JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India
R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

B.Tech II Year I Semester

S.No.	Category	Title	L	T	P	Credits
1	BS	Numerical Methods and Transform Techniques	3	0	0	3
2	HSMC	Universal Human Values– Understanding Harmony& Ethical Human Conduct	2	1	0	3
3	Engineering Science	Thermo dynamics	2	0	0	2
4	Professional Core	Mechanics of Solids	3	0	0	3
5	Professional Core	Material Science and Metallurgy	3	0	0	3
6	Professional Core	Mechanics of Solids and Materials Science Lab	0	0	3	1.5
7	Professional Core	Computer-aided Machine Drawing	0	0	3	1.5
8	Engineering Science	Python programming Lab	0	0	2	1.0
9	Skill Enhancement Course	Embedded Systems and IoT	0	1	2	2
10	Audit Course	Environmental Science	2	0	0	-
		Total	**15**	**2**	**10**	**20**

B.Tech. II Year II Semester

S.No.	Category	Title	L	T	P	Credits
1	Management Course- I	Industrial Management	2	0	0	2
2	Basic Science	Complex Variables, Probability and Statistics	3	0	0	3
3	Professional Core	Manufacturing processes	3	0	0	3
4	Professional Core	Fluid Mechanics & Hydraulic Machines	3	0	0	3
5	Professional Core	Theory of Machines	3	0	0	3
6	Professional Core	Fluid Mechanics & Hydraulic Machines Lab	0	0	3	1.5
7	Professional Core	Manufacturing processes Lab	0	0	3	1.5
8	Skill Enhancement course	Soft Skills	0	1	2	2
9	Engineering Science	Design Thinking & Innovation	1	0	2	2
		Total	**15**	**1**	**10**	**21**
Mandatory Community Service Project Internship of 08 weeks duration during summer Vacation						

L	T	P	C
3	0	0	3

II Year I Semester

NUMERICAL METHODS AND TRANSFORM TECHNIQUES

Course Objectives:

- To elucidate the different numerical methods to solve nonlinear algebraic equations
- To disseminate the use of different numerical techniques for carrying out numerical integration.
- To furnish the learners with basic concepts and techniques at plus two level to lead them into advanced level by handling various real world applications.

Course Outcomes:

1. Evaluate the approximate roots of polynomial and transcendental equations by different algorithms. Apply Newton's forward & backward interpolation and Lagrange's formulae for equal and unequal intervals (L3)
2. Apply numerical integral techniques to different Engineering problems. Apply different algorithms for approximating the solutions of ordinary differential equations with initial conditions to its analytical computations (L3)
3. Apply the Laplace transform for solving differential equations (L3)
4. Find or compute the Fourier series of periodic signals (L3)
5. Know and be able to apply integral expressions for the forwards and inverse Fourier transform to a range of non-periodic waveforms (L3)

UNIT – I: Iterative Methods:

Introduction – Solutions of algebraic and transcendental equations: Bisection method – Secant method – Method of false position – Iteration method – Newton-Raphson method (Simultaneous Equations)

Interpolation: Newton's forward and backward formulae for interpolation – Interpolation with unequal intervals – Lagrange's interpolation formula

UNIT – II: Numerical integration, Solution of ordinary differential equations with initial conditions:

Trapezoidal rule– Simpson's $1/3^{rd}$ and $3/8^{th}$ rule– Solution of initial value problems by Taylor's series– Picard's method of successive approximations– Euler's method –Runge-Kutta method (second and fourth order) – Milne's Predictor and Corrector Method.

UNIT –III: Laplace Transforms:

Definition of Laplace transform - Laplace transforms of standard functions – Properties of Laplace Transforms – Shifting theorems–Transforms of derivatives and integrals – Unit step

function – Dirac's delta function – Inverse Laplace transforms – Convolution theorem (with out proof).

Applications: Solving ordinary differential equations (initial value problems) and integro differential equations using Laplace transforms.

UNIT – IV: Fourier series:

Introduction– Periodic functions – Fourier series of periodic function –Dirichlet's conditions – Even and odd functions –Change of interval– Half-range sine and cosine series.

UNIT – V: Fourier Transforms:

Fourier integral theorem (without proof) – Fourier sine and cosine integrals – Infinite Fourier transforms – Sine and cosine transforms – Properties– Inverse transforms – Convolution theorem (without proof) – Finite Fourier transforms.

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. **B. V. Ramana,**Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

Reference Books:

1. **Erwin Kreyszig,**Advanced Engineering Mathematics, 10th Edition, Wiley-India.
2. **Steven C. Chapra,** Applied Numerical Methods with MATLAB for Engineering and Science,Tata Mc. Graw Hill Education.
3. **M. K. Jain, S.R.K. Iyengar and R.K. Jain,** Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
4. **Lawrence Turyn,**Advanced Engineering Mathematics, CRC Press.

II Year-I Semester

L	T	P	C
2	1	0	3

UNIVERSAL HUMAN VALUES – UNDERSTANDING HARMONY& ETHICAL HUMAN CONDUCT

Course Objectives:

- To help the students appreciate the essential complementary between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
- To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
- To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.

Course Outcomes:

- Define the terms like Natural Acceptance, Happiness and Prosperity (L1, L2)
- Identify one's self, and one's surroundings (family, society nature) (L1, L2)
- Apply what they have learnt to their own self in different day-to-day settings in real life (L3)
- Relate human values with human relationship and human society. (L4)
- Justify the need for universal human values and harmonious existence (L5)
- Develop as socially and ecologically responsible engineers (L3, L6)

Course Topics

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 1-hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

UNIT I Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Tutorial 1: Practice Session PS1 Sharing about Oneself
Lecture 3: self-exploration as the Process for Value Education

Lecture4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice Session PS2 Exploring Human Consciousness
Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Tutorial 3: Practice Session PS3 Exploring Natural Acceptance

UNIT II Harmony in the Human Being (6 lectures and 3 tutorials for practice session)
Lecture 7: Understanding Human being as the Co-existence of the self and the body.
Lecture 8: Distinguishing between the Needs of the self and the body
Tutorial 4: Practice Session PS4 Exploring the difference of Needs of self and body.
Lecture 9: The body as an Instrument of the self
Lecture 10: Understanding Harmony in the self
Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the self
Lecture 11: Harmony of the self with the body
Lecture 12: Programme to ensure self-regulation and Health
Tutorial 6: Practice Session PS6 Exploring Harmony of self with the body

UNIT III Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)
Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS9 Exploring Systems to fulfil Human Goal

UNIT IV Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)
Lecture 19: Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature
Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence.

UNIT V Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)
Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct
Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics
Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession
Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Practice Sessions for UNIT I – Introduction to Value Education
PS1 Sharing about Oneself
PS2 Exploring Human Consciousness
PS3 Exploring Natural Acceptance

Practice Sessions for UNIT II – Harmony in the Human Being
PS4 Exploring the difference of Needs of self and body
PS5 Exploring Sources of Imagination in the self
PS6 Exploring Harmony of self with the body

Practice Sessions for UNIT III – Harmony in the Family and Society
PS7 Exploring the Feeling of Trust
PS8 Exploring the Feeling of Respect
PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for UNIT IV – Harmony in the Nature (Existence)
PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for UNIT V – Implications of the Holistic Understanding – a Look at Professional Ethics
PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

READINGS:
Textbook and Teachers Manual
a. The Textbook

R R Gaur, R Asthana, G P Bagaria, *A Foundation Course in Human Values and Professional Ethics*, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

R R Gaur, R Asthana, G P Bagaria,*Teachers' Manual for A Foundation Course in Human Values and Professional Ethics*, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

Reference Books

1. *JeevanVidya: EkParichaya*, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. *Human Values*, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. *The Story of Stuff* (Book).
4. *The Story of My Experiments with Truth* - by Mohandas Karamchand Gandhi
5. *Small is Beautiful* - E. F Schumacher.
6. *Slow is Beautiful* - Cecile Andrews
7. *Economy of Permanence* - J C Kumarappa
8. *Bharat Mein Angreji Raj* – PanditSunderlal
9. *Rediscovering India* - by Dharampal
10. *Hind Swaraj or Indian Home Rule* - by Mohandas K. Gandhi
11. *India Wins Freedom* - Maulana Abdul Kalam Azad
12. *Vivekananda* - Romain Rolland (English)
13. *Gandhi* - Romain Rolland (English)

Mode of Conduct:

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analyzing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses. This course is to be taught by faculty from every teaching department, not exclusively by any one department.
Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

Online Resources:

1. https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%201-Introduction%20to%20Value%20Education.pdf
2. https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%202-Harmony%20in%20the%20Human%20Being.pdf
3. https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%203-Harmony%20in%20the%20Family.pdf
4. https://fdp-si.aicte-india.org/UHV%201%20Teaching%20Material/D3-S2%20Respect%20July%2023.pdf
5. https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%205-Harmony%20in%20the%20Nature%20and%20Existence.pdf
6. https://fdp-si.aicte-india.org/download/FDPTeachingMaterial/3-days%20FDP-SI%20UHV%20Teaching%20Material/Day%203%20Handouts/UHV%203D%20D3-S2A%20Und%20Nature-Existence.pdf
7. https://fdp-si.aicte-india.org/UHV%20II%20Teaching%20Material/UHV%20II%20Lecture%2023-25%20Ethics%20v1.pdf
8. https://www.studocu.com/in/document/kiet-group-of-institutions/universal-human-values/chapter-5-holistic-understanding-of-harmony-on-professional-ethics/62490385
9. https://onlinecourses.swayam2.ac.in/aic22_ge23/preview

L	T	P	C
2	0	0	2

II Year-I Semester

THERMO DYNAMICS

Course Objectives

- Familiarize concepts of heat, work, energy and governing rules for conversion of one form to other.
- Explain relationships between properties of matter and basic laws of thermodynamics.
- Teach the concept of entropy for identifying the disorder and feasibility of a thermodynamic process.
- Introduce the concept of available energy for maximum work conversion.
- Provide fundamental concepts of Refrigeration and Psychrometry.

Unit - I

Introduction: Basic Concepts : System, boundary, Surrounding, control volume, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process, Cycle – Reversibility – Quasi static Process, Irreversible Process, Causes of Irreversibility

Unit -II

Energy in State and in Transition, Types, Work and Heat, Point and Path function. Zeroeth Law of Thermodynamics – PMM-I, Joule's Experiment – First law of Thermodynamics and applications. Limitations of the First Law – Enthalpy, Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance.

Unit - III

Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence / Corollaries, PMM-II, Carnot's principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Increase – Energy Equation, Availability and Irreversibility – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

Unit - IV

Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation Property tables. Mollier charts – Various Thermodynamic processes and energy Transfer – Steam Calorimetry.

Unit – V

Introduction to Refrigeration: working of Air,Vapour compression,VCR system Components, COP Refrigerants.

Introduction to Air Conditioning**:** Psychrometric properties & processes – characterization of sensible and latent heat loads – load concepts of SHF.

Requirements of human comfort and concept of effective temperature- comfort chart – comfort air conditioning, and load calculations.

Text Books:

1. P.K.Nag, Engineering Thermodynamics, 5/e, Tata McGraw Hill, 2013.
2. Claus Borgnakke Richard E. Sonntag, Fundamentals of Thermodynamics, 7/e, Wiley, 2009.

Reference Books

1. J.B. Jones, and R.E. Dugan, Engineering Thermodynamics, 1/e, Prentice Hall, 1995.
2. Y.A.Cengel & M.A.Boles , Thermodynamics – An Engineering Approach, 7/e, McGraw Hill, 2010.
3. P.Chattopadhyay, Engineering Thermodynamics, 1/e, Oxford University Press, 2011.
4. CP Arora, Refrigeration and Air-conditioning, 4/e, McGraw Hill, 2021.

Online Learning Resources:

- https://www.edx.org/learn/thermodynamics.
- https://archive.nptel.ac.in/courses/112/106/112106310.
- https://www.youtube.com/watch?v=7NI5P4KqrAs&t=1s
- https://kp.kiit.ac.in/pdf_files/02/Study-Material_3rd-Semester_Winter_2021_Mechanical-Engg.-_Thermal-Engineering-1_Abhijit-Samant.pdf
- https://www.coursera.org/learn/thermodynamics-intro

Course Outcomes:

COs	Statements	Blooms Level
CO1	Explain the importance of thermodynamic properties related to conversion of heat energy into work.	L3
CO2	Apply the Zeroeth and First Law of Thermodynamics.	L3
CO3	Understand Second Law of Thermodynamics.	L2
CO4	Analyze the Mollier charts, T-S and h-s diagrams, Steam calorimetry, Phase Transformations	L4
CO5	Evaluate the COP of refrigerating systems and properties, processes of psychrometry and sensible and latent heat loads.	L5

L	T	P	C
3	0	0	3

II Year I Semester

MECHANICS OF SOLIDS

Course Objectives: The objectives of the course are to

- Understand the behaviour of basic structural members subjected to uni axial and bi axial loads.
- Apply the concept of stress and strain to analyse and design structural members and machine parts under axial, shear and bending loads, moment and torsional moment.
- Students will learn all the methods to analyse beams, columns, frames for normal, shear, and torsion stresses and to solve deflection problems in preparation for the design of such structural components. Students are able to analyse beams and draw correct and complete shear and bending moment diagrams for beams.
- Students attain a deeper understanding of the loads, stresses, and strains acting on a structure and their relations in the elastic behavior
- Design and analysis of Industrial components like pressure vessels.

UNIT– I

SIMPLE STRESSES & STRAINS : Elasticity and plasticity – Types of stresses & strains–Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Bars of varying section – composite bars – Temperature stresses- Complex Stresses - Stresses on an inclined plane under different uniaxial and biaxial stress conditions - Principal planes and principal stresses - Mohr's circle - Relation between elastic constants, Strain energy – Resilience – Gradual, sudden, impact and shock loadings.

UNIT–II

SHEAR FORCE AND BENDING MOMENT : Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of abeam.

UNIT–III

FLEXURAL STRESSES : Theory of simple bending, Derivation of bending equation, Determination of bending stresses – section modulus of rectangular, circular, I and T sections– Design of simple beam sections.

SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I and T sections.

UNIT–IV

DEFLECTION OF BEAMS : Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply

supported beams subjected to point loads, UDL and UVL. Mohr's theorem and Moment area method – application to simple cases.

TORSION: Introduction-Derivation- Torsion of Circular shafts- Pure Shear-Transmission of power by circular shafts, Shafts in series, Shafts in parallel.

UNIT– V

THIN AND THICK CYLINDERS: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and volumetric strains – changes in dia, and volume of thin cylinders– Thin spherical shells. Wire wound thin cylinders. Lame's equation – cylinders subjected to inside & outside pressures – compound cylinders.

COLUMNS:

Buckling and Stability, Columns with Pinned ends, Columns with other support Conditions, Limitations of Euler's Formula, Rankine's Formula

Text Books:

1. GH Ryder, Strength of materials, Palgrave Macmillan publishers India Ltd, 1961.
2. B.C. Punmia, Strength of materials,10/e, Lakshmi publications Pvt. Ltd, New Delhi, 2018.

Reference Books:

1. Gere & Timoshenko, Mechanics of materials, 2/e, CBS publications, 2004.
2.U.C.Jindal, Strength of Materials, 2/e, Pearson Education, 2017.
3.Timoshenko, Strength of Materials Part – I& II, 3/e, CBS Publishers, 2004.
4. Andrew Pytel and Ferdinand L. Singer, Strength of Materials,4/e, Longman Pulications, 1990.
5. Popov, Mechanics of Solids, 2/e, New Pearson Education, 2015.

Online Learning Resources:

- https://onlinecourses.nptel.ac.in/noc19_ce18/preview.
- https://youtube/iY_ypychVNY?si=310htc4ksTQJ8Fv6.
- https://www.youtube.com/watch?v=WEy939Rkd_M&t=2s
- https://www.classcentral.com/course/swayam-strength-of-materials-iitm-184204
- https://www.coursera.org/learn/mechanics-1
- https://www.edx.org/learn/engineering/massachusetts-institute-of-technology-mechanical-behavior-of-materials-part-1-linear-elastic-behavior
- https://archive.nptel.ac.in/courses/112/107/112107146/

Course Outcomes:

COs	Statements	Blooms Level
CO1	Learn all the methods to analyze beams, columns, frames for normal, shear, and torsion stresses and to solve deflection problems in preparation for the design of such structural components	L1
CO2	Analyse beams and draw correct and complete shear and bending moment diagrams for beams.	L4
CO3	Apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moments.	L3
CO4	Model &Analyze the behavior of basic structural members subjected to various loads	L4
CO5	Design and analysis of Industrial components like pressure vessels.	L6

L	T	P	C
3	0	0	3

II Year-I Semester

MATERIAL SCIENCE & METALLURGY

Course Objective:

- Understand the crystalline structure of different metals and study the stability of phases in different alloy systems.
- Study the behavior of ferrous and non ferrous metals and alloys and their application in different domains
- Able to understand the effect of heat treatment, addition of alloying elements on properties of ferrous metals.
- Grasp the methods of making of metal powders and applications of powder metallurgy
- Comprehend the properties and applications of ceramic, composites and other advanced methods

UNIT– I

Structure of Metals and Constitution of alloys: Crystallization of metals, Packing Factor - SC, BCC, FCC& HCP-line density, plane density. Grain and grain boundaries, effect of grain boundaries– determination of grain size. Imperfections, Slip and Twinning.

Necessity of alloying, types of solid solutions, Hume Rothery's rules, intermediate alloy phases, and electron compounds

Equilibrium Diagrams: Experimental methods of construction of equilibrium diagrams, Isomorphous alloy systems, equilibrium cooling and heating of alloys, Lever rule, coring miscibility gaps, eutectic systems, congruent melting intermediate phases, peritectic reaction. Transformations in the solid state – allotropy, eutectoid, peritectoid reactions, phase rule, relationship between equilibrium diagrams and properties of alloys. Study of binary phase diagrams such as Cu-Ni and Fe-Fe_3C.

UNIT–II

Ferrous metals and alloys: Structure and properties of White Cast iron, Malleable Cast iron, grey castiron,Spheriodalgraphitecastiron,Alloycastiron.Classificationofsteels,structure and properties of plain carbon steels, Low alloy steels, Hadfield manganese steels, tool and die steels.

Non-ferrous Metals and Alloys: Structure and properties of Copper and its alloys, Aluminium and its alloys, Titanium and its alloys, Magnesium and its alloys, Super alloys.

UNIT–III

Heat treatment of Steels: Effect of alloying elements on Fe-Fe_3C system, annealing, normalizing, hardening, TTT diagrams, tempering, harden ability, surface - hardening methods, age hardening treatment, Cryogenic treatment.

UNIT–IV

Powder Metallurgy: Basic processes- Methods of producing metal powders- milling atomization- Granulation-Reduction-Electrolytic Deposition. Compacting methods – Sintering - Methods of manufacturing sintered parts. Secondary operations, Applications of powder metallurgical products.

UNIT– V

Ceramic and Advanced materials: Crystalline ceramics, glasses, cermets, abrasive materials, Classification of composites, manufacturing methods, particle reinforced composites, fiber reinforced composites, PMC, MMC, CMC and CCCs. Introduction to Nano materials and smart materials.

Text Books:

1. S.H.Avner, Introduction to Physical Metallurgy, 2/e, Tata McGraw- Hill, 1997.
2. Donald R.Askeland, Essentials of Materials science and Engineering, 4/e, CL Engineering publications, 2018.

Reference Books:

1. Dr. V.D.kodgire, Material Science and Metallurgy, 39/e, Everest Publishing House, 2017.
2. V.Raghavan, Material Science and Engineering, 5/e, Prentice Hall of India, 2004.
3. William D. Callister Jr, Materials Science and Engineering: An Introduction, 8/e, John Wiley and Sons, 2009.
4. George E.Dieter, Mechanical Metallurgy, 3/e, McGraw-Hill, 2013.
5. Yip-Wah Chung, Introduction to Material Science and Engineering, 2/e, CRC Press, 2022.
6. A V K Suryanarayana, Material Science and Metallurgy, B S Publications, 2014.
7. U. C. Jindal, Material Science and Metallurgy, 1/e, Pearson Publications, 2011.

Online Learning Resources:

- https://archive.nptel.ac.in/courses/113/106/113106032/
- https://www.edx.org/learn/mechanics/massachusetts-institute-of-technology-mechanical-behavior-of-materials-part-3-time-dependent-behavior.
- https://www.youtube.com/watch?v=9Sf278j1GTU
- https://www.coursera.org/learn/fundamentals-of-materials-science
- https://www.coursera.org/learn/material-behavior.

Course Outcomes:

COs	Statements	Blooms Level
CO1	Understand the crystalline structure of different metals and study the stability of phases in different alloy systems.	L2
CO2	Study the behavior of ferrous and non-ferrous metals and alloys and their application in different domains.	L1
CO3	Understand the effect of heat treatment, addition of alloying elements on properties of ferrous metals.	L2
CO4	Grasp the methods of making of metal powders and applications of powder metallurgy.	L3
CO5	Comprehend the properties and applications of ceramic, composites and other advanced methods.	L4

II Year I Semester

L	T	P	C
0	0	3	1.5

MECHANICS OF SOLIDS & MATERIALS SCIENCE LAB

Course Objective:

- Evaluate the values of yield stress, ultimate stress and bending stress of the given specimen under tension test and bending test
- Conduct the torsion test to determine the modulus of rigidity of given specimen.
- Justify the Rockwell hardness test over with Brinell hardness and measure the hardness of the given specimen.
- Examine the stiffness of the open coil and closed coil spring and grade them.
- Analyze the microstructure and characteristics of ferrous and non ferrous alloy specimens.

NOTE: Any 6 experiments from each section A and B.

A) MECHANICS OF SOLIDS LAB:

1. Tensile test
2. Bending test on
   a) Simply supported beam
   b) Cantilever beam
3. Torsion test
4. Hardness test
   a) Brinell's hardness test
   b) Rockwell hardness test
   c) Vickers hardness test
5. Test on springs
6. Impact test
   a) Charpy test
   b) Izod test
7. Punch shear test
8. Liquid penetration test

B) MATERIAL SCIENCE LAB:

1. Preparation and study of the Microstructure of pure metals.
2. Preparation and study of the Microstructure of Mild steel, medium carbon steels, and High carbon steels.
3. Study of the Microstructures of Cast Irons.
4. Study of the Microstructures of Non-Ferrous alloys.
5. Study of the Microstructures of Heat treated steels.
6. Hardenability of steels by Jominy End Quench Test.

Virtual lab:

1. To investigate the principal stresses σa and σb at any given point of a structural element or machine component when it is in a state of plane stress. (https://virtual-labs.github.io/exp-rockwell-hardness-experiment-iiith/objective.html)
2. To find the impact resistance of mild steel and cast iron.(https://sm-nitk.vlabs.ac.in/exp/izod-impact-test).
3. To find the impact resistance of mild steel.(https://sm-nitk.vlabs.ac.in/exp/charpy-impact-test/index.html)
4. To find the Rockwell hardness number of mild steel, cast iron, brass, aluminum and spring steel etc. (https://sm-nitk.vlabs.ac.in/exp/rockwell-hardness-test)
5. To determine the indentation hardness of mild steel, brass, aluminum etc. using Vickers hardness testing machine. (https://sm-nitk.vlabs.ac.in/exp/vickers-hardness-test).

Course Outcomes:

COs	Statements	Blooms Level
CO1	Understand the stress strain behavior of different materials.	L2
CO2	Evaluate the hardness of different materials.	L4
CO3	Explain the relation between elastic constants and hardness of materials.	L1
CO4	Identify various microstructures of steels and cast irons.	L3
CO5	Evaluate hardness of treated and untreated steels.	L4

II Year I Semester

L	T	P	C
0	0	3	1.5

COMPUTER-AIDED MACHINE DRAWING

Course Objectives

- Introduce conventional representations of material and machine components.
- Train to use software for 2D and 3D modeling.
- Familiarize with thread profiles, riveted, welded and key joints.
- Teach solid modeling of machine parts and their sections.
- Explain creation of 2D and 3D assembly drawings and Familiarize with limits, fits, and tolerances inmating components

The following are to be done by any 2D software package

Conventional representation of materials and components:
Detachable joints: Drawing of thread profiles, hexagonal and square-headed bolts and nuts, bolted joint with washer and locknut, stud joint, screw joint and foundation bolts.
Riveted joints: Drawing of rivet, lap joint, butt joint with single strap, single riveted, double riveted double strap joints.
Welded joints: Lap joint and T joint with fillet, butt joint with conventions.
Keys: Taper key, sunk taper key, round key, saddle key, feather key, woodruff key.
Couplings: rigid – Muff, flange; flexible – bushed pin-type flange coupling, universal coupling, Oldham's' coupling.

The following exercises are to be done by any 3D software package:
Sectional views:
Creating solid models of complex machine parts and sectional views.

Assembly drawings:(Any four of the following using solid model software)
Lathe tool post, tool head of shaping machine, tail-stock, machine vice, gate valve, carburetor, piston, connecting rod, eccentric, screw jack, plumber block, axle bearing, pipe vice, clamping device, Geneva cam, universal coupling.
Production drawing:
Representation of limits, fits and tolerances for mating parts. Use any four parts of above assembly drawings and prepare manufacturing drawing with dimensional and geometric tolerances.

Textbooks:

1 Machine Drawing by K.L.Narayana, P.Kannaiah and K.Venkat Reddy, New Age International Publishers, 3/e, 2014
2 Machine drawing by N.Sideshwar, P. Kannaiah, V.V.S.Sastry, TMH Publishers. 2014.

Reference Books:

1. Cecil Jensen, Jay Helsel and Donald D.Voisinet, Computer Aided Engineering Drawing, Tata McGraw-Hill, NY, 2000.
2. James Barclay, Brain Griffiths, Engineering Drawing for Manufacture, Kogan Page Science, 2003.
3. N.D.Bhatt, Machine Drawing, Charotar Publishers, 50/e, 2014.

Online Learning Resources:

- https://eeedocs.wordpress.com/wp-content/uploads/2014/02/machinedrawing.pdf
- https://archive.nptel.ac.in/courses/112/105/112105294/
- https://www.edx.org/learn/engineering/dassault-systemes-solidworks-solidworks-cad-fundamentals?index=product&queryID=c90b35a82a6ef58b0d6f89679c63f6a1&position=2&linked_from=autocomplete&c=autocomplete
- https://www.youtube.com/watch?v=0bQkS3_3Fq4

Course Outcomes:

COs	Statements	Blooms Level
CO1	Demonstrate the conventional representations of materials and machine components.	L3
CO2	Model riveted, welded and key joints using CAD system.	L6
CO3	Create solid models and sectional views of machine components.	L6
CO4	Generate solid models of machine parts and assemble them.	L5
CO5	Translate 3D assemblies into 2D drawings.	L6

II Year I Semester

L	T	P	C
0	0	2	1

PYTHON PROGRAMMING LAB

Course Objectives:

1. **Fundamental Understanding:** Develop a solid foundation in Python programming, covering essential syntax, semantics, and constructs.
2. **Data Manipulation:** Equip students with skills to handle and manipulate data using Python libraries like Pandas and NumPy.
3. **Problem-Solving:** Enhance problem-solving abilities by implementing various algorithms and data structures in Python.
4. **Software Development:** Foster software development skills, including version control, package management, and project documentation.
5. **Advanced Techniques:** Introduce advanced Python topics such as web scraping, API interaction, and database management.

Experiment 1: Introduction to Python
- Objective: Install Python and set up the development environment.
- Tasks:
  - Install Python and an IDE (e.g., PyCharm, VSCode, or Jupyter Notebook).
  - Write and run a simple "Hello, World!" program.
  - Understand and demonstrate basic Python syntax and semantics.

Experiment 2: Basic Python Programming
- Objective: Learn basic programming constructs in Python.
- Tasks:
  - Create programs using variables, data types, and operators.
  - Implement basic input and output functions.
  - Write programs using control structures (if statements, for loops, while loops).

Experiment 3: Functions and Modules
- Objective: Understand functions and module usage in Python.
- Tasks:
  - Define and call functions with different types of arguments and return values.
  - Explore and use built-in Python modules.
  - Write a script that imports and utilizes at least two different standard library modules.

Experiment 4: Lists and Tuples
- Objective:Work with Python lists and tuples.
- Tasks:
  - Create, modify, and iterate over lists and tuples.
  - Perform list comprehensions to create new lists.
  - Demonstrate the immutability of tuples.

Experiment 5: Dictionaries and Sets
- Objective: Explore dictionaries and sets in Python.
- Tasks:
  - Create and manipulate dictionaries.
  - Use dictionary comprehension.

- Create and perform operations on sets.

Experiment 6: Strings and File I/O
- Objective: Manipulate strings and perform file I/O operations.
- Tasks:
  - Demonstrate various string methods.
  - Write programs to read from and write to text files.
  - Work with different file formats, including CSV and JSON.

Experiment 7: Error Handling and Exceptions
- Objective: Implement error handling in Python programs.
- Tasks:
  - Write programs using try, except, else, and finally blocks.
  - Handle specific exceptions.
  - Create and raise custom exceptions.

Experiment 8:Object-Oriented Programming (OOP)
- Objective: Understand and implement OOP concepts in Python.
- Tasks:
  - Define classes and create objects.
  - Demonstrate inheritance and polymorphism.
  - Use class and instance variables in programs.

Experiment 9:Libraries and Packages
- Objective: Utilize third-party libraries and create Python packages.
- Tasks:
  - Install and use libraries like NumPy and Pandas.
  - Create a simple Python package and distribute it.
  - Work with virtual environments to manage dependencies.

Experiment 10: Working with Data
-Objective: Perform data manipulation and visualization.
- Tasks:
  - Use Pandas to load, manipulate, and analyze datasets.
  - Create visualizations using Matplotlib and Seaborn.
  - Conduct basic data analysis tasks and summarize findings.

Experiment 11: Web Scraping and APIs
- Objective: Extract data from the web and interact with APIs.
- Tasks:
  - Access and parse data from RESTful APIs.
  - Process and analyze JSON data from APIs.

Experiment 12: Databases
- **Objective:** Work with databases in Python.
- **Tasks:**
  - Connect to a database using SQLite and SQLAlchemy.
  - Perform CRUD operations on the database.
  - Write queries to manage and retrieve data.

Course Outcomes:

- https://www.udemy.com/course/python-the-complete-python-developer-course/?matchtype=e&msclkid=0584dfb54dc715f39c0bb9aaf74033be&utm_campaign=BG-Python_v.PROF_la.EN_cc.INDIA_ti.7380&utm_content=deal4584&utm_medium=udemyads&utm_source=bing&utm_term=_._ag_1220458320107116_._ad__._kw_Python+language_._de_c_._dm__._pl__._ti_kwd-76278984197882%3Aloc-90_._li_116074_._pd__._&couponCode=IND21PM
- https://www.w3schools.com/python/python_intro.asp
- https://www.youtube.com/watch?v=eWRfhZUzrAc
- https://onlinecourses.nptel.ac.in/noc20_cs83/preview
- https://www.edx.org/learn/python
- Virtual Labs - https://python-iitk.vlabs.ac.in/
- Virtual Labs - https://virtual-labs.github.io/exp-arithmetic-operations-iitk/
- Virtual Labs - https://cse02-iiith.vlabs.ac.in/

https://mlritm.ac.in/assets/cse/cse_lab_manuals/R20_cse_manuals/Python%20Lab%20Manual.pdf

II Year I Semester

L	T	P	C
0	1	2	2

EMBEDDED SYSTEMS & IoT

Course Objectives:

- To comprehend Microcontroller-Transducers Interface techniques
- To establish Serial Communication link with Arduino
- To analyse basics of SPI interface.
- To interface Stepper Motor with Arduino
- To analyse Accelerometer interface techniques
- To introduce the Raspberry PI platform, that is widely used in IoT applications
- To introduce the implementation of distance sensor on IoT devices.

Embedded Systems Experiments: (Any 5 experiments from the following)

1. Measure Analog signal from Temperature Sensor.
2. Generate PWM output.
3. Drive single character generation on Hyper Terminal.
4. Drive a given string on Hyper Terminal.
5. Full duplex Link establishment using Hyper terminal.
6. Drive a given value on a 8 bit DAC consisting of SPI.
7. Drive Stepper motor using Analog GPIOs.
8. Drive Accelerometer and Display the readings on Hyper Terminal.

COMPONENTS/ BOARDS: 1. Arduino Duemilanove Board 2. Arduino Software IDE.

Text Books:

1. Embedded Systems Architecture- By Tammy Noergaard, Elsevier Publications, 2013.
2. Embedded Systems-By Shibu. K.V-Tata McGraw Hill Education Private Limited, 2013.
3. Embedded System Design, Frank Vahid, Tony Givargis, John Wiley Publications, 2013.
4. Embedded Systems-Lyla B.Das-Pearson Publications,2013.

Internet of Things Experiments: (Any 5 experiments from the following)

1. Getting started with Raspberry Pi, Install Raspian on your SD card.
2. Python-based IDE (integrated development environments) for the Raspberry Pi and how to trace and debug Python code on the device.
3. Using Raspberry pi a. Calculate the distance using distance sensor. b. Basic LED functionality.
4. Raspberry Pi interact with online services through the use of public APIs and SDKs.
5. Study and Install IDE of Arduino and different types of Arduino.
6. Study and Implement Zigbee Protocol using Arduino / Raspberry Pi.
7. Calculate the distance using distance sensor Using Arduino.

8. Basic LED functionality Using Arduino.
9. Calculate temperature using temperature sensor Using Arduino.
10. Calculate the distance using distance sensor Using Node MCU.
11. Basic LED functionality Using Node MCU.

Text Books:

1. Arsheep Bahga &Vijay Madisetti, Internet of Things - A Hands-on Approach, 1/e, Orient Blackswan Private Limited - New Delhi, 2015.
2. Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015.
3. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014,.

Online Learning Sources

1. https://onlinecourses.nptel.ac.in/noc21_cs17/preview
2. https://onlinecourses.nptel.ac.in/noc20_ee98/preview
3. https://archive.nptel.ac.in/courses/108/105/108105057/
4. https://www.edx.org/learn/embedded-systems/the-university-of-texas-at-austin-embedded-systems-shape-the-world_microcontroller_input_output?index=product&objectID=course-785cf551-7f66-4350-b736-64a93427b4db&webview=false&campaign=Embedded+Systems+-+Shape+The+World%3A+Microcontroller+Input%2F_Output&source=edX&product_category=course&placement_url=https%3A%2F%2Fwww.edx.org%2Flearn%2Fembedded-systems
5. https://www.edx.org/learn/iot-internet-of-things/universitat-politecnica-de-valencia-introduction-to-the-internet-of-things?index=product&queryID=e1322674dcb3d246be981d0669265399&position=4&linked_from=autocomplete&c=autocomplete
6. https://www.edx.org/learn/iot-internet-of-things/curtin-university-iot-sensors-and-devices?index=product&queryID=94ff5bcb80b8e4f427a0985bb2a5e07f&position=3&results_level=first-level-results&term=IOT&objectID=course-967eee29-87e8-4f2d-9257a1b38ec07e85&campaign=IoT+Sensors+and+Devices&source=edX&product_category=course&placement_url=https%3A%2F%2Fwww.edx.org%2Fsearch
7. Virtual Labs - http://vlabs.iitkgp.ac.in/rtes/
8. Virtual Labs - https://cse02-iiith.vlabs.ac.in/
9. Virtual Labs - https://iotvirtuallab.github.io/vlab/Experiments/index.html

Course Outcomes:

COs	Statements	Blooms Level
CO1	Comprehend Microcontroller-Transducers Interface techniques.	L4
CO2	Establish Serial Communication link with Arduino	L6
CO3	Analyse basics of SPI interface.	L4
CO4	Understand the concept of M2M (machine to machine) with necessary protocols and get awareness in implementation of distance sensor.	L2
CO5	Realize the revolution of internet in mobile devices, cloud and sensor networks	L3

II Year I Semester

L	T	P	C
2	0	0	--

ENVIRONMENTAL SCIENCE

Course Objectives:

- To make the students to get awareness on environment
- To understand the importance of protecting natural resources, ecosystems for future generations and pollution causes due to the day-to-day activities of human life
- To save earth from the inventions by the engineers.

UNIT – I

Multidisciplinary Nature of Environmental Studies: – Definition, Scope and Importance – Need for Public Awareness.

Natural Resources : Renewable and non-renewable resources – Natural resources and associated problems – Forest resources – Use and over – exploitation, deforestation, case studies – Timber extraction – Mining, dams and other effects on forest and tribal people – Water resources – Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. – Energy resources:

UNIT – II

Ecosystems: Concept of an ecosystem. – Structure and function of an ecosystem – Producers, consumers and decomposers – Energy flow in the ecosystem – Ecological succession – Food chains, food webs and ecological pyramids – Introduction, types, characteristic features, structure and function of the following ecosystem:

a. Forest ecosystem.
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

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

UNIT – III

Environmental Pollution: Definition, Cause, effects and control measures of:

a. Air Pollution.
b. Water pollution
c. Soil pollution
d. Marine pollution
e. Noise pollution
f. Thermal pollution
g. Nuclear hazards

Solid Waste Management: Causes, effects and control measures of urban and industrial wastes – Role of an individual in prevention of pollution – Pollution case studies – Disaster management: floods, earthquake, cyclone and landslides.

UNIT – IV

Social Issues and the Environment: 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 – Environmental ethics: Issues and possible solutions – Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies – Wasteland reclamation. – Consumerism and waste products. – Environment Protection Act. – Air (Prevention and Control of Pollution) Act. – Water (Prevention and control of Pollution) Act – Wildlife Protection Act – Forest Conservation Act – Issues involved in enforcement of environmental legislation – Public awareness.

UNIT – V

Human Population And The Environment: Population growth, variation among nations. Population explosion – Family Welfare Programmes. – Environment and human health – Human Rights – Value Education – HIV/AIDS – Women and Child Welfare – Role of information Technology in Environment and human health – Case studies.

Field Work: Visit to a local area to document environmental assets River/forest grassland/hill/mountain – Visit to a local polluted site-Urban/Rural/Industrial/Agricultural Study of common plants, insects, and birds – river, hill slopes, etc.

Textbooks:

1. Erach Bharucha,Text book of Environmental Studies for Undergraduate Courses,Universities Press (India) Private Limited, 2019.
2. Palaniswamy, Environmental Studies, 2/e, Pearson education, 2014.
3. S.Azeem Unnisa, Environmental Studies, Academic Publishing Company, 2021.
4. K.Raghavan Nambiar, “Text book of Environmental Studies for Undergraduate Courses as per UGC model syllabus”, SciTech Publications (India), Pvt. Ltd, 2010.

Reference Books:

1. Deeksha Dave and E.Sai Baba Reddy, Textbook of Environmental Science, 2/e, Cengage Publications, 2012.

2. M.Anji Reddy, "Textbook of Environmental Sciences and Technology", BS Publication, 2014.
3. J.P. Sharma, Comprehensive Environmental studies, Laxmi publications, 2006.
4. J. Glynn Henry and Gary W. Heinke, Environmental Sciences and Engineering, Prentice Hall of India Private limited, 1988.
5. G.R. Chatwal, A Text Book of Environmental Studies, Himalaya Publishing House, 2018.
6. Gilbert M. Masters and Wendell P. Ela, Introduction to Environmental Engineering and Science, 1/e, Prentice Hall of India Private limited, 1991.

Online Learning Resources:

- https://onlinecourses.nptel.ac.in/noc23_hs155/preview
- https://www.edx.org/learn/environmental-science/rice-university-ap-r-environmental-science-part-3-pollution-and-resources?index=product&objectID=course-3a6da9f2-d84c-4773-8388-1b2f8f6a75f2&webview=false&campaign=AP%C2%AE+Environmental+Science++Part+3%3A+Pollution+and+Resources&source=edX&product_category=course&placement_url=https%3A%2F%2Fwww.edx.org%2Flearn%2Fenvironmental-science
- http://ecoursesonline.iasri.res.in/Courses/Environmental%20Science-I/Data%20Files/pdf/lec07.pdf
- https://www.youtube.com/watch?v=5QxxaVfgQ3k

Course Outcomes:

COs	Statements	Blooms Level
CO1	asp multi disciplinary nature of environmental studies and various renewable and non-renewable resources.	L2
CO2	derstand flow and bio-geo- chemical cycles and ecological pyramids.	L2
CO3	derstand various causes of pollution and solid waste management and related preventive measures.	L2
CO4	derstand the rainwater harvesting, watershed management, ozone layer depletion and waste land reclamation.	L2
CO5	strate the causes of population explosion, value education and welfare programmes.	L3

II Year II Semester

L	T	P	C
2	0	0	2

INDUSTRIAL MANAGEMENT

Course Objectives: The objectives of the course are to

- Introduce the scope and role of industrial engineering and the techniques for optimal design of layouts
- Illustrate how work study is used to improve productivity
- Explain TQM and quality control techniques
- Introduce financial management aspects and
- Discuss human resource management and value analysis.

UNIT– I

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and break down maintenance.

UNIT–II

WORK STUDY: Importance, types of production, applications, work study, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

UNIT–III

STATISTICAL QUALITY CONTROL: Quality control, Queuing assurance and its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – $\bar{X}$ and R –charts X and S charts and their applications, numerical examples.

TOTALQUALITYMANAGEMENT: zero defect concept, quality circles, implementation, applications, ISO quality systems. Six Sigma–definition, basic concepts

UNIT– IV

FINANCIAL MANAGEMENT: Scope and nature of financial management, Sources of finance, Ratio analysis, Management of working capital, estimation of working capital requirements, stock management, Cost accounting and control, budget and budgetary control, Capital budgeting – Nature of Investment Decisions – Investment Evaluation criteria- NPV, IRR, PI, Payback Period, and ARR, numerical problems.

UNIT–V

HUMAN RESOURCE MANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, meritrating, quantitative methods, wage incentive plans, and types.

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

Text Books:

1. O.P Khanna, Industrial Engineering and Management, Dhanpat Rai Publications (P) Ltd, 2018.
2. Mart and Telsang, Industrial Engineering and Production Management, S.Chand&Company Ltd. NewDelhi, 2006.

Reference Books:

1. Bhattacharya DK, Industrial Management,S.Chand, publishers, 2010.
2. J.G Monks, Operations Management,3/e, McGraw Hill Publishers1987.
3. T.R. Banga, S.C.Sharma, N. K. Agarwal, Industrial Engineering and Management Science, Khanna Publishers, 2008.
4. KoontzO' Donnell, Principles of Management, 4/e, McGraw Hill Publishers, 1968.
5. R.C. Gupta, Statistical Quality Control, Khanna Publishers, 1998.
6. NVS Raju, Industrial Engineering and Management,1/e, Cengage India Private Limited, 2013.

Online Learning Sources

- https://onlinecourses.nptel.ac.in/noc21_me15/preview
- https://onlinecourses.nptel.ac.in/noc20_mg43/preview
- https://www.edx.org/learn/industrial-engineering
- https://youtube.com/playlist?list=PL299B5CC87110A6E7&si=TghLCbEobuxjEaXi
- https://youtube.com/playlist?list=PLbjTnj-t5Gkl0z3OHOGK5RB9mvNYvnImW&si=oaX_5RG69hS3v2ll

Course Outcomes:

COs	Statements	Blooms Level
CO1	Learn about how to design the optimal layout	L1
CO2	Demonstrate work study methods	L3
CO3	Explain Quality Control techniques	L2
CO4	Discuss the financial management aspects and	L2
CO5	Understand the human resource management methods.	L2

II Year II Semester

L	T	P	C
3	0	0	3

COMPLEX VARIABLES, PROBABILITY AND STATISTICS

Course Objectives:

- To familiarize the complex variables.
- To familiarize the students with the foundations of probability and statistical methods.
- To equip the students to solve application problems in their disciplines.

UNIT– I: Functions of a complex variable and Complex integration:

Introduction–Continuity –Differentiability–Analyticity –Cauchy-Riemann equations in Cartesian and polar coordinates–Harmonic and conjugate harmonic functions– Milne–Thompson method.

Complex integration: Line integral –Cauchy's integral theorem –Cauchy's integral formula–Generalized integral formula (all without proofs) and problems on above theorems.

UNIT – II: Series expansions and Residue Theorem:

Radius of convergence – Expansion in Taylor's series, Maclaurin's series and Laurent series.

Types of Singularities: Isolated – Essential –Pole of order m– Residues – Residue theorem (without proof) – Evaluation of real integral of the types $\int_{c}^{c+2\pi} f(x)dx$ and $\int_{C} f(\cos\theta,\sin\theta)d\theta$.

UNIT–III: Probability and Distributions:

Review of probability and Baye's theorem – Random variables – Discrete and Continuous random variables – Distribution functions – Probability mass function, Probability density function and Cumulative distribution functions – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

UNIT–IV: Sampling Theory:

Introduction – Population and Samples – Sampling distribution of Means and Variance (definition only)–Central limit theorem (without proof)–Representation of the normal theory distributions– Introduction to t, χ^2 and F-distributions- point and interval estimations – maximum error of estimate.

UNIT–V: Tests of Hypothesis:

Introduction – Hypothesis – Null and Alternative Hypothesis – Type I and Type II errors – Level of significance – One tail and two-tail tests – Tests concerning one mean and two means (Large and Small samples)–Tests on proportions.

Text Books:

1. B.S. Grewal, Higher Engineering Mathematics, 44/e, Khanna Publishers.
2. Miller and Freund's, Probability and Statistics for Engineers,7/e,Pearson,2008.

ReferenceBooks:

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 9/e, Mc-Graw Hill,2013.
2. S.C.Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics,11/e, Sultan Chand &Sons Publications,2012.
3. Jay l. Devore, Probability and Statistics for Engineering and the Sciences, 8/e, Cengage.
4. ShronL. Myers, KeyingYe, Ronald E Walpole, Probability and Statistics Engineers and the Scientists,8/e,Pearson 2007.
5. Sheldon, M.Ross, Introduction to probability and statistics Engineers and the Scientists, 4/e, Academic Foundation,2011.

Online Learning Sources:

- https://archive.nptel.ac.in/courses/111/103/111103070/
- https://biet.ac.in/pdfs/PROBABILITY%20AND%20STATISTICS%20&%20COMPLEX%20VARIABLES.pdf
- https://archive.nptel.ac.in/courses/111/105/111105090/
- http://acl.digimat.in/nptel/courses/video/111102160/L23.html
- https://onlinecourses.nptel.ac.in/noc21_ma57/preview

Course Outcomes:

COs	Statements	Blooms Level
CO1	Apply Cauchy-Riemann equations to complex functions in order to determine whether a given continuous function is analytic	L3
CO2	Make use of the Cauchy residue theorem to evaluate certain integrals	L3
CO3	Infer the statistical inferential methods based on small and large sampling tests	L4
CO4	Find the differentiation and integration of complex functions used in engineering problems	L5
CO5	Design the components of a classical hypothesis test	L6

L	T	P	C
3	0	0	3

II Year II Semester

MANUFACTURING PROCESSES

Course Objective: The objectives of the course are to

- Know the working principle of different metal casting processes and gating system.
- Classify the welding processes, working of different types of welding processes and welding defects.
- Know the nature of plastic deformation, cold and hot working process, working of a rolling mill and types, extrusion processes.
- Understand the principles of forging, tools and dies, working of forging processes.
- Know about the Additive manufacturing.

UNIT– I

Casting: Steps involved in making a casting – Advantage of casting and its applications. Patterns and Pattern making – Types of patterns – Materials used for patterns, pattern allowances and their construction, Molding, different types of cores , Principles of Gating, Risers, casting design considerations. Methods of melting and types of furnaces, Solidification of castings and casting defects- causes and remedies. Basic principles and applications of special casting processes - Centrifugal casting, Die casting, Investment casting and shell molding.

UNIT–II

Welding: Classification of welding processes, types of welded joints and their characteristics, Gas welding, Different types of flames and uses, Oxy – Acetylene Gas cutting. Basic principles of Arc welding, power characteristics, Manual metal arc welding, submerged arc welding, TIG & MIG welding. Electro–slag welding.

Resistance welding, Friction welding, Friction stir welding, Forge welding, Explosive welding; Thermit welding, Plasma Arc welding, Laser welding, electron beam welding, Soldering &Brazing.

Heat affected zones in welding; pre & post heating, welding defects –causes and remedies.

UNIT–III

Bulk Forming: Plastic deformation in metals and alloys-recovery, recrystallization and grain growth. Hot working and Cold working-Strain hardening and Annealing. Bulk forming processes: Forging-Types of Forging, forging defects and remedies; Rolling – fundamentals, types of rolling mills and products, Forces in rolling and power requirements. Extrusion and its characteristics. Types of extrusion, Impact extrusion, Hydrostatic extrusion; Wire drawing and Tube drawing.

UNIT– IV

Sheet metal forming-Blanking and piercing, Forces and power requirement in these operations, Deep drawing, Stretch forming, Bending, Spring back and its remedies, Coining, Spinning, Types of presses and press tools.

High energy rate forming processes: Principles of explosive forming, electromagnetic forming, Electro hydraulic forming, rubber pad forming, advantages and limitations.

UNIT -V

Additive manufacturing - Steps in Additive Manufacturing (AM), Classification of AM processes, Advantages of AM, and types of materials for AM, VAT photo polymerization AM Processes, Extrusion - Based AM Processes, Powder Bed Fusion AM Processes, Direct Energy Deposition AM Processes, Post Processing of AM Parts, Applications

Text books:

1. Kalpakjain S and Steven R Schmid, Manufacturing Processes for Engineering Materials, 5/e, Pearson Publications, 2007.
2. P.N. Rao, Manufacturing Technology -Vol I, 5/e, McGraw Hill Education, 2018.

Reference Books:

1. A.Ghosh & A.K.Malik, Manufacturing Science, East West Press Pvt. Ltd, 2010.
2. Lindberg and Roy, Processes and materials of manufacture, 4/e, Prentice Hall India Learning Private Limited, 1990.
3. R.K. Jain, Production Technology, Khanna Publishers, 2022.
4. Sharma P.C., A Text book of Production Technology, 8/e, S Chand Publishing, 2014.
5. H.S. Shaun, Manufacturing Processes, 1/e, Pearson Publishers, 2012.
6. WAJ Chapman , Workshop Technology, 5/e, CBS Publishers & Distributors Pvt. Ltd, 2001.
7. Hindustan Machine Tools, Production Technology, Tata McGraw Hill Publishers, 2017.
8. Ian Gibson, David W Rosen, Brent Stucker., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2/e, Springer, 2015.

Online Learning Resources:

- https://www.edx.org/learn/manufacturing/massachusetts-institute-of-technology-fundamentals-of-manufacturing-processes
- https://onlinecourses.nptel.ac.in/noc21_me81/preview
- www.coursera.org/learn/introduction-to-additive-manufacturing-processessera
- https://archive.nptel.ac.in/courses/112/103/112103263/
- https://elearn.nptel.ac.in/shop/nptel/principles-of-metal-forming-technology/?v=c86ee0d9d7ed

Course Outcomes:

COs	Statements	Blooms Level
CO1	Design the patterns and core boxes for metal casting processes	L6
CO2	Understand the different welding processes	L2
CO3	Demonstrate the different types of bulk forming processes	L3
CO4	Understand sheet metal forming processes	L2
CO5	Learn about the different types of additive manufacturing processes	L2

II Year II Semester

L	T	P	C
3	0	0	3

FLUID MECHANICS & HYDRAULIC MACHINES

Course Objectives: The students completing this course are expected to

- Understand the properties of fluids, manometry, hydrostatic forces acting on different surfaces
- Understand the kinematic and dynamic behavior through various laws of fluids like continuity, Euler's, Bernoulli's equations, energy and momentum equations.
- Understand the theory of boundary layer, working and performance characteristics of various hydraulic machines like pumps and turbines.

UNITI

Fluid statics: Dimensions and units: physical properties of fluids - specific gravity, viscosity and its significance, surface tension, capillarity, vapor pressure. Atmospheric, gauge and vacuum pressure, Measurement of pressure – Manometers - Piezometer, U-tube, inverted and differential manometers. Pascal's & hydrostatic laws.
Buoyancy and floatation: Meta center, stability of floating body. Submerged bodies. Calculation of metacenter height. Stability analysis and applications.

UNITII
Fluid Kinematics: Introduction, flow types. Equation of continuity for one dimensional flow, circulation and vorticity, Stream line, path line and streak lines and stream tube. Stream function and velocity potential function, differences and relation between them. Condition for irrotational flow, flownet, source and sink, double tand vortex flow.
Fluid dynamics: surface and body forces –Euler's and Bernoulli's equations for flow along a streamline, momentum equation and its applications, force on pipe bend.
Closed conduit flow: Reynold's experiment- Darcy Weisbach equation- Minor losses in pipes- pipes in series and pipes in parallel total energy line hydraulic gradient line.

UNITIII
Boundary Layer Theory: Introduction, momentum integral equation, displacement, momentum and energy thickness, separation of boundary layer, control of flow separation, Stream lined body, Bluff body and its applications, basic concepts of velocity profiles.
Dimensional Analysis: Dimensions and Units, Dimensional Homogeneity, Non dimensionalization of equations, Method of repeating variables and Buckingham Pi Theorem.

UNITIV
Basics of turbo machinery: hydrodynamic force of jets on stationary and moving flat, inclined, and curved vanes, jet striking centrally and at tip, velocity diagrams, work done and efficiency, flow over radial vanes.
Hydraulic Turbines: classification of turbines, impulse and reaction turbines, Pelton

wheel, Francis turbine and Kaplan turbine-working proportions, work done, efficiencies, hydraulic design –draft tube-theory-functions and efficiency.

UNITV

Performance of hydraulic turbines: Geometric similarity, Unit and specific quantities, characteristic curves, governing of turbines, selection of type of turbine, cavitation, surge tank, water hammer. Hydraulic systems- hydraulic ram, hydraulic lift, hydraulic coupling. Fluidics – amplifiers, sensors and oscillators. Advantages, limitations and applications.

Centrifugal pumps: classification, working, work done – manometric head- losses and efficiencies-specific speed- pumps in series and parallel-performance characteristic curves, cavitation & NPSH. **Reciprocating pumps:** Working, Discharge, slip, indicator diagrams.

Text Books:

1. Y.A. Cengel, J.M.Cimbala, Fluid Mechanics, Fundamentals and Applications,6/e,McGraw Hill Publications, 2019.
2. Dixon, Fluid Mechanics and Thermodynamics of Turbo machinery, 7/e, Elsevier Publishers, 2014.

Reference Books:

1. P N Modi and S M Seth, Hydraulics & Fluid Mechanics including Hydraulics Machines, Standard Book House, 2017.
2. RK Bansal, Fluid Mechanics and Hydraulic Machines, 10/e, Laxmi Publications (P)Ltd, 2019.
3. Rajput, Fluid Mechanics and Hydraulic Machines, S Chand & Company, 2016.
4. D.S. Kumar, Fluid Mechanics and Fluid Power Engineering, S K Kataria &Sons, 2013.
5. D. Rama Durgaiah, Fluid Mechanics and Machinery,1/e, New Age International, 2002.

Online Learning Resources:

- https://archive.nptel.ac.in/courses/112/105/112105206/
- https://archive.nptel.ac.in/courses/112/104/112104118/
- https://www.edx.org/learn/fluid-mechanics
- https://onlinecourses.nptel.ac.in/noc20_ce30/previewnptel.ac.in
- www.coursera.org/learn/fluid-powerera

Course Outcomes:

COs	Statements	Blooms Level
CO1	Understand the basic concepts of fluid properties.	L2
CO2	Estimate the mechanics of fluids in static and dynamic conditions.	L5
CO3	Apply the Boundary layer theory, flow separation and dimensional analysis.	L3
CO4	Estimate the hydro dynamic forces of jet on vanes indifferent positions.	L5
CO5	Understand the working Principles and performance evaluation of hydraulic pump and turbines.	L2

L	T	P	C
3	0	0	3

II Year II Semester

THEORY OF MACHINES

Course Objectives: The objectives of the course are to make the students learn about

- Introduce various basic mechanisms and their applications.
- Explain importance of degree of freedom.
- Familiarize velocity and acceleration in mechanisms.
- Describe the cams and follower motions.
- Explain the importance of gyroscopic couples.
- Introduce the equation of motion for single degree of freedom system.

UNIT – I: Simple Mechanisms **10 Hrs**

Simple Mechanisms: Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, mobility – Grashof's law, kinematic inversions of four bar chain and slider crank chains- Limit positions – Mechanical advantage- Transmission angle- Description of some common mechanisms- Quick return mechanism, straight line mechanisms – UniversalJoint – Rocker mechanisms.

UNIT – II: Plane and motion analysis **12 Hrs**

Plane and motion analysis: Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations – kinematic analysis of simple mechanisms – slider crank mechanism dynamics – Coincident points – Coriolis component of acceleration.

UNIT – III: Gyroscope & Gear Profile **10Hrs**

Gyroscope: Principle of gyroscope, gyroscopic effect in an aeroplane, ship, car and two wheeler, simple problems

Gear Profile: Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting – helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT – IV: Balancing of Rotating masses & Cams **12 Hrs**

Balancing of Rotating masses: Need for balancing, balancing of single mass and several masses in different planes, using analytical and graphical methods.

Cams: Classification of cams and followers- Terminology and definitions – Displacement diagrams –Uniform velocity, parabolic, simple harmonic and cycloidal motions – derivatives of follower motions- specified contour cams- circular and tangent cams –pressure angle and undercutting.

UNIT – V: Vibrations & Turning Moment Diagrams and Flywheels **10Hrs**

Vibrations: Introduction, degree of freedom, types of vibrations, free natural vibrations, Newton method and energy method for single degree of freedom. Damped vibrations- under damped, critically damped; and over damped systems, forced vibrations with and without damping in single degree of freedom; Vibration isolation and transmissibility.

Turning Moment Diagrams and Flywheels: Turning moment diagrams for steam engine, I.C engine and Multi Cylinder Engine. Crank effort – coefficient of fluctuation of energy, coefficient of fluctuation of speed – Fly Wheel and their design, fly wheels for punching press.

Text Books:

1. S.S.Rattan, Theory of Machines, 4/e, Tata Mc-Graw Hill, 2014.
2. P.L.Ballaney, Theory of Machines & Mechanisms, 25/e, Khanna Publishers, Delhi, 2003.

Reference Books:

1. F. Haidery, Dynamics of Machines, 5/e, NiraliPrakashan, Pune, 2003.
2. J.E.Shigley, Theory of Machines and Mechanisms, 4/e, Oxford, 2014.
3. G.K.Groover, Mechanical Vibrations, 8/e, Nemchand Bros, 2009.
4. Norton, R.L., Design of Machinery – An Introduction to Synthesis and Analysis of Mechanisms and Machines, 2/e, McGraw Hill, New York, 2000.
5. William T. Thomson, Theory of vibration with applications, 4/e, Englewood Cliffs, N.J.: Prentice Hall, 1993.

Course Outcomes:

COs	Statements	Blooms Level
CO1	Understand different mechanisms and their inversions.	L2
CO2	Calculate velocity and acceleration of different links in a mechanism	L4
CO3	Apply the effects of gyroscopic couple in ships, aero planes and road vehicles.	L3
CO4	Evaluate unbalance mass in rotating machines.	L5
CO5	Analyze free and forced vibrations of single degree freedom systems.	L4

II Year II Semester

L	T	P	C
0	0	3	1.5

FLUID MECHANICS & HYDRAULIC MACHINES LAB

Course Objective: To impart practical exposure on the performance evaluation methods of various flow measuring equipment and hydraulic turbines and pumps.

List of Experiments

1. Impact of jets on Vanes.
2. Performance Test on Pelton Wheel.
3. Performance Test on Francis Turbine.
4. Performance Test on Kaplan Turbine.
5. Performance Test on Single Stage Centrifugal Pump.
6. Performance Test on Multi Stage Centrifugal Pump.
7. Performance Test on Reciprocating Pump.
8. Calibration of Venturimeter.
9. Calibration of Orificemeter.
10. Determination of friction factor for a given pipeline.
11. Determination of loss of head due to sudden contraction in a pipeline.
12. Turbine flow meter.

Virtual Lab:

1. To study different patterns of a flow through a pipe and correlate them with the Reynolds number of the flow. (https://me.iitp.ac.in/Virtual-Fluid-Laboratory/reynolds/introduction.html)
2. To calculate Total Energy at different points of venture meter. (https://me.iitp.ac.in/Virtual-Fluid-Laboratory/bernoulli/introduction.html).
3. To calculate the flow (or point) velocity at center of the given tube using different flow rates. (https://me.iitp.ac.in/Virtual-Fluid-Laboratory/pitot/introduction.html)
4. To determine the hydrostatic force on a plane surface under partial submerge and full submerge condition. (https://me.iitp.ac.in/Virtual-Fluid-Laboratory/cop/introduction.html).
5. To determine the discharge coefficient of a triangular notch. (https://me.iitp.ac.in/Virtual-Fluid-Laboratory/notch/introduction.html)
6. To determine the coefficient of impact of jet on vanes. (https://fm-nitk.vlabs.ac.in/exp/impact-of-jet).
7. To determine friction in pipes. (https://fm-nitk.vlabs.ac.in/exp/friction-in-pipes/index.html).

Course Outcomes:

COs	Statements	Blooms Level
CO1	Demonstrate the devices used for measuring flow.	L3
CO2	Compute major losses in pipes.	L5
CO3	Illustrate the operating parameters of turbines.	L2
CO4	Explain the working of different types of pumps.	L2
CO5	Explain the devices used for measuring flow.	L2

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

KAKINADA–533003, Andhra Pradesh, India

R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

II Year II Semester

L	T	P	C
0	0	3	1.5

MANUFACTURING PROCESSES LAB

Course Objective: Acquire practical knowledge on Metal Casting, Welding, Press Working and Processing of Plastics.

List of Experiments

1. Design and making of pattern
   i. Single piece pattern
   ii. Split pattern
2. Sand properties testing
   i. Sieve analysis(dry sand)
   ii. Clay content test
   iii. Moisture content test
   iv. Strength test(Compression test & Shear test)
   v. Permeability test
3. Mould preparation
   i. Straight pipe
   ii. Bent pipe
   iii. Dumble
   iv. Gear blank
4. Gas cutting and welding
5. Manual metal arc welding
   i. Lap joint
   ii. Butt joint
6. Injection Molding
7. Blow Molding
8. Simple models using sheet metal operations
9. Study of deep drawing and extrusion operations
10. To make weldments using TIG/MIG welding
11. To weld using Spot welding machine
12. To join using Brazing and Soldering
13. To make simple parts on a 3D printing machine
14. Demonstration of metal casting.

Virtual Lab:

1. To study and observe various stages of casting through demonstration of casting process. (https://virtual-labs.github.io/exp-sand-casting-process-dei/theory.html)
2. To weld and cut metals using an oxyacetylene welding setup. (https://virtual-labs.github.io/exp-gas-cutting-processes-iitkgp/index.html).
3. To simulate Fused deposition modelling process (FDM) (https://3dpdei.vlabs.ac.in/exp/simulation-modelling-process)

4. https://altair.com/inspire-mold/
5. https://virtual-labs.github.io/exp-simulation-cartesian-system-dei/theory.html

Course Outcomes:

COs	Statements	Blooms Level
CO1	Make moulds for sand casting.	L2
CO2	Fabricate different types of components using various manufacturing techniques.	L5
CO3	Adapt unconventional manufacturing methods.	L3
CO4	Develop Different Weld joints.	L6
CO5	Explain different types of 3d Printing techniques.	L2

II Year- II Semester

SOFT SKILLS

L	T	P	C
0	1	2	2

Course Objectives:

- To prepare to face global competition for employment and excellence in profession.
- To help the students understand and build interpersonal and interpersonal skills that will enable them to lead meaningful professional life.

UNIT – 1: INTRODUCTION

Introduction- Emergence of life skills, Definition & Meaning, Importance& need, reasons for skill gap, Analysis--Soft Skills vs Hard skills, Linkage between industry and soft skills, Challenges, Personality Developments. Soft Skills, Soft Skills vs English - Improving Techniques.

UNIT – II: Intra-Personal:

Definition-Meaning – Importance-SWOT analysis, Johari windows - Goal Setting-quotient skills - Emotional Intelligence- Attitudinal skills - Right thinking- Problem Solving-Time management, stress management.

UNIT – III: Inter-Personal:

Definition – Meaning – Importance-Communications skills- Team Work, managerial skills -Negotiation skills- Leadership skills, corporate etiquettes.

UNIT – IV: Verbal Skills:

Definition and Meaning-Listening skills, need- types, advantages, Importance-Improving Tips for Listening, Speaking, need- types, advantages, Importance-Improving Tips, Reading- Writing Skills, Report, Resume, statement of purpose, need- types, advantages, Importance-Improving Tips .

UNIT – V: Non Verbal Skills& Interview skills

Definition and Meaning – Importance- Facial Expressions- Eye Contact – Proxemics-Haptics -Posture, cross cultural body language, body language in interview room, appearance and dress code – Kinetics- Para Language - tone, pitch, pause, neutralization of accent, use of appropriate language, Interview skills, interview methods and questions.

Text Books:

1) Sherfield, M. Robert at al, Cornerstone Developing Soft Skills, 4/e, Pearson Publication, New Delhi, 2014.

2) Alka Wadkar, Life Skills for Success, 1/e, Sage Publications India Private Limited, 2016.

Reference Books:

1. Sambaiah.M. Technical English, Wiley publishers India. New Delhi. 2014.
2. Gangadhar Joshi, From Campus to Corporate, SAGE TEXT.
3. Alex.K, Soft Skills, 3rd ed. S. Chand Publication, New Delhi, 2014.
4. Meenakshi Raman and Sangita Sharma, Technical Communication: Principle and Practice, Oxford University Press, 2009.
5. Shalini Varma, Body Language for Your Success Mantra, 4/e, S. Chand Publication, New Delhi, 2014.
6. Stephen Covey, Seven Habits of Highly Effective People, JMD Book, 2013.

Online Learning Resources:

- https://onlinecourses.nptel.ac.in/noc20_hs60/preview
- http://www.youtube.com/@softskillsdevelopment6210
- https://youtube.com/playlist?list=PLLy_2iUCG87CQhELCytvXh0E_y-bOO1_q&si=Fs05Xh8ZrOPsR8F4
- https://www.coursera.org/learn/people-soft-skills-assessment?language=English
- https://www.edx.org/learn/soft-skills

Course Outcomes:

COs	Statements	Blooms Level
CO1	Assimilate and understood the meaning and importance of soft skills and learn how to develop them.	L1
CO2	Understand the significance of soft skills in the working environment for professional excellence.	L2
CO3	Prepare to undergo the placement process with confidence and clarity.	L3
CO4	Ready to face any situation in life and equip themselves to handle them effectively.	L6
CO5	Understand and learn the importance of etiquette in both professional and personal life	L2

II Year II Semester

L	T	P	C
1	0	2	2

DESIGN THINKING & INNOVATION

Course Objectives: The objectives of the course are to

- Bring awareness on innovative design and new product development.
- Explain the basics of design thinking.
- Familiarize the role of reverse engineering in product development.
- Train how to identify the needs of society and convert into demand.
- Introduce product planning and product development process.

UNIT – I Introduction to Design Thinking

Introduction to elements and principles of Design, basics of design-dot, line, shape, form as fundamental design components. Principles of design. Introduction to design thinking, history of Design Thinking, New materials in Industry.

UNIT - II Design Thinking Process

Design thinking process (empathize, analyze, idea & prototype), implementing the process in driving inventions, design thinking in social innovations. Tools of design thinking - person, costumer, journey map, brainstorming, product development

Activity: Every student presents their idea in three minutes, Every student can present design process in the form of flow diagram or flow chart etc. Every student should explain about product development.

UNIT - III Innovation

Art of innovation, Difference between innovation and creativity, role of creativity and innovation in organizations. Creativity to Innovation. Teams for innovation, Measuring the impact and value of creativity.

Activity: Debate on innovation and creativity, Flow and planning from idea to innovation, Debate on value-based innovation.

UNIT - IV Product Design

Problem formation, introduction to product design, Product strategies, Product value, Product planning, product specifications. Innovation towards product design Case studies.

Activity: Importance of modeling, how to set specifications, Explaining their own product design.

UNIT – V Design Thinking in Business Processes

Design Thinking applied in Business & Strategic Innovation, Design Thinking principles that redefine business – Business challenges: Growth, Predictability, Change, Maintaining Relevance, Extreme competition, Standardization. Design thinking to meet corporate needs. Design thinking for Startups. Defining and testing Business Models and Business Cases. Developing & testing prototypes.

Activity: How to market our own product, about maintenance, Reliability and plan for startup.

Textbooks:

1. Tim Brown, Change by design, 1/e, Harper Bollins, 2009.
2. Idris Mootee, Design Thinking for Strategic Innovation, 1/e, Adams Media, 2014.

Reference Books:

1. David Lee, Design Thinking in the Classroom, Ulysses press, 2018.
2. Shrrutin N Shetty, Design the Future, 1/e, Norton Press, 2018.
3. William lidwell, Kritinaholden, &Jill butter, Universal principles of design, 2/e, Rockport Publishers, 2010.
4. Chesbrough.H, The era of open innovation, 2003.

Online Learning Resources:

- https://nptel.ac.in/courses/110/106/110106124/
- https://nptel.ac.in/courses/109/104/109104109/
- https://swayam.gov.in/nd1_noc19_mg60/preview
- https://onlinecourses.nptel.ac.in/noc22_de16/preview

Course Outcomes:

COs	Statements	Blooms Level
CO1	Define the concepts related to design thinking.	L1
CO2	Explain the fundamentals of Design Thinking and innovation.	L2
CO3	Apply the design thinking techniques for solving problems in various sectors.	L3
CO4	Analyse to work in a multidisciplinary environment.	L4
CO5	Evaluate the value of creativity.	L5

B.Tech. – III Year I Semester

S.No.	Category	Title	L	T	P	C
1	Professional Core	Machine Tools and Metrology	3	0	0	3
2	Professional Core	Thermal Engineering	3	0	0	3
3	Professional Core	Design of Machine Elements	3	0	0	3
4	Professional Elective	Professional Elective - I	3	0	0	3
5	Open Elective-I	OR Entrepreneurship Development & Venture Creation 1. Sustainable Energy Technologies 2. Applied Operations Research 3. Nano Technology 4. Thermal Management of Electronic systems 5. Entrepreneurship	3	0	0	3
6	Professional Core	Thermal Engineering Lab	0	0	3	1.5
7	Professional Core	Theory of Machines Lab	0	0	3	1.5
8	Skill Enhancement course	Machine tools and Metrology Lab	0	0	4	2
9	Engineering Science	Tinkering Lab	0	0	2	1
10	Evaluation of Community Service Internship	Community Service Internship	-	-	-	2
Total			**15**	**0**	**10**	**23**

MC	Minor Course (Student may select from the same specialized minors pool)	3	0	3	4.5
MC	Minor Course through SWAYAM / NPTEL (Minimum 12 Week, 3 credit course)	3	0	0	3
HC	Honors Course (Student may select from the same Honors pool)	3	0	0	3
HC	Honors Course (Student may select from the same Honors Pool)	3	0	0	3

Professional Elective – I

1) Design for Manufacturing
2) Conventional and futuristic vehicle technology
3) Renewable Energy Technologies
4) Non-destructive Evaluation

B.Tech. III Year II Semester

S.No.	Category	Title	L	T	P	C
1	Professional Core	Heat Transfer	3	0	0	3
2	Professional Core	Artificial Intelligence and Machine Learning	3	0	0	3
3	Professional Core	Finite Element Methods	3	0	0	3
4	Professional Elective	Professional Elective-II	3	0	0	3
5	Professional Elective	Professional Elective-III	3	0	0	3
6	Open Elective - II	1.Introduction to Industrial Robotics 2. Industrial Management 3. Additive Manufacturing 4.Vechicle Technology 5. Industrial Safety	3	0	0	3
7	Professional Core	Heat Transfer Lab	0	0	3	1.5
8	Professional Core	Artificial Intelligence and Machine Learning Lab	0	0	3	1.5
9	Skill Enhancement course	Robotics and Drone Technologies Lab	0	0	4	2
10	Audit Course	Technical paper writing and IPR	2	0	0	-
Total			**20**	**0**	**10**	**23**
Mandatory Industry Internship of 08 weeks duration during summer vacation						

MC	Student may select from the same minors pool	3	0	3	4.5
MC	Minor Course (Student may select from the same specialized minors pool)	3	0	0	3
HC	Student may select from the same honors pool	3	0	0	3
HC	Honors Course (Student may select from the honors pool)	3	0	0	3

Professional Elective-II

1. Mechanical Vibrations
2. Advanced Manufacturing Processes
3. Micro Electro Mechanical Systems
4. Sensors and Instrumentation

Professional Elective-III

1. Energy Storage Technologies
2. Industrial Hydraulics and Pneumatics
3. Industrial Robotics
4. Refrigeration & Air-Conditioning

Professional Elective-IV

1. Mechatronics
2. Computational Fluid Dynamics
3. Advanced Material Science
4. Embedded Systems and Programming

Professional Elective-V

1. Hydrogen and Fuel Cell Technology
2. Smart manufacturing
3. Cryogenics
4. Electrical drives and actuators

For Honors :

I. Mechanical Engineering design and Robotics (Any 5 theory and 2 Labs)

1. Advanced Mechanics of solids
2. Design of Machine Members
3. Theory of machines
4. Advanced Finite element methods
5. Mechanical vibrations
6. Robotics
7. Product design
8. Design for manufacturing
9. CAD Lab
10. Mechanisms and Robotics Lab

II. Smart Manufacturing (Any 5 theory and 2 Labs)

1. Automation in manufacturing
2. MEMS
3. Mechatronics
4. CIM
5. Smart manufacturing
6. Robotics
7. Manufacturing processes
8. Artificial intelligence and Machine learning
9. AI & ML Lab
10. Mechatronics Lab

III. Thermal Systems Engineering (Any 5 theory and 2 Labs)

1. Advanced Thermodynamics
2. Thermal Engineering
3. Advanced Heat transfer
4. Refrigeration and Air-conditioning
5. Power plant engineering
6. Advanced Fluid mechanics
7. Automobile Engineering
8. Computation fluid dynamics
9. Heat transfer Lab
10. Advanced Thermal Engineering Lab

For Minors (Any 5 theory and 2 Labs):

1. Advanced Mechanics of Solids
2. Advanced Finite Element Methods
3. Advanced CAD
4. Advanced Manufacturing Processes
5. Advanced Fluid Mechanics
6. Advanced Heat Transfer
7. Advanced Mechanisms & Robotics
8. Optimization & Reliability
9. Mechanisms and Robotics Lab
10. Advanced Manufacturing Processes lab
11. Modeling & Simulation of Manufacturing Systems Lab
12. Computational Fluid Dynamics Lab

III Year I Semester	MACHINE TOOLS & METROLOGY	L	T	P	C
		3	0	0	3

Course objectives:

1. To learn the fundamental knowledge and principles of material removal processes.
2. To understand the basic principles of lathe, shaping, slotting and planning machines
3. To demonstrate the fundamentals of drilling, milling and boring processes.
4. To discuss the concepts of super finishing processes and limits and fits.
5. To understand the concepts of surface roughness and optical measuring instruments

UNIT – 1
FUNDAMENTALS OF MACHINING:
Elementary treatment of metal cutting theory – element of cutting process – Single point cutting tools, nomenclature, tool signature, mechanism of metal cutting, types of chips, mechanics of orthogonal and oblique cutting –Merchant's force diagram, cutting forces, Taylor's tool life equation, simple problems - Tool wear, tool wear mechanisms, machinability, economics of machining, coolants, tool materials and properties.

UNIT – 2
LATHE MACHINES:
Introduction- types of lathe - Engine lathe – principle of working - construction - specification of lathe - accessories and attachments – lathe operations – taper turning methods and thread cutting – drilling on lathes.
SHAPING, SLOTTING AND PLANNING MACHINES: Introduction - principle of working – principle parts – specifications - operations performed - slider crank mechanism - machining time calculations.

UNIT – 3
DRILLING & BORING MACHINES: Introduction – construction of drilling machines – types of drilling machines - principles of working – specifications- types of drills - operations performed – machining time calculations - Boring Machines – types.
MILLING MACHINES: Introduction - principle of working – specifications – milling methods - classification of Milling Machines –types of cutters - methods of indexing- machining time calculations

UNIT – 4
FINISHING PROCESSES: Classification of grinding machines- types of abrasives- bonds, specification and selection of a grinding wheel- Lapping, Honing & Broaching operations- comparison to grinding.
SYSTEMS OF LIMITS AND FITS: Types of fits -Unilateral and bilateral tolerance system, hole and shaft basis systems- interchangeability & selective assembly- International standard system of tolerances, simple problems related to limits and fits, Taylor's principle – design of go and no go gauges; plug, ring, snap, gap, taper, profile and position gauges.
LINEAR MEASUREMENT: Length standards, end standards, slip gauges- calibration of the slip
Gauges, dial indicators, micrometers.

UNIT – 5

ANGULAR MEASUREMENT: Bevel protractor, angle slip gauges- angle dekkor- spirit levels- sine bar- sine table.

SURFACE ROUGHNESS MEASUREMENT: Differences between surface roughness and surface waviness –Numerical assessment of surface finish, Profilograph, Talysurf, ISI symbols.

OPTICAL MEASURING INSTRUMENTS: Tools maker's microscope, Autocollimators, Optical projector, Optical flats-working principle, construction, merits, demerits and their uses. optical comparators.

TEXT BOOKS:

1. Manufacturing Processes / JP Kaushish/ PHI Publishers-2nd Edition
2. Manufacturing Technology Vol-II/P.N Rao/Tata McGraw Hill
3. Engineering Metrology – R.K. Jain/Khanna Publishers

REFERENCES:

1. Metal cutting and machine tools /Geoffrey Boothroyd, Winston A.Knight/ Taylor & Francis
2. Production Technology / H.M.T. Hand Book (Hindustan Machine Tools).
3. Production Engineering/K.C Jain & A.K Chitaley/PHI Publishers
4. Technology of machine tools/S.F.Krar, A.R. Gill, Peter SMID/ TMH
5. Manufacturing Processes for Engineering Materials-Kalpak Jian S & Steven R Schmid/Pearson Publications 5th Edition

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

CO1	Learned the fundamental knowledge and principals in material removal process.
CO2	Acquire the knowledge on operations in conventional, automatic, Capstan and turret lathes
CO3	Capable of understanding the working principles and operations of shaping, slotting, planning , drilling and boring machines.
CO4	able to make gear and keyway in milling machines and understand the indexing mechanisms
CO5	Understand the different types of Surface roughness and Optical measuring instruments

III Year I Semester	THERMAL ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1) To give insight into basic principles of air standard cycles.
2) To impart knowledge about IC engines and Boilers
3) To make the students learn the working principles of steam nozzles, turbines and compressors
4) To impart the knowledge about the various types of compressors and gas turbines
5) To make the students gain insights about, rockets and jet propulsion and solar engineering.

UNIT– I

Air standard Cycles: Otto, diesel and dual cycles, its comparison, Brayton cycle

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT–II

I.C Engines: Classification - Working principles of SI and CI engines, Valve and Port Timing Diagrams, -Engine systems – Fuel, Carburetor, Fuel Injection System, Ignition, Cooling and Lubrication, principles of supercharging and turbocharging, Measurement, Testing and Performance.

Boilers : Principles of L.P & H.P boilers, mountings and accessories, Draught- induced and forced.

UNIT -III

Steam nozzles: Functions, applications, types, flow through nozzles, condition for aximum discharge, critical pressure ratio, criteria to decide nozzle shape, Wilson line.

Steam turbines: Classification – impulse turbine; velocity diagram, effect of friction, diagram efficiency, De-leval turbine - methods to reduce rotor speed, combined velocity diagram.

Reaction turbine: Principle of operation, velocity diagram, Parson's reaction turbine – condition for maximum efficiency.

Steam condensers: Classification, working principles of different types – vacuum efficiency and condenser efficiency.

UNIT -IV

Compressors: Classification, Reciprocating type - Principle, multi-stage compression, Rotary type – Lysholm compressor –principle and efficiency considerations.

Centrifugal Compressors: Principle, velocity and pressure variation, velocity diagrams.

Axial flow Compressors: Principle, pressure rise and efficiency calculations.

Gas Turbines: Simple gas turbine plant – ideal cycle, components –regeneration, inter cooling and reheating.

UNIT -V

Jet Propulsion: Principle, classification, t-s diagram - turbo jet engines – thermodynamic cycle, performance evaluation.

Rockets: Principle, solid and liquid propellant rocket engines.

Solar Engineering: Solar radiation, Solar collectors, PV cells, storage methods and applications

Text Books:

1.Thermal Engineering - Mahesh Rathore- McGraw Hill publishers
2. Heat Engineering /V.P Vasandani and D.S Kumar/Metropolitan Book Company, New Delhi.

References:

1.I.C. Engines - V. Ganesan- Tata McGraw Hill Publishers
2. Thermal Engineering-M.L.Mathur& Mehta/Jain bros. Publishers
3. Thermal Engineering-P.L.Ballaney/ Khanna publishers.
4. Thermal Engineering / RK Rajput/ Lakshmi Publications
5. Thermal Engineering-R.S Khurmi, &J S Gupta/S.Chand.

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

CO1: Explain the basic concepts of air standard cycles.
CO2: Get knowledge about IC Engines and Biolers.
CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.
CO4: Gain knowledge about the concepts of compressors and gas turbines.
CO5: Acquire insights about jet propulsion, rockets and solar engineering.

III Year-I Semester	DESIGN OF MACHINE ELEMENTS	L	T	P	C
		3	0	0	3

Course Objectives:

- Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
- Provide an introduction to design of bolted and welded joints.
- Explain design procedures for shafts and couplings.
- Discuss the principles of design for clutches and brakes and springs.
- Explain design procedures for bearings and gears.

UNIT-I: Introduction, Design for Static and Dynamic loads

Mechanical Engineering Design: Design process, design considerations, codes and standards of designation of materials, selection of materials.

Design for Static Loads: Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

Design for Dynamic Loads: Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

UNIT-II: Design of Bolted and Welded Joints

Design of Bolted Joints: Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints.

Welded Joints: Strength of lap and butt welds, Joints subjected to bending and torsion.

UNIT-III: Power transmission shafts and Couplings

Power Transmission Shafts: Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

Couplings: Design of flange and bushed pin couplings, universal coupling.

UNIT-IV: Design of Clutches, Brakes and Springs

Friction Clutches: Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.

Brakes: Different types of brakes. Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

Springs: Design of helical compression, tension, torsion and leaf springs.

UNIT-V: Design of Bearings and Gears

Design of Sliding Contact Bearings: Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.

Design of Rolling Contact Bearings: Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

Design of Gears: Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

Note: Data book is not allowed.

Textbooks:

1. R.L. Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2. V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGraw Hill, 2010.
3. Dr. N. C. Pandya &Dr. C. S. Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

Reference Books:

1. R.K. Jain, Machine Design, Khanna Publications, 1978.
2. J.E. Shigley, Mechanical Engineering Design, 2/e, Tata McGraw Hill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.

Online Learning Resources:

https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design-ofmachine-elements-1-npte
https://www.digimat.in/nptel/courses/video/112105124/L01.html
https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html
http://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html

Course Outcomes:

At the end of the course the students will be able to

- Design the machine members subjected to static and dynamic loads.
- Design shafts and couplings for power transmission
- Learn how to design bolted and welded joints.
- Know the design procedures of clutches, brakes and springs.
- Design bearings and gears.

III Year-I Semester	DESIGN FOR MANUFCTURING (Professional Elective-I)	L	T	P	C
		3	0	0	3

Course Objectives: The students will acquire the knowledge:
1) To understand the basic concepts of design for manual assembly
2) To interpret basic design procedure of machining processes
3) To understand design considerations metal casting, extrusion and sheet metal work
4) To interpret the design considerations of various metal joining process.
5) To interpret the basic design concepts involved in the assembly automation

UNIT-1
Introduction to DFM, DFMA: How Does DFMA Work? Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design? Typical DFMA Case Studies, Overall Impact of DFMA on Industry.
Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, weight on Handling Time, Effects of Combinations of Factors and application of the DFA Methodology.

UNIT– 2
Machining processes: Overview of various machining processes-general design rules for machining dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT – 3
Metal casting: Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design product design rules for sand casting.
Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking.

UNIT– 4
Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. **Forging:** Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.

UNIT– 5
Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, and single station assembly lines.

Design for Additive Manufacturing:
Introduction to AM, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers.

TEXT BOOKS:

1. Design for manufacture, John Cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla,

REFERENCE:

1. Molloy, E.A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998

2. ASM Hand book Vol.20

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the basic concepts of design for manual assembly
CO2: Identify basic design procedure of various machining processes.
CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work
CO4: Interpret the design considerations of various metal joining process.
CO5: Understand the basic design concepts involved in the assembly automation

III Year I Semester	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1.To study the advanced engine technologies
2.To learn various advanced combustion technologies and its benefits
3.To learn the methods of using low carbon fuels and its significance
4.To learn and understand the hybrid and electric vehicle configurations
5.To study the application of fuel cell technology in automotive

UNIT – I: ADVANCED ENGINE TECHNOLOGY
Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT – II: COMBUSTION TECHNOLOGY
Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT – III: LOW CARBON FUEL TECHNOLOGY
Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT – IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)
Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward

UNIT – V: FUEL CELL TECHNOLOGY
Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.

TEXT BOOKS:
1.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER
REFERENCES:
1.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3.Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

4.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
5.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Course Outcomes*:* At the end of the course the students would be able to

1.Discuss the latest trends in engine technology
2.Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.
3.Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
4.Discuss the working and energy flow in various hybrid and electric configurations.
5.Analyzing the need for fuel cell technology in automotive applications.

III Year I Semester	RENEWABLE ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PV modules
2. To understand the principles of storage in PV systems
3. To discuss solar energy storage systems and their applications.
4. To get knowledge in wind energy and bio-mass
5. To gain insights in geothermal energy, ocean energy and fuel cells.

UNIT – 1

SOLAR RADIATION: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULES AND PV SYSTEMS:

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

UNIT – 2

STORAGE IN PV SYSTEMS:

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

UNIT – 3

SOLAR ENERGY COLLECTION: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

UNIT – 4

WIND ENERGY: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

BIO-MASS: Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

UNIT – 5

GEOTHERMAL ENERGY: Origin, Applications, Types of Geothermal Resources, Relative Merits

OCEAN ENERGY: Ocean Thermal Energy; Open Cycle & Closed Cycle OTEC Plants, Environmental Impacts, Challenges

FUEL CELLS: Introduction, Applications, Classification, Different Types of Fuel Cells Such as Phosphoric Acid Fuel Cell, Alkaline Fuel Cell, PEM Fuel Cell, MC Fuel Cell.

Text Books:

1. Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K.Nayak/TMH
2. Non-Conventional Energy Resources- Khan B.H/ Tata McGraw Hill, New Delhi, 2006
3. Green Manufacturing Processes and Systems - J. Paulo Davim/Springer 2013

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth& John F Kreider / Taylor &Francis
2. Non-Conventional Energy - Ashok V Desai /New Age International (P) Ltd
3. Renewable Energy Technologies -Ramesh & Kumar /Narosa
4. Non-conventional Energy Source- G.D Roy/Standard Publishers

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

CO1	Illustrate the importance of solar radiation and solar PV modules.
CO2	Discuss the storage methods in PV systems
CO3	Explain the solar energy storage for different applications
CO4	Understand the principles of wind energy, and bio-mass energy.
CO5	Attain knowledge in geothermal energy, ocean energy and fuel cells.

III Year I Semester	**NON- DESTRUCTIVE EVALUATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To learn basic concepts of non-destructive testing and industrial applications
2. To understand the elements of ultrasonic test and limitations of ultrasonic test
3. To learn the concepts involved in the liquid penetrant test and eddy current test
4. To know the basic principles and operating procedures of magnetic particle testing
5. To understand the basic concepts involved in the infrared and thermal testing

UNIT – 1

Introduction to non-destructive testing and industrial Applications of NDE: Span of NDE Activities Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions. Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography, neutron ray radiography

UNIT – 2

Ultrasonic test: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics,

Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection - Effectiveness and Limitations of Ultrasonic Testing.

UNIT – 3

Liquid Penetrant Test: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness, DPI, FPI,Limitations of Liquid Penetrant Testing**.**

Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing

UNIT – 4

Magnetic Particle Test: Magnetic Materials, Magnetization of Materials , Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test

UNIT – 5

Infrared And Thermal Testing: Introduction and fundamentals to infrared and thermal testing–Heat transfer –Active and passive techniques –Lock in and pulse thermography, tomography-Contact and non-contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals –other temperature sensitive coatings –Inspection methods –Infrared radiation and infrared detectors–thermo mechanical

behaviour of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Text Books:

1. Nondestructive test and evaluation of Materials/J Prasad, GCK Nair/TMH Publishers
2. Ultrasonic testing of materials/ H KrautKramer/Springer
3. Nondestructive testing/Warren, J Mc Gonnagle / Godan and Breach Science publishers
4. Nondestructive evaluation of materials by infrared thermography / X. P. V. Maldague, Springer-Verlag, 1st edition, (1993)

References:

1. Ultrasonic inspection training for NDT/E.A.Gingel/PrometheusPress,

CO1	Understand the concepts of various NDE techniques and the requirements of radiography techniques and safety aspects.
CO2	Interpret the principles and procedure of ultrasonic testing
CO3	Understand the principles and procedure of Liquid penetration and eddy current testing
CO4	Illustrate the principles and procedure of Magnetic particle testing
CO5	Interpret the principles and procedure of infrared testing and thermal testing

2. ASTM Standards,Vol3.01,Metalsandalloys
3. Non-destructive Evaluation, Hand Book – R. Ham Chand

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

III Year I Semester	SUSTAINBLE ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PVmodules
2. To understand the principles of storage in PV systems
3. To discuss solar energy storage systems and their applications.
4. To get knowledge in wind energy and bio-mass
5. To gain insights in geothermal energy, ocean energy and fuel cells.

UNIT – 1

SOLAR RADIATION: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULES AND PV SYSTEMS:

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

UNIT – 2

STORAGE IN PV SYSTEMS:

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

UNIT – 3

SOLAR ENERGY COLLECTION: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

UNIT – 4

WIND ENERGY: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

BIO-MASS: Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

UNIT – 5

GEOTHERMAL ENERGY: Origin, Applications, Types of Geothermal Resources, Relative Merits

OCEAN ENERGY: Ocean Thermal Energy; Open Cycle & Closed Cycle OTEC Plants, Environmental Impacts, Challenges

FUEL CELLS: Introduction, Applications, Classification, Different Types of Fuel Cells Such as Phosphoric Acid Fuel Cell, Alkaline Fuel Cell, PEM Fuel Cell, MC Fuel Cell.

Text Books:

1. Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K.Nayak/TMH
2. Non-Conventional Energy Resources- Khan B.H/ Tata McGraw Hill, New Delhi, 2006
3. Green Manufacturing Processes and Systems - J. Paulo Davim/Springer 2013

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth& John F Kreider / Taylor &Francis
2. Non-Conventional Energy - Ashok V Desai /New Age International (P) Ltd
3. Renewable Energy Technologies -Ramesh & Kumar /Narosa
4. Non-conventional Energy Source- G.D Roy/Standard Publishers

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

CO1	Illustrate the importance of solar radiation and solar PV modules.
CO2	Discuss the storage methods in PV systems
CO3	Explain the solar energy storage for different applications
CO4	Understand the principles of wind energy, and bio-mass energy.
CO5	Attain knowledge in geothermal energy, ocean energy and fuel cells.

III Year I Semester	APPLIED OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

Course Objectives: To

1. Understand Linear Programming models
2. Learn Transportation and sequencing problems
3. Solve replacement problems and analyze games theory models
4. Understand waiting line and project management problems
5. Learn dynamic programming and simulation.

UNIT – 1

INTRODUCTION - definition– characteristics and phases – types of operation research models – applications.

Linear programming: Problem formulation – graphical solution – simplex method – artificial variables techniques -two–phase method, big-M method – duality principle.

UNIT – 2

TRANSPORTATION PROBLEM: Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- travelling salesman problem.

SEQUENCING – Introduction – flow –shop sequencing – *n* jobs through two machines – *n* jobs through three machines – job shop sequencing – two jobs through 'm' machines.

UNIT – 3

REPLACEMENT THEORY: Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.

GAME THEORY: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.

UNIT – 4

WAITING LINES: Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel.

PROJECT MANAGEMENT: Basics for construction of network diagram,Program Evaluation and Review Technique (PERT), Critical Path Method (CPM) – PERT Vs. CPM, determination of floats- Project crashing and its procedure.

UNIT – 5

DYNAMIC PROGRAMMING: Introduction – Bellman's principle of optimality – applications of dynamic programming-shortest path problem – linear programming problem.

SIMULATION: Definition – types of simulation models – phases of simulation– applications of simulation – inventory and queuing problems – advantages and disadvantages

Text Books:

1. Operations Research-An Introduction/Hamdy A Taha/Pearson publishers
2. Operations Research –Theory & publications / S.D.Sharma Kedarnath/McMillan publishers India Ltd

References:

1. Introduction to O.R/Hiller & Libermann/TMH
2. Operations Research /A.M. Natarajan, P. Balasubramani, A. Tamilarasi /Pearson Education.
3. Operations Research: Methods & Problems / Maurice Saseini, ArhurYaspan& Lawrence Friedman/Wiley
4. Operations Research / R.Pannerselvam/ PHI Publications.
5. Operations Research / Wagner/ PHI Publications.
6. Operation Research /J.K.Sharma/Macmillan Publ.
7. Operations Research/ Pai/ Oxford Publications
8. Operations Research/S Kalavathy / Vikas Publishers
9. Operations Research / DS Cheema/University Science Press
10. Operations Research / Ravindran, Philips, Solberg / Wiley publishers

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

CO1 Understand Linear Programming models

CO2 Interpret Transportation and sequencing problems

CO3 Solve replacement problems and analyze queuing models

CO4 Understand game theory and inventory problems

CO5 Interpret dynamic programming and simulation.

III Year I Semester	NANO TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the classification of Nano structured Materials
2. To understand the unique properties of Nano materials
3. To interpret the Synthesis Routes - Bottom up and Top down approaches
4. To identify the tools to characterize Nano materials
5. To understand the applications of Nano materials

UNIT – 1

INTRODUCTION: History and Scope, Classification of Nano structured Materials, Fascinating Nanostructures, and applications of nano-materials, challenges and future prospects.

UNIT – 2

UNIQUE PROPERTIES OF NANO MATERIALS: Microstructure and Defects in Nano crystalline Materials: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and disclinations. Effect of Nano-dimensions on Materials Behavior: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

UNIT – 3

SYNTHESIS ROUTES: Bottom up approaches: Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly. Top down approaches: Mechanical alloying, Nano-lithography. Consolidation of Nano powders: Shock wave consolidation, Hot iso-static pressing and Cold iso-static pressing, Spark plasma sintering.

UNIT – 4

TOOLS TO CHARACTERIZE NANOMATERIALS: X-Ray Diffraction (XRD), Small Angle X-ray scattering, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP), Nano indentation.

UNIT – 5

APPLICATIONS OF NANO MATERIALS: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS),Nano sensors, Nano catalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water- Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defense and Space Applications, Concerns and challenges of Nanotechnology

TEXT BOOKS:

1. Introduction to Nano Technology by Charles. P. Poole Jr& Frank J. Owens.Wiley India Pvt. Ltd.
2. Nano Materials- A.K.Bandyopadhyay/ New Age Publishers.
3. Nano Essentials- T.Pradeep/TMH

REFERENCE BOOKS:

1. Solid State physics by Pillai, Wiley Eastern Ltd.
2. Introduction to solid state physics 7th edition by Kittel. John Wiley & sons (Asia) Pvt Ltd.

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

CO1 Understand the classification of nanostructured Materials

CO2 Understand the unique properties of nano materials

CO3 Interpret the Synthesis Routes - Bottom up and Top down approaches

CO4 Identify the tools to characterize nano materials

CO5 Understand the applications of nano materials

III Year I Semester	THERMAL MANAGEMENT OF ELECTRONIC SYSTEMS	L	T	P	C
		3	0	0	3

Course Objective:

1. To understand the basics of heat transfer and analyze heat transfer through fins
2. To acquire the knowledge on Free and forced convective systems.
3. To understand the air cooling and single phase liquid cooling systems with case studies.
4. To demonstrate the concepts of two phase cooling and heat pipes.
5. To understand thermo electric coolers, mini and micro channels.

UNIT – 1

Introduction of Heat Transfer: Modes – Conduction, Convection and Radiation – Basic Laws – Applications of Heat Transfer.

Basics of Conduction –Conduction equation – Thermal analogy – Lumped heat capacity analysis - Heat conduction with phase change - Thermal Resistance – Extended Surfaces – Uniform cross section fins – Fin efficiency – Selection and design of fins

UNIT – 2

Forced and Free Convection – Heat transfer coefficient - Parameters effecting heat transfer – Thermal Properties of fluids - Combined Modes.

Radiation – Stefan- Boltzmann Law – Kirchoff's law and Emissivity – Radiation between Black Isothermal Surfaces – Radiation between Grey Isothermal Surfaces – Extreme Climatic conditions - Radiation at normal ambient Temperature measurement and its Instrumentation.

UNIT – 3

Printed Circuit boards – Chip packaging – thermal Resistance – Board Cooling methods – Board thermal Analysis – Equivalent thermal Conductivity.

Air Cooling – Fans – Heat transfer Enhancement – Air handling systems - Blowers

Single Phase Cooling – Coolant Selection – Natural Convection – Forced Convection - Air Cooling - Convective cooling in Small systems – Forced cooling in medium and large systems – Liquid cooling in high power modules – Case Studies.

UNIT – 4

Two Phase Cooling – Direct Immersion Cooling – Basics of Pool Boiling – Enhancement of Pool Boiling – Flow Boiling.

Heat Pipes – Operation Principles – Useful Characteristics – Operating Limits and Temperatures – Operation Methods – Applications – Micro Heat Pipes.

UNIT – 5

Thermo Electric coolers: Basics theories – Thermo electric effect – Operation Principles.

Phase change materials, Thermal Interface materials, Heat Spreaders and Heat Sinks – Working Principles

Mini and Micro Channels. Use of nano fluids in electronic cooling.

Text Books:

1. Thermal Analysis and Control of Electronic Equipment – Allan D. Kraus and Avram BarCohen, McGraw Hill, New York, NY, 1983.
2. Fundamentals of Microelectronics Packaging – Ed: Rao Tummala, McGraw Hill, New York, NY, 2001.
3. Packaging of Electronic Systems – James W. Dally, McGraw Hill, New York, NY, 1990.

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

CO1	Understand the basics of heat transfer and analyze heat transfer through fins
CO2	Acquire the knowledge on Free and forced convective systems
CO3	Understand the air cooling and single phase liquid cooling systems with case studies
CO4	Demonstrate the concepts of Two phase cooling and heat pipes
CO5	Understand thermo electric coolers, mini and micro channels

III Year I Semester	ENTREPRENEURSHIP	L	T	P	C
		3	0	0	3

Course objective:

1) To develop and strengthen entrepreneurial quality and motivation in students.
2) To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.

UNIT-I : ENTREPRENEURAL COMPETENCE

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.

UNIT-II: ENTREPRENEURAL ENVIRONMENT

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organisational Services.

UNIT-III: INDUSTRIAL POLACIES

Central and State Government Industrial Policies and Regulations - International Business.

UNIT-IV: BUSINESS PLAN PREPARATION

Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.

UNIT- V: LAUNCHING OF SMALL BUSINESS

Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.

Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.

TEXT BOOKS

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.

REFERENCES

1. Mathew Manimala, Entrepreneurship Theory at the Crossroads, Paradigms & Praxis, Biztrantra ,2nd Edition ,2005
2. Prasanna Chandra, Projects – Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill, 1996.
3. P.Saravanavel, Entrepreneurial Development, Ess Pee kay Publishing House, Chennai -1997.
4. Arya Kumar. Entrepreneurship. Pearson. 2012 5. Donald F Kuratko, T.V Rao. Entrepreneurship: A South Asian perspective. Cengage Learning. 2012

III Year I Semester	THERMAL ENGINEERING LAB	L	T	P	C
		0	0	3	1.5

COURSE OUTCOME: Students will gain knowledge and skills needed to run a business.

Course objectives:

1) To demonstrate the characteristics of two stroke and four stroke compression and spark ignition engines.
2) To determine flash point, fire point, calorific value of different fuels using various apparatus.
3) To find out engine friction, and conduct load test of petrol and diesel engines.
4) To demonstrate performance test on petrol and diesel engines.
5) To conduct performance test and determine efficiency of air compressor.

Experiments:

1. To determine the actual Valve Timing diagram of a four stroke Compression/Spark Ignition Engine.
2. To determine the actual Port Timing diagram of a two stroke Compression/Spark Ignition Engine.
3. Determination of Flash & Fire points of Liquid fuels / Lubricants using (i) Abels Apparatus; (ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Saybolt Viscometer and (ii) Redwood Viscometer.
5. Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
6. To perform the Heat Balance Test on Single Cylinder four Stroke Petrol/Diesel Engine.
7. To conduct a load test on a single cylinder Petrol/Diesel engine to study its performance under various loads.
8. To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.
9. To conduct a performance test on an air compressor and determine its different efficiencies.
10. Study of boilers with accessories and mountings
11. Experimentation on installation of Solar PV Cells
12. Demonstration of electronic controls in an automobile.

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

CO1: Experiment with two stroke and four stroke compression and spark ignition engines for various characteristics.
CO2: Determine flash point, fire point, calorific value of different fuels using various apparatus.
CO3: Perform engine friction, heat balance test, load test of petrol and diesel engines.
CO4: Conduct performance test on petrol and diesel engines
CO5: Perform test and determine efficiency of air compressor

III Year I Semester	THEORY OF MACHINES LAB	L	T	P	C
		0	0	3	1.5

Course Objectives

- To demonstrate the motion of a gyroscope
- To study the characteristics of governors
- To find the frequencies of damped and undamped free and forced vibrations
- To analyze different mechanisms
- To demonstrate various types of gears

List of Experiments:

1. To determine whirling speed of shaft theoretically and experimentally.
2. To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation.
3. To analyse the motion of a motorized gyroscope when the couple is applied along its spin axis
4. To determine the frequency of undamped free vibration of an equivalent spring mass system.
5. To determine the frequency of damped force vibration of a spring mass system
6. To study the static and dynamic balancing using rigid blocks.
7. To find the moment of inertia of a flywheel
8. To plot follower displacement vs cam rotation for various Cam Follower systems.
9. To plot slider displacement, velocity and acceleration against crank rotation for single slider crank mechanism/Four bar mechanism
10. To find the coefficient of friction between the belt and pulley.
11. To study simple and compound screw jack and determine the mechanical advantage, velocity ratio, and efficiency
12. To study various types of gears- Spur, Helical, Worm and Bevel Gears

Course Outcomes:

- Get knowledge about the motion of a gyroscope
- Discuss the characteristics of governors
- Find the frequencies of damped and undamped free and forced vibrations
- Analyze different mechanisms
- Demonstrate various types of gears

III Year I Semester	MACHINE TOOLS & METROLOGY LAB	L	T	P	C
		0	0	4	2

Course Objectives:

1. To understand the parts of various machine tools and about different shapes of products that can be produced on them.
2. To measure bores, angles and tapers
3. To perform alignment tests on various machines

Note: The students have to conduct at least 6 experiments from each lab

MACHINE TOOLS LAB

1. Introduction of general purpose machines -Lathe, Drilling machine, Milling machine, Shaper, Planing machine, Slotting machine, Cylindrical grinder, Surface grinder and Tool and cutter grinder.
2. Operations on Lathe machines- Step turning, Knurling, Taper turning,Thread cutting and Drilling
3. Operations on Drilling machine - Drilling, reaming, tapping, Rectangular drilling, circumferential drilling
4. Operations on Shaping machine - (i) Round to square (ii) Round to Hexagonal
5. Operations on Slotter - (i) Keyway (T –slot) (ii) Keyway cutting
6. Operations on milling machines - (i) Indexing (ii) Gear manufacturing

METROLOGY LAB

1. Calibration of vernier calipers, micrometers, vernier height gauge and dial gauges.
2. Measurement of bores by internal micrometers and dial bore indicators.
3. Use of gear tooth vernier caliper for tooth thickness inspection and flange micrometer for checking the chordal thickness of spur gear.
4. Machine tool alignment test on the lathe.
5. Machine tool alignment test on drilling machine.
6. Machine tool alignment test on milling machine.
7. Angle and taper measurements with bevel protractor, Sine bar, rollers and balls.
8. Use of spirit level in finding the straightness of a bed and flatness of a surface.
9. Thread inspection with two wire/ three wire method & tool makers microscope.
10. Surface roughness measurement with roughness measuring instrument.

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

1. Gain knowledge about the parts of various machine tools and about different shapes of products that can be produced on them.
2. Learn measure bores, angles and tapers
3. Perform alignment tests on various machines

III Year I Semester	TINKERING LAB	L	T	P	C
		0	0	2	1

The aim of tinkering lab for engineering students is to provide a hands-on learning environment where students can explore, experiment, and innovate by building and testing prototypes. These labs are designed to demonstrate practical skills that complement theoretical knowledge.

Course Objectives : To

1. **Encourage Innovation and Creativity**
2. **Provide Hands-on Learning**
3. **Impart Skill Development**
4. **Foster Collaboration and Teamwork**
5. **Enable Interdisciplinary Learning**
6. **Impart Problem-Solving mind-set**
7. **Prepare for Industry and Entrepreneurship**

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of experiments:

1) Make your own parallel and series circuits using breadboard for any application of your choice.
2) Demonstrate a traffic light circuit using breadboard.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinkercad.
5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
6) Interfacing IR Sensor and Servo Motor with Arduino.
7) Blink LED using ESP32.
8) LDR Interfacing with ESP32.
9) Control an LED using Mobile App.
10) Design and 3D print a Walking Robot
11) Design and 3D Print a Rocket.
12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
13) Demonstrate all the steps in design thinking to redesign a motor bike.

Students need to refer to the following links:

1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf
2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf

Course Outcomes: The students will be able to experiment, innovate, and solve real-world challenges.

III Year I Semester	**COMMUNITY SERVICE INTERNSHIP**	**L**	**T**	**P**	**C**
		--	**--**	**--**	**2**

III Year II Semester	HEAT TRANSFER	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn the different modes of heat transfer and conduction heat transfer through various solid bodies
2. To learn the one dimensional steady state heat conduction heat transfer and one dimensional transient heat conduction
3. To learn the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows
4. To learn the free convection heat transfer concepts and heat transfer processes in heat exchangers
5. To learn the concepts of radiation heat transfer.

UNIT – 1

Introduction

Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

Conduction Heat Transfer

Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer

Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature.

UNIT – 2

One Dimensional Transient Conduction Heat Transfer

Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

Convective Heat Transfer

Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations

UNIT – 3

Forced convection: External Flows:

Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows:

Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus

flow.

Free Convection:

Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT – 4

Heat Transfer with Phase Change:

Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling

Condensation: Film wise and drop wise condensation –Nusselt's Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT – 5

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks

Note: Heat transfer data book by C P Kothandaraman and Subrahmanyan **is allowed.**

TEXT BOOKS:

1. Heat Transfer by HOLMAN, Tata McGraw-Hill
2. Heat Transfer by P.K.Nag, TMH

REFERENCE BOOKS:

1. Fundamentals of Heat Transfer by Incropera& Dewitt, John Wiley
2. Fundamentals of Engineering, Heat& Mass Transfer by R.C.Sachdeva, New Age.
3. Heat& Mass Transfer by Amit Pal – Pearson Publishers
4. Heat Transfer by Ghoshadastidar, Oxford University press.
5. Heat Transfer by a Practical Approach, YunusCengel, Boles, TMH
6. Engineering Heat and Mass Transfer by Sarit K. Das, Dhanpat Rai Pub

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

CO1	Find heat transfer rate for 1D, steady state composite systems with heat generation and performance of pins.
CO2	Understand the concepts transient heat conduction and basic laws involved in the convection heat transfer.
CO3	Apply the empirical equations for forced convection and free convection problems
CO4	Examine the rate of heat transfer with phase change and in the heat exchangers.
CO5	Illustrate the concepts of radiation heat transfer

III Year II Semester	ARTIFICIAL INTELLIGENCE & MACHINE LEARNING	L	T	P	C
		3	0	0	3

Course objectives:

1) To impart the basic concepts of artificial intelligence and the principles of knowledge representation and reasoning.
2) To introduce the machine learning concepts and supervised learning methods
3) To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
4) To make the students learn about neural networks and genetic algorithms.
5) To understand the machine learning analytics and deep learning techniques.

UNIT– I:

Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents.

Knowledge–Representation and Reasoning: Logical Agents: Knowledge-based agents, the Wumpus world, logic. Patterns in Propositional Logic, Inference in First-Order Logic-Propositional vs first order inference, unification.

UNIT– II:

Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, overfitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.

UNIT– III:

Unsupervised Learning: Clustering**,** K-means, Dimensionality Reduction, PCA and Kernel.

Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning- K-Nearest neighbour learning.

UNIT– IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and backpropagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.

UNIT– V:

Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.

Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods - Boosting, Bagging, and Random Forests.

TEXT BOOKS:

1) Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.

2) Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.

3) Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCE BOOKS:

1) Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.

2) Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.

ONLINE RESOURCES:

https://www.tpointtech.com/artificial-intelligence-ai

https://www.geeksforgeeks.org/

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

CO1: Explain the basic concepts of artificial intelligence
CO2: Learn about the principles of supervised learning methods
CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms
CO4: Get knowledge about neural networks and genetic algorithms.
CO5: Understand the machine learning analytics and apply deep learning techniques.

III Year II Semester	FINITE ELEMENT METHODS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn basic principles of finite element analysis procedure
2. To learn how to solve the bar and truss problems
3. To learn how to solve beam problems
4. To understand the formulation of 2D problems
5. To get knowledge in heat transfer analysis and dynamic analysis.

UNIT – 1

Introduction to finite element method, stress and equilibrium, strain–displacement relations, stress–strain relations, plane stress and plane strain conditions, variational and weighted residual methods, concept of potential energy, one-dimensional problems.

UNIT – 2

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

Analysis of Trusses: Finite element modeling, coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations

UNIT – 3

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT – 4

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axisymmetric problems. Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

UNIT – 5

Steady state heat transfer analysis: one dimensional analysis of a fin.

Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, free vibration analysis.

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition/ Tirupati Reddy Chandrupatla/Prentice-Hall.
2. The Finite Element Methods in Engineering /S.S.Rao/Pergamon.

REFERENCES:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho & Shah /Pearson publishers
2. An introduction to Finite Element Method /JNReddy/McGraw-Hill
3. The Finite Element Method for Engineers–Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. By rom/John Wiley & sons (ASIA) Pvt Ltd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education
5. Finite Element Analysis: for students & Practicing Engineers / G.LakshmiNarasaiah

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

CO1 Understand the concepts behind variational methods and weighted residual methods in FEM

CO2 Solve bar and truss problems.

CO3 Solve beam problems.

CO4 Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements

CO5 Evaluate the concepts of steady state heat transfer analysis and dynamic analysis

III Year II Semester	MECHANICAL VIBRATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn basic principles of mathematical modeling of vibrating systems
2. To understand the basic concepts free and forced multi degree freedom systems
3. To get concepts involved in the torsional vibrations
4. To learn the principles involved in the critical speed of shafts
5. To understand the basic concepts of Laplace transformations response to different inputs

UNIT – 1

Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modelling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT – 2

Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT – 3

Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non- linear and random vibrations.

UNIT – 4

Vibration Measuring Instruments and Critical Speeds of Shafts: Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT – 5

Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method

Text books:

1. S.S.Rao, “Mechanical Vibrations ", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, “Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York, 1985.

References:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, “Theory of Vibration with Applications”, 5th Edition,Pearson Education, 2008.
2. M.L.Munjal, “Noise and Vibration Control”, World Scientific, 2013.
3. Beranek and Ver, “Noise and Vibration Control Engineering: Principles and Applications”,JohnWiley and Sons, 2006.

4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.

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

CO1	Understand the concepts of vibrational analysis
CO2	Understand the concepts of free and forced multi degree freedom systems
CO3	Summarize the concepts of torsional vibrations
CO4	Solve the problems on critical speed of shafts
CO5	Apply and Analyze the systems subjected to Laplace transformations response to different inputs

III Year II Semester	ADVANCED MANUFACTURING PROCESSESS	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn the basic principle of advanced machining processes
- To know about the various additive manufacturing processes
- To understand the principles of coating and processing of ceramics.
- To get insights about processing of composites and nanomaterials
- To know the fabrication of microelectronic components.

UNIT – 1

ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT – 2

ADDITIVE MANUFACTURING: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.

UNIT – 3

SURFACE TREATMENT: Scope, Cleaners, Methods of cleaning, Surface coating types, Electro forming, Chemical vapour deposition, Physical vapour deposition, thermal spraying methods, Ion implantation, diffusion coating, ceramic and organic methods of coating, and cladding methods.

PROCESSING OF CERAMICS: Applications, characteristics, classification Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application.

UNIT – 4

PROCESSING OF COMPOSITES: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, processing methods for MMC, CMC, Polymer matrix composites.

PROCESSING OF NANOMATERIALS: Introduction, Top down Vs Bottom up techniques-Ball milling, Lithography, Plasma Arc Discharge, Pulsed Laser Deposition, Sputtering, Sol-Gel, Molecular beam Epitaxy.

UNIT – 5

FABRICATION OF MICROELECTRONIC DEVICES:

Crystal growth and wafer preparation, Film Deposition, oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, surface mount technology, Integrated circuit economics.

TEXT BOOKS:

1. Manufacturing Engineering and Technology*I*Kalpakijian / AdissonWesley, 1995.
2. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

REFERENCES:

1 Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold,
2 MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3 Advanced Machining Processes / V.K.Jain / Allied Publications.
4 Introduction to Manufacturing Processes / John A Schey*I*McGraw Hill.
5 Introduction to Nanoscience and NanoTechnology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learing

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

CO1: Explain the working principle of various nonconventional machining processes and their applications.
CO2: Explain the working principles of additive manufacturing methods.
CO3: Understand various laser material processing techniques.
CO4: Gain on Advanced coating processes
CO5: Describe various fabrication methods for microelectronic devices

III Year II Semester	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

1) To understand basics of Micro Electro Mechanical Systems(MEMS), mechanical sensors and actuators
2) To illustrate thermal sensors and actuators used in MEMS.
3) To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems
   (MOEMS), magnetic sensors and actuators.
4) To analyze applications and considerations on micro fluidic systems.
5) To illustrate the principles of chemical and biomedical microsystems.

UNIT–I:

INTRODUCTION: Definition of MEMS, MEMS history and development, micromachining, lithography principles &methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micromachining, wafer bonding, LIGA.

MECHANICAL SENSORS AND ACTUATORS: Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inch worm technology.

UNIT–II*:*

THERMAL SENSORS AND ACTUATORS: Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, datastorage cantilever.

UNIT–III*:*

MICRO-OPTO-ELECTROMECHANICALSYSTEMS: Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement.

MAGNETIC SENSORS AND ACTUATORS: Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOKE, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.

UNIT– IV*:*

MICRO FLUIDIC SYSTEMS: Applications, considerations on micro scale fluid, fluid actuation methods, dielectro-phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. RADIOFREQUENCY (RF) MEMS: RF – based communication systems, RF MEMS, MEMS inductors, tuner/filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT– V*:*

CHEMICAL AND BIOMEDICAL MICRO SYSTEMS: Sensing mechanism &principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo-resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

TEXTBOOK:

1.MEMS, Nitaigour Prem chand Mahalik, TMH

REFERENCE BOOKS:

1. Foundation of MEMS, Chang Liu, Prentice HallLtd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-RanHsu, TMHPublishers.
4. Introductory MEMS,Thomas MAdams, Richard ALayton, Springer International Publishers.

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

CO1: To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
CO2: Illustrate thermal sensors and actuators used in MEMS.
CO 3: To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
CO 4: Analyze applications and considerations on micro fluidic systems.
CO5: Illustrate the principles of chemical and biomedical micro systems.

III Year-II Semester	SENSORS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the concepts of measurement technology.
2. To learn the various sensors used to measure various physical parameters.
3. To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development
4. To learn about the optical, pressure and temperature sensor
5. To understand the signal conditioning and DAQ systems

UNIT I
INTRODUCTION

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

UNIT II
MOTION, PROXIMITY AND RANGING SENSORS

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III
FORCE, MAGNETIC AND HEADING SENSORS

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT IV
OPTICAL, PRESSURE AND TEMPERATURE SENSORS

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT V
SIGNAL CONDITIONING AND DAQ SYSTEMS

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw- Hill, 2009.
2. Sawney A K and Puneet Sawney, "A Course in Mechanical Measurements and Instrumentation and Control", Dhanpat Rai & Co, 12th edition New Delhi, 2013.

REFERENCES

1. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001.
2. Hans Kurt Tönshoff (Editor), Ichiro, "Sensors in Manufacturing" Volume 1, Wiley-VCH April 2001.
3. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.
4. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2011.
5. Richard Zurawski, "Industrial Communication Technology Handbook" 2nd edition, CRC Press, 2015.

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

CO1: Recognize with various calibration techniques and signal types for sensors.
CO2: Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers.
CO3: Apply the various sensors and transducers in various applications
CO4: Select the appropriate sensor for different applications.
CO5: Acquire the signals from different sensors using Data acquisition systems.

	TECHNOLOGIES	3	0	0	3

Course Objectives: To

- Get the insights into importance of energy storage systems
- Understand the chemical and electromagnetic storage systems
- Know the principles of electrochemical storage systems
  Learn the working of super capacitors and fuel cells
- Know how to design batteries for transportation

UNIT 1:

Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. Thermal storage system-heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT 2:

Chemical storage system- hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

Electromagnetic storage systems - double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT 3:

Electrochemical storage system

Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages-Li-ion battery& Metal hydride battery vs lead-acid battery

UNIT 4:

Super capacitors- Working principle of super capacitor, types of super capacitors, cycling and performance characteristics, difference between battery and super capacitors, Introduction to Hybrid electrochemical super capacitors

Fuel cell- Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-super capacitor systems.

UNIT 5:

Battery design for transportation, Mechanical Design and Packaging of Battery

Packs for Electric Vehicles, Advanced Battery, Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

Text books:

1. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
2. Ralph Zito, Energy storage: A new approach, Wiley (2010)

References:

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010**)**

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

- Learn the importance of energy storage systems
- Gain knowledge on chemical and electromagnetic storage systems
- Understand the principles of electrochemical storage systems
- Know the working of super capacitors and fuel cells
- Learn how to design batteries for transportation

III Year-II Semester	INDUSTRIAL HYDRAULICS AND PNEUMATICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn basic concepts of fluid power
2. To understand the functions and working of basic elements of Hydraulic and Pneumatic system
3. To get knowledge about the basic components and their functions of Hydraulic and Pneumatic circuits
4. To learn the operating principles and working of hydraulic and pneumatic devices
5. To gain knowledge about the procedures of installation, maintenance and troubleshooting of Hydraulic and pneumatic systems

UNIT – 1

Fluid Power: Power transmission modes, hydraulic systems, pneumatic systems, laws governing fluid flow: Pascal's law, continuity equation, Bernoulli's theorem, Boyle's, Charles', Gay-Lussec' laws, flow through pipes - types, pressure drop in pipes, Working fluids used in hydraulic and pneumatic systems- types, ISO/BIS standards and designations, properties.

UNIT – 2

Hydraulic and Pneumatic Elements: Hydraulic pipes-Types, standards, designation methods and specifications, pressure ratings, applications and selection criteria, pumping theory, Hydraulic Pumps - types, construction, working principle, applications, selection criteria and comparison, hydraulic Actuators, Control valves, Accessories - their types, construction and working, pneumatic Pipes - materials, designations, standards, properties and piping layout, air compressors, Air receivers, air dryers, Air Filters, Regulators, Lubricators (FRL unit): their types, construction, working, specifications and selection criteria of following air preparation and conditioning elements, pneumatic Actuators and Control valves - types, construction, working, materials and specifications

UNIT – 3

Hydraulic and Pneumatic Circuits:

ISO symbols used in hydraulic and pneumatic circuit, basic Hydraulic Circuits – types (such as intensifier, regenerative, synchronizing, sequencing, speed control, safety), circuit diagram, components, working and applications, basic Pneumatic Circuits – types (such as speed control, two step feed control, automatic cylinder reciprocation, time delay, quick exhaust), circuit diagram, components, working and applications, pneumatic Logic circuit design - classic method, cascade method, step counter method, Karnaugh- veitch maps and combinational circuit design.

UNIT – 4

Hydraulic and Pneumatic Devices:

Hydraulic and Pneumatic devices – Concept and applications, construction, working principle, major elements, performance variables of: Automotive hydraulic brake, Industrial Fork lift, Hydraulic jack, Hydraulic press, Automotive power steering, Automotive pneumatic brake, Automotive air suspension, Pneumatic drill, Pneumatic gun.

UNIT – 5

Installation, Maintenance and Trouble-Shooting:

Installation of hydraulic and pneumatic system causes and remedies for common troubles arising in hydraulic elements, maintenance of hydraulic systems, causes and remedies for troubles arising in pneumatic elements, maintenance of pneumatic systems.

Textbooks:

1. Majumdar, S.R. Oil Hydraulic Systems Tata McGraw-Hill Publication, New Delhi,3/e, 2013
2. Majumdar, S.R. Pneumatic Systems Tata McGraw-Hill Publication, New Delhi,3/e, 2013

References:

1. Srinivasan, R. Hydraulic and Pneumatic Controls Vijay Nicole Imprints Private, New Delhi, Limited, 2/e, 2008
2. Jagadeesha, T. Fluid Power Generation, Transmission and Control Universities Press (India) Private Limited, New Delhi,1/e, 2014
3. Jagadeesha, T. Pneumatics Concepts, Design and Applications Universities Press (India) Private Limited, New Delhi,1/e, 2014
4. Parr, Andrew Hydraulic and Pneumatics, A Technician's and Engineer's Guide, Jaico Publishing House, New Delhi,2/e, 2013
5. Shanmuga Sundaram, K. Hydraulic and Pneumatics Controls - Understanding Made Easy S. Chand Company Ltd., New Delhi, 1/e, 2006

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

CO1	Illustrate the basic concepts of fluid power
CO2	Understand the functions of elements of Hydraulic and Pneumatic systems
CO3	Analyze the functions of hydraulic and Pneumatic circuits
CO4	Illustrate the working of various hydraulic and pneumatic devices.
CO5	Interpret the procedure of installation, maintenance of hydraulic and pneumatic systems.

III Year II Semester	INDUSTRIAL ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives: The Students will acquire the knowledge to

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

UNIT – 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms –- requirements and challenges of end effectors, determination of the end effectors.

UNIT – 2

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric& stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion–Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/Groover MP/Pearson Edu.
2. Robotics and Control /Mittal R K &Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGraw Hill.

2. Robotic Engineering /Richard D. Klafter, Prentice Hall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/PearsonEdu.

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

CO1 Discuss various applications and components of industrial robot systems

CO2 Learn about the types of actuators used in robotics

CO3 Calculate the forward kinematics and inverse kinematics.

CO4 Learn about programming principles and languages for a robot control system

CO5 Discuss the applications of image processing and machine vision in robotics.

III Year II Semester	REFRIGERATION & AIR-CONDITIONING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To illustrate the operating cycles and different systems of refrigeration
2. To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
3. To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
4. To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
5. To describe different component of refrigeration and air conditioning systems

UNIT – 1

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT – 2

VAPOUR COMPRESSION REFRIGERATION SYSTEM &COMPONENTS: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures**,** multi stage vapour compression refrigeration.

UNIT – 3

REFRIGERANTS– Desirable properties – classification - refrigerants –green refrigerants- nomenclature – ozone depletion – global warming.

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH_3 – water system and Li Br –water (Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.

UNIT – 4

INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF- problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature- comfort chart –comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT – 5

AIR CONDITIONING SYSTEMS: Classification of equipments, cooling, heating

humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

Note: Refrigeration and Psychrometric tables and charts are allowed.

Text Books:

1. A Course in Refrigeration and Air conditioning / SC Arora & Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora / TMH.

References:

1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration /Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH

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

CO1	Illustrate the operating cycles and different systems of refrigeration.
CO2	Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
CO3	Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants
CO4	Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
CO5	Demonstrate different components of refrigeration and air conditioning systems.

III Year II Semester	INTRODUCTION TO INDUSTRIAL ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives: To

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

UNIT – 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms -– requirements and challenges of end effectors, determination of the end effectors.

UNIT – 2

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric& stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – 3

MOTIO ANANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion–Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/GrooverMP/Pearson Edu.
2. Robotics and Control /MittalR K &Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGraw Hill.
2. Robotic Engineering /Richard D. Klafter, PrenticeHall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/PearsonEdu.

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

CO1 Discuss various applications and components of industrial robot systems

CO2 Learn about the types of actuators used in robotics
CO3 Calculate the forward kinematics and inverse kinematics.
CO4 Learn about programming principles and languages for a robot control system
CO5 Discuss the applications of image processing and machine vision in robotics.

III Year II Semester	INDUSTRIAL MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives: The objectives of the course are to

1) Introduce the scope and role of industrial engineering and the techniques for optimal design of layouts.
2) Illustrate how work study is used to improve productivity
3) Explain TQM and quality control techniques
4) Introduce financial management aspects and
5) Discuss human resource management and value analysis.

UNIT– I

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and break down maintenance.

UNIT–II

WORK STUDY: Importance, types of production, applications, work study, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

UNIT–III

STATISTICAL QUALITY CONTROL: Quality control, Quality assurance and its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – $\bar{X}$ and R –charts $\bar{X}$ and S charts and their applications, numerical examples.

TOTAL QUALITY MANAGEMENT: zero defect concept, quality circles, implementation, applications, ISO quality systems. Six Sigma–definition, basic concepts

UNIT– IV

FINANCIAL MANAGEMENT: Scope and nature of financial management, Sources of finance, Ratio analysis, Management of working capital, estimation of working capital requirements, stock management, Cost accounting and control, budget and budgetary control, Capital budgeting – Nature of Investment Decisions – Investment Evaluation criteria- NPV, IRR, PI, Payback Period, and ARR, numerical problems.

UNIT–V

HUMAN RESOURCEMANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, and types.

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

Text Books:

1.Industrial Engineering and Management/ O.P Khanna /Khanna Publishers.
2.Industrial Engineering and Production Management/Mart and Telsang / S.Chand&Company Ltd. New Delhi.

Reference Books:

1) Industrial Management/ Bhattacharya DK/ Vikas publishers
2) Operations Management/ J.GMonks / McGrawHilPublishers.
3) Industrial Engineering and Management Science/T.R. Banga, S.C.Sharma, N. K. Agarwal /Khanna Publishers
4) Principles of Management / KoontzO'Donnel/ McGraw Hill Publishers.
5) Statistical Quality Control / Gupta/ Khanna Publishers
6) Industrial Engineering and Management/ NVSRaju/ CengagePublishers

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

1) Learn about how to design the optimal layout
2) Demonstrate work study methods
3) Explain Quality Control techniques
4) Discuss the financial management aspects and
5) Understand the human resource management methods.

III Year II Semester	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
2. To understand and apply different types of solid-based RP systems.
3. To understand and apply powder-based RP systems.
4. To understand and apply various rapid tooling techniques.
5. To understand different types of data formats and to explore the applications of AM processes in various fields.

UNIT – 1

INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.

LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 2

SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 3

POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT – 4

RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.

UNIT – 5

RAPID PROTOTYPING DATA FORMATS: STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP

medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

Text Books:

1.Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific publications

References:

1. Rapid Manufacturing / D.T. Pham and S.S. Dimov/Springer
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates
3. Rapid Prototyping & Manufacturing / Paul F.Jacobs/ASME Press
4. Rapid Prototyping / Chua and Liou

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

CO1	Understand the principles of prototyping, classification of RP processes and liquid-based RP systems.
CO2	Understand and apply different types of solid-based RP systems.
CO3	Apply powder-based RP systems.
CO4	Analyze and apply various rapid tooling techniques.
CO5	Understand different types of data formats and explore the applications of AM processes in various fields.

III Year I Semester	VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1.To study the advanced engine technologies
2.To learn various advanced combustion technologies and its benefits
3.To learn the methods of using low carbon fuels and its significance
4.To learn and understand the hybrid and electric vehicle configurations
5.To study the application of fuel cell technology in automotives

UNIT – I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT – II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT – III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT – IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward

UNIT – V: FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.

TEXT BOOKS:

1.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER

REFERENCES:

1.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3.Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998
4.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

5.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Course Outcomes*: At the end of the course the students would be able to*

1. Discuss the latest trends in engine technology
2. Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.
3. Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
4. Discuss the working and energy flow in various hybrid and electric configurations.
5. Analyzing the need for fuel cell technology in automotive applications.

III Year II Semester	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

Course objectives:

1) To understand the concepts of industrial safety and management.
2) To demonstrate the accident preventions and protective equipment.
3) To understand and apply the knowledge of safety acts
4) To have the knowledge about fire prevention and protection systems
5) To understand and apply fire safety principles in buildings

UNIT-I

INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETY AND MANAGEMENT: History and development of Industrial safety: Implementation of factories act, Safety and productivity, Safety organizations. Safety committees and structure, Role of management and role of Govt.in industrial safety.

UNIT-II

ACCIDENT PREVENTIONS AND PROTECTIVE EQUIPMENT: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Accident reporting, Investigations. Industrial psychology in accident prevention, Safety trials, Safety related to operations.

UNIT-III

SAFETY ACTS: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical environment, Engineering methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it, Code and regulations for worker safety and health, codes for safety of systems.

UNIT-IV

FIRE PREVENTION AND PROTECTION: Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E-Fire extinguishing agents- Water, Foam, Dry chemical powder, Carbon-dioxide Halon alternatives Halocarbon compounds-Inert gases, dry powders – types of fire extinguishers – fire stoppers –hydrant pipes – hoses – monitors – fire watchers – layout of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills –first aid for burns.

UNIT-V

BUILDING FIRE SAFETY: Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design -exit– width calculations –fire certificates – fire safety

requirements for high rise buildings.

TEXT BOOKS*:*

1. Industrial Maintenance Management Srivastava, S.K.- S.Chandand Co.
2. Occupational Safety Management and Engineering Willie Hammer– PrenticeHall
3. Purandare D.D & Abhay D.Purandare, "Handbook on Industrial Fire Safety" P&A publications, NewDelhi, 2006.
4. McElroy,FrankE.,"Accident Prevention Manual for Industrial Operations", NSC, Chicago, 1988.
5. Green, A.E.,"High Risk Safety Technology", John Wiley and Sons, 1984.

REFERENCE BOOKS*:*

1. Installation, Servicing and Maintenance Bhattacharya, S.N.-S.Chandand Co.
2. Jain VK "Fire Safety in Building" New Age International 1996.
3. Reliability, Maintenance and Safety Engineering by Dr.A. K.Guptha
4. A Text book of Reliability and Maintenance Engineering by Alakesh Manna

Course outcomes:

CO1: Students learn the concepts of industrial safety and management.
CO2: Learn about the smart machines and smart sensors
CO3: Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry
CO4: Students learn about fire prevention and protection systems.
CO5: Students learn and apply the fire safety principles in buildings

III Year II Semester	HEAT TRANSFER LAB	L	T	P	C
		0	0	3	1.5

Course Objective: The laboratory course is aimed to provide the practical exposure to the students with regard to the determination of amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

PART-A

1. Determination of overall heat transfer co-efficient of a composite slab
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin
6. Determination of heat transfer coefficient in natural and forced convection
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan-Boltzmann constant.
10. Determination of heat transfer rate in drop and film wise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

PART-B

Virtual labs (https://mfts-iitg.vlabs.ac.in/) on

(i) Conduction Analysis of a Single Material Slab
(ii) Conduction Analysis of a single Material Sphere
(iii) Conduction Analysis of a single Material Cylinder
(iv) Conduction Analysis of a Double Material Slab
(v) Conduction Analysis of a Double Material Sphere
(vi) Conduction Analysis of Double Material Cylinder
(vii) To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger
(viii) To investigate the Lambert's distance law.
(ix) To investigate the Lambert's direction law (cosine law).

Note: Virtual labs are only for learning purpose, and are not for external examination.

III Year II Semester	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LAB	L	T	P	C
		0	0	3	1.5

Course Objectives: Students will acquire the knowledge of artificial intelligence and machine learning models using various software tools.

Course Objectives: To enable the students write coding for various artificial intelligence and machine learning algorithms.

1. Learning of Python libraries – Numpy, Pandas, Matplotlib, Seaborn and TensorFlow
2. Numerical examples on Python libraries
3. Data Preprocessing and data cleaning using Python
4. Write a program for Linear regression
5. Write a program for Logistic regression
6. Write a program for ANN
7. Write a program for CNN
8. Write a program for RNN
9. Write a program to build a Decision tree
10. Write a program to build a Naïve Bayes classifier
11. Write a program for SVM
12. Write a program for Auto-encoder

Course Outcomes: Students at the end of the course will be able to
CO1: Learn various Python libraries.
CO2: Do programming for regression methods
CO3: Write coding for different types of neural networks
CO4: Write a program for decision tree, Naïve Bayes and SVM
CO4: Generate code for autoencoders

Course Outcomes: At the end of the course, student will be able to apply the knowledge of artificial intelligence and machine learning models along with image classifiers using various software tools.

Note: Databases can be taken from https://www.kaggle.com/datasets.

III Year II Semester	ROBOTICS AND DRONE TECHNOLOGIES LAB	L	T	P	C
		0	0	4	2

Course Objective: Robotics and Drone Technologies Laboratory offers the students hands-on experience in robotics, and unmanned aerial systems.

List of experiments:

Robotics:

1) Simulation of Mathematical Model of Robot.
2) Forward and Inverse Dynamic Analysis of a 2-DOF Robotic Manipulator using Software Tools.
3) Building and Programming a Simple Arduino-Based Robot for basic movement.
4) Build a robot that can navigate through a maze or an environment by using sensors to detect obstacles and avoid them.
5) Construct a robotic arm using servo motors or stepper motors and program the arm to perform various tasks, such as picking up objects, sorting the colour, or drawing shapes.
6) Build a robot that follows a black line on a contrasting surface using line-following sensors.
7) Designing a 3D Model of a Robotic Arm and Grippers Using Software
8) Implement a PID controller for a robotic arm or mobile robot and simulate its performance in tracking a desired trajectory.

Drone technologies:

1) Demonstration of parts and functions of a drone.
2) Demonstration of effects of forces, manoeuvres of a drone by roll, pitch and yaw.
3) Demonstration of various sensors and battery management used in drones.
4) Build a prototype drone to record videos and photos.
5) Make a drone for a certain payload.

Students need to refer to the following links:

1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf
2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf
6) https://aim.gov.in/pdf/ATL_Drone_Module.pdf

Course outcome: Students at the end of the course will get enough knowledge and knowhow about how to design a variety of robots and drones for diversified applications.

III Year II Semester	TECHNICAL PAPER WRITING AND IPR	L	T	P	C
		2	0	0	--

Course objectives:

1) To understand the structure of the technical paper and its components.
2) To review the literature and acquire the skills to write a technical paper for first submission.
3) To understand the process and development of IPR.
4) To create awareness about the scope of patent rights.
5) To analyze the new developments in IPR include latest software.

UNIT-I: Planning and preparation

Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness. Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

UNIT-II: Literature review

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Key skills needed when writing a Title, Abstract, Introduction, a Review of the Literature, the Methods, the Results, the Discussion, and the Conclusions. Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

UNIT-III: Process and Development

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

UNIT-IV: Patent Rights

Scope of Patent Rights. Licensing and transfer of technology, Patent information and databases, Geographical Indications.

UNIT-V: New Developments In IPR

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies.

Text Books:

1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.

References:

1) Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2) Highman N (1998), Handbook of Writing for the Mathematical

Sciences, SIAM. Highman's book.
3) Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
4) Mayall, "Industrial Design", McGraw Hill, 1992.
5) Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age" 2016.
6) T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

Course outcomes: Upon completion of course, students will be able to:

1) Understand the structure of the technical paper and its components.
2) Review the literature and acquire the skills to write a technical paper for first submission.
3) Understand the process and development of IPR.
4) Create awareness about the scope of patent rights.
5) Analyze the new developments in IPR include latest software.

III Year II Semester	**INDUSTRY INTERNSHIP**				

MINORS

Minors Course	MECHANICS OF SOLIDS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives: The objectives of the course are to

1) Understand the behavior of basic structural members subjected to uni-axial loads.
2) Apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moment.
3) Students will learn all the methods to analyze beams, frames for normal, shear to solve deflection problems in preparation for the design of such structural components. Students are able to analyse beams and draw correct and complete shearand bending moment diagrams for beams.
4) Students attain a deeper understanding of the loads, stresses, and strains acting on a structure and their relations in the elastic behavior
5) Design and analysis of Industrial components like pressure vessels.

UNIT – I

SIMPLE STRESSES & STRAINS : Elasticity and plasticity – Types of stresses & strains– Hooke's law – stress-strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Bars of varying section – composite bars – Temperature stresses- Relation between elastic constants, Strain energy – Resilience – Gradual, sudden, impact and shock loadings.

UNIT – II

SHEAR FORCE AND BENDING MOMENT : Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of abeam.

UNIT – III

FLEXURAL STRESSES : Theory of simple bending – Assumptions – Derivation of bending equation: M/ I = f/y = E/R Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections

SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beamssections like rectangular, circular, triangular, I, T angle sections.

UNIT – IV

DEFLECTION OF BEAMS : Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, - U.D.L uniformly varying load. Mohr's theorems – Moment area method – application to simple cases including overhanging beams.

UNIT – V

THIN AND THICK CYLINDERS: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders – Riveted boiler shells – Thin spherical shells. Wire wound thin cylinders. Lame's equation – cylinders subjected to inside & outside pressures - compound cylinders.

TEXT BOOKS:

1. Strength of materials /GH Ryder/ Mc Millan publishers India Ltd.
2. Strength of materials by B.C. Punmia, Lakshmi publications Pvt.Ltd, NewDelhi.

REFERENCES:

1. Mechanics of Materials by Gere &Timeshenko
2. Strength of Materials -By Jindal, Umesh Publications.
3. Strength of Materials by S.Timshenko- PHI Publishers
4. Strength of Materials by Andrew Pytel and Ferdinond L. Singer Longman- Harper Collins College Division
5. Solid Mechanics by Popov
6. Mechanics of Materials/Gere and Timoshenko, CBS Publishers

Course outcomes:

On the completion of the course the student will able to

CO1: Model & Analyze the behavior of basic structural members subjected to various loading andsupport conditions based on principles of equilibrium.
CO2: Understand the apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moment.
CO3: Students will learn all the methods to analyze beams, columns, frames for normal, shear, to solve deflection problems in preparation for the design of such structural components. Students are able to analyse beams and draw correct and complete shear and bending moment diagrams for beams.
CO4: Students attain a deeper understanding of the loads, stresses, and strains acting on a structureand their relations in the elastic behavior

Minors Course	DESIGN OF MACHINE MEMBERS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives:

- Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
- Provide an introduction to design of bolted and welded joints.
- Explain design procedures for shafts and couplings.
- Discuss the principles of design for clutches and brakes and springs.
- Explain design procedures for bearings and gears.

UNIT-I: Introduction, Design for Static and Dynamic loads

Mechanical Engineering Design: Design process, design considerations, codes and standards of designation of materials, selection of materials.

Design for Static Loads: Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

Design for Dynamic Loads: Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

UNIT-II: Design of Bolted and Welded Joints

Design of Bolted Joints: Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints.

Welded Joints: Strength of lap and butt welds, Joints subjected to bending and torsion.

UNIT-III: Power transmission shafts and Couplings

Power Transmission Shafts: Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

Couplings: Design of flange and bushed pin couplings, universal coupling.

UNIT-IV: Design of Clutches, Brakes and Springs

Friction Clutches: Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.

Brakes: Different types of brakes. Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

Springs: Design of helical compression, tension, torsion and leaf springs.

UNIT-V: Design of Bearings and Gears

Design of Sliding Contact Bearings: Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.

Design of Rolling Contact Bearings: Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

Design of Gears: Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

Note: Data book is not allowed.

Textbooks:

1. R.L. Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2. V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGraw Hill, 2010.
3. Dr. N. C. Pandya & Dr. C. S. Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

Reference Books:

1. R.K. Jain, Machine Design, Khanna Publications, 1978.
2. J.E. Shigley, Mechanical Engineering Design, 2/e, Tata McGraw Hill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.

Online Learning Resources:

https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design-ofmachine-elements-1-npte
https://www.digimat.in/nptel/courses/video/112105124/L01.html
https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html
http://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html

Course Outcomes:

At the end of the course the students will be able to

- Design the machine members subjected to static and dynamic loads.
- Design shafts and couplings for power transmission
- Learn how to design bolted and welded joints.
- Know the design procedures of clutches, brakes and springs.
- Design bearings and gears.

Minors Course	THEORY OF MACHINES (MECHANICAL ENGINEERING DESIGN AND ROBOTICS)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To identify and enumerate different link based mechanisms with basic understanding of motion
2. To interpret and analyse various velocity and acceleration diagrams for various mechanisms
3. To understand about balancing of masses
4. To learn about governors and gyroscope
5. To design and evaluate the performance of different cams and followers.

UNIT-I

Links and Mechanisms:
Definitions Link or Element, Kinematic Pairs, Degrees of Freedom, Grubler's Criterion (without derivation), Kinematic Chain, Mechanism, Structure, Mobility of Mechanism, Inversion, Machine. Kinematic Chains and Inversions: Inversions of Four Bar Chain; Single Slider Crank Chain and Double Slider Crank Chain.
Static force analysis: Introduction: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction.

UNIT- II

Force principle:
Alembert's principle, Inertia force, inertia torque, Dynamic force analysis of four-bar mechanism and slider crank mechanism.
Friction and Belt Drives: Definitions: Types of friction: laws of friction, Friction in pivot bearings. Belt drives: Flat belt drives, ratio of belt tensions, centrifugal tension, and power transmitted.
Turning moment diagrams: Turning moment diagrams – fluctuation of energy – fly wheels and their design.

UNIT-III

Balancing of Rotating Masses:
Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.
Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, single cylinder engine

UNIT-IV

Governors: Types of governors; force analysis of Porter and Hartnell governors. Controlling force, stability, sensitiveness, isochronism, effort and power.
Gyroscope: Vectorial representation of angular motion, gyroscopic couple.

Effect of gyroscopic couple on ship, plane disc, aero plane, stability of two wheelers.

UNIT- 5

Cams: Types of Cams, Types of Followers. Displacement, Velocity & Acceleration Time Curves for Cam Profiles. Disc Cam with Reciprocating Follower Having Knife- Edge, Roller & Flat-Face Follower, Disc Cam With Oscillating Roller Follower. Follower Motions including, SHM, Uniform Velocity, Uniform Acceleration & Retardation and Cycloidal Motion.

TEXT BOOKS:

1. "Theory of Machines", Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd Ed-2009
2. "Theory of Machines", Sadhu Singh, Pearson Education (Singapore) Pvt. Ltd, Indian Branch New Delhi, 2nd Ed 2006/

REFERENCE BOOKS

1. "Theory of Machines & Mechanisms", J.J. Uicker, , G.R. Pennock, J.E. Shigley, OXFORD 3rd Ed. 2009.
2. "Theory of Machines"by Thomas Bevan, CBS Publication 1984.
3. "Design of Machinery" by Robert L. Norton, McGraw Hill, 2001.
4. "Mechanisms and Dynamics"of Machinery by J. Srinivas, Scitech Publications,Chennai,2002.
5. "Dynamics of machinery" by J. B. K. Das & P. L. S. Murthy.

COURSE OUTCOMES: At the end of the course, students will be able

1. To learn different link based mechanisms
2. To analyse various velocity and acceleration diagrams for various mechanisms
3. To learn about how to balance the masses
4. To gain knowledge in governors and gyroscope.
5. To design and evaluate the performance of different cams and followers.

Minors Course	FINITE ELEMENT METHODS (MECHANICAL ENGINEERING DESIGN AND ROBOTICS)	L	T	P	C
		3	0	0	3

Course Objectives:

- To learn basic principles of finite element analysis procedure
- To learn how to solve the bar and truss problems
- To learn how to solve beam problems
- To understand the formulation of 2D problems
- To get knowledge in heat transfer analysis and dynamic analysis.

UNIT – 1

Introduction to finite element method, stress and equilibrium, strain–displacement relations, stress–strain relations, plane stress and plane strain conditions, variational and weighted residual methods, concept of potential energy, one-dimensional problems.

UNIT – 2

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

Analysis of Trusses: Finite element modeling, coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations

UNIT – 3

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT – 4

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axisymmetric problems. Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

UNIT – 5

Steady state heat transfer analysis: one dimensional analysis of a fin. Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, free vibration analysis.

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition/ Tirupati Reddy Chandrupatla/Prentice-Hall.
2. The Finite Element Methods in Engineering /S.S.Rao/Pergamon.

REFERENCES:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho & Shah /Pearson publishers
2.An introduction to Finite Element Method /JNReddy/McGraw-Hill
3. The Finite Element Method for Engineers–Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. By rom/John Wiley & sons (ASIA) Pvt Ltd.
4.Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education

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

CO1 Understand the concepts behind variational methods and weighted residual methods in FEM

CO2 Solve bar and truss problems.

CO3 Solve beam problems.

CO4 Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements

CO5 Evaluate the concepts of steady state heat transfer analysis and dynamic analysis

Minors Course	MECHANICAL VIBRATIONS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives:

1) To learn basic principles of mathematical modeling of vibrating systems
2) To learn the basic concepts free and forced multi degree freedom systems
3) To learn concepts involved in the torsional vibrations
4) To learn the principles involved in the critical speed of shafts
5) To learn the basic concepts of Laplace transformations response to different inputs

UNIT– I:
Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT– II:
Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT– III:
Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non-linear and random vibrations.

UNIT– IV:
Vibration Measuring Instruments and Critical Speeds of Shafts:Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary crit ical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT– V:
Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method.

TEXT BOOKS:

1. S.S.Rao, “Mechanical Vibrations ", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, “Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York,1985.

REFERENCES:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5th Edition,Pearson Education, 2008.
2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications",JohnWiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.

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

CO1: Understand the concepts of vibrational analysis
CO2: Understand the concepts of free and forced multi degree freedom systems CO3: Summarize the concepts of torsional vibrations
CO4: Solve the problems on critical speed of shafts
CO5: Apply and Analyze the systems subjected to Laplace transformations response to differentinputs

Minors Course	ROBOTICS (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives: The Students will acquire the knowledge to

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

UNIT – 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms -– requirements and challenges of end effectors, determination of the end effectors.

UNIT – 2

ROBOT ACTUATORS AND FEEDBACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric& stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion –Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/GrooverMP/Pearson Edu.
2. Robotics and Control /Mittal R K & Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, Prentice Hall

3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt. Ltd.
4. Introduction to Robotics/John JCraig/Pearson Edu.

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

CO1 Discuss various applications and components of industrial robot systems

CO2 Learn about the types of actuators used in robotics

CO3 Calculate the forward kinematics and inverse kinematics.

CO4 Learn about programming principles and languages for a robot control system

CO5 Discuss the applications of image processing and machine vision in robotics.

Minors Course	PRODUCT DESIGN (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understanding of materials, processes, ergonomics, human behaviour and systems with reference to product design.
- To develop conceptual thinking, and workshop and computer skills for modelling and simulation of a variety of individual and group projects ranging from basic to the complex.
- To understand various risks involved through various techniques and perform reliability analysis.
- To acquaint with different product testing procedures under thermal, vibration, electrical and combined environments.
- To learn about how to design a component for manufacturability

UNIT – I:

PRODUCT DESIGN PROCESS:

Design Process Steps, Morphology of Design. Problem Solving and Decision Mak Problem-Solving Process, Creative Problem Solving, Invention, Brainstorm Morphological Analysis, Behavioural Aspects of Decision Making, Decision The Decision Matrix, Decision Trees.

MODELING AND SIMULATION:

Triz, Role of Models in Engineering Design, Mathematical Modeling, Similitude and Models, Computer Simulation, Geometric Modeling on Computer, Finite-Element Anal

UNIT – II:

PRODUCT MANAGEMENT:

The operation of product management: Customer focus of product management, pro planning process, Levels of strategic planning, Wedge analysis, Opportunity search, Pro life cycle Life cycle theory and practice.

PRODUCT DEVELOPMENT:

Managing new products, generating ideas, Sources of product innovation, Selecting best ideas, the political dimension of product design, Managing the product launch customer feedback.

PRODUCT MANAGERS AND MANUFACTURING:

Need for effective relationships, Impact of manufacturing processes on product decisions, Prototype planning,, Productivity potentials, Management of product quality, Customer service levels.

UNIT – III:

RISK AND RELIABILITY:

Risk and Reliability: Risk and Society, Hazard Analysis, Fault Tree Analysis. Failure Analysis and Quality: Causes of Failures, Failure Modes, Failure Mode and Effect Analysis, FMEA Procedure, Classification of Severity, Computation of Criticality Index, Determination of Corrective Action, Sources of Information, Copyright and Copying. Patent Literature.

UNIT – IV:

PRODUCT TESTING:

Thermal, vibration, electrical, and combined environments, temperature testing, vibra testing, test effectiveness. Accelerated testing and data analysis, accelerated factors. We probability plotting, testing with censored data.

UNIT – V:

DESIGN FOR MANUFACTURABILITY:

Maintenance Concepts and Procedures, Component Reliability, Maintainability Availability, Fault Isolation in design and Self-Diagnostics.

Product Design for Safety, Product Safety and User Safety Concepts, Examples of Safe Designs.

DESIGN STANDARDIZATION AND COST REDUCTION:

Standardization Methodology, Benefits of Product Standardization; International, National, Association and Company Level Standards; Parts Modularization

TEXTBOOKS:

1. Engineering Design, George E. Dieter, McGraw-Hill
2. Product Integrity and Reliability in Design, John W. Evans and Jillian Y. Evans, Springer Verlag.

REFERENCE BOOKS:

1. The Product Management Handbook, Richard S. Handscombe, McGraw-Hill
2. New Product Design, Ulrich Eppinger
3. Product Design, Kevin Otto.

COURSE OUTCOMES:

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

CO1 Apply creative thinking skills for idea generation

CO2 Translate conceptual ideas into clear sketches

CO3 Able to identify causes of failure through fault free analysis and perform failure analysis

CO4 Test a product under thermal, vibration, electrical and combined environments.

CO5 Know how to design for manufacturability

Minors Course	DESIGN FOR MANUFACTURING (Mechanical Engineering Design and Robotics)	L	T	P	C
		3	0	0	3

Course Objectives: The students will acquire the knowledge:
1) To understand the basic concepts of design for manual assembly
2) To interpret basic design procedure of machining processes
3) To understand design considerations metal casting, extrusion and sheet metal work
4) To interpret the design considerations of various metal joining process.
5) To interpret the basic design concepts involved in the assembly automation

UNIT-1

Introduction to DFM, DFMA: How Does DFMA Work? Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design? Typical DFMA Case Studies, Overall Impact of DFMA on Industry.

Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, weight on Handling Time, Effects of Combinations of Factors and application of the DFA Methodology.

UNIT– 2

Machining processes: Overview of various machining processes-general design rules for machining dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT – 3

Metal casting: Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design product design rules for sand casting. Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking

UNIT– 4

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. Forging: Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.

UNIT– 5

Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, and single station assembly lines.

Design for Additive Manufacturing: Design considerations, allowances

TEXT BOOKS:

1. Design for manufacture, John cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla

REFERENCE:

1. ASM Hand book Vol.20

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

CO1: Understand the basic concepts of design for manual assembly
CO2: Identify basic design procedure of various machining processes.
CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work
CO4: Interpret the design considerations of various metal joining process.
CO5: Understand the basic design concepts involved in the assembly automation

Minors Course	CAD LAB (Mechanical Engineering Design and Robotics)	L	T	P	C
		0	0	3	1.5

Course Objectives:

- To develop skill to use software to create 2D models.
- To learn how to use software 3D models.
- To use software Assembly.

LIST OF EXPERIMENT:

1. **DRAFTING**: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.

2. **SURFACE MODELING** - Generation of various Surfaces using surface modeling.

A) DRAFTING: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.

B) SURFACE MODELING - Generation of various Surfaces using surface modeling.

C) The following contents to be done by any 3D software package:

(i) PART MODELING: Generation of various 3D models through Pad, revolve, shell, sweep, parent child relation, Boolean operations and various standard translators.

(ii) Assembly drawings: (Any four of the following using solid model software) Generation of various Parts/assemblies: like Screw Jack, Oldham's Coupling, Foot step bearing, Couplings, knuckle and cotter joints, Crankshaft, Connecting Rod, Piston and Cylinder.

Course Outcomes: At the end of the course, students learn drafting, surface modeling and 3D modeling

Minors Course	**MECHANISMS AND ROBOTICS LAB (Mechanical Engineering Design and Robotics)**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVE: The student will learn

- To design RRRR and RRRP planar mechanisms for function and path generation applications and verify the designs using simulations through ADAMS/CATIA software packages.
- To program robot manipulators to do pick and place operations and trace a given path.

LIST OF EXPERIMENTS

I. ROBOTICS LAB

1. To demonstrate Forward and inverse Kinematics of articulated robot.
2. To program and perform the following operations by using an articulated robot:
   a) Pick and place operation
   b) To traverse given path (for arc welding)

II. KINEMATICS AND DYNAMICS OF NISMS LABORATORY

Design the following mechanisms and simulate using CATIA Software/ADAMS Software:

1. A '*RRRR'* mechanism whose coupler curve will pass through 3 given point.
2. A '*RRRR*' mechanism whose coupler will guide a straight line segment through at least three given positions.
3. A '*RRRR*' mechanism whose input and output motion is coordinated at atleast three given positions.
4. A '*RRRR*' mechanism whose coupler will guide a straight line segment through at least three given positions.
5. A '*RRRP*' mechanism whose input and output motion is coordinated at least two given positions
6. A '*RRRP*' mechanism whose input and output motion is coordinated at least three given positions.
7. A '*RRRR*' mechanism whose input and output motion is coordinated at least two given positions.
8. A '*RRRR*' mechanism whose coupler curve will pass through 4 given points.
9. A '*RRRR*' mechanism whose coupler curve will pass through 3 given points.

COURSE OUTCOMES:

After successfully completing this course, the student will be able to:

10.

Course Outcome

CO1 Write programs to perform the pick and place operations and trace a path for arc welding process using any articulated robot

CO2 Demonstrate the procedure for forward and inverse kinematic analysis any articulated robot

CO3 Design planar mechanisms using procedures for path generation and rigid body guidance and simulate the motions using ADAMS software

Minors Course	AUTOMATION IN MANUFACTURING (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the types and strategies and various components in Automated Systems
2. To classify the types of automated flow lines and analyze automated flow lines
3. To solve the line balancing problems in the various flow line systems with and without buffer storage
4. To interpret different automated material handling systems, storage and retrieval systems and automated inspection systems
5. To understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

UNIT – 1

INTRODUCTION: Types and strategies of automation, pneumatic and hydraulic components, circuits, automation in machine tools, power transmission in CNC machines, optical encoders, other sensors, mechanical feeding and tool changing and machine tool control.

UNIT – 2

AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT – 3

ASSEMBLY SYSTEM AND LINE BALANCING: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

AUTOMATED INSPECTION: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision

UNIT – 4

AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS:

Types of equipment, functions, analysis and design of material handling systems, conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT – 5

ADAPTIVE CONTROL SYSTEMS: Introduction, adaptive control with optimization, adaptive control with constraints, application of adaptive control in machining operations. Consideration of various parameters such as cutting force, temperatures, vibration and acoustic emission in the adaptive controls systems.

TEXT BOOK:

Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover/ PE/PHI.

Automation by W. Buekinsham.

REFERENCES:

1. Computer Control of Manufacturing Systems by Yoram Coren.
2. CAD / CAM/ CIM by Radhakrishnan.

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

CO1 Understands the types and strategies and various components in Automated Systems.

CO2 Classify the types of automated flow lines and analyze automated flow lines

CO3 Solves the line balancing problems in the various flow line systems with and without buffer storage

CO4 Interpret different automated material handling systems, storage and retrieval systems and automated inspection systems

CO5 Understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

Minors Course	MICRO ELECTRO MECHANICAL SYSTEMS (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objectives:

1) To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators
2) To illustrate thermal sensors and actuators used in MEMS.
3) To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
4) To analyze applications and considerations on micro fluidic systems.
5) To illustrate the principles of chemical and bio medical micro systems.

UNIT – I: INTRODUCTION:

Definition of MEMS, MEMS history and development, micro machining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micro machining, wafer bonding, LIGA. MECHANICAL SENSORS AND ACTUATORS: Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inchworm technology.

UNIT – II: THERMAL SENSORS AND ACTUATORS:

Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, data storage cantilever.

UNIT – III: MICRO-OPTO-ELECTRO MECHANICAL SYSTEMS:

Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement. MAGNETIC SENSORS AND ACTUATORS: Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOKE, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.

UNIT – IV: MICRO FLUIDIC SYSTEMS:

Applications, considerations on micro scale fluid, fluid actuation methods, dielectro-phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. RADIO FREQUENCY (RF) MEMS: RF – based communication systems, RF MEMS, MEMS inductors, tuner/filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT – V:

CHEMICAL AND BIO MEDICAL MICRO SYSTEMS: Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo-resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

TEXT BOOK:

1.MEMS, Nitaigour Premchand Mahalik, TMH

REFERENCE BOOKS:

1. Foundation of MEMS, Chang Liu, Prentice Hall Ltd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
4. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.

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

CO 1: To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
CO 2: Illustrate thermal sensors and actuators used in MEMS.
CO 3: To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
CO 4: Analyze applications and considerations on micro fluidic systems.
CO 5: Illustrate the principles of chemical and bio medical micro systems.

Minors Course	**MECHATRONICS (Smart Manufacturing)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understand various elements of a mechatronics system
- Model and simulate simple physical systems
- Suggest appropriate sensors and actuators for an engineering application
- Write simple microcontroller programs
- Build simple homemade projects using electronic devices integrating with mechanical systems

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

UNIT – I:
Mechatronics systems, elements, levels of mechatronics system, Mechatronics design proc system, measurement systems, control systems, microprocessor-based controllers, advanta and disadvantages of mechatronics systems. Sensors and transducers, types, displacem position, proximity, velocity, motion , force, acceleration, torque, fluid pressure, liquid fl liquid level, temperature and light sensors.

UNIT – II:
Solid state electronic devices, PN junction diode, BJT, FET, DIA and TRIAC. Analog sig conditioning, amplifiers, filtering. Introduction to MEMS & typical applications.

UNIT – III:
Hydraulic and pneumatic actuating systems, Fluid systems, Hydraulic and pneumatic syste components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic se systems. Mechanical actuating systems and electrical actuating systems.

UNIT – IV:
Digital electronics and systems, digital logic control, microprocessors and micro controlle programming, process controllers, programmable logic controllers, PLCs versus compute application of PLCs for control.

UNIT – V:
System and interfacing and data acquisition, DAQS, SCADA, A-D and D-A conversions; Dynamic models and analogies, System response. Design of mechatronics systems & future trends.

TEXTBOOKS:

1. Mechatronics Integrated Mechanical Electronics Systems/KP Ramachandran & G K Vijaya Raghavan/WILEY India Edition/2008
2. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.

REFERENCE BOOKS:

1. Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.
2. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
3. Mechatronics System Design / Devdas Shetty/Richard/Thomson.
4. Mechatronics/M. D. Singh/J. G. Joshi/PHI.

COURSE OUTCOMES:

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

Course Outcome

CO1 Identification and demonstration of key elements of mechatronics system representation in terms of block diagram.

CO2 Describe the use of solid-state electronic devices, diodes, amplifiers, designing the mechatronics systems and MEMS.

CO3 Illustrate the applications of various hydraulic, pneumatic, mechanical, ele actuating systems and valves in designing the mechatronic systems.

CO4 Develop the PLC ladder programming for the creation of real-time mech system.

CO5 Develop dynamic models using system interfacing and data acquisition meth design mechatronics systems for future applications.

Minors Course	CIM (SMART MANUFACTURING)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand the basic fundamentals of computer aided manufacturing.
- To understand the principles of flexible manufacturing systems
- To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication
- To learn the overall configuration and elements of computer integrated manufacturing systems.
- To learn the part programming, importance of group technology, computer aided process planning, computer aided quality control

UNIT- 1

MANUFACTURING IN A COMPETITIVE ENVIRONMENT: Automation of manufacturing process - Numerical control - Adaptive control - material handling and movement - Industrial robots - Sensor technology - flexible fixtures - Design for assembly, disassembly and service.

UNIT- 2

GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS: Part families - classification and coding - Production flow analysis - Machine cell design - Benefits. Components of FMS - Application work stations - Computer control and functions - Planning, scheduling and control of FMS - Scheduling - Knowledge based scheduling - Hierarchy of computer control - Supervisory computer.

UNIT- 3

COMPUTER SOFTWARE, SIMULATION AND DATABASE OF FMS: System issues - Types of software - specification and selection - Trends - Application of simulation - software - Manufacturing data systems - data flow - CAD/CAM considerations - Planning FMS database.

UNIT- 4

COMPUTER INTEGRATED MANUFACTURING SYSTEMS: Types of manufacturing systems, machine tools and related equipment, material handling systems, material requirement planning, computer control systems, human labor in manufacturing systems, CIMS benefits.

UNIT- 5

COMPUTER AIDED QUALITY CONTROL: Terminology used in quality control, use of computers in Quality control. Inspection methods- contact and noncontact types, computer aided testing, integration of CAQC with CAD/CAM.

REFERENCES:

1. Groover M.P., " Automation, Production Systems and Computer Integrated

Manufacturing ", Third Edition, Prentice-Hall, 2007.
2. Jha, N.K. “Handbook of Flexible Manufacturing Systems ", Academic Press Inc., 1991.
3. Kalpkjian, “Manufacturing Engineering and Technology ", Addison-Wesley Publishing Co., 1995.
4. Pascal Dennis, “Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System”, (Second edition), Productivity Press, New York, 2007.
5. Taiichi Ohno, Toyota, " Production System Beyond Large-Scale production Productivity Press (India) Pvt.Ltd. 1992.

COURSE OUTCOMES: At the end of the course, students will be able to

- Gain knowledge about the fundamentals of computer aided manufacturing.
- Learn the principles of flexible manufacturing systems
- Gain knowledge about different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication
- Learn the overall configuration and elements of computer integrated manufacturing systems.
- Understand the part programming, importance of group technology, computer aided process planning, computer aided quality control

Minors Course	SMART MANUFACTURING (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course objectives:

1. To apply knowledge of smart manufacturing systems' components in the context of Industry 4.0
2. To understand the concepts of smart machines and smart sensors
3. To understand and apply the concepts of IoT connectivity to Industry 4.0
4. To understand the concepts of Digital Twin and apply Machine Learning and Artificial Intelligence concepts in Manufacturing
5. To understand the concepts of Metaverse platform

UNIT – 1

Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.

UNIT – 2

Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Introduction to IoT, IIoT, and Cyber physical systems, Sensing for Manufacturing Process in IIoT, Block Diagram of an IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces,

UNIT – 3

IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

UNIT – 4

Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology

Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML.

UNIT – 5

Metaverse – Basic concepts, AR/VR, Social Metaverse, Industrial Metaverse, How Web 3.0 is changing the Internet, Asset Classes Inside the Metaverse, Land, Coins, Characters/ Avatars, Skins, Utility, Industries Disrupted by the Metaverse, Smart wearables,

TEXT BOOKS:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2. Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.
4. Aurélien Géron, Hands on Machine Learning with Scikit-Learn and TensorFlow [Concepts, Tools, and Techniques to Build Intelligent Systems], Published by O'Reilly Media, 2017.
5. Artificial Intelligence and Machine Learning, Principles and applications by Vinod Chandra S.S., Anand Hareendran S., PHI

REFERENCE BOOKS:

1. Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.
3. M.C. Trivedi, A Classical Approach to Artifical Intelligence, Khanna Publishing House,New Delhi, 2018.
4. S. Kaushik, Artificial Intelligence, Cengage Learning India, 2011.

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

CO1 Learn about smart manufacturing systems' components and can handle it more effectively in context of Industry 4.0
CO2 Learn about the smart machines and smart sensors
CO3 Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry
CO4 Learn about concepts of Digital Twin and able to apply Machine Learning and Artificial Intelligence concepts in Manufacturing
CO5 Learn the concepts of AR/VR and Metaverse platform

Minors Course	ROBOTICS (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objectives: To

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

UNIT – 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms -– requirements and challenges of end effectors, determination of the end effectors.

UNIT – 2

ROBOT ACTUATORS AND FEEDBACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric& stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT – 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion –Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/GrooverMP/Pearson Edu.
2. Robotics and Control /Mittal R K & Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, Prentice Hall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt. Ltd.

4. Introduction to Robotics/John JCraig/Pearson Edu.

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

CO1	Discuss various applications and components of industrial robot systems
CO2	Learn about the types of actuators used in robotics
CO3	Calculate the forward kinematics and inverse kinematics.
CO4	Learn about programming principles and languages for a robot control system
CO5	Discuss the applications of image processing and machine vision in robotics.

Minors Course	MANUFACTURING PROCESSES (Smart Manufacturing)	L	T	P	C
		3	0	0	3

Course Objective:
To impart basic knowledge and understanding about the primary manufacturing processes such as casting, welding, bulk forming, sheet metal forming, and additive manufacturing and their relevance in the current manufacturing industry.

UNIT – I
Casting: Steps involved in making a casting – Advantage of casting and its applications. Patterns and Pattern making – Types of patterns – Materials used for patterns, pattern allowances and their construction, Molding, different types of cores , Principles of Gating, Risers, casting design considerations. Methods of melting and types of furnaces, Solidification of castings and Casting defects. Basic principles and applications of special casting processes - Centrifugal casting – True, semi and centrifuging, Die casting, Investment casting and shell molding.

UNIT – II
Welding: Classification of welding processes, types of welded joints and their characteristics, Gas welding, Different types of flames and uses, Oxy – Acetylene Gas cutting. Basic principles of Arc welding, power characteristics, Manual metal arc welding, submerged arc welding, TIG & MIG welding. Electro – slag welding. Resistance welding, Friction welding, Friction stir welding, Forge welding, Explosive welding; Thermit welding, Plasma Arc welding, Laser welding, electron beam welding, Soldering & Brazing. Heat affected zones in welding; pre & post heating, Weldability of metals, welding defects – causes and remedies – destructive and nondestructive testing of welds.

UNIT – III
Bulk Forming: Plastic deformation in metals and alloys-recovery, recrystallization and grain growth.
Hot working and Cold working-Strain hardening and Annealing. Bulk forming processes: Forging - Types of Forging, Smith forging, Drop Forging, Roll forging, Forging hammers, Rotary forging, forging defects; Rolling – fundamentals, types of rolling mills and products, Forces in rolling and power requirements. Extrusion and its characteristics. Types of extrusion, Impact extrusion, Hydrostatic extrusion; Wire drawing and Tube drawing

UNIT – IV
Sheet metal forming - Blanking and piercing, Forces and power requirement in these operations, Deep drawing, Stretch forming, Bending, Spring back and its remedies, Coining, Spinning, Types of presses and press tools.
High energy rate forming processes: Principles of explosive forming, electromagnetic forming, Electro hydraulic forming, rubber pad forming, advantages and limitations.

UNIT -V

Additive manufacturing - Steps in Additive Manufacturing (AM), Classification of AM processes, Advantages of AM, and types of materials for AM, VAT photopolymerization AM Processes, Extrusion - Based AM Processes, Powder Bed Fusion AM Processes, Directed Energy Deposition AM Processes, Post Processing of AM Parts, Applications

TEXTBOOKS:

1. Manufacturing Processes for Engineering Materials – Kalpakjian S and StevenR Schmid- Pearson Publ , 5th Edn.
2. Manufacturing Technology -Vol I- P.N. Rao-TMH

REFERENCES:

3. Manufacturing Science – A.Ghosh &A.K.Malik – East West Press Pvt.Ltd
4. Process and materials of manufacture- Lindberg-PHI
5. Production Technology- R.K. Jain-Khanna
6. Production Technology-P C Sharma-S.Chand
7. Manufacturing Processes- H.S. Shaun-Pearson
8. Manufacturing Processes- J.P. Kaushish-PHI
9. Workshop Technology -WAJ Chapman/CBS Publishers & Distributors Pvt.Ltd.
10. Production Technology-HMT- Tata Mc Graw Hill
11. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015

Course Outcomes:

Students will be able to

CO1: design the patterns and core boxes for metal casting processes
CO2: understand the different welding processes
CO3: know the different types of bulk forming processes
CO4: understand sheet metal forming processes
CO5: learn about the different types of additive manufacturing processes.

Minors Course	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (Smart Manufacturing)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course objectives:

1) To impart the basic concepts of artificial intelligence and the
2) principles of knowledge representation and reasoning.
3) To introduce the machine learning concepts and supervised learning methods
4) To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
5) To make the students learn about neural networks and genetic algorithms.
6) To understand the machine learning analytics and deep learning techniques.

UNIT– I:
Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents.

Knowledge–Representation and Reasoning: Logical Agents: Knowledge-based agents, the Wumpus world, logic. Patterns in Propositional Logic, Inference in First-Order Logic- Propositional vs first order inference, unification.

UNIT– II:
Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, overfitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.

UNIT– III:
Unsupervised Learning: Clustering**,** K-means, Dimensionality Reduction, PCA and Kernel.
Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning- K-Nearest neighbour learning.

UNIT– IV:
Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and backpropagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.

UNIT– V:
Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.
Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model,

Minors Course	ARTIFICIAL INTELLIGENCE AND	L	T	P	C

Selection, Ensemble Methods - Boosting, Bagging, and Random Forests.

TEXT BOOKS:

1) Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2) Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3) Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCE BOOKS:

1) Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2) Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.

ONLINE RESOURCES:

https://www.tpointtech.com/artificial-intelligence-ai

https://www.geeksforgeeks.org/

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

CO1: Explain the basic concepts of artificial intelligence
CO2: Learn about the principles of supervised learning methods
CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms
CO4: Get knowledge about neural networks and genetic algorithms.
CO5: Understand the machine learning analytics and apply deep learning techniques.

	MACHINE LEARNING LAB (Smart Manufacturing)	**0**	**0**	**3**	**1.5**

Course Objectives: To enable the students write coding for various artificial intelligence and machine learning algorithms.

- Learning of Python libraries – Numpy, Pandas, Matplotlib, Seaborn and TensorFlow
- Numerical examples on Python libraries
- Data Preprocessing and data cleaning using Python
- Write a program for Linear regression
- Write a program for Logistic regression
- Write a program for ANN
- Write a program for CNN
- Write a program for RNN
- Write a program to build a Decision tree
- Write a program to build a Naïve Bayes classifier
- Write a program for SVM
- Write a program for Auto-encoder

Course Outcomes: Students at the end of the course will be able to
CO1: Learn various Python libraries.
CO2: Do programming for regression methods
CO3: Write coding for different types of neural networks
CO4: Write a program for decision tree, Naïve Bayes and SVM
CO4: Generate code for autoencoders

Course Outcomes: At the end of the course, student will be able to apply the knowledge of artificial intelligence and machine learning models along with image classifiers using various software tools.

Note: Databases can be taken from https://www.kaggle.com/datasets.

Course Objectives:

Minors Course	MECHATRONICS LAB (Smart Manufacturing)	L	T	P	C
		0	0	3	1.5

1) Measure load, displacement and temperature using analogue and digital sensors.
2) Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
3) Simulate and analyze PID controllers for a physical system using MATLAB.
4) Develop pneumatic and hydraulic circuits using Automation studio.

List of Experiments

1. Transducers Kit :-
a. Characteristics of LVDT
b. Principle & Characteristics of Strain Gauge
c. Characteristics of Summing Amplifier
d. Characteristics of Reflective Opto Transducer
2. PLC PROGRAMMING & Simulation of Allen Bradley, Siemens or IEC Ladder Using Automation Studio
a. Ladder programming on Logic gates ,Timers (TON,TOFF) &counters (UP,DOWN)
b. Ladder Programming for digital &Analogy sensors
c. Ladder programming & Simulations of Virtual System such as Traffic Light control, Washing machine, Garage Door, Water level control, Lift control, Conveyor Belt etc.
d. Ladder programming to control circuits such as single solenoid spring return latch circuit, double solenoid Hydraulic / Pneumatic circuits, Self-Reciprocating Hydraulic / Pneumatic Circuit.
3. AUTOMATION STUDIO SOFTWARE (Design, Simulate & Analyze)
a. Introduction to Automation studio & its control.
b.Draw & Simulate Hydraulic circuits for series &parallel cylinders connection, Accumulator circuit, Pressure intensifier circuit, Simple Electro- Hydraulic Electro - Pneumatic circuits (Plot Waveforms for different parameters).
c. Design & Simulate Meter-in, Meter-out, Regenerative circuit, sequencing circuit, traverse and feed hydraulic circuit, hydraulic press and clamping.
d. Position Control of Proportional Servo Valve Circuit using PID Feedback controller.
4. MATLAB Programming
a. Sample programs on Mat lab
b. Simulation and analysis of PID controller using SIMULINK

Course Outcomes: At the end of the course, student will be able to.
CO1: Understand the Characteristics of LVDT
CO2: Measure load, displacement and temperature using analogue and digital sensors.
CO3: Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts. CO4: Simulate and analyze PID controllers for a physical system using MATLAB.
CO4: Develop pneumatic and hydraulic circuits using Automaton studio.

Minors Course	THERMODYNAMICS (THERMAL SYSTEMS ENGINEERING)	L	T	P	C
		3	0	0	3

Course Objectives:

To impart the knowledge of the thermodynamic laws and principles so as to enable the student to prepare an energy audit of any mechanical system that exchange heat and work with the surroundings.

UNIT – I

Introduction: Basic Concepts : System, boundary, Surrounding, Universe, control volume, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process - Reversible, Quasi static & Irreversible Processes, cycle, Causes of Irreversibility. Energy in State and in Transition - Types, Work and Heat, Point and Path function.

Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Reference Points – Const. Volume gas Thermometer – Scales of Temperature.

UNIT – II

Joule's Experiments – First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system –Energy balance for closed systems-Specific heats- Internal energy, Enthalpy and Specific heats of Solids, liquids and Ideal gases, Some steady flow energy equation applied to Nozzle, Turbine, Compressor and heat exchanger devices, PMM-I.

UNIT III

Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM of Second kind, Carnot cycle and its specialties, Carnot's theorem, Thermodynamic scale of Temperature.

Clausius Inequality, Entropy, Principle of Entropy Increase, Availability and Irreversibility (Basic definitions) – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

UNIT IV

Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point and critical point, properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation, Property tables. Various Thermodynamic processes and energy Transfer – Steam Calorimetry.

UNIT – V

Ideal Gas equation of state- Compressibility factor- Van der Waals equation of state- Beattie- Bridgeman equation of state- Benedict-Webb-Rubin equation of state- Viral equation of state- compressibility charts – variable specific heats .

Mixtures of perfect Gases – Dalton's Law of partial pressure, Avogadro's Laws of additive volumes- Equivalent Gas constant and Molecular Internal Energy, Enthalpy, Specific Heat and Entropy of Mixture of Perfect Gases and Vapour.

Psychrometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, Saturated Air, Vapour pressure, Degree of saturation – Adiabatic Saturation , Carrier's Equation – Psychrometric chart.

TEXT BOOKS:

1. Engineering Thermodynamics, PK Nag 6th Edn , McGraw Hill.
2. Fundamentals of Thermodynamics – Sonntag, Borgnakke, Van Wylen, 6th Edn, Wiley

REFERENCES:

1. Thermodynamics by Prasanna Kumar, Pearson Publishers
2. Engineering Thermodynamics – Jones & Dugan PHI
3. Thermodynamics, an Engineering Approach, Yunus A Cenegel, Michael A Boles, 8th EdninSI Units, McGraw Hill.
4. Thermodynamics – J.P.Holman , McGrawHill
5. An Introduction to Thermodynamics - Y.V.C.Rao – Universities press.
6. Thermodynamics – W.Z.Black & J.G.Hartley, 3rd Edn Pearson Publ.
7. Engineering Thermodynamics – D.P.Misra, Cengage Publ.
8. Engineering Thermodynamics – P.Chattopadhyay – Oxford Higher Edn Publ.

COURSE OUTCOMES:

After undergoing the course the student is expected to learn
CO1: Basic concepts of thermodynamics
CO2: Laws of thermodynamics
CO3: Concept of entropy
CO4: Property evaluation of vapors and their depiction in tables and charts
CO5: Evaluation of properties of perfect gas mixtures.

Minors Course	THERMAL ENGINEERING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:

1) To give insight into basic principles of air standard cycles.
2) To impart knowledge about IC engines and Biolers
3) To make the students learn the working principles of steam nozzles, turbines and compressors
4) To impart the knowledge about the various types of compressors and gas turbines
5) To make the students gain insights about, rockets and jet propulsion and solar engineering.

UNIT– I

Air standard Cycles: Otto, diesel and dual cycles, its comparison, Brayton cycle

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT–II

I.C Engines: Classification - Working principles of SI and CI engines, Valve and Port Timing Diagrams, -Engine systems – Fuel, Carburettor, Fuel Injection System, Ignition, Cooling and Lubrication, principles of supercharging and turbocharging, Measurement, Testing and Performance.

Boilers : Principles of L.P & H.P boilers, mountings and accessories, Draught-induced and forced.

UNIT -III

Steam nozzles: Functions, applications, types, flow through nozzles, condition for maximum discharge, critical pressure ratio, criteria to decide nozzle shape, Wilson line.

Steam turbines: Classification – impulse turbine; velocity diagram, effect of friction, diagram efficiency, De-leval turbine - methods to reduce rotor speed, combined velocity diagram.

Reaction turbine: Principle of operation, velocity diagram, Parson's reaction turbine – condition for maximum efficiency.

Steam condensers: Classification, working principles of different types – vacuum efficiency and condenser efficiency.

UNIT -IV

Compressors: Classification, Reciprocating type - Principle, multi-stage compression, Rotary type – Lysholm compressor –principle and efficiency considerations.

Centrifugal Compressors: Principle, velocity and pressure variation, velocity diagrams.

Axial flow Compressors: Principle, pressure rise and efficiency calculations.

Gas Turbines: Simple gas turbine plant – ideal cycle, components –regeneration, inter cooling and reheating.

UNIT -V

Jet Propulsion: Principle, classification, t-s diagram - turbo jet engines – thermodynamic cycle, performance evaluation.

Rockets: Principle, solid and liquid propellant rocket engines.

Solar Engineering: Solar radiation, Solar collectors, PV cells, storage methods and applications

Text Books:

1.Thermal Engineering - Mahesh Rathore- McGraw Hill publishers
2. Heat Engineering /V.P Vasandani and D.S Kumar/Metropolitan Book Company, New Delhi.

References:

1.I.C. Engines - V. Ganesan- Tata McGraw Hill Publishers
2. Thermal Engineering-M.L.Mathur& Mehta/Jain bros. Publishers
3. Thermal Engineering-P.L.Ballaney/ Khanna publishers.
4. Thermal Engineering / RK Rajput/ Lakshmi Publications
5. Thermal Engineering-R.S Khurmi, &J S Gupta/S.Chand.

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

CO1: Explain the basic concepts of air standard cycles.
CO2: Get knowledge about IC Engines and Biolers.
CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.
CO4: Gain knowledge about the concepts of compressors and gas turbines.
CO5: Acquire insights about jet propulsion, rockets and solar engineering.

Minors Course	HEAT TRANSFER (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course objectives:

1) To gain knowledge about mechanism and modes of heat transfer.
2) To understand the concepts of conduction and convective heat transfer.
3) To gain knowledge about the forced and free convection.
4) To understand the concepts of heat transfer with phase change and condensation along with heat exchangers.
5) To gain knowledge about radiation mode of heat transfer.

UNIT– I:

Introduction: Modes and mechanisms of heat transfer – Basic laws of heat transfer – General discussion about applications of heat transfer.

Conduction Heat Transfer: Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer: Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature.

UNIT– II:

One Dimensional Transient Conduction Heat Transfer: Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

Convective Heat Transfer: Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations

UNIT– III:

Forced convection: External Flows: Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows: Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.

Free Convection: Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT– IV:

Heat Transfer with Phase Change: Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling

Condensation: Film wise and drop wise condensation –Nusselt's Theory of

Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations. **Heat Exchangers:** Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT– V:

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

Note: Heat transfer data book is allowed.

TEXT BOOKS:

1) Heat Transfer by HOLMAN, Tata McGraw-Hill.
2) Heat Transfer by P.K.Nag, TMH.

REFERENCE BOOKS:

1) Fundamentals of Heat Transfer by Incropera& Dewitt, John Wiley.
2) Fundamentals of Engineering, Heat& Mass Transfer by R.C.Sachdeva, NewAge.
3) Heat& Mass Transfer by Amit Pal – Pearson Publishers.
4) Heat Transfer by Ghoshadastidar, Oxford University press.
5) Heat Transfer by a Practical Approach, YunusCengel, Boles, TMH.
6) Engineering Heat and Mass Transfer by Sarit K. Das, DhanpatRai Pub.

Note: Heat and Mass transfer Data Book by C P Kothandaraman and Subrahmanyan is used to design and analyze various thermal processes and thermal equipment.

Course outcomes: At the end of the course, student will be able to CO1: Apply knowledge about mechanism and modes of heat transfer. CO2: Understand the concepts of conduction and convective heat transfer. CO3: Learn about forced and free convection.
CO4: Analyze the concepts of heat transfer with phase change and condensation along with heat exchangers.
CO5: Interpret the knowledge about radiation mode of heat transfer.

Minors Course	**REFRIGERATION&AIR-CONDITIONING (Thermal Systems Engineering)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1) To illustrate the operating cycles and different systems of refrigeration
2) To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
3) To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
4) To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
5) To describe different component of refrigeration and air conditioning systems

UNIT– I:

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT– II:

VAPOUR COMPRESSION REFRIGERATION SYSTEM & COMPONENTS: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures**,** multi stage vapour compression refrigeration.

UNIT– III:

REFRIGERANTS – Desirable properties – classification - refrigerants –green refrigerants - nomenclature – ozone depletion – global warming.

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH_3 – water system and Li Br –water (Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.

UNIT– IV:

INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF- problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature- comfort chart –comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT– V:

AIR CONDITIONING SYSTEMS: Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

TEXT BOOKS:

1. A Course in Refrigeration and Air conditioning / SC Arora &Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora / TMH.

REFERENCES:

1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration /Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH

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

CO1: Illustrate the operating cycles and different systems of refrigeration.

CO2: Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics

CO3: Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants.

CO4: Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.

CO5:Demonstrate different components of refrigeration and air conditioning systems.

Minors Course	POWER PLANT ENGINEERING (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course Objectives:

1) To understand the sources of energy and concepts of steam power plant.
2) To design of components of steam, gas and diesel power plants.
3) To explain the principles of hydro power plant and nuclear power station.
4) To apply the concepts of nuclear reactors and understand the operations of different power plants.
5) To understand the principles and concepts relevant to power plant instrumentation, control, economics and environmental considerations.

UNIT – I

Introduction to the sources of energy – resources and development of power in India.
STEAM POWER PLANT: Plant layout, working of different circuits, fuel handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems. Combustion: properties of coal – overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components,

UNIT – II

STEAM POWER PLANT: Combustion needs and draught system, cyclone furnace, design and Construction, dust collectors, cooling towers and heat rejection. Corrosion and feed water treatment. **INTERNAL COMBUSTION AND GAS TURBINE POWER PLANTS:**
DIESEL POWER PLANT: Plant layout with auxiliaries – fuel supply system, air starting equipment, super charging.
GAS TURBINE PLANT: Introduction – classification - construction – layout with auxiliaries, combined cycle power plants and comparison.

UNIT – III

HYDRO ELECTRIC POWER PLANT: Water power – hydrological cycle / flow measurement – drainage area characteristics – hydrographs – storage and pondage – classification of dams and spillways.
HYDRO PROJECTS AND PLANT: Classification – typical layouts – plant auxiliaries – plant operation pumped storage plants.
NUCLEAR POWER STATION: Nuclear fuel – breeding and fertile materials – nuclear reactor – reactor operation.

UNIT – IV

TYPES OF NUCLEAR REACTORS: Pressurized water reactor, boiling water reactor, sodium- graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding – radioactive waste disposal.

Minors Course	**FLUID MECHANICS (Thermal Systems Engineering)**	**L**	**T**	**P**	**C**

COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co-ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.

UNIT – V

POWER PLANT INSTRUMENTATION AND CONTROL: Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O_2 and CO_2 measurements, measurement of smoke and dust, measurement of moisture in carbon dioxide circuit, nuclear measurements, smart grids, power plant control room.

POWER PLANT ECONOMICS AND ENVIRONMENTAL CONSIDERATIONS: Capita cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment –pollutants and pollution standards – methods of pollution control.

TEXT BOOKS:

1. A course in Power Plant Engineering /Arora and Domkundwar/Dhanpatrai ; Co.
2. Power Plant Engineering /P.C.Sharma / S.K.Kataria Pub

REFERENCES:

1. Power Plant Engineering: P.K.Nag/ II Edition /TMH.
2. Power station Engineering – ElWakil / McGraw-Hill.
3. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers

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

CO1: Illustrate the functions of different components of steam power plant
CO2: Describe basic working principles, performance characteristics and components of gas turbine and diesel power plants
CO3: Illustrate basic working principles of hydroelectric power plants and analyze the importance of hydrological cycles, measurements and drainage characteristics
CO4: Learn about the principal components and types of nuclear reactors
CO5: Analyze the working of power plant instrumentation and estimate the economics of power plants

		3	0	0	3

Course Objectives:

1) To understand the general concepts of in viscid flow of incompressible fluids.
2) To apply the concepts of viscous flow.
3) To analyze the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
4) To understand fundamental concept of turbulence.
5) To illustrate the compressible fluid flow and supersonic wave drag

UNIT – I:

Introduction: Basics of Fluid Mechanics – Continuity Equation – Euler's Equation – Bernoulli's equation

Viscous Flow: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poiseuille flow, Couette flow with and without pressure gradient, Hagen Poiseuille flow

UNIT – II:

Boundary Layer Concepts: Prandtl contribution to real fluid flows – Prandtl boundary layer theory, Boundary layer thickness for flow over a flat plate – Blasius solution. Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.

UNIT – III:

Introduction to Turbulent Flow: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model - Universal Velocity Distribution Law - Van Driest Model – k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.

UNIT – IV:

nternal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy , Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State.

UNIT – V:

Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Rayleigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXT BOOKS:

1. Fluid Mechanics / L. Victor Streeter / TMH
2. Fluid Mechanics / Frank M. White / MGH

REFERENCES:

1. Fluid Mechanics and Machines/ Modi and Seth/Standard Book House
2. Fluid Mechanics/Cohen and Kundu/Elsevier/5th edition
3. Fluid Mechanics/Potter/Cengage Learning
4. Fluid Mechanics/William S Janna/CRC Press
5. Fluid Mechanics / Y.A Cengel and J.M Cimbala/MGH
6. Boundary Layer Theory/ Schlichting H /Springer Publications
7. Dynamics & Theory and Dynamics of Compressible Fluid Flow/ Shapiro.
8. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH
9. Fluid Mechanics / K.L Kumar /S Chand & Co.

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

CO 1: Understand the general concepts of in viscid flow of incompressible fluids. CO 2: Apply the concepts of viscous flow.

CO 3: Analyse the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.

CO 4: Understand fundamental concept of turbulence.

CO 5: Illustrate the compressible fluid flow and supersonic wave drag.

Minors Course	**AUTOMOBILE ENGINEERING (Thermal Systems Engineering)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

1.To study the advanced engine technologies
2.To learn various advanced combustion technologies and its benefits
3.To learn the methods of using low carbon fuels and its significance
4.To learn and understand the hybrid and electric vehicle configurations
5.To study the application of fuel cell technology in automotive

UNIT – I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT – II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT – III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT – IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward

UNIT – V: FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.

TEXT BOOKS:

1.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER

REFERENCES:

1.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3.Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

4.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
5.James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Course Outcomes*:* At the end of the course the students would be able to

1. Discuss the latest trends in engine technology
2. Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.
3. Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
4. Discuss the working and energy flow in various hybrid and electric configurations.
5. Analyzing the need for fuel cell technology in automotive applications.

Minors Course	COMPUTATIONAL FLUID DYNAMICS (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Develop an understanding of introductory concepts in computational fluid mechanics with emphasis on the numerical solution of ordinary and partial differential equations
- Able to find solution of ODEs by numerical integration; finite difference and finite volume methods for parabolic, elliptic, and hyperbolic PDEs (techniques for single and multi-dimensional problems); numerical linear algebra
- Able to implement and utilize various numerical methods and basic mathematical analysis for canonical problems in fluid mechanics.
- Able to understand formulation of 2D & 3D problems using FVM
- To get acquainted with the application of standard variational problems

UNIT – I:
INTRODUCTION:
Finite difference method, finite volume method, finite element method, governing equations a boundary conditions. Derivation of finite difference equations.
SOLUTION METHODS:
Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination.
UNIT – II:
PARABOLIC EQUATIONS:
Explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.
HYPERBOLIC EQUATIONS:
Explicit schemes and Von Neumann stability analysis, implicit schemes, multi-step methods, nonlinear problems, second order one-dimensional wave equations.
BURGERS EQUATIONS:
Explicit and implicit schemes, Runge-Kutta method.

UNIT – III:
FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS:
Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.
FORMULATIONS OF COMPRESSIBLE FLOWS:
Potential equation, Euler equations-Central schemes, Navier-stokes system of equations, boundary conditions, example problems..

UNIT – IV:
FINITE VOLUME METHOD:
Finite volume method via finite difference method, formulations for two and three-dimensional problems.

UNIT – V:
FINITE ELEMENT METHODS:

Introduction to Finite Element Methods, Finite Element Interpolation Functions, Linear Problems-Steady-State Problems – Standard Galerkin's Methods, Transient Problems – Generalized Galerkin's Methods, Example Problems.

TEXTBOOKS:

1. Computational fluid dynamics, T. J. Chung, Cambridge University press, 2002.

REFERENCE BOOKS:

1. Text book of fluid dynamics, Frank Chorlton, CBS Publishers &distributors, 1985.
2. Patankar, S. V., 2017, Numerical Heat Transfer and Fluid Flow, Special Indian ed., CRC Press.
3. Muralidhar K., and Sundararajan T. (Editors), 2017, Computational Fluid Flow and Heat Transfer, 2nd ed. tenth reprint, Narosa.
4. Anderson Jr., J. D., 2017, Computational Fluid Dynamics: The Basics with Applications, Indian ed., McGraw Hill Education.
5. Donea, J., and Huerta, A., 2003, Finite Element Methods for Flow Problems, John Wiley & Sons, Ltd.
6. Zienkiewicz, O. C, Nithiarasu, P., and Taylor, R. L, 2013, The Finite Element Method for Fluid Dynamics, 7th ed., Butterworth-Heinemann Ltd.

Minors Course	**HEAT TRANSFER LAB (Thermal Systems Engineering)**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

Course Outcome

CO1 Explain classification of PDEs and differential solutions and methods for parabolic and hyperbolic equations.
CO2 Explain basic principles and Derive governing equations of CFD
CO3 Apply finite differential method for incompressible viscous flow problems and compressible flow problems.
CO4 Apply finite volume formulations for two dimensional and three dimensional problems
CO5 Apply finite element methods for steady state and transient fluid flow problems

Course objectives:

1) To determine the heat transfer rate and coefficient.
2) To determine the thermal conductivity, efficiency and effectiveness.
3) To determine the emissivity and Stefan-Boltzman constant.
4) To determine critical heat flux and investigate Lambert's cosine law.
5) To experiment with Virtual labs and analyze conduction, HT coefficient.
6) To experiment with Virtual labs and investigate Lambert's laws.

PART-A

1. Determination of overall heat transfer co-efficient of a composite slab
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin
6. Determination of heat transfer coefficient in natural and forced convection
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan-Boltzmann constant.
10. Determination of heat transfer rate in drop and film wise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

PART-B

Virtual labs (https://mfts-iitg.vlabs.ac.in/) on

1) Conduction Analysis of a Single Material Slab
2) Conduction Analysis of a Single Material Sphere
3) Conduction Analysis of a Single Material Cylinder

4) Conduction Analysis of a Double Material Slab
5) Conduction Analysis of a Double Material Sphere
6) Conduction Analysis of Double Material Cylinder
7) To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and
   (ii) Counter flow heat exchanger
8) To investigate the Lambert's distance law.
9) To investigate the Lambert's direction law (cosine law).

Note: Virtual labs are only for learning purpose, and are not for external examination.

Course outcomes: *Students are expected to learn the concepts and to*

CO1: Determine the heat transfer rate and coefficient.
CO2: Determine the thermal conductivity, efficiency and effectiveness. CO3: Determine the emissivity and Stefan-Boltzman constant.
CO4: Determine critical heat flux and investigate Lambert's cosine law. CO5: Experiment with Virtual labs and analyse conduction, HT coefficient. CO6: Experiment with Virtual labs and investigate Lambert's laws.

Minors Course	**THERMAL ENGINEERING LAB (Thermal Systems Engineering)**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

Course objectives:

1) To demonstrate the characteristics of two stroke and four stroke compression and spark ignition engines.
2) To determine flash point, fire point, calorific value of different fuels using various apparatus.
3) To determine engine friction, heat balance test, volumetric efficiency, load test of petrol and diesel engines.
4) To demonstrate speed test, performance test and cooling temperature on petrol and diesel engines.
5) To demonstrate performance test and determine efficiency of air compressor.
6) To understand the principles through assembly and disassembly of 2/3 wheelers, 2/4 stroke engines, tractor, heavy duty engines and boilers and their mountings and accessories.

Experiments :

1. To determine the actual Valve Timing diagram of a four stroke Compression/Spark Ignition Engine.
2. To determine the actual Port Timing diagram of a two stroke Compression/Spark Ignition Engine.
3. Determination of Flash & Fire points of Liquid fuels / Lubricants using (i) Abels Apparatus; (ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Saybolt Viscometer and (ii) Redwood Viscometer.
5. Determination of Calorific value of Gaseous Fuels using Junkers Gas Calorimeter.
6. Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
7. Evaluation of Engine Friction by Motoring/Retardation Test on a Single Cylinder 4 Stroke Petrol/Diesel Engine.
8. To perform the Heat Balance Test on Single Cylinder four Stroke Petrol/Diesel Engine.
9. Determination of Air/Fuel Ratio and Volumetric Efficiency on a four Stroke Petrol/Diesel Engine.
10. To conduct a load test on a single cylinder Petrol/Diesel engine to study its performance under various loads.
11. To determine the optimum cooling temperature of a Petrol/Diesel engine.
12. To conduct economical speed test on a four stroke Petrol/Diesel engine.
13. To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.
14. To conduct a performance test on an air compressor and determine its different efficiencies.
15. Dis-assembly / assembly of different parts of two wheelers. 3 wheelers & 4 wheelers. Tractor & Heavy duty engines covering 2-stroke and 4 stroke, SI and CI engines. Study of Boilers with mountings and accessories.

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

CO1: Experiment with two stroke and four stroke compression and spark ignition engines for various characteristics.

CO2: Perceive flash point, fire point, calorific value of different fuels using various apparatus.

CO3: Perform engine friction, heat balance test, volumetric efficiency, load test of petrol and diesel engines.

CO4: Perform speed test, performance test and cooling temperature on petrol and diesel engines.

CO5: Utilize air compressor for its performance test and to determine efficiency.

CO6: Discuss the principles through assembly and disassembly of 2/3 wheelers, 2/4 stroke engines, tractor, heavy duty engines, boilers and their mountings and accessories.

HONORS

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

KAKINADA–533003, Andhra Pradesh, India

R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

Honors Course	**ADVANCED MECHANICS OF SOLIDS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

CO1 Learn about how to calculate stresses in the machine components and analyzing the failure modes.

CO2 Identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures

CO3 Calculate bending stresses in curved beams and beams subjected to non symmetrical bending

CO4 Compute torsional stresses in circular and non circular cross section members and multi walled thin walled tubes

CO5 Analyze contact stresses when two bodies are in contact.

UNIT – 1 Theories of stress and strain, Definition of stress at a point, stress notation, principal stresses, other properties, differential equations of motion of a deformable body, deformation of a deformable body, strain theory, principal strains, strain of a volume element, small displacement theory.

Stress –strain temperature relations, Elastic response of a solid, Hooke's Law, isotropic elasticity, Anisotropic elasticity, initiation of Yield, Yield criteria.

UNIT – 2 **Failure criteria:** Modes of failure, Failure criteria, Excessive deflections, Yield initiation, fracture, Progressive fracture, High Cycle fatigue for number of cycles $N > 10^6$, buckling.

Application of energy methods: Elastic deflections and statically indeterminate members and structures: Principle of stationary potential energy, Castiglione's theorem on deflections, Castiglione's theorem on deflections for linear load deflection relations, deflections of statically determinate structures.

UNIT – 3 **Unsymmetrical bending:** Bending stresses in Beams subjected to Nonsymmetrical bending; Deflection of straight beams due to nonsymmetrical bending.

Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors –Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.

UNIT – 4 **Torsion :** Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section ;Hollow thin wall torsion members ,Multiply connected Cross Section.

UNIT – 5 **Contact stresses:** Introduction; problem of determining contact stresses; Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Method of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular

area (Line contact), Loads normal to area; Stresses for two bodies in line contact, Normal and Tangent to contact area.

Text Books:

1.Advanced Mechanics of materials by Boresi& Sidebottom-Wiely International.
2. Theory of elasticity by Timoschenko S.P. and Goodier J.N. McGraw-Hill Publishers 3rd Edition
3. Advanced Mechanics of Solids, L.S Srinath

Reference Books:

1. Advanced strength of materials by Den Hortog J.P.
2. Theory of plates – Timoshenko.
3. Strength of materials & Theory of structures (Vol I & II) by B.C Punmia
4. Strength of materials by Sadhu singh

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

CO1 Able to calculate stresses in the machine components and analyzing the failure modes.

CO2 Able to identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures

CO3 Able to calculate bending stresses in curved beams and beams subjected to non symmetrical bending

CO4 Able to calculate torsional stresses in circular and non circular cross section members and multi walled thin walled tubes

CO5 Able to calculate and analyze contact stresses when two bodies are in contact.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA–533003, Andhra Pradesh, India
R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

Honors Course	**ADVANCED FINITE ELEMENT METHODS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

- Learn the methodology, applications and types of finite element method.
- Solve the problems of bars, trusses, beams and frames
- Solve plates and axisymmetric problems
- Learn about isoparametric formulation
- Solve the dynamic problems

UNIT 1 – **Formulation Techniques:** Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

UNIT 2 – **One-dimensional elements:** Bar, trusses, beams and frames, displacements, stresses and temperature effects.

UNIT 3 – **Two dimensional problems:** CST, LST, four noded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin.

UNIT 4 – **Isoparametric formulation:** Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test.

Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages.

UNIT 5 – **Introduction to Non-linear finite element Analysis** (Syllabus from Ref. 3)

Nonlinear Material Problems(Syllabus from Ref. 2)**:** Introduction ,General procedure for solutions of Non- linear Discrete Problems, Nonlinear Constitutive problems in solid mechanics. Non-linear elasticity, Plasticity.

Geometrically Non-linear problems(Syllabus from Ref. 2)**:** General considerations

TEXT BOOKS:

1. Chandrubatla & Belagondu, Finite element methods .
2. S.S. Rao ,The Finite Element Method in Engineering, Fifth Edition

REFERENCES:

1.J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994.
2. Zienckiwicz O.C. Finite Element Method, McGraw-Hill,Third Edition, 1977.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996.

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

CO1	Understand the methodology, applications and types of finite element method.
CO2	Solve the problems of bars, trusses, beams and frames using finite element method
CO3	Apply the finite element method to plates and axisymmetric problem
CO4	Understand the isoparametric formulation and requirements for convergence.
CO5	Solve the dynamic problems and learn about the commericial finite element packages.

Honors Course	**ADVANCED CAD**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

CO1 Write parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.

CO2 Learn about Bezier curve.

CO3 Know about B-Spline curve

CO4 Develop parametric representation of analytic and synthetic surfaces

CO5 Learn various schemes used for construction of solid models

UNIT – 1	**Introduction:** Definition, Explicit and implicit equations, parametric equations.
UNIT – 2	**Cubic Splines-1:** Algebraic and geometric form of cubic spline, tangent vectors, parametric space of a curve, blending functions, four point form, reparametrization, truncating and subdividing of curves. Graphic construction and interpretation, composite pc curves.
UNIT – 3	**Bezier Curves:** Bernstein basis, equations of Bezier curves, properties, derivatives. **B-Spline Curves:** B-Spline basis, equations, knot vectors, properties, and derivatives.
UNIT – 4	**Surfaces:** Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.
UNIT – 5	**Solids:** Tricubic solid, Algebraic and geometric form. **Solid modeling concepts:** Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem.

TEXT BOOKS:

1. CAD/CAM by Ibrahim Zeid, Tata McGraw Hill.
2. Elements of Computer Graphics by Roger & Adams Tata McGraw Hill.

REFERENCES:

1. Geometric Modeling by Micheal E. Mortenson, McGraw Hill Publishers
2. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.MallikarjunaRao, MMM Sarcar, PHI Publishers

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

CO1 Develop parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.

CO2 Develop equations for Bezier curve.

CO3 Develop equations for B-Spline curve

CO4 Develop parametric representation of analytic and synthetic surfaces

CO5 Understand and implement various schemes used for construction of solid models

Honors Course	**ADVANCED MANUFACTURING PROCESSESS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

- To learn the basic principle of advanced machining processes
- To know about the various additive manufacturing processes
- To understand the principles of coating and processing of ceramics.
- To get insights about processing of composites and nanomaterials
- To know the fabrication of microelectronic components.

UNIT – 1

ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT – 2

ADDITIVE MANUFACTURING: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.

UNIT – 3

SURFACE TREATMENT: Scope, Cleaners, Methods of cleaning, Surface coating types, Electro forming, Chemical vapour deposition, Physical vapour deposition, thermal spraying methods, Ion implantation, diffusion coating, ceramic and organic methods of coating, and cladding methods.

PROCESSING OF CERAMICS: Applications, characteristics, classification Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application.

UNIT – 4

PROCESSING OF COMPOSITES: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, processing methods for MMC, CMC, Polymer matrix composites.

PROCESSING OF NANOMATERIALS: Introduction, Top down Vs Bottom up techniques-Ball milling, Lithography, Plasma Arc Discharge, Pulsed Laser Deposition, Sputtering, Sol-Gel, Molecular beam Epitaxy.

UNIT – 5

FABRICATION OF MICROELECTRONIC DEVICES:

Crystal growth and wafer preparation, Film Deposition, oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, surface mount technology, Integrated circuit economics.

TEXT BOOKS:

1.Manufacturing Engineering and Technology*I*Kalpakijian / Adisson Wesley, 1995.
2.Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

REFERENCES:

1.Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold,
2.MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3.Advanced Machining Processes / V.K.Jain / Allied Publications.
4.Introduction to Manufacturing Processes / John A Schey*I*McGraw Hill.
5.Introduction to Nanoscience and Nano Technology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learning

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

CO1: Explain the working principle of various nonconventional machining processes and their applications.
CO2: Explain the working principles of additive manufacturing methods.
CO3: Understand various laser material processing techniques.
CO4: Gain on Advanced coating processes
CO5: Describe various fabrication methods for microelectronic devices

Honors Course	**ADVANCED FLUID MECHANICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

- Learn the principles of Inviscid flow of incompressible fluid flow
- Transform the physics of viscous fluid flow problems into its equivalent mathematical model.
- Solve laminar boundary layer problems for the flow over a flat plate.
- Solve fundamental problems of turbulent flows
- Understand principles and techniques for solving compressible flow problems.

UNIT -I:
INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerian descriptions of fluid motion, Path lines, Streamlines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three-dimensional continuity equation, Stream and Velocity potential functions, Condition for irrotationality, circulation & vorticity, accelerations in Cartesian systems, normal and tangential accelerations.

UNIT -II:
VISCOUS FLOW: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain cases: Plain Poiseuille flow, Couette flow with and without pressure gradient , Hagen Poiseuille flow.

UNIT -III:
BOUNDARY LAYER CONCEPTS : Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory, Boundary layer thickness for flow over a flat plate, Blasius solution – Approximate solutions, Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.

UNIT- IV:
INTRODUCTION TO TURBULENT FLOW: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model, Universal Velocity Distribution Law: Van Driest Model, k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.
INTERNAL FLOW: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

UNIT -V:
COMPRESSIBLE FLUID FLOW: Thermodynamic basics – Equations of continuity, Momentum and Energy, Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State, Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Raleigh Lines–

Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXT BOOKS:

1. L. Victor Steeter, Fluid Mechanics, 10th Edition, Tata McGraw-Hill, 1996.
2. Frank M. White, Fluid Mechanics, 8th Edition, McGraw-Hill Education, 2016.

REFERENCES:

1. Modi and Seth, Fluid Mechanics and Machines, Standard Book House
2. Pijush K. Kundu, Ira M. Cohen, and David R. Dowling, Fluid Mechanics, 5th Edition, Elsevier
3. David R. Dowling, Ira M. Cohen, and Pijush K. Kundu, Fluid Mechanics, 5th Edition, Cengage Learning, 2011
4. William S Janna, Fluid Mechanics, CRC Press, 3rd Edition, 2019
5. Y.A Cengel and J.M Cimbala, Fluid Mechanics, MGH, 4th Edition, 2018
6. Schlichting H, Boundary Layer Theory, Springer Publications, 9th Edition, 2017
7. Shapiro, Dynamics & Theory and Dynamics of Compressible Fluid Flow, 2nd Edition
8. William F. Hughes & John A. Brighton, Fluid Dynamics, TMH, 2nd Edition, 2018

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

CO1	Understand the principles of Inviscid flow of incompressible fluid flow
CO2	Develop the capability to transform the physics of viscous fluid flow problems into its equivalent mathematical model.
CO3	Attain the ability to solve laminar boundary layer problems for the flow over a flat plate.
CO4	Develop an ability to solve fundamental problems of turbulent flows
CO5	Understand principles and techniques for solving compressible flow problems.

Honors Course	**ADVANCED HEAT TRANSFER**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

- Transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.
- Solve external forced and natural convection problems using analytical methods
- Analyze internal forced convection problems using analytical methods.
- Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.
- Evaluate radiant energy exchange.

UNIT-I:
INTRODUCTION: Review of basic concepts of conduction. Method of formulation: lumped, differential and integral formulations. Initial and boundary conditions
TRANSIENT HEAT CONDUCTION:
Differential formulation of transient heat conduction problems with time independent boundary conditions in different geometries and their analytical solutions: method of separation of variables, method of Laplace transforms. Differential formulation of steady two-dimensional heat conduction problems in different geometries and their analytical solutions: method of separation of variables, method of superposition.

UNIT II:
CONVECTION: Review of basics concepts and different non-dimensional numbers; Three-dimensional differential energy equation in Cartesian and Cylindrical coordinates.
FORCED CONVECTION: External flow:
External laminar forced convection for flow over a semi-infinite flat plate; Integral and similarity solutions for different thermal boundary conditions; Viscous dissipation effects in laminar boundary layer flow over a semi-infinite flat plate.

UNIT III:
FORCED CONVECTION: Internal flow:
Internal laminar forced convection: exact solutions to solution for rectilinear flows, axisymmetric rectilinear flows, and axisymmetric torsional flows; Solution for fully developed flow through a pipe with different thermal boundary conditions, Flow in the thermal entrance region of a circular duct: Graetz solution for uniform velocity, Graetz solution for parabolic velocity profile.

UNIT IV:
FREE CONVECTION:
External laminar free convection: integral and similarity solutions for semi-infinite vertical plate with different thermal boundary conditions
HEAT EXCHANGERS: Classification, LMTD and NTU methods
UNIT V:
RADIATION:
Basic definitions, Radiant energy exchange between two differential area elements. Radiation shape factor: properties and algebra. Radiant energy exchange between two surfaces. Reradiating surfaces. Radiation Shield.
Radiant energy exchange in enclosures: enclosures composed of black and diffuse-grey

surfaces. Electrical network analogy. Radiation in participating media: Radiative heat transfer equation, Radiant energy exchange in presence of absorbing and transmitting media, radiant energy exchange in presence of transmitting, reflecting, and absorbing media.

TEXT BOOKS:

1. Myers, G.E., 1971, Analytical methods in conduction heat transfer, McGraw Hill, New York.
2. Kays, W. M. and Crawford, M. E., 2005, Convective Heat and Mass Transfer, 3rd ed., McGraw Hill.
3. Howell, J.R., Mengüc, M.P., Daun, K., and Siegel, R., 2020, Thermal radiation heat transfer, CRC press, New York.

REFERENCES:

1. Arpaci, V.S.,1966, Conduction heat transfer, Addison-Wesley,Reading, Massachusetts.
2. Janna, W.S., 2018, Engineering heat transfer, CRC press, Boca Raton.
3. Fundamentals of Heat and Mass Transfer,5th Ed. / Frank P. Incropera/John Wiley
4. Sparrow, E.M., 2018, Radiation heat transfer, Routledge, New York.
5. Modest, M.F., and Mazumder, S., 2021, Radiative heat transfer, Academic press, New York.
6. Introduction to Heat Transfer/SK Som/PHI
7. Oostuizen, P. H. and Naylor, D., 1999, Introduction to Convective Heat Transfer Analysis, International ed., McGraw Hill.
8. Kakac, S. Yener, Y., and Pramuanjaroenkij. A., 2014, Convective Heat Transfer, 3rd ed., CRC Press

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

CO1	Develop the capacity to transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.
CO2	Demonstrate the ability to solve external forced and natural convection problems using analytical methods.
CO3	Develop the ability to analyze internal forced convection problems using analytical methods.
CO4	Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.
CO5	Evaluate radiant energy exchange in the presence of a participating medium.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

Honors Course	**ADVANCED MECHANISMS AND ROBOTICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

- Find the degree of freedom of various mechanisms.
- Develop the Euler-Savary equations
- locate the relative roto centre
- Design the Freudenstein's equation
- Study the kinematics of different manipulators

UNIT – 1 **Advanced Kinematics of plane motion- I:** The Inflection circle; Euler – Savary Equation; Analytical and graphical determination of d_i; Bobillier's Construction; Collineastion axis ; Hartmann's Construction.

Advanced Kinematics of plane motion - II: Polode curvature; Hall's Equation; Polode curvature in the four bar mechanism; coupler motion; relative motion of the output and input links; Determination of the output angular acceleration and its Rate of change.

UNIT – 2 **Introduction to Synthesis-Graphical Methods - I:** The Four bar linkage; Guiding a body through Two distinct positions; Guiding a body through Three distinct positions; The Rotocenter triangle ; Guiding a body through Four distinct positions; Burmester's curve.

Introduction to Synthesis-Graphical Methods - II: Function generation-General discussion; Function generation: Overlay's method; Path generation: Roberts's theorem.

UNIT – 3 **Introduction to Synthesis - Analytical Methods:** Function Generation: Freudenstien's equation, Precision point approximation, Precision – derivative approximation; Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition; Method of components; Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link; Method of components.

UNIT – 4 **Manipulator Kinematics:** D-H transformation matrix ; Direct and Inverse kinematic analysis of Serial manipulators: Articulated, spherical & industrial robot manipulators- PUMA, SCARA,STANFORD ARM, MICROBOT

UNIT – 5 **Differential motions and Velocities:**

Introduction, differential relationship, Jacobian, differential motions of a frame-translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian.

TEXT BOOKS:

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms,McGraw-Hill,1962.
2. L.Sciavicco and B.Siciliano, Modelling and control of Robot manipulators, Second edition ,
Springer -Verlag,London,2000.
3. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines.
E.W.P.Publishers.

REFERENCES:

1. Allen S.Hall Jr., Kinematics and Linkage Design, PHI,1964.
2. J.E Shigley and J.J . Uicker Jr., Theory of Machines and Mechanisms , McGraw-Hill, 1995.
3. Joseph Duffy, Analysis of mechanisms and Robot manipulators, Edward Arnold,1980

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

CO1	Develop the mobility criteria and use the criteria to find the degree of freedom of various mechanisms.
CO2	Develop the Euler savary equations using Hartmanns construction to determine the centre of curvature
CO3	To locate the relative roto centre using the function generation approach for 2-positions and 3-positions scenarios.
CO4	Design the Freudenstein's equation to find the lengths of the links in a four bar mechanism
CO5	To study the kinematics of different manipulators in daily life applications

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

Honors Course	**OPTIMIZATION AND RELIABILITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To

- Understand the classical optimization techniques
- Learn numerical methods for optimization
- Get insights into genetic algorithm and its variants
- Know the applications of optimization in mechanical engineering
- Understand the concept of reliability

UNIT – 1 **CLASSICAL OPTIMIZATION TECHNIQUES:** Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – method of Lagrange multipliers, Kuhn-Tucker conditions, merits and demerits of classical optimization techniques.

UNIT – 2 **NUMERICAL METHODS FOR OPTIMIZATION:** Nelder Mead's Simplex search method, Gradient of a function, Steepest descent method, Newton's method, Pattern search methods, conjugate method, types of penalty methods for handling constraints, advantages of numerical methods.

UNIT – 3 **GENETIC ALGORITHM (GA) :** Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA,

GENETIC PROGRAMMING (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.

MULTI-OBJECTIVE GA: Pareto's analysis, Non-dominated front, multi – objective GA, Non-dominated sorted GA, convergence criterion, applications of multi-objective problems .

UNIT – 4 **APPLICATIONS OF OPTIMIZATION IN DESIGN AND MANUFACTURING SYSTEMS:** Some typical applications like optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model of a machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.

UNIT – 5 **RELIABILITY:** Concepts of Engineering Statistics, risk and reliability, probabilistic approach to design, reliability theory, design for reliability, numerical problems, hazard analysis.

TEXT BOOKS:

1. Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers
2. Engineering Optimization – S.S.Rao, New Age Publishers
3. Reliability Engineering by L.S.Srinath
4. Multi objective genetic algorithm by Kalyanmoy Deb, PHI Publishers.

REFERENCES:

1. Genetic algorithms in Search, Optimization, and Machine learning – D.E.Goldberg, Addison-Wesley Publishers
2. Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publishers
3. Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers
4. An Introduction to Reliability and Maintainability Engineering by CE Ebeling, Waveland Printers Inc., 2009
5. Reliability Theory and Practice by I Bazovsky, Dover Publications, 2013

Course Outcomes: Students will be able to

- Learn the classical optimization techniques
- Understand numerical methods for optimization
- Gain knowledge about genetic algorithm and its variants
- Solve the applications of optimization in mechanical engineering
- Design for reliability

Honors Course	MECHANISMS AND ROBOTICS LAB	L	T	P	C
		3	0	0	3

Course Objectives: To enable the students get practical knowledge about various mechanisms and robotic configurations

ROBOTICS LAB

1. To demonstrate Forward and inverse Kinematics of articulated robot
2. To program and perform the following operation by using an articulated robot.

- Pick and place operation
- To traverse given path (for arc welding)

KINEMATICS AND DYNAMICS OF MECHANISMS LABORATORY
Design the following mechanisms and simulate using CATIA Software /ADAMS Software

1. RRRR mechanism whose coupler curve will pass through 3 given point .
2. RRRR mechanism whose coupler will guide a straight line segment through at least three given positions .
3. RRRR mechanism whose input and output motion are coordinated at least three given positions.
4. RRRP mechanism whose coupler will guide a straight-line segment through at least three given positions.
5. RRRP mechanism whose input and output motion are coordinated at at least two given positions
6. RRRP mechanism whose input and output motion are coordinated at at least three given positions.
7. RRRR mechanism whose input and output motion are coordinated at at least two given positions.
8. RRRR mechanism whose coupler curve will pass through 4 given points.
9. RRRR mechanism whose coupler curve will pass through 3 given points

Honors Course	**ADVANCED MANUFACTURING PROCESSES LAB**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcomes: The students will be able to understand the kinematics and dynamics of a variety of mechanisms and robots.

Course Objectives: The students will acquire knowledge about the various manufacturing processes and also the advanced characterization of materials.

Experiments (Any 10 out of 16):

1) To prepare the cup/ hole shape from the given work piece using deep drawing press
2) study of cutting ratio/chip thickness ratio in orthogonal cutting with different materials
3) Determination of cutting Forces and roughness on machined surface in orthogonal cutting with different materials
4) Study of arc, and spot welding processes
5) Study of TIG, MIG welding and Friction stir welding processes
6) Study of sintered density and relative density of given samples using Archimedes principle
7) Study of simple parts in 3D printing
8) Study of MRR and roughness on Wire EDM
9) Estimation of particle size using top down approaches and image analyser.
10) To find the ultimate tensile strength of given specimen using UTM
11) To find the Vickers/ Rockwell hardness of given specimen using hardness tester
12) To find the wear rate of a given specimen using Pin-on Disc apparatus
13) Study of roughness on machines surfaces for different materials using abrasive flow finishing.
14) To find the fatigue strength of a given specimen using fatigue-testing machine
15) To find the crystallite size and miller indices planes of a given specimen using X-ray diffractometer.
16) Study of Raman/FTIR spectroscopy

Honors Course	**MODELLING AND SIMULATION OF MANUFACTURING SYSTEMS LAB**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

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

CO1	Perform different manufacturing operations such as joining and forming
CO2	Determine the chip thickness ratio, shear angle, cutting forces, temperatures and surface roughness of machined surface during orthogonal turning operation
CO3	Determine Green Density and sintering density of P/M samples
CO4	Produce simple parts using a 3D printing machine
CO5	Perform destructive testing methods of materials to determine Brinell, Vickers Micro hardness, Tensile strength, bending strength and wear resistance, Fatigue strength.
CO6	Demonstrate different characterization methods for bulk materials (polymers, ceramics, composites etc.) using XRD, spectroscopic methods – UV-Vis, FTIR, Raman, microscopic – optical, SEM etc.

Honors Course	**COMPUTATIONAL FLUID DYNAMICS LAB**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives: To make the students learn how to model various manufacturing processes using Finite Element software.

Students shall carry out the modeling and FE analysis of the following:

1. Casting processes - Study of Solidification, temperatures, Residual stresses, metallurgical phases etc.
2. Forging processes - Study of cold working and hot working processes for extrusion, drawing, rolling, etc.
3. Forming Processes – Study of blanking, bending, deep drawing, etc.
4. Welding Processes – Study of arc, spot, laser welding, etc

Course Outcomes: Students at the end of the course will get knowledge about the analysis of manufacturing processes using pertinent FE tools.

Course Objectives: To make the students learn about how to analyze real-life engineering applications using CFD methods using Python coding.

Using any Programming Language, code the following methods with an example:

1. Solution of 1-D parabolic equations
   Explicit (FTCS, DuFort-Frankel)
   Implicit (Laasonen)
2. Fin problem with insulated and Convective end
3. Couette Problem with and without pressure Gradient
4. Solution of Elliptic Equations
   With Point Gauss-Seidel method
   With Point Successive Over Relaxation Method
   ■ Examples: (i) Temperature Distribution over a rectangular plate with different Boundary conditions on the sides.
5. Solution of Parabolic Equations
6. Solution of Linear Hyperbolic Equations.
   Using upwind and Lax explicit methods
   Using BTCS and Crank-Nicolson implicit methods
   ■ Examples: Wave propagation at a high altitude
7. Solution of Nonlinear Hyperbolic Equations.
   Lax Method
   MacCormack Method
   ■ Examples: Shock Tube Problem ➢ Solution of Incompressible NSEs Vorticity-Stream function formulation
8. Primitive Variable Formulation
   ■ Examples:
   ● Lid Driven Cavity Problem
   ● Mass entering and leaving a square chamber

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

CO1	Develop codes for solution of algebraic and differential equations
CO2	Develop skills in the actual implementation of CFD methods with their own codes
CO3	Analyze real-life engineering applications with the help of CFD.
CO4	Design thermal engineering equipment using CFD
CO5	Design and analysis of Industrial components like pressure vessels

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B. Tech. – IV Year I Semester

S. No.	Category	Title	L	T	P	Credits
1	Professional Core	CAD/CAM	2	0	0	2
2	Management Course- II	Operations Research	2	0	0	2
3	Professional Core	CAD/CAM Lab	0	0	2	1
4	Professional Elective	Professional Elective-IV	3	0	0	3
5	Professional Elective	Professional Elective-V	3	0	0	3
6	Open Elective - III	1. Finite Element Methods 2. Introduction to Mechatronics 3. Product design and development 4. Advanced Materials 5. Introduction to Smart Manufacturing	3	0	0	3
7	Open Elective-IV	1. Optimization Techniques 2.Advanced Manufacturing Processes 3. Total Quality Management 4. Operations Management 5. Energy Auditing	3	0	0	3
8	Skill Enhancement Course	Mechatronics Lab	0	0	4	2
9	Audit Course	Constitution of India	2	0	0	-
	Internship	Evaluation of Industry Internship	-	-	-	2
Total			**18**	**0**	**06**	**21**

Professional Elective-IV

5. Mechatronics
6. Computational Fluid Dynamics
7. Functional Materials and Applications
8. Drives and Actuators for Robotics

Professional Elective-V

5. Hydrogen and Fuel Cell Technology
6. Smart Manufacturing
7. Autonomous Systems
8. Embedded Systems and Programming

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B.Tech. – IV Year II Semester

S.No.	Category	Title	L	T	P	Credits
1	PR	Internship and Project	**-**	**-**	**24**	**12**

IV Year I Semester	CAD/CAM	L	T	P	C
		2	0	0	2

Course Objectives: The student will acquire the knowledge

- Introduce fundamentals of CAD/CAM and computer graphics used in product design.
- Explain wireframe and surface modeling techniques with their applications.
- Provide understanding of solid modeling and basics of CNC part programming.
- Introduce group technology concepts and flexible manufacturing systems.
- Explain computer-integrated manufacturing systems and process planning strategies.

UNIT **CONTENTS**

UNIT – 1 **INTRODUCTION**: Fundamentals of CAD, CAM, Automation, design process, Application of computers for design, Benefits of CAD, Product Design and CAD- Comparison, benefits of using CAD in product design and product development cycle.
COMPUTER GRAPHICS: Raster scan graphics coordinate system, database structure for graphics modeling, transformation of geometry, 3D transformations, mathematics of projections.

UNIT – 2 **WIRE FRAME MODELING**: Definition, advantages, dis-advantages, wire frame entities- analytic entities and synthetic entities.
SURFACE MODELING: Definition, advantages, disadvantages, surface entities-analytic entities and synthetic entities.
SOLID MODELING: Definition, constructive solid geometry, advantages, modelling entities. Curve representation: Implicit and explicit forms of straight line, circle, ellipse, cubic spline and Bezier curve, differences between Bezier curve and, cubic spline curve and Introduction to Data exchange formats.

UNIT – 3 **PART PROGRAMMING:** NC, NC modes, NC elements, CNC machine tools and their applications, Parts and power transmission in CNC machine tools, features of Machining center, turning center, CNC Part Programming: fundamentals, manual part programming methods, Computer Aided Part Programming- APT language, simple problems in manual part programming and Computer Aided Part Programming. Direct Numerical Control, Adaptive Control.

UNIT – 4 **GROUP TECHNOLOGY:** Part family, coding and classification, Optiz and MICLASS classification system, benefits of group technology - production flow analysis, types and advantages.
FMS: Introduction, types of FMS, Equipment, Tool management systems, Layouts, FMS Control.

UNIT – 5 **COMPUTER INTEGRATED MANUFACTURING SYSTEMS:** Types of manufacturing systems, machine tools and related equipment, material handling systems, material requirement planning, MRP, Enterprise resource planning, computer control systems, human labor in manufacturing systems, CIMS

benefits, computer aided quality control, Computer aided processes planning – variant process planning and generative process planning-Implementation considerations.

TEXT BOOKS:

1. Automation, Production systems & Computer integrated Manufacturing/ M.P. Groover/Pearson Education
2. Mastering CAD / CAM / Ibrahim Zeid / McGraw-Hill

REFERENCES

1. CAD / CAM Principles and Applications/PN Rao / McGraw-Hill
2. Principles of Computer Aided Design and Manufacturing / Farid Amirouche / Pearson
3. Computer Numerical Control Concepts and programming / Warren S Seames / Thomson learning, Inc
4. Product manufacturing and cost estimation using CAD/CAE/ Kuang Hua Chang/Elsevier Publishers

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

CO1 Describe the role of CAD in design and apply geometric transformations in graphics.

CO2 Distinguish between modeling types and model basic wireframe and surface geometries.

CO3 Create solid models and generate simple CNC part programs using manual and APT methods.

CO4 Classify parts using coding systems and explain FMS layouts and control systems.

CO5 Describe components of CIMS and differentiate variant and generative process planning.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	OPERATIONS RESEARCH	L	T	P	C
		2	0	0	2

Course Objectives: The student will acquire the knowledge

- Introduce the fundamentals of operations research and linear programming techniques.
- Teach optimization in transportation, assignment, and sequencing problems.
- Explain models for replacement strategies and decision-making using game theory.
- Provide knowledge on queuing models and inventory control techniques.
- Introduce dynamic programming principles and simulation modeling.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION** - definition– characteristics and phases – types of operation research models – applications.
LINEAR PROGRAMMING: Linear programming problem formulation – graphical solution – simplex method – artificial variables techniques -two–phase method, big-M method – duality principle.

UNIT – 2 **TRANSPORTATION PROBLEM:** Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- travelling salesman problem.
SEQUENCING – Introduction – flow –shop sequencing – n jobs through two machines – n jobs through three machines – job shop sequencing – two jobs through 'm' machines.

UNIT – 3 **REPLACEMENT:** Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.
THEORY OF GAMES: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.

UNIT – 4 **QUEUEING THEORY:** Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel.
INVENTORY CONTROL : Introduction – single item – deterministic models – purchase inventory models with one price break and multiple price breaks – shortages are not allowed – stochastic models – demand may be discrete variable or continuous variable, Instantaneous demand and continuous demand and no set up cost. ABC & VED Analysis.

UNIT – 5 **DYNAMIC PROGRAMMING:** Introduction – Bellman's principle of optimality – shortest path problem.
SIMULATION: Definition – types of simulation models – phases of simulation– applications of simulation – inventory problems

Text Books:

1. Operations Research-An Introduction/Hamdy A Taha/Pearson publishers
2. Operations Research –Theory & publications / S.D.Sharma-Kedarnath/McMillan publishers India Ltd

References:

1. Introduction to O.R/Hiller & Libermann/TMH
2. Operations Research /A.M. Natarajan, P. Balasubramani, A. Tamilarasi /Pearson Education.
3. Operations Research: Methods & Problems / Maurice Saseini, ArhurYaspan& Lawrence Friedman/Wiley
4. Operations Research / R.Pannerselvam/ PHI Publications.
5. Operations Research / Wagner/ PHI Publications.
6. Operation Research /J.K.Sharma/MacMilan Publ.
7. Operations Research/ Pai/ Oxford Publications
8. Operations Research/S Kalavathy / Vikas Publishers
9. Operations Research / DS Cheema/University Science Press
10. Operations Research / Ravindran, Philips, Solberg / Wiley publishers

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

CO1 Formulate and solve linear programming problems using graphical and simplex methods.

CO2 Solve transportation, assignment, and sequencing problems for efficient operations.

CO3 Analyze replacement scenarios and determine optimal strategies using game theory.

CO4 Apply queuing theory and inventory models to optimize service and stock management.

CO5 Solve multistage decision problems and apply simulation to real-life systems.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	CAD/CAM LAB	L	T	P	C
		0	0	2	1

Course Objectives: The student will acquire the knowledge

- Introduce students to simulation-based analysis of structural, thermal, and vibrational behavior using FEA tools.
- Provide practical knowledge of CNC part programming for lathe and milling operations.
- Familiarize students with CAM software for automatic toolpath planning and G-code generation.
- Introduce the concepts and workflow of rapid prototyping using 3D printing machines.
- Enable students to simulate and visualize the 3D printing process through online virtual labs.

Note: Student shall perform at least three experiments from each section

CONTENTS

1. Experiments to determine stresses, deflection, natural frequencies, harmonic analysis, HT analysis and buckling analysis.
   a) Determination of deflection and stresses in 2D and 3D trusses and beams.
   b) Determination of principal and Von-mises stresses in plane stress, plane strain and axisymmetric components.
   c) Determination of stresses in 3D and shell structures (at least one example in each case)
   d) Estimation of natural frequencies and mode shapes, harmonic response of 2D beam.
   e) Steady state heat transfer analysis of plane and axisymmetric components.
   f) Buckling analysis

2. Study of CNC part programming fundamentals and write part programmes for simple components on CNC lathe and Mill and Study of RP machine.
   A. CNC part programming for turned components
      (i) Plain turning and facing
      (ii) Step Turning Operation
      (iii) Taper turning
   B. CNC programming for milled components
      (i) Circular interpolation
      (ii) End milling
      (iii) Pocket milling

3. Automated CNC Tool path and G-Code generation using CAM packages.

4. Study and demonstration of RP machine-creation of simple parts.

5. Virtual 3D Printing Simulation lab using Vlabs.

https://3dp-dei.vlabs.ac.in/List%20of%20experiments.html

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

CO1 Perform structural, thermal, and buckling analyses using FEA and interpret stress, deflection, and frequency results.

CO2 Develop and execute CNC part programs for basic lathe and milling operations.

CO3 Generate optimized CNC toolpaths and G-codes using CAM packages for given part geometries.

CO4 Create and demonstrate simple 3D models using RP machines.

CO5 Perform and analyze virtual 3D printing experiments using online simulation platforms.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	MECHATRONICS (Professional Elective-IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce the fundamentals, components, and sensor technologies in mechatronic systems.
- Familiarize students with solid-state devices and analog signal conditioning techniques.
- Provide understanding of fluid-based and mechanical actuation systems in automation.
- Introduce digital control systems, microcontrollers, and PLCs in mechatronic applications.
- Teach interfacing techniques, data acquisition, and digital signal processing in mechatronic systems.

UNIT **CONTENTS**

UNIT – 1 **MECHATRONICS SYSTEMS:** Elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

UNIT – 2 **SOLID STATE ELECTRONIC DEVICES:** PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering

UNIT – 3 **HYDRAULIC AND PNEUMATIC ACTUATING SYSTEMS:** Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

UNIT – 4 **DIGITAL ELECTRONICS AND SYSTEMS:** Digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

UNIT – 5 **SYSTEM AND INTERFACING AND DATA ACQUISITION:** Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

Text Books:

1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan& MS Balasundaram/WILEY India Edition

References:

2. Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford University Press
3. Mechatronics Source Book / Newton C Braga/Thomson Publications, Chennai.
4. Mechatronics – N. Shanmugam / Anuradha AgenciesPublishers.
5. Mechatronics System Design / Devdasshetty/Richard/Thomson.
6. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
7. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson,2012
8. Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indianprint

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

CO1 Explain the structure of mechatronic systems and identify various sensors used for measurement and control.

CO2 Describe the working of electronic devices and apply analog signal conditioning using operational amplifiers.

CO3 Analyze hydraulic, pneumatic, and electromechanical actuation systems and their components.

CO4 Develop basic control logic using microprocessors, microcontrollers, and PLCs.

CO5 Implement data acquisition, signal processing, and motor drive interfacing in a mechatronic setup.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	COMPUTATIONAL FLUID DYNAMICS (Professional Elective-IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce PDE classification, fundamental fluid flow equations, and basic numerical solution techniques.
- Explain dimensionless momentum and energy equations and finite difference applications in heat transfer.
- Introduce discretization methods, consistency, and stability in finite difference fluid flow modelling.
- Provide understanding of wave equation stability and finite volume method in CFD.
- Introduce FEM formulation and its application to 1D and 2D fluid flow and heat transfer problems.

UNIT CONTENTS

UNIT – 1 **CONSERVATION PRINCIPLES:** Introduction, conservation of mass, Newton's second law of motion, expanded forms of Navier-stokes equations (Derivation), conservation of energy principle, special forms of the Navier-stokes equations.

APPLIED NUMERICAL METHODS: Solution of a system of simultaneous linear algebraic equations, iterative schemes of matrix inversion, direct methods for matrix inversion, direct methods for banded matrices, TDMA – Algorithms.

UNIT – 2 **CONDUCTION AND CONVENTION:** Steady flow, dimensionless form of momentum and energy equations, stokes equation, conservative body force fields, stream function -vorticity formulation.

Finite difference applications in heat conduction and convention –heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer, closure.

UNIT – 3 **EXPLICIT AND IMPLICIT METHODS**: Finite differences, discretization, consistency, stability, and fundamentals of fluid flow modelling: introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods.

UNIT – 4 **INTRODUCTION TO FIRST ORDER WAVE EQUATION: S**tability of hyperbolic and elliptic equations, fundamentals of fluid flow modelling, conservative property, the upwind scheme.

FINITE VOLUME METHOD: Approximation of surface integrals, volume integrals, interpolation and differentiation practices, upwind interpolation, linear interpolation and quadratic interpolation.

UNIT – 5 **FINITE ELEMENT METHOD:** Introduction – Weighted Residual and Variational Formulations – Rayleigh-Ritz Method – Interpolation – One dimensional and Two dimensional regions – Error Control – Applications of FEM to One dimensional Problems (Steady and Transient) – Two dimensional problems

Text Books:

1. Numerical heat transfer and fluid flow/Suhas V. Patankar/Butter-worth Publishers
2. Computational fluid dynamics-Basics with applications/ John.D. Anderson/McGraw Hill.

References:

1. Computational Fluid Flow and Heat Transfer/ Niyogi/Pearson Publications
2. Introduction to CFD: Finite Volume Method – H. Versteeg and W. Malalasekahara
3. Fundamentals of Computational Fluid Dynamics /TapanK.Sengupta/Universities Press.
4. Computational fluid dynamics: An introduction, 3rd edition/John.F Wendt/Springer publishers

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

CO1 Derive governing equations of fluid flow and apply numerical methods like TDMA for solving linear systems.

CO2 Analyze steady/transient heat conduction and convective problems using finite difference techniques.

CO3 Apply finite difference methods and assess consistency and stability of numerical schemes.

CO4 Analyze stability and implement interpolation schemes using finite volume methods for fluid flow problems.

CO5 Solve fluid flow and heat transfer problems using FEM with appropriate interpolation and error control techniques.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	FUNCTIONAL MATERIALS AND APPLICATIONS (Professional Elective-IV)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The student will acquire the knowledge

- Introduce crystal structures, defects, and deformation mechanisms in materials.
- Explain electrical and magnetic behavior of materials using classical and quantum theories.
- Provide understanding of semiconductor physics and charge transport mechanisms.
- Explore optical behavior of materials and principles behind optoelectronic devices.
- Introduce quantum phenomena in nanomaterials and their application in electronics and photonics.

UNIT **CONTENTS**

UNIT – 1 **CRYSTALLOGRAPHY**: Crystal structures: BCC, FCC and HCP – directions and planes - linear and planar densities – crystal imperfections- edge and screw dislocations – grain and twin boundaries - Burgers vector and elastic strain energy- Slip systems, plastic deformation of materials - Polymorphism – phase changes.

UNIT – 2 **ELECTRICAL AND MAGNETIC PROPERTIES OF MATERIALS**: Classical free electron theory - Expression for electrical conductivity – Thermal conductivity, expression - Quantum free electron theory: Tunneling – degenerate states – Fermi- Dirac statistics – Density of energy states – Electron in periodic potential – Energy bands in solids – tight binding approximation - Electron effective mass – concept of hole. Magnetic materials: Dia, para and ferromagnetic effects – paramagnetism in the conduction electrons in metals – exchange interaction and ferromagnetism – quantum interference devices – GMR devices.

UNIT – 3 **SEMICONDUCTORS AND TRANSPORT PHYSICS**: Intrinsic Semiconductors – Energy band diagram – direct and indirect band gap semiconductors – Carrier concentration in intrinsic semiconductors – extrinsic semiconductors - Carrier concentration in N-type & P-type semiconductors – Variation of carrier concentration with temperature – Carrier transport in Semiconductors: Drift, mobility and diffusion – Hall effect and devices – Ohmic contacts – Schottky diode

UNIT – 4 **OPTICAL PROPERTIES OF MATERIALS**: Classification of optical materials – Optical processes in semiconductors: optical absorption and emission, charge injection and recombination, optical absorption, loss and gain. Optical processes in quantum wells – Optoelectronic devices: light detectors and solar cells – light emitting diode – laser diode - optical processes in organic semiconductor devices –excitonic state – Electro-optics and nonlinear optics: Modulators and switching devices – plasmonics.

UNIT – 5 **NANOELECTRONIC MATERIALS:** Quantum confinement – Quantum structures – quantum wells, wires and dots – Zener-Bloch oscillations – Resonant tunneling – quantum interference effects - mesoscopic structures - Single electron phenomena – Single electron Transistor. Semiconductor photonic structures – 1D, 2D and 3D photonic crystal. Active and passive optoelectronic devices – photo processes – spintronics – carbon nanotubes: Properties and applications.

TEXT BOOKS:

1. V.Raghavan. Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited, 2015.
2. S.O. Kasap, Principles of Electronic Materials and Devices, Mc-Graw Hill, 2018.
3. Jasprit Singh, Semiconductor Devices: Basic Principles, Wiley (India), 2007.
4. Jasprit Singh, Semiconductor Optoelectronics: Physics and Technology, Mc-Graw Hill India (2019)
5. G.W.Hanson. Fundamentals of Nanoelectronics. Pearson Education (Indian Edition), 2009.

REFERENCES:

1. R.Bala subramaniam, Callister's Materials Science and Engineering. Wiley (Indian Edition), 2014.
2. Wendelin Wright and Donald Askeland, Essentials of Materials Science and Engineering, CL Engineering, 2013.
3. Robert F.Pierret, Semiconductor Device Fundamentals, Pearson, 2006
4. Pallab Bhattacharya, Semiconductor Optoelectronic Devices, Pearson, 2017
5. Ben Rogers, Jesse Adams and Sumita Pennathur, Nanotechnology: Understanding Small Systems, CRC Press, 2017.

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

CO1 Explain crystal geometries, imperfections, and their influence on material deformation and phase changes.
CO2 Analyze electrical conductivity, energy bands, and magnetic properties of different materials.
CO3 Calculate carrier concentration, mobility, and analyze transport phenomena in intrinsic and extrinsic semiconductors.
CO4 Explain optical transitions, recombination processes, and working of optoelectronic and nonlinear optical devices.
CO5 Describe quantum confinement, nanostructures, and emerging nano electronic and spintronic devices.

IV Year I Semester	DRIVES AND ACTUATORS FOR ROBOTICS (Professional Elective-IV)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The student will acquire the knowledge

- Introduce switching devices and their characteristics for motor control applications.
- Understand the dynamic behavior and performance characteristics of electric drives.
- Provide knowledge of DC motors, their characteristics, and drive configurations.
- Explain various control methods used in three-phase induction motor drives.
- Introduce stepper, servo, and BLDC motors and their applications in automation.

UNIT CONTENTS

UNIT – 1 **RELAY AND POWER SEMI-CONDUCTOR DEVICES**: Study of Switching Devices – Relay and Types, Switching characteristics -BJT, SCR, TRIAC, GTO, MOSFET, IGBT and IGCT-: SCR, MOSFET and IGBT - Triggering and commutation circuit - Introduction to Driver and snubber circuits

UNIT – 2 **DRIVE CHARACTERISTICS**: Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, torque, and Direction starting & stopping – Selection of motor

UNIT – 3 **DC MOTORS AND DRIVES**: DC Servomotor - Types of PMDC & BLDC motors - principle of operation- emf and torque equations - characteristics and control – Drives- H bridge - Single and Three Phases – 4 quadrant operation – Applications

UNIT – 4 **AC MOTORS AND DRIVES**: Introduction – Induction motor drives – Speed control of 3-phase induction motor – Stator voltage control – Stator frequency control – Stator voltage and frequency control – Stator current control – Static rotor resistance control – Slip power recovery control.

UNIT – 5 **STEPPER AND SERVO MOTOR**: Stepper Motor: Classifications-Construction and Principle of Operation – Modes of Excitation Drive System-Logic Sequencer - Applications. Servo Mechanism – DC Servo motor-AC Servo motor – Applications.

TEXT BOOKS:

1. Bimbhra B.S., "Power Electronics", 5th Edition, Kanna Publishers, New Delhi, 2012.
2. Mehta V.K. & Rohit Mehta, "Principles of Electrical Machines", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2016.

REFERENCES

1. Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosal Publishing House, New Delhi, 2001.
2. Theraja B.L. &Theraja A.K., "A Text Book of Electrical Technology", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2012.
3. Singh M.D. &Kanchandhani K.B., "Power Electronics", McGraw Hill, New Delhi, 2007

COURSE OUTCOMES: At the end of the course, the student able to

CO1 Explain the working, triggering, and protection of relays, SCRs, MOSFETs, IGBTs, and associated circuits.

CO2 Analyze motor-load dynamics and select suitable motors based on drive requirements.

CO3 Explain DC motor operation and implement single/three-phase drives with H-bridge control.

CO4 Apply different speed control techniques to three-phase induction motors using AC drives.

CO5 Describe construction, operation, and control methods of stepper, servo, and BLDC motors.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	HYDROGEN AND FUEL CELL TECHNOLOGY (Professional Elective-V)	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce the fundamental concepts of hydrogen as an energy carrier and its role in a sustainable energy system.
- To provide comprehensive knowledge on various hydrogen production technologies.
- To impart understanding of hydrogen storage technologies and associated challenges.
- To explore various applications of hydrogen in energy conversion devices and engines.
- To explain the principles, types, and performance characteristics of fuel cells.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION OF HYDROGEN ENERGY SYSTEMS:** Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing, utilization, safety and hydrogen production plants.

UNIT – 2 **HYDROGEN PRODUCTION PROCESSES**: Thermal-Steam reformation, thermo chemical water splitting, gasification-pyrolysis, nuclear thermal catalytic and partial oxidation methods, Electrochemical-Electrolysis, photo electro chemical, Biological-Anaerobic digestion, fermentation micro-organism, PM based electrolyser.

UNIT – 3 **HYDROGEN STORAGE:** Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage.

UNIT – 4 **HYDROGEN UTILIZATION:** Overview of hydrogen utilization, IC Engines, gas turbines, hydrogen burners, power plant, domestic cooking gas, marine applications, hydrogen dual fuel engines.

UNIT – 5 **FUEL CELLS:** History – principle - working - thermodynamics and kinetics of fuel cell process –performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, microbial fuel cells, relative merits and demerits and application of fuel cells.

Text Books:

1. Sorenson B, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorenson, Academic Press (2005).
2. Hordeski MF, Hydrogen and Fuel Cells: Advances in Transportation and Power, The Fairmont Press, Inc. (2009)
3. Busby RL, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Books (2005).

Course Outcomes (COs):

CO1: Understand the properties of hydrogen as a fuel and describe the infrastructure requirements for its production, storage, and utilization.

CO2: Analyze various hydrogen production methods including thermal, electrochemical, and biological processes.

CO3: Evaluate different hydrogen storage technologies such as compressed, cryogenic, and solid-state systems with their respective merits and challenges.

CO4: Examine the applications of hydrogen in IC engines, power generation, domestic usage, and hybrid fuel systems.

CO5: Understand the working principles, types, performance, and applications of various fuel cells and distinguish them from conventional batteries.

IV Year I Semester	SMART MANUFACTURING (Professional Elective-V)	L	T	P	C
		3	0	0	3

Course Objectives to:

- Introduce the key concepts, characteristics, and challenges of smart and circular manufacturing.
- Explain the role and architecture of smart machines and sensors in industrial environments.
- Provide an understanding of CPS design and the 5C architecture in smart factories.
- Introduce digital twin technology and the use of AI and ML in smart manufacturing.
- Explore IoT communication protocols and connectivity infrastructure for industrial automation.

CONTENTS

UNIT – 1 **CONCEPTS OF SMART MANUFACTURING:** Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Overview of circular manufacturing, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, Industry 5.0, and their benefits

UNIT – 2 **SMART MACHINES AND SMART SENSORS:** Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Sensing for Manufacturing Process in IIoT, Block Diagram of a IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces

UNIT – 3 **ARCHITECTURE OF CYBER-PHYSICAL SYSTEM (CPS):** Functions of CPS, 5C Architecture; Smart Connection Level, Data-to- Information Level, Cyber Level, Cognition Level, Configuration Level. Design of PHM based CPS systems. Comparison of today's factory and Industry 4.0 factory by the implementation of 5C CPS architecture

UNIT – 4 **DIGITAL TWIN:** Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology, Multiverse and AR and VR.
MACHINE LEARNING (ML) AND ARTIFICIAL INTELLIGENCE (AI) IN MANUFACTURING: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML, Application of AI and ML for predictive maintenance.

UNIT – 5 **IOT CONNECTIVITY FOR INDUSTRY 4.0:** Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols.

Text Books:

1. Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist, Apress
2. Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer

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

CO1 Explain the evolution, stages, and benefits of smart manufacturing, Industry 4.0 and Industry 5.0.

CO2 Identify and describe smart sensors, subsystems, and interfaces used in IIoT-based manufacturing.

CO3 Analyze CPS functions and compare traditional manufacturing with Industry 4.0 CPS-based systems.

CO4 Explain digital twin implementation and apply AI/ML concepts for predictive maintenance in manufacturing.

CO5 Understand and differentiate IoT network layers and protocols used in Industry 4.0 applications.

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IV Year I Semester	AUTONOMOUS SYSTEMS (Professional Elective-V)	L	T	P	C
		3	0	0	3

Course Objectives to:

- Introduce the concepts of intelligent agents and multi-agent systems in the context of autonomous systems.
- Provide an understanding of the architectural design and autonomy levels in unmanned systems like AGVs, AUVs, and drones.
- Equip students with knowledge of modelling and control techniques for different types of unmanned ground, aerial, and underwater vehicles.
- Familiarize students with various sensors, actuators, and computing platforms used in autonomous systems.
- Develop a foundational understanding of aerial robot flight concepts, control strategies, motion planning, and communication protocols.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION TO AGENT SYSTEMS:** Introduction to Agents, Agent Architectures, and Multi-agent Systems and Society of Agents, Distributed Problem Solving and Planning, Case Study: Collaborative Robotics, Robocup

UNIT – 2 **ARCHITECTURE OF AUTONOMOUS SYSTEMS:** Degree of Autonomy, Reactive Systems, Real-time Systems, Architecture of AGV's , AUV , Drones, Tele-Operation, AR, VR applications

UNIT – 3 **CLASSIFICATION, MODELLING, AND CONTROL ASPECTS OF UNMANNED VEHICLES:** Different types of unmanned vehicles: ground (wheeled and legged), aerial (fixed, flapping, and rotary wings), underwater vehicles , Modelling of unmanned vehicles considering basic forces, kinematics, and dynamics, Discussion on different types of control for aerial, underwater (fins and propulsion control), ground (biped and quadruped motion control for legged robots)

UNIT – 4 **SENSORS AND ACTUATORS:** Types of sensors used in unmanned vehicles (proximity, IMU, magnetometers, thermal imaging, vision, LiDAR, GPS, RTK, etc.) and their characteristics, Sensor data aggregation, processing, and sensor fusion, Introduction to popular computing platforms for data processing, Types of actuators: motors, servos, harmonic drive, linear actuators

UNIT – 5 **FLIGHT CONCEPTS:** Basic Aerial Robot Flight Concepts, Micro-aerial vehicle, Frame Rotations and Representations, Aerial robots equations of motion, State-Space Form, Time, Motion, and Trajectories, Linearization, 2-D and 3-D control of Aerial robots, PID Control, LQR control, Motion planning, Collision-free Navigation, Sensing and Estimation, Vision-based Guidance for aerial robots, Introduction to Communication and Networking Protocols.

Text books:

1. Roland Siegwart, Illah Reza Nourbakhsh, DavideScaramuzza(2018),
2. Introduction to autonomous mobile robots, MIT press. 2. Gerhard Weiss ed. (2013), Multiagent System, Second Edition, MIT Press
3. C. Venkatesan, (2014), Fundamentals of Helicopter Dynamics, 1st Edition, CRC Press 2. John D. Anderson, (2015), Introduction to Flight, 8th Edition, McGraw-Hill Education

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1: Understand the structure and functioning of intelligent agents and multi-agent systems for collaborative autonomous tasks.

CO2: Analyze and differentiate the architectural features and levels of autonomy in ground, aerial, and underwater autonomous systems.

CO3: Model and apply control techniques to different types of unmanned vehicles considering dynam ics and motion constraints.

CO4: Identify and evaluate suitable sensors and actuators used in autonomous systems, and implement basic sensor fusion techniques.

CO5: Apply control algorithms and motion planning strategies for aerial robots including trajectory tracking, guidance, and navigation.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	EMBEDDED SYSTEMS AND PROGRAMMING (Professional Elective-IV)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The students will acquire the knowledge:

- Introduce microcontrollers, their architecture, instruction sets, and memory organization.
- Develop programming skills in assembly and embedded C with communication interfaces.
- Teach interfacing of microcontrollers with external peripherals and actuators.
- Introduce ARM architecture, instruction sets, and its basic programming.
- Explain system-on-chip architecture and embedded programming using Python on SBCs.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION TO MICROCONTROLLER**: Fundamentals Functions of ALU - Microprocessor - Microcontrollers – CISC and RISC – Types Microcontroller - 8051 Family - Architecture - Features and Specifications - Memory Organization - Instruction Sets – Addressing Modes.

UNIT – 2 **PROGRAMMING AND COMMUNICATION**: Fundamentals of Assembly Language Programming – Instruction to Assembler – Compiler and IDE - C Programming for 8051 Microcontroller – Basic Arithmetic and Logical Programming - Timer and Counter - Interrupts – Interfacing and Programming of Serial Communication, I2C, SPI and CAN of 8051 Microcontroller – Bluetooth and WI-FI interfacing of 8051 Microcontroller.

UNIT – 3 **PERIPHERAL INTERFACING:** I/O Programming – Interfacing of Memory, Key Board and Displays – Alphanumeric and Graphic, RTC, interfacing of ADC and DAC, Sensors - Relays - Solenoid Valve and Heater - Stepper Motors, DC Motors - PWM Programming – Closed Loop Control Programming of Servomotor – Traffic Light

UNIT – 4 **ARM PROCESSOR:** Introduction ARM 7 Processor - Internal Architecture – Modes of Operations – Register Set – Instruction Sets – ARM Thumb - Thumb State Registers – Pipelining – basic programming of ARM 7 - Applications.

UNIT – 5 **SINGLE BOARD COMPUTERS AND PROGRAMMING**: System on Chip - Broadcom BCM2711 SoC – SBC architecture - Models and Languages – Embedded Design – Real Time Embedded Operating Systems - Real Time Programming Languages -– Python for Embedded Systems- GPIO Programming – Interfacing

TEXT BOOKS:

1. Frank Vahid and Tony Givagis, “Embedded System Design”, 2011, Wiley.
2. Kenneth J. Aylala, “The 8051 Microcontroller, the Architecture and Programming Applications”, 2003.

REFERENCES:

1. Muhammad Ali Mazidi and Janice GillispicMazdi, “The 8051 Microcontroller and Embedded Systems”, Pearson Education, 2006.
2. Simon Monk, Programming the Raspberry Pi, Second Edition: Getting Started with Python McGraw Hill TAB; 2nd edition,2015
3. James W. Stewart, “The 8051 Microcontroller Hardware, Software and Interfacing”, Regents Prentice Hall, 2003.
4. John B. Peatman, “Design with Microcontrollers”, McGraw Hill International, USA, 2005.

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

CO1 Explain 8051 architecture, instruction formats, addressing modes, and memory organization.

CO2 Write programs in assembly/C for 8051 and interface serial/I2C/SPI/CAN, Bluetooth, and Wi-Fi modules.

CO3 Interface 8051 with memory, displays, motors, sensors, and write closed-loop control programs.

CO4 Describe ARM7 architecture and write basic programs using ARM instruction sets.

CO5 Apply GPIO programming and interface peripherals using Python on single-board computers.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	FINITE ELEMENT METHODS (Open Elective – III)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce fundamentals of FEM including stress-strain relations and variational methods.
- Teach weighted residual methods and energy principles for solving 1D problems.
- Introduce bar element formulation and discretization techniques in FEM.
- Teach 2D finite element modeling using CST and rectangular elements.
- Introduce higher order and iso-parametric elements with natural coordinates and numerical integration.

UNIT **CONTENTS**

UNIT – 1 **VARIATIONAL METHODS:** Introduction to finite element method, stress and equilibrium, strain –displacement relations, stress–strain relations, plane stress and plane strain conditions, variational methods.

UNIT – 2 **WEIGHTED RESIDUAL METHODS:** solving differential equations using weighted residual methods, concept of potential energy, one dimensional problems.

UNIT – 3 **1D-ELEMENTS:** Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

UNIT – 4 **2D- ELEMENTS:** Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions.
Finite element modeling of four noded rectangular element.

UNIT – 5 **HIGHER ORDER AND ISO-PARAMETRIC ELEMENTS:** One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

Text Books:

1. The Finite Element Methods in Engineering /SSRao/Pergamon.

References:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho& Shah /Pearson publishers
2. An introduction to Finite Element Method /JNReddy/McGrawHill
3. The Finite Element Method for Engineers–KennethH.Huebner, Donald L. Dewhirst,

Douglas E. Smith and TedG. Byrom/John Wiley & sons (ASIA)PteLtd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education
5. Finite Element Methods / Chen
6. Finite Element Analysis: for students & Practicing Engineers / G.LakshmiNarasaiah / BSP Books Pvt. Ltd.

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

CO1 Explain stress-strain relations and apply variational methods in FEM formulations.

CO2 Apply weighted residual methods and potential energy principles to 1D FEM problems.

CO3 Formulate bar element stiffness matrix and perform mesh generation with appropriate boundary conditions.

CO4 Model 2D stress problems using CST and four-node rectangular elements with boundary conditions.

CO5 Apply quadratic, cubic, and iso-parametric elements using numerical integration in FEM.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	INTRODUCTION TO MECHATRONICS (Open Elective - III)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce mechatronics systems, their components, and various sensors used for measurement.
- Explain solid-state devices and analog signal conditioning using op-amps.
- Explore fluid power and mechanical actuation systems with their control mechanisms.
- Teach digital electronics, microcontrollers, and PLC-based control systems.
- Introduce data acquisition, digital signal processing, and mechatronic system design.

UNIT	CONTENTS
UNIT – 1	**MECHATRONICS SYSTEMS**: Elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.
UNIT – 2	**SOLID STATE ELECTRONIC DEVICES:** PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering
UNIT – 3	**HYDRAULIC AND PNEUMATIC ACTUATING SYSTEMS:** Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.
UNIT – 4	**DIGITAL ELECTRONICS AND SYSTEMS:** Digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.
UNIT – 5	**SYSTEM AND INTERFACING AND DATA ACQUISITION:** Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

Text Books:

1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan& MS Balasundaram/WILEY India Edition

References:

1. Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford University Press
2. Mechatronics Source Book / Newton C Braga/ThomsonPublications, Chennai.
3. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
4. Mechatronics System Design / Devdas shetty/Richard/Thomson.
5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson,2012
7. Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indianprint

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

CO1 Identify components of mechatronics systems and explain working principles of various sensors.

CO2 Analyze characteristics of electronic devices and apply signal conditioning techniques.

CO3 Describe operation of hydraulic, pneumatic, and mechanical actuating systems.

CO4 Develop basic logic control systems using microcontrollers and PLCs.

CO5 Design basic mechatronic systems incorporating data acquisition and interfacing techniques.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	PRODUCT DESIGN AND DEVELOPMENT (Open Elective - III)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The student will acquire the knowledge

- Introduce fundamental tools, standards, and practices in product design, engineering drawings, BOM, and project management.
- Familiarize students with global material standards, manufacturing processes, and product analysis tools.
- Teach the structured approach to product design from RFQ to initial sample submission with relevant documentation.
- Emphasize quality testing, customer validation, and risk assessment in new product qualification.
- Highlight the importance of standardized reporting, prototyping, reverse engineering, and concurrent engineering in NPD.

UNIT **CONTENTS**

UNIT – 1 **FUNDAMENTALS OF PRODUCT DESIGN AND DEVELOPMENT**: Introduction – Reading of Drawing – Grid reading, Revisions, ECN (Engg. Change Note), Component material grade, Specifications, customer specific requirements – Basics of monitoring of NPD applying Gantt chart, Critical path analysis – Fundamentals of BOM (Bill of Materials), Engg. BOM & Manufacturing BOM. Basics of MIS software and their application in industries like SAP, MS Dynamics, Oracle ERP Cloud – QFD.

UNIT – 2 **MATERIAL SPECIFICATIONS, ANALYSIS & PROCESS**: Material specification standards – ISO, DIN, JIS, ASTM, EN, etc. – Awareness on various manufacturing process like Metal castings & Forming, Machining (Conventional, 3 Axis, 4 Axis, 5 Axis,), Fabrications, Welding process. Qualifications of parts mechanical, physical & Chemical properties and their test report preparation and submission. Fundamentals of DFMEA & PFMEA, Fundamentals of FEA, Bend Analysis, Hot Distortion, Metal and Material Flow, Fill and Solidification analysis.

UNIT – 3 **ESSENTIALS OF PRODUCT DESIGN AND DEVELOPMENT**: RFQ (Request of Quotation) Processing – Feasibility Studies & reporting – CFT (Cross Function Team) discussion on new product and reporting – Concept design, Machine selection for tool making, Machining – Manufacturing Process selection, Machining Planning, cutting tool selection – Various Inspection methods – Manual measuring, CMM – GOM (Geometric Optical Measuring), Lay out marking and Cut section analysis. Tool Design and Detail drawings preparation, release of details to machine shop and CAM programing. Tool assembly and shop floor trials. Initial sample submission with PPAP documents.

UNIT – 4 **CRITERIONS OF PRODUCT DESIGN AND DEVELOPMENT**: New product qualification for Dimensions, Mechanical & Physical Properties, Internal Soundness proving through X-Ray, Radiography, Ultrasonic Testing, MPT, etc. Agreement with customer for testing frequencies. Market Survey on

similar products, Risk analysis, validating samples with simulation results, Lesson Learned & Horizontal deployment in NPD (New Product Development).

UNIT – 5 **REPORTING & FORWARD-THINKING OF NPD**: Detailed study on PPAP with 18 elements reporting, APQP and its 5 Sections, APQP vs PPAP, Importance of SOP (Standard Operating Procedure) – Purpose & documents, deployment in shop floor. Prototyping & RPT - Concepts, Application and its advantages, 3D Printing – resin models, Sand cores for foundries; Reverse Engineering. Cloud points generation, converting cloud data to 3D model – Advantages & Limitation of RE, CE (Concurrent Engineering) – Basics, Application and its advantages in NPD (to reduce development lead time, time to Market, Improve productivity and product cost.)

TEXT BOOKS:

1. Product Development – Sten Jonsson
2. Product Design & Development – Karl T. Ulrich, Maria C. Young, Steven D. Eppinger

REFERENCES:

1. Revolutionizing Product Development – Steven C Wheelwright & Kim B. Clark
2. Toyota Product Development System – James Morgan & Jeffrey K. Liker
3. Winning at New Products – Robert Brands 3rd Edition
4. Product Design & Value Engineering – Dr. M.A. Bulsara &Dr. H.R. Thakkar

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

CO1 Understand drawing interpretation, BOM structure, Gantt charts, QFD, and industrial MIS tools like SAP and Oracle ERP.

CO2 Identify material standards, manufacturing methods, and apply DFMEA, PFMEA, and FEA fundamentals in product evaluation.

CO3 Demonstrate the ability to process RFQs, select tools/machines, plan manufacturing, and prepare PPAP documents.

CO4 Evaluate product performance using testing methods and apply lessons learned for NPD improvement.

CO5 Prepare comprehensive reports (PPAP, APQP), utilize prototyping/RPT tools, and apply RE & CE to enhance product development.

IV Year I Semester	ADVANCED MATERIALS (Open Elective - III)	L	T	P	C
		3	0	0	3

Course Objectives: The students will acquire the knowledge:

- Introduce various metallic materials, their applications in extreme environments, and innovative forms like metallic foams.
- Provide knowledge of natural and synthetic polymers, ceramics, their structures, processing, and industrial applications.
- Explain the fundamentals, classifications, and reinforcements of composite materials and their engineering relevance.
- Introduce shape memory alloys and functionally graded materials, focusing on their effects, properties, and applications.
- Explore the principles, unique properties, and applications of nanomaterials compared to their bulk counterparts.

UNIT CONTENTS

UNIT – 1 **ADVANCED METALS & ALLOYS:** Metallic materials- super alloys, titanium and Nickel based alloys and intermetallics, Materials for cryogenic application, Materials for space environment, Evaluation of materials for extreme environment, Introduction to metallic foams.

UNIT – 2 **CERAMICS**: Applications - characteristics- classification-Processing of ceramics- Powder preparations- consolidation- hot compaction-drying-sintering-finishing of ceramics, Al_2O_3, silicon nitride Si3N4 and Cermets, Areas of applications.

UNIT – 3 **COMPOSITE MATERIALS**: Introduction, polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon–carbon composites, fiber- reinforced composites and nature-made composites, and applications.
REINFORCEMENTS: Fibres- glass, silica, kevlar, carbon, boron, silicon carbide, and born carbide fibres.

UNIT – 4 **SHAPE MEMORY ALLOYS:** Introduction-shape memory effect-classification of shape memory alloys-composition-properties and applications of shape memory alloys.
FUNCTIONALLY GRADED MATERIALS: Types of functionally graded materials-classification different systems-preparation-properties and applications of functionally graded materials.

UNIT – 5 **NANO MATERIALS:** Introduction-properties at nano scales-advantages & disadvantages applications in comparison with bulk materials (nano – structure, wires, tubes, composites). state of art nano advanced- topic delivered by student.

Text Books:

1. Nano material /A.K. Bandyopadyay/New age Publishers
2. Material science and Technology: A comprehensive treatment/Robert W.Cahn,/VCH
3. Engineering Mechanics of Composite Materials / Isaac and M Daniel/Oxford University Press

References:

1. Mechanics of Composite Materials / R. M. Jones/ Mc Graw Hill Company, New York, 1975.
2. Analysis of Laminated Composite Structures / L. R. Calcote/Van Nostrand Rainfold,NY 1969
3. Analysis and performance of fibre Composites /B. D. Agarwal and L. J. Broutman /Wiley-Interscience, New York, 1980
4. Mechanics of Composite Materials - Second Edition (Mechanical Engineering) /AutarK.Kaw /CRC Press

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

CO1 Identify and evaluate high-performance metals and alloys used in aerospace, cryogenics, and advanced engineering applications.

CO2 Classify and compare polymers and ceramics based on properties, processing techniques, and their functional uses.

CO3 Distinguish between various composite systems and reinforcement types, and identify their specific industrial applications.

CO4 Understand the composition, classification, and application areas of SMAs and FGMs in modern materials engineering.

CO5 Analyze nano-scale material behavior, assess their benefits and limitations, and present advanced nano topics through seminars.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	INTRODUCTION TO SMART MANUFACTURING (Open Elective - III)	L	T	P	C
		3	0	0	3

Course Objectives: The students will acquire the knowledge:

- Introduce the fundamentals and evolution of smart manufacturing with Industry 4.0 technologies.
- Explain the structure and functions of smart machines and sensors in industrial applications.
- Introduce CPS and its 5C architecture for implementing intelligent manufacturing systems.
- Teach digital twin technology, machine learning, and predictive maintenance in smart factories.
- Provide knowledge on IoT networking protocols and connectivity infrastructure for industrial automation.

UNIT	CONTENTS
UNIT – 1	**CONCEPTS OF SMART MANUFACTURING:** Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits
UNIT – 2	**SMART MACHINES AND SMART SENSORS:** Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Sensing for Manufacturing Process in IIoT, Block Diagram of aIoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces
UNIT – 3	**ARCHITECTURE OF CYBER- PHYSICAL SYSTEM (CPS):** Functions of CPS, 5C Architecture; Smart Connection Level, Data-to- Information Level, Cyber Level, Cognition Level, Configuration Level. Design of PHM based CPS systems. Comparison of today's factory and Industry 4.0 factory by the implementation of 5C CPS architecture
UNIT – 4	**DIGITAL TWINS:** Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology **MACHINE LEARNING (ML) AND ARTIFICIAL INTELLIGENCE (AI) IN MANUFACTURING**: Introduction, benefits and applicationsof ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML. **PREDICTIVE MAINTENANCE:** Introduction of predictive maintenance, difference between preventive and predictive maintenance, working and various components of predictive maintenance, benefits and tools of predictive maintenance. Common approaches to IoT predictive maintenance; Rule-based

(condition monitoring) and AI (artificial intelligence) based predictive maintenance.

UNIT – 5 **IoT CONNECTIVITY FOR INDUSTRY 4.0:** Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol

Text Books:

1. Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist, Apress
2. Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer

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

CO1 Explain the stages, challenges, and benefits of smart manufacturing and methods to reduce production losses.

CO2 Identify smart machine components and describe sensor roles and interfaces in IIoT-based manufacturing systems.

CO3 Analyze CPS architecture and compare traditional and Industry 4.0 factories using 5C implementation.

CO4 Apply digital twins, ML/AI techniques, and predictive maintenance tools including AR for system reliability.

CO5 Evaluate IoT communication protocols and select suitable connectivity models for smart manufacturing.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	OPTIMIZATION TECHNIQUES (Open Elective - IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce basic concepts, types, and formulations of optimization problems with classical solution methods.
- Explore numerical techniques for solving unconstrained optimization problems.
- Present methods for solving optimization problems with equality and inequality constraints.
- Teach the theory and solution techniques for unconstrained and constrained geometric programming problems.
- Introduce integer programming and zero-one programming with solution strategies.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION TO OPTIMIZATION:** Engineering applications of optimization- statement of an optimization problem- classification of optimization problem- optimization techniques.
CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization- multivariable optimization with equality constraints- multivariable optimization with inequality constraints.

UNIT – 2 **UNCONSTRAINED OPTIMIZATION TECHNIQUES:** Pattern search method- Rosenbrock's method of rotating coordinates- Simplex method- Descent methods- Gradient of function- Steepest Descent method.

UNIT – 3 **CONSTRAINED OPTIMIZATION TECHNIQUES:** Characteristics of constrained problem methods of feasible directions - basic approach in the penalty function method- interior penalty function method- convex programming problem- exterior penalty function method.

UNIT – 4 **GEOMETRIC PROGRAMMING (G.P):** Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P). Complimentary geometric programming (C.G.P)

UNIT – 5 **INTEGER PROGRAMMING (I.P):** Graphical representation. Gomory's cutting plane method. Algorithm for zero-one programming problem. Integer non-linear programming.

TEXT BOOK:

1. Optimization Theory and Applications/ S.S.Rao/Wiley Eastern Limited, New Delhi.

REFERENCES:

1. Engineering Optimization / Kalyanmanai Deb/Prentice Hall of India, New Delhi.
2. Optimization Techniques-Theory and applications/C.Mohan&Kusum Deep/New Age International
3. Operations Research /S.D.Sharma / MacMillan Publishers

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

CO1 Classify optimization problems and apply classical techniques for single and multivariable optimization.

CO2 Solve unconstrained problems using methods like pattern search, Rosenbrock's, simplex, and steepest descent.

CO3 Apply penalty methods, feasible direction methods, and solve convex programming problems.

CO4 Solve G.P. and C.G.P problems using primal-dual concepts and differential or arithmetic methods.

CO5 Solve integer and zero-one programming problems using Gomory's cutting plane and other algorithms.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	ADVANCED MANUFACTURING PROCESSES (Open Elective - IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce various surface coating methods, their applications, and economic aspects.
- Explain the processing methods for ceramics and composites used in engineering applications.
- Explore microelectronics fabrication steps from wafer preparation to packaging and CAD.
- Introduce nanomaterials, their synthesis techniques, and applications in manufacturing.
- Provide knowledge of rapid prototyping techniques and their use in product development.

UNIT	CONTENTS
UNIT – 1	**COATING TECHNIQUES:** Scope, Cleaners, Methods of cleaning, Surface coating types, ceramic and organic methods of coating, and economics of coating. Electro forming, Chemical vapor deposition, Physical vapor deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.
UNIT – 2	**PROCESSING OF CERAMICS:** Applications, characteristics, classification, Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application. **PROCESSING OF COMPOSITES:** Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.
UNIT – 3	**FABRICATION OF MICROELECTRONIC DEVICES**: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in micro electronics, surface mount technology, Integrated circuit economics.
UNIT – 4	**NANOMANUFACTURING:** Nanotubes, Nanoparticles, nanowires, Lithography, Eletrospinning, mechanical milling, Inert gas condensation, sputtering, laser ablation, Arc discharge, Sol-gel methods, working, applications, advantages.
UNIT – 5	**RAPID PROTOTYPING:** Working Principles, Methods, Stereo Lithography, Laser Sintering, Fused Deposition Method, Applications and Limitations, Rapid tooling, Techniques of rapid manufacturing.

TEXT BOOKS:

1. Manufacturing Engineering and Technology Kalpakijian / Adisson Wesley, 1995.
2. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

REFERENCES:

1. Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold,
2. MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3. Advanced Machining Processes / V.K.Jain / Allied Publications.
4. Introduction to Manufacturing Processes / John A ScheyIMcGraw Hill.

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

CO1 Apply and distinguish different coating techniques such as CVD, PVD, thermal spraying, and ion implantation for industrial surfaces.

CO2 Understand and apply the manufacturing processes of ceramics and composite materials, including powder consolidation and reinforcement types.

CO3 Analyze and describe the manufacturing sequence of microelectronic devices including lithography, PCB design, and surface mount technology.

CO4 Understand various nano manufacturing techniques and evaluate their applications, advantages, and working principles.

CO5 Explain the working principles and limitations of rapid prototyping technologies such as stereolithography and laser sintering.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	TOTAL QUALITY MANAGEMENT (Open Elective - IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce the fundamentals of TQM and the role of process quality and statistical control in business performance.
- Emphasize customer satisfaction, loyalty, and benchmarking practices for continuous improvement.
- Explain how to organize and transition a company toward TQM using systems thinking and productivity tools.
- Teach the concept and classification of quality costs and their role in quality management.
- Provide knowledge of ISO 9000 standards and the certification process for global quality assurance.

UNIT CONTENTS

UNIT – 1 **INTRODUCTION:** The concept of TQM, Quality and Business performance, attitude and involvement of top management, communication, culture and management systems. Management of Process Quality: Definition of quality, Quality Control, a brief history, Product Inspection vs, Process Control, Statistical Quality Control, Control Charts and Acceptance Sampling.

UNIT – 2 **CUSTOMER FOCUS AND SATISFACTION**: The importance of customer satisfaction and loyalty- Crating satisfied customers, Understanding the customer needs, Process Vs. Customer, internal customer conflict, quality focus, Customer Satisfaction, role of Marketing and Sales, Buyer – Supplier relationships. Bench Marketing: Evolution of Bench Marketing, meaning of Bench marketing, benefits of bench marketing, the bench marketing process, pitfalls of bench marketing.

UNIT – 3 **ORGANIZING FOR TQM**: The systems approach, Organizing for quality implementation, making the transition from a traditional to a TQM organizing, Quality Circles. Productivity, Quality and Reengineering: The leverage of Productivity and Quality, Management systems Vs. Technology, Measuring Productivity, Improving Productivity Re-engineering.

UNIT – 4 **3-D OBJECT REPRESENTATION:** spline representation, Hermitem **THE COST OF QUALITY:** Definition of the Cost of Quality, Quality Costs, Measuring Quality Costs, use of Quality Cost Information, Accounting Systems and Quality Management

UNIT – 5 **ISO9000:** Universal Standards of Quality: ISO around the world, The ISO9000 ANSI/ASQCQ-Series Standards, benefits of ISO9000 certification, the third party audit, Documentation ISO9000 and services, the cost of certification implementing the system

TEXT BOOKS:

1. Total Quality Management / Joel E.Ross/Taylor and Franscis Limited
2. Total Quality Management/P.N.Mukherjee/PHI

REFERENCES:

1. Beyond TQM / Robert L.Flood
2. Statistical Quality Control / E.L. Grant / McGraw Hill.
3. Total Quality Management- A Practical Approach/H. Lal
4. Quality Management/KanishkaBedi/Oxford University Press/2011
5. Total Engineering Quality Management/Sunil Sharma/Macmillan

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

CO1 Understand TQM principles and apply process control tools like control charts and acceptance sampling.

CO2 Evaluate customer-focused strategies and implement benchmarking processes to enhance quality.

CO3 Implement organizational changes for TQM and assess productivity improvements through quality circles and reengineering.

CO4 Analyze and utilize quality cost data to drive managerial decisions and quality improvements.

CO5 Understand and apply ISO 9000 certification procedures and assess their impact on business quality systems.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	OPERATIONS MANAGEMENT (Open Elective - IV)	L	T	P	C
		3	0	0	3

Course Objectives: The student will acquire the knowledge

- Introduce forecasting methods, production system types, and aggregate planning strategies.
- Explain scheduling policies and materials management techniques for effective production control.
- Teach inventory control models, MRP systems, and modern management concepts like Lean and ERP.
- Introduce statistical and philosophical approaches to quality control and management.
- Provide tools for optimization using linear programming, transportation models, and scheduling algorithms.

UNIT	CONTENTS
UNIT – 1	**FORECASTING**: Introduction, types of forecasting and their uses, General principles of forecasting, forecasting techniques: qualitative and quantitative methods of Forecasting. **PRODUCTION SYSTEMS:** Types of production systems: job, batch, mass and flow type production. **AGGREGATE PLANNING:** Introduction, aggregate planning strategies, aggregate planning methods, problems
UNIT – 2	**SCHEDULING:** Introduction, difference with loading, scheduling policies, techniques, standard scheduling methods. **MATERIALS MANAGEMENT:** Introduction, functions of materials management, inventory, inventory management, types of inventories, Selective inventory control techniques: ABC analysis, VED analysis.
UNIT – 3	**INVENTORY CONTROL:** P and Q Systems, Basic Economic Order Quantity model, Price break model, assumptions and problems **MATERIAL REQUIREMENT PLANNING**: Introduction, Inputs, outputs and MRP logic. **CONTEMPORARY MANAGEMENT TECHNIQUES:** Introduction to Lean, JIT, ERP and Supply chain Management.
UNIT – 4	**QUALITY MANAGEMENT:** Quality engineering, Taguchi Principles, SQC – X bar, p and c charts, problems, Juran‘s principles Introduction to quality acceptance sampling. Deming‘s Philosophy, Introduction to Total quality management, Quality Function Deployment, Introduction to six sigma and ISO 9000 2015 standards.
UNIT – 5	**OPTIMIZATION:** Linear Programming – Graphical and simplex method – problems, Demonstration of Transportation and Assignment Models, Travelling Salesman problem.

TEXT BOOKS:

1. Modern Production/ operations managements / Baffa& Rakesh Sarin
2. Operations Management – an Integrated Approach, International student Version, R. Dan Reid and Nada R. Sanders, John Wiley & Sons
3. Production and Operations management by K. C. Jain, Wiley
4. Operations Management by William J. Stevenson, McGraw-Hill Companies 2015
5. Operations Management by Jay Heizer , Barry Render, Chuck Munson , Amit Sachan Twelfth Edition, Pearson, 2017

REFERENCES:

1. Maynard‘s Industrial Engineering Handbook, Kjell B. Zandin, Fifth Edition 2001, The McGraw-Hill Companies, Inc.
2. Operations Management S.N. Chary.
3. Inventory Control Theory and Practice / Martin K. Starr and David W. Miller.

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

CO1 Apply forecasting and aggregate planning techniques to select appropriate production systems.

CO2 Develop scheduling plans and apply inventory classification methods like ABC and VED analysis.

CO3 Analyze inventory decisions using EOQ and implement MRP logic and Lean concepts.

CO4 Use tools like control charts and sampling to manage quality and understand TQM and Six Sigma principles.

CO5 Solve real-world problems using LPP, transportation, assignment, and travelling salesman models.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	ENERGY AUDITING (Open Elective - IV)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- Introduce global and national energy scenarios, energy auditing needs, and the role of energy managers.
- Explain electricity tariff systems and energy-saving techniques in electrical networks.
- Provide knowledge of combustion and conservation methods in major thermal systems.
- Discuss conservation measures in various electrical utilities and support systems.
- Explain monitoring, targeting, labelling, and economic evaluation of energy projects.

UNIT	CONTENTS
UNIT – 1	**INTRODUCTION**: 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 – 2	**ELECTRICAL SUPPLY SYSTEMS**: Electricity Tariff structures – Typical Billing - Demand Side Management - HT and LT supply - Power Factor – Energy conservation in Transformers – Harmonics
UNIT – 3	**ENERGY CONSERVATION IN MAJOR THERMAL UTILITIES**: 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 – 4	**ENERGY CONSERVATION IN MAJOR ELECTRICAL UTILITIES**: Energy conservation in: Motors - Pumps – Fans – Blowers - Compressed Air Systems - Refrigeration and Air Conditioning Systems - Illumination systems
UNIT – 5	**ENERGY MONITORING, TARGETING, LABELLING AND ECONOMICS**: 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

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. Nagabhushan Raju, 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", 7thEdition, 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

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

CO1 Analyze energy consumption patterns and perform basic energy audits using suitable tools.

CO2 Evaluate power systems for conservation opportunities and apply DSM and PF improvement strategies.

CO3 Apply energy-saving techniques in boilers, furnaces, steam systems, and waste heat recovery units.

CO4 Recommend energy-efficient practices for motors, compressors, HVAC, and lighting systems.

CO5 Perform energy performance analysis using economic tools and understand schemes like PAT and ESCO.

IV Year I Semester	MECHATRONICS LAB	L	T	P	C
		0	0	4	2

Course Objectives: The student will acquire the knowledge

- To study the characteristics and working principles of basic transducers and signal conditioning elements.
- To develop and simulate PLC ladder logic programs for real-time industrial control systems.
- To design, simulate, and analyze hydraulic and electro-pneumatic circuits using Automation Studio.
- To introduce MATLAB and SIMULINK for modeling and simulation of control systems.

CONTENTS

List of Experiments

1. DYNA 1750 Transducers Kit :-
   a. Characteristics of LVDT
   b. Principle & Characteristics of Strain Gauge
   c. Characteristics of Summing Amplifier
   d. Characteristics of Reflective Opto Transducer

2. PLC PROGRAMMING & Simulation of Allen Bradley, Siemens or IEC Ladder Using Automation Studio
   a. Ladder programming on Logic gates ,Timers (TON,TOFF) &counters (UP,DOWN)
   b. Ladder Programming for digital &Analogy sensors
   c. Ladder programming & Simulations of Virtual System such as Traffic Light control, Washing machine, Garage Door, Water level control, Lift control, Conveyor Belt etc.
   d. Ladder programming to control circuits such as single solenoid spring return latch circuit, double solenoid Hydraulic / Pneumatic circuits, Self-Reciprocating Hydraulic / Pneumatic Circuit.

3. AUTOMATION STUDIO SOFTWARE (Design, Simulate & Analyze)
   a. Introduction to Automation studio & its control.
   b. Draw & Simulate Hydraulic circuits for series &parallel cylinders connection, Accumulator circuit, Pressure intensifier circuit, Simple Electro- Hydraulic Electro - Pneumatic circuits (Plot Waveforms for different parameters).
   c. Design & Simulate Meter-in, Meter-out, Regenerative circuit, sequencing circuit, traverse and feed hydraulic circuit, hydraulic press and clamping.
   d. Position Control of Proportional Servo Valve Circuit using PID Feedback controller.

4. MATLAB Programming
   a. Sample programmes on MATLAB
   b. Simulation and analysis of PID controller using SIMULINK

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

CO1 Analyze and interpret the response of LVDT, strain gauges, opto transducers, and amplifiers.

CO2 Design and simulate PLC programs for sensors, actuators, and process control applications.

CO3 Create and simulate control circuits with various hydraulic and pneumatic configurations including PID-based position control.

CO4 Implement control algorithms and analyze system responses using MATLAB and SIMULINK.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	-

Course Objectives: The student will acquire the knowledge

- To Enable the student to understand the importance of constitution
- To understand the structure of executive, legislature and judiciary
- To understand philosophy of fundamental rights and duties
- To understand the autonomous nature of constitutional bodies like Supreme Court and highcourt controller and auditor general of India and election commission of India.
- To understand the central and state relation financial and administrative

UNIT **CONTENTS**

UNIT – 1 Introduction to Indian Constitution: Constitution meaning of the term, Indian Constitution - Sources and constitutional history, Features - Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

Learning outcomes:

After completion of this unit student will

- Understand the concept of Indian constitution
- Apply the knowledge on directive principle of state policy
- Analyze the History, features of Indian constitution
- Evaluate Preamble Fundamental Rights and Duties

UNIT – 2 Union Government and its Administration Structure of the Indian Union: Federalism, Centre- State relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha, The Supreme Court and High Court: Powers and Functions;

Learning outcomes:-After completion of this unit student will

- Understand the structure of Indian government
- Differentiate between the state and central government
- Explain the role of President and Prime Minister
- Know the Structure of supreme court and High court

UNIT – 3 State Government and its Administration Governor - Role and Position - CM and Council of ministers, State Secretariat: Organisation, Structure and Functions.

Learning outcomes: After completion of this unit student will

- Understand the structure of state government
- Analyze the role Governor and Chief Minister
- Explain the role of state Secretariat
- Differentiate between structure and functions of state secretariat

UNIT – 4 A. Local Administration - District's Administration Head - Role and Importance, Municipalities – Mayor and role of Elected Representative - CEO of Municipal Corporation PachayatiRaj: Functions PRI: ZilaPanchayat, Elected officials and their roles, CEO Zilla Panchayat: Block level Organizational Hierarchy - (Different departments), Village level - Role of Elected and Appointed officials - Importance of grass root democracy.

Learning outcomes: - After completion of this unit student will

- Understand the local Administration
- Compare and contrast district administration role and importance
- Analyze the role of Myer and elected representatives of Municipalities
- Evaluate Zilla Panchayat block level organization

UNIT – 5 Election Commission: Election Commission- Role of Chief Election Commissioner and Election Commissionerate State Election Commission: Functions of Commissions for the welfare of SC/ST/OBC and women

Learning outcomes: - After completion of this unit student will

- Know the role of Election Commission apply knowledge
- Contrast and compare the role of Chief Election commissioner and Commissionerate
- Analyze role of state election commission
- Evaluate various commissions of viz SC/ST/OBC and women

References*:*

1) Durga Das Basu, Introduction to the Constitution of India, Prentice – Hall of India Pvt. Ltd..New Delhi
2) Subash Kashyap, Indian Constitution, National Book Trust
3) J.A. Siwach, Dynamics of Indian Government & Politics
4) D.C. Gupta, Indian Government and Politics
5) H.M.Sreevai, Constitutional Law of India, 4th edition in 3 volumes (Universal Law Publication)
6) J.C. Johari, Indian Government and Politics Hans
7) J. Raj Indian Government and Politics
8) M.V. Pylee, Indian Constitution Durga Das Basu, Human Rights in Constitutional Law, Prentice
9) –Hall of India Pvt. Ltd.. New Delhi
10) Noorani, A.G., (South Asia Human Rights Documentation Centre), Challenges to Civil Right), Challenges to Civil Rights Guarantees in India, Oxford University Press 2012

E-resources:

1.nptel.ac.in/courses/109104074/8
2.nptel.ac.in/courses/109104045/
3.nptel.ac.in/courses/101104065/
4.www.hss.iitb.ac.in/en/lecture-details
5.www.iitb.ac.in/en/event/2nd-lecture-institute-lecture-series-indian-constitution

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

CO1	Understand historical background of the constitution making and its importance forbuilding a democratic India
CO2	Understand the functioning of three wings of the government i.e., executive, legislative and judiciary.
CO3	Understand the value of the fundamental rights and duties for becoming good citizen of India.
CO4	Analyze the decentralization of power between central, state and local self-government.
CO5	Apply the knowledge in strengthening of the constitutional institutions like CAG,Election Commission and UPSC for sustaining democracy.
CO6	Know the sources, features and principles of Indian Constitution.
CO7	Learn about Union Government, State government and its administration.
CO8	Get acquainted with Local administration and Pachayati Raj.
CO9	Be aware of basic concepts and developments of Human Rights.
CO10	Gain knowledge on roles and functioning of Election Commission.

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R23 MECHANICAL ENGINEERING COURSE STRUCTURE & SYLLABUS

IV Year I Semester	**EVALUATION AND INDUSTRY INTERNSHIP**	**L**	**T**	**P**	**C**
		-	**-**	**-**	**2**