIT II TRANSMISSION SYSTEMS 9

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT III ELECTRIC PROPULSION UNIT 9

EV consideration, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control Drives.

UNIT IV ENERGY STORAGE AND CHARGING**9**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Energy Charging: Charging methods for battery, Termination methods, charging from grid, The Z-converter, Isolated bidirectional DC-DC converter, Design of Z-converter for battery charging, High-frequency transformer based isolated charger topology, Transformer less topology.

UNIT V OPPORTUNITIES FOR E-VEHICLES AND HYBRID VEHICLES**9**

E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges, Connected Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.
2. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012.

REFERENCES:

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003.
2. Tariq Muneer and Irene IllescasGarcía, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017.
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013.
4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
5. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000

WEB RESOURCES:

1. <https://nptel.ac.in/courses/108/103/108103009/>
2. <https://www.diyguru.org/course/electric-vehicle/>
3. <https://www.udemy.com/course/hybrid-vehicles-the-fundamentals-mechanical-automobile/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/107/106/107106088/>
2. <http://support.skillscommons.org/showcases/open-courseware/energy/e-vehicle-tech-cert/>
3. <https://www.edx.org/professional-certificate/delftx-electric-cars>
4. <https://www.coursera.org/learn/electric-vehicles-mobility>
5. <https://www.edx.org/course/hybrid-vehicles>
6. <https://www.edx.org/course/electric-and-conventional-vehicles>
7. <https://www.edx.org/micromasters/chalmersx-emerging-automotive-technologies>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the fundamentals of conventional and electric vehicles, their architecture and its technologies. (K2)
2. Choose a suitable Transmission system for developing an Electric and Hybrid vehicle. (K1)
3. Choose a suitable propulsion system for developing an Electric and Hybrid vehicle. (K1)
4. Choose proper energy storage and charging systems. (K1)
5. Discover business opportunities in the area of E-Vehicles and Hybrid vehicles. (K2)
6. Interpret working principle of different electric vehicle configuration and its performance analysis. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	-	-	-	-	-	-	-	-	-	-	3	3
C02	3	3	-	-	-	-	-	-	-	-	-	-	3	2
C03	3	3	-	-	-	-	-	-	-	-	-	1	3	2
C04	3	3	-	-	-	-	-	-	-	-	-	1	3	3
C05	3	2	-	-	-	-	-	-	-	-	-	-	2	2
C06	3	2	-	-	-	-	-	-	-	-	-	-	3	2

PROFESSIONAL ELECTIVES - III

20MEEL706	COMPUTER INTEGRATED	L	T	P	C
SDG NO. 4,8,9,12	MANUFACTURING SYSTEMS	3	0	0	3

OBJECTIVES:

- To understand the application of various Manufacturing systems for Industrial Applications
- To streamline production processes by improving the skill set of the current workforce.
- To create automated manufacturing processes based on real-time input
- To have positive impact on profitability, customer retention and attracting new customers.

UNIT I MANUFACTURING SYSTEMS 9

Product Product relationship- Production Performance Metrics, Manufacturing Costs, Components and Types of Manufacturing – System Single station manufacturing system – Application and Analysis of Single Station Manned cell, Single station automated cell

UNIT II ANALYSIS OF ASSEMBLY SYSTEMS 9

Manual and Automated Production Line-Analysis, Line balancing algorithms, Mixed model assembly lines, Fundamentals and applications of Automated production Lines, Analysis of transfer lines. Analysis of assembly systems.

UNIT III MATERIAL HANDLING AND PART IDENTIFICATION 9

Automated material handling system - Transportation system - Automated guided vehicle, conveyor system and analysis of transportation system. Storage system - Automated storage and retrieval system and carousel storage system. Types - Bar code technique, RF identification system, Magnetic stripes, Optical character recognition and other AIDC Technologies.

UNIT IV GROUP TECHNOLOGY AND FLEXIBLE MANUFACTURING SYSTEMS 9

Group technology- Part classification and coding, cellular manufacturing, production flow analysis- Rank Order Clustering and Hollier method. Flexible manufacturing system – Types, Functions, FMS layout, computer control planning of FMS, Types of Flexibility - FMS – FMS Components – FMS Application and Benefits – FMS Planning and Control – Quantitative analysis in FMS

UNIT V MANUFACTURING SUPPORT SYSTEM AND SIMULATION 9

Process planning–Computer Aided Process planning, types. Production Planning- Master production schedule, bill of material, inventory record, working of material requirements planning and its outputs. Shop floor control – phases of shop floor control, factory data collection system. Simulation– Simulation of manufacturing shop and super market using GPSS.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Mikell P. Groover, "Automation, Production systems and Computer Integrated Manufacturing" PHI Learning Pvt. Ltd., 3rd Edition, 2009.
2. Vajpayee S. Kant, "Principles of Computer Integrated Manufacturing", Prentice Hall of India Learning, 2009.

REFERENCES:

1. P.M. Agarwal and V.J. Patel, "CNC Fundamentals and Programming", Charotar Publishing House Pvt. Ltd., Second Edition, 2014.
2. Hindustan Machine Tool Ltd., "Mechatronics", Tata McGraw Hill, 2000.
3. Jerry Banks and Barry L. Nelson, "Discrete Event System Stimulation", Pearson Education, 2006.
4. H.K. Shivanand and M.M. Benal, "Flexible Manufacturing System", New Age International Pvt Ltd Publishers, 2006.

WEB RESOURCES:

1. <https://lecturenotes.in/subject/200/computer-integrated-manufacturing-cim>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104289/>
2. <https://nptel.ac.in/courses/112/104/112104288/>
3. <https://nptel.ac.in/courses/110/106/110106044/>

OUTCOMES:

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

1. Gain suitable knowledge in Production Metrics and Analyse Single Station Cell. (K2)
2. Design and Analyse Manual and Automated assembly systems. (K3)
3. Explain the principles of part identification and inspection system, Transportation & ASRS Systems. (K2)
4. Explain the Concept of Group Technology and FMS. (K2)

5. Explain the working principles of different manufacturing support systems and to apply suitable simulation for a given manufacturing system.(K2)
6. Incorporate the suitable simulation for a given manufacturing system.(K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	2	1	-	-	-	1	1	1	2	2	2
CO2	2	2	1	2	1	-	-	-	1	1	1	2	2	2
CO3	2	2	1	2	1	-	-	-	1	1	1	2	2	2
CO4	2	2	1	2	1	-	-	-	1	1	1	2	2	2
CO5	2	2	1	2	1	-	-	-	1	1	1	2	2	2
CO6	1	1	1	1	1	-	-	-	1	1	1	1	1	1

PROFESSIONAL ELECTIVES - III

20MEEL707 SDG NO. 4,8,9,12	INDUSTRIAL ROBOTICS AND MATERIAL HANDLING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the basic concepts, parts of robots and types of robots.
- To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
- To select the robots according to its usage.
- To discuss about the various applications of robots, justification and implementation of robot.
- To know about material handling in a system.

UNIT I INTRODUCTION**9**

Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.

UNIT II ROBOTS FOR INSPECTION AND OTHER APPLICATIONS 9

Robotic vision systems, image representation, object recognition and categorization, image data compression, software considerations. Application of Robots in continuous arc welding process, cleaning, robot for underwater applications.

UNIT III END EFFECTORS 9

Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers.

UNIT IV SELECTION OF ROBOT 9

Factors influencing the selection of a robot, robot performance analysis, economics of robotisation, Impact of robot on industry and society.

UNIT V MATERIAL HANDLING 9

Concept of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicles, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Richard D Klafter, Thomas Achmielewski and MickaelNegin, –Robotic Engineering – An integrated Approach, Prentice Hall India, New Delhi, 2001.
2. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, 2015.

REFERENCES:

1. James A Rehg, –Introduction to Robotics in CIM Systems, Prentice Hall of India, 2002.
2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.

WEB RESOURCES:

1. <https://www.machinedesign.com/motion-control/difference-between-cartesian-six-axis-and-scara-robots>
2. <https://www.robotics.org/robotics/technical-report-ria-tr-r15-606-2016-for-robots-and-robotic-devices-collaborative-robots>
3. <https://www.iso.org/standard/51330.html>

ONLINE RESOURCES:

1. <https://blog.robotiq.com/bid/63528/what-are-the-different-types-of-industrial-robots>
2. <https://www.youtube.com/watch?v=EeIwoNqxtpg&feature=youtu.be>
3. <https://www.thefabricator.com/thewelder/article/automationrobotics/how-safe-is-your-robotic-workcell->

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the basics of Industrial robot design and industrial FMS workcell basics. (K2)
2. Know about the vision system of Robotics for various applications and various industrial applications of Robots. (K2)
3. Design and to analyse various grippers and its force. (K3)
4. Select Robot based on its performance, analyse the economy of robots, know the impact of robots in industry and society. (K2)
5. Know in detail about various material handling equipments and their operation techniques. (K2)
6. Validate the use of Robots and material handling systems for the enhancement of industry (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	-	2	2	3	3	3	3	2	3	2	1	2
C02	1	1	1	2	3	2	3	2	3	2	3	3	1	2
C03	2	2	2	2	2	1	2	2	2	1	2	2	2	2
C04	-	-	1	2	3	3	3	3	3	2	3	1	1	2
C05	-	-	2	2	3	2	3	3	3	2	3	3	1	2
C06	-	-	2	2	3	2	3	3	3	1	3	2	1	2

PROFESSIONAL ELECTIVES - III

20MEEL708	ARTIFICIAL INTELLIGENCE	L	T	P	C
SDG NO. 8,9	FOR ROBOTICS	3	0	0	3

OBJECTIVES:

- Study the concepts of Artificial Intelligence.
- Learn the methods of solving problems using Artificial Intelligence.
- Introduce the concepts of Expert Systems and machine learning.
- Learn about planning and reasoning artificial intelligence.
- Solve the risk in artificial intelligence.

UNIT I INTRODUCTION

13

History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents. Problem Solving: Informed search and exploration–Constraint satisfaction problems–Adversarial search, knowledge and reasoning– knowledge representation – first order logic.

UNIT II PLANNING

8

Planning with forward and backward State space search – Partial order planning – Planning graphs– Planning with propositional logic – Planning and acting in real world.

UNIT III REASONING

8

Uncertainty – Probabilistic reasoning–Filtering and prediction–Hidden Markov models–Kalman filters– Dynamic Bayesian Networks, Speech recognition, making decisions.

UNIT IV LEARNING

8

Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing, perception.

UNIT V AI IN ROBOTICS

8

Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Fourth Edition, Pearson Education, India, 2022.
2. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems", Third Edition Harlow: Addison-Wesley, 2020.

REFERENCE:

1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree Publishing Company, 1999.

WEB RESOURCES:

1. <https://www.edx.org/course/mind-of-the-universe-robots-in-society-blessing-or>
2. <https://www.udemy.com/course/introduction-to-robotics-artificial-intelligence>
3. <https://www.udacity.com/course/artificial-intelligence-for-robotics--cs373>

OUTCOMES:**At the end of the course, the student should be able to:**

1. Identify problems that are amenable to solution by AI methods. (K2)
2. Identify appropriate AI methods to solve a given problem. (K2)
3. Formalise a given problem in the language/framework of different AI methods. (K1)
4. Implement basic AI algorithms. (K3)
5. Design and carry out an empirical evaluation of different algorithms on a problem formalisation, and state the conclusions that the evaluation supports. (K2)
6. Interfacing AI with Robotics. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	3	2	1	1	3	1	2	3	1	2
CO2	1	2	3	3	3	2	1	1	3	1	2	3	2	3
CO3	-	-	2	1	3	1	1	1	2	-	1	2	1	2
CO4	1	1	2	2	3	1	1	2	2	1	2	3	1	3
CO5	2	1	3	2	3	1	1	1	2	1	2	3	1	3
CO6	2	1	3	2	3	1	1	1	2	1	2	3	1	3

PROFESSIONAL ELECTIVES - III

20MEEL709 SDG NO. 4,8,9,12	DESIGN FOR MANUFACTURING	L	T	P	C
		3	0	0	3

(Use of PSG Design Data Book and Ashby Charts are permitted)

OBJECTIVES:

- To use standardized parts wherever possible
- To create Modular design thereby reducing the number of product parts
- To minimize the redesign of the component
- To design the components meeting the Environmental standards

UNIT I DESIGN FOR MANUFACTURING AND ASSEMBLY (DFMA)**-INTRODUCTION****9**

Introduction to DFMA: History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA, Introduction to Manufacturing Process: Classification of manufacturing process. General design principles for Manufacturability, Strength and Mechanical factors, Mechanisms selection, Evaluation methods. Design for Quality, Reliability and Optimization, Approach to Robust Design.

UNIT II DESIGN AND REDESIGN FOR CASTING**9**

Design recommendation for Sand Casting, Investment casting, Die casting process and Injection Moulding. General design consideration, Specific Design recommendation: Effect of shrinkage for various Metals, Design to minimize Turbulence, Design to achieve directional solidification

Redesign of castings based on Parting line considerations: machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - Modifying the design

UNIT III DESIGN FOR FORMING AND MACHINING

9

Forging: Design factors for forging- Closed die forging design, Parting lines of dies, Drop forging, die design and General design recommendations.

Extrusion and sheet metal work: Design guidelines for extruded sections - Design principles for Punching, Blanking, Bending, and Deep drawing, Keeler Goodman forming line diagram, Component design for Blanking, Form design aspects of sheet metal components.

Design for Machining: Design features to facilitate machining - drills - milling cutters - keyways - Dwelling procedures, counter sunk screws, Reduction of machined area- Simplification by separation and amalgamation, Design for Machinability, Clampability and Accessibility

UNIT IV DESIGN FOR MATERIALS JOINING, ADDITIVE MANUFACTURING AND ASSEMBLY

9

Design for Material Joining: Various weld joint designs, Minimizing distortion, Design for Brazing, Soldering and Adhesive bonding.

Design for Additive Manufacturing: General Part and Feature Design, Part Design – Product Enclosure, Optimization of Path Planning

Design for Assembly: Interchangeable part manufacture and selective assembly, deciding the number of groups. Model-I: Group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal. Laminated shims, Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method, Design recommendation for Rivets, Fasteners, Gasket & Seals, Press fits, Snap fits; Design for Manual, Automated and Robotic Assembly, Economic significance of Assembly.

UNIT V TOLERANCE ANALYSIS & DESIGN FOR ASSEMBLY AND ENVIRONMENT 9

Tolerance Analysis: Cumulative effect of tolerances - Worst case method, root sum square method, dimensions following truncated normal distributions, Centrality analysis, Monte Carlo simulation. Tolerance synthesis, non-linear tolerance analysis, tolerance cost relationships. Process capability, mean, variance, Cp, Cpk, cost aspects, feature tolerances, geometric tolerances - ISO standards - surface finish, review of relationship between attainable tolerance grades and different machining and sheet metal processes

Design for the Environment: Introduction- Basic DFE methods - Design guide lines- Environmental objectives – Global, Regional and local issues,

Lifecycle assessment – 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 energy efficiency, Design to regulations and standards.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M.F.Ashby and K.Johnson: “Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
2. James G Bralla: “Hand Book of Product Design for Manufacturing”, McGraw Hill Publications, 1983.
3. Harry Peck: “Designing for Manufacture”, Pitman Publications, 1983.

REFERENCES:

1. Geoffrey Boothroyd: “Assembly Automation and Product Design”, Marcel Dekker Inc., NY, 3rd edition, 2010.
2. Geoffrey Boothroyd: “Hand Book of Product Design”, Marcel Dekker Inc., NY, 1992
3. Basem said EI-Haik: “Axiomatic Quality”, John Wiley and Sons, 2005.
4. Micheal Wader: “Lean Tools: A Pocket Guide to Implementing Lean Practices”, Productivity and Quality Publishing Private Limited, 2002.
5. Fixel J, “Design for the Environment” McGraw Hill, 1996.
6. Trucks H E: “Design for Economic Production”, Society of Manufacturing Engineers, Michigan, 1987.
7. Spotts M F: “Dimensioning and Tolerance for Quantity Production”, Prentice Hall Inc., 1983.

WEB REFERENCES:

1. <https://nptel.ac.in/courses/107/103/107103012/>
2. <https://nptel.ac.in/courses/112/101/112101005/>
3. <https://quality-one.com/dfm-dfa/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107258/>
2. <https://nptel.ac.in/courses/112/106/112106249/>
3. <https://www.solidprofessor.com/tutorials/dfm>

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Understand the factors to be considered in designing parts and components with focus on manufacturability and recyclability. (K2)
2. Grasp the concepts of dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture. (K2)
3. Focus on simplifying the design of a product to improve ease of manufacture and efficiency of assembly. (K2)
4. Detect, Quantify and eliminate waste and manufacturing inefficiency within a product design. (K3)
5. Understand datum and dwelling features (K2)
6. Analyze the cost considerations while designing for manufacturability on compliance with Environmental standards. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	3	2	2	-	3	-	2	-	-	3	3	3
C02	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C03	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C04	3	2	3	3	2	-	3	-	2	-	-	3	3	3
C05	3	2	2	3	2	-	3	-	2	-	-	3	3	3
C06	2	2	2	3	2	-	3	-	2	-	-	3	3	3

PROFESSIONAL ELECTIVES - III

20MEEL710 SDG NO.4,8,9,12	VIRTUAL PROTOTYPING				L	T	P	C
					3	0	0	3

OBJECTIVES:

- To understand the terminology of product data modeling and management.
- To understand the concepts of graphical image visualization and data representation.
- To provide basic knowledge on Virtual reality and its applications.
- To carry out the factory layout planning and simulations.

UNIT 1 INTRODUCTION**9**

Overview: Issues in product modeling and product data management. Spline-based modeling: polynomials, B-splines, tangent, curvature and continuity conditions. Subdivision-based modeling: Doo-Sabin, Catmull-Clark, Loop, Butterfly, and other schemes.

UNIT II PRODUCT DATA VISUALIZATION**9**

Graphics fundamentals, graphics data representation, polygonal based operations, LOD management, lighting and coloring, illumination, and shading.

UNIT III VIRTUAL REALITY AND ITS APPLICATIONS**9**

Computer animation, viewing in 3D, input/output devices, virtual and augmented reality, virtual design, virtual prototyping and virtual manufacturing.

UNIT IV DESIGN AND ASSEMBLY**9**

Collaborative design and assembly: Methods and tools for collaborative design, assembly process simulation and assembly sequences generation. Process design and planning: Process flow design, process planning, operation and work plan generation, resources planning.

UNIT V PRODUCTION SYSTEM SIMULATION**9**

Factory flow simulation, factory layout planning and simulating, control and scheduling, efficiency analysis, analysis and validating facility layout and process flow, etc.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Prashant Banerjee and Dan Zetu, Virtual Manufacturing, John Wiley & Sons, Inc., New York, 2001.
2. Gerald Farin, Curves and Surfaces for CAGD - A Practical Guide, Fifth Edition, Morgan Kaufmann Publishers, San Francisco, 2002.
3. James D. Foley, Andries van Dam, Steven K. Feiner and John F. Hughes, Computer Graphics, Addison-Wesley Publishing Company, New York, 1990
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing.

REFERENCE BOOKS:

1. J. A. Rehg and H. W. Kraebber, Computer-Integrated Manufacturing, 2nd Edition, Prentice Hall, 2001.
2. J. J. Shah and M. Mantyla, Parametric and Feature-based CAD/CAM, Wiley & Sons, Inc, 1995.
3. Joe Warren and Henrik Weimer, Subdivision Methods For Geometric Design - A Constructive Approach, Morgan Kaufmann Publishers, San Francisco, 2002.

ONLINE RESOURCES:

1. <https://www.coursera.org/lecture/making-virtual-reality-game/prototyping-xShTQ>
2. <https://www.ni.com/virtualprototyping/training>

COURSE OUTCOMES:**Upon completion of the course, the student should be able to:**

1. To understand the product data management, B-Spline and subdivision based modelling. (K1)
2. To develop product data visualization technique in graphics data representation. (K1)
3. To impart the knowledge on computer animation, virtual design and manufacturing. (K2)
4. To understand and analyze design & assembly and process design and planning. (K1)
5. To apply production system simulation in factory layout. (K3)
6. To analyze the virtual reality of 3D prototype modelling. (K3)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	1	-	-	-	-	1	-	-	-	-	3	3	3
C02	2	-	-	-	-	-	2	-	-	-	-	3	3	3
C03	3	-	-	1	1	1	2	-	-	1	-	3	3	3
C04	2	2	1	2	3	3	2	1	-	2	-	3	3	3
C05	3	2	1	2	2	2	2	2	2	2	-	3	3	3
C06														

PROFESSIONAL ELECTIVES - III

20MEEL711 SDG NO. 4, 9, 11	TOOL DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To enable the student to create awareness on Design of various Cutting Tools, Jigs & Fixtures, Press Tools, Gauges, Moulds and Die.
- To reduce the overall cost to manufacture a product by making acceptable parts at the lowest cost
- To increase the production rate by designing tools to produce parts as quickly as possible.
- To increase the productivity of Manufacturing firm.

UNIT I DESIGN OF CUTTING TOOLS

9

Single point cutting tools- Tool Signature, Design of Drills, Reamers, Milling cutters, Broaching tools, Gear cutting tools, Thread cutting tools, Inserts, Tool holders, Selection of inserts and tool holders for specific applications. Ferrous and non-ferrous tooling materials - Carbides, Ceramics and Diamond - Non-metallic tool materials, Importance of tool design in PLM and process planning Selection of machine tool.

UNIT II LOCATING AND CLAMPING PRINCIPLES

9

Basic elements – principles of location – Locating methods and devices – Redundant Location – Principles of clamping – Mechanical actuation – pneumatic and hydraulic actuation Standard parts – Drill bushes and Jig buttons – Tolerances and materials used

UNIT III DESIGN OF JIGS AND FIXTURES

9

Design and development of jigs and fixtures for given component- Types of Jigs – Post, Turnover, Channel, latch, box, pot, angular post jigs – Indexing jigs – General principles of milling, Lathe, boring, broaching and grinding fixtures – Assembly, Inspection and Welding fixtures – Modular fixturing systems- Quick change fixtures.

UNIT IV DESIGN OF PRESS TOOLS

9

Power presses, Press operations, Press tonnage, Elements of press tool die, Types of dies, Clearance, Strip layout, Selection of standard die set, Centre of pressure, Design of blanking and piercing die, Sheet metal bending methods,

Bending force, Bend allowance, Spring back, design of bending die, drawing operations, metal flow during drawing, drawing force, design of drawing die, pilots, strippers and pressure pads, presswork materials, formation of bucklers or wrinklers

UNIT V DESIGN OF GAUGES

9

Gauges: Plain limit gauges: Review of systems of Limits, Fits and Tolerances. Taylor's principles and applications. Calculation of dimensions and design details of plain gauges: Study of standard tapers and methods of dimensioning. Design calculations – Spline gauges– Functional Gauges – CNC gauging.

Design of plain gauges, taper gauges, thread ring gauges, turning mandrel. Selection of material for gauges, indicating gauges, automatic gauges, importance of surface finish

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Cyril Donaldson, George H LeCain, Goold V.C. and Joyjeet Ghose, "Tool Design", Tata McGraw Hill Education Private Limited, New Delhi, 2012.
2. G.R.Nagpal, "Tool Engineering and Design", Khanna Publishers, New Delhi

REFERENCES:

1. M.H.A.Kempster, "An Introduction to Jigs and Fixtures", 3rd ELBS
2. Joshi P.H., "Jigs and Fixtures", Tata McGraw Hill Education Private Limited, New Delhi, 2010.
3. Joshi P.H., "Press Tools Design and Construction", S.Chand & Company Ltd., New Delhi, 2010.
4. Henrickson, Manual of Jigs and Fixtures Design, Industrial Press Inc., New York, 1973.
5. Fundamentals of the Tool Design, ASTME, Prentice-Hall of India Private Ltd., New Delhi, 1976.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/101/112101005/>
2. <http://nitc.ac.in/index.php?url=users/view/270/12/3>
3. <https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-33.pdf>
4. <http://www.ignou.ac.in/upload/jig.pdf>

ONLINE RESOURCES:

1. <https://www.youtube.com/watch?v=6BFTe1avMyE>
2. <https://www.youtube.com/watch?v=vOo2MCYPsm4>
3. <https://www.youtube.com/watch?v=6KsqVKGvgrg>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Design a Cutting Tool for various Machining operations. (K3)
2. Design Jig for a given component. (K3)
3. Design Fixture for a given component. (K3)
4. Design different Press Tools for various operations. (K3)
5. Develop various gauges for inspection purpose. (K3)
6. Develop various gauges for inspection purpose. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	2	2	2	1	2	1	-	-	-	2	1	2	2	2
C02	2	2	2	1	2	1	-	-	-	2	1	2	2	2
C03	2	2	2	1	2	1	-	-	-	2	1	2	2	2
C04	2	2	2	1	2	1	-	-	-	2	1	2	2	2
C05	2	2	2	1	2	1	-	-	-	2	1	2	2	2
C06	2	2	2	1	2	1	-	-	-	2	1	2	2	2

PROFESSIONAL ELECTIVES - III

20MEEL712 SDG NO. 4,9,11,12	COMPOSITE MATERIALS AND MECHANICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge about different matrix and reinforcement materials and selection of them for compositemaking.
- To impart knowledge on various manufacturing methods for making polymer matrix composites.
- To impart knowledge on various manufacturing techniques interface design and developing different in-situ reactions for making metal matrixcomposites.
- To impart knowledge to fabricate different ceramic matrix composites and carbon-carbon composites
- To impart knowledge to develop constitutive equations for different laminates.

UNIT I INTRODUCTION TO COMPOSITES

9

Composite Materials: Definition- Need-Classifications- Characteristics- Applications in various industries -Aircraft, Military, Space Applications, Automotive, Sporting Goods, Marine, Infrastructure. Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight

Reinforcements and Matrix Materials :Reinforcements -Types - Fibers- Glass fiber; Boron fiber; carbon fiber; organic fiber; ceramic and metallic fibers - whiskers-Fabrication of Glass fibre and carbon fibre .Matrix materials- Polymers, Classification of Polymers – Properties of Thermo and Thermosetting Plastics- Metals and ceramics and their properties – interfaces – Wettability – Types of bonding at the interface – Physical and chemical properties, True particulate and Dispersion strengthened composites - Function and examples of dispersoids

UNIT II PROCESSING OF POLYMER MATRIX COMPOSITES (PMCs)

9

Polymer matrix composites: hand layup, spray, filament winding, Pultrusion, resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet Moulding Compound – thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding – Interfaces in PMCs, Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates - Mechanical properties, Recycling of PMCs- Applications of PMCs, Polymer Nano Composites

UNIT III PROCESSING OF METAL MATRIX COMPOSITES (MMCs) 9

Metallic matrices: Aluminum, titanium, magnesium, copper alloys – Processing of MMCs: liquid state, Solid state, in situ fabrication techniques – diffusion bonding – Powder metallurgy techniques, Metal Matrix Nanocomposites

UNIT IV PROCESSING OF CERAMIC MATRIX COMPOSITES (CMCs) AND CARBON-CARBON COMPOSITES 9

Physical methods (different techniques of grinding), Chemical routes - Co precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction). Basic principles and techniques of consolidation and shaping of Ceramic Composites, Calendaring, Multilayering, Slip and Slurry Casting, Tape-casting Powder processing, Sintering-Liquid Phase sintering, Chemical Vapour Impregnation, Lanxide process, Interfaces in CMCs – mechanical properties and applications of CMCs, Ceramic Matrix Nanocomposites.

Carbon-carbon Composites – Carbon Fiber Reinforcements Matrix Systems - Processing of Carbon-Carbon Composites - Properties and applications.

UNIT V MECHANICS OF COMPOSITES 9

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

TOTAL: 45 PERIODS**TEXT BOOKS:**

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

REFERENCES:

1. Broutman, L.J. and Krock, R.M., "Modern Composite Materials", Addison-Wesley, 1967
2. Clyne, T. W. and Withers, P. J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.

3. Sharma, S.C., "Composite materials", Narosa Publications, 2000.
4. Strong, A.B., "Fundamentals of Composite Manufacturing", SME, 1989

WEB RESOURCES:

1. <https://nptel.ac.in/courses/105/108/105108124/>
2. <https://nptel.ac.in/courses/101/104/101104010/>
3. <https://nptel.ac.in/courses/112/104/112104161/>
4. <https://nptel.ac.in/courses/112/104/112104168/>
5. <https://nptel.ac.in/courses/112/104/112104160/>
6. <https://nptel.ac.in/courses/101/106/101106038/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107221/>
2. <https://nptel.ac.in/courses/112/104/112104221/>
3. <https://nptel.ac.in/courses/112/104/112104229/>
4. <https://nptel.ac.in/courses/112/104/112104249/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Define and Classify Composite Materials (K1)
2. Identify the suitable fabrication technique to fabricate Polymer Matrix Composites. (K2)
3. Identify the suitable Manufacturing technique for fabrication of Metal Matrix Composites. (K2)
4. Identify the suitable Manufacturing technique for the Production Ceramic Matrix Composites and Carbon-Carbon Composites. (K2)
5. Develop and use the constitutive equation for the composite components design. (K5)
6. Enumerate the various mechanics of ceramics and evaluate its mechanical properties. (K1)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C02	1	2	2	2	2	-	-	-	-	-	-	2	3	2
C03	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C04	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C05	1	2	2	2	2	-	-	-	-	-	-	2	3	2
C06	1	1	1	1	-	-	-	-	-	-	-	1	1	1

PROFESSIONAL ELECTIVES - IV

20MEEL807 SDG NO. 4,9,12	WEAR, CORROSION AND SURFACE PROTECTION OF MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To protect the Engineering Materials from Surface Degradations Especially Wear and Corrosion through proper Surface modification techniques.
- To enhance the service life of several engineering components by improving their Wear and Corrosion resistance
- To test and validate the surface to ensure that the necessary fitness-for-purpose characteristics have been achieved
- To select the most appropriate coating type and deposition method that requires an understanding of the operational requirements, together with the candidate application methods

UNIT I INTRODUCTION TO WEAR

7

Basics of surfaces features – Roughness parameters – surface measurement - Cause of friction- Laws of friction – Static friction – Rolling Friction – Stick-slip Phenomenon - Friction properties of metal and nonmetals – Friction in extreme conditions – Thermal considerations in sliding contact. Laws of Wear - Types of Wear mechanism

UNIT II INTRODUCTION TO CORROSION

7

Introduction – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In- service monitoring, Simulated service, Laboratory testing –

Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors

UNIT III SURFACE MODIFICATION TECHNIQUES-I

11

Conventional Surface Modification Techniques: Flame hardening, Induction Hardening, Carburizing, Nitriding, Aluminizing, Chromising, Siliconising, Hot Dip Galvanizing, Tinning, Babbiting and Sulphurizing

Surface Coatings by Physical Routes: Physical Vapour Deposition (PVD), Pulsed LASER Deposition, Cathodic Arc Evaporation, Electric Discharge Coatings, Sputtering Techniques

Surface Coatings by Chemical Routes: Chemical Vapour Deposition (CVD), Electro and Electroless Coatings, Anodizing, Micro Arc Oxidation

UNIT IV SURFACE MODIFICATION TECHNIQUES-II

11

Advanced Surface Modification Techniques: LASER Glazing, LASER Cladding, LASER Alloying, LASER Hardening, Electron Beam and Plasma Assisted Surface Modifications- Plasma Electrolytic Oxidation, Plasma Transfer Arc Deposition, Plasma Nitriding, Weld Overlaying

Thermal Spraying: Flame Spraying, High Voltage Oxy – Fuel (HVOF), Wire Arc Spray, Kinetic Spray, Electrospark Coatings, Thermal Barrier Coatings.

New Trends in coating technology: Diamond like Coatings, Nano coatings, Organic & Inorganic Coatings, Hydrophobic and Super Hydrophobic coatings

UNIT V CHARACTERIZATION AND PERFORMANCE EVALUATIONS OF COATINGS

9

Physical Characterization, Assessment of Coating Hardness, Friction and Wear of Coating, Surface Roughness and Thickness of Coating, Adhesion of Coating
Case Studies: Performance Evaluation of TiN Coated Tool and Diamond Coated Tool.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fontana.M.G., "Corrosion Engineering", McGraw Hill, 1985.
2. S.K.Basu, S.N.Sengupta and B.B.Ahuja, "Fundamentals of Tribology", Prentice Hall of India, 2005.

REFERENCES:

1. Halling, J. (Editor), "Principles of Tribology", MacMillan, 1984.
2. Rabinowicz, E., "Friction and Wear of materials", John Willey & Sons, 1995.
3. Williams J.A., "Engineering Tribology", Oxford University Press, 1994.

4. Joseph R. Davis, Corrosion: Understanding the Basics, ASM International, 2000.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/113/108/113108051/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/105/112105053/>
2. <https://nptel.ac.in/courses/113/104/113104074/>
3. <https://nptel.ac.in/courses/112/104/112104219/>
4. <https://nptel.ac.in/courses/113/107/113107075/>
5. <https://nptel.ac.in/courses/112/107/112107248/>
6. <https://nptel.ac.in/courses/113/105/113105086/>
7. <https://nptel.ac.in/courses/113/104/113104082/>
8. <https://nptel.ac.in/courses/113/104/113104089/>
9. <https://nptel.ac.in/courses/113/108/113108083/>
10. <https://nptel.ac.in/courses/113/104/113104061/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Analyze the different types of wear mechanism and its standard measurement. (K2)
2. Understand the basics of Corrosion and its types. (K1)
3. Analyze the different types of Conventional Surface modification techniques. (K2)
4. Analyze the different types of Advanced Surface modification techniques. (K2)
5. Characterize and Evaluate the performance of various Surface Coatings. (K1)
6. Apply the coating and surface techniques for preventing corrosion and performance evaluation. (K3)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C02	1	2	2	2	2	-	-	-	-	-	-	2	3	2
C03	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C04	1	2	2	1	1	-	-	-	-	-	-	2	3	2
C05	1	2	2	2	2	-	-	-	-	-	-	2	3	2
C06	2	2	1	2	1	-	-	-	-	-	1	2	2	1

PROFESSIONAL ELECTIVES - III

20MEEL714 SDG NO: 4, 8, 9, 12	PROJECT PLANNING AND MANAGEMENT			L	T	P	C
				3	0	0	3

OBJECTIVES:

- To understand the various techniques of Project planning and execute the project efficiently.
- To achieve the project's main goal within the given constraints
- To Optimize the allocated necessary inputs and their application meeting the project's pre-defined objectives
- To complete the project which follows the client's exclusive needs

UNIT I PROJECT MANAGEMENT AND INITIATION**9**

Definition of Project, Project Life Cycle, Selection and criteria of choice, selection models and analysis under uncertainty-the management of risk, project portfolio process, project proposals. Role of project managers, problems of cultural differences, impact of institutional environments, multi cultural communication and managerial behaviour. Working and partnering with others – Nature of negotiation, partnering, chartering and scope change, conflict and the project life cycle, requirements and principles of negotiation.

UNIT II PROJECT PLANNING AND TOOLS**9**

Initial project coordination and the project plan, systems integration, the action plan. Project costs and Budgets – estimating project budgets, expert opinion, analogy, parametric estimate; cost engineering –example, contingency amount, elements of budgets and estimates improving the process of costestimation.

UNIT III RESOURCE AND RISK MANAGEMENT**9**

Allocating resources on the project – crashing a project, resource allocation problem, resource loading, resource leveling, constrained resource scheduling, multi-project scheduling and resource allocation. Risk analysis – objectives of risk analysis, identify the risk, determine the most important risk, and identify control measures.

UNIT IV PROJECT CONTROL, EVALUATION AND TERMINATION**9**

The planning, monitoring and controlling cycle, information needs and reporting, earned value analysis, computerized PMIS. Controlling Project execution – fundamental purpose of control, types of control processes, design of control system, control of change and scope creep. Project evaluation – goals of the system, project audit, construction and use of audit report, project audit lifecycle.

UNIT V PROJECT FEASIBILITY ANALYSIS**9**

Marketing Feasibility: Types of market - identification of investment opportunities - market and demand analysis - forecasting demand (review) - forecast control - Secondary sources of information.

Technical Feasibility: Product design-concept of concurrent engineering-make Vs buy decisions – BPO – value analysis – FAST approach – product life cycle management.

TOTAL:45PERIODS**TEXT BOOKS:**

1. Prasanna Chandra, "Projects: Planning, Analysis, Selection, Financing, Implementation, and Review", Tata Mc GrawHill, 8th Edition.
2. Clifford. F. Gray, Erik. W. Larson and Gautam. V. Desai "Project Management: The Managerial Process", Tata Mc Graw Hill, 6th Edition.

REFERENCE:

1. John M Nicholas, "Project Management for Business and Technology", Prentice Hall India Pvt. Ltd., NewDelhi,2002.
2. Anastasia Pagnoni, "Project Engineering–Computer Oriented Planning and Operational Decision Making", Springer Verlag, 1990.
3. Parameshwar Piyer, "Engineering Project Management-with Case Studies", Wheeler Publishing, 1996.
4. Dennis Lock, "The Essentials of Project Management", Gower Publishing Ltd., 1997.5. Vasant Desai, "Project Management", Himalaya Publishing House, 2001.
5. Joseph Phillips, "IT Project Management on Track from Start to Finish", Tata Mc Graw Hill, 2004.

6. Jack R Meredith and Samuel J Mantel, "Project management: A Managerial Approach", John Wiley & Sons, Inc., New Delhi,

WEB REFERENCES:

1. <https://nptel.ac.in/courses/112/102/112102107/>

ONLINE REFERENCES:

2. <https://nptel.ac.in/courses/112/102/112102106/>
 3. <https://nptel.ac.in/courses/103/103/103103039/>
 4. <https://nptel.ac.in/courses/105/106/105106149/>
 5. <https://nptel.ac.in/courses/110/104/110104073/>
 6. <https://nptel.ac.in/courses/110/107/110107081/>
 7. <https://nptel.ac.in/courses/105/102/105102199/>

OUTCOMES:

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

1. Understand the requirements of project management. (K2)
2. Learn the Tools for project planning. (K2)
3. Understand the allocation of Resources and Risk management. (K2)
4. Evaluate and Control the progress of the Project. (K3)
5. Learn to conduct the feasibility analysis. (K2)
6. Perform Project Management Effectively and Efficiently.(K2)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	3	3	3	2	2	1	2	2	3	3	3	3
C02	3	3	3	3	3	2	2	2	3	3	3	3	3	3
C03	3	3	3	3	3	3	3	2	3	3	3	3	3	3
C04	2	2	2	2	2	2	2	2	2	3	3	3	3	3
C05	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C06	3	3	3	3	3	3	3	3	3	3	3	3	3	3

PROFESSIONAL ELECTIVES - III

20MEEL715	SIX SIGMA QUALITY	L	T	P	C
SDG NO: 9		3	0	0	3

(Use of statistical process control charts permitted)

OBJECTIVES:

- To understand the concepts of six sigma and the goals of an organisation.
- To know the basics of lean principles.
- To learn about design of experiments, statistical process control charts and other related concepts.
- To study about the five phases of six sigma namely define, measure, analyse, improve and control.

UNIT I OVERVIEW OF SIX SIGMA AND THE ORGANIZATION 9

Remember & Understand: Six sigma and organizational goals - Remember & Understand: Lean principles in the organization

UNIT II DEFINE PHASE 9

Apply & Analyze: Process Management for projects - Understand & Apply: Project management basics - Understand & Apply: Management and planning tools - Analyze: Business results for projects - Understand & Apply: Team dynamics and performance

UNIT III MEASURE PHASE 9

Analyze: Process analysis and documentation - Understand & Apply: Probability and statistics - Apply, Analyze, Evaluate, & Create: Collecting and summarizing data - Analyze and Evaluate: Measurement system analysis - Analyze & Evaluate: Process capability and performance

UNIT IV ANALYZE PHASE 9

Analyze & Evaluate: Variation and process inputs - Analyze & Evaluate: Data through charts and graphs

UNIT V IMPROVE & CONTROL PHASES 9

Understand & Apply: Design of experiments (DOE) - Understand, Apply, and Analyze: Statistical process control (SPC) - Evaluate & Create: Implement and validate solutions - Understand & Apply: Assist in developing a control plan to

document and hold the gains, and assist in implementing controls and monitoring systems. (Apply)

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Munro, R. A., Maio, M. J., Nawaz, M. B., Ramu, G., & Zrymiak, D. J “The Certified Six Sigma Green Belt Handbook”. Milwaukee, ASQ Quality Press, Second Edition 2015.

REFERENCES:

1. George, M. L., Rowlands, D., Price, M., & Maxey, J “The Lean Six Sigma Pocket Toolbook”, McGraw-Hill, 2004.

WEB RESOURCES:

1. <https://youtu.be/T2Gs5Xb07hs>
2. <https://youtu.be/SMOQV2CyVQo>
3. <https://www.udemy.com/course/six-sigma-hands-on-white-belt/>
4. <https://www.udemy.com/course/six-sigma-white-belt-for-engineers/>
5. <https://www.udemy.com/topic/six-sigma-green-belt/>
6. <https://www.edx.org/professional-certificate/tumx-six-sigma-and-lean>

ONLINE RESOURCES:

1. <https://innocentrix.com/files/presentationintosixsigma.pdf>
2. <https://www.mtcbh.net/mt-content/uploads/2017/01/6-sigma-handnbook.pdf>
3. <https://www.sixsigmacouncil.org/wp-content/uploads/2018/08/Six-Sigma-A-Complete-Step-by-Step-Guide.pdf>
4. <https://www.sixsigmaonline.org/wp-content/uploads/2018/06/SSO-Book-Complete-SS-WB.pdf>
5. https://www.academia.edu/13628867/The_Six_Sigma_Handbook_A_Complete_Guide_for_Green_Belts_Black_Belts_and_Managers_At_All_Levels
6. <http://docshare04.docshare.tips/files/26901/269011073.pdf>

OUTCOMES:

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

1. Remember and understand the concepts of six sigma, organization goals and lean principles in an organization. (K2)
2. Explain the concepts of probability and statics, DOE, SPC and team dynamics and performance. (K2)
3. Apply the concepts of project management for projects, management and

planning tools probability and statics, collection and summarization of data DOE, SPC and control plans; interpret the concepts on team dynamics and performance. (K3)

4. Analyse the concepts involved in process management for process, business results for projects, project analysis and documentation, collection and summarization of data; infer measurement system analysis, process capability and performance, variation and process inputs and data through charts and graphs. (K3)
5. Evaluate and use the concepts on variation and process inputs, data through charts and graphs, and implementation and validation of solutions. (K3)
6. Organize data Collection and summarizing, and implementation and validation of solutions. (K2)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	-	-	-	-	-	3	-	3	2
C02	3	1	-	-	-	-	-	-	-	-	3	-	3	2
C03	3	1	-	-	-	-	-	-	-	-	3	-	3	2
C04	3	1	1	1	-	-	-	-	-	-	3	-	3	1
C05	3	1	1	1	1	-	-	-	-	-	3	-	3	1
C06	3	1	1	1	1	-	-	-	-	-	3	-	3	1

PROFESSIONAL ELECTIVES - III

20MGEL701 SDG NO. 1,3,4,8, 9,11,12	ECONOMICS FOR ENGINEERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand people, businesses, markets and Government.
- To learn the economic models in domestic and in the global context.
- To critically think about importance of Economics in the Nation’s growth.
- To analyse various market factors and also the macroeconomics outcomes.

UNIT I INTRODUCTION**9**

Introduction to economics- definition- field of economics- Basic fundamental economic concepts-Utility- Value-Consumer and producer goods-Utility- Economic of exchanges- Engineering costs and estimation- types of estimates- Estimating models-Cost indexes-power sizing model, improvement & learning curve.

UNIT II MICRO ECONOMICS**9**

Meaning – definition – contents of micro economics-demand- factors affecting demand- Supply- factors affecting supply, Market Equilibrium, surplus and shortage- change in equilibrium and changes in supply and demand- Law of supply and demand.

UNIT III PRODUCTION AND COST**9**

Production function and analysis- Cost functions – types of costs- Production possibility curves- Economics of scale- Production –land- labour-Capital- Raw materials- Isoquant- properties- Industry economics- Break even analysis- Market share- Market performance – Economic Order Quantity – India Industrial growth and pattern- Problems in current Industries- Case study.

UNIT IV MACROECONOMICS**9**

National income-components–meaning, analysis- circular flow of economy- National income sources- GDP and standard of living- Business cycles- Power of sustainable economic growth.

UNIT V INFLATION AND PRICE CHANGE**9**

Definition, effects, causes, price change with indexes, types of index, composite Vs. commodity indexes, use of price indexes in engineering economics, analysis, cash flow that inflate at different rates- Effects of inflation and deflation- Case study- competition in the advertise segment in India.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. PanneerSelvam.R, “Engineering Economics”, Prentice Hall of India Ltd, New Delhi, 2001.

REFERENCES:

1. Sullivan and Wicks: “Engineering Economy”, Pearson publication
2. Desai, B: “Indian Economy in India”, Himalaya Publishing House, Mumbai.
2. Nag, A, “Macro Economics for Management Students” MacMillan India Ltd., New Delhi, 2005.

3. James L. Riggs, David D. Bedworth, Sabah U. Randhawa: "Economics for Engineers", Tata Mc Graw Hill.
4. John A. White, Kenneth E. Case, David B. Pratt: "Principle of Engineering Economic Analysis", John Wiley publication.

WEB RESOURCES:

1. www.economicshelp.org
2. <https://data.oecd.org/economy.htm>
3. <https://www.focus-economics.com>
4. www.mospi.gov.in
5. <https://www.imf.org/external/>

ONLINE RESOURCES:

1. <https://www.coursera.org/learn/uva-darden-bcg-pricing-strategy-cost-economics>
2. <https://www.coursera.org/learn/microeconomics>
3. <https://www.edx.org/course/fundamentals-of-macroeconomics>
4. <https://online.stanford.edu/courses/sohs-yeconschool-principles-economics>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. To describe the principles of economics that governs the operation of any organization under diverse market conditions. (K2)
2. To understand the major capabilities and limitations of cash flow analysis for evaluating proposed capital investments. (K2)
3. To study the traits of micro economics, the demand and supply factors. (K2)
4. To comprehend the production and industrial economics components. (K2)
5. To analyse the National GDP and the sustainable economic growth. (K3)
6. To understand the various factors, effects of inflation and deflation. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	3	3	1	-	1	-	1	1	-	-	-	1	2	2
C02	3	2	3	2	2	-	1	1	-	-	-	1	2	2
C03	3	3	2	2	2	-	1	1	-	-	-	1	1	2
C04	2	2	3	2	2	-	1	1	-	-	-	1	2	2
C05	3	2	3	2	2	-	1	1	-	-	-	1	2	2
C06	3	2	3	2	2	-	1	1	-	-	-	1	2	2

PROFESSIONAL ELECTIVES - III

20MGEL702 SDG NO: 4,9,12	STATISTICS, QUALITY CONTROL AND RELIABILITY ENGINEERING	L	T	P	C
		3	0	0	3

(Use of Statistics and Sampling Tables are permitted)

OBJECTIVES:

- To provide the basic concepts of statistical quality monitoring
- To learn various available statistical tools for quality monitoring.
- To demonstrate the ability to design and implement these tools.
- To understand the importance of Reliability in Engineering.
- To develop the ability to measure the reliability of engineering system

UNIT I QUALITY CONTROL**8**

Definition of Quality, quality control, factors affecting quality, methods of control, chance causes and assignable causes. Quality control and Quality assurance, Quality Costs, Organization for quality, Quality circles.

UNIT II QUALITY CHARTS**9**

Statistical process control –Control charts for variables and attributes. purpose of the chart – X, R, p and np chart - construction of charts - choice between chart for p and chart for np - construction of c-chart- Process and machine capabilities. Six Sigma concept.

UNIT III ACCEPTANCE SAMPLING**10**

Types of sampling, sampling inspection, inspection by Attributes and Variables, Role of acceptance sampling - Producer's risk and consumer's risk,

Procedure for sampling inspection, single, double, multiple sequential sampling plans, O.C. Curves, quality indices for acceptance sampling plans, acceptance sampling by attributes, AQL, LTPD, AOQL – Sampling plans.

UNIT IV RELIABILITY ENGINEERING

9

Definition of reliability, quality, availability, maintainability, types of failures, various parameters of system effectiveness, concept of failure modes, Failure data analysis; Failure rate; Useful life and wear out phase of a system

UNIT V MEASURES OF RELIABILITY

9

Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems – Reliability in terms of Hazard rate and failure density – Examples

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Douglas C. Montgomery, Introduction to Statistical Quality Control, Wiley
2. Reliability Engineering, E. Balagurusamy, Tata McGraw- Hill.

REFERENCES:

1. David Smith Chambers and Donald J. Wheeler, Understanding Statistical Process Control, SPC Press
2. John Oakland, Statistical Process Control, Butterworth-Heinemann
3. Peihua Qiu, Introduction to Statistical Process Control, CRC Press
4. Practical Reliability Engineering/ Patrick D. T., O'Connor / John Wiley & Sons 4th edition.
5. Reliability Engineering, L. S. Srinath, East West press (P) Ltd
6. B. S. Dhillon, C. Singh, Engineering Reliability, John Wiley & Sons,

WEB RESOURCES:

1. https://www.researchgate.net/publication/331514969_Quality_Control_and_Quality_Assurance
2. https://www.researchgate.net/publication/279355662_Statistical_Quality_Control
3. https://www.researchgate.net/publication/302006959_Reliability_Engineering_A_Perspective

ONLINE RESOURCES:

1. <https://alison.com/courses/quality-control>
2. https://www.koenig-solutions.com/quality-management-training-courses-certification?keyword=quality%20management%20online%20course&device=c&gclid=EAlaIqobChMI4ODP_tHB6QIVFqmWCh2OC

QjhEAAYyAAEgKx7fD_BwE

3. <https://www.coursera.org/specializations/six-sigma-green-belt>
4. <https://www.udemy.com/course/an-introduction-to-reliability-engineering/>
5. <https://www.lifetime-reliability.com/cms/training/online-training-courses/reliability-engineering-training-course-beginners/>
6. <https://www.classcentral.com/course/site-reliability-engineering-slos-12834>

OUTCOMES:

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

1. Understand the philosophy and basic concepts of quality improvement. (K2)
2. Demonstrate deep knowledge about statistical methods for quality control. (K2)
3. Demonstrate the ability to design, use, and interpret control charts. (K2)
4. Understand the importance of reliability in Engineering system. (K2)
5. Measure reliability of various engineering systems. (K2)
6. Understand the procedure of quality control in an organization. (K2)

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	-	-	-	-	1	-	-	-	1	-	2	1	1
C02	1	1	1	1	2	1	2	-	-	1	-	2	2	2
C03	2	1	2	1	2	1	2	-	-	-	-	3	1	2
C04	2	2	3	1	-	1	-	-	-	1	-	2	1	1
C05	1	-	1	-	2	1	2	-	-	1	-	3	2	2
C06	2	2	3	3	3	3	3	2	3	3	2	3	3	3

PROFESSIONAL ELECTIVES - IV

20MEEL801	ADVANCED INTERNAL COMBUSTION ENGINES	L	T	P	C
SDG NO: 4,7,9,13,15		3	0	0	3

OBJECTIVES:

- To enable to understand the concepts of S.I and C.I Engines
- To introduce the usage of software for simulating the performance of IC engines.
- To acquire ability to simulate the various types of combustion processes of IC engines.
- To provide the knowledge in performance simulation of IC engines

UNIT I COMBUSTION OF FUELS

9

Chemical composition and molecular structure of hydrocarbon fuels. Combustion Stoichiometry of hydrocarbon fuels – Chemical energy and heat reaction calculations – Chemical equilibrium and adiabatic flame temperature calculation. Flame velocity and area of flame front. Fuel spray characteristics, droplet size, depth of penetration and atomization.

UNIT II SI AND CI ENGINES

9

SI ENGINE: Mixture requirements – Fuel injection systems – Monopoint, Multipoint & Direct injection - Stages of combustion – Normal and Abnormal combustion – Knocking - Factors affecting knocking – Combustion chamber.

CI ENGINE: Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knocking.

– Direct and Indirect injection systems – Combustion chamber – Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Introduction to Turbocharging.

UNIT III COMBUSTION MODELLING AND ANALYSIS

9

Basic concepts of engine simulation – Governing equations, Classification of engine models. Thermodynamic models for Intake and exhaust flow process – Quasi static flow - Gas dynamic Models. Thermodynamic based in cylinder models for SI engine and CI engines.

UNIT IV NON-CONVENTIONAL IC ENGINES

9

Concept of L.H.R. engine and its recent developments. Variable compression ratio engine and its use in research. Rotary combustion engine. Dual fuel engine concept for multi fuel usage in CI engines - Performance calculation of

dual fuel engine. Free piston engine. Stratified charge and lean burn engines. Locomotive and marine engines. Adiabatic and low heat rejection engines, homogeneously charged compression ignition engines - multifuel engines

UNIT V COMBUSTION ANALYSIS IN IC ENGINES

9

Photographic studies of combustion processes – Analysis of Pressure crank angle diagrams in SI and CI engines. Knocking study for Pressure crank angle history. Apparent heat release rate and Wiebe's law analysis for combustion. Calculation of ignition delay and combustion duration. – Hot wire and laser Doppler anemometry and velocimetry for flow and combustion analysis in IC engines. Air assisted Combustion, Homogeneous charged compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles – NOx Adsorbers - Onboard Diagnostics systems.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ramalingam. K. K., "Internal Combustion Engine Fundamentals", Scitech Publications, 2002.
2. Ganesan. V, "Internal Combustion Engines", II Edition, TMH, 2002.

REFERENCES:

1. Mathur. R. B. and R.P. Sharma, "Internal Combustion Engines", Dhanpat Rai & Sons 2007.
2. Duffy Smith, "Auto Fuel Systems", The Good Heart Willcox Company, Inc., 1987.
3. Eric Chowenitz, "Automobile Electronics", SAE Publications, 1995
4. Benson, R.S., Whitehouse, N.D., "Internal Combustion Engines", Pergamon Press, Oxford, 1979.
5. John, B., Heywood, "Internal Combustion Engine Fundamentals", Mc Graw Hill Publishing Co., New York, 1990.
6. Ganesan. V. "Computer Simulation of spark ignition engine process", Universities Press (I) Ltd, Hyderabad, 1996.
7. Ganesan, V., "Computer Simulation of Compression Ignition engine process", Universities Press (India) Ltd., Hyderabad, 1996

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/104/112104033/>
2. <https://nptel.ac.in/courses/103/105/103105110/>
3. <https://ocw.mit.edu/courses/mechanical-engineering/2-61-internal-combustion-engines-spring-2017/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/103/112103262/>
2. <https://nptel.ac.in/courses/107/106/107106088/>

OUTCOMES:

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

1. Explain the chemical kinetics of fuels and combustion. (K2)
2. Classify the various types of engines and its operation. (K2)
3. Formulate equation and models for engine combustion. (K3)
4. Demonstrate the application of various non-convictional engines. (K2)
5. Evaluate the performance and emission character of various engines. (K2)
6. Select suitable engine for various application. (K3)

CO - PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	-	-	-	-	1	-	-	-	2	1	-	3	2
C02	3	-	-	-	-	1	-	-	-	2	1	-	3	2
C03	3	2	2	-	-	2	3	3	-	2	1	1	3	2
C04	3	1	-	2	-	2	2	3	-	2	1	2	3	2
C05	3	2	2	1	-	2	2	1	-	2	1	2	3	3
C06	3	-	2	1	-	1	-	-	-	2	1	2	2	2

PROFESSIONAL ELECTIVES - IV

20MEEL802 SDG NO. 4,8,9,11,12	MICROBOTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose students to the fundamental aspects of the emerging field of microrobotics.
- To focus on physical laws that predominate at the microscale, technologies
- To fabricate small devices and bio-inspired design
- To study microscale challenges that are faced with the fabrication and controlling of microrobots like the energy requirements and locomotion methods

UNIT I SCALING LAWS AND MATERIALS FOR MEMS 9

MST (Micro System Technology) – Micromachining - Working principle of Microsystems - Application of Microsystems. Scaling laws - Scaling effect on physical properties, scaling effects on Electrical properties, scaling effect on physical forces. Physics of Adhesion - Silicon-compatible material system - Shape memory alloys - Material properties: Piezoresistivity, Piezoelectricity and Thermo electricity.

UNIT II FLEXURES, ACTUATORS AND SENSORS 9

Elemental flexures - Flexure systems - Mathematical formalism for flexures. Electrostatic actuators, Piezo-electric actuators, Magneto-strictive actuators. Electromagnetic sensors, Optical-based displacement sensors, Motion tracking with microscopes.

UNIT III MICROROBOTICS 9

Introduction, Task specific definition of micro-robots - Size and development Technology based definition of micro- robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

UNIT IV IMPLEMENTATION OF MICROROBOTS 9

Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro-grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication.

UNIT V MICRO FABRICATION TECHNOLOGY AND MICRO ASSEMBLY 9

Micro-fabrication principles - Design selection criteria for micro machining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Mohamed Gad-el-Hak, — The MEMS Handbook, Volume 3, CRC Press, New York, 2005.
2. Yves Bellouard, —Microrobotics Methods and Applications, CRC Press, Massachusetts, 2011.

REFERENCES:

1. Nadim Maluf and Kirt Williams, An Introduction to Micro electro mechanical systems Engineering, Artech House, MA, Second Edition, 2004.

- Julian W Gardner, —Microsensors: Principles and Applications, John Wiley & Sons, Second Edition, 2021.

WEB RESOURCES:

- <https://en.wikipedia.org/wiki/Microbotics>
- <https://www.sciencedirect.com/topics/engineering/microrobots>
- <https://www.robotpark.com/academy/robot-video-library/>

ONLINE RESOURCES:

- <https://www.youtube.com/watch?v=TYrh3MgB-8Q>
- <https://www.youtube.com/watch?v=8ztQOj7Z4ls>
- <https://www.youtube.com/watch?v=AbjNTjUtAJ4>
- <https://www.robotpark.com/academy/robot-video-library/>

OUTCOMES:

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

- Understand the various properties of SEM, MEMS, scaling effects. (K2)
- Brief about elemental flexures, micro actuators and sensors. (K1)
- Learn the basics about micro robotics. (K1)
- Implement MEMS in robotics, powering, gripper and communication. (K3)
- Apply Micro robotics in packaging and assembly. (K3)
- Understand the basic materials and design of micro robots. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	-	2	-	2	1	1	-	1	-	2	3	1	2
C02	1	-	2	-	2	1	1	-	1	-	2	3	1	2
C03	1	-	2	-	2	1	1	-	1	-	2	3	1	2
C04	1	-	2	-	2	1	1	-	1	-	2	3	1	2
C05	1	-	2	-	2	1	1	-	1	-	2	3	1	2
C06	1	1	2	-	2	1	1	-	1	-	2	3	1	2

PROFESSIONAL ELECTIVES - IV

20MEEL803 SDG NO: 4,8,9,12	SMART MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the concepts of Artificial Intelligence
- To Practice the methods of solving problems using Artificial Intelligence
- To build components of intelligent decision support system for Manufacturing
- To impart knowledge of sensor technologies used in the manufacturing industry for monitoring workpiece, machine tools, machining processes and advanced sensors.

UNIT I INTRODUCTION TO SMART MANUFACTURING**9**

Need - Internet technology and Manufacturing Industry - Digital enterprises - Manufacturing portals - Benefits, Artificial Neural Networks, Fuzzy Logic, Genetic Algorithms, Expert Systems with case studies. Neural Networks for Intelligent Process Monitoring and Control : Applications to CNC machining, Metal Forming - Intelligent Manufacturing, Planning, Scheduling and Control - Intelligent Assembly and Layout Planning

UNIT II INTERNET BASED COLLABORATIVE CAD/CAM**9**

Intelligent CAD systems, integrating product and process design, manufacturing analysis and CAD/CAM integration, design methodology for automated manufacturing, the impacts of intelligent process control on product design, and fuzzy knowledge-based controller design. Applications to web based CAD, CAPP, CNC, Assembly planning, and Rapid Prototyping - Challenging issues of Collaborative CAD/CAM.

UNIT III ARTIFICIAL INTELLIGENCE IN MANUFACTURING**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. Heuristic search-logic programming and reasoning-automatic programming-scope of AI-in manufacturing components of intelligent manufacturing Aspects of intelligence and AI Requirements of AI languages, LISP & PROLOG - Simple programs

UNIT IV INTELLIGENT SYSTEMS**9**

Knowledge engineering-protocol analysis -fuzzy logic -Semantic networks, Learning systems Knowledge Engineering Knowledge representation – Knowledge acquisition and optimization - Knowledge based approaches to design of mechanical parts and mechanisms and design for automated assembly. Knowledge based system for material selection – Intelligent process planning system. Intelligent system for equipment selection -Intelligent system for project management & factory monitoring. Inference engine Vision programme - vision systems -machine learning, The role of Artificial Intelligence in the factory of the future Features of Expert systems - applications in manufacturing planning and control – Intelligent systems. Scheduling the shop floor Manufacturing – Diagnosis & trouble shooting.

UNIT V SENSORS FOR MANUFACTURING AND CONDITION MONITORING**9**

Sensors for Workpiece Monitoring: Mechanical, Electrical, Electro-mechanical, Opto-electrical, Optical, Pneumatic, Capacitance, Eddy current and Magnetic sensors.

Sensors for Position Monitoring: Linear, angular and velocity sensors – Calibration of machine tools – Collision detection measurements.

Sensors for condition monitoring: Force, torque, power, temperature, vibration, acoustic emission, tool sensors, chip control sensors – Adaptive control system – Intelligent systems for machining processes.

Advanced Sensors: Optical and machine vision sensors – Smart/Intelligent sensors – Integrated sensors – Robot sensors – Micro-sensors – Nano-sensors.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Rich, E., "Artificial Intelligence", McGraw Hill, 1986.
2. Kusiak, A., "Intelligent Design and Manufacturing", Wiley-Interscience, 1992.

REFERENCES:

1. Considine, D.M. and Glenn, D., "Standard Handbook of Industrial Automation: Advanced Industrial Technology 01", Chapman and Hall, New York, DOI: 10.1017/S0263574700004392, 1987.
2. Sinclair, I.R., "Sensors and Transducers" Elsevier India Private Limited, New Delhi, India, ISBN: 978- 0-7506-4932-1, 2001.
3. Tönshoff, H.K. and Inasaki, I., "Sensors in Manufacturing: Sensors Applications- Volume1", WileyVCHVerlag GmbH, Weinheim, ISBNs: 3-527-29558-5 (Hardcover); 3-527-60002-7 (Electronic), 2001.

4. Venkatesh, V.C. and Chandrasekaran, H., "Experimental Techniques in Metal Cutting", Prentice-Hall of India Private Limited, New Delhi, India, ISBN: 0-87692-449-6, 1987.
5. Wang, L. and Gao, R.X., "Condition Monitoring and Control for Intelligent Manufacturing", SpringerVerlog London Limited, ISBN-13:978-1-84628-263-3, 2006
6. Dagli, C.H., "Intelligent systems in design and manufacturing", ASME, 1994.
7. Huang, G.Q. and Mak, K.L., "Internet Applications in Product design and Manufacturing", Springer, 2003.
8. Parsaei, H.R. and Jamshidi, M., "Design and implementation of intelligent manufacturing systems", Prentics Hall, 1995
9. Andrew Kussiak, "Intelligent Manufacturing Systems", Prentice Hall, 1990.
10. Simons, G.L., "Introducing Artificial Intelligence", NCC Pub, 1990.

WEB REFERENCES:

1. <https://nptel.ac.in/courses/106/105/106105078/>
2. <https://www.coursera.org/learn/sensors-circuit-interface>
3. <https://www.coursera.org/lecture/intelligent-machining/sensors-2w3Am>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/106/106/106106226/>
2. <https://nptel.ac.in/courses/106/102/106102220/>
3. <https://nptel.ac.in/courses/112/103/112103280/>
4. <https://nptel.ac.in/courses/108/108/108108147/>

OUTCOMES:**Upon completion of the course, the student should be able to:**

1. Apply various knowledge based techniques. (K3)
2. Practice building of intelligent systems. (K3)
3. Adopt intelligent system for Manufacturing. (K3)
4. Apply Internet technology in manufacturing Industry and use techniques of Knowledge Representation. (K3)
5. Choose appropriate sensors for monitoring work pieces, machine tools, machining processes. (K2)
6. Integrate Operations Technology (OT) and Information Technology (IT) to realize significant untapped market opportunities. (K2)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C02	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C03	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C04	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C05	3	3	3	3	3	3	3	3	3	3	3	3	3	3
C06	3	3	3	3	3	3	3	3	3	3	3	3	3	3

PROFESSIONAL ELECTIVES - IV

20MEEL804 SDG NO. 4,8,9,11, 12,13,15	POLYMER MATERIALS AND THEIR PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the science and technology of Polymer synthesis.
- To study Mechanical and Degradation behavior of Polymeric materials.
- To select a suitable manufacturing technique for the production of Polymers.
- To select polymers for domestic as well as industrial appliances.

UNIT I INTRODUCTION TO POLYMERS**9**

Basic Concept, Raw Materials for Polymers, Polymerization principles and processes (step, chain and other polymerizations, polymer kinetics), Polymerization techniques, Polymer manufacture (unit operations, polymer reactors, polymer isolation, handling and storage), polymer structure and property

UNIT II POLYMER MOLECULAR WEIGHT DETERMINATION, CHARACTERIZATION AND MODIFICATION**9**

Number average and weight average molecular weights – Degree of polymerization – Molecular weight distribution – Polydispersity – Molecular weight determination-Methods – viscometry - Gel Permeation Chromatography. Polymer Characterization and Polymer Modification.

UNIT III MECHANICAL AND DEGRADATION BEHAVIOUR OF POLYMERS

9

First and second order transitions – Glass transition, T_g – multiple transitions in polymers – experimental study – significance of transition temperatures. Crystallinity in polymers – effect of crystallization – factors affecting crystallization, crystal nucleation and growth – Relationship between T_g and T_m – Structure–Property relationship. Viscoelasticity-creep and stress relaxation in polymers. Yielding and fracture of polymers, crazing of polymers. Degradation mechanisms – thermal, mechanical and photo degradations, Problems with polymers (thermo oxidative degradation, fire hazards, toxicity, effluent disposal, feedstock scarcity).

UNIT IV PROCESSING AND TESTING OF POLYMERS

9

Overview of Features of Single screw extruder –Tubular blown film process - Coextrusion.-Injection Mouldingprocess – Compression & Transfer Moulding - Blow Moulding – Rotational Moulding – Thermoforming – Vacuum forming - Calendering process – Fiber Spinning process –Structural Foam Moulding/ Foaming - Sandwich Moulding. - Reaction Injection Moulding& Reinforced Reaction Injection Moulding, Polymer compounding and fabrication (polymer additives, Compounding processes, fabrication techniques, post fabrication operations) Polymer testing (sample preparation, testing standards and methods, analysis of polymer and additives).

UNIT V APPLICATIONS OF POLYMERS

9

Polymer applications: Biodegradable polymers, Biomedical polymers, Conducting polymers, Engineering Plastics, High performance polymers, Polymer Assisted Abrasive Finishing process for Mechanical and Medical Components, Multicomponent polymeric materials (polymer miscibility, polymer blends and alloys, filled plastics, polymer composites).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gowariker V R, Viswanathan N V and JayadevSreedhar, “Polymer Science”, New Age International P Ltd., 2005.
2. Bahadur and Sastry, “Principles of Polymer Science”, Narosa Publishing House, 2002

REFERENCES:

1. Billmayer Jr. and Fred. W., “Textbook of Polymer Science”, WileyTappers, 1965
2. Crawford R.J, Plastics Engineering (3rd Ed), Pergamon Press, London(1987)

3. Fried J. R., "Polymer Science and Technology", Prentice Hall, 1995.
4. Gowarikar, "Polymer Science", Johan Wiley and Sons, 1986.
5. Griskey G., "Polymer Process Engineering", Chapman & Hall, New York, 1995.

WEB RESOURCES:

1. <https://ocw.mit.edu/courses/materials-science-and-engineering/3-064-polymer-engineering-fall-2003/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/113/105/113105028/>
2. <https://nptel.ac.in/courses/104/105/104105039/>
3. <https://nptel.ac.in/courses/112/107/112107221/>
4. <https://nptel.ac.in/courses/113/105/113105077/>
5. <https://nptel.ac.in/courses/103/103/103103139/>
6. <https://nptel.ac.in/courses/112/103/112103264/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the basics concepts and fundamental principles of Polymers and Polymerization. (K2)
2. Evaluate the molecular weights of polymers and Characterize them. (K3)
3. Understand the Mechanical and Degradation behaviour of Polymers. (K2)
4. Identify suitable Polymer processing methods for Polymer products. (K2)
5. Learn the Applications of Polymer. (K2)
6. Acquire the knowledge on applications of Polymer. (K2)

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
C01	2	2	2	1	1	1	-	-	-	-	-	2	2	2
C02	2	2	2	1	1	1	-	-	-	-	-	2	2	2
C03	2	2	2	1	1	1	-	-	-	-	-	2	2	2
C04	2	2	2	2	2	1	1	-	-	-	1	2	2	2
C05	2	2	2	2	2	1	1	-	-	-	1	2	2	2
C06	2	2	2	2	2	1	1	-	-	-	1	2	2	2

PROFESSIONAL ELECTIVES - IV

20MEEL805 SDG NO. 3,4,9,11,12, 13,14,15	INDUSTRIAL SAFETY AND MAINTENANCE ENGINEERING			L	T	P	C
				3	0	0	3

OBJECTIVES:

- To achieve an understanding of principles of safety management, functions and activities of safety department.
- To enable students to conduct safety audit and write audit reports effectively in auditing situations.
- To have knowledge about sources of information for safety promotion and training and familiarize students with evaluation of safety performance.
- To enable the student to understand the principles, functions and practices adapted in industry for the successful management of maintenance activities.
- To explain the different maintenance categories like Preventive maintenance, condition monitoring and repair of machine elements.

UNIT I SAFETY MANAGEMENT AND OPERATIONAL SAFETY 9

Evaluation of modern safety concepts - Safety management functions - safety organization, safety department - safety committee, safety audit - performance measurements and motivation - employee participation in safety - safety and productivity. Hot metal Operation - Boiler, pressure vessels - heat treatment shop - gas furnace operation - electroplating-hot bending pipes - Safety in welding and cutting. Cold-metal Operation - Safety in Machine shop - Cold bending and chamfering of pipes - metal cutting - shot blasting, grinding, painting - Power press and other machines

UNIT II SAFETY MEASURES AND ACCIDENT PREVENTION 9

SAFETY MEASURES: Layout design and materials handling - Use of electricity - Management of toxic gases and chemicals - Industrial fire and prevention - Road safety - highway and urban safety - Safety of sewage disposal and cleaning - Control of environmental pollution - Managing emergency in Industries - planning, security and risk assessments, on- site and off site. Control of major industrial hazards.

ACCIDENT PREVENTION: Human safety - personal protective equipment - Causes and cost analysis of accidents. Accident prevention techniques - Specific hazard control strategies - HAZOP - Training and development of employees - First aid- Firefighting devices - Accident reporting, investigation methods.

UNIT III SAFETY, HEALTH, WELFARE & LAWS 9

Safety and health standards - Industrial hygiene - occupational diseases prevention - Welfare facilities - History of legislations related to Safety- pressure vessel acts - Indian boiler regulation - The environmental protection acts - Electricity act - Explosive act.

UNIT IV PRINCIPLES AND POLICIES OF MAINTENANCE ENGINEERING 9

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization – Maintenance economics. Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication

UNIT V CONDITION MONITORING AND REPAIR METHODS 9

Condition Monitoring (CM) – Cost comparison with and without CM – On-load testing and offload testing

Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis Repair methods for beds, slide ways, spindles, gears, lead screws and bearings – Failure analysis

Failures and their development – Logical fault location methods – sequential fault location. Repair methods for Material handling equipment - Equipment records – Job order systems - Use of computers in maintenance.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. L M Deshmukh, Industrial Safety Management, Tata McGraw-Hill Education, 2005.
2. Garg, HP, Maintenance Engineering, S. Chand Publishing

REFERENCES:

1. Industrial safety and the law by P.M.C. Nair Publisher's, Trivandrum.
2. John V. Grimaldi and Rollin H. Simonds, "Safety Management", All India Travellers bookseller, New Delhi-1989.
3. Krishnan N.V., "Safety in Industry", Jaico Publisher House, 1996
4. Managing emergencies in industries, Loss Prevention of India Ltd., Proceedings, 1999.
5. Occupational Safety Manual BHEL.
6. Safety security and risk management by U.K. Singh & J.M. Dewan, A.P.H. Publishing company, New Delhi, 1996.
7. Singh, U.K. and Dewan, J.M., "Safety, Security and risk management", APH Publishing Company, New Delhi, 1996.
8. Charles D. Reese, Occupational Health and Safety Management: A Practical Approach, CRC Press, 2003.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/103/106/103106071/>
2. <https://www.osha.gov/laws-regs>
3. <https://www.mantenimientopetroquimica.com/en/typesofmaintenanc.html>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/110/105/110105094/>
2. <https://nptel.ac.in/courses/114/106/114106017/>
3. <https://nptel.ac.in/courses/114/106/114106039/>
4. <https://nptel.ac.in/courses/115/106/115106087/>
5. <https://nptel.ac.in/courses/112/107/112107241/>

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Understand the functions and activities of safety engineering department carry out a safety audit and prepare a report for the audit. (K2)
2. Prepare an accident investigation report and estimate the accident cost using supervisor's report and data. (K2)
3. Evaluate the safety performance of an organization from accident records and identify various agencies, support institutions and government organizations involved in safety training and promotion. (K3.)
4. Implement the maintenance function and different practices in industries for the successful management of maintenance activities. (K2)
5. Identify the different maintenance categories like, conditioning,

monitoring and repair of machine elements. (K2)

6. Know the importance safety measures and control and governing laws with conditional monitoring techniques. (K1)

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	1	1	2	2	2	3	2	1	2	3	2	2	2	2
C02	2	2	3	2	2	2	1	2	2	2	1	2	2	2
C03	1	1	2	2	1	2	2	1	2	2	3	2	2	2
C04	1	1	2	3	2	2	3	1	1	2	2	2	2	2
C05	1	2	2	3	3	1	2	2	-	-	-	2	2	2
C06	2	2	2	2	3	2	2	2	1	-	-	2	2	3

PROFESSIONAL ELECTIVES - IV

20MEEL806 SDG NO. 4,8,9,11,12	THEORY OF VIBRATION AND NOISE CONTROL			L	T	P	C
				3	0	0	3

OBJECTIVES:

- To understand the sources of vibration and noise in automobiles
- To make design modifications to reduce the vibration and noise and improve the life of the components.
- To improve human comfort by reducing noise and vibration levels.
- To make sure noise and vibration impacts are assessed prior to work commencement, mitigated, and controlled during the works.

UNIT I BASICS OF VIBRATION

9

Introduction, classification of vibration: free and forced vibration, Undamped and damped vibration, linear and non-linear vibration, response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, determination of natural frequencies.

UNIT II BASICS OF NOISE

9

Introduction, amplitude, frequency, wavelength and sound pressure level, addition, subtraction and averaging decibel level, noise dose level, legislation,

measurement and analysis of noise, measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis

UNIT III AUTOMOTIVE NOISE SOURCES

9

Noise Characteristics of engines, engine overall noise levels, assessment of combustion noise, assessment of mechanical noise, engine radiated noise, intake and exhaust noise, engine necessary contributed noise, transmission noise, aerodynamic noise, tire noise and brake noise.

UNIT IV CONTROL TECHNIQUES

9

Vibration isolation, tuned absorbers, un-tuned viscous dampers, damping treatments, application dynamic forces generated by IC engines, engine isolation, crank shaft damping, modal analysis of the mass elastic model shock absorbers.

UNIT V SOURCE OF NOISE AND CONTROL

9

Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis, palliative treatments and enclosures, automotive noise control principles, sound in enclosures, sound energy absorption, sound transmission through barriers

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Singiresu S. Rao, "Mechanical Vibrations", 6th Edition, Pearson Education, 2016.

REFERENCES:

1. Balakumar Balachandran and Edward B. Magrab, "Fundamentals of Vibrations", 1st Edition, Cengage Learning, 2009.
2. Benson H. Tongue, "Principles of Vibrations", 2nd Edition, Oxford University, 2007.
3. Bernard Challen and Rodica Baranescu - "Diesel Engine Reference Book", Second Edition, SAE International, 1999.
4. David Bies and Colin Hansen, "Engineering Noise Control - Theory and Practice", 4th Edition, E and FN Spon, Taylore & Francise e-Library, 2009.
5. Grover. G.T., "Mechanical Vibrations", Nem Chand and Bros., 2009.

WEB RESOURCES:

1. <https://nptel.ac.in/courses/112/106/112106072/>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/112/107/112107088/>
2. <https://nptel.ac.in/courses/112/107/112107087/>
3. <https://nptel.ac.in/courses/112/105/112105197/>
4. <https://nptel.ac.in/courses/112/107/112107212/>
5. <https://nptel.ac.in/courses/112/104/112104211/>
6. <https://nptel.ac.in/courses/101/105/101105081/>
7. <https://nptel.ac.in/courses/112/104/112104194/>
8. <https://nptel.ac.in/courses/112/106/112106225/>
9. <https://nptel.ac.in/courses/112/104/112104227/>

OUTCOMES:

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

1. Summarize the basics of Vibrations. (K2)
2. Summarize the basics of Noise. (K2)
3. Explain the sources of Automotive noise. (K2)
4. Understand the control techniques for vibration. (K2)
5. Discuss the sources and control of noise. (K1)
6. Improve the life of the components and human comfort by noise and vibration reduction. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	-	-	1	2	-	-	-	-	2	2	2
C02	3	3	2	-	-	1	2	-	-	-	-	2	2	2
C03	3	2	2	-	-	1	1	-	-	-	-	2	2	2
C04	3	2	2	-	-	1	1	-	-	-	-	2	3	2
C05	3	2	2	-	-	1	1	-	-	-	-	2	3	2
C06	3	2	2	-	-	1	1	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - IV

20MEEL807 SDG NO. 4,8,9,12	SYSTEMS ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate the life cycle phases and framework for systems engineering.
- To describe about decision assessment methods in systems engineering.
- To apply ergonomic and system dynamic models for evaluation of alternatives.
- To create knowledge on Reliability, Markov and Time series models for analysis of alternatives

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING 9

Systems engineering – Origin, and examples; Systems Engineering as a profession Power of systems Engineering and examples; Systems Engineering viewpoint, perspective, domains; Systems Engineering – fields, approaches, activities and products. Complex system structure-building blocks, hierarchy, interfaces; Complex system structure-environment, interactions, complexity; System development process–life cycle, evolutionary characteristics; Systems Engineering method; Systems testing throughout development, logical steps of systems engineering, Frame works for systems engineering.

UNIT II SYSTEM MANAGEMENT AND ARCHITECTURE 9

Managing systems development, risks, work breakdown structure (WBS), systems Engineering management plan (SEMP) Systems risk management, organizing for systems Engineering; Need analysis – originating, operations, functional and feasibility validation, systems requirement; System requirements development, performance requirements. Implementing concept exploration, validating requirements; Concept de–finition – selection and validation, functional analysis and allocation ; Systems architecture, system modeling languages, Model-Based Systems Engineering (MBSE) Decision making, modeling for decisions; Simulation, Trade-off analysis

UNIT III SYSTEM IMPLEMENTATION 9

Engineering development stage – program risk reduction, prototype development for risk mitigation Development testing, risk reduction; Revision of functional analysis and design; Overview of probability data analysis; Hypothesis testing, Engineering design – implementing system building blocks, component design; Design validation, change management; Concepts

of reliability, redundancy; Concepts of maintainability, availability, producibility; User interface design and GUI

UNIT IV TESTING AND INSTALLATION

9

Integration, testing and evaluating total system; Test planning and preparation, system integration Developmental and operational test and evaluation; Engineering for production, transition from development to production. Installation, maintenance and upgrading; Installation testing; In-service support Upgrades and modernization

UNIT V ANALYSIS OF ALTERNATIVES AND DECISION ASSESSMENT

9

Cross-impact analysis, Structural modeling tools, System Dynamics models with case studies, Economic models: present value analysis – NPV, Benefits and costs over time, ROI, IRR; Work and Cost breakdown structure. Reliability, Availability, Maintainability and Supportability models; Stochastic networks and Markov models, Queuing network optimization, Time series and Regression models, Evaluation of large scale models/ Decision assessment types, Five types of decision assessment effort, Utility theory, Group decision making and Voting approaches, Social welfare function; Systems Engineering methods for Systems Engineering Management

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Andrew P. Sage, James E. Armstrong Jr. Introduction to Systems Engineering, John Wiley and Sons, Inc, 2008.

REFERENCE:

1. INCOSE Systems Engineering Handbook, v3.2. San Diego, CA: INCOSE, 2010.
2. Miller, John. QBQ! The Question Behind the Question: Practicing Personal Accountability at Work and in Life. East Rutherford, NJ: Putnam Publishing Group, 2004. ISBN: 9780399152337.
3. Altshuller, Genrich, Dana W. Clarke, Uri Fedozeev, and Steve Rodman. 40 Principles: TRIZ Keys to Innovation. Worcester, MA: Technical Innovation Center, Inc., 2021. ISBN: 9780964074057.

WEB REFERENCES:

1. <https://www.mitre.org/capabilities/systems-engineering/se-resources>
2. <https://www.systemsengineering.com/>

ONLINE RESOURCES:

1. <https://www.coursera.org/learn/systems-engineering>
2. <https://www.coursera.org/learn/mbse>
3. <https://nptel.ac.in/courses/110/104/110104074/>

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Develop a systems engineering plan for a realistic project. (K2)
2. Judge the applicability of any proposed process, strategy, or methodology for systems engineering using the fundamental concepts from disciplines such as probability, economics, and cognitive science. (K3)
3. Understand system engineers' role and responsibilities and the role of organizations. (K2)
4. Apply systems engineering tools (e.g., requirements development and management, robust design, Design Structure Matrix) to realistic problems.(K3)
5. Recognize the value and limitations of modeling and simulation. (K2)
6. Formulate an effective plan for gathering and using data and to know how to proactively design for and manage system lifecycle targets. (K3)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	3	2	2	3	3	3	2	1	1	3	3	3
C02	3	3	3	3	2	3	3	3	2	1	1	3	3	3
C03	2	2	2	2	2	2	2	2	2	1	1	3	3	3
C04	3	3	3	3	2	3	3	3	2	1	1	3	3	3
C05	3	3	3	3	2	1	1	3	2	1	1	3	3	3
C06	3	3	3	3	2	3	3	3	3	1	1	3	3	3

PROFESSIONAL ELECTIVES - IV

20MEEL808 SDG NO. 2,4,6,9,12, 14,15	MACHINE VISION SYSTEMS & IMAGING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce students, the fundamentals of Human Vision, Machine Vision and Computer Vision.
- To introduce students, the major ideas, methods, and techniques of Machine vision, Image formation and its Lighting Systems.
- To develop an appreciation for various issues in the design of Machine vision and object recognition systems
- To provide the student with Case studies experience from implementing Machine vision and object recognition techniques in various fields.

UNIT – I INTRODUCTION

9

Human Vision - Machine Vision and Computer Vision – HMI – Hardware Components - MVS camera -Analog, Digital- CID, CCD, CMOS, Camera Calibration - Frame Grabber, Manual & Auto shutter.

UNIT – II MACHINE VISION LIGHTING SYSTEMS

9

Digital image fundamentals, binary, gray and color images, steps in digital image processing, imaging requirements, human vision and machine vision. Lighting parameters, Lighting source, selection - Lighting Techniques - Type and selection. Image sampling and quantization, image enhancement - gray level transformations, histogram processing, image sharpening and smoothing, spatial and frequency domain filters, image restoration - noise models, noise reduction by spatial and frequency domain filtering.

UNIT – III IMAGE ACQUISITION & PROCESSING

9

Digital camera Interfaces, Camera Computer Interfaces, Specification and selection. Image segmentation - edge and line detection, thresholding, region-based segmentation, image representation, feature extraction, object recognition. Study of various image operations, 2D and 3D measurements. Fundamentals of Digital Image-Filtering technique -Processing of binary and grey scale images-segmentation- thresholding-connectivity-noise reduction-edge detection-region growing and region splitting - binary and gray morphology operations.

UNIT – IV IMAGE ANALYSIS & SENSING**9**

Image sensing and acquisition, types of cameras and their principle, machine vision lightings, design of machine vision system- lens design, choice of camera and illumination, laser vision system, software for image processing, Feature extraction-Texture Analysis -Pattern recognition, image resolution-depth and volume, color processing, Template Matching -Decision Making, 3D Machine Vision Techniques.

UNIT - V CASE STUDIES**9**

Machine vision in factory automation, dimensional measurement, identification of flaws and defects, pattern recognition applications, sorting and counting, study of surface finish, tool wear measurement, robot guidance, safety monitoring.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. E. R. Davies, Vaclav Hlavac, Roger Boyle, Image Processing Analysis and machine Vision (2014), Cengage Learning
2. Tinku Acharya and Ajoy K Ray, "Image Processing - Principles and Applications", John Wiley and Sons Publication, 2005.

REFERENCE BOOKS:

1. Alexander Hornberg, Handbook on Machine Vision (2006), Wiley.
2. Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing Analysis and machine Vision (2014), Cengage Learning.
3. Rafael C. Gonzalez, Richard Eugene Woods, Digital Image Processing 4 th edition (2018), Pearson.
4. Fabio Solari, Manuela Chessa and Silvio P. Sabatini, Machine Vision – Applications and Systems, Published by InTech.
5. E. R. DAVIES, Computer and Machine Vision: Theory, Algorithms, Practicalities Fourth Edition, Academic Press is an imprint of Elsevier
6. Linda G Shapriro and George C Stockman, "Computer Vision", Prentice Hall, 2001

WEB RESOURCES:

1. <https://www.coursera.org/specializations/digital-signal-processing>
2. <https://www.coursera.org/learn/digital>
3. <https://www.coursera.org/learn/computer-vision-basics>
4. <https://www.edx.org/course/computer-vision-fundamentals>

ONLINE RESOURCES:

1. <https://nptel.ac.in/courses/117/105/117105079/>
2. <https://nptel.ac.in/courses/108/103/108103174/>
3. <https://nptel.ac.in/courses/108/106/108106168/>

OUTCOMES:**After completing the course you will be able to:**

1. Choose the suitable sensing techniques & Hardware components related to the field of Vision. (K3)
2. Explain the Intensity and selection of lighting system required for the external environment. (K2)
3. Identify Basic Concepts, Terminology, Theories, Models and Methods in the Field of Machine Vision. (K2)
4. Identify the appropriate digital interfaces for Image Acquisition & Processing. (K2)
5. Demonstrate the use of Machine Vision systems & Image Analyzing Techniques in various fields. (K3)
6. Understand the usage of sensors and various devices for machine vision system. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	3	3	3	2	2	1	1	2	2	3	3	3
C02	3	3	2	2	3	2	2	1	1	2	2	3	3	3
C03	3	3	3	3	3	2	2	1	1	2	2	3	3	3
C04	3	3	3	3	3	2	2	2	1	2	2	3	3	3
C05	3	3	3	3	3	2	2	1	1	2	2	3	3	3
C06	3	3	3	3	3	2	2	1	1	2	2	3	3	3

PROFESSIONAL ELECTIVES - IV

20MEEL809 SDG NO. 4,8,9,11,12	FATIGUE DESIGN & ANALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various fatigue mechanisms.
- To study on uniaxial fatigue
- To study the life prediction methods under different fatigue conditions
- To learn about residual stresses

UNIT I INTRODUCTION

9

Fatigue Mechanisms - Overview and Examples - Fatigue Design Strategies.

UNIT II UNIAXIAL FATIGUE

9

Elastic Stress Analysis - S-N Data, Mean Stress Effect, Stress Concentration (Notch) Effect, Localized Elastic-Plastic Stress-Strain Analysis - Cyclic Stress-Strain Behavior, Strain-Life Data, Notch Stress-Strain Analysis (Neuber's Rule)

UNIT III CUMULATIVE FATIGUE DAMAGE AND LIFE PREDICTION FOR VARIABLE AMPLITUDE AND IRREGULAR LOADINGS

9

Miner's Rule - Cycle Counting – Rain flow Method - Load Sequence Effects

UNIT IV FATIGUE CRACK GROWTH LIFE PREDICTION METHODS

9

Basics of Linear Elastic Fracture Mechanics - Crack Growth Rate Data - Mean Stress Effect - Variable Amplitude and Irregular Loadings- Load Sequence Effects - Fatigue Micro crack Growth Behavior

UNIT V RESIDUAL STRESSES

9

Sources in Manufacturing and Fabrication - Effects on Fatigue Performance - Use of Manufacturing Processes to Improve Fatigue Strength - Methods to Account for Residual Stresses in Life Predictions. Multiaxial fatigue - Conventional Life Prediction Approaches and their Limitations.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Schijve, J, Fatigue of Structures and Materials, 2009, Springer
2. S. Suresh, Fatigue of Materials, 2nd Edition, Massachusetts Institute of Technology, Cambridge University Press, 1998

REFERENCE BOOKS:

1. George E Diter, Mechanical Metallurgy, McGraw Hill Education, 3rd Edition, (Indian Edition) 2017.
2. Dowling, N. E., Mechanical Behavior of Materials - Engineering Methods for Deformation, Fracture and Fatigue, Pearson Prentice Hall, 3rd. edition, 2007
3. Carl C. Osgood, Fatigue Design: International Series on the Strength and Fracture of Materials and Structures, Pergamon Press, USA. 2nd Edition, 2013
4. Yung-Li Lee, Jwo Pan, Richard Hathaway and Mark Barkey, Fatigue Testing and Analysis: Theory and Practice Hardcover, 2004, Elsevier Butterworth-Heinemann, 2011
5. ASM HANDBOOK, Fatigue and Fracture, Volume 19, ASM International, 1996

WEB REFERENCES:

1. <https://nptel.ac.in/courses/112106065/>
2. <https://youtu.be/Oo2rLpbTY-8?list=PLEEC3p3fjt1foeormrh0jdctHEtn0sYew>
3. <https://youtu.be/Y3v7jUWmzA?list=PLEEC3p3fjt1foeormrh0jdctHEtn0sYew>
4. <https://youtu.be/7xjKYLfa3Vk?list=PLEEC3p3fjt1foeormrh0jdctHEtn0sYew>
5. <https://youtu.be/c7jf0XDzE9k?list=PLEEC3p3fjt1foeormrh0jdctHEtn0sYew>

OUTCOME:**Upon completion of the course, students will be able to**

1. Understand an overview of mechanical behavior includes tensile and fatigue behavior of materials. (K2)
2. Interpret the results from stress – strain behavior of the materials under fatigue load and explain the physical phases in a fatigue life of a component. (K2)
3. Analyze the fatigue damage for variable and irregular loading. (K3)
4. Identify the fatigue crack growth and its behavior. (K2)
5. Apply various manufacturing process to improve fatigue strength. (K3)
6. Explain the fatigue based design philosophies and classify the materials based on their fatigue life. (K2)

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C02	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C03	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C04	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C05	3	3	2	-	-	1	1	-	-	-	-	1	2	2
C06	3	3	2	-	-	1	1	-	-	-	-	1	2	2

PROFESSIONAL ELECTIVES - IV

20MGEL801 SDG NO: 4,6,7,8, 9,11,12	ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively.
- To write a business plan the project report
- To learn the steps involved in starting and running a business
- To gain knowledge and skills needed to run a business successfully.

UNIT I INTRODUCTION TO ENTREPRENEURSHIP**9**

Entrepreneur and Entrepreneurship - Concepts and Definition, Role of Entrepreneur in Economy, Types of Entrepreneurs. Entrepreneur Personality and Behaviour, Entrepreneurial Skills, Factors affecting Entrepreneurial growth, Manager vs Entrepreneur, Steps in Entrepreneurial Process.

UNIT II OPPORTUNITY IDENTIFICATION AND PRODUCT SELECTION**9**

SWOT Analysis. Entrepreneurial Opportunity Search and Identification, Criteria to select a Product for business, Feasibility Study – Economic and Market Feasibility, Entry Strategies, IPR, Negotiation and Conflict Management.

UNIT III ENTREPRISE LAUNCHING & PROJECT REPORT PREPARATION**9**

Small Scale Business – Definition, Role of SME in Economy, Registration

Procedure, Rules of Pollution Board for NOC, Machinery and Location selection. Specimen of Project Report, Project Planning and Scheduling, Project Appraisal Methods –Liabilities under different Statutory Laws

UNIT IV TRENDS IN ENTREPRENEURSHIP

9

Women Entrepreneurship – Role, Challenge, Trends and Benefits. Rural Entrepreneurship –Need, Challenges, Government support, Opportunities and Benefits. Social Entrepreneurship – Emergence and Pioneers, Social Entrepreneurs vs Business Entrepreneurs, Challenges. Technology Driven Entrepreneurship – Types of Technological venture, Challenges, International Entrepreneurship – Opportunities and Challenges

UNIT V ROLE OF SUPPORT INSTITUTIONS

9

Start up schemes by Indian Government - Director of Institutions – DIC – SIDO – SIDBI – SIDC – SISI – NSIC – SFC – SSDIC - NABARD. Cottage and small scale industries – Khadi and Village Industries Corporation/Board, DGS & DNSIC – Export & Import – Applying for assistance – Procedure and Forms – Role of Commercial Banks, Venture Capital.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Donald F Kuratko, “Entrepreneurship – Theory, Process and Practice”, 9th edition cengage Learning, 2014.
2. Khanka. S.S., “Entrepreneurial Development” S.Chand& Co. Ltd., Ram Nagar, New Delhi, 2013.

REFERENCES:

1. EDII “Faulty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development”, Institute of India, Ahmadabad, 1986.
2. Hisrich R D, Peters M P, “Entrepreneurship” 8th Edition, Tata McGraw-Hill, 2013.
3. Mathew J Manimala, "Enterprenuership theory at cross roads: paradigms and praxis" 2nd Edition Dream tech, 2005.
4. Rajeev Roy, "Entrepreneurship" 2nd Edition, Oxford University Press, 2011.
5. Raj Shankar, Text Books Entrepreneurship - Theory and Practice, TMGH.
6. K Ramchandran: Entrepreneurship – Indian Cases on Change Agents, TMGH
7. Kuratko, D.F. & Hodgetts, R.M: Entrepreneurship: Theory, Process and Practice by Cengage Press.

WEB RESOURCES:

1. <https://www.ediindia.org/>
2. <https://nptel.ac.in/courses/110/101/110101004/>
3. <https://www.editn.in/pages/view/edp-course-materials>
4. <https://www.startupindia.gov.in/content/sih/en/government-schemes.html>
5. <https://inc42.com/buzz/startup-scheme-indian-government-startups>

ONLINE RESOURCES:

1. <https://www.coursera.org/learn/entrepreneurship-development?>
2. <https://www.coursera.org/specializations/wharton-entrepreneurship>
3. <https://www.coursera.org/learn/wharton-entrepreneurship-opportunity>
4. <https://www.coursera.org/learn/entrepreneurship-strategy>
5. <https://www.coursera.org/specializations/start-your-own-business>
6. <https://www.udemy.com/course/intro-to-entrepreneurship-get-started-as-an-entrepreneur/>
7. <https://www.udemy.com/course/launch-your-idea-idea-to-mvp-with-no-cto-and-no-coding/>
8. <https://www.udemy.com/course/entrepreneurship-start-a-business-from-scratch/>
9. <https://www.udemy.com/course/entrepreneurship-101-from-idea-to-launch-and-beyond/>
10. https://swayam.gov.in/nd1_noc20_hs66/preview
11. https://swayam.gov.in/nd1_noc20_mg46/preview

OUTCOMES:**Upon completion of the course, the students will be able to:**

1. Instil knowledge and spirit of entrepreneurship among students. (K2)
2. Impart competencies required to become an entrepreneur. (K2)
3. Provide insights into feasibility study and procedures of starting business. (K3)
4. Have awareness of recent trends in entrepreneurship. (K2)
5. Understand the support system for entrepreneurship in India. (K2)
6. Understand the step by step procedure of starting and running the business(K2)

CO- PO, PSO MAPPING :

	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012	PS01	PS02
C01	1	1	1	3	1	3	3	2	3	3	2	1	2	2
C02	1	1	1	3	1	2	3	2	3	2	3	1	2	2
C03	1	1	1	3	1	3	3	3	2	3	3	1	2	2
C04	1	1	1	2	1	2	3	2	2	2	2	2	2	2
C05	1	1	1	2	1	3	3	2	3	3	3	3	2	2
C06	2	2	2	2	3	3	3	3	3	3	3	3	3	3

Imagine the Future and Make it happen!



Together let's build a better world where there is **NO POVERTY** and **ZERO HUNGER**.
 We have **GOOD HEALTH AND WELL BEING** **QUALITY EDUCATION** and full **GENDER EQUALITY** everywhere.
 There is **CLEAN WATER AND SANITATION** for everyone. **AFFORDABLE AND CLEAN ENERGY**
 which will help to create **DECENT WORK AND ECONOMIC GROWTH**. Our prosperity shall be fuelled
 by investments in **INDUSTRY, INNOVATION AND INFRASTRUCTURE** that will help us to
REDUCE INEQUALITIES by all means. We will live in **SUSTAINABLE CITIES AND COMMUNITIES**.
RESPONSIBLE CONSUMPTION AND PRODUCTION will help in healing our planet.
CLIMATE ACTION will reduce global warming and we will have abundant,
 flourishing **LIFE BELOW WATER**, rich and diverse **LIFE ON LAND**.
 We will enjoy **PEACE AND JUSTICE** through **STRONG INSTITUTIONS**
 and will build long term **PARTNERSHIPS FOR THE GOALS**.



For the goals to be reached,
 everyone needs to do their part:
 governments, the private sector,
 civil society and **People like you.**

Together we can...

Sai Prakash Leo Muttu

CEO - Sairam Institutions

We build a Better nation
through Quality education.



Sri

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An Autonomous Institution

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