Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV)

(University U/S 3 of UGC Act 1956)
(Accredited with "A" Grade by NAAC)
Enathur, Kanchipuram - 631 561

DEPARTMENT OF MECHANICAL ENGINEERING

CURRICULUM AND SYLLABUS
(Regulation – 2025)

B.E. (Part Time) Mechanical Engineering

Choice Based Credit System

(Students Admitted from AY-2025-26)

PROGRAM OUTCOMES [PO's]	
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex Mechanical engineering problems
PO 2	Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering scien ces
PO 3	Design/development of solutions: Design solutions for complex Mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO 4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, 5analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO 5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools that are relevant to Mechanical engineering, including prediction and modeling to complex engineering activities with an understanding of the limitations
PO 6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Mechanical engineering practice
PO 7	Environment and sustainability: Understand the impact of the Mechanical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the Mechanical engineering practice
PO 9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO 11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO 12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOME (PSO's) – Mechanical Engineering	
PSO 1	Apply modern engineering tools such as CAD/CAM, Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), and automation technologies to analyze and solve complex problems in mechanical and interdisciplinary engineering domains.
PSO 2	Demonstrate technical competencies and innovative problem-solving abilities to address real-world challenges in sectors like automotive, aerospace, energy, and manufacturing through internships, industry-driven projects, and collaborative engagements

PROGRAM SPECIFIC OUTCOME (PSO's) – Mechatronics Engineering	
PSO 1	Graduates will be able to apply the integrated knowledge of mechanical, electrical, electronics, and computer engineering to design, develop, and implement intelligent mechatronic systems and automation solutions for real-world applications.
PSO 2	Graduates will be capable of designing and deploying embedded systems, control algorithms, and real-time interfaces to address challenges in automation, robotics, and various industrial domains.

CURRICULUM
B.E. (Part Time) Mechanical Engineering

SEMESTER - I (First year)

SL. No	Course Category	Course Code	Course Type	Name of the Course	Hours per week			Credit	IA	EA	TM
					L	T	P				
1.	BSC	BMEP251 T10	T	Mathematics III (PDE, Probability & Statistics)	3	1	-	**4**	40	60	100
2.	ESC	BMEP251 T20	T	Engineering Mechanics	3	-	-	**3**	40	60	100
3.	PCC	BMEP251 T30	T	Engineering Thermodynamics	3	-	-	**3**	40	60	100
4.	PCC	BMEP251 T40	T	Manufacturing Science	3	-	-	**3**	40	60	100
5.	PCC	BMEP251 T50	T	Materials Engineering	3	-	-	**3**	40	60	100
Total					**15**	**01**	**-**	**16**			

SEMESTER - II (First year)

SL. No	Course Category	Course Code	Course Type	Name of the Course	Hours per week			Credit	IA	EA	TM
					L	T	P				
1.	ESC	BMEP252 T10	T	Electronics Engineering	3	-	-	**3**	40	60	100
2.	PCC	BMEP252 T20	T	Thermal Engineering	3	-	-	**3**	40	60	100
3.	PCC	BMEP252 T30	T	Fluid Mechanics & Machinery	3	-	-	**3**	40	60	100
4.	PCC	BMEP252 T40	T	Machine Tools and Metal Cutting	3	-	-	**3**	40	60	100
5.	PCC	BMEP252 T50	T	Strength of Materials	3	-	-	**3**	40	60	100
Total					**15**	**-**	**-**	**15**			
Total Credit in First year								**31**			

SEMESTER - III (Second year)											
SL. No	**Course Category**	**Course Code**	**Course Type**	**Name of the Course**	**Hours per week**			**Credit**	**IA**	**EA**	**TM**
					L	**T**	**P**				
1.	PCC	BMEP253 T10	L/T	Heat and Mass Transfer	3	-	2	**4**	40	60	100
2.	PCC	BMEP253 T20	L/T	Theory of Machines	3	-	2	**4**	40	60	100
3.	PCC	BMEP253 T30	T	Design of Machine Elements	3	-	-	**3**	40	60	100
4.	PCC	BMEP253 T40	T	Power Plant Engineering	3	-	-	**3**	40	60	100
5.	OEC	-	T	Open Elective - I	3	-	-	**3**	40	60	100
Total					**15**	**-**	**04**	**17**			

SEMESTER - IV (Second year)											
SL. No	**Course Category**	**Course Code**	**Course Type**	**Name of the Course**	**Hours per week**			**Credit**	**IA**	**EA**	**TM**
					L	**T**	**P**				
1.	HSMC	BMEP254 T10	L/T	Operation Research & Management	3	-	2	**4**	40	60	100
2.	PCC	BMEP254 T20	T	Sustainable Manufacturing	3	-	-	**3**	40	60	100
3.	PCC	BMEP254 T30	L/T	CAD / CAM	3	-	2	**4**	40	60	100
4.	PCC	BMEP254 T40	L/T	Metrology and Measurements	3	-	2	**4**	40	60	100
5.	PEC	-	T	PEC - I	3	-	-	**3**	40	60	100
Total					**15**	**-**	**06**	**18**			
Total Credit in Second year								**35**			

Course Type: T – Theory Course, L – Laboratory Course, L/T – Laboratory integrated Theory Course

SEMESTER - V (Third year)

SL. No	Course Category	Course Code	Course Type	Name of the Course	Hours per week			Credit	IA	EA	TM
					L	T	P				
1.	PCC	BMEP255 T10	T	Design of Transmission Systems	3	-	-	**3**	40	60	100
2.	PCC	BMEP255 T20	L/T	Mechatronics	3	-	2	**4**	40	60	100
3.	PCC	BMEP255 T30	L/T	Finite Element Analysis	3	-	2	**4**	40	60	100
4.	PEC	-	T	PEC - II	3	-	-	**3**	40	60	100
5.	PEC	-	T	PEC - III	3	-	-	**3**	40	60	100
6.	VSEC	BMEP25 MC01	T	Entrepreneurship and Start-ups	1	-	-	**1**	100	-	100
Total					**16**	**-**	**04**	**18**			

SEMESTER - VI (Third year)

SL. No	Course Category	Course Code	Course Type	Name of the Course	Hours per week			Credit	IA	EA	TM
					L	T	P				
1.	PCC	BMEP256 T10	T	Automation in Manufacturing	3	-	-	**3**	40	60	100
2.	PCC	BMEP256 T20	T	Autotronics	3	-	-	**3**	40	60	100
3.	PCC	BMEP256 T30	T	Production and Operations Management	3	-	-	**3**	40	60	100
4.	PEC	-	T	PEC - IV	3	-	-	**3**	40	60	100
5.	PCC	BMEP256 P40	L	Machine Drawing Practical	-	-	4	**2**	40	60	100
6.	PSC	BMEP256 Z50	L	Design and Fabrication Project	-	-	8	**4**	40	60	100
7.	VSEC	BMEP25 MC02	-	Presentation / Publication in Conference / Seminar /Competitions	-	-	-	**2**	100	-	100
Total					**12**	**-**	**12**	**20**			
Total Credit in Third year								**38**			

Course Type: T – Theory Course, L – Laboratory Course, L/T – Laboratory integrated Theory Course

SEMESTER - VII (Fourth year)										
SL. No	**Course Category**	**Course Code**	**Course Type**	**Name of the Course**	**Hours per week**			**Credit**	**IA**	**EA**	**TM**
					L	**T**	**P**				
1.	PCC	BMEP257T10	T	Principles of Industrial Management	3	-	-	**3**	40	60	100
2.	OEC	-	T	Open Elective - II	3	-	-	**3**	40	60	100
3.	PROJ-ME	BMEP257Z20	L	Project Work	-	-	20	**10**	40	60	100
Total					**06**	**-**	**20**	**16**			
Total Credit in Fourth year								**16**			

Total Credit	**120**

Course Type: T – Theory Course, L – Laboratory Course

PROFESSIONAL ELECTIVE COURSES							
SL. No	**Category**	**Code**	**Course Title**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	**PEC-I** (Product Design)	BMEP254E1A	Fluid Power Systems	**3**	**-**	**-**	**3**
2.		BMEP254E1B	Product Design & Development				
3.		BMEP254E1C	Composite Materials				
4.		BMEP254E1D	Tribology in Design				
5.		BMEP254E1E	Geometric Dimensioning and Tolerancing				
1.	**PEC-II** (Energy Systems)	BMEP255E2A	Refrigeration & Air Conditioning	**3**	**-**	**-**	**3**
2.		BMEP255E2B	Electric and Hybrid Vehicles				
3.		BMEP255E2C	Energy Storage Technologies				
4.		BMEP255E2D	Energy Conservation in Industries				
5.		BMEP255E2E	Gas Dynamics & Jet Propulsion				
6.		BMEP255E2F	Renewable Energy Sources				
7.		BMEP255E2G	Measurement and Control for Energy Systems				
1.	**PEC-III** (Manufacturing & Robotics)	BMEP255E3A	Digital Twin and Industry 4.0	**3**	**-**	**-**	**3**
2.		BMEP255E3B	Digital Manufacturing				
3.		BMEP255E3C	Flexible Manufacturing Systems				
4.		BMEP255E3D	Intelligent Machining				
5.		BMEP255E3E	Non-Traditional Machining Process				
6.		BMEP255E3F	Medical Robotics				
7.		BMEP255E3G	Mobile Robotics				
8.		BMEP255E3H	Humanoid Robotics				
9.		BMEP255E3I	Agricultural Robotics				
1.	**PEC-IV** (Industrial Management)	BMEP256E4A	Total Quality Management	**3**	**-**	**-**	**3**
2.		BMEP256E4B	Process planning and cost Estimation				
3.		BMEP256E4C	Supply Chain and Logistics Management				
4.		BMEP256E4D	Reliability and Maintenance Engineering				
5.		BMEP256E4E	Engineering Economics				
6.		BMEP256E4F	Material Handling Equipment, Repair and Maintenance				
7.		BMEP256E4G	Production Planning and Control				

OPEN ELECTIVE COURSES							
SL. No	**Category**	**Code**	**Course Title**	**Hours per week**			**Credit**
				L	**T**	**P**	
1.	**OEC – I**	BMEP253OEA	Cloud Computing	**3**	**-**	**-**	**3**
2.		BMEP253OEB	Web Design				
3.		BMEP253OEC	Digital Image Processing				
4.		BMEP253OED	Data Analysis				
5.		BMEP253OEE	Astro-Physics				
6.		BMEP253OEF	Business Administration				
7.		BMEP253OEG	Chemistry in Crime Investigation				
8.		BMEP253OEH	Bioinformatics				
9.		BMEP253OEI	Finance for Non-Finance Managers				
10.		BMEP253OEJ	Fuel Cell and Batteries				
11.		BMEP253OEK	French Primer				
12.		BMEP253OEL	Japanese				
13.		BMEP253OEM	German Primer				
14.		BMEP253OEN	Communication Skills				
15.		BMEP253OEO	Hindi Literatures				
1.	**OEC - II**	BMEP257OEA	Artificial Intelligence & Machine Learning	**3**	**-**	**-**	**3**
2.		BMEP257OEB	Nano Technology & Surface Engineering				
3.		BMEP257OEC	Disaster Management & Mitigation				
4.		BMEP257OED	Robotics				
5.		BMEP257OEE	HR Management				
6.		BMEP257OEF	Nuclear and particle physics				
7.		BMEP257OEG	Internet of Things (IOT)				
8.		BMEP257OEA	Psychology				
9.		BMEP257OEH	Statistical methods with excel				
10.		BMEP257OEI	Key Board				
11.		BMEP257OEJ	Logistics and Supply Chain				
12.		BMEP257OEK	Panini Grammar				
13.		BMEP257OEL	Violin				
14.		BMEP257OEM	Vocal Music				

SYLLABUS
B.E. (Part Time) Mechanical Engineering
SEMESTER – I

Course Code	Course Name	Semester	Credits	L T P C
	MATHEMATICS - III (PDE, Probability & Statistics)	**1**		3 1 0 4

COURSE OBJECTIVES

- To provide an overview of probability and statistical inferences to engineers
- To introduce the solution methodologies for second order Partial Differential Equations with applications in engineering

UNIT-I BASIC PROBABILITY **9**

Probability spaces, conditional probability, Independent random variables, sums of independent random variables, Bayes' Theorem, Discrete and Continuous one-dimensional random variables - Expectations, Moments, Variance of a sum, Moment generating function, Tchebyshev's Inequality.

UNIT-II PROBABILITY DISTRIBUTIONS **9**

Discrete Distributions – Binomial, Poisson and Negative Binomial distributions, Continuous Distributions - Normal, Exponential and Gamma distributions.

UNIT-III BASIC STATISTICS **9**

Measures of Central tendency: Averages, mean, median, mode, Measures of dispersion – Range, Mean deviation, Quartile deviation and Standard deviation, Moments, skewness and Kurtosis, Correlation and regression – Rank correlation.

UNIT-IV APPLIED STATISTICS **9**

Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations- Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

UNIT-V APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS **9**

Method of separation of variables – Vibration of a stretched string: Wave equation – Solution of Wave equation - D'Alembert's solution of wave equation – One dimensional heat flow – Solution of heat equation.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	They understand the concept of basic probability, conditional probability and Baye's theorem and its application of analysis the Engineering problems.
2.	They Know to apply the discrete and continuous distributions in probability for the real life problems.
3.	They identify and improve their basic ideas of statistics including measures of central tendency, dispersion, correlation and regression.
4.	Analyzing the large and small samples using tools like z, t, F and chi-square.
5.	Design solution to PDE and to solve field problems in engineering involving PDEs.

TEXT BOOKS

1.	T. Veerarajan, Probability, Statistics and Random Processes, Third edition, Tata McGraw-Hill, New Delhi, 2017.
2.	S.P. Gupta, Statistical Methods, 46th edition, Sultan Chand & sons, New Delhi, 2021.
3.	Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

REFERENCES	
1.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 45th Edition, 2012.
2.	S. Ross, A First Course in Probability, 8th Ed., Pearson Education India, 2019.
3.	W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
4.	N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, 9th edition, 2016.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	✓	✓											✓	
CO2	✓	✓											✓	
CO3	✓	✓		✓			✓				✓		✓	
CO4	✓	✓		✓			✓				✓		✓	
CO5	✓	✓		✓			✓				✓		✓	

Course Code	Course Name	Semester	Credits	L T P C
	ENGINEERING MECHANICS	1		3 0 0 3

COURSE OBJECTIVES

- To familiarize the basics laws of physics, vector operations and forces.
- To understand the principles of beams, supports and equilibrium of rigid bodies.
- To know the area and mass property calculations of various sections and solids.
- To study and analyse the dynamics of particles by various methods.
- To understand the applications of friction and rigid body dynamics.

UNIT-I STATICS OF PARTICLES **9**

Introduction – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces, Principle of transmissibility, Vectors – Vectorial representation of forces and moments – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Single equivalent force.

UNIT-II EQUILIBRIUM OF RIGID BODIES **9**

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

UNIT-III PROPERTIES OF SURFACES AND SOLIDS **9**

Determination of Area and Volume – First moment of area and the Centroid of sections – Rectangle, circle, triangle from integration – T section, I section, - Angle section, Hollow section by using standard formula – second and product moments of plane area – Rectangle, triangle, circle from integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Polar moment of inertia – Principal moments of inertia of plane areas – Principal axes of inertia – Mass moment of inertia – Derivation of mass moment of inertia for rectangular section, prism, sphere from first principle – Relation to area moment of inertia.

UNIT-IV DYNAMICS OF PARTICLES **9**

Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion – Newton's law – Work Energy Equation of particles – Impulse- Momentum principle – Impact of elastic bodies.

UNIT-V FRICTION AND RIGID BODY DYNAMICS **9**

Frictional force – Laws of Coloumb friction – simple contact friction – Rolling resistance – Belt friction-Ladder friction- Translation and Rotation of Rigid Bodies – Velocity and acceleration – General Plane motion of bodies.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Get familiarized with the basic laws of physics, vector operations and forces.
2.	Understand the principles of beams, supports and equilibrium of rigid bodies.
3.	Calculate the area and mass properties of various sections and solids.
4.	Know about dynamics of particles and their analysis by various methods.
5.	Know about the applications of friction and rigid body dynamics.

TEXT BOOKS	
1.	Rajas Rajasekaran, S, Sankarasubramanian, G., "Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., 3rd edition, Reprint 2011.
2.	Beer, F.P and Johnson Jr. E.R. "Vector Mechanics for Engineers", Vol. 1 Statics and Vol. 2 Dynamics, Tata McGraw-Hill International Edition, 2017, 12th edition.
REFERENCES	
1.	Hibbeler, R.C., "Engineering Mechanics", Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 14th edition, 2017.
2.	Palanichamy, M.S., Nagam, S., "Engineering Mechanics – Statics & Dynamics", Tata McGraw-Hill, 3rd edition, 2004.
3.	Irving H. Shames, "Engineering Mechanics – Statics and Dynamics", IV Edition – Pearson Education Asia Pvt. Ltd.,(2008).
4.	Ashok Gupta, "Interactive Engineering Mechanics – Statics – A Virtual Tutor (CDROM)", Pearson Education Asia Pvt., Ltd., (2002).
5.	K.L. Kumar, "Engineering Mechanics" Tata McGraw-hill,, 4th Edition, 2017.
6.	S.S. Bhavikatti, " Engineering Mechanics", New Age International Publishers, 3rd edition, 2019.
7.	R. S. Khurmi, " Engineering Mechanics", S. Chand Publishers, 22nd edition, 2018.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	√	√	√		√								√	√
CO2	√	√	√		√								√	√
CO3	√	√	√		√								√	√
CO4	√	√	√		√								√	√
CO5	√	√	√		√								√	√

Course Code	Course Name	Semester	Credits	L T P C
	ENGINEERING THERMODYNAMICS	1		3 0 0 3

COURSE OBJECTIVES

- To learn about the basic concepts of thermodynamics & first law of thermodynamics
- To learn about application of II law and to understand the concept of entropy/availability
- To evaluate the changes in properties of pure substances
- To understand various thermodynamic relations & ideal gas concept
- To learn about the concept of psychrometry

UNIT - I BASIC CONCEPTS AND FIRST LAW **9**

Concept of continuum- microscopic and macroscopic approach-Path and point functions - Properties – Thermodynamics system and their types - Thermodynamic Equilibrium - State, path and process - Quasi-static, reversible and irreversible processes - Modes of work - P-V diagram - Zeroth law of thermodynamics – Concept of temperature & heat - First law of thermodynamics - application to closed and open systems – steady and unsteady flow processes

UNIT- II SECOND LAW & AVAILABILITY ANALYSIS **9**

Statements of second law and its corollaries – Carnot theorem - Carnot cycle & Reversed Carnot cycle - Clausius inequality. Concept of entropy, entropy of ideal gas - Principle of increase in entropy. Applications of II Law. Available and non-available energy of a source and finite body. Energy and irreversibility. Expressions for the energy of a closed system and open systems. Energy balance and entropy generation. Irreversibility. I and II law Efficiency

UNIT - III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE **9**

Formation of steam & its thermodynamic properties - P-v, P-T, T-v, T-s, h-s diagrams. P-v-T surface. Use of Steam Table & Mollier Chart - Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles.

UNIT - IV IDEAL GAS & THERMODYNAMIC RELATIONS **9**

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases- Reduced properties. Compressibility factor- Generalized Compressibility Chart -. Simple Calculations.
Maxwell relations, Tds equations, Specific heat capacities - Energy equation - Joule-Thomson co-efficient, Clausius -Clapeyron equation – Third law of thermodynamics.

UNIT V PSYCHROMETRY **9**

Psychrometric properties - Psychrometric chart - Psychrometric processes – Adiabatic saturation - Sensible heating and cooling, humidification, dehumidification, Evaporative cooling and adiabatic mixing of air streams - Property calculations

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply the first law of thermodynamics for simple open and closed systems under steady and unsteady conditions.
2.	Apply second law of thermodynamics to open and closed systems and calculate entropy and availability
3.	Apply Rankine cycle to steam power plant and compare few cycle improvement methods.
4.	Derive simple thermodynamic relations of ideal and real gases.
5.	Calculate the properties of gas mixtures and moist air and its use in psychrometric processes.

TEXT BOOK

1.	Yunus A, Cengel & Michael A. Boles, "Thermodynamics – An Engineering Approach", McGraw Hill Education, 8th edition, 2017.

REFERENCES	
1.	Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2012.
2.	Borgnakke & Sonnatag, "Fundamental of Thermodynamics", John Wiley, 8th edition, 2016.
3.	Chattopadhyay P, "Engineering Thermodynamics", Oxford University Press, 2nd edition, 2016.
4.	J.P Holman, Thermodynamics – Tata McGraw Hill, 2019, 9th edition.
5.	Nag. P. K., "Engineering Thermodynamics", 6th edition, Tata McGraw-Hill, New Delhi, 2017.
6.	Vanwylen & Sonntag, Introduction to Thermodynamics, Classical & Statistical – Wiley Eastern, 2007, 4th edition.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	√	√	√			√						√		√
CO2	√	√	√			√						√		√
CO3	√	√	√			√						√		√
CO4	√	√	√			√						√		√
CO5	√	√	√			√						√		√

Course Code	Course Name	Semester	Credits	L T P C
	MANUFACTURING SCIENCE	1		3 0 0 3

COURSE OBJECTIVES

- To understand the concepts casting techniques.
- To understand the concepts of basic metal forming processes
- To understand the concepts of sheet metal forming processes
- To understand the various joining process.
- To understand the basic manufacturing concepts of plastic components

UNIT–I CASTING AND MOLDING **9**

Sand casting – Sand moulds - Type of patterns – Pattern materials – Pattern allowances – Types of Moulding sand – Properties – Core making– Working principle of Special casting processes – Shell, investment casting -die casting – Centrifugal casting – Sand Casting defects – Inspection methods

UNIT–II METAL FORMING PROCESSES **9**

Hot working and cold working of metals – Forging processes – Open, impression and closed die forging – Characteristics of the process – Types of Forging Machines – Typical forging operations – Rolling of metals – Types of Rolling mills - Shape rolling operations – Defects in rolled parts - Principle of rod and wire drawing - Tube drawing –– Principles of Extrusion – Types of Extrusion – Hot and Cold extrusion –– Equipment used

UNIT–III SHEET METAL FORMING **9**

Forming Operations- Blanking-blank size calculation, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch Forming, Deep Drawing, Shearing, Metal Spinning, Bending, Tube bending, Tube forming -Embossing & Coining, Types of Dies, Progressive, Compound and Combination dies. Forming Methods - Explosive Forming, Electro Hydraulic Forming, Electro Magnetic Forming, Dynapack Machine, Rubber Forming, Super Plastic Forming.

UNIT–IV JOINING/FASTENING PROCESSES **9**

Fusion welding processes – Types of Gas welding – Equipments used – Flame characteristics – Filler and Flux materials - Arc welding equipments - Electrodes – Coating and specifications – Principles of Resistance welding – Spot/butt, seam welding – Gas metal arc welding – Flux cored – Submerged arc welding – Electro slag welding – TIG welding – Principle and application of special welding processes - Plasma arc welding – Electron beam welding – Friction welding – Diffusion welding – Weld defects – Brazing and soldering process – Methods and process capabilities – Filler materials and fluxes – Types of Adhesive bonding.

UNIT–V MANUFACTURE OF PLASTIC COMPONENTS **9**

Types and characteristics of plastics — Moulding of thermoplastics — working principles and typical applications — injection moulding — Plunger and screw machines — Compression moulding, Transfer Moulding — Typical industrial applications — introduction to blow moulding –Rotational moulding — Film blowing — Extrusion — Thermoforming — Bonding of Thermoplastics

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply the concepts of different metal casting processes, associated defects
2.	Gain the knowledge in various metal forming processes.
3.	Understand the sheet metal and forming processes.
4.	Understand the application of welding process
5.	Understand the different unconventional Manufacturing Methods employed for making different products.

TEXT BOOKS	
1.	Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)-Pearson India, 2014.
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 7th Edition, 2019.
3.	J.T. Black & Ronald A. Kohser, Degarmo's Materials and Processes in Manufacturing, John Wiley & Sons, 12th Edition 2017.
REFERENCES	
1.	Banga T.R, Agarwal. R.K. & Manghrani. T.M., "Foundry Engineering", Khanna Publishers, New Delhi, 1995.
2.	Jain.R.K. "Production Technology" Khanna Publishers, 17th edition, 2013.
3.	Bhattacharyya.A. "Metal Cutting Theory and Practice", Central Book Publishers, 1984.
4.	S. K. Hajra Chowdhery, & A. K. Hajra Chowdhery, Elements of Workshop Technology, Vol 1 & 2, Media Promoters and Publishers, 2007, 14th Edition.
5.	B.S. Magendran Parashar & R.K. Mittal,"Elements of Manufacturing Processes", Prentice Hall of India, 2003.
6.	P.N. Rao,"Manufacturing Technology",Tata McGraw-Hill Publishing Limited, 4th Edition, 2019.
7.	P.C. Sharma, "A text book of production technology",S. Chand and Company, 10th Revised Edition, 2010.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	√		√	√	√	√	√		√				√	
CO2	√	√	√	√	√	√	√		√				√	
CO3	√	√	√	√	√	√	√		√				√	
CO4	√		√	√	√	√	√		√				√	
CO5	√		√	√	√	√	√		√				√	

Course Code	Course Name	Semester	Credits	L T P C
	MATERIALS ENGINEERING	1		3 0 0 3

COURSE OBJECTIVES

- Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
- To provide a detailed interpretation of equilibrium phase diagrams.
- Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

UNIT-I CRYSTAL STRUCTURE **9**

Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.

UNIT-II MECHANICAL PROPERTY MEASUREMENT **9**

Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength. Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, Introduction to nondestructive testing (NDT).

UNIT-III ALLOYS, SOLID SOLUTIONS AND PHASE DIAGRAMS **9**

Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron-carbon phase diagram and microstructure aspects of ledeburite, austenite, ferrite and cementite, cast iron.

UNIT-IV HEAT TREATMENT OF STEEL **9**

Annealing, tempering, normalizing and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening.

UNIT-V METALS AND ALLOYS **9**

Introduction to Nano Materials Alloying of steel, properties of stainless steel and tool steels, maraging steels-cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminum and Al-Cu – Mg alloys- Nickel based super alloys and Titanium alloys.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Identify crystal structures for various materials and understand the defects in such structures.
2.	Understand how to tailor material properties of ferrous and non-ferrous alloys and how to quantify mechanical integrity and failure in materials
3.	Understand the micro structural aspects and phases of Fe-C systems.
4.	Understand the various heat treatment process.
5.	properties and applications of ferrous and non ferrous metals.

TEXT BOOKS

1.	W. D. Callister, 2018, "Materials Science and Engineering-An Introduction", 10th Edition, Wiley India.
2.	Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.

REFERENCES

1.	V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 2015, 6th Edition.
2.	Jin U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 1st edition, 2011.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	√	√	√					√			√	√	√	√
CO2	√	√	√	√			√		√	√	√	√	√	√
CO3	√					√					√	√	√	√
CO4	√		√		√	√	√	√	√	√	√	√	√	√
CO5	√						√			√	√	√	√	√

SEMESTER - II

Course Code	Course Name	Semester	Credits	L T P C
	ELECTRONICS ENGINEERING	2		3 0 0 3

COURSE OBJECTIVES

- To provide an overview of electronic device components to Mechanical engineering students.

UNIT-I SEMICONDUCTOR DEVICES AND APPLICATIONS **9**

Introduction to P-N junction Diode and V-I characteristics, Half wave and Full-wave rectifiers, capacitor filter. Zener diode and its characteristics, Zener diode as voltage regulator. Regulated power supply IC based on 78XX and 79XX series, Introduction to BJT, its input-output and transfer characteristics, BJT as a single stage CE amplifier, frequency response and bandwidth.

UNIT-II OPERATIONAL AMPLIFIER AND ITS APPLICATIONS **9**

Introduction to operational amplifiers, Op-amp input modes and parameters, Op-amp in open loop configuration, op-amp with negative feedback, study of practical op-amp IC 741, inverting and non-inverting amplifier applications: summing and difference amplifier, unity gain buffer, comparator, integrator and differentiator.

UNIT-III TIMING CIRCUITS AND OSCILLATORS **9**

RC-timing circuits, IC 555 and its applications as table and mono-stable multi-vibrators, positive feedback, Barkhausen's criteria for oscillation, R-C phase shift and Wein bridge oscillator.

UNIT-IV DIGITAL ELECTRONICS FUNDAMENTALS **9**

Difference between analog and digital signals, Boolean algebra, Basic and Universal Gates, Symbols, Truth tables, logic expressions, Logic simplification using K- map, Logic ICs, half and full adder/subtractor, multiplexers, demultiplexers, flip-flops, shift registers, counters, Block diagram of microprocessor/microcontroller and their applications.

UNIT-V ELECTRONIC COMMUNICATION SYSTEMS **9**

The elements of communication system, IEEE frequency spectrum, Transmission media: wired and wireless, need of modulation, AM and FM modulation schemes, Mobile communication systems: cellular concept and block diagram of GSM system.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the principles of semiconductor devices and their applications.
2.	Design an application using Operational amplifier.
3.	Understand the working of timing circuits and oscillators.
4.	Understand logic gates, flip flop as a building block of digital systems.
5.	Learn the basics of Electronic communication system.

TEXT BOOKS

1.	Floyd ," Electronic Devices" Pearson Education 9th edition, 2015.
2.	R.P. Jain , "Modern Digital Electronics", Tata Mc Graw Hill, 4th Edition, 2010.
3.	Frenzel, "Communication Electronics: Principles and Applications", Tata Mc Graw Hill, 3rd Edition, 15th Reprint, 2008.

REFERENCES

1.	Floyd ," Electronic Devices" Pearson Education 9th edition, 2015.
2.	R.P. Jain , "Modern Digital Electronics", Tata Mc Graw Hill, 4th Edition, 2010.
3.	Frenzel, "Communication Electronics: Principles and Applications", Tata Mc Graw Hill, 3rd Edition, 15th Reprint, 2008.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	√	√			√								√	
CO2		√		√	√								√	
CO3	√	√			√								√	
CO4	√	√											√	
CO5	√				√					√			√	

Course Code	Course Name	Semester	Credits	L T P C
	THERMAL ENGINEERING	2		3 0 0 3

COURSE OBJECTIVES

- To apply the concept of thermodynamics to steam Nozzle & to understand the velocity triangle diagram of various turbines
- To understand the various systems of I.C. Engines
- To analyse the different gas power cycles
- The principles of reciprocating & rotary air compressors are studied
- To apply the concepts of thermodynamics to refrigeration & Air conditioning

UNIT- I FLOW THROUGH NOZZLE & STEAM TURBINES **9**

One-dimensional flow of steam through nozzle – Nozzle types - Critical pressure ratio – Nozzle efficiency - Super saturated flow in nozzles.
Impulse and Reaction turbine Principles - Compounding – Types - Velocity diagrams for simple and multistage turbines - Speed regulations – Governors.

UNIT-II I.C. ENGINES **9**

Classification – Working Principle - Components and their function. Valve timing & port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple Carburettor Diesel pump and injector system - Ignition System - Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculations.

UNIT-III GAS POWER CYCLES **9**

Air Standard Cycles - Otto, Diesel, Dual & Brayton cycle Analysis – methods of cycle improvement. Regenerative, intercooled, reheated cycles and their combinations –Performance Calculations.

UNIT-IV AIR COMPRESSORS **9**

Reciprocating Air Compressors – Classifications - Working principle – work done - Effect of clearance volume - Single and multi-stage compressors, Volumetric efficiency – calculation of power requirement – Rotary compressors (Working Principle).

UNIT-V REFRIGERATION & AIR CONDITIONING **9**

Refrigeration cycles- Reversed Carnot – Bell Coleman cycle - Vapour compression system –Super heating/Sub cooling - Vapour absorption refrigeration system- Properties of refrigerants. – Simple Problems on VCR system
Principles of air-conditioning - Types of A/C Systems –Industrial, Summer, Winter - Comfort and Year-round air conditioners – Window & Centralised A/C - Concept of GSHF – RSHF – ESHF.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Analyse the problems of nozzles & turbines.
2.	Explain the functioning & features of I.C. Engines & Calculate the performance of I.C. Engines.
3.	Analyse & solve the problems of air standard cycles.
4.	Analyse the performance behaviour of single & multi stage reciprocating air compressors.
5.	Understand the different Refrigeration & A/C systems and solve the problems of VCR system.

TEXT BOOKS

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

REFERENCES	
1.	Arora.C.P, "Refrigeration and Air Conditioning ," Tata McGraw-Hill Publishers, 3rd edition, 2017.
2.	Ganesan V.." Internal Combustion Engines",4th Edition, Tata McGraw-Hill 2017.
3.	Rudramoorthy, R, "Thermal Engineering ",Tata McGraw-Hill, New Delhi,2003.
4.	Sarkar, B.K,"Thermal Engineering" Tata McGraw-Hill Publishers, 2007.
5.	P. L. Ballaney, Thermal Engineering, Khanna Publishers, 2007, 24th Edition.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	√	√	√			√						√	√	
CO2	√	√	√			√						√	√	
CO3	√	√	√			√						√	√	
CO4	√	√	√			√						√	√	
CO5	√	√	√			√						√	√	

Course Code	Course Name	Semester	Credits	L T P C
	FLUID MECHANICS & MACHINERY	2		3 0 0 3

COURSE OBJECTIVES

- To understand the properties of fluids and concept of control volume.
- To understand the applications of the conservation laws to flow through pipes.
- To understand the importance of dimensional analysis
- To understand the importance of various types of flow in pumps.
- To understand the importance of various types of flow in turbines.

UNIT-I FLUID PROPERTIES & FLOW CHARACTERISTICS **9**

Units and dimensions - Types of flows - Properties of fluids - mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapor pressure – Gas laws - Surface tension and capillarity. Flow characteristics – concept of control volume – Bernoulli's Theorem – Concept of control volume – Application of continuity equation, energy equation, momentum equation and moment of momentum equation

UNIT - II FLOW THROUGH CIRCULAR CONDUITS **9**

Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli- Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation –friction factor- Moody diagram- commercial pipes- minor losses – Flow through pipes in series and parallel

UNIT-III DIMENSIONAL ANALYSIS **9**

Dimensional analysis – methods of dimensional analysis - Similitude –types of similitude – Dimensionless parameters- Application of dimensionless parameters – Model analysis

UNIT-IV HYDRAULIC PUMPS **9**

Impact of jets - Euler's equation - Theory of roto-dynamic machines – various efficiencies - velocity triangles - Centrifugal pumps– Multi stage centrifugal pumps - working principle - work done by the impeller - performance curves – Priming – Cavitation - Reciprocating pump- working principle – Air vessels – Indicator diagram - Rotary pumps – Working Principles.

UNIT-V HYDRAULIC TURBINES **9**

Hydraulic turbines – Classification - working principles - Pelton wheel, Kaplan turbine - Francis turbine - velocity triangles - theory of draft tubes – Performance – Specific speed – Unit Quantities - Selection of turbines - governing of turbines - hydraulic coupling - Torque converter

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply mathematical knowledge to predict the properties and characteristics of a fluid.
2.	Analyse and calculate major and minor losses associated with pipe flow in piping networks.
3.	Mathematically predict the nature of physical quantities
4.	Analyse the performance of pumps
5.	Analyse the performance of turbines

TEXT BOOKS

1.	K.L. Kumar, Engineering Fluid Mechanics, S. Chand Publishing, 2016.
2.	Modi P.N. & Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi, 23rd edition, 2022.

REFERENCES	
1.	S. K. Som, G. Biswas, S Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 2017, 3rd Edition.
2.	K. R. Arora, Fluid Mechanics Hydraulics and Hydraulic Machines, Standard Publishers, 2017, 9th Edition.
3.	C. P. Kothandaraman & R. Rudramoorthy. Fluid Mechanics and Machinery, New Academia Science, 2012, 3rd Edition.
4.	Douglas J.F, Solving Problems in Fluid Mechanics Vol I & II, John Wiley & Sons Inc., 3rd edition, 1996.
5.	Victor L. Streeter and E. Benjamin Wylie & Keith W.Bedford. Fluid Mechanics, Mc Graw-Hill 1999, 8th Edition.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	√	√	√	√	√	√	√			√			√	√
CO2	√	√	√	√	√	√	√			√	√	√	√	√
CO3	√	√	√	√	√					√			√	√
CO4	√	√	√	√	√	√	√			√	√	√	√	√
CO5	√	√	√	√	√	√	√			√	√	√	√	√

Course Code	Course Name	Semester	Credits	L T P C
	MACHINE TOOLS AND METAL CUTTING	2		3 0 0 3

COURSE OBJECTIVES

- To understand the concepts metal cutting
- To provide knowledge on various types of lathes used
- To understand the difference between shaper planner and slotter in manufacturing domain
- To provide knowledge on different types of grinding machines and related tools for manufacturing various components
- To identify the basic gear manufacturing machines used in industries

UNIT - I THEORY OF METAL CUTTING **9**

Introduction, mechanics of metal cutting –Chip formation, Types of Chips, Cutting force calculations, Torque and Power Calculations in Machining, nomenclature of single point cutting tool, Tool materials, Influence of tool Geometry, Tool Life, machining time calculation, Machinability – evaluating and rating, metal cutting economics, problems in Merchant's circle, tool life, and machining time.

UNIT - II LATHE **9**

Centre lathe, constructional features, cutting tool geometry, various operations, taper turning methods, thread cutting methods, special attachments, machining time and power estimation. Capstan and turret lathes – automats – single spindle, Swiss type, automatic screw type, multi spindle - Turret Indexing mechanism, bar feed mechanism.

UNIT - III SHAPER, PLANER AND SLOTTER **9**

Introduction, types, specification, mechanism - holding devices, hydraulic drives in shaper, difference between shaper and planer.

UNIT - IV ABRASIVE PROCESSES **9**

Grinding wheel – specifications and selection, types of grinding process– cylindrical grinding, surface grinding, centreless grinding, internal grinding- micro finishing methods - Typical applications – concepts of surface integrity, broaching machines: broach construction – push, pull, surface and continuous broaching machines. Introduction, types and specifications, mechanisms, holding devices, types of milling operation. Milling tool nomenclature and its specifications, Indexing – Types-Simple, Compounding and differentials.

UNIT - V GEAR MANUFACTURING PROCESSES **9**

Gear manufacturing processes - Gear Machining-Forming or Form cutting - Gear generating process-Gear shaping, Gear hobbing Gear planning, Gear broaching. Bevel gear generation.
Gear finishing process- Gear Finishing Methods – Gear Shaving, Gear Grinding, Gear lapping, Gear honing.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the mechanics of metal cutting process
2.	Understand the various types of lathe machines
3.	Understand the shaper, planer and slotter machines
4.	Understand the application grinding operation in manufacturing
5.	Understand the gear manufacturing used in industries

TEXT BOOKS

1.	Kalpakjian and Schmid, Manufacturing processes for engineering materials (6th Edition)-Pearson India, 2014.
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 5th Edition, 2013.
3.	Degarmo's Materials and Processes in Manufacturing, Black & Kohser, Wiley, 13th edition, 2021.
4.	Hajra Choudhury, "Elements of Workshop Technology, Vol. I and II", Media Promotors Pvt Ltd., Mumbai, 2005.

REFERENCES	
1.	B.S. Magendran Parashar & R.K. Mittal,"Elements of Manufacturing Processes", Prentice Hall of India, 2003.
2.	P.N. Rao,"Manufacturing Technology",Tata McGraw-Hill Publishing Limited, 4th Edition, 2019.
3.	P.C. Sharma, "A text book of production technology",S. Chand and Company, 10th Revised Edition, 2010.
4.	Beddoes.J and Bibby M.J, 'Principles of Metal Manufacturing Processes', Elsevier, 2006.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	√	√	√	√	√							√	√	√
CO2	√	√	√	√	√							√	√	√
CO3	√	√	√	√	√							√	√	√
CO4	√	√	√	√	√							√	√	√
CO5	√	√	√	√	√							√	√	√

Course Code	Course Name	Semester	Credits	L T P C
	STRENGTH OF MATERIALS	2		3 0 0 3

COURSE OBJECTIVES

- To understand the nature of stresses developed in simple and composite bars.
- To understand the nature of stresses developed in beams.
- To understand the slope and deflection developed in beams.
- To calculate the elastic deformation occurring in various simple geometries for different types of loading.
- To understand the nature of stresses developed in cylinders and spheres for various types of simple loads.

UNIT - I SIMPLE STRESS AND STRAIN **9**

Deformation in solids– Hooke's law– stress and strain –tension, compression and shear stresses– composite bars - elastic constants and their relations–Volumetric, linear and shear strains.

UNIT - II SHEAR FORCE AND BENDING MOMENT DIAGRAM **9**

Beams and types–Transverse loading on beams– shear force and bend moment diagrams– Types of beam supports–Simply supported, over-hanging beams and cantilevers– Theory of bending of beams–bending stress distribution and neutral axis–shear stress distribution– point and distributed loads.

UNIT - III DEFLECTION OF BEAMS **9**

Deflection of a beam using double integration method, moment area method and macaulay's method– computation of slopes and deflection in beams–Maxwell's reciprocal theorems.

UNIT - IV TORSION OF SHAFT AND SPRINGS **9**

Torsion–Stresses and deformation in circular and hollow shafts– stepped shafts–Deflection of shafts fixed at both ends–Stresses and deflection of helical springs, laminated spring - principal stresses and principal planes– Mohr's circle.

UNIT- V THIN AND THICK CYLINDER **9**

Axial and hoop stresses in cylinders subjected to internal pressure–Deformation of thick and thin cylinders– Deformation in spherical shells subjected to internal pressure.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

1.	Tensile test on MS rod and twisted bar (Electronic UTM)
2.	Comparison of hardness value of steel, copper and aluminium using Rockwell and Brinell hardness measuring machines
3.	Estimation of notch toughness of steel using impact testing machine
4.	Estimation of spring constant under tension and compression
5.	Tension test on MS wire (Tensile Testing Machine)
6.	Torsion test on mild steel rod.
7.	Deflection Test on Steel and Wooden Beam

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Recognize various types loads applied on machine components of simple and composite bars.
2.	Recognize the stresses developed on various types of beams.
3.	Recognize the slope and deflection developed on various types of beams.
4.	Evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading.
5.	Understand the nature of internal stresses.

TEXT BOOKS	
1.	S. Ramamrutham and R. Narayan, Strength of Materials, Dhanpat Rai and Sons, New Delhi.2022, 20th Editon.
2.	L.S. Srinath, Advanced Mechanics of Solids, Tata McGraw HIll, 2017, 3rd Edition.
REFERENCES	
1.	Beer & Johnson, Mechanics of materials, SI Metric Edition, McGraw Hill, ISE, 17th edition, 2017.
2.	Gere and Timensenko, Mechanics of Materials, CBS Publishers, 7th edition, 2006.
3.	S.P. Timoshenko J.N Goodier, Theory of Elasticity, Mc Graw Hill International Edition, 3rd edition, 2017.
4.	S.M.A.Kazimi, Solid Mechanics, Tata McGraw Hill Publishing Company Ltd., First revised edition, 2006.
5.	Timoshenko & D.H. Young, J.V. Rao, Sukumar Pati, Engineering Mechanics, McGraw Hill, 5th edition, 2017.
6.	J. B. K Das & P.L. Srinivasa Murthy, Mechanics of Materials, Sapna Book House, 2018.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	√	√	√	√								√	√	
CO2	√	√	√	√								√	√	
CO3	√	√	√	√	√							√	√	
CO4	√	√	√	√								√	√	
CO5	√	√	√	√								√	√	

SEMESTER - III

Course Code	Course Name	Semester	Credits	L T P C
	HEAT AND MASS TRANSFER	5		3 0 2 4

COURSE OBJECTIVES

- To understand the mechanisms of conduction heat transfer under steady and transient conditions.
- To understand the mechanisms of convection heat transfer and boundary layer concept.
- To learn the thermal analysis and sizing of heat exchangers.
- To study the conduction heat transfer phenomena, predict the thermal conductivity of materials.
- To study the radiation heat transfer phenomena, predict the Stefan Boltzmann constant and emissivity.

UNIT- I	CONDUCTION	9

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction –– plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids – Use of Heisler's charts.

UNIT-II	CONVECTION	9

Free and Forced Convection – Hydrodynamic and Thermal Boundary Layer – Free and Forced Convection of external flow over Plates and Cylinders and Internal flow through tubes – Dimensional analysis (Forced & free convection)

UNIT-III	PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS	9

Nusselt theory of condensation – Regimes of Pool boiling and Flow boiling – Correlations in boiling and condensation – Heat Exchanger Types – Overall Heat Transfer Coefficient – Fouling Factor – Analysis – LMTD method – NTU method.

UNIT-IV	RADIATION	9

Black Body Radiation – Radiation laws – Grey body radiation – Shape Factor – Electrical Analogy – Radiation Shields – Radiation through gases.

UNIT-V	MASS TRANSFER	9

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state molecular Diffusion – Convective Mass Transfer – Momentum – Heat and Mass Transfer Analogy – Convective Mass Transfer Correlations.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

1.	Thermal conductivity of a metal rod
2.	Thermal conductivity measurement of pipe insulation using the lagged pipe apparatus
3.	Determination of the heat transfer coefficient under natural convection mode
4.	Determination of the heat transfer coefficient under forced convection mode
5.	Determination of the thermal conductivity of the composite wall
6.	Determination of the thermal conductivity of insulating powder
7.	Heat transfer from pin-fin apparatus (natural & forced convection modes)
8.	Determination of Stefan – Boltzmann constant
9.	Determination of the emissivity of a grey surface
10.	Effectiveness of Parallel/counter-flow heat exchanger
11.	Effectiveness of the Shell & tube heat exchanger
12.	Determination of heat transfer coefficient of film & dropwise condensation

13.	Determination of COP of a refrigeration system
CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Apply heat conduction equations to different surface configurations under steady state and transient conditions and solve problems
2.	Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems
3.	Explain the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems
4.	Conduct tests on heat conduction apparatus and evaluate thermal conductivity of materials.
5.	Conduct tests to evaluate the performance of parallel/counter flow heat exchanger & shell & tube heat exchanger apparatus.
TEXT BOOKS	
1.	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000
2.	Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 5th Edition, 2015.
3.	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2009.
REFERENCES	
1.	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 1998.
2.	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
3.	Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002
4.	Ozisik, M.N., "Heat Transfer", Tata McGraw Hill Book Co., 1994.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓			✓			✓			✓	✓	
CO2	✓	✓	✓			✓			✓			✓	✓	
CO3	✓	✓	✓			✓			✓			✓	✓	
CO4	✓	✓	✓			✓			✓			✓	✓	
CO5	✓	✓	✓			✓			✓			✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	THEORY OF MACHINES	5		3 0 2 4

COURSE OBJECTIVES

- To understand the force motion relationship in components subjected to external forces and analysis of standard mechanisms.
- To understand the motion resulting from a specified set of cam mechanisms for specified output motions.
- To understand the basic concepts of toothed gearing, kinematics of gear trains and the effects of friction in motion transmission and in machine components.
- To understand the principle in mechanisms used for speed, stability control and effects of unbalances resulting from prescribed motions in mechanism.
- To understand the effect of dynamics of free vibrations and forced vibration.

UNIT- I	MECHANISMS AND FORCE ANALYSIS	9

Mechanisms – Terminology and definitions – Kinematics inversions of 4 bar and slider crank chain – kinematics analysis in simple mechanisms – Velocity and acceleration polygon – Dynamic Force Analysis – Inertia Forces and Inertia Torque – Turning moment diagrams – Reciprocating engine mechanisms – Fluctuation of energy and speed, Weight of flywheels..

UNIT-II	CAMS	9

Classification of Cam and Follower – Displacement diagrams – Cam profile construction for Uniform velocity, Uniform acceleration, SHM and Cycloidal motion of follower.

UNIT-III	GEARS AND GEAR TRAINS	9

Fundamentals of toothed gearing – Spur gear terminology and definition – Involute as a gear tooth profile – Interchangeable of gears – Interference and under cutting – Minimum number of teeth to avoid interference – Contact ratio – Internal gears – cycloidal tooth form – Gear trains – Types of gear trains – Velocity ratio and Torque calculations in Epicyclic gear – Automobile differential.

UNIT-IV	BALANCING AND GOVERNORS	9

Static and dynamic balancing of rotating masses in same and different planes – Function of governors – Porter, Proell and Spring-loaded governors, Sensitivity, Stability, Hunting and Isochronisms – Calculation of equilibrium speeds and ranges of governors.

UNIT-V	VIBRATIONS	9

Introduction – Types of Vibration – Frequency of undamped system – Viscous damping – Damped free vibration – Stiffness of spring – Series, Parallel and combined springs – Critical speed of shafts – Torsional vibration – Forced vibration – Harmonic Forcing – Vibration isolation.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

DYNAMICS

1.	Study of cutting force using Lathe/Drill tool dynamometer
2.	Determination of critical speed of Whirling of shaft
3.	Static & dynamic balancing of rotors
4.	Dynamic balancing of masses using computerised M/C.
5.	Determination of M.I by suspension of Simple and compound pendulum method
6.	Study of undamped of free vibration of equivalent spring mass system
7.	Study of undamped torsional vibrations of single rotor system
8.	Porter, Proell and Hartnell Governors
9.	Characteristics of Hydrodynamics – Journal bearing.

10.	Cam and follower analysis.
CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Analyze the force motion relationship of standard mechanisms.
2.	Develop CAM profiles and analyze the motion of the follower.
3.	Analyze the gears and gear trains to transmit the motion in machine components.
4.	Analyze and calculate speed, stability control in mechanisms and effects of unbalances in mechanism.
5.	Analyze the effect of dynamics of free and forced vibrations.
TEXT BOOKS	
1.	Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2017.
2.	R.S. KHURMI & GUPTA .J.K, A TEXT BOOKS of Theory of Machines, S. Chand & Co., 2008, 14th Edition.
3.	Ramamurthi. V, "Mechanics of Machines", Narosa Publishing House, 3rd edition 2019.
REFERENCES	
1.	Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanisms and Machines", Affiliated East-West Pvt. Ltd., 1988..
2.	Rao.J.S. and Dukkipati.R.V. "Mechanism and Machine Theory", New Age International Pvt. Ltd., 2nd edition, 2014.
3.	P.L.Ballaney, Theory of Machines, Khanna Publishers, 2005, 24th Edition.
4.	S.S.Rattan, Theory of Machines, Tata McGraw Hill. 2008, 2nd Edition.
5.	Sadhu Singh, Theory of Machines, Pearson Education Ltd, 2007.
6.	Wilson and Sadler, Kinematics and Dynamics of Machinery, Pearson, 2008.
7.	Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw-Hill, 2013.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓	✓										✓
CO2	✓	✓	✓	✓									✓	
CO3	✓	✓	✓	✓										✓
CO4	✓	✓	✓	✓									✓	
CO5	✓	✓	✓	✓									✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	DESIGN OF MACHINE ELEMENTS	5		3 0 0 3

COURSE OBJECTIVES

- To familiarize various steps involved in the design process and failure of machine parts.
- To understand the design principles of shafts with cyclic loads and various springs.
- To know the design procedures of shafts, keys and couplings
- To study and analyse welded and riveted joints.
- To understand and design various types of joints for assembly.

UNIT- I	DESIGN PROCESS AND THEORIES OF FAILURES	9

Introduction to design process – Factors influencing the machine design, Selection of materials based on its physical properties – Direct, bending and torsional stress equation – impact and shock loading – Criteria of failure – Factor of safety – design stress – theories of failures – Simple problems.

UNIT-II	VARIABLE STRESSES AND DESIGN OF SPRINGS	9

Variable and cyclic loads – Fatigue strength and limit, S-N curve, Stress concentration factor, Size factor, Surface finish factor, Combined cyclic stress, Soderberg's and Goodman's equations. Design of helical, leaf, disc, and torsional springs under constant load and varying load.

UNIT-III	DESIGN OF SHAFTS AND COUPLINGS	9

Design of solid and hollow shaft based on strength, rigidity, combined twisting and bending, shafts with fluctuating loads – Keys – Types, design and drawing of keys, keyways – Couplings – types, design of rigid and flexible couplings.

UNIT-IV	DESIGN OF WELD AND RIVETED JOINTS	9

Welded joints – Strength of transverse and parallel fillet joints, Stress concentration factor for welded joints, Eccentrically loaded joints – Riveted joints – failure of riveted joints, strength, efficiency – Design of riveted joints for pressure vessel and structure.

UNIT-V	DESIGN OF THREADED FASTENERS AND COTTER JOINTS	9

Threaded fasteners, Design of socket and spigot cotter joint, sleeve and cotter joint, gib and cotter joint – knuckle joints and pipe joints.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Get familiarized in various steps involved in the design process.
2.	Understand and design shafts with cyclic stresses and various springs.
3.	Design shafts with different loads, keys and couplings.
4.	Design and evaluate the features of welded and riveted joints.
5.	Design various types of joints for assembly of machine structures.

TEXT BOOKS

1.	Joseph Edward Shighley, Mechanical Engineering Design, McGraw Hill. 2008, 8th Edition.
2.	R.S. Khurmi & J.K. Gupta, A TEXT BOOKS of Machine Design, S. Chand & Co.,
3.	Donaldson. C, Tool Design, Tata McGraw Hill & Co.

REFERENCES

1.	A.S. Hall, A.R. Holowenko, And H.G. Laughlim, Theory And Problems In Machine Design Schaum's series
2.	Hall And Allen. S. Machine Design, Schaum's Series. 2008, TMH.
3.	M.F. Spolts, Design of Machine Elements, Pearson Education, 2005, 7th Edition.

4.	Gitin M. Maitra, Hand Book of Mechanical Design, 2nd Edition.
5.	J. B. K Das, Design of Machine Elements, Sapna Book House, 2007, 2nd Edition.
6.	A. S. Ravindra, Design of Machine Elements, Best Publishers, 2005. 2nd Edition.
7.	V. B. Bhandari, Design of Machine Elements, TMH, 2007.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓			✓				✓			✓	✓
CO2	✓	✓	✓	✓			✓			✓			✓	
CO3	✓	✓	✓	✓		✓	✓			✓			✓	✓
CO4	✓	✓	✓	✓		✓				✓				✓
CO5	✓	✓	✓	✓			✓			✓			✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	POWER PLANT ENGINEERING	5		3 0 0 3

COURSE OBJECTIVES

- To understand the layout and various systems of coal based thermal power plant.
- To have the knowledge of types of boilers, mountings/accessories.
- To understand the layout and various systems of gas, diesel and hydel power plants.
- To understand the layout and various systems of nuclear power plant.
- To study the economics of power plant & estimate the costs of electrical energy generation.

UNIT- I	THERMAL POWER PLANT	9

Essential of steam power plant equipment – Power station design – Characteristics of steam power plant – Layout – Stokers – Types– Pulverized fuel firing – Principles of FBC – Types & arrangement of different FBC plants – Ash handling – Dust collectors – Draft measurements – Chimneys – Calculation of chimney heights – Feed water treatment – Air preheater – Super heaters, condenser, and cooling towers.

UNIT-II	STEAM GENERATORS	9

Boilers – Types of modern high-pressure boiler – Boiler mountings and accessories – Thermal efficiency of boiler – Boiler performance – Selection of fuel for boiler – Boiler maintenance – Selection of boiler – Heat balance sheet for boiler – Indian boiler act.

UNIT-III	GAS TURBINE, HYDEL& DIESEL POWER PLANT	9

Gas turbine power plant layout - Classification &comparison of different types – Governing system – Hydro-electric power plant layout - Classification – Storage reservoir plants – Pump storage plants – MHD power plant – Diesel power plant layout.

UNIT-IV	NUCLEAR POWER PLANT	9

Nuclear Reactor – General components – Types of reactors – Pressurized water reactor (PWR) – Boiling water reactor (BWR), Heavy water cooled and moderated – Reactor – Gas cooled reactor – Liquid metal cooled reactor – Fast breeder reactor – Site selection of nuclear power plant – Comparison of nuclear power plant with thermal power plant – Nuclear materials – Fuels – Coolant – Moderators & reflecting materials – Control rod – Shielding materials.

UNIT-V	POWER PLANT ECONOMICS	9

Load curves – Terminologies – Effect of variable load on power plant design & operation – Requirement of peak load plants – Fixed or operating cost – Load diversion – Power tariff methods – Comparison of economics of various power plants – Environmental hazards of various power plants.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Explain the layout, construction and working of the components inside a thermal power plant.
2.	Discuss the types of steam boilers & its performance
3.	Explain the layout, construction and working of the components inside a Diesel, Gas and hydel power plants.
4.	Explain the layout, construction and working of the components inside nuclear power plant.
5.	Explain the applications of power plants while extend their knowledge to power plant economics and environmental hazards and estimate the costs of electrical energy generation.

TEXT BOOKS

1.	El-Wakil. M.M., "Power Plant Technology", Tata McGraw – Hill Publishing Company Ltd., 2019
2.	Archiew, Culp Jr., Principle of Energy Conversation, Tata McGraw Hill, 1979
3.	P. K. Nag, Power Plant Engineering, Tata McGraw Hill, 2017.4th Edition
4.	G. R. Nagpal, Power Plant Engineering, Khanna Publishers, Sixteenth edition, 1995

REFERENCES	
1.	Vopal and Stortzki, Power Plant Engineering, PHI, year.
2.	Domkundwar, Power Plant Engineering, Dhanpat Rai & Sons, Eight Edition, 2016.
3.	Joel Weisman and Roy Eckart, Morden Power Plant Engineering, Prentice Hall, 1985.
4.	Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, "Power Plant Engineering", Second Edition, Standard Handbook of Tata McGraw – Hill, 2nd edition, 2012.
5.	V. Kadambi, An Introduction to Energy Conversion, New Age Publication Ltd, 2011

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓			✓					✓			✓	✓	
CO2	✓	✓	✓	✓		✓			✓			✓	✓	
CO3	✓	✓	✓			✓			✓			✓	✓	
CO4	✓	✓							✓			✓	✓	
CO5	✓	✓							✓			✓	✓	

SEMESTER - IV

Course Code	Course Name	Semester	Credits	L T P C
	OPERATION RESEARCH & MANAGEMENT	6		3 0 2 4

COURSE OBJECTIVES

- Formulate real-life engineering and managerial problems as Linear Programming problems using Graphical method and Simplex algorithm.
- Formulate and solve Transportation and Assignment problems.
- Analyze project scheduling problems using CPM and PERT techniques.
- Apply EOQ, quantity discount, multi-product inventory and single-server & multi-server queuing models.
- Formulate and solve replacement, search, and dynamic programming models.

UNIT- I	LINEAR PROGRAMMING, GRAPHICAL METHOD, AND SIMPLEX METHOD	9

Introduction – Structure of Linear Programming – Advantages of Using Linear Programming – Limitations of Linear Programming – Application Areas of Linear Programming – General Mathematical Model of Linear Programming – Guidelines on Linear Programming Model Formulation – Examples of LP Model Formulations.
The Graphical Method: Introduction – Important Definitions – Graphical Solution Methods of LP Problems – Special Cases in Linear Programming.
The Simplex Method: Introduction – Standard Form of LP Problem – Simplex Algorithm (Minimization Case) – Simplex Algorithm (Maximization Case): The Big-M Method.

UNIT-II	TRANSPORTATION AND ASSIGNMENT PROBLEMS	9

Transportation Problem: Introduction – Mathematical Model of Transportation Problem – The Transportation Algorithm – Method for finding Initial Solution – Test for Optimality – Variations in Transportation Problem – Maximization Transportation Problem – Tran-Shipment Problem.
Assignment Problem: Introduction – Mathematical Model of Assignment Problem – Solution Method of Assignment Problem – Variations of Assignment Problem – A Typical Assignment Problem – Travelling-Salesman Problem.

UNIT-III	THEORY OF GAMES AND SEQUENCING PROBLEMS	9

Theory of Games: Introduction – Two-Person Zero-Sum Games – Pure Strategies (Minimax and Maximin Principles):Games with Saddle Point – Mixed Strategies: Games without Saddle Point – The Rules (Principles) of Dominance – Solution Methods Games without Saddle Point.
Sequencing Problems: Introduction – Notations, Terminology and Assumptions – Processing *n* jobs through Two Machines – Processing *n* jobs through Three Machines – Processing *n* jobs through *m* machines – Processing Two jobs through *m* machines.

UNIT-IV	DETERMINISTIC INVENTORY MODELS – REPLACEMENT AND MAINTENANCE MODELS	9

Deterministic Inventory Control Models: Introduction – The Meaning of Inventory Control – Functional Role of Inventory – Reasons for Carrying Inventory – Factors involved in Inventory Problem Analysis – Inventory Model Building – Single Item Inventory Control Model without Shortages – Single Item Inventory Control Model with Shortages.
Replacement and Maintenance Models: Introduction – Types of Failures – Replacement of Items whose Efficiency Deteriorates with Time – Replacement of Items that Completely Fail.

UNIT-V	PROJECT MANAGEMENT: PERT AND CPM	9

Introduction – Basic differences between PERT and CPM – Phases of Project Management – PERT/CPM Network Components and Precedence Relationships – Critical Path Analysis – Project Scheduling with Uncertain Activity Times – Project Time-Cose Trade-off.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

Tool Used: Microsoft Excel Solver Add-in will be used to solve operations research problems hands-on

1.	**Linear Programming:**

	a) Simplex method, b) Integer Programming
2.	**Transportation Problem:** a) Maximization Problem, b) Minimization Problem, c) Unbalanced problem.
3.	**Assignment Problem:** a) Maximization Problem, b) Minimization Problem, c) Unbalanced problem, d) Travelling Salesman Problem
4.	**Network Scheduling:** a) Problems on PERT, b) Problems on CPM
CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Formulate linear programming models for real-life problems and solve them using graphical and simplex methods.
2.	Model transportation and assignment problems and use standard algorithms to find optimal solutions, including basic variants.
3.	Analyze two-person zero-sum games with pure and mixed strategies and design suitable job sequencing schedules.
4.	Develop simple deterministic inventory and replacement models and compute suitable inventory policies and replacement plans.
5.	Draw PERT/CPM networks for projects, identify the critical path, and perform basic time–cost trade-off analysis.
TEXT BOOKS	
1.	Operations Research: Theory and Applications, J.K. Sharma, Sixth Edition (Reprint: 2017), TRINITY Press, Laxmi Publications PVT. LTD.
REFERENCES	
1.	Operations Research, Hamdy A. Taha, Prentice Hall, Eighth Edition, 2007.
2.	Operations Research, Gupta P.K. and Hira, D.S., S. Chand and Co. Ltd., New Delhi, Fifth Edition, 2001.
3.	Operations Research, Manmohan P.K. and Gupta, S.C, Sultan Chand and Co. New Delhi, Seventh Edition, 2001.
4.	Introduction to Operations Research, Fredrich. S. Hillier and Gerald . J. Liberman, McGraw Hill, Seventh Edition, 2001.
5.	Operations Research – Principle and Practice, Ravindran, Philips and Soleberg, John Wiley and sons, Second Edition, 1987.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	SUSTAINABLE MANUFACTURING	**6**		**3 0 0 3**

COURSE OBJECTIVES

- To provide students with a clear understanding of sustainability principles
- To enable students to analyze material selection and energy usage in manufacturing processes
- To develop knowledge of cleaner production methods and green manufacturing practices
- To equip students with the ability to evaluate environmental impacts of products
- To provide insights into industrial waste management for improving overall environmental performance.

UNIT- I	**Introduction to Sustainability and Manufacturing**	**9**

Concept of sustainability and sustainable development - Triple Bottom Line (economic, environmental, social aspects) - Need for sustainable manufacturing - Environmental issues in manufacturing industries - Global standards and regulations (ISO 14000).

UNIT-II	**Materials and Energy in Manufacturing**	**9**

Sustainable material selection - Renewable and non-renewable resources - Energy consumption in manufacturing processes - Energy efficiency and conservation techniques - Waste minimization and resource optimization.

UNIT-III	**Green Manufacturing Processes**	**9**

Cleaner production and green manufacturing concepts - Sustainable machining and forming processes - Eco-friendly cutting fluids and lubricants - Additive manufacturing and sustainability benefits - Process optimization to reduce emissions and waste.

UNIT-IV	**Life Cycle Assessment and Product Design**	**9**

Introduction to Life Cycle Assessment (LCA) - Phases: Goal definition, inventory analysis, impact assessment, interpretation - Environmental impact indicators (carbon footprint, water footprint) - Design for Environment (DfE) - Design for disassembly, reuse, and recycling.

UNIT-V	**Waste Management and Sustainable Systems**	**9**

Types of industrial waste and disposal methods - Recycling and reuse techniques - Concept of circular economy - green supply chain management - Case studies of sustainable manufacturing industries.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Understand sustainability principles in manufacturing.
2.	Analyze energy and material efficiency.
3.	Apply green manufacturing techniques.
4.	Perform basic LCA studies.
5.	Implement waste reduction and recycling strategies.
TEXT BOOKS	
1.	Sustainable Manufacturing: Fundamentals and Applications Author: David A. Dornfeld.
2.	Manufacturing Engineering and Technology Authors: Serope Kalpakjian & Steven Schmid.
3.	Introduction to Life Cycle Assessment Author: Mary Ann Curran.
REFERENCES	
1.	Green Manufacturing: Fundamentals and Applications Authors: David A. Dornfeld et al.
2.	Sustainable Manufacturing Author: Günther Seliger.
3.	Product Design for the Environment Author: Joseph Fiksel.
4.	Industrial Ecology and Sustainable Engineering Authors: Thomas E. Graedel & Braden R. Allenby.
5.	Waste Management for Sustainable Development Author: John Pichtel.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓		✓			✓	✓						✓	
CO2	✓	✓				✓	✓						✓	
CO3			✓	✓			✓						✓	
CO4	✓	✓				✓	✓						✓	
CO5	✓	✓				✓	✓						✓	

Course Code	Course Name	Semester	Credits	L T P C
	CAD / CAM	6		3 0 2 4

COURSE OBJECTIVES

- To understand the basics of CAD/CAM.
- To gain exposure over the concepts of computer graphics.
- To learn about the geometric issues concerned to the manufacturing and its related areas.
- To understand the latest advances in the manufacturing perspectives.
- To provide an overview of how computers are being used in design, development of manufacturing plants.

UNIT- I	COMPUTER AIDED DESIGN	9

Product Development Cycle – Introduction to CAD/CAM – Graphics I/O Devices – Bresenham's Algorithm and Digital Differential Analyzer (DDA), Graphics software – Clipping – Hidden line/surface removal – Color models – Lighting and shading – Graphics Standards – Neutral File formats – IGES & STEP.

UNIT-II	PRINCIPLES OF COMPUTER GRAPHICS	9

Geometric Modelling – Wireframe, Surface and Solid – Parametric representation of curves & surfaces – CSG and B-Rep – World/device coordinate representations – 2D & 3D Geometric transformations – Matrix representation – Translation, scaling, shearing, rotation and reflection – Composite transformations – Concatenation.

UNIT-III	MACHINE TOOLS	9

Introduction to NC, CNC, DNC – Manual part Programming – Computer Assisted Part Programming – Examples using NC codes – Adaptive Control – Canned cycles and subroutines – CAD / CAM approach to NC part programming – APT language – Machining from 3D models.

UNIT-IV	GROUP TECHNOLOGY, CAPP & FMS	9

Introduction to part families – Parts classification and cooling – Group technology machine cells – Benefits of Group technology – Process Planning – CAPP & Types of CAPP – Flexible manufacturing systems (FMS) – FMS concept – Transfer systems – Head changing FMS – Rapid prototyping – Knowledge Based Engineering.

UNIT-V	COMPUTER INTEGRATED MANUFACTURING	9

CIM wheel – CIM Database – CIM – OSI Model – Networking Standards in CIM Environment – Network structure – Network architecture – TCP/IP – MAP – Virtual Reality – Augmented Reality – Artificial Intelligence and Expert system in CIM.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

3D GEOMETRIC MODELLING

Creation of 3D assembly model of following machine elements using 3D modelling software
Introduction of 3D Modelling software

1.	Flange Coupling
2.	Plummer Block
3.	Screw Jack
4.	Lathe Tailstock
5.	Universal Joint
6.	Machine Vice
7.	Connecting rod
8.	Piston
9.	Crankshaft

MANUAL PART PROGRAMMING

I. Part Programming - CNC Machining Centre

1.	Linear Cutting.
2.	Circular cutting.
3.	Cutter Radius Compensation.
4.	Canned Cycle Operations.

II. Part Programming - CNC Turning Centre	
1.	Straight, Taper and Radius Turning.
2.	Thread Cutting.
3.	Rough and Finish Turning Cycle.
4.	Drilling and Tapping Cycle.
III. Computer Aided Part Programming	
1.	CL Data and Post process generation using CAM packages.
2.	Application of CAPP in Machining and Turning Centre.
3.	Study of CNC EDM, CNC EDM Wire-Cut and rapid Prototyping.
CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Understand the basics of CAD/CAM.
2.	Exposure over the concepts of computer graphics.
3.	Learn about the geometric issues concerned to the manufacturing and its related areas.
4.	Understand the latest advances in the manufacturing perspectives.
5.	Provide an overview of how computers are being used in design, development of manufacturing plants.
TEXT BOOKS	
1.	P.N. Rao, CAD/CAM: Principles and Applications 3rd Edition, Tata McGraw Hill, India, 2010.
2.	Ibrahim Zeid and R. Sivasubramaniam, Mastering CAD/CAM, 2nd Edition, Tata McGraw Hill, India, 2009
3.	Prof. Sham Tickoo, Pro/Engineer Wildfire 4.0: For Engineers And Designers, Dreamtech Press, 2008.
4.	K. Venugopal, Engineering Drawing & Graphics, New Age International, 2016.
REFERENCES	
1.	Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, 2007
2.	James A. Rehg, Henry W. Kraebber, "Computer Integrated Manufacturing", Pearson Education. 2007
3.	Donald Hearn and M.Pauline Baker "Computer Graphics" with OpenGL Prentice Hall, International, 2010
4.	Thomas Ewing French, Charles J. Vierck, Robert Jay Foster, Engineering Drawing and Graphic Technology, McGraw-Hill, 1993.
5.	Frederick E. Giesecke, Alva E. Mitchell, Henry C. Spencer , Technical Drawing with Engineering Graphics, Mechanical Design Technology, 2016.
6.	Kuang-Hua Chang, Machining Simulation Using SOLIDWORKS CAM, SDC Publications, 2019.
7.	Hans B. Kief, Helmut A. Roschiwal, CNC Handbook, McGraw Hill Professional, 2012.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓		✓		✓					✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓							✓	
CO3	✓	✓	✓	✓										✓
CO4	✓	✓	✓	✓									✓	✓
CO5	✓	✓	✓	✓									✓	

Course Code	Course Name	Semester	Credits	L T P C
	METROLOGY AND MEASUREMENTS	6		3 0 2 4

COURSE OBJECTIVES

- To understand the concept of metrology and principles of measuring instruments
- To understand the concept of different types of comparative measurements
- To gain the knowledge about calibration technique in measuring instruments
- To learn about various sensors used for measurement of mechanical quantities
- To identify the type of measuring instrument required for a specific application.

UNIT- I	BASICS OF METROLOGY	9

Definition of metrology - Objective of metrology - Precision and Accuracy - Sources of errors - Concept of Repeatability, Sensitivity, Readability and Reliability – Linear measurements – types – Vernier caliper – Micrometer – types - Vernier height gauges – depth gauges – Slip gauges – Angular measurements – Types - Vernier and optical Bevel protractor - Sine Principle and Sine Bar - Optical Instruments for angular measurement – Autocollimator - Angle Gauge.

UNIT-II	COMPARATIVE MEASUREMENT	9

Comparators – Introduction – Characteristics and uses – types – mechanical – Optical – profile projector – Electrical – pneumatic – Testing of straightness – Flatness – parallelism and circularity- Limit gauges – types- Taylors principle - Snap gauges – plain plug gauges – progressive plug gauges - Ring gauges – Thread pitch gauges - feeler gauges – radius gauges – engineers square and parallel – dial gauges – types – plunger type – needle type – Magnetic V block.

UNIT-III	CALIBRATION AND MEASURING DEVICES	9

Introduction – sensitivity – Range – standards – Traceability - Calibration of Vernier caliper – Micrometer – Dial gauges – Measurement using surface roughness tester – Co-ordinate measuring machine – Types - Tool makers microscope - Gear measurement – Gear tooth caliper – Circular pitch measuring machine – Parkinson gear tester – shore hardness tester – Surface plates – bore gauges – Machine tool metrology for Lathe.

UNIT-IV	PRESSURE, TEMPERATURE AND FLOW MEASUREMENTS	9

PRESSURE MEASUREMENT: Gravitational, Bourdon, Elastic transducers, strain gauge, Pressure cells, Measurement of high and low pressure, Dynamic characteristic of pressure measuring devices.
TEMPERATURE MEASUREMENT: Bi-metallic, pressure and resistance thermometer, Thermocouples, Pyrometer & Thermistors, Calibration. Pressure and temperature measurement in rotating systems – slip rings.
FLOW MEASUREMENTS: Orifice, Flow nozzle, Venturi, Pitot tube, Rotameter, Turbine type Anemometer, Hot-wire anemometer, Magnetic flow meter, Ultrasonic flow meter - Calibration.

UNIT-V	STRAIN, FORCE AND TORQUE MEASUREMENTS	9

STRAIN MEASUREMENT: Strain gauges, types, surfaces preparation and bonding technique, Wheatstone Circuit, Temperature compensation, Gauge rosettes, Calibration.
FORCE MEASUREMENT: Scales and balance, Elastic force meter, Strain gauge, Load cells Hydraulic and pneumatic load cells.
TORQUE MEASUREMENT: Mechanical torsion meter, Optical torsion meter, Electrical torsion meter, Strain gauge torsion meter.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

METROLOGY

1.	Use precision measuring instruments and calibration – Vernier calliper – Vernier height gauge – Micrometer (outside) dial gauge and depth gauge
2.	Measurement of gear tooth thickness by Gear tooth Vernier
3.	Measurements of angles and tapers using bevel tooth protractors, sine bar and sine centers
4.	Measuring fundamental dimensions of gear using profile projector
5.	Testing squareness of try square using slip gauges
6.	Determination of tool angle using tool makers microscope
7.	Use of mechanical comparator for determining – flatness
8.	Use of bore gauges or measuring internal diameter

9.	Taper and bore measurements using spheres
10.	Checking straightness of a surface plate using Autocollimator
11.	Measurement of surface roughness using roughness meter.
MEASUREMENTS	
1.	Pressure measuring devices – pressure & vacuum gauge calibration
2.	Temperature measuring devices – Thermocouples
3.	Speed measuring device – Stroboscope, tachometer
4.	Force measuring device – load cells, proving rings
5.	Torque measuring device – Rope & Prony brake arrangements
6.	Strain measurement - strain gauge
7.	Displacement measuring device – LVDT
8.	Velocity and acceleration measurement – Accelerometer - Piezo electric accelerators
9.	Vibration measurement – Vibrometer
CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Understand the basics of metrology and linear and angular measuring instruments
2.	Explain the working principles of comparators and limit gauges
3.	Determine the status of the measuring instruments and different parameters using measuring devices
4.	Understand the measurement of various quantities using instruments.
5.	Understand the types of sensors used in mechanical systems
TEXT BOOKS	
1.	R.K.Jain, Engineering Metrology, Khanna publishers, 21st edition, 1984
2.	Grant, Eugene.L "Statistical Quality Control", Tata McGraw-Hill, 7th edition, 2005
3.	Instrumentation and control systems by W. Bolton, 2nd edition, Newnes, 2000
4.	Thomas G. Beckwith, Roy D. Marangoni, John H. LienhardV , Mechanical Measurements (6th Edition), Pearson Education India, 2007
5.	Gregory K. McMillan, Process/Industrial Instruments and Controls Handbook, Fifth Edition, Tata McGraw-Hill: New York, 1999.
REFERENCES	
1.	Kumar. D.S. Mechanical Measurements & Control, Metropolitan Book Co., 1989
2.	Sirohi Rs. & Radhakrishnan H.C, Mechanical Measurement, New Age International (P) Ltd., 2005, 3rd Edition.
3.	Rangan C.S, Sarma G.S & Mani VSV, Instrumentation Device and Systems, TMH, 1989
4.	A. K. Sawhney, Mechanical Measurements and Instrumentation, Dhanpat Rai & Company (P) Ltd, 2007, 12th Edition
5.	R.K. Jain, Mechanical and Industrial Measurements, Khanna Publishers, 2004, 12th Edition.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓		✓	✓	✓							✓	✓
CO2	✓		✓	✓		✓							✓	
CO3		✓	✓		✓	✓								✓
CO4	✓		✓	✓									✓	
CO5	✓	✓			✓	✓								✓

SEMESTER - V

Course Code	Course Name	Semester	Credits	L T P C
	DESIGN OF TRANSMISSION SYSTEMS	7		3 0 0 3

COURSE OBJECTIVES

- To understand the design concepts and applications of bearings, belt, chain and rope drives.
- To know the basic concepts and applications of clutches, brakes and cams and to design them for suitable applications.
- To know the design procedure and to design spur and helical gears for industrial applications.
- To understand the working procedure and to design various machine parts like power screws, worm gears, bevel gears and ratchet mechanism.
- To understand the design procedure for gear box of an automobile.

UNIT- I	BEARINGS AND DRIVES	9

Design of sliding contact bearings using Somerfield number – Design using McKee's equation – Selection of rolling contact bearing for radial and axial load combination and for varying load cycles – Design of flat belt and V belt using manufacturer's data – Introduction to continuously variable speed transmission – Design of step cone pulley – Design of chain drives – Design of hoisting and hauling ropes.

UNIT-II	BRAKES, SCREWS AND CAMS	9

Design of clutches – Various service factors – Dry and wet clutches – Design of brakes - Heat generation and dissipation in brakes – Force analysis in drum brakes with external shoes – Permissible bearing pressure – Selection of brake material – Braking power – Power absorbed – Bearing load calculations – Width of shoe – Design of band brakes – Simple and differential type – Width and thickness design – Introduction to design of disk brakes – brake lining fade – Design of cams for parabolic, SHM, and cycloid follower motions – Undercutting in cams – Torque required to drive cams – Polynomial motion cams – Cam size determination – Inertia force calculation – Contact stress calculation.

UNIT-III	DESIGN OF SPUR AND HELICAL GEARS	9

Design of spur and helical gears – Design of Geneva wheel mechanism – Power rating calculations based on strength and wear considerations – Gear tooth correction.

UNIT-IV	DESIGN OF POWER SCREWS	9

Introduction – Design of power screws – Wear and strength considerations – Design of lead screws for machine tools – Design of screw jacks & toggle jacks – Design of bevel and worm gears – Design of Ratchet & Pawl mechanism.

UNIT-V	MULTI SPEED GEAR BOXES	9

Design of speed reducers – Design of multi speed gearboxes for Automobile – Machine tools – Structural diagrams – Ray diagrams.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the design concepts and applications of bearings, belt, chain and rope drives.
2.	Know the concepts and applications of clutches, brakes and cams and to design them for suitable applications.
3.	Design spur and helical gears for industrial applications.
4.	Explain the working procedure and to design various machine parts like power screws, worm gears, bevel gears and ratchet mechanism.
5.	Understand the design procedure for gear box of an automobile.

TEXT BOOKS

1.	Sundararajamurthy.T.V and Shanmugam, Machine Design, Khanna Publishers.
2.	Joseph Edward Shighley, Mechanical Engineering Design, McGraw Hill. 2008, 8th Edition.
3.	R.S. Khurmi & Gupta J.K, A TEXT BOOKS of Machine Design, S. Chand & Co.,

4.	Donaldson. C, Tool Design, Tata McGraw Hill & Co.
REFERENCES	
1.	V. Dobrovolsky, Machine Elements, Mir Publication, 1978.
2.	Shigley, Mechanical Engineering Design, McGraw Hill.
3.	Maitra, Handbook of Gear Design, Tata McGraw Hill.
4.	A.S. Hall, A.R. Holowenko, and H.G. Laughlim, Theory And Problems In Machine Design Schaum's series
5.	Hall and Allen. S. Machine Design, Schaum's Series. 2008, TMH.
6.	M.F. Spolts, Design of Machine Elements, Pearson Education, 2005, 7th Edition.
7.	Gitin M. Maitra, Hand Book of Mechanical Design, 2nd Edition.
8.	J. B. K Das, Design of Machine Elements, Sapna Book House, 2007, 2nd Edition.
9.	A. S. Ravindra, Design of Machine Elements, Best Publishers, 2005. 2nd Edition.
10.	V. B. Bhandari, Design of Machine Elements, TMH, 2007.
11.	A.S.Holowenko, A.R., and Laughlin H.G Theory and problems in Machine Design, Hall, Schaum's series.
Hand Book	
1.	Design data book, PSG College of technology, Coimbatore. (Use of approved data books are permitted in all the examinations)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓		✓	✓				✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓			✓				✓	✓
CO3	✓	✓								✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓			✓				✓	✓
CO5	✓	✓		✓		✓	✓	✓		✓		✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	MECHATRONICS	7		3 0 2 4

COURSE OBJECTIVES

- Understand the working principles of sensors, transducers, and measurement systems used in mechatronics
- Develop mathematical models for mechanical, electrical, thermal, and fluid systems.
- Analyze various actuation systems including pneumatic, hydraulic, and electrical actuators
- Understand the structure and programming of PLC and implement ladder logic.
- Design and analyze complete mechatronics systems for real-world applications.

UNIT- I	MECHATRONICS, SENSORS AND TRANSDUCERS	9

Introduction to Mechatronics Systems – Measurement Systems – Control Systems – Microprocessor based Controllers–Sensors and Transducers – Performance Terminology – Sensors for Displacement, Position and Proximity – Velocity, Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature – Light Sensors – Selection of Sensors.

UNIT-II	ACTUATION SYSTEMS	9

Pneumatic and Hydraulic System – Directional Control Valves – Rotary Actuators – Mechanical Actuation Systems – Cam, Gear Train, Ratchet & pawl, Belt & Chain Drives, Bearings – Electrical Actuation Systems – Mechanical Switches – Solid State Switches – Solenoids – D.C Motors – A.C Motors – Stepper Motors.

UNIT-III	SYSTEM MODELS AND CONTROLLERS	9

Building blocks of Mechanical, Electrical, Fluid and Thermal Systems – Rotational & Translational Systems – Electro-Mechanical Systems – Hydro-Mechanical Systems – Continuous and discrete process Controllers – Control Mode – Two-step mode, Proportional Mode, Derivative Mode, Integral Mode – PID Controllers – Digital Controllers – Velocity Control – Adaptive Control – Digital Logic Control – Micro Processor Control.

UNIT-IV	PROGRAMMING LOGIC CONTROLLERS	9

Introduction – Basic Structure – Memory – Input / Output Processing –Programming – Mnemonics – Timers, Internal relays and counters – Shift Registers – Master and Jump Controls – Data Handling – Analogs Input /Output – Selection of a PLC – Applications.

UNIT-V	DESIGN OF MECHATRONICS SYSTEMS	9

Stages in designing Mechatronics Systems – Traditional and Mechatronics Design – Possible Design Solutions – Case Studies – Pick and place robot – Automatic Car Park Systems – Engine Management Systems – Automatic Camera – Domestic Washing machine.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

1.	Design and testing of fluid power circuits to control. (i) velocity (ii) direction and (iii) force of single and double acting actuators
2.	Design of circuits with logic sequence using electro pneumatic trainer kit.
3.	Simulation of basic hydraulic, Pneumatic and electric circuits using software.
4.	PID controller interfacing.
5.	Modelling and analysis of basic electrical, hydraulic and pneumatic systems using Lab View software
6.	Computerized data logging system with control for process variables like Pressure, flow and temperature.
7.	Circuits with multiple cylinder sequences in electro pneumatic using PLC.
8.	Study and demonstration of various sensors (Optical, Proximity, Displacement, Motion Sensors).
9.	Interfacing and control of a stepper motor using PLC.
10.	Interfacing and control of a DC motor using PLC.

11.	Interfacing sensors with Arduino and displaying output.
12.	Interfacing sensors with ESP32 and transmitting data.
13.	Interfacing sensors with Raspberry Pi and performing basic data processing.
CO	**COURSE OUTCOMES**
At the end of the course, students will be able to	
1.	Explain different sensors, transducers, and their selection criteria.
2.	Model and analyze mechanical, electrical, thermal, and fluid systems.
3.	Evaluate and select appropriate actuators for mechatronics applications.
4.	Develop PLC programs using ladder diagrams for industrial automation.
5.	Design and implement mechatronics systems such as robots and automated systems.
TEXT BOOKS	
1.	W. Bolton, "Mechatronics", Pearson Education, 3rd Edition, 2007.
2.	HMT Ltd, Mechatronics, Tata McGraw Hill, 2007.
REFERENCES	
1.	Michael B. Histand and David G. Alciatore, "Introduction to Mechatronics and Measurement Systems", McGraw-Hill International Editions, 2007. 3rd Edition
2.	Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, "Mechatronics", Chapman and Hall, 1993.
3.	Dan Necsulesu, "Mechatronics", Pearson Education Asia, 2002 (Indian Reprint).
4.	Lawrence J. Kamm, "Understanding Electro – Mechanical Engineering", An Introduction to Mechatronics, Prentice – Hall of India Pvt., Ltd., 2000.
5.	Nitaigour Premchand Mahadik, "Mechatronics", Tata McGraw-Hill publishing Company Ltd, 2003
6.	Prof. C. R. Venkataramana, Mechatronics, Sapna Book House, 2003.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓	✓	✓							✓	✓	
CO2	✓	✓	✓	✓	✓						✓	✓	✓	
CO3	✓	✓	✓	✓	✓						✓	✓	✓	
CO4	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	FINITE ELEMENT ANALYSIS	7		3 0 2 4

COURSE OBJECTIVES

- To appreciate the use of FEM to a range of Engineering Problems and impart the basic knowledge in finite element method.
- To provide knowledge in 1D and 2D elements.
- To provide knowledge on isoperimetric elements and Numerical Integration methods.
- To gain knowledge and develop skill for the 1D, 2D and 3D component to find out stress distribution and reactions.
- To gain knowledge and develop skill for an axisymmetric component analysis.

UNIT- I	INTRODUCTION	9

Historical background – Matrix approach – Application to the continuum – Discretization – Matrix algebra – Gaussian elimination – Governing equations for continuum – Classical Techniques in FEM – Weighted residual method – Ritz method.

UNIT-II	ONE DIMENSIONAL PROBLEMS	9

Finite element modeling – Coordinates and shapes functions – Potential energy approach – Galarkin approach – Assembly of stiffness matrix and load vector – Finite element equations – Quadratic shape functions – Applications to plane trusses.

UNIT-III	TWO DIMENSIONAL CONTINUUM	9

Introduction – Finite element modelling – Scalar valued problem – Poisson equation – Laplace equation – Triangular elements – Element stiffness matrix – Force vector – Galarkin approach – Stress calculation – Temperature effects.

UNIT-IV	AXISYMMETRIC CONTINUUM	9

Axisymmetric formulation – Element stiffness matrix and force vector – Galarkin approach – Body forces and temperature effects – Stress calculations – Boundary conditions – Applications to cylinders under internal or external pressure – Rotating discs.

UNIT-V	ISOPARAMETRIC ELEMENTS FOR TWO DIMENSIONAL CONTINUUM	9

The four node quadrilateral – Shape functions – Element stiffness matrix and force vector – Numerical integration – Stiffness integration – Stress calculations – Four node quadrilateral for axisymmetric problems.

LIST OF EXPERIMENTS FOR LABORATORY COURSE

1.	Force and stress analysis using link elements in trusses, cables etc.
2.	Stress and deflection analysis in beams with different support conditions.
3.	Stress analysis of flat plates and simple shells.
4.	Stress analysis of axisymmetric components.
5.	Thermal stress and heat transfer analysis of plates.
6.	Thermal stress analysis of cylindrical shells.
7.	Vibration analysis of spring-mass systems.
8.	Model analysis of beams.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply the numerical methods to formulate the simple finite element problems
2.	Apply one dimensional finite element method to solve bar and truss type problems
3.	Apply two-dimensional finite element method to plane stress and strain type problems
4.	Determine temperature distribution of one-dimensional heat transfer problems using one dimensional finite element
5.	Implement finite element method using isoparametric elements

TEXT BOOKS	
1.	Chandrupatla T.R., And Belegundu A.D., "Introduction to Finite Elements in Engineering", Pearson Education 2002, 3rd Edition.
2.	David V Hutton "Fundamentals of Finite Element Analysis"2004. Tata McGraw-Hill Int. Ed.
3.	Rao S.S., "The Finite Element Method in Engineering", Pergammon Press, 1989
REFERENCES	
1.	Logan D.L., "A First course in the Finite Element Method", Third Edition, Thomson Learning, 2002.
2.	Robert D.Cook., David.S, Malkucs Michael E Plesha, "Concepts and Applications of Finite Element Analysis" 4 Ed. Wiley, 2003.
3.	REDDY J.N., "An Introduction to Finite Element Method", McGraw-Hill International Student Edition, 1985
4.	O.C.Zienkiewicz And R.L.Taylor, "The Finite Element Methods, Vol.1", "The basic formulation and linear problems, Vol.1", Butterworth Heineman, 5th Edition, 2000.
5.	C. S. Krishnamoorthy, Finite Element Analysis, TMH, 2007, 2nd Edition.
6.	K. J. Bathe, Finite Element Procedures, PHI, 2006,
7.	Desai Abel, Introduction to Finite Element Method, CBS Publishers, 2005.
8.	S. M. Murigendrappa, Fundamental of Finite Element Method, Interline Publishing, 2006.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓		✓		✓	✓						✓	✓
CO2	✓	✓	✓	✓	✓	✓		✓					✓	
CO3	✓	✓	✓		✓		✓	✓						✓
CO4	✓	✓	✓	✓		✓	✓						✓	
CO5	✓	✓	✓		✓	✓		✓						✓

SEMESTER - VI

Course Code	Course Name	Semester	Credits	L T P C
	AUTOMATION IN MANUFACTURING	8		3 0 0 3

COURSE OBJECTIVES

- To know the basic components of CIM and its hardware and software
- To understand about CAD/CAM and its integration with manufacturing
- To nurture the principles of computer aided process planning and GT
- To understand about different Control and monitoring systems used in CIM
- To study about FMS and its applications

UNIT- I	INTRODUCTION TO AUTOMATION SYSTEM	9

Production system facilities – Manufacturing Support Systems – Automation in Production Systems – Automated Manufacturing Systems – Types of Automation – Computerized manufacturing Support System – Reasons for Automating – Manufacturing Industries and Products – Manufacturing operations – Product / Production Relationships – Production Concepts and Mathematical Models – Basic elements of an Automated System – Advanced Automation Functions – Levels of Automation.

UNIT-II	INTEGRATION OF MANUFACTURING SYSTEM	9

Fundamentals of CAD, CAM and CAE – CIM Definition – CIM Wheel – CIM components – Evolution of CIM – Development of computers – Needs and Benefits of CIM – CIM Hardware & Software – CIM Models – DBMS and Network system – Data base and DBMS – Requirement, features and architecture of DBMS – CIM Communications (Network) System – Communication Matrix – Network Architectures – Tools and Techniques.

UNIT-III	AUTOMATED PROCESS PLANNING SYSTEM	9

Process Planning – Structure of Process Planning – Process Planning function – CAPP – Types of CAPP – Retrieval and Generative type – Concurrent engineering – Design for Manufacturing and Assembly – Advanced Manufacturing Planning – Group Technology – Coding and classification system – Production Flow Analysis (PFA) – Coding System – OPTIZ & MICLASS – Benefits of Group Technology – Machine cell design.

UNIT-IV	AUTOMATED CONTROL AND MONITORING SYSTEM	9

Fundamentals of NC Technology – Basic components of an NC System – NC Coordinate and Motion Control systems – Computer Numerical Control – Features of CNC – Machine Control Unit for CNC – CNC Software – DNC Machines – Application of NC machine tools – Applications & Structure of CNC Machines – CNC Controllers – NC Part Programming – Computer-Assisted Part Programming – Features and Applications of CNC Turning Centre – CNC Milling Machine – CNC Turn & Mill Centre – CNC machining Centre – CNC Tooling system – Automatic Tool Changing System – Computer Aided Quality Control – Contact, non-contact inspection methods – Coordinate Measuring Machine (CMM) – Integration of CAQC with CAD / CAM.

UNIT-V	FLEXIBLE MANUFACTURING SYSTEMS	9

Introduction of FMS – Components of FMS – Type of FMS – Classification of FMS Configurations – FMS Planning, scheduling and control – Knowledge Based Scheduling – Applications and Benefits of FMS – Production Support Machines and Systems – Industrial Robots – Automated Material Handling – Automatic Guided Vehicles (AGV) – Automated Storage and Retrieval system – Developments in Manufacturing Technologies – AI and Expert Systems – Agile manufacturing – Lean Manufacturing – Virtual Manufacturing – Simulation in Manufacturing – Factories of Future.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Classify the Production system and Automated Systems in Manufacturing
2.	Discuss the various Components, Evolution, Network and Data base system for CIM.
3.	Acquire Process Planning, part coding and Group technology concept
4.	Get CNC machining and programming knowledge
5.	Obtain Knowledge in Flexible Manufacturing.

TEXT BOOKS	
1.	Kant Vajpayee.S, Principles of Computer- Integrated Manufacturing; 1st ed. PHI
2.	Mikell P. Groover, Automation, Production Systems & CIM, 2nd ed. PHI.
3.	James A.Rehg, Henry W.Kraebber, Computer- Integrated Manufacturing, second Edition, Pearson Education.
4.	P.N. Rao, CAD/CAM Principles and Applications Second Edition, TMH.
REFERENCES	
1.	Radhakrishnan.P, Subramanyan. S, Raju.V, 'CAD/CAM/CIM', Second Edition, New Age International publishers,
2.	Daniel Hunt.V., 'Computer Integrated Manufacturing Hand Book', Chapman & Hall,
3.	Groover M.P, 'Computer Aided Design and Manufacturing', Prentice Hall of India,
4.	Yorem Koren, 'Computer Control of Manufacturing System', Tata McGraw Hill,
5.	Ranky Paul. G., 'Computer Integrated Manufacturing', Prentice Hall International,.
6.	ROGER MANNAM, Computer Integrated Manufacturing from Concepts of Realization 1st ed. Addison Wiley.
7.	P. N. Rao, Computer Aided Manufacturing, TMH.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓					✓							✓	
CO2	✓	✓	✓	✓									✓	✓
CO3	✓	✓	✓		✓									✓
CO4	✓	✓		✓									✓	
CO5	✓	✓			✓	✓		✓						✓

Course Code	Course Name	Semester	Credits	L T P C
	AUTOTRONICS	**6**		**3 0 0 3**

COURSE OBJECTIVES

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

- To make the students understand the evolution of electronics in automobiles and basics of charging and starting system.
- To provide student with knowledge on ignition and injection systems.
- To make the students learn about various sensors and actuators for controlling engine parameters.
- To acquaint students with various engine control systems.
- To teach the students about various chassis and safety system operation and applications.

UNIT- I	INTRODUCTION	9

Evolution of electronics in automobiles – emission laws – introduction to Euro I, Euro II, Euro III, Euro IV, Euro V standards – Equivalent Bharat Standards. Charging systems: Working and design of charging circuit diagram – Alternators – Requirements of starting system - Starter motors and starter circuits.

UNIT-II	IGNITION AND INJECTION SYSTEMS	9

Ignition systems: Ignition fundamentals - Electronic ignition systems - Programmed Ignition – Distribution less ignition - Direct ignition – Spark Plugs. Electronic fuel Control: Basics of combustion – Engine fuelling and exhaust emissions – Electronic control of carburetion – Petrol fuel injection – Diesel fuel injection.

UNIT-III	SENSOR AND ACTUATORS	9

Working principle and characteristics of Airflow rate, Engine crankshaft angular position, Hall effect, Throttle angle, temperature, exhaust gas oxygen sensors – study of fuel injector, exhaust gas recirculation actuators, stepper motor actuator, vacuum operated actuator.

UNIT-IV	ENGINE CONTROL SYSTEMS	9

Control modes for fuel control-engine control subsystems – ignition control methodologies – different ECU"s used in the engine management – block diagram of the engine management system. In vehicle networks: CAN standard, format of CAN standard – diagnostics systems in modern automobiles.

UNIT-V	CHASSIS AND SAFETY SYSTEMS	9

Traction control system – Cruise control system – electronic control of automatic transmission – antilock braking system – electronic suspension system – working of airbag and role of MEMS in airbag systems – centralized door locking system – climate control of cars.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the evolution of automotive electronics and charging system
2.	Develop through basic knowledge about various ignition and injection systems
3.	Analyse required sensors and actuators for an automotive application
4.	Understand the automotive electronics for engine management system
5.	Acquire knowledge on the safety systems of the automobile

TEXT BOOKS

1.	Ribbens, "Understanding Automotive Electronics", 7th Edition, Elsevier, Indian Reprint, 2013

REFERENCES

1.	Tom Denton, "Automobile Electrical and Electronics Systems", Edward Arnold Publishers, 2000
2.	Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 2001
3.	Richard K. Dupuy "Fuel System and Emission controls", Check Chart Publication, 2000
4.	Ronald. K. Jurgon, "Automotive Electronics Handbook", McGraw-Hill, 1999

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓			✓		✓					✓	✓	
CO2	✓	✓	✓		✓		✓					✓	✓	
CO3	✓	✓	✓	✓	✓		✓					✓	✓	
CO4	✓	✓	✓	✓	✓		✓					✓	✓	
CO5	✓	✓	✓		✓	✓	✓	✓				✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	PRODUCTION AND OPERATIONS MANAGEMENT	**6**		**3 0 0 3**

COURSE OBJECTIVES

- Understand the fundamentals of production systems, productivity, and strategic role of operations management.
- Learn product design, process planning, and capacity planning decisions.
- Apply forecasting techniques and facility location/layout planning methods.
- Analyze aggregate planning, inventory control models, and MRP systems.
- Develop skills in scheduling, project management techniques (CPM/PERT), and modern production tools like JIT and TQM.

UNIT- I	INTRODUCTION	9

Functional sub systems if organizations, Systems concept of production, Types of production systems, Productivity, Strategic management. Product Design and Analysis: New product development, Process Planning and Design, Value analysis and Value Engineering, Standardization, Simplification, Make or Buy decisions, Ergonomic considerations in Product design. Capacity Planning and Investment Decisions: Capacity planning and strategies, Investment formulas and comparisons of alternatives.

UNIT-II	FORECASTING AND FACILITY LOCATION AND LAYOUT	9

Forecasting: Introduction, Nature and use of forecasting, Measures of Forecasting, factors affecting forecasting, Types and models of forecasting. Facility Location and Lay out: Factors influencing plant location, location evaluation methods, Different types of lay outs for operations and production, arrangement of facilities within the department, CRAFT, ALDEP, CORELAP etc.

UNIT-III	MPS AND INVENTORY CONTROL	9

Aggregate Planning and Master Production Scheduling: Nature of aggregate planning, Methods of aggregate planning, Approaches to aggregate planning - graphical, empirical and optimization, Development of MPS, MRPI and MRPII. Inventory Analysis and Control: Definitions, ABC inventory systems, Inventory modals, EOQ models for purchased and manufactured parts, lot sizing techniques.

UNIT-IV	SCHEDULING AND PROJECT MANAGEMENT	9

Scheduling and Controlling: Objectives in scheduling, Major steps involved, Information systems linkages in production planning and control, Production control in repetitive, batch / flow shop and job shop scheduling environment - SPT, EDD, WMFT. Project Planning and Management: Phases of project planning, Evolution of network planning techniques - Critical Path Method (CPM) and Project Evolution and Review Technique (PERT), Crashing of project network, Project scheduling with constrained resources - RLT & RAT, Graphical Evolution and Review Technique (GERT), Project monitoring, Line balance.

UNIT-V	MODERN PRODUCTION MANAGEMENT TOOLS	9

Just In Time(JIT) - Introduction, elements, pull and push method, KANBAN systems, Small lot size, quick inexpensive set up, Continuous improvement, optimized production technology, CIM and FMS, Benefits and Scope of TQM, Factors affecting quality and Quality control activities in product cycle and ISO 9000 series - Scope and Benefits.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Explain production systems, productivity concepts, and strategic importance of operations management
2.	Apply product design techniques, value engineering, and capacity planning methods in real-world scenarios
3.	Analyze forecasting methods and design efficient facility layouts for production systems
4.	Evaluate inventory models, aggregate planning techniques, and MRP systems for effective resource management
5.	Apply scheduling techniques and project management tools like CPM and PERT
6.	Demonstrate knowledge of modern production systems such as JIT, Kanban, TQM, CIM, and

	FMS
TEXT BOOKS	
1.	
REFERENCES	
1.	Panneerselvam. R., 'Production and Operations Management', Prentice Hall India, 2001.
2.	Vollman.T.E., 'Manufacturing Planning & Control Systems', Galgotia publication (p) ltd, New Delhi, 1998.
3.	Dilworth. B. James., 'Operations Management - Design, Planning and Control for Manufacturing and services', Mc Graw Hill Inc., New Delhi, 1992.
4.	Bedworth D.D., 'Integrated Production Control Systems' - Management, Analysis, Design, John Wiley & sons, New York, 1982.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓								✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓					✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓					✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	MACHINE DRAWING PRACTICAL	5		0 0 4 2

COURSE OBJECTIVES

- To familiarize with the standard conventions for different materials and machine parts in working drawings.
- To understand the general aspects of Limits, Fits and Tolerances in the various parts of the machine drawings.
- To make part drawings including sectional views for various machine elements.
- To get the knowledge on the surface finish and welding symbols on the various machine elements.
- To prepare assembly drawings given the details of part drawings.

UNIT- I	FUNDAMENTALS OF ENGINEERING DRAWINGS	9

Indian standard code of practice for engineering drawing - BIS specifications – Conventional representations of threaded parts, springs, gear and common features – Conventions for sectioning and dimensioning.

UNIT-II	TOLERANCES AND FITS	9

General aspects of Limits – Tolerance – Types – Representation of tolerances on drawing – Fits – Types – Selection and specification of fits – Allowance.

UNIT-III	GEOMETRIC TOLERANCES	9

Geometric tolerances – Form and positional tolerances – Surface finish and welding symbols on the machine elements.

UNIT-IV	ASSEMBLY OF MACHINE ELEMENTS	9

Assembly and Detailed drawings of the various Machine Elements

UNIT-V	ASSEMBLY OF MACHINE TOOLS AND ENGINE PARTS	9

Joints: Cotter joint and knuckle joint - **Couplings:** Flange coupling and Universal coupling - **Engine parts:** Connecting rod and Cross head for horizontal and vertical engines - **Machine tool parts:** Plummer block, Lathe Tail stock, Screw Jack, Machine Vices Swivel bearing, Tool head shaper

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the significance of the standard codes & specifications of the machine components.
2.	Realize the importance of the conventional representations of machine parts, such as springs, gears and various threaded sections.
3.	Understand the fundamentals of the fits, tolerance and allowances of the various machine parts.
4.	Understand the working principles of an assembly of the final product from the various machine parts effectively.
5.	Apply their knowledge to produce new machine parts to meet the standards effectively.

TEXT BOOKS

1.	Gopalakrishnan K.R., "Machine Drawing", 22nd Edition, Subhas Stores Books Corner, Bangalore, 2013
2.	K.L. Narayana, P.Kannaiah & K.Venkata Reddy., "Machine Drawing", New Age Publishers, 4th Edition, 2012
3.	Dhawan., "Machine Drawing", S. Chand Publications, 1st Revised Edition,1998

REFERENCES

1.	N. D. Bhatt and V.M. Panchal, "Machine Drawing", 48th Edition, Charotar Publishers, 2013
2.	Junnarkar, N.D., "Machine Drawing", 1st Edition, Pearson Education, 2004
3.	N. Siddeshwar, P. Kanniah, V.V.S. Sastri, "Machine Drawing" , published by Tata Mc GrawHill, 2006
4.	Machine drawing – P.S. Gill S.K. Kataria & Sons Delhi
5.	P.S.G. Design Data book", Coimbatore

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
CO2	✓	✓	✓	✓									✓	✓
CO3	✓	✓	✓	✓			✓						✓	✓
CO4	✓	✓	✓	✓				✓			✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓						✓	✓	✓	✓

SEMESTER - VII

Course Code	Course Name	Semester	Credits	L T P C
	PRINCIPLES OF INDUSTRIAL MANAGEMENT	**7**		**3 0 0 3**

COURSE OBJECTIVES

- Understand the fundamental concepts, evolution, and environment of management.
- Learn the functions of management such as planning, organizing, staffing, leading, and controlling.
- Analyze individual and group behavior in industrial organizations.
- Develop knowledge of organizational structure, leadership, communication, and conflict management.
- Gain exposure to modern management concepts and tools used in industry.

UNIT- I	**MANAGEMENT AND ITS ENVIRONMENT**	**9**

Management – definition – functions, evolution of modern management, scientific management movement, development of management thoughts, different schools of management, forms of organization – individual ownership – partnership – companies – public sector undertakings, corporate framework – share holders – board of directors – committees – chief executive – line and functional managers, constraints – environmental – financial – legal – trade unions – technology - cooperative enterprises.

UNIT-II	**MANAGEMENT OF ORGANISATION**	**9**

Planning – nature and purpose – objectives – strategies – policies and planing premises – decision making, Organising - nature and process – premises – departmentalization – line and staff – decentralisation – organisational culture, Staffing – selection and training – placement – performance appraisal – career strategy, Leading – managing human factor – motivation, leadership – communication, Controlling – system and process of controlling – controlling techniques.

UNIT-III		**9**

Industrial Behavior - Organisational behavior – definition – managerial role and functions – organisational approaches, individual behavior – causes – environmental effect – behavior and performance, perception – organisational implications, personality – contributing factors – dimension - motivation – need theories – process theories – job satisfaction, learning and behavior – learning curves, work design and approaches.

UNIT-IV	**GROUP BEHAVIOR**	**9**

Groups – contributing factors – group norms, communication – process – barriers to communication – effective communication, managerial grid – leadership styles – group decision making – leadership role in group decision, group conflict.

Formal and informal – organisational structures, organisational change and development – change process – resistance to change – O.D. programme – culture and ethics.

UNIT-V	**MODERN MANAGEMENT CONCEPTS**	**9**

Management by objectives (MBO) – Principles and steps – advantages and disadvantages, management by exception (MBE), strategic management, planning for future direction – SWOT analysis – evolving development strategies, information technology in management – decision support systems –electronic commerce/business, newer concepts – business process reengineering (BPR) - enterprise resource planning (ERP) – supply chain management (SCM) – activity based management (ABM).

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Explain management principles, functions, and organizational structures in industrial environments.
2.	Apply planning, organizing, staffing, leading, and controlling techniques in real-world situations.
3.	Analyze individual behavior, motivation, and job satisfaction in organizations.
4.	Evaluate group dynamics, leadership styles, communication processes, and conflict resolution methods.
5.	Apply modern management tools such as MBO, ERP, SCM, BPR, and strategic management in decision-making.

6.	
TEXT BOOKS	
1.	HARROLD KOONTZ AND HEINZ WEIHRICH, Essentials Of Management, Mc Graw Hill.
REFERENCES	
1.	Jit. S. CHANDRAN, Organisational Behaviors, Vikas publishing House Pvt. Ltd., New Delhi.
2.	ERNEST DALE, Management Theory And Practice, International edition, Mc Graw Hill.
3.	
4.	

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓				✓		✓			✓	✓	✓	
CO2	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	
CO3	✓	✓				✓		✓	✓	✓	✓	✓	✓	
CO4		✓	✓			✓		✓	✓	✓	✓	✓	✓	
CO5	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	Principles of Industrial Management	**6**		**3 0 0 3**

COURSE OBJECTIVES

- Understand the fundamentals of production systems, productivity, and strategic role of operations management.
- Learn product design, process planning, and capacity planning decisions.
- Apply forecasting techniques and facility location/layout planning methods.
- Analyze aggregate planning, inventory control models, and MRP systems.
- Develop skills in scheduling, project management techniques (CPM/PERT), and modern production tools like JIT and TQM.

UNIT- I	**INTRODUCTION**	**9**

Functional sub systems if organizations, Systems concept of production, Types of production systems, Productivity, Strategic management. Product Design and Analysis: New product development, Process Planning and Design, Value analysis and Value Engineering, Standardization, Simplification, Make or Buy decisions, Ergonomic considerations in Product design. Capacity Planning and Investment Decisions: Capacity planning and strategies, Investment formulas and comparisons of alternatives.

UNIT-II	**FORECASTING AND FACILITY LOCATION AND LAYOUT**	**9**

Forecasting: Introduction, Nature and use of forecasting, Measures of Forecasting, factors affecting forecasting, Types and models of forecasting. Facility Location and Lay out: Factors influencing plant location, location evaluation methods, Different types of lay outs for operations and production, arrangement of facilities within the department, CRAFT, ALDEP, CORELAP etc.

UNIT-III	**MPS AND INVENTORY CONTROL**	**9**

Aggregate Planning and Master Production Scheduling: Nature of aggregate planning, Methods of aggregate planning, Approaches to aggregate planning - graphical, empirical and optimization, Development of MPS, MRPI and MRPII. Inventory Analysis and Control: Definitions, ABC inventory systems, Inventory modals, EOQ models for purchased and manufactured parts, lot sizing techniques.

UNIT-IV	**SCHEDULING AND PROJECT MANAGEMENT**	**9**

Scheduling and Controlling: Objectives in scheduling, Major steps involved, Information systems linkages in production planning and control, Production control in repetitive, batch / flow shop and job shop scheduling environment - SPT, EDD, WMFT. Project Planning and Management: Phases of project planning, Evolution of network planning techniques - Critical Path Method (CPM) and Project Evolution and Review Technique (PERT), Crashing of project network, Project scheduling with constrained resources - RLT & RAT, Graphical Evolution and Review Technique (GERT), Project monitoring, Line balance.

UNIT-V	**MODERN PRODUCTION MANAGEMENT TOOLS**	**9**

Just In Time(JIT) - Introduction, elements, pull and push method, KANBAN systems, Small lot size, quick inexpensive set up, Continuous improvement, optimized production technology, CIM and FMS, Benefits and Scope of TQM, Factors affecting quality and Quality control activities in product cycle and ISO 9000 series - Scope and Benefits.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
5.	Explain production systems, productivity concepts, and strategic importance of operations management
6.	Apply product design techniques, value engineering, and capacity planning methods in real-world scenarios
7.	Analyze forecasting methods and design efficient facility layouts for production systems
8.	Evaluate inventory models, aggregate planning techniques, and MRP systems for effective resource management
9.	Apply scheduling techniques and project management tools like CPM and PERT
10.	Demonstrate knowledge of modern production systems such as JIT, Kanban, TQM, CIM, and

	FMS
TEXT BOOKS	
2.	
REFERENCES	
11.	Panneerselvam. R., 'Production and Operations Management', Prentice Hall India, 2001.
12.	Vollman.T.E., 'Manufacturing Planning & Control Systems', Galgotia publication (p) ltd, New Delhi, 1998.
13.	Dilworth. B. James., 'Operations Management - Design, Planning and Control for Manufacturing and services', Mc Graw Hill Inc., New Delhi, 1992.
14.	Bedworth D.D., 'Integrated Production Control Systems' - Management, Analysis, Design, John Wiley & sons, New York, 1982.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓								✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓					✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓					✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

PROFESSIONAL ELECTIVE COURSES – I

(Product Design)

Course Code	Course Name	Semester	Credits	L T P C
	FLUID POWER SYSTEMS	**6**		**3 0 0 3**

COURSE OBJECTIVES

- To provide student with knowledge on the application of fluid power and about various types of hydraulic pumps.
- To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
- To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.
- To provide students with knowledge on pneumatics and is applications in industries.
- To teach the students about the various trouble shooting methods and applications of hydraulic and pneumatic systems.

UNIT- I	**FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS**	**9**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids – Pascal's Law and its application – Principles of flow & Pumping Theory – Pump Classification, Construction, Working, Design, Advantages, Disadvantages – Performance & Selection criterion of Linear, Rotary – Fixed and Variable displacement pumps.

UNIT-II	**HYDRAULIC ACTUATORS AND VALVES**	**9**

Hydraulic Actuators – Linear and Rotary Actuators – Types and construction – Hydraulic cushioning – Hydraulic control valves – Direction control valves – Flow control valves – Pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Types of actuation – Reservoirs – Cylinder mountings – Fluid Power ANSI Symbols.

UNIT-III	**HYDRAULIC SYSTEMS**	**9**

Accumulators – Application circuits – Intensifiers – Application circuit – Hydraulic circuits – Regenerative – Counter balance – Sequencing – Automatic Reciprocation – Synchronization – Speed control – Electrical control elements – Electro-hydraulic circuits – Cylinder control by limit switch – Reciprocation – Cylinder sequencing.

UNIT-IV	**PNEUMATIC SYSTEMS**	**9**

Properties of air – Perfect Gas Laws – Compressors – Filter, Regulator, Lubricator, Muffler, Air control Valves – Actuators – Pneumatic Circuits – Speed control – Quick exhaust – Air-Oil-reservoir circuit – Design of pneumatic circuit by cascade method.

UNIT-V	**TROUBLE SHOOTING AND APPLICATIONS**	**9**

Maintenance & Trouble Shooting in Hydraulic and Pneumatic systems – Design of hydraulic circuits for Shaper – Milling, Grinding & Pressing – Hydraulic lift – Conveyer feed system – Low cost Automation.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Acquire knowledge of the working principles of fluid power systems and hydraulic pumps.
2.	Acquire knowledge of the working principles of hydraulic actuators and control components.
3.	Understand different types of hydraulic circuits and systems.
4.	Explain the working of different pneumatic circuits and systems.
5.	Summarize the various troubleshooting methods and applications of hydraulic and pneumatic systems

TEXT BOOKS

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. Shanmugasundaram.K, "Hydraulic and Pneumatic Controls", S Chand & Co, 2006.

REFERENCES	
1.	Majumdar, S.R., "Oil Hydraulics Systems- Principles and Maintenance", Tata McGraw Hill, 2001
2.	Majumdar, S.R., "Pneumatic Systems – Principles and Maintenance", Tata McGraw Hill, 2007.
3.	Dudelyt, A Pease and John J Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
4.	Srinivasan.R, "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008.
5.	Joji.P, "Pneumatic Controls", John Wiley & Sons India, 2008

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓		✓									✓	✓	
CO2	✓		✓									✓	✓	
CO3	✓	✓	✓	✓			✓					✓	✓	✓
CO4	✓	✓	✓	✓			✓					✓	✓	✓
CO5	✓	✓	✓	✓		✓	✓					✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	PRODUCT DESIGN & DEVELOPMENT	6		3 0 0 3

COURSE OBJECTIVES

- To teach the students about the basic concepts of Product Design and Process Development.
- To expose the students about concept generation, selection and its testing for product development.
- To literate various parts of product architecture and its importance in product design and development.
- To explain the needs of various tools in industrial design process.
- To teach the students about the design for manufacturing and prototyping techniques used for product development.

UNIT- I	INTRODUCTION	9

Strategic importance of Product development – Integration of customer, designer, material supplier and process planner – Competitor and customer – Behavior analysis – Understanding customer – Promoting customer understanding – Involve customer in development and managing requirements – Organization process management and improvement.

UNIT-II	CONCEPT GENERATION, SELECTIONAND TESTING	9

Plan and establish product specifications – Task – Structured approaches – Clarification – Search externally and internally – Explore systematically – Reflect on the solutions and processes – Concept selection – Methodology – Benefits – Implications – Product change – Variety – Component standardization – Product performance – Manufacturability.

UNIT-III	PRODUCT ARCHITECTURE	9

Product development management – Establishing the architecture – Creation – Clustering – Geometric layout development – Fundamental and incidental interactions – Related system level design issues – Secondary systems – Architecture of the chunks – Creating detailed interface specifications – Portfolio Architecture.

UNIT-IV	INDUSTRIAL DESIGN	9

Integrate process design – Managing costs – Robust design – Integrating CAE, CAD, CAM tools – Simulating product performance & manufacturing processes electronically – Need for industrial design – Impact – Design process – Investigation of customer needs–conceptualization – Refinement – Management of the industrial design process.

UNIT-V	DESIGN FOR MANUFACTURINGAND PRODUCT DEVELOPMENT	9

Definition – Estimation of Manufacturing cost – Reducing the component costs and assembly costs – Minimize system complexity – Prototype basics – Principles of prototyping – Planning for prototypes – Economic Analysis.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Get familiarized about the basic concepts of Product Design and Process Development.
2.	Know about the importance of concept generation, selection and its testing.
3.	Get a clear vision on product architecture.
4.	Understand about various tools in industrial design process.
5.	Know about the prototyping techniques used for product development.

TEXT BOOKS

1.	Ulrich K.T. and Eppinger S.D., "Product Design and Development" Tata McGraw –Hill International Editions,1999.

REFERENCES

1.	BelzA., 36-Hour Course: "Product Development" Tata McGraw-Hill, 2010.
2.	Rosenthal S., "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
3.	Pugh S.," Total Design –Integrated Methods for successful Product Engineering", Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓		✓		✓	✓					✓		✓	
CO2	✓	✓	✓				✓						✓	✓
CO3	✓				✓				✓	✓	✓		✓	
CO4	✓		✓		✓							✓	✓	
CO5	✓	✓	✓		✓								✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	COMPOSITE MATERIALS	6		3 0 0 3

COURSE OBJECTIVES

- To learn about the fundamentals, classifications and need for composite materials.
- To know about the various manufacturing methods of polymer matrix composites.
- To learn about the properties and various processing techniques of metal matrix composites.
- To learn about the properties, classifications and production methods of ceramic composites.
- To know about the advances in composite materials and testing procedures.

UNIT- I	BASICS OF COMPOSITES	9

Introduction to composites – Need for composites – Enhancement of properties – Classification of composites – Matrix-Polymer matrix composites (PMC) – Metal matrix composites (MMC) – Ceramic matrix composites (CMC) – Reinforcement – Particle reinforced composites – Fiber reinforced plastics (FRP) – Applications and advantages of various types of composites.

UNIT-II	POLYMER MATRIX COMPOSITES	9

Introduction – Polymer matrix resins – Thermosetting resins – Thermoplastic resins – Reinforcement fibers – Rovings – Woven fabrics – Non woven random mats – Various types of fibers – PMC processes - Hand layup – Spray layup processes – Vacuum bagging – Compression moulding – Reinforced Reaction injection moulding – Resin transfer moulding – Pultrusion – Filament winding – Injection moulding.

UNIT-III	METAL MATRIX COMPOSITES	9

Introduction – Characteristics of MMC – Various types of Metal matrix composites – Alloy vs. MMC – Advantages of MMC – Limitations of MMC – Metal Matrix – Reinforcements – Particles – Fibers – Effect of reinforcement – Volume fraction – Rule of mixtures – Processing of MMC – Powder metallurgy process – Diffusion bonding – Stir casting – Squeeze casting.

UNIT-IV	CERAMIC MATRIX COMPOSITES	9

Introduction – Engineering ceramic materials – Properties – Advantages – Limitations – Monolithic ceramics – Need for CMC – Ceramic matrix – Various types of Ceramic Matrix composites – Oxide ceramics – Non oxide ceramics – Aluminium oxide – Silicon nitride – Reinforcements – Particles – Fibers – Whiskers – Sintering – Hot pressing – Cold Isostatic Pressing (CIP) – Hot Isostatic Pressing (HIP).

UNIT-V	ADVANCES IN COMPOSITES	9

Introduction – Carbon / Carbon composites – Advantages of carbon matrix – limitations of carbon matrix – Carbon fiber – Chemical Vapour Deposition of carbon on carbon fibre preform – Sol-gel technique – Composites for Aerospace applications – Introduction to Nano composites – Various testing procedures for composite materials – Eco-friendly composite materials.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Learn about the fundamentals of composite materials.
2.	Know the manufacturing methods of polymer matrix composites.
3.	Understand about the processing techniques of metal matrix composites.
4.	Know production methods of ceramic composites.
5.	Understand about the advances in composite materials.

TEXT BOOKS

1.	Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.
2.	Chawla K.K., "Composite materials", Springer – Verlag, 1987

REFERENCES

1.	Clyne T.W. and Withers P.J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.

2.	Strong A.B., "Fundamentals of Composite Manufacturing", SME, 1989.
3.	Sharma S.C., "Composite materials", Narosa Publications, 2000.
4.	"Short Term Course on Advances in Composite Materials, Composite Technology Centre, Department of Metallurgy", IIT- Madras, December 2001.
5.	Madhu Jit Mukho Padhyay, Mechanics of Composite Materials and Structures, University Press, 2004.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓		✓	✓					✓		✓	✓
CO2	✓		✓	✓	✓	✓						✓	✓	✓
CO3	✓	✓	✓	✓							✓	✓	✓	✓
CO4	✓	✓		✓	✓	✓							✓	✓
CO5	✓		✓		✓	✓					✓		✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	TRIBOLOGY IN DESIGN	6		3 0 0 3

COURSE OBJECTIVES

- To understand the concept and different types of friction
- To understand the concept and different types of wear
- To understand the mechanism of hydro static lubrication
- To understand the mechanism of hydro static lubrication
- To understand the concept and testing of lubricants

UNIT- I	FRICTION	9

Dry friction – Topography of surfaces – Contact between surfaces – Sliding friction – Energy dissipation – Theory of molecular attraction – Fretting corrosion and prevention – Variables in dry friction – Present concept of friction – Boundary friction – Oiliness – Variables of boundary friction – Friction characteristics of metals and non-metals– Rolling friction – Sources of measurement of friction.

UNIT-II	Wear	9

Wear – Types – Mechanism – Factors affecting wear – Adhesive wear – Abrasive Wear – Fatigue wear – Corrosive wear – Brittle fracture wear – Delamination – Wear measurement.

UNIT-III	VISCOSITY AND FLOW	9

Fundamentals of viscosity and flow – Petroff's equation – Friction torque – Viscosity measurement – Factors affecting viscosity – Principle of hydrostatic lubrication – Hydrostatic step bearing – Multi recess bearing – Design problems – Different types of compensation and their effect on bearing, parameters – Hydrostatic lift – Simple problems – Hydrostatic journal bearing – Simple problems – Hydrostatic squeeze films.

UNIT-IV	HYDRODYNAMIC LUBRICATION	9

Hydrodynamic lubrication – Solution of Reynold's equation – Application to tilting pad thrust bearing – Design of hydrodynamic journal bearings – Force feed of oil flow with various types of grooves – Dynamic bearings and rotor systems – Brief discussion – Lubrication systems – Bearing materials – Gas bearings – Elasto hydrodynamic lubrication.

UNIT-V	LUBRICANTS AND MAINTENANCE	9

Lubricants and maintenance – Lubricants – Types – Solids and liquid-properties – Additives – Testing – Reclamation of lubricants – Surface treatment – Phosphating of metal surface – Teflon coating – Predictive maintenance – Signature analysis and condition monitoring – Basic principles – Instrumentation.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	The mechanism and types of friction
2.	The mechanism and types of wear
3.	The mechanism of hydrostatic lubrication
4.	The mechanism of hydrodynamic lubrication
5.	The concept and testing of lubricants

TEXT BOOKS

1.	Hutchings. M, Tribology, Friction and Wear of Engg. Materials, Edward Arnold, London, 1992.
2.	Majumdar, Introduction of Tribology of Bearings, A.H.Wheeler & Co., 1986.

REFERENCES

1.	Ncalc, Newncs, Tribology Handbook, Butterworths, 1975.
2.	Dudley D.Fuller, Theory and Practice of Lubrication for Engineers, John Wiley & Sons, 1984.
3.	Cameron.A, Basic Lubrication Theory, Wiley Eastern Ltd., 1987.
4.	Bharat Bhusan & B.K.Gupta, Handbook of Tribology, Tata McGraw Hill Inc., 1991.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓							✓	✓	✓
CO2	✓	✓	✓	✓	✓							✓	✓	✓
CO3	✓	✓	✓	✓	✓							✓	✓	✓
CO4	✓	✓	✓	✓	✓							✓	✓	✓
CO5	✓	✓	✓	✓	✓							✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	GEOMETRIC DIMENSIONING AND TOLERANCING	6		3 0 0 3

COURSE OBJECTIVES

- Recognize the key GD&T terminology and comprehend the applied meaning of each
- Identify the engineering drawing symbols most closely associated with GD&T
- Differentiate between datums, datum features, and the parts of datum systems
- Understand various forms and orientation
- Understand various tolerances and its application

UNIT- I	INTRODUCTION	9

Dimensioning and Tolerancing – Dimensioning Units – Fundamental Dimensioning Rules Tolerancing Fundamentals – Maximum Material Condition (MMC) – Least Material Condition (LMC) – Basics of Fits – Dimensioning – Rules and Concepts of GD&T.

UNIT-II	DATUM CONTROL	9

Datums – Datum Feature Symbol – Datum Feature – The Datum Reference Frame Concept – Datum Target Symbols – Partial Datum Surface – Coplanar Surface Datums – Datum Axis – Movable Datum Target Symbols and Datum Target Points – Movable Datum Target Symbols and Datum Target Spheres – Datum Center Plane – The Center of a Pattern of Features as the Datum Axis.

UNIT-III	FORM AND ORIENTATION CONTROL	9

Introduction – Straightness, Flatness, Circularity, Free State Variation, Cylindricity Tolerance – Applying Form Control to a Datum Feature – Orientation Tolerances – Parallelism Tolerance – Perpendicularity Tolerance – Angularity Tolerance.

UNIT-IV	LOCATION TOLERANCE	9

Positional Tolerance – Locating Multiple Features – Positional Tolerancing of Coaxial Features – Positional Tolerancing of Nonparallel Holes – Locating Slotted Features – Positional Tolerancing of Spherical Features – Fasteners – Projected Tolerance Zone – Virtual Condition – Concentricity Tolerance – Positional Tolerancing for Coaxially – Symmetry – Composite – Mini Project – GD&T analysis of real-time product.

UNIT-V	PROFILE AND RUNOUT TOLERANCE	9

Non-Uniform Profile Tolerance Zone – Specifying Basic Dimensions in a Note – Combination of Geometric Tolerances – Runout Tolerances – Combination of Geometric Tolerances Specifying Independency – Development of gauge design using GD&T – Applying GD&T with CADD software Mini Project – GD&T analysis of real-time product.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Read and understand basic GDT symbols on a print.
2.	Explain basic GDT concepts.
3.	Identify minimum and maximum material conditions
4.	Measure and verify position tolerances with applied material conditions
5.	Set up and use basic rectangular datum reference frames

TEXT BOOKS

1.	Dimensioning and Tolerancing, Engineering Product Definition and Related Documentation Practices, ASMEY14.5-2018,2019.
2.	James D Meadows, Geometric Dimensioning and Tolerancing applications and techniques for use in design, manufacturing and inspection, Marcel Dekker Inc. 2009
3.	N D Bhatt and VM Panchal, Machine Drawing, Charotar Publishing, 2014.
4.	P.S. Gill, Geometric Dimensioning & Tolerancing, S.K. Kataria & Sons, 2013

REFERENCES

1.	David A. Madsen and David P. Madsen. Geometric Dimensioning and Tolerancing, 9th Edition, The Goodheart-Wilcox Company Inc, USA,2013.

2.	Hoda A. ElMaraghy. Geometric Design Tolerancing: Theories, Standards and Applications. 2nd edition Springer US. 2012
3.	Henzold. G. Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection. 2ndedition, Elsevier Science, 2006
4.	P.S. Gill Geometric Dimensioning and Tolerancing, S K Kataria and Sons, 2009

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓		✓								✓	✓	✓
CO2	✓	✓		✓								✓	✓	✓
CO3	✓	✓		✓								✓	✓	✓
CO4	✓	✓		✓								✓	✓	✓
CO5	✓	✓		✓								✓	✓	✓

PROFESSIONAL ELECTIVE COURSES - II

(Energy Systems)

Course Code	Course Name	Semester	Credits	L T P C
	REFRIGERATION & AIR CONDITIONING	7		3 0 0 3

COURSE OBJECTIVES

- To learn the concepts of refrigeration & its related cycles.
- To learn the concepts of refrigeration systems and the mechanisms of refrigeration equipments.
- To analyze the principles of other refrigeration systems.
- To apply the concepts of thermodynamics to air conditioning.
- To analyze the principles of air conditioning equipments.

UNIT- I	INTRODUCTION	9

Introduction to Refrigeration – Unit of Refrigeration and C.O.P. – Ideal cycles – Refrigerants – Desirable properties – Classification – Nomenclature – ODP & GWP.

UNIT-II	VAPOUR COMPRESSION REFRIGERATION SYSTEM	9

Vapor compression cycle – p-h and T-s diagrams – Deviations from theoretical cycle – Sub cooling and super heating – Effects of condenser – Evaporator pressure on COP – Multi pressure system – Low temperature refrigeration – Cascade systems – problems – Equipments – Type of Compressors – Condensers – Expansion devices – Evaporators (Elementary treatment).

UNIT-III	OTHER REFRIGERATION SYSTEMS	9

Working principles of Vapour absorption systems – Adsorption cooling systems – Steam jet refrigeration – Thermoelectric refrigeration – Air refrigeration – Magnetic – Vortex and Pulse tube refrigeration systems.

UNIT-IV	PSYCHROMETRIC PROPERTIES AND PROCESSES	9

Fundamental properties of psychometry – Use of psychometric chart – Psychometric processes – Grand and room sensible heat factor – By pass factor – Requirements of comfort air conditioning – Comfort and comfort chart – Factor governing optimum effective temperature recommended design conditions – ventilation standards.

UNIT-V	AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION	9

Air conditioning loads – Outside and inside design conditions – Heat transfer through structure – Solar radiation – Electrical appliances – Infiltration and ventilation – internal heat load – Apparatus selection – Fresh air load – Human comfort & IAQ principles – Effective temperature & chart – Calculation of summer & winter air conditioning load – Classifications & Layout of plants – Air distribution system – Filters – Air Conditioning Systems with Controls – Temperature, Pressure and Humidity sensors – Actuators & Safety controls.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Explain the basic concepts of refrigeration.
2.	Explain the vapor compression refrigeration systems and to solve problems
3.	Discuss the various types of refrigeration systems
4.	Calculate the psychrometric properties and its use in psychrometric processes
5.	Explain the concepts of air conditioning and to solve problems

TEXT BOOKS

1.	Arora, C.P., "Refrigeration and Air Conditioning", 3rd edition, McGraw Hill, New Delhi, 2017.
2.	P.L Ballany, "Refrigeration and Air conditioning" Khanna Publishers, 1972

REFERENCES

1.	Arora S.C and Domkundwar S, Refrigeration & Air Conditioning, Dhanpat Rai and Sons Publishers, 2007.

2.	Manohar Prasad, Refrigeration and Air Conditioning, Wiley Eastern Ltd, 2015
3.	Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2007.
4.	Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2011.
5.	Stoecker, W.F. and Jones J. W., "Refrigeration and Air Conditioning", Tata McGraw Hill, 2ndEdition, New Delhi, 2014.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓				✓		✓			✓	✓	✓
CO2	✓	✓		✓		✓	✓		✓			✓		✓
CO3	✓	✓	✓	✓		✓			✓			✓	✓	
CO4	✓	✓	✓			✓	✓		✓			✓		✓
CO5	✓	✓		✓		✓	✓					✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	ELECTRIC & HYBRID VEHICLES	**3**		**3 0 0 3**

COURSE OBJECTIVES

- To understand the concept of electric vehicles.
- To study about the motors & drives for electric vehicles.
- To understand the electronics and sensors in electric vehicles.
- To understand the concept of hybrid vehicles.
- To study about the EV manufacturing concepts, charging infrastructure, and servicing

UNIT - I	**Introduction to Electric Vehicles**	**9**

Electric Vehicle – Need - Types – Cost and Emissions – End of life. Comparison with ICE vehicles, types of EVs (BEV, HEV, PHEV, FCEV), Electric Vehicle - layouts, cables, major EV components, Controls. Batteries – overview and its types. Battery plug-in and life. Ultra-capacitor, alternate charging sources – Wireless & Solar.

UNIT - II	**Electric Vehicle Motors and Drive Systems**	**9**

Electric motors in EVs – DC, three-phase Induction, BLDC, PMSM, Switched Reluctance and Synchronous Reluctance motors – working principles, characteristics, and construction. Power rating design, Peak Power Source (PPS)– Basic structure of electric drive systems - Motor control techniques -Field Oriented Control (FOC) - **FOC Topologies/Variations - Pros and Cons of FOC for EV/HEV.**

UNIT - III	**Power Electronics, Control and Thermal Management**	**9**

Power Electronics Devices – Diodes, Thyristors, BJTs, MOSFETs, IGBTs, Converters, Inverters - Introduction to sensors, autonomous EV cars, Self-drive cars, Hacking, sensor-less – Introduction to control methods- Phase Flux Linkage-based Method, Phase Inductance-based, Modulated Signal Injection, Mutually Induced Voltage-Based, Observer-Based. Safety – Risks and Guidance, Precautions, High Voltage safety, Hazard management, and system-level thermal management of battery, motor, and power electronics. EMI/EMC, isolation, harmonics, reliability, and serviceability.

UNIT - IV	**Hybrid Vehicles**	**9**

Hybrid Electric vehicles – Classification – Micro, Mild, Full, Plug-in, EV. Layout and Architecture – Series, Parallel, and Series-Parallel (Power Split) hybrid drive train, Propulsion systems and components. Regenerative Braking, Economy, Vibration, and Noise reduction. Hybrid Electric Vehicles System – Analysis and its Types, Controls.

UNIT - V	**EV Manufacturing, charging, and Servicing**	**9**

EV manufacturing -Vehicle topology, Modular architecture and Skateboard platforms, Comparison of ICEVs and BEVs, Vehicle performance calculations, Battery sizing, Motor sizing- EV Charging – Methods and Standards-EV Maintenance, Diagnostics and Servicing practices.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Describe about working principle of electric vehicles.
2.	Analyse the operation and characteristics of electric motors and electric drive systems used in EV applications.
3.	Apply knowledge of power electronics, control techniques, and safety practices in electric vehicle systems.
4.	Describe the different types and working principle of hybrid vehicles.
5.	Evaluate EV performance parameters, battery and motor sizing, charging infrastructure, and servicing requirements of electric vehicles.

TEXT BOOKS

1.	Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2.	Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007
3.	Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric

	and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, Second Edition 2018.
4.	Electric Vehicle Technology, James Larminie and John Lowry, Wiley, 2003.
5.	C. Mi, M. A. Masrur, and D. W. Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd, Second Edition, 2018.
REFERENCES	
1.	Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
2.	Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
3.	Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
4.	Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.
5.	Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓			✓		✓					✓	✓	
CO2	✓	✓	✓	✓	✓		✓				✓	✓	✓	
CO3	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	
CO4	✓	✓			✓		✓					✓	✓	
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	ENERGY STORAGE TECHNOLOGIES	7		3 0 0 3

COURSE OBJECTIVES

- To understand the various types of energy storage technologies and its applications.
- To study the various modelling techniques of energy storage systems using TRNSYS.
- To learn working concepts and types of batteries.
- To make the students to get understand the concepts of Hydrogen and Biogas storage.
- To provide the insights on super capacitor, Fly wheel and compressed energy storage systems.

UNIT- I	Introduction	9

Need and role of energy storage systems in power system – General considerations – Energy and power balance in a storage unit – Mathematical model of storage system – Modelling of power transformation system (PTS) – Central store (CS) and charge-discharge control system (CDCS) – Econometric model of storage system – Applications.

UNIT-II	Thermal Storage System	9

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modelling of phase change storage system – Simple units – Packed bed storage units – Modelling using porous medium approach – Use of TRNSYS software.

UNIT-III	Electrical Energy Storage	9

Fundamental concept of batteries – Measuring of battery performance – Charging and discharging of a battery – Storage density – Energy density and safety issues – Types of batteries – Lead Acid – Nickel-Cadmium – Zinc-Manganese di-oxide and modern batteries for examples (i) zinc-Air (ii) Nickel Hydride (iii) Lithium Battery.

UNIT-IV	Hydrogen and Biogas Storage	9

Hydrogen storage options – Compressed gas – Liquid hydrogen – Metal Hydrides – Chemical Storage – Cryofuel storage and handling – Biogas storage – Comparisons – Safety and management of hydrogen and Biogas storage – Applications.

UNIT-V	Alternate Energy Storage Technologies	9

Flywheel – Super capacitors – Principles & Methods – Applications – Compressed air Energy storage – Concept of Hybrid Storage – Applications.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Identify the energy storage technologies for suitable applications
2.	Analyse the energy storage systems using TRNSYS.
3.	Summarise the concepts and types of batteries.
4.	Examine the principle of operation of Hydrogen and Biogas storage systems.
5.	Explain the working of super capacitor, Flywheel and compressed energy storage systems

TEXT BOOKS

1.	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2010
2.	Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015.

REFERENCES

1.	Viswanathan, M Aulice Scibioh, Fuel cell principle and applications, university press, First Edition, 2006.
2.	Luisa F. Cabeza, Advances in Thermal Energy Storage Systems: Methods and Applications, Elsevier Wood head Publishing, 2015.
3.	Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications,2012
4.	National Energy Technology Laboratory, U.S. Department of Energy, Fuel Cell Handbook (Seventh Edition).

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓		✓	✓	✓	✓					✓		✓	✓
CO2	✓		✓			✓		✓			✓			✓
CO3	✓		✓	✓	✓	✓		✓					✓	✓
CO4	✓		✓	✓		✓		✓			✓		✓	
CO5	✓			✓	✓	✓		✓						✓

Course Code	Course Name	Semester	Credits	L T P C
	ENERGY CONSERVATION IN INDUSTRIES	7		3 0 0 3

COURSE OBJECTIVES

- To Understand and analyze the energy data of industries, Energy Auditing and Role of Energy Managers.
- To understand the energy conservation in Transformers, electrical motors, energy-efficient and variable speed motors.
- To understand the methodology of improving the boiler performance, steam turbine & distribution systems
- To understand the energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems.
- To learn the concepts of Economic analysis of energy and Energy auditing.

UNIT- I	INTRODUCTION	9

Energy – Power – Past & Present scenario of World – National Energy consumption Data – Environmental aspects associated with energy utilization – Energy Auditing – Need – Types, Methodology and Barriers – Role of Energy Managers – Instruments for energy auditing.

UNIT-II	ELECTRICAL SYSTEMS	9

Components of EB billing – HT and LT supply – Transformers – Cable Sizing – Concept of Capacitors – Power Factor Improvement – Harmonics – Electric Motors - Motor Efficiency Computation – Energy Efficient Motors – Illumination – Lux & Lumens – Types of lighting – Efficacy – LED Lighting – Scope of Encon in Illumination.

UNIT-III	THERMAL SYSTEMS	9

Stoichiometry – Boilers – Furnaces and Thermic Fluid Heaters – Efficiency computation and encon measures – Steam – Distribution & Usage – Steam Traps – Condensate Recovery –Flash Steam Utilization – Insulators & Refractories.

UNIT-IV	ENERGY CONSERVATION IN MAJOR UTILITIES	9

Pumps – Fans – Blowers – Compressed Air Systems – Refrigeration and Air Conditioning Systems – Cooling Towers – D.G. sets – Case studies for energy conservation in various industries such as cement, iron and steel, glass, fertilizer, food processing, refinery etc.

UNIT-V	ECONOMICS	9

Energy Economics – Discount Rate – Payback Period – Internal Rate of Return – Net Present Value – Life Cycle Costing – ESCO concept

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply availability analysis of various thermodynamics processes, devices and cycles and explain the energy conservation in domestic, transportation, agricultural and industrial sectors.
2.	Apply the methodology of improving the boiler performance, steam turbine and distribution systems: explain the energy conservation in turbines.
3.	Explain the concepts of heat exchanger systems, heat pumps, heat pipes and heat recovery from industrial processes and apply the heat exchange networking, waste heat recovery and cogeneration schemes.
4.	Explain the energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems, emergency DG sets, illumination, electrical motors, energy efficient motors and variable speed motors.
5.	Apply economic analysis of energy, energy auditing, explain the energy conservation systems analysis for safety, health and pollution.

TEXT BOOKS

1.	Patrick, D. and Fardo, S. W., Energy conservation and Management, Prentice-Hall Inc., 1990
2.	Witte, Larry C., Industrial energy management and utilization, Hemisphere publishers, Washington, 1988
3.	Tyagi, A. K., Handbook of energy audits and management, TERI PCRA Booklets.

REFERENCES	
1.	Thipse, S.S., Energy conservation and management, Alpha Science International Ltd., 2014
2.	Frank Kreith and Yogi Goswami, D., Energy Management and Conservation Hand Book, CRC Press, 2008.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓			✓	✓					✓	✓	✓	✓
CO2	✓	✓	✓		✓						✓			✓
CO3	✓	✓	✓		✓	✓					✓	✓	✓	
CO4	✓	✓		✓		✓	✓					✓	✓	
CO5	✓	✓	✓	✓	✓		✓				✓	✓		✓

Course Code	Course Name	Semester	Credits	L T P C
	GAS DYNAMICS & JET PROPULSION	7		3 0 0 3

COURSE OBJECTIVES

- To understand the basic difference between incompressible flow and compressible flow and flow through variable area ducts.
- To understand the flow through constant area Ducts.
- To understand the phenomenon of shock waves and its effect on flow.
- To gain the basic knowledge about jet propulsion
- To gain the basic knowledge and rocket propulsion.

UNIT- I	Basic concepts and Isentropic flows	9

Basic concepts and Isentropic flows – Energy and momentum equations of compressible fluid flows – Stagnation states – Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable area ducts – Nozzle and Diffusers – Use of Gas tables.

UNIT-II	Flow through ducts	9

Flow through ducts – Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – Variation of flow properties – Use of tables and charts – Generalized gas dynamics.

UNIT-III	Normal and Oblique shocks	9

Normal and Oblique shocks – Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl-Meyer relations – Use of table and charts – Applications.

UNIT-IV	Jet propulsion	9

Jet propulsion – Theory of jet propulsion – Thrust equation – Thrust power – Propulsive efficiency – Operating principle – Cycle analysis – Use of stagnation state performance of Ram jet, Turbojet, Turbofan & Turboprop engines – Aircraft combustors.

UNIT-V	Space propulsion	9

Space propulsion – Types of rocket engines – Propellants – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – Space flights.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Apply the concept of compressible flows in variable area ducts.
2.	Apply the concept of compressible flows in constant area ducts.
3.	Examine the effect of compression and expansion waves in compressible flow.
4.	Use the concept of gas dynamics in Jet Propulsion.
5.	Apply the concept of gas dynamics in Space Propulsion.

TEXT BOOKS

1.	S.M. Yahya, "Fundamentals of Compressible Flow ", New Age International (P)Limited, New Delhi, 2018.
2.	Anderson, J.D., "Modern Compressible flow", 3rd Edition, Tata McGraw Hill, 2017.

REFERENCES

1.	Cohen. H., G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", Longman Group Ltd.,2001.
2.	Ganesan. V., "Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi, 2017.
3.	Shapiro. A.H.," Dynamics and Thermodynamics of Compressible Fluid Flow", John wiley, New York, 1977.
4.	Sutton. G.P., "Rocket Propulsion Elements", John wiley, New York, 7thEdition. 2017
5.	Zucrow. N.J., "Principles of Jet Propulsion and Gas Turbines", John Wiley, New York.
6.	E. Radhakrishnan, Gas Dynamics, PHI, 6thEdition. 2017.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓				✓							✓	✓
CO2	✓	✓	✓										✓	
CO3	✓	✓	✓			✓								✓
CO4	✓	✓		✓	✓	✓	✓						✓	✓
CO5	✓	✓	✓	✓	✓		✓						✓	

Course Code	Course Name	Semester	Credits	L T P C
	RENEWABLE ENERGY SOURCES	7		3 0 0 3

COURSE OBJECTIVES

- To identify the sources available to mankind, in relation to available technologies.
- To discuss the human beings and need for energy
- To know basic characteristics of renewable sources of energy and technologies for their utilization.
- To apply the principle of energy conversion technologies of various renewable energy resources.
- To give effective review on utilization trends of renewable sources of energy.

UNIT- I	Energy Scenario	9

Introduction to energy – Present energy status – Global and Indian energy scenario – Sector wise energy consumption in India – Energy needs of growing economy – Integrated energy policy – Energy intensity on purchasing power parity – Long term energy scenario for India – Energy security – Potential of renewable energy – Sustainability development – Global Environmental issues – Emission of carbon dioxide – Review on new technologies and future energy plans.

UNIT-II	Solar Energy	9

Spectral distribution of Solar radiation – Solar radiation measurement – Solar thermal collectors – Flat plate and concentrating collectors – Basics of solar concentrators – Solar thermal power generation – Solar thermal energy storage – Solar thermal applications – Solar stills – Solar pond – Physics of solar cells – Cell types – Fundamentals of solar photo voltaic conversion – PV system configurations – System components: Battery, charge controller and inverter – Solar PV applications – Building Integrated Solar.

UNIT-III	Wind Energy	9

Power in the wind – Wind data and energy estimation – Wind rose diagram – Betz limit – Site select for wind farms – Types of wind mills – Horizontal axis wind turbine – Vertical axis wind turbine components of wind mill – Wind turbine generators and its performance – Building Integrated Wind Energy – Environmental issues – Applications – Indian wind potential – Introduction to onshore offshore wind farms.

UNIT-IV	Bio-Energy	9

Bio resources – Biomass direct combustion – biochemical conversion – Thermochemical conversion – Mechanical conversion – Biomass combustion and power generation – Biomass gratifier – Types gasifiers – Cogeneration – Carbonization – Pyrolysis – Biogas plants – Digesters – Biodiesel production – Ethanol production – Waste to energy technologies – Heat Pumps.

UNIT-V	Water And Other Renewable Energy Resources	9

Technologies for harnessing Water energy – Small hydro – Tidal energy – Types of Tidal energy – Ocean Thermal Energy – Open and Closed OTEC – Geothermal energy – Types of Geothermal energy – Hydrogen energy technology – Fuel Cells – Types of fuel cell – Energy storage technology Hybrid technology – Environmental impact assessment.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Analyse the current energy scenario in terms of conventional renewable energy and future plan.
2.	Understand basic properties of different renewable sources of energy and technologies for their utilization
3.	Describe main elements of technical systems designed for utilization of renewable source of energy.
4.	Explain the correlation between different operational parameters.
5.	Select Engineering approach to problem solving when implementing the projects to renewable sources of energy.
TEXT BOOKS	
1.	John T Widell, Tony Weir, and Anthony D. Weir, Renewable Energy Resources, Taylor &Francis, 2006.
2.	G.D. Rai, Non-Conventional Energy Sources‖, Standard Publishers Distributors, 1992.

REFERENCES	
1.	K. Bansal, Non-Conventional Energy Resources, Vikas Publishing House, 2014.
2.	Godfrey Boyle, Renewable Energy, Power for a Sustainable Future‖, Oxford University Press, 20
3.	B.H. Khan, Non-Conventional Energy Resources‖, McGraw Hill, 2009.
4.	J John A. Duffie and William A. Beckman (2006), Solar Engineering of Thermal Process, 3rd Edition Wiley & Sons.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓		✓			✓	✓				✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
CO3	✓		✓		✓	✓		✓				✓	✓	✓
CO4		✓	✓	✓		✓	✓					✓	✓	✓
CO5	✓	✓		✓		✓	✓	✓				✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	MEASUREMENT AND CONTROL FOR ENERGY SYSTEMS	7		3 0 0 3

COURSE OBJECTIVES

- To impart knowledge about characteristics of measurement system & statistical analysis of the measured data.
- To make students conversant with the electrical measurements and signal conditioning circuits.
- To provide insight into the digital measuring techniques of physical quantities and solar instruments.
- To make the students get acquainted with the measurement of Thermo-Physical properties and pollutants.
- To inculcate skills in the design and development of measurement and control systems.

UNIT- I	Measurement System: Characteristics and Statistical Analysis	9

Introduction to measurement system – Errors in Measurement – Static and Dynamic characteristics – Transducers – Statistical analysis of experimental data – Uncertainty analysis – Regression analysis – Design experiments – Full and Half factorial design.

UNIT-II	Electrical Measurements and Signal Conditioning	9

Voltage, Current, Power, Energy, Time and Frequency measurement – Frequency Counter – Signal conditioning Circuits – Wheatstone bridge – Differential Amplifier – Integrator – Differentiator – Instrumentation Amplifier – V to I Converter, I to V Convertor – Attenuators and Filters, DAC, ADC and PID Control.

UNIT-III	Digital Measurement of Physical Quantities	9

Digital measuring techniques of Displacement, Temperature, Pressure, Force, Torque, Vibration, Acceleration, Velocity, Level, Flow – Thermal and Nuclear Radiation – Solar instruments: Pyrheliometers – Pyranometers – Albedometers – Pyrradiometers – Pyrgeometers – Net Pyrradiometer – Sun photometers.

UNIT-IV	Measurement of Thermo-Physical Properties and Air Pollutants	9

Measurement of Thermal Conductivity – Solids, Liquids and Gas – Viscosity – Gas Diffusion – Calorimeter – Bomb Calorimeter – Continuous flow Calorimeter – Measurement of Heat Transfer – Humidity – Heat pH – Air pollution – Sampling and Measurement – Particulate Sampling techniques – Measurement of Sulphur Dioxide – Combustion products – Opacity and Odour.

UNIT-V	Control Systems	9

Introduction to Controller – Interfacing with I/O devices of system – Sensors – Display devices – Stepper motor – Servomotors – Measurement by Data Acquisition System – Introduction to Internet of Things (IoT Application of IoT with Raspberry Pi for Process monitoring and control – Energy management – Controller in thermal systems – Application of Smart Sensors – Intelligent instrumentation and Control.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Analyze and evaluate the uncertainties in measurement data.
2.	Identify appropriate sensors for measuring electrical quantities and signal conditioning Circuits.
3.	Explain the digital measurement techniques of physical quantities and solar instruments.
4.	Compare the thermo-physical properties of air pollutants and identify air pollutant measurement techniques.
5.	Design and develop the appropriate measurement and control system for an application

TEXT BOOKS

1. Stoecker, W.F., Design of Thermal Systems, McGraw Hill, 1989.
2. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons 1996.

REFERENCES

1. Barney G.C., —Intelligent instrumentation: microprocessor applications in measurement and Control‖, Prentice Hall,1988.

2.	Bell C., —Beginning Sensor Networks with Arduino and Raspberry Pi, A press, 2013.
3.	Doebelin E. and Manik D.N., —Doebelin's Measurement Systems‖, Tata McGraw Hill, 2011.
4.	George, B., Roy, J.K., Kumar, V.J., Mukhopadhyay, S.C., —Advanced Interfacing Techniques for Sensors‖, Springer, 2017. 5. Holman J.P., —Experimental methods for Engineers, Tata McGraw Hill, 2007.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓											✓
CO2		✓	✓		✓				✓		✓	✓	✓	
CO3	✓	✓	✓	✓					✓			✓		
CO4	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓
CO5				✓	✓	✓	✓	✓		✓		✓	✓	✓

PROFESSIONAL ELECTIVE COURSES - III

(Manufacturing & Robotics)

Course Code	Course Name	Semester	Credits	L T P C
	DIGITAL TWIN AND INDUSTRY 4.0	**7**		**3 0 0 3**

COURSE OBJECTIVES

- To know the basic concepts in digital twin and aware of its applications in process, product and service industries.
- To analyse the concepts of digital twin in a discrete Industry to improve the product and production.
- To apply the concepts of digital twin in a process Industry for process improvements.
- To learn about the basics of industry 4.0, smart manufacturing, IOT.
- To explore about the role of industry 4.0 in smart factory, key principles of smart factory and technologies used.

UNIT- I	**INTRODUCTION TO DIGITAL TWIN**	**9**

Digital twin – Definition – Types of Industry and its key requirements – Importance – Application of Digital Twin in process, product and service industries – History of Digital Twin – DTT role in industry innovation – Technologies/tools enabling Digital Twin – Virtual CAD Models – Control Parameters – Real time systems – Control Parameters – Hand shaking Through Internet – Cyber physical systems.

UNIT-II	**DIGITAL TWIN IN A DISCRETE INDUSTRY**	**9**

Basics of Discrete Industry – Trends in the discrete industry – Control system requirements in a discrete industry – Digital Twin of a Product – Digital Thread in Discrete Industry – Data collection & analysis for product & production improvements – Automation simulation – Digital Enterprise.

UNIT-III	**DIGITAL TWIN IN A PROCESS INDUSTRY**	**9**

Basics of Process Industry – Trends in the process industry – Control system requirements in a process industry – Digital Twin of a plant – Digital Thread in process Industry – Data collection and analysis for process improvements – Process safety – Automation simulation – Digital Enterprise.

UNIT-IV	**INTRODUCTION TO INDUSTRY4.0**	**9**

Industrial Revolutions, – Industry 4.0 – Definition, principles, Application of Industry 4.0 in process & discrete industries – Benefits of Industry 4.0 – Challenges in Industry 4.0 – Smart manufacturing – Internet of Things 4.0 – Industrial Gateways – Basics of Communication requirements – Cognitive systems 4.0.

UNIT-V	**ROLE OF INDUSTRY 4.0 IN SMART FACTORY**	**9**

Intelligent networks of manufacturing – Cloud computing – Data analytics – Cyber physical systems – Machine to Machine communication – Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT – Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cyber security.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Remember the basics concepts of digital twin, and its applications in process, product and service industries.
2.	Apply the concept of digital twin in a discrete Industry to improve the product and production.
3.	Appreciate the use of digital twin in a process Industry for improving the process.
4.	Understand the basics concepts of Industry 4.0 and smart factory.
5.	Recognize the role of Industry 4.0 in smart factory, technologies in smart factory.

TEXT BOOKS

1.	Tao, Fei, Digital Twin Driven Smart Manufacturing, Elsevier Science, 18 Feb 2019.
2.	Alp Ustundag and Emre Cevikcan, Industry 4.0: Managing The Digital Transformation, Springer Series in Advanced Manufacturing., Switzerland, 2018.
3.	Madison A. Thompson, Understanding The Basic Of Industry 4.0, ISBN-13: 979-8867319656, Independently published November 11, 2023.

REFERENCES	
1.	Alasdair Gilchrist,—Industry 4.0:TheIndustrial Internet of Things, A press United States ,2015.
2.	Christoph Jan, Bartodziej, The Concept Industry4.0 an Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gambler., Germany, 2017.
3.	Ibrahim Garbie, Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0,Springer, Switzerland, 2016.
4.	Ronald R. Yager and Jordan Pascual Espada, New Advances in the Internet of Things, Springer, Switzerland, 2018.
5.	Ulrich Sendler, The Internet of Things, Industries 4.0 Unleashed, Springer., Germany, 2018.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓		✓	✓	✓						✓	✓	✓	
CO2		✓	✓		✓						✓	✓		✓
CO3	✓	✓	✓	✓							✓	✓	✓	✓
CO4	✓		✓	✓	✓						✓	✓	✓	✓
CO5	✓	✓	✓		✓						✓	✓	✓	

Course Code	Course Name	Semester	Credits	L T P C
	DIGITAL MANUFACTURING	7		3 0 0 3

COURSE OBJECTIVES

- To develop ideas on digital manufacturing.
- To import and export CAD data and generate .stl file.
- To gain knowledge on reverse engineering for the given application.
- To gain knowledge on virtual manufacturing.
- To develop knowledge on IoT.

UNIT- I	INTRODUCTION TO DIGITAL MANUFACTURING	9

Definition of digital manufacturing – Historical perspective on industrial production and outlook – Industrial Revolutions – Industry 4.0 – Cyber physical system – Factory of the future – Operation Mode and Architecture of Digital Manufacturing System.

UNIT-II	CAD / CAM	9

Design process and role of CAD – Types and applications of design models – Three dimensional modeling schemes – Wire frames and surface representation schemes – Solid modeling – Parametric modeling – Assembly modeling – Component modeling – Machine and tool selection – Defining process and parameters – Tool path generation – Simulation – Post processing.

UNIT-III	REVERSE ENGINEERING AND CONCEPT MODELERS	9

Needs on Reverse engineering process – Reverse engineering hardware and software – Geometric model development – Introduction to concept modelers – Principle – Thermo jet printer – Sander's model market – 3-D printer – GenisysXs printer – JP systems – Object Quadra system – Rapid proto typing.

UNIT-IV	DIGITAL FACTORY, VIRTUAL MANUFACTURING AND PLM	9

Introduction – Scope – Methods and tools used in virtual manufacturing – benefits – Virtual factory simulation – Introduction to Product Life Cycle Management – Types of Product Data – PLM systems – Features of PLM System – System architecture – Product information models – Functionality of the PLM Systems.

UNIT-V	INTERNET OF THINGS	9

Introduction to Internet of Things – Applications – IOT data management requirements – Architecture of IOT – Technological challenges – RFID and the Electronic Product Code (EPC) network – The web of things – Issues in implementing IOT.

TUTORIAL SESSION: 3D Modeling of Engineering components and assemblies in CAD software – Machining simulation using CAM software – Reverse Engineering using Microscribe.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Develop ideas on digital manufacturing.
2.	Import and export CAD data and generate .stl file.
3.	Gain knowledge on reverse engineering for the given application.
4.	Gain knowledge on virtual manufacturing.
5.	Develop knowledge on IoT.

TEXT BOOKS

1.	Ibrahim Zeid and Sivasubramaniam R, "CAD/CAM - Theory and Practice", Tata McGraw Hill Education, 2011.
2.	Vinesh Raja and Kiran J Fernandes, "Reverse Engineering- An Industrial Perspective", Springer-Verlag, 2008
3.	Pham D T and Dimov S S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping", Springer-Verlag, 2001.
4.	Adrian McEwan and Hakim Cassimally, "Designing the internet of things", Wiley, 2013.

REFERENCES	
1.	Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", Springer, 2005.
2.	Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management", Springer, 2004.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓							✓	✓	✓
CO2	✓	✓	✓	✓	✓							✓	✓	✓
CO3	✓	✓	✓	✓	✓							✓	✓	✓
CO4	✓	✓	✓	✓	✓							✓	✓	✓
CO5	✓	✓	✓	✓	✓							✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	FLEXIBLE MANUFACTURING SYSTEMS	7		3 0 0 3

COURSE OBJECTIVES

- To understand the basic concepts of flexible manufacturing systems
- To gain the knowledge on computer control & software associated with flexible manufacturing systems
- To educate students about simulation and database systems with respect to flexible manufacturing systems
- To know about group technology and justifications on implementing flexible manufacturing system
- To educate the applications of flexible manufacturing systems in various industrial sectors

UNIT- I	PLANNING, SCHEDULING AND CONTROL	9

Introduction to FMS – Development of manufacturing systems – Benefits – Major elements – Types of flexibility – FMS application and flexibility – Single product – Single batch – n-batch scheduling problem – Knowledge based scheduling system.

UNIT-II	COMPUTER CONTROL AND SOFTWARE	9

Introduction – Composition of FMS – Hierarchy of computer control – Computer control of work center and assembly lines – FMS supervisory computer control – Types of software specification and selection – Trends.

UNIT-III	FMS SIMULATION AND DATA BASE	9

Application of simulation – Model of FMS – Simulation software – Limitation – Manufacturing data systems – Data flow – FMS database systems – Planning for FMS database.

UNIT-IV	GROUP TECHNOLOGY AND JUSTIFICATION OF FMS	9

Introduction – Matrix formulation – Mathematical programming formulation – Graph formulation – Knowledge based system for Group Technology – Economic justification of FMS – Application of possibility distributions in FMS systems justification.

UNIT-V	APPLICATIONS OF FMS AND FACTORY OF THE FUTURE	9

FMS application in machining – Sheet metal fabrication – Prismatic component production – Aerospace application – FMS development towards factories of the future – Artificial intelligence and expert systems in FMS – Design philosophy and characteristics for future.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Appreciate the fundamentals of flexible manufacturing systems
2.	Explain the use of software and computer control in flexible manufacturing systems
3.	Recognise the importance of simulation and database systems
4.	Explain the group technology and understand the justification of implementing flexible manufacturing systems
5.	Recognise the effectiveness of imparting flexible manufacturing systems in various industrial sectors

TEXT BOOKS

1. Nand K. Jha., "Handbook of flexible manufacturing systems", Academic Press Inc., 1991
2. Shivanand. H. K., Benal. M. M., Koti. V., "Flexible manufacturing system" New Age International Publishers., 2006.

REFERENCES

1. Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New Age International Ltd., 1994.
2. Raouf A. and Daya B.M., "Flexible manufacturing systems: recent development", Elsevier Science, 1995.
3. Groover M.P., "Automation, production systems and computer integrated manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.

4.	Kalpakjian S., "Manufacturing Engineering and Technology", Addison-Wesley Publishing Co., 1995.
5.	Ohno T., "Toyota production system: beyond large-scale production", Productivity Press (India) Pvt. Ltd., 1992.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓		✓							✓	✓
CO2	✓	✓		✓		✓						✓	✓	
CO3	✓	✓	✓	✓	✓							✓		✓
CO4	✓		✓			✓						✓		✓
CO5	✓	✓	✓	✓	✓								✓	

Course Code	Course Name	Semester	Credits	L T P C
	INTELLIGENT MACHINING	**7**		**3 0 0 3**

COURSE OBJECTIVES

- To provide an overview of intelligent machining systems, their components and emerging technologies.
- To introduce advanced control systems and their applications in intelligent machining processes.
- To explore data-driven optimization techniques for enhancing machining efficiency and performance.
- To familiarize students with AI and machine learning techniques applicable to machining processes.
- To examine cutting-edge technologies and sustainable practices in intelligent machining.

UNIT- I	**OVERVIEW OF INTELLIGENT MACHINING**	**9**

Definition – Importance and evolution – Conventional Vs Intelligent Machining – Key differences & advantages – Intelligent Machining Systems – Components – Hardware and software – Introduction to Machine Learning and AI in Machining – Sensors in Machining – Types, applications & integration – Real-time Data Acquisition and Analysis – Challenges in Implementing Intelligent Machining.

UNIT-II	**CONTROL SYSTEMS IN INTELLIGENT MACHINING**	**9**

Fundamentals of Control Systems in Machining – CNC Systems – Advanced capabilities for intelligent machining – Adaptive Control – Principles and applications in machining processes – Closed-loop Control Systems in Intelligent Machining – Predictive Control – Basics and applications – Role of IoT in Intelligent Machining Control – Signal Processing for Feedback Control – Machine Health Monitoring and Diagnostics.

UNIT-III	**PROCESS OPTIMIZATION IN INTELLIGENT MACHINING**	**9**

Fundamentals of Process Optimization – Data-driven Machining – Role of big data and analytics – Toolpath Optimization – Algorithms and techniques – Tool Wear Monitoring and Compensation – Energy-efficient Machining – Principles and practices – Multi-objective Optimization in Machining – Intelligent Process Planning and Scheduling – Autonomous Machining Systems.

UNIT-IV	**MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN MACHINING**	**9**

Basics of Machine Learning (ML) for Machining – Types of ML Algorithms – Supervised, unsupervised & reinforcement learning – Applications of ML in Tool Wear Prediction – AI Techniques for Process Control – Digital Twin Technology for Intelligent Machining – Neural Networks for Surface Roughness Prediction – Deep Learning in Machining Processes – Challenges in Implementing ML/AI in Machining.

UNIT-V	**APPLICATIONS AND FUTURE TRENDS IN INTELLIGENT MACHINING**	**9**

Industry 4.0 and Intelligent Machining – Collaborative Robots (Cobots) in Machining – Cyber-Physical Systems in Manufacturing – Advanced Materials and Machining Strategies – Hybrid Machining Processes with Intelligence – Sustainability and Green Manufacturing in Intelligent Machining – Additive Manufacturing with Intelligent Features – Future Trends – AI-powered Machining Systems.

CO	**COURSE OUTCOMES**
Upon completion of this course, Students should be able to	
1.	Explain the fundamentals, advantages, and key trends of intelligent machining systems.
2.	Analyze and implement control strategies, including IoT-based and predictive systems, for machining processes.
3.	Apply optimization methods for toolpath planning, energy efficiency, and autonomous machining systems.
4.	Utilize machine learning and AI tools to predict outcomes and improve machining processes, such as tool wear and surface finish.
5.	Evaluate and propose solutions using advanced machining strategies, collaborative robots, and green manufacturing techniques.

TEXT BOOKS

1.	Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson, 2016.
2.	Tiago Antunes and Filipe Portela, Intelligent Machining: Tools and Strategies for Automation in Manufacturing, Springer, 2021.

3.	B. Bhushan, Principles and Applications of Tribology and Intelligent Machining, Wiley, 2020.
REFERENCES	
1.	Rao, P.N., CAD/CAM: Principles and Applications, McGraw-Hill, 2017.
2.	Jain, A.K., Machine Learning, McGraw-Hill, 2022.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓			✓		✓	✓				✓	✓	✓
CO2	✓	✓			✓					✓		✓	✓	✓
CO3	✓	✓	✓		✓	✓	✓	✓					✓	✓
CO4	✓	✓		✓	✓				✓			✓	✓	✓
CO5	✓	✓			✓		✓	✓			✓	✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	NON-TRADITIONAL MACHINING PROCESSES	7		3 0 0 3

COURSE OBJECTIVES

- To develop ideas on traditional machining
- To gain knowledge on mechanical process for the given application
- To impart knowledge on electrical discharge machining
- To gain knowledge on chemical machining
- To understand material removal by using high energy process

UNIT- I	INTRODUCTION	9

Need of non-Traditional machining processes – Classification based on energy, mechanism, source of energy, transfer media and process - Process selection-based on physical parameters, shapes to be machined, process capability and economics – Overview of all processes.

UNIT-II	MECHANICAL PROCESS	9

Ultrasonic machining: principle- Transducer types – Concentrators - Abrasive slurry - Process parameters – Tool feed mechanism – Advantages and limitations – Applications. abrasive jet machining: process- principle – Process variables – Material removal rate - advantages and limitations – Applications. Water jet machining: principle – Process variables - Advantages and limitations – Practical applications – Abrasive water jet machining process.

UNIT-III	ELECTRICAL DISCHARGE MACHINING	9

Electrode materials - Spark erosion generators – Electrode feed system – Material removal rate – Process parameters – Tool electrode design – Tool wear characteristics of spark eroded surfaces - Advantages and limitations – Practical applications. Electrical discharge wire cut and grinding: principle – wire feed system - advantages and limitations – Practical applications

UNIT-IV	CHEMICAL AND ELECTRO CHEMICAL MACHINING	9

Chemical machining: fundamentals, principle – Classification and selection of etchant -chemical milling, engraving, blanking - advantages and limitations – Applications. electro chemical machining: electro-chemistry of the process- electrolytes - electrolyte and their properties – material removal rate – tool material – tool feed system – design for electrolyte flow – process variables - advantages and limitations – applications - electro chemical grinding: honing, cutting off, deburring and turning.

UNIT-V	HIGH ENERGY MACHINING PROCESS	9

Electron beam machining: principle – Generation and control of electron beam- Advantages and limitations – applications. laser beam machining: principle –solid and gas laser application – Thermal features of LBM - Advantages and limitations – Applications. Ion beam machining: equipment – process characteristics - advantages and limitations – applications. Plasma arc machining: principle – Gas mixture– Types of torches – Process parameters - advantages and limitations – applications. Ion beam machining – principle – MRR – advantages, limitation, applications

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Acquire the knowledge on the various types of non-traditional machining techniques
2.	Understand the basics of mechanical process
3.	Understand the basics of EDM
4.	Understand the various types of chemical machining
5.	Understand the basics of HIGH ENERGY PROCESS

TEXT BOOKS

1.	P.C Pandey And H.S. Shan, "Modern Machining Process", Tata Mc Graw – Hill Publishing Company Limited, New Delhi, 2007
2.	V.K. Jain, " Advanced Machining Process", Allied Publishers Pvt Limited 2007

REFERENCES	
1.	Amithaba Bhattacharyya , "New Technology", The Institution of Engineers , (India) "Production Technology", HMT Bangalore, Tata Mc Graw–Hill Publishing Company Limited, New Delhi, 2006.
2.	Hassan El – Hofy "Advanced machining Processes" Tata MC Graw-Hill, 2005.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓							✓	✓	✓
CO2	✓	✓	✓	✓	✓							✓	✓	✓
CO3	✓	✓	✓	✓	✓							✓	✓	✓
CO4	✓	✓	✓	✓	✓							✓	✓	✓
CO5	✓	✓	✓	✓	✓							✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	MEDICAL ROBOTICS	7		3 0 0 3

COURSE OBJECTIVES

- Identify and describe different types of medical robots and their potential applications.
- Know basic concepts in kinematics, Dynamics, and control relevant to Medical Robotics.
- Develop the Analytical and Experimental skills necessary to Design and Implement robotic assistance for both minimally invasive surgery and Image guided interventions
- Be familiar with the state of the art in applied medical robotics and medical robotics research
- Understand the various roles that robotics can play in healthcare.

UNIT- I INTRODUCTION **9**

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics – State of art of robotics in the field of healthcare-DICOM

UNIT-II LOCALIZATION AND TRACKING **9**

Position sensors requirements - Tracking - Mechanical linkages - Optical – Sound based - Electromagnetic - Impedance-based - In-bore MRI tracking-Video matching - Fiber optic tracking systems - Hybrid systems.

UNIT-III DESIGN OF MEDICAL ROBOTS **9**

Characterization of gestures to the design of robots - Design methodologies - Technological choices - Security

UNIT-IV SURGICAL ROBOTICS **9**

Minimally invasive surgery and robotic integration -surgical robotic sub systems - synergistic control - Control Modes - Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging -Cardiac Surgery – Neurosurgery - case studies.

UNIT-V ROBOTS IN REHABILITATION AND MEDICAL CARE **9**

Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles - Assistive robots – Robots in Physiotherapy - case studies.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Identify various medical robots and their potential applications.
2.	Recognize the position tracking and hybrid systems
3.	Apply Robotics and its concepts in medical field
4.	Simulate a MIS procedure and be aware of the state of art in surgical and oncology robotics
5.	Design a medical robotic system given the specific requirements for Rehabilitation and Medical care.

TEXT BOOKS

1.	Achim Ernst Floris Schweikard, Medical Robotics, Springer, 2016.
2.	Paula Gomes, Medical robotics Minimally invasive surgery, Woodhead, 2013.

REFERENCES

1.	Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, The Encyclopedia of Medical Robotics, World Scientific Publishing Co. Pvt. Ltd, 2019.
2.	Jocelyne Troccaz , Medical Robotics, John Wiley & Sons Incorporated, 2013.
3.	Vanja Bonzovic , Medical Robotics, I-tech Education publishing, Austria, 2008.
4.	Farid Gharagozloo Robotic Surgery, Springer, 2022

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓
CO2	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	MOBILE ROBOTICS	**7**		**3 0 0 3**

COURSE OBJECTIVES

- To formulate the challenges in developing autonomous mobile robots.
- To abstract kinematic control of wheeled mobile robots.
- To understand the challenges involved in sensory perception for mobile robots.
- To understand the localization and path planning algorithms.
- To comprehend the challenges in implementing controllers

UNIT- I INTRODUCTION **9**

Mobile Robots vs. Manipulators - Introduction to autonomous mobile robots - Locomotion aspects of mobile robots - Introduction to wheeled mobile robots- wheel types - Wheeled Configurations - Maneuverability, controllability, Stability of mobile robots - Wheeled Locomotion - Case studies - Degrees of freedom, differential degrees of freedom - Holonomic and non-holonomic systems- Kinematic constraints of a fixed standard wheel- Kinematic constraints of a omni-directional wheels.

UNIT-II KINEMATICS AND DYNAMICS OF MOBILE ROBOTS **9**

Forward kinematic models of three wheeled differential drive robot - Forward kinematics of a three wheeled omni-directional robot - Degree of Maneuverability- Mobility analysis of various wheeled configurations - Workspace and trajectory considerations - Comparison of maneuverability and controllability- State space modelling of three wheeled differential drive robot- Multi-rotor aerial robot, Types and applications- Modelling of Control of Quadrotor Aerial Vehicle-Introduction to Underwater vehicles- Modelling of dynamics of underwater vehicle.

UNIT-III SENSORS FOR MOBILE ROBOTS **9**

Sensors for mobile robots - Characteristics applicable to mobile robots - Relating the characteristics to performance attributes of mobile robot - Physical and computational attributes of sensors applicable to mobile robots - sensor noise and sensor aliasing - GPS and heading sensors - Principles, challenges and interpretation Light and sound based ranging - Principles, challenges and interpretation -Wheel Odometry- Implementation algorithm for wheel odometry- Wheel Odometry Critical Analysis- Wheel Odometry error reduction- Vision for mobile robots- Introduction to Visual Odometry and V-SLAM- Multi-sensor combinations- Need and types

UNIT-IV MOBILE ROBOT CONTROL **9**

Robot Motion - Smoothing Algorithm, Path Smoothing - Zero Data Weight- PID - Implementation aspects of proportional control, integral control, derivative control: Systematic Bias - PID Tuning for autonomous mobile systems - Parameter Optimization: Go-goal Controller - Cruise Controller

UNIT-V LOCALIZATION AND PATH PLANNING **9**

Introduction to localization, Localization challenges - Belief representations, Considerations in Belief representations & Map representations - Types, trade-offs -Introduction to Kalman filtering & Derivation of Kalman gain - Kalman filter and Extended Kalman Filter for localization - Sensor fusion using Kalman filter - Particle Filter Based Localization - Object Detection and Sensor Data Fusion Introduction to path planning, D* Lite - Bug algorithms - Vector field histogram Collision avoidance algorithms

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Explain the fundamentals of mobile robots, locomotion mechanisms, and kinematic constraints.
2.	Analyze and model kinematics and dynamics of wheeled, aerial, and underwater mobile robots.
3.	Evaluate different sensors and perception techniques used in mobile robotics, including odometry and vision systems.
4.	Design and implement control strategies such as PID and motion planning controllers for mobile robots.
5.	Apply localization and path planning algorithms like Kalman Filter, Particle Filter, and collision avoidance techniques.

TEXT BOOKS	
1.	Siegwart, Nourbakhsh & Scaramuzza – Introduction to Autonomous Mobile Robots
2.	Roland Siegwart & Illah Reza Nourbakhsh – Autonomous Mobile Robots
REFERENCES	
1.	Howie Choset et al. – Principles of Robot Motion
2.	Mark W. Spong, Seth Hutchinson, M. Vidyasagar – Robot Modeling and Control
3.	Sebastian Thrun, Wolfram Burgard, Dieter Fox – Probabilistic Robotics
4.	Kevin M. Lynch & Frank C. Park – Modern Robotics: Mechanics, Planning, and Control

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓	✓	✓						✓			✓	✓	✓
CO2	✓	✓	✓	✓					✓	✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	HUMANOID ROBOTICS	**7**		**3 0 0 3**

COURSE OBJECTIVES

- To know the basic knowledge about Humanoid robots.
- To impart knowledge in kinematics of humanoids.
- To learn about the dynamics in humanoid robots.
- To understand the basic in biped walking.
- To know about the different walking patterns.

UNIT- I Introduction **9**

Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots

UNIT-II Kinematics **9**

Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis

UNIT-III ZMP and Dynamics **9**

ZMP Overview,2D Analysis,3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force , Momentum, Angular Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum

UNIT-IV Biped Walking **9**

Two Dimensional Walking Pattern Generation, Two Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain

UNIT-V Walking Pattern Generation **9**

ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation,Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Describe about the evolution of Humanoid robots
2.	Expose the basic knowledge in kinematics of humanoids.
3.	Calculate the Humanoid Robot Motion and Ground Reaction Force.
4.	Identify Two-Dimensional Walking pattern on different terrain.
5.	Create the Walking Pattern models

TEXT BOOKS

1.	Dragomir N. Nenchev, Atsushi Konno, "Humanoid Robots Modeling and Control", Butterworth Heinemann, 2019
2.	2. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH "Introduction to Humanoid Robotics", Springer, London, 2014.
3.	Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.
4.	J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022

REFERENCES

1.	J K. Harada, E. Yoshida, K. Yokoi (Eds.), "Motion Planning for Humanoid Robots", Springer, London, 2010.
2.	Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", Second Edition, Springer, 2000.
3.	Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	✓	✓	✓	✓								✓	✓	✓
CO2	✓	✓	✓	✓								✓	✓	✓
CO3	✓	✓	✓									✓	✓	✓
CO4	✓		✓	✓								✓	✓	✓
CO5	✓	✓	✓	✓								✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	AGRICULTURAL ROBOTICS	**7**		**3 0 0 3**

COURSE OBJECTIVES

- To learn about Farming related Machines.
- To understand the global position and information system in machines.
- To know about traction and testing
- To familiarize the concept on weed management
- To learn about machinery selection

UNIT- I Introduction **9**

History of Mechanized Agriculture - Farming Operations and Related Machines - Tillage, Planting Cultivation, and Harvesting, Agricultural Automation - Agricultural Vehicle Robot.

UNIT-II Precision Agriculture **9**

Sensors – types and agricultural applications, Global Positioning System (GPS) - GPS for civilian use, Differential GPS, Carrier-phase GPS, Real-time kinematic GPS, Military GPS, Geographic Information System, Variable Rate Applications and Controller Area Networks

UNIT-III Traction and Testing **9**

Hitching- Principles of hitching, Types of hitches, Hitching and weight transfer, Control of hitches, Tires and Traction models, Traction predictor spread sheet, Soil Compaction, Traction Aids, Tractor Testing.

UNIT-IV Soil Tillage and Weed Management **9**

Tillage Methods and Equipment, Mechanics of Tillage Tools, Performance of Tillage Implements, Hitching of Tillage Implements, Weed Management - Conventional Cropping Systems, Tools, Crop Rotation, Mechanical Cultivation

UNIT-V Machinery Selection **9**

Screw Conveyors, Pneumatic Conveyors, Bucket Elevators, Forage Blowers and Miscellaneous Conveyors, Machinery Selection - Field Capacity and Efficiency, Draft and Power Requirements, Machinery Costs

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Recognize the areas in agricultural process where robotics can be applied.
2.	Integrate sensor and system for a required specific process in agricultural applications.
3.	Apply Mechanics to the design various robot parameters
4.	Convert various mechanisms into robot by providing actuation at specific links and joints of the mechanism
5.	Develop suitable robotic system for specific agricultural tasks

TEXT BOOKS

1.	Ajit K. Srivastava, Carroll E. Goering, Roger P. Rohrbach, Dennis R. Buckmaster, "Engineering Principles of Agricultural Machines", ASABE Publication, 2012.
2.	Myer Kutz , "Handbook of Farm, Dairy and Food Machinery Engineering", Academic Press, 2019

REFERENCES

1.	Qin Zhang, Francis J. Pierce, "Agricultural Automation Fundamentals and Practices", CRC Press, 2016.
2.	Stephen L Young, Francis J. Pierce, "Automation: The Future of Weed Control in Cropping Systems", Springer, Dordrecht Heidelberg New York London, 2014.
3.	R.A. Kepner, Roy Bainer, E.L. Barger, "Principles of Farm Machinery", 3rd Edition, CBS Publishers, New Delhi, 2005.
4.	Guangnan Chen, "Advances in Agricultural Machinery and Technologies", 1st Edition, CRC Press, 2021.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PS02**
CO1	✓	✓	✓	✓								✓	✓	✓
CO2	✓	✓	✓	✓								✓	✓	✓
CO3	✓	✓	✓									✓	✓	✓
CO4	✓		✓	✓								✓	✓	✓
CO5	✓	✓	✓	✓								✓	✓	✓

PROFESSIONAL ELECTIVE COURSES - IV

(Industrial Management)

Course Code	Course Name	Semester	Credits	L T P C
	TOTAL QUALITY MANAGEMENT	8		3 0 0 3

COURSE OBJECTIVES

- To introduce the basic functions of Total Quality Management
- To learn the principles of TQM
- To impart knowledge on statistical process control techniques
- To study the usage of tools for problem solving
- To familiarize various system standards

UNIT- I	INTRODUCTION	9

Definition of quality – Dimensions of quality – Quality planning – Quality costs - Analysis Techniques for quality Costs – Basic concepts of total quality management – Historical review – Principles of TQM – Leadership – Concepts – Role of senior management, Quality council – Quality statements – Strategic planning – Deming philosophy – Barriers to TQM implementation.

UNIT-II	TOTAL QUALITY MANAGEMENT PRINCIPLES	9

Customer satisfaction – Customer perception of quality – Customer complaints – Service quality – Customer retention – Employee involvement – Motivation – Empowerment – Teams – Recognition and reward – Performance appraisal – Benefits – Continuous process improvement – Juran trilogy – PDSA cycle – 5S – Kaizen – Supplier partnership – Partnering – Sourcing – Supplier selection – Supplier rating – Relationship development – Performance measures – Basic concepts – Strategy – Performance measure.

UNIT-III	TOTAL QUALITY MANAGEMENT TOOLS	9

Bench marking – Reasons to benchmark – Benchmarking process – Quality function deployment (QFD) – House of quality – QFD process & benefits – Taguchi quality loss function – Total productive maintenance (TPM) – Concept, improvement needs – FMEA – Stages of FMEA.

UNIT-IV	QUALITY SYSTEMS	9

Quality Auditing – Need for ISO 9000 and Other Quality Systems –ISO 9000:2000 Quality System – Elements – Implementation of Quality System – Documentation – TS 16949 – ISO 14000 – Concept, Requirements and Benefits.

UNIT-V	STATISTICAL PROCESS CONTROL (SPC)	9

The seven tools of quality – Statistical fundamentals – Measures of central tendency and Dispersion – Population and sample – Normal curve – Control charts for variables and attributes – Process capability – concept of six sigma – New seven management tools.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Understand the basics of TQM
2.	Explain the principles of TQM
3.	Solve problems on statistical process control
4.	Use the tools for finding solutions
5.	Gain knowledge on system standards

TEXT BOOKS

1. Dale H. Besterfiled, et al., "Total Quality Management", Pearson Education, Inc. 2003. (Indian reprint 2004). ISBN 81-297-0260-6.

REFERENCES

1. James R. Evans & William M. Lidsay, "The Management and Control of Quality", (5th Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
2. Oakland.J.S. "Total Quality Management", Butterworth – Heinemann Ltd., Oxford. 1989.

3.	Narayana V. and Sreenivasan, N.S. "Quality Management – Concepts and Tasks", New Age International 1996.
4.	Zeiri. "Total Quality Management for Engineers", Wood Head Publishers, 1991.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓		✓	✓		✓	✓					✓
CO2	✓	✓	✓		✓	✓		✓	✓				✓	✓
CO3	✓	✓	✓			✓	✓	✓	✓				✓	
CO4	✓	✓	✓				✓	✓	✓					✓
CO5	✓	✓	✓					✓	✓				✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	PROCESS PLANNING AND COST ESTIMATION	8		3 0 0 3

COURSE OBJECTIVES

- To provide students with foundational knowledge about process planning and its significance in manufacturing and economics of process planning.
- To describe the factors influencing the selection of production processes, including process and operation sequencing.
- To emphasize the importance of costing and estimation in decision-making and resource optimization.
- To provide in-depth knowledge of cost estimation principles for various production processes, including forging, welding, and foundry operations.
- To develop an understanding of the procedures and calculations involved in estimating machining time for various conventional machining processes.

UNIT- I	INTRODUCTION TO PROCESS PLANNING	9

Introduction – Activities involved in process planning – Documents required for process planning – Process planning methods – Manual & Computer aided process planning – Retrieval & Generative CAPP Methods – Standardization – Simplification – Introduction to process parameters calculation – Economics of process planning – Break even analysis.

UNIT-II	PROCESS PLANNING ACTIVITIES	9

Drawing interpretation – Material selection process and methods – Selection of Production Processes – Factors to be considered in selecting – Process Sequencing – Operation Sequencing – Process parameters – Equipment & Tool Selection – Case studies in process planning – Selection of jigs and fixtures.

UNIT-III	COST ESTIMATION AND COST ACCOUNTING	9

Aims of costing and estimation – Functions and procedure – Importance of costing and estimation – Methods of costing – Elements of cost estimation – Types of estimates – Estimating procedure – Estimation labor cost – material cost and overhead cost – Ladder cost – Allocation of overhead charges – Problems in cost estimation – Introduction to depreciation cost.

UNIT-IV	COST ESTIMATION OF CASTING, FORGING & WELDING COSTS	9

Estimation of cost for various production processes – Estimation of Forging Shop – Losses in forging – Forging cost – Estimation of Welding Shop – Electric welding cost – Gas Welding cost – Estimation of Foundry Shop – Pattern cost – Casting cost – Introduction to open access software for cost estimation.

UNIT-V	ESTIMATION OF MACHINING TIME AND COSTS	9

Estimation of Machining Time – Importance of Machine Time Calculation – Machining Time Calculation for the Conventional Machining Processes – Calculation of Machining Time and Cost for Lathe operations, Drilling, Boring, Milling and Grinding.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Contrast the documents required for effective process planning and do economic analysis of process planning.
2.	Recognize the drawing and make a standard and detailed process plan for a given product.
3.	Estimate labour, material, and overhead costs and allocate overhead charges effectively.
4.	Evaluate the cost for various production processes like casting, forging and welding processes for a given product.
5.	Solve practical problems involving machining time and cost estimation, demonstrating analytical and problem-solving skills.

TEXT BOOKS

1.	Peter Scallan, Process Planning, The Design/Manufacture Interface, Butterworth Heinemann, 2018.
2.	Sinha B.P, Mechanical Estimating and Costing‖, Tata-McGraw Hill publishing co, 2016.

REFERENCES / Web links:	
1.	Chitale A. K., and Gupta R. C., Product Design and manufacturing, Prentice Hall of India, New Delhi, 2016.
2.	Narang G.B.S. & Kumar. V, Production and Costing, Khanna Publishers, 2020.
3.	Phillip F. Ostwald & Jairo Munoz, Manufacturing Processes and Systems‖, 9th Edition, Wiley student edition, 2016.
4.	Robert Creese, Adithan M. & Pabla B. S., Estimating and Costing for the Metal Manufacturing Industries, Marcel Dekker, 2019.
5.	https://onlinecourses.nptel.ac.in/noc23_ce59

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓								✓	✓	✓	✓
CO2	✓	✓		✓							✓		✓	✓
CO3			✓	✓							✓	✓	✓	✓
CO4	✓	✓	✓	✓								✓	✓	✓
CO5	✓	✓	✓								✓	✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	SUPPLY CHAIN AND LOGISTIC MANAGEMENT	8		3 0 0 3

COURSE OBJECTIVES

- Infer the role and drivers of supply chain management in achieving competitiveness.
- Understand about Supply Chain Network Design.
- Illustrate the issues related to Logistics in Supply Chain.
- Appraise about Sourcing and Coordination in Supply Chain.
- Summarize the application of Information Technology and Emerging Concepts in Supply Chain.

UNIT- I	INTRODUCTION TO SUPPLY CHAIN AND LOGISTICS MANAGEMENT	9

Supply Chain and Logistics Management – Scope and Importance – Evolution of Supply Chain – Examples of supply Chains – Decision Phases in Supply Chain – Competitive and Supply chain Strategies – Drivers of Supply Chain Performance and Obstacles – Relationship of Logistics to Supply Chain Management.

UNIT-II	SUPPLY CHAIN NETWORK DESIGN	9

Role of Distribution in Supply Chain – Factors influencing Distribution network design – Design options for Distribution Network – Distribution Network in Practice – Role of network Design in Supply Chain – Framework for network Decisions – Impact of uncertainty on Network Design – Network design decisions – Network design decisions using Decision Trees.

UNIT-III	LOGISTICS IN SUPPLY CHAIN	9

Role of transportation in supply chain – Factors affecting transportations decision – Design option for transportation network – Tailored transportation – Routing and scheduling in transportation – 3PL – 4PL – Global Logistics – Reverse Logistics – Reasons, Activities and issues.

UNIT-IV	SOURCING AND COORDINATION IN SUPPLY CHAIN	9

Role of Sourcing in supply chain – Supplier selection – Assessment and contracts – Design Collaboration – Sourcing – Planning and Analysis – Supply chain co-ordination – Bull whip effect – Effect of lack of coordination in supply chain and obstacles – Building strategic partnerships and trust within a supply chain.

UNIT-V	IT AND EMERGING CONCEPTS IN SUPPLYCHAIN	9

The role IT in supply chain – The supply chain IT framework – Customer Relationship Management – Internal Supply Chain Management – Supplier Relationship Management – Future of IT in supply chain – E-Business in supply chain – Risks in Supply Chain – Lean supply Chains – Sustainable supply Chains.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Correlate the scope of Supply Chain & Logistics Management and the drivers of Supply Chain performance.
2.	Design suitable Supply Chain network for a given situation.
3.	Analyze and solve the issues related to Logistics in SCM.
4.	Evaluate Sourcing, Coordination and current issues in SCM.
5.	Appraise about the applications of IT in SCM and apply SCM concepts in selected enterprises.
TEXT BOOKS	
1.	Sunil Chopra, Peter Meindl and D.V. Kalra, Supply Chain Management: Strategy, Planning and Operation", Pearson Education, 2016.
2.	Dr. Shila Bootwala, Raisa Shaikh, Mohd Fazil Shareef ,‖Supply Chain and Logistics Management‖ Nirali Prakashan Publications, 2018 edition.
REFERENCES / Web links	
1.	Ravi Ravindran A, Donald P. Warsing, Jr, Supply Chain Engineering: Models and Applications‖, CRC Press, 2012.
2.	Srinivasan G.S, Quantitative models in Operations and Supply Chain Management‖, PHI, 2010.

3.	Janat Shah, Supply Chain Management: Text and Cases‖, Pearson Education India, 2016.
4.	Ashley McDonough, Operations and Supply Chain Management‖ Vibrant Publishers-2019 Edition
5.	Khalid Zidan ,‖ Supply Chain Management‖ Create space Independent Publication, 2016 Edition
6.	https://onlinecourses.nptel.ac.in/noc23_mg71/preview
7.	https://www.linkedin.com/learning/supply-chain-foundations-2014

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓	✓			✓				✓	
CO2	✓	✓	✓	✓	✓	✓			✓					✓
CO3	✓	✓	✓	✓	✓	✓			✓				✓	
CO4	✓	✓	✓	✓	✓	✓			✓				✓	✓
CO5	✓	✓	✓	✓	✓	✓			✓					✓

Course Code	Course Name	Semester	Credits	L T P C
	RELIABILITY AND MAINTENANCE ENGINEERING	8		3 0 0 3

COURSE OBJECTIVES

- To understand the fundamentals of reliability engineering.
- To apply reliability estimation techniques and design systems with improved reliability.
- To describe basic maintenance concepts and practices.
- To evaluate different maintenance policies.
- To explore the root cause for maintenance problems.

UNIT- I	RELIABILITY CONCEPTS	9

Fundamentals of reliability engineering – Mortality curves concept of burn-in period – Useful life and wear out phase of a system – Failure data analysis – Mean failure rate – Mean Time To Failure (MTTF) – Mean Time Between Failure (MTBF) – Hazard rate – Failure density and conditional reliability – Maintainability and availability – Simple problems.

UNIT-II	RELIABILITY ESTIMATION	9

System reliability – Series, Parallel and Mixed configurations – Reliability improvement techniques – use of Pareto analysis – Design for reliability – Redundancy unit and standby redundancy – Fault tree analysis – Optimization in reliability – Product design – Product analysis – Product development – Product life cycles.

UNIT-III	MAINTENANCE CONCEPT	9

Maintenance definition – Maintenance objectives and scope – Maintenance challenges and functions – Terotechnology – Maintenance costs – General introduction to maintenance types.

UNIT-IV	MAINTENANCE MODELS	9

Proactive and reactive maintenance – Maintenance policies – Imperfect maintenance – Preventive and breakdown maintenance – Optimal preventive maintenance schedule – Product characteristics – Inspection decisions – Maximizing profit – Minimizing downtime – Replacement decisions.

UNIT-V	MAINTENANCE QUALITY	9

Total Productive Maintenance fundamentals – Chronic and sporadic losses – TPM pillars – Five zero concept – Failure Modes and Effects Analysis (FMEA) – Failure Modes – Effects and Criticality Analysis (FMECA) – Root cause analysis – Repair time distribution – Analysis of downtime – Maintainability prediction – Design for maintainability – Reliability Centered Maintenance.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Calculate and interpret different reliability concepts for engineering systems.
2.	Develop and analyze reliability models for complex systems and implement reliability improvement techniques.
3.	Identify and classify different types of maintenance practices and their applications in industrial scenarios.
4.	Formulate optimal maintenance policies and apply decision-making techniques.
5.	Perform root cause analysis of maintenance problems.

TEXT BOOKS

1.	Andrew K.S. Jardine& Albert H.C. Tsang, "Maintenance, Replacement and Reliability", Taylor and Francis, Third Edition 2021.
2.	Srinath. L.S., "Reliability Engineering", 4th edition Affiliated East west press, 2011

REFERENCES

1.	Balaguruswamy.E., "Reliability Engineering", McGraw Hill Education India, 2017
2.	Bikas Badhury & S.K.Basu, "Terotechnology: Reliability Engineering and Maintenance Management", Asian Books, 2003.

3.	Mishra R.C, "Reliability and Maintenance Engineering" New age International publisher, First Edition, 2006.
4.	Venkataraman. K "Maintenance Engineering and Management", PHI Learning, Pvt. Ltd., Fourth Edition, 2010

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓		✓	✓	✓		✓			✓	✓	
CO2	✓	✓	✓		✓	✓	✓		✓	✓		✓		✓
CO3	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
CO4	✓	✓	✓		✓	✓	✓		✓		✓		✓	
CO5	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓		✓

Course Code	Course Name	Semester	Credits	L T P C
	ENGINEERING ECONOMICS	8		3 0 0 3

COURSE OBJECTIVES

- To understand about the basic principles and methodologies of economics such as demand-supply, government policies, taxes etc.
- To acquire knowledge in public sector economics which includes labour market, banking, debts etc.
- To understand the importance of managerial economics and various forms of organizations.
- To know the importance of process planning and cost estimation in engineering economics.
- To understand the procedure followed in economics of different machining operations.

UNIT- I	FUNDAMENTALS OF ECONOMICS	9

Basic Principles and Methodology of Economics – Demand/Supply – Elasticity – Government Policies and Application – Theory of the Firm and Market Structure – Basic Macroeconomic Concepts (including GDP/GNP/NI/Disposable Income) – Identities for both closed and open economies – Aggregate demand and Supply (IS/LM) – Price Indices (WPI/CPI) – Interest rates – Direct and Indirect Taxes.

UNIT-II	PUBLIC SECTOR ECONOMICS	9

Public Sector Economics – Welfare & Externalities – Labour Market – Components of Monetary and Financial Systems – Central Bank – Monetary Aggregates – Commercial Banks & their functions – Capital and Debt Markets – Monetary and Fiscal Policy Tools & their impact on the economy – Inflation and Phillips Curve.

UNIT-III	MANAGERIAL ECONOMICS AND CAPITAL BUDGETING	9

Elements of Business/Managerial Economics – Forms of organizations – Cost & Cost Control – Techniques – Types of Costs – Life cycle costs – Break even Analysis – Capital Budgeting – Application of Linear Programming – Investment Analysis – NPV, ROI, IRR and Payback Period – Depreciation – Time value of money (Present and Future worth of cash flows) – Business Forecasting – Elementary techniques – Cash flow & Financial statements.

UNIT-IV	PROCESS PLANNING AND COST ESTIMATION	9

Introduction – Methods of process planning – Drawing interpretation – Material evaluation – Steps in process selection – Production equipment – Tooling selection – Cost estimation – Importance of costing and estimation – Methods of costing – Elements of cost estimation – Types of estimates – Estimating procedure – Estimation of labor cost – Material cost – Allocation of overhead charges – Calculation of depreciation cost.

UNIT-V	MACHINING TIME ESTIMATION	9

Machining time estimation – Importance of machine time calculation – Machining time for different lathe operations – Drilling and Boring time calculations – Machining time calculation for Milling, Shaping, Planning and Grinding – Production costs – Different production processes for different jobs – Estimation of forging cost – Estimation of welding cost – Estimation of foundry cost – Estimation of machining cost.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Describe the role of economics in the decision-making process and perform calculations in regard to interest formulas
2.	Understand the Monetary and Fiscal Policy Tools
3.	Estimate the Present, annual and future worth comparisons for cash flows
4.	Explain the concept of process planning and cost estimation.
5.	Compute the job order cost for different type of shop floor and to calculate the machining time for various machining operations.

TEXT BOOKS

1.	Pannerselvam, R., Engineering Economics., Prentice Hall India Learning Private Limited; 2nd Revised edition, 2013.
2.	Donald G. Newnan, Ted G. Eschenbach., Jerome P. Lavelle., Engineering Economic Analysis, Oxford University Press; 13th edition, 2017.

REFERENCES	
1.	Leland Blank and Anthony Tarquin., Basics of Engineering Economy., McGraw-Hill Education; 2nd edition, 2013.
2.	Chan S. Park., Contemporary Engineering Economics, Pearson Education, 6th Edition, 2015.

Mapping of COs with POs and PSOs														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓				✓	✓						✓	✓	✓
CO2	✓	✓	✓	✓			✓		✓				✓	✓
CO3	✓	✓	✓		✓				✓			✓	✓	✓
CO4	✓	✓		✓		✓							✓	✓
CO5	✓	✓			✓	✓		✓			✓	✓	✓	✓

Course Code	Course Name	Semester	Credits	L T P C
	MATERIAL HANDLING EQUIPMENT, REPAIR AND MAINTENANCE	8		3 0 0 3

COURSE OBJECTIVES

- To provide knowledge of the classification and functional categories of material handling equipment.
- To familiarize with the design, features, and functions of various hand trucks and power trucks, including their advantages and limitations.
- To analyse conveyor systems and their role in enhancing automation and efficiency in material handling processes.
- To impart the knowledge on industrial applications and advancements Auxiliary Equipment and Hoisting Equipment.
- To study operational functions of Bulk Handling Equipment and Systems.

UNIT- I	INTRODUCTION TO MATERIALS HANDLING	9

Basic principles – Objectives in material handling and its benefits – Classification of material handling equipments – Selection of material handling equipments – Guidelines for effective utilization of material handling equipments – Unit load concepts.

UNIT-II	INDUSTRIAL VEHICLES	9

Introduction and types – Hand trucks – Two wheel Hand Trucks – Multiple wheel Hand Trucks – Hand Lift Trucks – Power Trucks – Fixed Platform Truck – Platform Lift Truck – Pallet Lift Truck – Walkie Truck – Straddle Carrier – Fork Lift Trucks – Specifications of FLT – FLT Attachments – Tractors – Industrial Tractor – Trailer – Self-propelled trucks and fork trucks – Automated guided vehicles Theory.

UNIT-III	CONVEYORS	9

Classification of conveyors – Definition – Description – General Characteristics – Types and uses of belt Conveyors – Roller conveyors – Haulage Conveyors – Screw Conveyors – Bucket Conveyors – Chain Conveyors – Cable Conveyors – Pneumatic and Hydraulic conveyors – Vibrating and actuating conveyors – Computer controlled conveyor systems.

UNIT-IV	AUXILIARY EQUIPMENTAND HOISTING EQUIPMENT	9

Hoppers – Gates – Feeders – Chutes – Positioners – Ball Table – Weighing and Control Equipments – Pallet loaders and un loaders – Applications and advancements – Hoisting Equipments – Parts of hoisting equipments – Description and uses of hoists – Description and uses of ropes – Description and purpose of crane hooks – Elevators – Cranes – Derricks and its types.

UNIT-V	BULK HANDLING EQUIPMENT AND SYSTEMS	9

Storage of bulk solids – Bulk handling equipment – Robotic handling – Materials handling at the workplace – Robots and their classification – Major components of a robots – Classification of Robotic manipulators – Robotic handling applications – Maintenance and safety of material handling equipments.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Evaluate and select suitable material handling equipment considering operational, financial, and safety factors.
2.	Recognize and describe various types of hand trucks, power trucks, and forklifts, including their functional differences and industrial applications.
3.	Develop material handling strategies by selecting the appropriate type of conveyor system.
4.	Elaborate the basic working principles of various Auxiliary Equipment and Hoisting Equipment.
5.	Explain the basic working principles of various Bulk Handling Equipment and Systems.

TEXT BOOKS

1. Allegri (Sr.), T.H., Material Handling, Principles and Practices, CBS Publishers and Distributors, Delhi, 2019.
2. Siddharta Ray, Introduction to Materials Handling, New Age International Publishers, 2017.

REFERENCES

1. Bolz, H. A and Hagemann, G. E (ed.), „„Materials Handling Handbook"", Ronald Press 2011

2.	8005:1976, Classification of Unit Loads, Bureau of Indian Standards.
3.	Apple, J.A., Material Handling System Design"", John Wiley & Sons, 2021
4.	Theodore H., Allegre Sr., Material Handling Principles and Practice, CBS Publishers and Distributors, 2019

Mapping of COs with POs and PSOs													
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	✓	✓	✓	✓	✓							✓	✓	
CO2	✓	✓	✓	✓	✓							✓	✓	
CO3	✓	✓	✓	✓	✓							✓		✓
CO4	✓	✓	✓	✓	✓							✓	✓	
CO5	✓	✓	✓	✓	✓							✓		✓

Course Code	Course Name	Semester	Credits	L T P C
	PRODUCTION PLANNING AND CONTROL	8		3 0 0 3

COURSE OBJECTIVES

- To familiarize with various types of production and aspects of production planning.
- To understand the concepts and steps involved in work study.
- To identify various steps involved in product and process planning.
- To evaluate various components and functions of production scheduling.
- To integrate the inventory control and recent trends like JIT, MRP- II and ERP.

UNIT- I	INTRODUCTION TO PRODUCTION PLANNING AND CONTROL	9

Objectives – Benefits of production planning – Functions of production Control – Types of productions – Job shop, batch and continuous – Product Analysis – Marketing aspects – Durability – Dependability and Aesthetic aspects – Production Aspects – General approach to DFM – Guidelines for the selection of production Processes – Guidelines for specific processes like casting, forming, machining and assembly – Elements of production control – Organization of production planning and control.

UNIT-II	WORK & TIME STUDY METHODS	9

Method study and basic procedure – Selection – Recording of process – Critical analysis – Development – Implementation of method study – Micro motion and memo motion study – Work measurement – Techniques of work measurement – Time study – Production study – Work sampling – Synthesis from standard data – Pre-determined motion time standards (PMTS) – SIMO chart – Factors influencing working environment and productivity – Allowances and types.

UNIT-III	PRODUCT PLANNING AND PROCESS PLANNING	9

Product planning and Information – Value Analysis – Problems in lack of product Planning – Process planning and Routing – Information needed for process planning – Steps in process planning – Manual Vs CAPP – Computer Aided Process Planning – Generative CAPP – Retrieval CAPP – Quantity determination in batch Production – Machine capacity – Balancing – Analysis of process capabilities in a multi-product system – Importance of forecasting – Types of forecasting – Principles of forecasting techniques.

UNIT-IV	PRODUCTION SCHEDULING TECHNIQUES	9

Production Control Systems – Loading and scheduling – Master Scheduling – Scheduling Rules – Gantt Charts – Perpetual Loading – Basic scheduling problems – Line of balance – Flow production scheduling – Batch Production Scheduling – Product sequencing – Routing procedure – Route sheets – Bill of materials – Factors affecting routing procedure – MRP-I – Kanban – Dispatching – Progress reporting and expediting – Manufacturing lead time – Techniques for aligning completion times and due dates.

UNIT-V	INVENTORY CONTROL AND RECENT TRENDS IN PPC	9

Inventory Control – Purpose of holding Stock – Effect of demand on Inventories – Ordering procedures – Two bin System – Ordering Cycle System – Determination of Economic order quantity(EOQ) – Economic lot size – ABC Analysis – Recent trends in computer integrated production planning systems – Elements of JIT – Fundamentals of MRP-II and ERP – Exponential smoothing technique for demand forecasting – Stochastic demand forecasting.

CO	COURSE OUTCOMES
Upon completion of this course, Students should be able to	
1.	Distinguish the types of production and aspects of production planning.
2.	Construct the various charts, diagrams and eliminate unnecessary movements and delays, also to calculate standard time to complete the assigned job.
3.	Execute various analysis of a product, prepare routing chart, and also analyze process capabilities in a multi-product system.
4.	Investigate a better scheduling and line balancing, also to apply techniques for aligning completion times and due dates.
5.	Implement various methods to control Inventory in manufacturing organization and to apply recent trends like JIT, MRP-II and ERP systems in PPC.

TEXT BOOKS	
1.	O P Khanna, Industrial Engineering and Management, Dhanpat Rai & Co., 2019..
2.	K C Jain and L N Agarwal, Production Planning and Control, 6th edition, Khanna Publishers, 2018.
3.	Anurag Singh Parihar, Production planning & control: An Overview of Production Systems and Production Planning and Control,2nd Edition 2021..
REFERENCES	
1.	D R Kiran, Production Planning and Control : A Comprehensive Approach‖
2.	P Ramamurthy, —Production and Operations Management‖, New Age International Publications, 2007.
3.	R. Pannerselvam, —Production & Operations Management‖, 2nd edition, PHI Publications, 2010.
4.	Jawad Akhtar —Production Planning and Control with SAP ERP 2016 edition.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	✓						✓					✓		✓
CO2		✓			✓				✓				✓	
CO3			✓	✓	✓		✓			✓			✓	
CO4	✓				✓	✓								✓
CO5			✓		✓						✓		✓	