Curriculum for Undergraduate Degree (B.Tech.) in Mechanical Engineering (w.e.f. AY: 2020-21)

Part III: Detailed Curriculum

Sixth Semester

Course Name:	**Manufacturing Technology**		
Course Code:	PC-ME 601	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	4
L-T-P:	4-0-0	**Pre-Requisites:**	Basic manufacturing process
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To impart knowledge to make students able to demonstrate the tooling needed for manufacturing, the dimensional accuracy and tolerances of products, assembly of different components.
2	To understand the principles of working of NC, CNC machine tools and rapid prototyping.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	**Module 1: Introduction** Machining: Basic principle, purpose, definition and requirements	2L
2	**Module-2: Cutting tool and tool geometry** Theory of metal cutting supplemented with numerical problems. Tool geometry, chip formation, cutting force calculations and measurement, tool wear	8L
3	**Module-3: Mechanism of machining** Chip formation mechanism, yielding and brittle fracture, chip reduction coefficient, cutting ratio, shear angle and cutting strain. Built-up edge formation, cause, type and effects, orthogonal cutting and oblique cutting. Machining chips: types and conditions, chip formation in drilling and	10L

	milling.	
4	**Module-4: Mechanics of machining** Purposes of determination of cutting forces and basic two approaches, cutting force components in ORS and Merchant's circle diagram. Determination of cutting forces, analytical methods, measurement.	6L
5	**Module-5: Cutting tools-failure, life and materials** Methods of failure of cutting tools mechanisms, geometry and assessment of tool wear Tool life, definition, assessment and measurement, Taylor's tool life equation and its use Cutting tool materials, essential properties, characteristics and applications of HSS, carbide (uncoated/coated), ceramic, diamond and CBN tools.	4L
6	**Module-6: Metal cutting** Single and multi-point cutting; Orthogonal cutting, various force components: Chip formation, Tool wear and tool life, Surface finish and integrity, Machinability, Cutting tool materials, Cutting fluids; Turning, Drilling, Milling and finishing processes.	16L
7	**Module-7: Introduction to Automation** Introduction to automation, classification, need for automation, evolution from conventional machine tools to automated machine tools, future prospects	2L
Total		**48L**

Course Outcomes:
After completion of the course, students will be able to:
1. Understand the basics of metal cutting and working of different types of machine tools. 2. Apply cutting mechanics to metal machining based on cutting force and power consumption. 3. Select appropriate machining processes and conditions for different metals.

Learning Resources:	
1	S. Kalpakjian and S.R. Schmid, Manufacturing Processes for Engineering Materials, 5th Edition, Pearson India, 2014.
2	A. Ghosh & A.K. Mullick, Manufacturing Science, EW Press.

3	P.N. Rao, N.K. Tewari and T.K. Kundra, Computer Aided Manufacturing, McGraw Hill, 2017.
4	M.P. Grover, Fundamentals of Modern Manufacturing, 3rd Edition, Wiley.
5	M.P. Groover, Automation, Production Systems and CIM, Prentice Hall.

Course Name:	**Design of Machine Elements**		
Course Code:	PC-ME602	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	4
L-T-P:	3-1-0	**Pre-Requisites:**	Basic knowledge of Strength of materials, Machine Drawing
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	A strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components.
2	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3	An overview of codes, standards and design guidelines for different elements
4	An appreciation of the relationships between component level design and overall machine system design and performance
5	An appreciation of parameter optimization and design iteration.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	**Module 1:** Objective and scope of Mechanical Engineering Design; Design considerations; Review and selection of materials and manufacturing processes; codes and standards;	4L
2	**Module 2:** Modes of failure; Design/allowable stress; Factor of safety (FoS); Theories of failure – maximum normal stress theory, maximum shear stress theory, Distortion energy theory. Choice of Failure criteria; Design for stability : buckling analysis – Johnson and Euler columns	4L
3	**Module 3:** Fatigue in metals; S-N curve; Endurance limit and fatigue strength; Stress concentration factors – effect of discontinuity, fillets and notches; Effect of size, surface finish, stress concentration and degree of reliability on endurance limit; Design for finite and infinite life;	5L

	Goodman, modified Goodman and Soderberg diagrams with respect to fatigue failure under variable stresses; Cumulative fatigue damage – Miner's equation.	
4	**Module 4:** Design of (i) Cotter joint; (ii) Knuckle joint and (iii) Fillet Welded joint of brackets under different types of loading	6L
5	**Module 5:** Bolted joints : Metric thread, standard sizes, use of lock nuts and washers; Applications in structures including brackets, turn buckle; Pre-stressed bolts; Riveted joints : Unwin's formula; Brief discussion on single, double and triple row lap joints, butt joints with single or double strap / cover plate; simple strength design; joint efficiencies.	6L
6	**Module 6:** Design of: (i) Solid and hollow shafts, strength design of shafts, design based on torsional rigidity; (ii) Shaft coupling-rigid, pin-bush and geared flexible type, alignment of coupling; (iii) Belt drives-geometrical relations, derivation of torque and power transmission by flat and V-belt drives, selection of belt from manufacturers' catalogues, pulley (iv) Chain drives – roller chains, polygonal effect, power rating, sprocket wheel, silent chain	10L
7	**Module 7:** Design of: (i) Transmission screw, Screw jack, (ii) Helical compression spring - stress and deflection equations, stiffness, curvature effect : Wahl's factor, springs in parallel and series; (iii) Multi-leaf springs : load-stress and load-deflection equations, Nipping	8L
8	**Module 8:** Analysis and design of sliding and rolling contact bearings, Design of transmission elements: spur, helical, bevel and worm gears; Analysis of clutches and brakes	5L
Total		**48L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	understand and apply principles of gear design to spur gears and industrial spur gear boxes
2	become proficient in Design of Helical and Bevel Gear

3	develop capability to analyze Rolling contact bearing and its selection from manufacturer's Catalogue.
4	achieve an expertise in design of Sliding contact bearing in industrial applications.

Learning Resources:	
1	J. E. Shigley and C. R. Mischke, Mechanical Engineering Design, 5th Edition, McGraw Hill International, 1989.
2	D. Deutschman, W.J. Michels and C.E. Wilson, Machine Design Theory and Practice, Macmillan, 1992.
3	R.C. Juvinal, Fundamentals of Machine Component Design, John Wiley, 1994.
4	M.F. Spottes, Design of Machine elements, Prentice-Hall India, 1994.
5	V. B. Bhandari, Design of Machine Elements by, McGraw Hill Publishing Co. Ltd., 2007.

Course Name:	**Operations Research**		
Course Code:	HM-HU 601	**Category:**	Professional Core Courses
Semester:	Sixth	**Credit:**	4
L-T-P:	3-1-0	**Pre-Requisites:**	
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To study the various Operations Research tools,
2	To study to apply an appropriate model to the given situation.
3	To formulate the problem.
4	To solve and analyze the problems on Operations Research.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools, Structure of the Mathematical Model, Limitations of Operations Research	2L
2	**Module 2:** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Graphical Methods to Solve Linear Programming Problems, Applications,	8L

	Advantages, Limitations. Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Some Basic Definitions, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP. Simplex Method: Introduction, Standard Form of LPP, Fundamental theorem of LPP, Solution of LPP - Simplex Method, The Simplex Algorithm, Penalty Cost Method or Big M-method, Two Phase Method, Solved Problems on Minimization. Duality in Linear Programming Problem: Introduction, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis.	
3	**Module 3:** Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality.	3L
4	**Module 4:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem.	3L
5	**Module 5:** Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT, Float calculation and its importance. Cost reduction by Crashing of activity	5L
6	**Module 6:** Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Queue discipline, Service Mechanism, Classification of Queuing models, [M/M/1]:{//FCFS} Queue System, numerical.	3L
7	**Module 7:** Inventory classification, Different costs associated to Inventory, Inventory models with deterministic demands (EOQ, EPQ and price discount models), inventory classification systems.	4L
8	**Module 8:** Introduction to sequencing and scheduling models: n job two machines problem, n job 3 machines problem	2L
9	**Module 9:** Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree.	3L

10	**Module 10:** Introduction, Replacement of capital equipment which depreciated with time, replacement by alternative equipment, Group and individual replacement policy.	3L
Total		**36L**

Course Outcomes:
After completion of the course, students will be able to:
1. Apply forecasting methods for predicting demands.
2. Make decisions under certainty, uncertainty and conflicting situations.
3. Apply linear programming tools for optimal utilization of resources in various types of industries.
4. Solve transportation problems to minimize cost and understand the principles of assignment of jobs and recruitment polices.
5. Understand the basic elements of a Queuing model
6. Apply PERT/CPM for project scheduling and resource allocation in an optimal way.
7. Manage inventory with cost effectiveness.

Learning Resources:	
1	F.S. Hillier, G.J. Lieberman, B. Nag and P. Basu, Introduction to Operation Research, 10th Edition, McGraw Hill, 2017.
2	K.V. Mittal and C. Mohan, Optimization Methods in Operations Research and Systems Analysis, New Age, 2003.
3	H. A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002.
4	A. Ravindran, D.T. Phillips and J.J. Solberg, Operations Research: Principles and Practice, 2nd Edition, John Willey and Sons, 2009.
5	J.K. Sharma, Operation Research: Theory and Applications, 5th Edition, Macmillan Pub., 2013.

Course Name:	**Constitution of India**		
Course Code:	MC 672	**Category:**	Mandatory Courses
Semester:	Sixth	**Credit:**	0
L-T-P:	0-2-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To provide basic information about Indian constitution.
2	To identify individual role and ethical responsibility towards society.

3	To understand human rights and its implications.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	Introduction to the Constitution of India, The Making of the Constitution and Salient features of the Constitution. Preamble to the Indian Constitution Fundamental Rights & its limitations.	4L
2	Directive Principles of State Policy & Relevance of Directive Principles State Policy Fundamental Duties. Union Executives – President, Prime Minister Parliament Supreme Court of India.	5L
3	State Executives – Governor, Chief Minister, State Legislature High Court of State. Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments.	5L
4	Special Provision for SC & ST Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights –Meaning and Definitions, Legislation Specific Themes in Human Rights- Working of National Human Rights Commission in India Powers and functions of Municipalities, Panchyats and Co - Operative Societies.	5L
5	Special Provision for SC & ST Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights –Meaning and Definitions, Legislation Specific Themes in Human Rights- Working of National Human Rights Commission in India Powers and functions of Municipalities, Panchyats and Co - Operative Societies.	5L
Total		**29L**

Course Outcomes:
After completion of the course, students will be able to:
1. Have general knowledge and legal literacy and thereby to take up competitive examinations. 2. Understand state and central policies, fundamental duties. 3. Understand Electoral Process, special provisions. 4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies, 5. Understand Engineering ethics and responsibilities of Engineers 6. Understand Engineering Integrity & Reliability

Learning Resources:	
1	D.D. Basu, Introduction to the Constitution on India, 19th/ 20th Students Edition, Prentice Hall EEE, 2001.
2	C.E. Haries, M.S. Pritchard and M.J. Robins, Engineering Ethics, Thompson Asia, 2003.
3	M.V. Pylee, An Introduction to Constitution of India, Vikas Publishing, 2002.
4	M. Govindarajan, S. Natarajan and V.S. Senthilkumar, Engineering Ethics, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5	B.K. Sharma, Introduction to the Constitution of India, PHI Learning, New Delhi, 2011.
6	Latest Publications, Indian Institute of Human Rights, New Delhi.

Course Name:	**Aptitude Skill Development-II**		
Course Code:	MC 671	**Category:**	Mandatory course
Semester:	Sixth	**Credit:**	0
L-T-P:	0-2-0	**Pre-Requisites:**	Basic knowledge of Mathematics and English Language
Full Marks:	100		
Examination Scheme:	Semester Examination: 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To be familiar with the basic concepts of QUANTITATIVE ABILITY.
2	To be familiar with the basic concepts of LOGICAL REASONING Skills.
3	To be familiar with the basic concepts of PROBABILITY.
4	Acquire knowledge in VERBAL REASONING and VOCABULARY

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	Basics of Quantitative Abilities: Number System, HCF and LCM, Average, Ratio, Proportion and Variations, Problems on Percentage.	4L
2	Arithmetic Quantitative Abilities: Problems on Ages, Profit and Loss, Time and Work, Problems on Simple and Compound Interest, Problems on Time, Speed and Distance.	6L
3	Permutation and Combination, Set theory, Mensuration and Logarithm.	5L
4	Logical Reasoning: Number Series, Alpha Numerical, Letter & Symbol Series, Numerical and Alphabet Puzzles, Seating Arrangement, Blood Relation and Calendars.	7L

5	Data Interpretation	2L
Total		**24L**

Course Outcomes:
After completion of the course, students will be able to:
1. Understand the basic concepts of QUANTITATIVE ABILITY. 2. Understand the basic concepts of LOGICAL REASONING Skills. 3. Understand the basic concepts of PROBABILITY. 4. Acquire satisfactory competency in use of VERBAL REASONING

Learning Resources:	
1	Arun Sharma, "Quantitative abilities", McGraw-Hill
2	R. S. Agrawal, "Quantitative Aptitude for Competitive Examinations", S. Chand
3	R. S. Agarwal,"A Modern Approach to Verbal & Non-Verbal Reasoning ",S. Chand

Course Name:	**Mechanical Engineering Laboratory-II (Design)**		
Course Code:	PC-ME 691	**Category:**	Professional Core Courses
Semester:	Sixth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Machine Deisgn
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To understand the measurement of mechanical properties of materials
2	To understand the deformation behaviour of materials
3	To understand the kinematic and dynamic characteristics of mechanical devices

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	Uniaxial tension test on mild steel rod	3P
2	Torsion test on mild steel rod	3P
3	Impact test on a metallic specimen	3P

4	Brinnell/Vickers and Rockwell hardness tests on metallic specimens	3P
5	Bending deflection test on beams	3P
6	Strain measurement using Rosette strain gauge, or like.	3P
7	Microscopic examination of heat-treated and untreated metallic samples	3P
8	Determination of velocity ratios of simple, compound, epicyclic and differential gear trains	3P
9	Studying kinematics of four bar, slider crank, crank rocker, double crank, double rocker and oscillating cylinder mechanisms	3P
10	Studying kinematics of typical mechanisms like pantograph, some straight line motion mechanisms, wiper, drafter, etc.	3P
11	Motion studies of different cams & followers	3P
12	Single degree of freedom Spring-mass-damper system: determination of natural frequency and damping coefficient	3P
13	Determination of torsional natural frequency of single and double rotor systems- undamped and damped natural frequencies	3P
14	Studying machine vibration using sensor	3P
15	Solving simple balancing problems experimentally	3P
*Minimum 12 experiments are to be performed		
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
Students who have undergone the course will be able to understand the measurement of mechanical properties of materials and will be able to characterize the dynamic behavior of mechanical system.

Learning Resources:	
1	Laboratory manual

Course Name:	**Soft skill Development Lab**		
Course Code:	HM-HU 691	**Category:**	Professional Core Courses
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	NIL
Full Marks:	100		
Examination	Semester Examination:	Continuous	Attendance: 05

Scheme:	60	Assessment: 35	

Course Objectives:	
1	Today's world is all about relationship, communication and presenting oneself, one's ideas and the company in the most positive and impactful way. This course intends to enable students to achieve excellence in both personal and professional life.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Know Thyself/ Understanding Self Introduction to Soft skills-Self-discovery-Developing positive attitude-Improving perceptions-Forming values	6P
2	**Module 2:** Interpersonal Skills/ Understanding: Others Developing interpersonal relationship-Team building-group dynamics-Networking Improved work relationship	6P
3	**Module 3:** Communication Skills / Communication: with others Art of listening-Art of reading-Art of speaking-Art of writing-Art of writing e-mails-e mail etiquette	6P
4	**Module 4:** Corporate Skills / Working with Others Developing body language-Practicing etiquette and mannerism-Time management Stress management	6P
5	**Module 5:** Selling Self / Job Hunting Writing resume/cv-interview skills-Group discussion- Mock interview-Mock GD – Goal setting - Career planning	6P
Total		**30P**

Course Outcomes:
After completion of the course, students will be able to:
1. Effectively communicate through verbal/oral communication and improve the listening

skills. 2. Write precise briefs or reports and technical documents. 3. Actively participate in group discussion / meetings / interviews and prepare & deliver presentations. 4. Become more effective individual through goal/target setting, self motivation and practicing creative thinking. 5. Function effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, Inter-personal relationships, conflict management and leadership quality.

Learning Resources:	
1	Meena. K and V. Ayothi (2013) A Book on Development of Soft Skills (Soft Skills : A Road Map to Success), P.R. Publishers & Distributors,
2	Alex K. (2012) Soft Skills – Know Yourself & Know the World, S.Chand & Company LTD
3	

Course Name:	**Mini Project-II**		
Course Code:	PW-ME 681	**Category:**	Professional Core Courses
Semester:	Fifth	**Credit:**	2
L-T-P:	0-0-4	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

Course Outcomes:
After completion of the course, students will be able to:
technical event/ competition to fabricate and demonstrate an innovative machine or product, etc.

Course Name:	**Internal combustion Engines and Gas Turbines**		
Course Code:	A	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Thermodynamics and Heat Transfer
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To acquire knowledge about the IC engine cycles, classification, working Principles and to measure performance parameters along with heat balance sheet.
2	To explain different alternate fuels, gas turbines and about jet propulsion.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction to Engines: The working principle of Engines, Comparison of 2-Stroke and 4-Stroke Engines; CI, and SI Engines, Ideal and Actual Working Cycles and their analysis, Valve timing Diagram. Fuels: Fossil fuels, Chemical structure of Petroleum, Properties of SI and CI Engine Fuels, Fuel Ratings; Octane Number, Cetane Number.	6L
2	**Module 2:** Carburetors and fuel injectors: Carburetor, Calculation of Air-Fuel Ratio, Parts of Carburetor. Requirement of Injection Systems, Classification of Injection Systems, Fuel Feed pump, Injection Pumps, Working principles of Governors, Nozzles and Fuel Injector, Injection in SI and CI Engines. Combustion and Ignition Systems in SI and CI Engines: Normal and abnormal combustion, detonation and knocking.	7L
3	**Module 3:** Testing and Performance: Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and indicated power –	7L

	Performance test – Heat balance sheet and chart Classification of compressors – Fans, blowers and compressors – positive displacement and dynamic types – reciprocating and rotary types. Modern Automotive engines:	
4	**Module 4:** Alternative fuels for IC Engines: Necessity and advantages of alternate fuels over conventional fuels, Biofuels, Hydrogen based engines, concern about pollution and its adverse effects.	3L
5	**Module 5:** Gas Turbine: Introduction to Gas Turbine, Development, Classification and Application of Gas Turbines, Ideal and Actual Cycles; Effect of Intercooling, Reheating, Regeneration, Combined cycle and Cogeneration	6L
6	**Module 6:** Gas Turbine Cycle for Aircraft Propulsion: Simple Turbojet Cycle, The turboprop engine, Thrust augmentation, Gas turbine combustion systems, Combustion chamber designs, Gas Turbine Emissions.	7L
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. Develop concepts of IC engines along with its working principles. 2. Describe the combustion phenomenon in SI and CI engines. 3. Evaluate the performance of IC engines and the importance of alternate fuels. 4. Classify the essential components of gas turbine along with its performance improving methods. 5. Illustrate the working principle of different types of Jet propulsive engines and Rockets.

Learning Resources:	
1	V. Ganesan, IC Engines, McGraw Hill, 2004
2	V. Ganesan, Gas Turbines, McGraw Hill, 2004
3	J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Co., 1988.
4	W.W. Pulkrabek, Engineering Fundamentals of IC Engine, PHI Pvt. Ltd., 2002.

Course Name:	**Refrigeration and Air Conditioning**		
Course Code:	B	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Thermodynamics and Heat Transfer
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To Know the basics of refrigeration and air-conditioning system.
2	To learn about different types of Refrigeration, Air-Conditioning and ventilation systems.
3	To know about designing a Refrigeration and Air-Conditioning system.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	**Module 1:** Introduction to Refrigeration: – Necessity and applications – Unit of refrigeration and C.O.P. – Mechanical Refrigeration – Types of Ideal cycle of refrigeration. Air Refrigeration: Bell Coleman cycle and Brayton Cycle, Open and Dense air systems – Actual air refrigeration system – Refrigeration needs of Air crafts- Air systems – Application of Air Refrigeration, Justification – Types of systems – Problems.	8L
2	**Module 2:** Vapour compression refrigeration – working principle and essential components of the plant – Simple Vapour compression refrigeration cycle – COP – Representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – Actual cycle Influence of various parameters on system performance – Use of p-h charts – Problems.	7L
3	**Module 3:** System Components: Compressors – General classification – comparison – Advantages and Disadvantages. Condensers – classification – Working Principles. Evaporators – classification – Working Principles. Expansion devices – Types – Working Principles.	7L

	Refrigerants – Desirable properties – common refrigerants used – Nomenclature – Ozone Depletion – Global Warming – Azeotropes and Zeotropes.	
4	**Module 4:** Vapor Absorption System – Calculation of max COP – description and working of NH3 – water system Li – Br system. Principle of operation Three Fluid absorption system, salient features. Steam Jet Refrigeration System – Working Principle and Basic Components Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.	6L
5	**Module 5:** Introduction to Air Conditioning: Psychometric Properties & Processes – Sensible and latent heat loads – Characterization – Need for Ventilation, Consideration of Infiltration – Load concepts of RSHF, ASHF, ESHF and ADP. Concept of human comfort and effective temperature –Comfort Air conditioning – Industrial air conditioning and Requirements – Air conditioning Load Calculations. Air Conditioning systems – Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, deodorants, fans and blowers. Heat Pump – Heat sources – different heat pump circuits – Applications.	8L
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. know about the systems of Refrigeration, Air-Conditioning and Ventilation. 2. learn about different components of these systems. 3. know about designing a Refrigeration and Air-Conditioning system.

Learning Resources:	
1	J.W. Jones, Refrigeration and Air Conditioning, McGraw Hill, 2014.
2	C.P. Arora, Refrigeration and Air Conditioning, McGraw Hill India, 2017.
3	P.L. Ballaney, Refrigeration and Air Conditioning, Khanna Publication, New Delhi, 1972.
4	R.C. Arora, Refrigeration and Air Conditioning, PHI, 2010.
5	S.C. Arora and S. Domkundwar, Refrigeration and Air Conditioning, Dhanpat Rai Publication, 2018.
6	Sadhu Singh, Refrigeration and Air Conditioning, Khanna Publishing House, 2018.

Course Name:	**Turbo Machinery**		
Course Code:	C	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Fluid Mechanics and Fluid Machinery
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To know about the basic characteristics of compressible and incompressible flow machines.
2	To learn about deriving dimensionless numbers through dimensional analysis.
3	To know about system of testing and performance analysis of turbo machines.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction: Radial, axial and mixed flow machines; Turbines vs pumps, fans and compressors. Applications: Water supply, ventilation, power generation, propulsion.	2L
2	**Module 2:** Incompressible flow machines: i) Hydraulic Turbines: Headrace, penstock, nozzle, runner, draft tube and tail race; Gross head and net head; Velocity diagrams for impulse and reaction turbines; Discharge, head, power and efficiencies. ii) Pumps: Reservoir, foot valve, suction line, pump, delivery line and overhead tank; Static head and losses; Velocity diagrams; Discharge, head, power and efficiencies.	16L
3	**Module 3:** Compressible flow machines: Static and stagnation states; Isentropic and adiabatic expansion and compression processes; Nozzle, diffuser and rows of stationary and moving blades; Efficiencies.	8L
4	**Module 4:** Dimensional analysis: coefficients, pressure ratio, enthalpy ratio, Reynolds number, Mach number; Specific speed and machine selection.	4L
5	**Module 5:** Measurement devices; affinity laws and unit quantities. Set up and	6L

	operating characteristics of pumps, turbines; fans and turbo-compressors. Cavitation– cause of cavitation and definition of Thoma's cavitation parameter, surge and choking.	
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. know basic characteristics of compressible and incompressible flow machines. 2. learn how to derive dimensionless numbers using dimensional analysis. 3. know about the method of testing and performance analysis of turbo machines.

Learning Resources:	
1	S. M. Yaha, Compressors and Fans, 4th Edition, McGraw Hill Education, 2017.
2	J. Lal, Hydraulic Machines, Metropolitan Book Co., New Delhi, 6th Edition, 2016.
3	S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics & Fluid Machines, McGraw Hill, 2017.
4	M.M. Das, Fluid Mechanics & Turbo Machines, PHI, 2010.
5	R.K. Bansal, Fluid Mechanics & Machinery, Laxmi Publications, 2018.
6	C. Ratnam, A.V. Kothapalli, Fluid Mechanics & Machinery, I.K. International Publishing House Ltd, 2010.

Course Name:	**Fluid Power Control**		
Course Code:	D	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Fluid Mechanics and Fluid Machinery
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To know the basics of different types of fluid power control systems and their applications.
2	To understand working principles of different components of a pneumatic or hydraulic system.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Fluid power; Applications and advantages; Components of a hydraulic and pneumatic system. Desired properties of a hydraulic fluid; advantage of mineral oil over water; definition of terms like pressure, head, force, density, specific gravity, kinematic and absolute viscosity, compressibility and incompressibility. Pascal's law; analysis of simple hydraulic jack, Mechanical advantage; continuity equation; hydraulic power of a cylinder	5L
2	**Module 2:** Hydraulic pumps: positive displacement pumps, constructional features, working principle and volumetric capacity of external gear pump, vane pump, axial piston pump and radial piston pump.	6L
3	**Module 3:** Hydraulic Actuators: Constructional features of single acting and double acting hydraulic cylinders; mounting of cylinders, cushioning of cylinder; different application of cylinder through mechanical linkages; force, velocity and power from a cylinder. Hydraulic motors; torque, power and flow rate in a hydraulic motor.	4L
4	**Module 4:** Hydraulic Valves: Direction control valves – operation and graphical symbol of 3-way and 4-way valves; different modes of activation of valves. Operation and graphical symbols of check valves, pressure relief valve pressure reducing valve, unloading valve and flow control valve.	4L
5	**Module 5:** Representation of hydraulic components through ANSI symbols. Analysis of hydraulic circuits for single and double acting cylinder control, regenerative circuit, pump unloading circuit, double pump hydraulic system, cylinder synchronization circuit, speed control of a hydraulic motor, circuit to lift and hold heavy load, automatic sequencing of two cylinders.	7L
6	**Module 6:** Advantages & disadvantages of pneumatic system compared to hydraulic system; constructional details and operation of a reciprocating compressor; working principle and use of filter, pressure regulator, lubricator and silencer; symbols of different pneumatic components; compressed air distribution system in a plant; drawing pneumatic circuits for different operations.	6L
7	**Module 7:** Use of electrical devices for controlling fluid circuits; function of electrical devices like push-button switches, limit switches, pressure	4L

	switches, solenoids, relays and timers and their symbols; concept of ladder diagram; study of circuits using electrical control devices such as control of a solenoid actuated cylinder using one limit switch, reciprocation of a cylinder using pressure or limit switches, and two cylinder sequencing circuit using two limit switches.	
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. know about different types of fluid power control systems and their applications. 2. learn working principles of different components of a pneumatic and hydraulic system. 3. learn about drawing fluid power control circuits to suit an application.

Learning Resources:	
1	A. Esposito, Fluid Power with Applications, Pearson, 2003.
2	S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, McGraw Hill, 1999.
3	E. C. Fitch Jr., Fluid Power and Control Systems, McGraw Hill, New York,1966.
4	D. S. Banks and D. D. Banks, Industrial Hydraulics, Prentice Hall, 1988.
5	C. Ratnam, A. V. Kothapalli, Fluid Mechanics & Machinery, I.K. International Publishing House Ltd, 2010.

Course Name:	**Composite Materials**		
Course Code:	E	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Materials Engineering
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To understand the mechanical behaviour of composite materials.
2	To get an overview of the methods of manufacturing composite materials.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Definition and applications of composite materials, Fibres-glass, carbon,	12L

	ceramic and aramid fibres; Matrices- polymer, graphite, ceramic and metal matrices; characteristics of fibres and matrices. Lamina- assumptions, macroscopic viewpoint, generalized Hooke's law, reduction of homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix, commercial material properties, rule of mixtures, transformation matrix, transformed stiffness	
2	**Module 2:** Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes	8L
3	**Module 3:** Basic assumptions of laminated anisotropic plates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli, evaluation of lamina properties, determination of lamina stresses, maximum stress and strain criteria, von Mises Yield criterion for isotropic materials, generalized Hill's criterion for anisotropic materials, Tsai-Hill's criterion for composites, prediction of laminate failure, thermal analysis of composite laminates.	8L
4	**Module 4:** Analysis of laminated plates- equilibrium equations of motion, energy formulation, static bending analysis, buckling analysis, free vibrations, natural frequencies.	8L
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. know different types of composite materials. 2. learn about the application of composite materials. 3. realize the advantages of composite materials over conventional materials.

Learning Resources:	
1	R. K. Gibson, Principles of Composite Material Mechanics, 2nd Edition, McGraw Hill, 1994.
2	M.W. Hyer, Stress Analysis of Fiber-Reinforced Composite Materials, McGraw Hill, 1998.
3	K.K. Chawla, Composite Materials- Science and Engineering, Springer International Publishing, 2019.
4	M. Mukhopadhyay, Mechanics of Composite Materials and Structures, University Press, 2013.

Course Name:	**Mechatronics**		
Course Code:	F	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Fluid Mechanics and Fluid Machinery, Kinematics and Theory of Machines, Basic Electrical Engineering, Basic Electronics Engineering
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To make familiar about control system and power electronics in designing mechatronic system
2	To provide knowledge on electrical circuits, signal conditioning.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction to Mechatronics: Definition, Mechatronics in design and manufacturing, Comparison between Traditional and Mechatronic approach; Concurrent engineering	3L
2	**Module 2:** Review of fundamentals of electronics: Logic gates and their operations, Signal processing devices, Data conversion devices, Input and output devices. Sensors and Transducers, Actuators, Limit switches, Relays	6L
3	**Module 3:** Control Systems: Open loop and closed loop control, block diagrams, transfer functions, Laplace transforms.	3L
4	**Module 4:** Electrical Drives: Stepper motors, servo drives.	2L
5	**Module 5:** Mechanical Drives: Different mechanisms, Ball screws, Linear motion bearings, Transfer systems.	3L
6	**Module 6:** Pneumatic and Hydraulic drives: elements of Pneumatic and Hydraulic	4L

	drives, comparison between them. Design of pneumatic and hydraulic circuits, symbolic representations of such circuits indicating different valves, actuators, etc	
7	**Module 7:** Basics of 8085 microprocessor, programmable register architecture, buses, memory mapping, clock pulse and data transfer operations, and simple assembly and mnemonic programming on 8085 microprocessor.	5L
8	**Module 8:** Use of On-Off, PI and PID controllers to control different drives, Programming in PLC controller using Ladder diagram.	4L
9	**Module 9:** Mathematical modeling of physical systems, such as spring-mass vibration system, linear and rotary motion and its Laplace Transform.	2L
10	**Module 10:** Basics of time domain analysis, Introduction to discrete-time systems and Z-transform.	2L
11	**Module 11:** Introduction to Mechatronic systems, such as automatic brake, door closing and opening, robot, CNC machine, AGV, etc.	2L
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. Model and analyze mechatronic systems for an engineering application 2. Identify sensors, transducers and actuators to monitor and control the behaviour of process or product. 3. Develop PLC programs for an engineering application. 4. Evaluate the performance of mechatronic systems.

Learning Resources:	
1	M.D. Singh and J.G. Joshi, Mechatronics, Prentice Hall of India, 2006.
2	D. Shetty and R. Kolk, Mechatronics System Design, 3rd Edition, PWS Publishing, 2009.
3	D.G. Alciatore & M.B. Histand, Introduction to Mechatronics and Measurement systems, 4th Edition, McGraw Hill, 2006.
4	A. Smaili and F. Arnold, Applied Mechatronics, Oxford University Press, Indian Edition, 2007.
5	K.K. Appu Kuttan, Introduction to Mechatronics, Oxford University Press, New Delhi, 2007.

Course Name:	**Robotics**		
Course Code:	G	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Manufacturing Technology and Basics of automation
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To impart knowledge about the engineering aspects of Robots and their application

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction: Basic concepts- Robot anatomy- Manipulators kinematics: Forward and inverse kinematics- Precision movement, robot specifications and Work volume, Types of Robot drives- Basic robot motions- Point to point control, continuous path contour.	8L
2	**Module 2:** End Effectors: End effectors- classification- mechanical, magnetic, vacuum and adhesive gripper- gripper force analysis and design. Robot control- Unit control system concept- servo and non-servo control of robot joints, adaptive and optimal control.	7L
3	**Module 3:** Sensors: Sensor devices, Types of sensors- contact, position and displacement sensors, Force and torque sensors- Proximity and range sensors- acoustic sensors- Robot vision systems- Sensing and digitizing- Image processing and analysis.	6L
4	**Module 4:** Robot Programming: Robot language classification- programming methods- off and on line programming- Lead through method- Teach pendent method- VAL systems and language, simple program.	8L
5	**Module 5:** Machine loading and unloading, Assembly, Inspection, Welding, Spray painting, Mobile robot, Micro-robots- Recent developments in	7L

	robotics- safety consideration.	
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. familiarize the basics of robots control system. 2. know about the end effectors, Sensor technology and Industrial application of robot.

Learning Resources:	
1	M.P. Groover. Industrial Robotics Technology Programming and Applications, McGrawHill Book Co, Singapore, 1987.
2	S.K. Saha, Introduction to Robotics, McGraw-Hill Publication, 2014.
3	Y. Koren, Robotics for Engineers, McGraw Hill, New York, 1985.
4	P.G. Ranky and C.Y. Ho, Robots Modelling Control and Applications with Software, Springer Verlag, 1985.
5	J.J. Craig, Introduction to Robotics, Addison-Wesley, 2009.

Course Name:	**Material Handling**		
Course Code:	H	**Category:**	Professional Elective Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Material Science and Engineering Mechanics and Mechanism
Full Marks:	100		
Examination Scheme:	Semester Examination (Viva-voce form): 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To know about the material handling systems used in industry
2	To learn about basic designing principles of some material handling
3	To know about modern handling system using a robot.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction: Definition, importance and scope of material handling	4L

	(MH); classification of materials; codification of bulk materials; utility of following principles of MH– (i) materials flow, (ii) simplification, (iii) gravity, (iv) space utilization, (v) unit size, (vi) safety, (vii) standardization, (viii) dead-weight, (ix) idle time, (x) motion.	
2	**Module 2:** Unit load: Definition; advantages & disadvantages of unitization; unitization by use of platform, container, rack, sheet, bag and self-contained unit load; descriptive specification and use of pallets, skids, containers, boxes, crates and cartons; shrink and stretch wrapping. Classification of MH Equipment: Types of equipment– (i) industrial trucks & vehicles, (ii) conveyors, (iii) hoisting equipment, (iv) robotic handling system and (v) auxiliary equipment; Independent equipment wise sub classification of each of above type of equipment.	6L
3	**Module 3:** Industrial trucks & vehicles: Constructional features and use of the following equipment – (i) wheeled hand truck, (ii) hand pallet truck, (iii) fork lift truck; Major specifications, capacity rating and attachments of fork lift truck.	6L
4	**Module 4:** Conveyors: Use and characteristics of belt conveyor, constructional features of flat and troughed belt conveyor; Use and constructional features of chain conveyors– (i) apron, car and trolley type; Construction of link-plate chains; Dynamic phenomena in chain drive; Use and constructional features of roller conveyors; Gravity and powered roller conveyor; Pneumatic conveyor-use and advantages; Positive, negative and combination system of pneumatic conveyors; constructional feature, application and conveying capacity of screw conveyor.	8L
5	**Module 5:** Hoisting Equipment: Advantage of using steel wire rope over chain; constructional features of wire ropes; Rope drum design; Pulley system-simple vs. multiple pulley; Load handling attachments: hooks, grabs, tongs, grab bucket; Arrangement of hook suspension with cross piece and pulleys (sheaves); Use and constructional features of (i) hand operated trolley hoist, (ii) winch; (iii) bucket elevator, (iv) Jib crane, (v) overhead traveling crane and (vi) wharf crane; Level luffing system of a wharf crane; Utility of truck mounted and crawler crane.	8L
6	**Module 6:** Robotic handling: Materials handling at workplace; Major components of a robot; Applications of robotic handling.	1L
7	**Module 7:** Auxiliary Equipment: Descriptive specification and use of (i) Slide and	3L

	trough gates, (ii) belt, screw and vibratory feeders, (iii) Chutes, (iv) positioners like elevating platform, ramps, universal vice; (v) ball table.	
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. know about constructional features, working principle and specific applications of each of the material handling system. 2. learn about unit load calculation and selecting specification of some material handling system.

Learning Resources:	
1	2. T.K. Ray, Mechanical Handling of Materials, Asian Books Pvt. Ltd., 2005.
2	T.H. Allegri, Materials Handling: Principles and Practices, CBS Publishers and Distributors, 2018.
3	J.M. Apple, Material Handling System Design, John Wiley & Sons, 1972.