SANJIVANI RURAL EDUCATION SOCIETY'S

SANJIVANI COLLEGE OF ENGINEERING KOPARGAON

(An Autonomous Institute Affiliated to SPPU Pune)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE – 2020 PATTERN for AY 2023-24

THIRD YEAR B. TECH.

LIST OF ABBREVIATIONS			
Abbreviation	**Full Form**	**Abbreviation**	**Full Form**
ES	Engineering Science	HSMC	Humanity Science
PCC	Professional Core	CIA	Continuous Internal Assessment
PE	Professional Elective	OR	End Semester Oral Examination
OE	Open Elective	PR	End Semester Practical Examination
ISE	In-Semester Evaluation	TW	Continuous Term Work Evaluation
ESE	End-Semester Evaluation	BSC	Basic Science Course
PRJ	Project	MLC	Mandatory Learning Course

T.Y.B. Tech SEM V 2021

Cat	Code	Course Title	Hrs./Week			Credits	Marks					
			L	T	P		Theory		TW	OR	PR	Total
							CIA	ESE				
PCC	ME301	Heat Transfer and CFD	3	-	-	3	40	60	-	-	-	100
PCC	ME302	Mechanical Component Design	3	-	-	3	40	60	-	-	-	100
PCC	ME303	Industrial Measurements and Quality Control	3	-	-	3	40	60	-	-	-	100
PCC	ME304	Industrial Automation (METX+HP)	3	-	-	3	40	60	-	-	-	100
PEC	ME305	Professional Elective-I	3	-	-	3	40	60	-	-	-	100
PCC	ME306	Lab-I (Heat Transfer and CFD)	-	-	2	1	-	-	-	-	25	25
PCC	ME307	Lab-II(Mechanical Component Design)	-	-	2	1	-	-	25	-	-	25
PCC	ME308	Lab-III (IMQC)	-	-	2	1	-	-	-	25	-	25
PCC	ME309	Lab-IV (Industrial Automation)	-	-	2	1	-	-	-	-	25	25
PRJ	ME310	Seminar and Technical Communication Skills	-	-	4	2	-	-	-	50	-	50
PRJ	HS311	Corporate Readiness - III	-	-	2	1	-	-	50	-	-	50
MLC	MC312	Mandatory Learning Course-V	1	-	-	Non Credit	-	-	-	-	-	Pass/ Fail
		Total	**16**		**14**	**22**	**200**	**300**	**75**	**75**	**50**	**700**

T.Y.B. Tech SEM VI 2021

Cat	Code	Course Title	Hrs./Week			Credits	Marks					
			L	T	P		Theory		TW	OR	PR	Total
							CIA	ESE				
PCC	ME313	Refrigeration and Air Conditioning	3	-	-	3	40	60	-	-	-	100
PCC	ME314	Transmission System Design	4	-	-	4	40	60	-	-	-	100
PCC	ME315	Production Technology	3	-	-	3	40	60	-	-	-	100
PEC	ME316	Professional Elective-II	3	-	-	3	40	60	-	-	-	100
PRJ	ME317	IPR & EDP	2	-	-	2	20	30	-	-	-	50
PCC	ME318	Lab-I (RAC)	-	-	2	1	-	-	-	-	25	25
PCC	ME319	Lab-II (Transmission System Design)	-	-	2	1	-	-	-	50	-	50
PCC	ME320	Lab-III (Production Technology)	-	-	2	1	-	-	-	-	25	25
PRJ	ME321	Project Based Learning	-	-	2	1	-	-	25	-	-	25
HSMC	HS322	Creational Activity Lab	-	-	2	1	-	-	25	-	-	25
MLC	MC323	Mandatory Learning Course-VI	1	-	-	Non Credit	-	-	-	-	-	Pass/ Fail
		Total	**16**	**-**	**10**	**20**	**180**	**270**	**50**	**50**	**50**	**600**

Professional Elective – I		Professional Elective – II	
ME305A	Waste Heat Recovery and Sustainable Energy	ME316A	Computational Fluid Dynamics
ME305B	Optimization Techniques	ME316B	Jigs, Fixtures and Tool Design
ME306C	Computer Integrated Manufacturing	ME316C	Additive Manufacturing
ME306D	Electric Vehicles	ME316D	Foundations of AI and ML
ME312	Mandatory Learning Course-V	Proficiency Skills (Design Thinking)	
ME323	Mandatory Learning Course -VI	Proficiency Skills (Programing Skills)	

HEAT TRANSFER & CFD (ME301)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA**	40 Marks
Credits:	**3**	**End Sem Exam:**	60 Marks
		Total:	100 Marks

==========

Prerequisite Course: Basic Thermodynamics.

==========

Course Objectives:

1. Formulate and apply the general three-dimensional heat conduction equations.
2. Analyse the thermal systems with internal heat generation and lumped heat capacitance
3. Understand the mechanism of convective heat transfer
4. Determine the radiative heat transfer between surfaces.
5. Understand and explain different types of heat exchangers and its performance.
6. Understand application of CFD in Heat Transfer

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	**Apply** heat conduction equation to solve one-dimensional steady state heat transfer problem.	3	Apply
CO2	**Determine** heat transfer rate for the thermal systems with internal heat generation, fins and transient heat conduction	3	Apply
CO3	**Evaluate** heat transfer in natural and forced convection	3	Apply
CO4	**Calculate** heat transfer by radiation between two bodies.	3	Apply
CO5	**Calculate** the heat transfer rate in heat exchangers and investigate their performance using LMTD and NTU approach	3	Apply
CO6	**Apply** CFD tool to solve heat transfer problem using a software.	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	1	1	3	3	-	1	-	1	2
CO2	3	2	1	-	-	-	1	1	3	3	-	1	-	1	2
CO3	3	2	2	-	-	-	1	1	3	3	-	1	-	1	3
CO4	3	2	2	-	-	-	1	1	3	3	-	1	-	1	3
CO5	3	2	1	-	-	-	1	1	3	3	-	1	-	1	3
CO6	3	2	2	2	2	-	1	1	3	3	-	1	-	1	2

Course Contents

Unit	Contents	No. of Hours	COs
1	**Introduction and Basic Concept**		
	Introduction-Modes and mechanisms of heat transfer: Basic laws of heat transfer- three modes, concept of Thermal conductivity, Thermal diffusivity and heat transfer coefficient. **Conduction Heat Transfer:** General heat conduction equation in Cartesian (derivation), Discussion on Cylindrical and Spherical coordinates (no derivation) Steady, unsteady state heat transfer. Thermal resistance, Thermal contact Resistance. Electrical analogy to 1-D steady state heat conduction in plane wall, cylinder and sphere without heat generation. Insulating materials, Critical thickness of insulation.	6 Hrs.	CO1
2	**Conductive Heat Transfer**		
	1-D steady state heat conduction with heat generation: Application of 1-D Poisson's heat conduction equation for plane wall, cylinder and sphere with various boundary conditions. **Heat transfer in extended surfaces:** Types, applications, Governing Equation for constant cross sectional area fins, solution for infinitely long & insulated fin tip, fin efficiency & fin effectiveness. **Transient Conduction** Concept of Internal Temperature Gradient (ITG), lumped capacity analysis, dimensionless numbers in unsteady state Heat transfer, Time constant of thermocouple.	8 Hrs.	CO2

3	**Convective Heat Transfer**		
	Convective Heat Transfer: classification of convection, Local and overall heat transfer coefficient., dimensionless numbers in forced convection, velocity and thermal boundary layer in laminar and turbulent flow condition. **External Forced Convective Heat Transfer:** Flow over a flat horizontal plate, Cylinder and sphere (Laminar and turbulent), numerical based on empirical correlation **Internal Forced Convective Heat Transfer:** concept of hydraulic diameter, Flow through a pipe or tube (Turbulent flow, Laminar flow). **Heat Transfer by Natural Convection:** Introduction, dimensionless numbers, Convection around a flat horizontal/vertical plate, horizontal/vertical cylinder, numericals based on empirical correlation.	6 Hrs.	CO3
4	**Radiation**		
	Stefan and Boltzmann's law, concept of black body, grey body, Planck's law, Wien's law, Kirchhoff's law, Lambert's law, heat exchange between two black bodies, concepts of shape factor. Laws of shape factor, radiosity, irradiation, electrical analogy. Calculation of radiation heat transfer between two surfaces, radiation shield.	6 Hrs.	CO4
5	**Heat exchangers, condensation and Boiling**		
	Heat exchangers: Classification and applications, heat exchanger analysis – LMTD, effectiveness– NTU method for parallel and counter flow heat exchanger, LMTD correction factor, cross flow heat exchanger, design criteria for heat exchanger, Introduction to TEMA. **Applications of heat transfer:** heat pipe, thermowell, cooling of electronic equipment, phase change materials, heat transfer improvement methods. **Condensation and Boiling:** Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation.	6 Hrs.	CO5
6	**Application of CFD in Heat Transfer**		
	Introduction to CFD, Use of CFD in various industries, Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Discritization of Navier Stokes Equations (Only Introduction) Hands on suitable Workbench and discussion about the validation of the results. - Convection heat transfer.	6 Hrs.	CO6

Books

S.N.	Title of Book	Authors	Publication House	Accession No
1	Heat and Mass Transfer – Fundamentals and Applications	Y. A. Cengel	Tata McGraw Hill	
2	Fundamentals of Heat and Mass Transfer	F.P. Incropera, D.P.Dewit	John Wiley	
3	Fundamentals of Heat and Mass Transfer	J.P. Holman	McGraw–Hill	
4	A Textbook on Heat Transfer	S.P. Sukhatme	Universities Press	
5	Heat and Mass Transfer	Nag P.K.	Tata McGraw Hill	
6	Computational Fluid Dynamics	John D. Anderson	McGraw-Hill Education	
7	Fundamentals of Engineering Heat and Mass Transfer	R.C. Sachdeva	New Age Science.	
8	Heat and Mass Transfer	R.K.Rajput	S. Chand Publishing house	
9	Fundamentals of Heat and Mass Transfer	Kothandraman C.P.	New Age International publication	
10	Heat Transfer	Chapman A.J.	McMillan	
11	Compact Heat Exchanger	Kays William S	McGraw–Hill	
12	Standards of The Tubular Exchanger Manufacturers Association.		TEMA	
13	Numerical Heat Transfer and Fluid Flow	Patankar Suhas V.	CRC Press	
14	Computational fluid dynamics the basics with applications	S.R. Majumdar	TataMcGrawHill	

MECHANICAL COMPONENT DESIGN (ME302)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA :**	40 Marks
Practical:	-	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: (Strength of Machine Elements, Basics of Mechanical Engineering)

==========

Course Objectives:

1. To understanding of design function in Mechanical Engineering, different steps involved in designing and the relation of design activity with manufacturing activity.
2. To choose proper materials for different machine elements depending on their physical and mechanical properties. They will learn to apply the knowledge of material science in real life situations.
3. To understand the different types of failure modes and criteria. They will be conversant with various failure theories and be able to judge which criterion is to be applied for a particular situation.
4. To gain design knowledge of the different types of elements used in the machine design process, for e.g. shafts, couplings etc. and will be able to design these elements for each application.
5. To gain a thorough understanding about the design of the various types of springs.
6. To gain thorough knowledge about the design of clutch and brake.

Course Outcomes (COs): At the end of the course, learner will be able to

CO's	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Identify and understand failure modes for mechanical elements and design of machine elements based on strength.	2	Understand
CO2	Design Shafts, Keys and Coupling for industrial applications.	3	Apply
CO3	Design machine elements subjected to fluctuating loads.	3	Apply
CO4	Design Power Screws for various applications.	3	Apply

CO5	Design various Springs for strength and stiffness.	3	Apply
CO6	Design various Clutch and brake	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	1	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	1	-	-	3	-	-
CO3	3	2	2	1	-	-	-	-	-	1	-	-	3	-	-
CO4	3	2	2	-	1	-	-	-	-	1	-	-	2	-	-
CO5	3	-	1	2	1	-	-	-	-	1	-	-	1	-	-
CO6	3	-	-	2	1	1	-	-	-	1	-	-	1	-	-

Course Contents

Unit	**Contents**	No.of Hours	COs
1	**Design of Simple Machine Elements**		
	Introduction to Machine Design, product life cycle, types of stress, strains, Design considerations - Strength, Rigidity, Manufacture, Assembly and Cost, Standards and codes, Use of preferred series, Factor of safety, Service factor. Design of Cotter joint, Knuckle joint, Levers - hand / foot lever, components subjected to eccentric loading. Use of Design data books.	6 Hrs.	CO1
2	**Design of Shafts, Keys and Couplings**		
	Shaft design on the basis of strength, torsional rigidity and lateral rigidity, A.S.M.E. code for shaft design. Hollow shaft, Design of keys (square and rectangular key) and splines. Design of Flange Coupling and Flexible Bushed Pin Coupling.	6 Hrs	C02
3	**Design for Fluctuating Load**		
	Stress concentration - causes & remedies, fluctuating stresses, fatigue failures, S-N curve, endurance limit, notch sensitivity, endurance strength modifying factors, design for finite and infinite life, cumulative damage in fatigue failure, Soderberg, Gerber, Goodman, Modified Goodman diagrams, Fatigue design of components	6 Hrs	C03

	under combined stresses:- Theoretical treatment only.		
4	**Power Screws**		
	Forms of threads, multiple start screws, Torque analysis and Design of power screws with square and trapezoidal threads, Self-locking screw, Collar friction torque, Stresses in power screws, design of a C-Clamp. Design of screw jack.	6 Hrs	C04
5	**Mechanical Springs**		
	Types, applications and materials for springs, Stress and deflection equations for helical compression Springs, Style of ends, Design of helical compression and tension springs, Springs in series and parallel, Concentric helical springs, Surge in springs, Helical torsion Spring, Design of Multi-leaf springs. (Theoretical treatment only).	6 Hrs	
6	**Friction Clutches and brakes**		
	Clutch: Introduction, Torque transmission capacity, multidisc clutches, friction materials, cone clutches, centrifugal clutches Brakes - Introduction, Energy to be dissipated, Heating of brakes, Shoe or Block brakes (Single & Double), internal and external shoe brakes, self-locking brakes, Differential band brakes, Internal expanding brakes.	6 Hrs.	C05

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Mechanical Engineering Design	Shigley J.E. and Mischke C.R.	McGraw Hill Publication Co. Ltd.	621.815
2.	Design of Machine Elements	Spotts M.F. and Shoup T.E	Prentice Hall International	621.815
3.	Design of Machine Elements	Bhandari V.B	Tata McGraw Hill Publication Co. Ltd.	621.815
4.	Fundamentals of Machine Components Design	Juvinal R.C	John Wiley and Sons	621.815

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Machine Design	Black P.H. and O. Eugene Adams	McGraw Hill Book Co. Inc.	621.815
2.	Machine Components Design	Willium C. Orthwein	West Publishing Co. and Jaico Publications House.	--
3.	Theory and Problems of Machine Design,	Hall A.S., Holowenko A.R. and Laughlin H.G	Schaum's Outline Series	--
4.	Design of Machine Elements,	C.S.Sharma and Kamlesh Purohit	PHI Learing Pvt. Ltd	621.815
5.	Machine Design	D.K.Aggarwal & P.C.Sharma	S.K Kataria and Sons	621.815
6.	Machine Design: Fundamentals and Applications	P. C. Gope	PHI Learing Pvt. Ltd	621.815

INDUSTRIAL MEASUREMENTS AND QUALITY CONTROL (ME303)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA:**	40 Marks
Practical:	-	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: (if Any)-Nil

==========

Course Objectives:

1. To Understand the knowledge of basics of Measurements, Metrology and Measuring devices.
2. To Understand thread, gear and surface roughness metrology.
3. To Understand the advances in Metrology such as use of CMM, Laser, Machine Vision System.
4. To Apply appropriate Quality Control Technique for given application.
5. To Select and Apply appropriate Quality Management Tool
6. To Understand and apply statistical quality control (SQC) for given application

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	Apply methods and devices for measurement of length, angle etc. and to design the gauges.	3	Apply
CO2	Apply methods and devices for measurement of gear, thread parameters, surface roughness and geometric features of parts.	3	Apply
CO3	Describe the advances in Metrology such as use of CMM, Laser, Machine Vision System.	2	Understand
CO4	Determine appropriate Quality tools such as check sheets, Pareto charts, flowchart, cause and effect diagrams, histogram, scatter diagram and control charts for a particular application	3	Apply
CO5	Apply appropriate Quality Management Tool	3	Apply
CO6	Apply statistical quality control (SQC) technique for given application to improve quality of processes / products and to predict whether a process is under statistical control.	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	2	-	-	2	2	-	1	1	-	-
CO2	2	1	-	-	-	2	-	-	2	2	-	1	1	-	-
CO3	2	-	-	-	-	2	-	-	2	2	-	1	1	-	-
CO4	3	-	-	-	-	2	-	-	2	2	-	1	1	-	-
CO5	2	-	-	-	-	2	-	-	2	2	-	1	1	-	-
CO6	2	2	1	1	2	2	-	-	2	2	-	1	1	-	-

Course Contents

Unit	Contents	No.of Hours	COs
1	**Unit-I Fundamentals of Metrology, Comparators and Design of Gauges**		
	Introduction: Principles of Engineering metrology, Measurement standards, Types and sources of errors, Accuracy and Precision, Calibration: Concept and procedure, traceability, Linear And Angular Measurements(Conventional and Digital) **Comparators:** Mechanical, Pneumatic, Optical, Electrical (LVDT). **Design of Gauges**: Tolerances, Limits and Fits [IS 919-1993], Region of uncertainty, Taylor's principle, Types of gauges, Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials, Considerations of gauge design (numerical).Gauge R & R.	8 Hrs.	CO1
2	**Unit-II Thread and Gear Metrology, Surface Roughness Metrology**		
	Geometric Form Measurement: Straightness, Flatness, Roundness - Straight edge, use of level beam comparator, autocollimator, testing of flatness of surface plate. **Measurement of Thread form:** Thread form errors, Measurement of Minor, Major and Effective diameter (Three Wire Method),Best wire size(Derivation and Numerical) Flank angle and Pitch, Floating Carriage Micrometer (Numerical). **Gear Metrology**: Errors in Spur Gear form, Gear tooth Vernier, Constant chord, Base tangent (Numerical), Gear Rolling Tester. Profile Projector, Tool maker's microscope and their applications **Surface Roughness Measurement**: Introduction to Surface texture, Parameters for measuring surface roughness, Surface roughness measuring instrument:	6 Hrs.	CO2

Unit	Contents	No.of Hours	COs
	TalySurf, Surface roughness tester.		
3	**Unit – III Advances in Metrology**		
	Coordinate Measuring Machine (CMM): Fundamental features of CMM – development of CMMs – role of CMMs – types of CMM and Applications, types of probes **Machine Vision Systems:** vision system measurement – Multisensory systems. **Interferometry:** Principle, Concept of Optical Flat and its types, NPL Interferometer, Laser interferometer. Introduction to Nanometrology and its importance.	4 Hrs.	CO3
4	**Unit – IV Introduction to Quality and Quality Tools**		
	Concept of Quality: Various Definitions and Quality Statements, Cost of quality & value of quality, Deming's cycles & 14 Points, Juran Trilogy approach, Old and New Seven Quality Tools, 5-Why technique, 8 Disciplines (8-D) technique, Quality Circles, Areas and criteria for National and International Quality Awards.	6 Hrs.	CO4
5	**Unit –V Total Quality Management**		
	TQM: Introduction, Quality Function Deployment, 5S, Kaizen, Poka yoke, Kanban, JIT,FMECA, Zero defects, TPM. Six Sigma: DMAIC - Concept and Applications. **Quality Management System** Need for quality management system – design of quality management system – quality management system requirements – ISO 9001, TS-16949, ISO-14000, Introduction to IATF-16949, Quality Audit-terminology, types of QA, Quality conformance and Quality Assurance.	6 Hrs.	CO5
6	**Unit –VI Statistical Quality Control (SQC)**		
	Statistical quality control: Statistical concept, Frequency diagram, Concept of variance analysis, Control Chart for Variable (**X & R** Chart) & Attribute (**P & C** Chart), Process capability, Statistical Process Control (Numerical). Production Part Approval Method (PPAP). **Acceptance Sampling:** Sampling Inspection, OC Curve and its characteristics, sampling methods, Sampling Plan: Single, Double (Numerical), Multiple, Comparison of Plan, calculation of sample size, AOQ, Probability of Acceptance (Numerical)	6 Hrs.	CO6

Text Books:-

Sr. No.	Title of Book	Authors	Publication House
1.	Engineering Metrology	Jain R.K.	Khanna Publication
2.	Engineering Metrology	I. C. Gupta	Dhanpath Rai Publication
3.	Metrology and Measurements	Bewoor A. K. and Kulkarni V. A	Tata McGraw hill Publication.
4.	Quality Handbook	Juran J. M.	McGraw Hill Publications.
5.	Statistical Quality Control	Grant S.P.	Tata McGraw hill Publication

Reference Books:

Sr. No.	Title of Book	Authors	Publication House
1.	Metrology for engineers	Galyer J.F & Shotbolt C.R.	Cengage Learning
2.	Handbook of Industrial Metrology	ASTME	Prentice Hall of India Ltd
3.	Fundamentals of Dimensional Metrology	Connie Dotson	Thomson Publn., 4th Edition
4.	Quality control	Basterfield D. H.	Pearson Education India, 2004
5.	Modern Methods for Quality control and Improvement	Harrison M. Wordsworth, Stefeen Godfrey	Willy Publication

INDUSTRIAL AUTOMATION (ME304)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA**	40 Marks
Practical:	-	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: Fluid Mechanics, Engineering Mathematics.

==========

Course Objectives:

1. To study basics of hydraulic and pneumatic systems
2. To study symbols and circuits
3. To study fluid power automation.
4. To study mechatronic systems and sensors
5. To study control systems
6. To study about controllers in industrial applications

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Understand principles and components of Hydraulic and pneumatic systems.	2	Understand
CO2	Apply symbols for the construction and working of simple Hydraulic and pneumatic circuits	3	Apply
CO3	Analyze working of hydraulic and pneumatic circuits and select its components from standard manufacturer's catalog.	4	Analyze
CO4	Understand basics of mechatronic systems and sensors.	2	Understand
CO5	Analyze the different control systems using transfer functions	4	Analyze
CO6	Describe the various mechatronic systems using controllers for Industrial applications	2	Understand

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
CO2	3	2	-	-	-	-	-	2	-	2	-	-	1	-	-
CO3	3	3	2	-	2	-	-	2	1	2	-	-	3	1	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	2	-	1	-	-	-	-	-	-	3	-	-	-	-
CO6	3	1	2	-	-	-	-	-	-	1	3	-	-	-	-

COURSE CONTENTS

Unit	**Contents**	No. of Hours	COs
1	**Unit 1: Basics of Fluid Power, Pumps and Actuators**	6	CO1
	Fluid power - principles, properties of fluids, advantages and limitations. Hydraulic Pumps - types, classification, working, constructional details, power, efficiency calculations and characteristics curves. Linear and rotary actuators, Actuator performance, Valves – Flow control, Direction control, Pressure control. Pneumatic components – Compressors, FRL unit, Shuttle valves, Quick exhaust valve, Time delay valve, mufflers.		
2	**Unit 2: Symbols and circuits**	6	CO2
	Industrial hydraulic and pneumatic symbols. Hydraulic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, fail safe circuit, counter balance circuit, actuator locking, unloading circuit, motor breaking circuit.		
3	**Unit 3: Design of Fluid Power Control & Automation circuits**	6	CO3
	Calculation and design considerations of hydraulic components for practical applications (Students are advised to refer manufacturers' catalogues for design and use simulation tool like Automation Studio / Fluidsim for simulation). Electro-pneumatics- cascading circuit, Fluid logic gates.		

4	**Unit 4: Introduction to Mechatronic systems and sensors**	6	CO4
	Measurement characteristics – static and dynamic, Sensors – LVDT, Potentiometer, Encoder, LIDAR, Proximity sensors – Optical, Inductive and Capacitive, Temperature sensors – RTD, Thermocouple, Thermistor, Force and Pressure sensors, Biosensors – Enzyme, ECG, EMG, D/A and A/D converters, Signal conditioning – Isolation and filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Signal Display systems.		
5	**Unit 5: Control systems**	6	CO5
	Open loop and closed loop systems, Concept of transfer function, transfer function based on mechanical system, block diagram and reduction principles and problems, Time and Frequency domain analysis, Introduction to Bode Plot, Time domain analysis, Unit step response, Analysis via transient response specification (percentage overshoot, rise time, delay time, steady state error		
6	**Unit 6: Controllers, Analysis and Industrial applications**	6	CO6
	Concept of poles and zeros, PI, PD and PID controller and its applicaitons, Fault detection and isolation, web-based monitoring and control, Fieldbus technology, Web based Monitoring and control, Ladder Logic diagrams, PLC-Architecture and applications in plastic injection moulding machines bottle filling plants and material handling systems.		

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Fluid Power with application	Esposito A,	Prentice Hall	54539
2.	Oil Hydraulic system- Principle and maintenance	Majumdar S.R,	Tata McGraw Hill	58405
3.	Hydraulics and Pneumatics	Stewart H. L	Taraporewala Publication	21916
4.	Mechatronics, Electronics control system in mechanical and electrical engineering	William Bolton	Pearson	23769
5.	Mechatronics: Integrated mechanical electronic systems	K.P.Ramachandran, G.K.Vijayaraghavan, M.S. Balasundaram	Wiley Publication	15611
6.	Control system principles and design	M.Gopal	Mc-Grawhill	14411

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Industrial Hydraulics	Pipenger J.J	McGraw Hill	
2.	Industrial Fluid Power	Pinches	Prentice Hall	
3.	Process Control instrumental technology	C.D.Johnson	Prentice Hall	
4.	Mechatronics-Principle concepts and applications	Mahalik	Tata Mc-Grawhill publications.	

WASTE HEAT RECOVERY AND SUSTAINABLE ENERGY (ME305A)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA**	40 Marks
Practical:	--	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: Thermodynamics

==========

Course Objectives:

1. To learn about the energy saving opportunities from waste heat and optimum power utilization.
2. To make students understand the concepts & broad principles of effective recovery of waste heat.
3. To provide the understanding on available technologies for industrial waste heat recovery systems
4. To provide knowledge of energy storage using various waste heat recovery methods and devices.
5. To study the significance of economic analysis of waste heat recovery systems.
6. To understand the importance of sustainable energy in achieving SDGs.

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	Comprehend the Rankine cycle, coupled cycles for combined plants for energy conservation.	2	understand
CO2	Analyze the waste heat recovery technologies developed for various thermal systems.	4	analyze
CO3	Acquire knowledge on waste heat recovery in heat pump, thermoelectric and HVAC systems.	2	understand
CO4	Identify the need for various energy storage systems in waste heat recovery applications.	2	understand
CO5	Apply the economic analysis concepts for the effective implementation of waste heat recovery.	3	apply
CO6	Identify the need to adopt sustainable energy technologies for mitigating of environmental challenges across all sectors.	2	understand

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	1	2	-	-	-	-	-	1	-	3
CO2	3	3	3	1	-	1	2	1	-	-	-	-	2	-	3
CO3	3	2	3	-	-		2	-	-	-	-	-	1	-	3
CO4	3	2	2	-	-	1	1	-	-	-	-	-	-	-	2
CO5	2	2	2	-	-		2	-	-	-	-	-	1	-	2
CO6	3	2	1	-	-	1	3	2	-	-	-	-	1	-	2

COURSE CONTENTS

Unit	CONTENTS	No. of Hours	COs
1	**INTRODUCTION**		
	Heat losses- its quality and quantity, Waste heat sources: steam, compressed air, refrigeration, flue gases, furnace/air stream exhaust, high grade heat, low grade heat. Potential for energy conservation, importance of waste heat recovery, Review of Thermodynamics – Energy and Exergy efficiencies, Rankine Cycle, Coupled cycles and combined plants, optimal utilization of fossil fuels, total energy approach.	6	CO1
2	**WASTE HEAT RECOVERY SYSTEMS**		
	Selection criteria for waste heat recovery technologies-recuperators-regenerators-economizers-plate heat exchangers-thermic fluid heaters. Waste heat boilers-classification, location, service conditions, design considerations-fluidized bed heat exchangers-heat pipe exchangers-heat pumps –sorption systems.	6	CO2
3	**PRIME MOVER EXHAUSTS**		
	Incineration plants; heat pump systems; thermoelectric devices. Utilization of low grade reject heat from power plants, Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat.	6	CO3
4	**ENERGY STORAGE SYSTEMS**		
	Need for energy storage, thermal, electrical, magnetic and chemical storage systems. Energy storage using phase change materials, micro encapsulation,	6	CO4

	Nano-PCMs, sensible and latent heat thermal energy storage systems, active and passive types.		
5	**ECONOMIC ANALYSIS**		
	Investment cost –economic concepts–measures of economic performance – procedure for economic analysis–examples–procedure for optimized system selection and design–load curves -sensitivity analysis –regulatory and financial frame work for cogeneration and waste heat recovery system.	6	CO5
6	**SUSTAINABLE ENERGY**		
	Energy Consumption Pattern: Global Scenario-Indian Scenario, Energy and Environmental Quality: Fossil Fuels and Air Pollution-Global Climate Change, Renewable and Sustainable Energy: Renewable Energy: Global Landscape-Installed Capacity of India, Sustainable Energy Policies, Institutions, and Programs in India, Renewable and Sustainable Energy Technologies: Wind Power, Solar Energy, Small Hydropower (Less than 25 MW), Geothermal Energy, Biomass-Derived Bioenergy and Biofuels, Hydrogen Energy, Biogas, Contribution of Sustainable Energy to clean development mechanism (CDM).	6	CO6

Text Books:

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Waste Heat Recovery in Process Industries	Hussam Jouhara	WILEY-VCH	
2.	WASTE HEAT RECOVERY: Principles and Industrial Applications	Chirla Chandra Sekhara, Reddy, Gade Pandu, Rangaiah	World Scientific Publishing Co. Pte. Ltd.	
3.	Fueling Our Future: An Introduction to Sustainable Energy	Robert Evans	Cambridge University Press	
4.	Waste Heat Recovery	Institute of Fuel, London,	Chapman and Hall Publishers, London, 1963	
5.	Waste heat recovery systems	D.A. Reay	Pergamon Press	
6.	Energy Efficiency	F. Kreith and R. E. West	CRC handbook, CRC Press,1999	

Reference Books:

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Energy Conversion	Goswami, D. Y., and Kreith, F.	CRC Press, 2007.	
2.	Process Heat Transfer	Hewitt, G. F., Shires, G. L., and Bott, T. R.	CRC Press, Florida, 1993	
3.	Power Plant System Design	Li, K. W., and Priddy, A. P.	John Wiley and Sons, New York, 1985.	
4.	Waste Heat Utilization and Management	Sengupta Subrata, Lee SS EDS,	Hemisphere, Washington, 1983.	
5.	Energy from Waste: An Evaluation of Conversion Technologies	Parker, Colin & Roberts	Elsevier Applied Science	

OPTIMIZATION TECHNIQUES [ME305B]

Teaching Scheme

Lectures: 3 Hrs. / Week

Practical: -----

Credits: 3

Examination Scheme

CIA : 40 Marks

End Sem Exam: 60 Marks

Total: 100 Marks

==========

Pre-requisite Course: Mathematics

==========

Course Objectives :

1. To research models using optimization techniques based upon the fundamentals of engineering mathematics (minimization and Maximization of objective function).
2. To formulate by using linear, dynamic programming, game theory and queuing models.
3. To Formulate of mathematical models for quantitative analysis of managerial problems in industry.

Course Outcomes (COs): At the end of the course, learner will be able to

Course Outcome	Statements	Blooms Taxonomy	
		Level	Descriptor
CO1	Explain the theoretical workings of the graphical, simplex and analytical methods for making effective decision on variables	2	Understand
CO2	Identify appropriate optimization method to solve complex problems involved in various industries	3	Apply
CO3	Identify the suitable parameter from the available multiple parameters	3	Apply
CO4	Determine the suitable based on multiple decision criterias	3	Apply
CO5	Determine the optimum parameter from available multiple parameters	3	Apply
CO6	Apply the optimsation method for solving real world problem	3	Apply

Course Contents

Unit	Contents	No. of Hours	COs
1	**Linear Programming**		
	Linear Programming Various definitions, statements of basic theorems and properties, Advantages, Limitations and Application areas of Linear Programming, Graphical method of Linear Programming problem. **Simplex Method –** Phase I and Phase II of the Simplex Method, The Revised Simplex method, Primal and Dual Simplex Method, Big –M method.	6 Hrs.	CO1
2	**Constrained and unconstrained problems**		
	Optimization algorithms for solving unconstrained optimization problems – Gradient based method: Cauchy's steepest descent method, Newton's method, Conjugate gradient method. Optimization algorithms for solving constrained optimization problems – direct methods – penalty function methods – steepest descent method – Engineering applications of constrained and unconstrained algorithms.	6 Hrs.	C02
3	**Multi Objective Decision making (MODM) Methods**		
	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming.	6 Hrs.	C03
4	**Multi Criterion Decision-making (MCDM) Methods**		
	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method TOPSIS Method PROMETHEE	6 Hrs.	C04
5	**Robust Design Methods**		
	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design:The one-half fraction and one-quarter of the 2k design, The general 2k-p fractional factorial design Application of related software (Minitab, Design Expert or MATLAB)	6 Hrs.	C05

6	**Modern Methods of Optimization**		
	GENETIC ALGORITHM (GA): Differences and similarities between conventional and evolutionary algorithms, working principle, Genetic Operators- reproduction, crossover, mutation	6 Hrs.	CO6

Text Books:

1.Engineering optimization: Theory and practice"-by S.S.Rao, New Age International (P) Limited.

2.Operations Research: An Introduction" by H A Taha, 5th Edition, Macmillan, New York.

3.Operations Research by NVR Naidu, G Rajendra, T Krishna Rao, I K International Publishing house, New Delhi.

Reference Books:

1. Optimization Methods in Operations Research and systems Analysis" – by K.V. Mittal and C. Mohan, New Age, International (P) Limited, Publishers

2. Operations Research – by S.D.Sharma, KedarnathRamanath& Co

3. Linear programming, G. Hadley, Narosa Publishing House, New Delhi.

4. Industrial Engineering and Production Management, M. Mahajan, DhanpatRai& co.

5. Deb K. – 'Optimization for Engineering Design Algorithms and Examples' – PHI – 2000

6.Arora J. – 'Introduction to Optimization Design' – Elsevier Academic Press, New Delhi – 2004

7.Saravanan R. – 'Manufacturing Optimization through Intelligent Techniques' – Taylor & Francis (CRC Press) – 2006

8.Hardley G. -'Linear Programming' – Narosa Book Distributors Private Ltd. – 2002

COMPUTER INTEGRATED MANUFACTURING (ME305C)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA**	40 Marks
Practical:	-	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: Manufacturing Process, CNC, Production Technology

==========

Course Objectives: (Please specify Six Objectives)

1. To make the student conversant with fundamentals of CIM.
2. To learn CIM Database management and Data Communication.
3. To demonstrate computer aided process planning in manufacturing process.
4. To expose to the various fundamentals of computer assisted manufacturing systems.
5. To learn the concepts of Integrative Manufacturing Planning And Control
6. To understand the emerging trends of manufacturing system.

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	**Explain** the concept of CAD/CAM integration and its importance in CIM.	2	Understand
CO2	**Compare** database models and their applicability in the context of CIM	3	Apply
CO3	**Utilize** Computer process planning to organize manufacturing processes for improved efficiency and productivity.	3	Apply
CO4	**Demonstrate** the principles of Flexible manufacturing system to design and integrate manufacturing processes for improved efficiency and flexibility.	3	Apply
CO5	**Utilize** manufacturing plan and control for smooth production in industry.	3	Apply
CO6	**Demonstrate** the future trends in the production technology like lean manufacturing, web based manufacturing system.	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	-	1	-	3	3	-	1	2	2	-
CO2	3	2	2	1	3	3	1	-	3	3	-	1	2	2	-
CO3	3	2	2	1	3	3	1	-	3	3	-	1	2	2	-
CO4	3	2	2	1	3	2	1	-	3	3	-	1	2	2	-
CO5	3	2	2	1	3	2	1	-	3	3	-	2	2	2	-
CO6	3	2	2	1	3	-	1	-	3	3	-	1	2	2	-

Course Contents

Unit	**Contents**	No. of Hours	COs
1	**Introduction to Computer Integrated Manufacturing (CIM)**		
	Evolution of Computer Integrated Manufacturing (CIM). Computer-Aided Design (CAD).Computer-Aided Manufacturing (CAM). CAD/CAM Integration, CIM hardware and software, Elements of CIM. CIM. Advantages, limitations, scope.	6 Hrs.	CO1
2	**CIM Database**		
	Introduction to CIM Database, Database requirements of CIM, Database, Database management, Database Models, EDM, Product Data Management (PDM), Advantage of PDM, Collaboration Engineering. Data Communication technologies.	6 Hrs.	CO2
3	**Computer Aided Process Planning**		
	Structure, information requirements, CAD based process planning, Group Technology, Coding structure, MICLASS system, Variant and generative process planning, Implementation considerations	6 Hrs.	CO
4	**Work Cell & Flexible Manufacturing System**		
	Manufacturing cell, Cellular Manufacturing. DNC system and transfer of program from PC to machine. Introduction to FMS, flexible manufacturing strategy, Components of Flexible Manufacturing-Pallets and fixtures.	6 Hrs.	CO4
5	**Integrative Manufacturing Planning And Control**		

	Role of integrative manufacturing in CAD/CAM integration, Over view of production control - Forecasting, Master production schedule, Capacity planning, M.R.P., Order release, Shop-floor control, Quality assurance.	6 Hrs.	CO5
6	**Future Trends In Manufacturing Systems**		
	Lean Manufacturing: Definition, Principles of Lean Manufacturing, Characteristics of Lean Manufacturing, Value of Product, Benefits of Lean Manufacturing. Introduction to Agile and Web Based Manufacturing systems. Process management and control through web.	6 Hrs.	CO6

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	An Analysis of CAD/CAM Application with Introduction to C.I.M.	Richard N. Shover,	Prentice hall	
2.	Computer Integrated Design and Manufacturing	David Bedworth	McGraw hill	
3.	Fundamental of CIM Technology	David L. Goetsch,	Delmar Publication	
4.	Computer Integrated Manufacturing	Alavudeen, Venkateshwaran	Prentice-Hall India	

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	The Design and Operation of FMS	Paul G. Ranky,	I.F.S. Publications	
2.	Automation, Production Systems & Computer Integrated Manufacturing	Groover, M.P.,	Pearson Education	
3.	C.I.M Interfaces	Scolz B. Reiter	Chapman & Hall	
4.	Systems Approach to Computer Integrated Design and Manufacturing	Nanua Singh,	John Wiley Publications.	

ELECTRIC VEHICLES (ME305D)

Teaching Scheme		Examination Scheme	
Lectures:	3 Hrs. / Week	**CIA**	40 Marks
Practical:	-	**End Sem Exam:**	60 Marks
Credits:	**3**	**Total:**	100 Marks

==========

Prerequisite Course: basic mechanical, electrical and electronics engineering,

==========

Course Objectives:

1. To understand the concept of electric vehicles (EV)
2. To understand the energy storage system in electric vehicles
3. To study about the motors & drives for electric vehicles.
4. To understand the components and systems in electric vehicles.
5. To understand the concept of hybrid vehicles.
6. To understand the safety and other standards related to EV

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	Discuss the basics of electric vehicle, its importance and types	2	Understand
CO2	Describe the energy storage system and batteries in EV	2	Understand
CO3	explain the drivetrains and motors used in EV	2	Understand
CO4	discuss the systems in ev - braking, steering, suspension	2	Understand
CO5	Describe the hybrid vehicle and its architecture	2	Understand
CO6	discuss safety and automotive standards related to ev	2	Understand

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1
CO2	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1
CO3	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1
CO4	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1
CO5	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1
CO6	2	1	-	-	1	2	2	-	-	-	-	3	1	-	1

Course Contents

Unit	Contents	No. of Hours	COs
1	**Introduction to Electric and Hybrid Vehicles**		
	introduction to hybrid and electric vehicle, past, present, future, their motivation, need and legislative push, comparison with IC engine driven vehicles, concepts of PHEV (Plug-in Hybrid Vehicle), HEV (Hybrid Electric Vehicle), Range Extended Electric Vehicle	6	CO1
2	**Energy Storage System in Electric Vehicles**		
	Energy storage requirements for vehicle applications, Batteries overview, types of batteries, choice of a battery type for electric vehicles, lead acid batteries, nickel based batteries, lithium based batteries, accumulators- types and working principles, battery management systems,	6	CO2
3	**Electric Vehicle Drivetrain**		
	Motors - types, principles, construction, control, DC motor, induction motor, BLDC motor, power and power rating, electric drive trains, HEDT (Hybrid Electric drivetrain)	6	CO3
4	**Electric Vehicle Components and systems**		
	Different components in EV, Frame structure and body of vehicle, Motor and battery allocation, Braking, steering and suspension systems	6.	CO4
5	**Hybrid Vehicles**		
	Hybrid Electric vehicles, Classification, Layout and Architecture – Series, Parallel and Series-Parallel Hybrid, Regenerative Braking system, Economy involved in HEV	6	CO5

6	**Safety and Automotive Standards**		
	Standards Roadmap for Electric Vehicles - SAE; UL; IEC - Performance and Safety, Battery Transportation & Safety - Battery Pack: SAE J2464/J2929, Electric Vehicle Performance Standards: AIS 038.	6	CO6

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Hussein	CRC Press	
2.	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi	CRC Press	

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Electric Vehicle Technology Explained	James Larminie, John Lowry	Wiley	
2	Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives	Chris Mi, M. Abul Masrur, David Wenzhong Gao	John Wiley & Sons	
3	Modern Electric Vehicle Technology	C.C. Chan and K.T. Chau	OXFORD University Press	

LAB-1 HEAT TRANSFER AND CFD (ME306)

Teaching Scheme		Examination Scheme	
Practical:	2 Hrs./ Week	**PR Exam:**	25 Marks
Credits:	**1**	**Total:**	25 Marks

==========

Prerequisite Course: Basic Thermodynamics.

==========

Course Objectives:

1. To Demonstrate conduction, convection and radiation heat transfer through Experiment.
2. To Interpret heat transfer enhancement Mechanism.
3. To Understand performance analysis of Heat Exchanger.
4. To Solve Heat transfer Problems by using CFD.

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Determine thermal conductivity of metal and non-metal.	3	Apply
CO2	Determine heat transfer coefficient in natural and forced convection and analyse using CFD software.	4	Analyze
CO3	Determine Stefan Boltzmann constant and emissivity of surface	3	Apply
CO4	Determine effectiveness of heat exchanger	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

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

List of Practicals

Ex. No.	Description	COs
1.	Determination of Thermal Conductivity of insulating powder.	1
2.	Determination of Thermal Conductivity of Composite wall.	1
3.	Determination of Emissivity of a Test surface.	3
4.	Determination of Stefan Boltzmann Constant.	3
5.	Determination of heat transfer coefficient in Natural Convection	2
6.	Determination of heat transfer coefficient in Forced Convection.	2
7.	Determination of temperature distribution, fin efficiency in Natural / Forced Convection.	2
8.	Determination of effectiveness of a parallel and counter flow heat exchanger.	4
9.	One Example with hands on suitable Workbench and discussion about the validation of the results. e.g Convection heat transfer.	2

Books

S.N.	Title of Book	Authors	Publication House	Accession No
1	Heat and Mass Transfer – Fundamentals and Applications	Y. A. Cengel	Tata McGraw Hill	
2	Fundamentals of Heat and Mass Transfer	F.P. Incropera, D.P.Dewit	John Wiley	
3	Fundamentals of Heat and Mass Transfer	J.P. Holman	McGraw–Hill	
4	A Textbook on Heat Transfer	S.P. Sukhatme	Universities Press	
5	Heat and Mass Transfer	Nag P.K.	Tata McGraw Hill	
6	Computational Fluid Dynamics	John D. Anderson	McGraw-Hill Education	
7	Fundamentals of Engineering Heat and Mass Transfer	R.C. Sachdeva	New Age Science.	
8	Heat and Mass Transfer	R.K.Rajput	S. Chand Publishing house	
9	Fundamentals of Heat and Mass Transfer	Kothandraman C.P.	New Age International publication	

LAB-II MECHANICAL COMPONENT DESIGN (ME307)

Teaching Scheme		Examination Scheme	
Lectures:	- Hrs. / Week	**TW :**	25 Marks
Practical:	2 Hrs./ Week		
Credits:	**1**	**Total:**	25 Marks

==========

Prerequisite Course: Strength of Machine Elements, Basics of Mechanical Engineering.

==========

Course Objectives:

1. To understanding of design function in Mechanical Engineering, different steps involved in designing and the relation of design activity with manufacturing activity.
2. To choose proper materials for different machine elements depending on their physical and mechanical properties. They will learn to apply the knowledge of material science in real life situations.
3. To understand the different types of failure modes and criteria. They will be conversant with various failure theories and be able to judge which criterion is to be applied for a particular situation.
4. To gain design knowledge of the different types of elements used in the machine design process, for e.g. shafts, couplings etc. and will be able to design these elements for each application.
5. To gain a thorough understanding about the design of the various types of springs.
6. To gain thorough knowledge about the design of clutch and brake.

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Identify and understand failure modes for mechanical elements and design of machine elements based on strength.	2	Understand
CO2	Design Shafts, Keys and Coupling for industrial applications.	3	Apply
CO3	Design machine elements subjected to fluctuating loads.	3	Apply
CO4	Design Power Screws for various applications.	3	Apply
CO5	Design various Springs for strength and stiffness.	3	Apply
CO6	Design various Clutch and brake	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	1	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	1	-	-	3	-	-
CO3	3	2	2	1	-	-	-	-	-	1	-	-	3	-	-
CO4	3	2	2	-	1	-	-	-	-	1	-	-	2	-	-
CO5	3	-	1	2	1	-	-	-	-	1	-	-	1	-	-
CO6	3	-	-	2	1	1	-	-	-	1	-	-	1	-	-

List of Practical:

Pr No	Description	CO	PO
1.	**Two design projects on Assemblies covering above syllabus**. The design project shall consist of half imperial sheets (A2 size) involving assembly-drawing with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of three to five students. **Project 1 shall be based on any one of the following topics-** i) Cotter joint/ knuckle joint/turn buckle for a specified application. ii) Transmission Shaft/Machine tool spindles/coupling for specified application. iii) Hand or foot operated levers/lever for safety valve. **Project 2 shall be based on any one of the following topics-** i) Bench vice/Machine vice for specified applications. ii) Bottle type/toggle jack for vehicles. iii) Lead screw for machine tool/other applications. iv) Design of Clutches and brakes Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary for selection of standard components. Drawings of design project should be done manually.	**CO1, CO2, CO3, CO4, CO5, CO6**	**PO1, PO3, PO6**
2.	Preparation of program using programing languages/modern tools for	**CO1,**	**PO1**

	design of following elements: (any one) 1. Knuckle joint 2. Cotter joint 3. Spring 4. Power screw 5. Lever	**CO3, CO6**	**PO6**

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Mechanical Engineering Design	Shigley J.E. and Mischke C.R.	McGraw Hill Publication Co. Ltd.	621.815
2.	Design of Machine Elements	Spotts M.F. and Shoup T.E	Prentice Hall International	621.815
3.	Design of Machine Elements	Bhandari V.B	Tata McGraw Hill Publication Co. Ltd.	621.815
4.	Fundamentals of Machine Components Design	Juvinal R.C	John Wiley and Sons	621.815

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Machine Design	Black P.H. and O. Eugene Adams	McGraw Hill Book Co. Inc.	621.815
2.	Machine Components Design	Willium C. Orthwein	West Publishing Co. and Jaico Publications House.	--
3.	Theory and Problems of Machine Design,	Hall A.S., Holowenko A.R. and Laughlin H.G	Schaum's Outline Series	--
4.	Design of Machine Elements,	C.S.Sharma and Kamlesh Purohit	PHI Learing Pvt. Ltd	621.815
5.	Machine Design	D.K.Aggarwal & P.C.Sharma	S.K Kataria and Sons	621.815
6.	Machine Design: Fundamentals and Applications	P. C. Gope	PHI Learing Pvt. Ltd	621.815

LAB-III INDUSTRIAL MEASUREMENTS AND QUALITY CONTROL (ME308)

Teaching Scheme		Examination Scheme	
Practical:	2 Hrs./ Week	**Oral:**	25 Marks
Credits:	**1**	**Total:**	25 Marks

Course Objectives:

1. To Understand the knowledge of basics of Measurements, Metrology and Measuring devices.
2. To Understand thread, gear and surface roughness metrology.
3. To Understand the advances in Metrology such as use of CMM, Laser, Machine Vision System.
4. To Apply appropriate Quality Control Technique for given application.
5. To Select and Apply appropriate Quality Management Tool
6. To Understand and apply statistical quality control (SQC) for given application

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	Descriptor
CO1	Understand, Identify and apply methods and devices for measurement of length, angle, gear parameters, thread parameters, surface roughness and geometric features of parts etc.	3	Apply
CO2	Check errors and/or calibrate measuring instruments.	3	Apply
CO3	Select and apply appropriate Quality Control/Quality Management Tool to solve quality related problem.	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO3	2	2	-	-	2	2	-	-	2	2	-	2	2	-	-

List of Practicals

Part (A)	Description	CO
Pr No	**Any eight experiments out of following to be performed**	**CO**
1.	Demonstration of linear measuring instruments and their applications for linear measurements.	**1**
2.	Demonstration of angular measuring instruments and Angular measurements by using sine bar/sine centre/any other angular measuring instruments.	**1**
3.	Error determination of linear / angular measuring instruments.	**2**
4.	Calibration of measuring instrument. Example – Dial gauge, Micrometer, Vernier (any one) (Refer ISO 17025).	**2**
5.	Verification of dimensions and geometry of given components using Mechanical/Pneumatic comparator. [An assignment with this experiment write-up as, Introduction to use of Standard CODE viz. ASME-Y14.5, ISO-1101].	**1**
6.	Demonstration of surfaces inspection using optical flat/interferometers OR Demonstration of surface roughness measurement using surface roughness tester.	**1**
7.	Determination of geometry and dimensions of given composite object using profile projector and/or tool maker's microscope.	**1**
8.	Measurement of thread parameters using floating carriage diameter measuring machine.	**1**
9.	Measurement of spur gear parameters using Gear Tooth Vernier / Span Micrometer / Gear Rolling Tester.	**1**
10.	Determination of given geometry using coordinate measuring machine (CMM).	**1**
Part: B]	**Assignment:** Application of appropriate Quality tool/technique **(e.g.** Plotting cause and effect diagram for errors in measurement or plotting control charts) with the help of Open Source software or software like Minitab or MS excel sheet for given engineering application.	**3**

Part: C] Preferably an Industrial visit to: Calibration lab / CMM Lab / Gear Inspection Unit/Automotive Industry / Engineering Industry.

Text Books:

Sr. No.	Title of Book	Authors	Publication House
1.	Engineering Metrology	Jain R.K.	Khanna Publication
2.	Engineering Metrology	I. C. Gupta	Dhanpath Rai Publication
3.	Metrology and Measurements	Bewoor A. K. and Kulkarni V. A	Tata McGraw hill Publication.
4.	Quality Handbook	Juran J. M.	McGraw Hill Publications.
5.	Statistical Quality Control	Grant S.P.	Tata McGraw hill Publication

Reference Books

Sr. No.	Title of Book	Authors	Publication House
1.	Metrology for engineers	Galyer J.F & Shotbolt C.R.	Cengage Learning
2.	Handbook of Industrial Metrology	ASTME	Prentice Hall of India Ltd
3.	Fundamentals of Dimensional Metrology	Connie Dotson	Thomson Publn., 4th Edition
4.	Quality control	Basterfield D. H.	Pearson Education India, 2004
5.	Modern Methods for Quality control and Improvement	Harrison M. Wordsworth, Stefeen Godfrey	Willy Publication

LAB IV - INDUSTRIAL AUTOMATION (ME309)

Teaching Scheme		Examination Scheme	
Lectures:	-	**Practical exam**	25 Marks
Practical:	2 Hrs. / Week	**-**	-
Credits:	**1**	**Total:**	25 Marks

==========

Prerequisite Course: Fluid Mechanics, Engineering Mathematics.

==========

Course Objectives:

1. To study the performance of hydraulic pumps.
2. To study symbols and fluid power automation circuits.
3. To study simulation of functions using software
4. To study PID control system
5. To study sensors and control systems.
6. To study PLC.

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Evaluate performance of vane pump on basis of characteristics curves	4	Analyze
CO2	Construct simple hydraulic and pneumatic circuits using various actuators, valves and components	5	Construct
CO3	Simulate software-based outputs for a given fluid circuit or transfer function	4	Analyze
CO4	Interpret data from PID controller system and experiment with sensors, PLC and other Industrial automation modules.	3	Apply

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	3	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	3	-	-	-	2	-	-
CO3	3	3	2	1	3	-	-	-	3	-	-	1	-	1	-
CO4	3	2	-	-	-	-	-	-	3	2	-	-	-	-	3

List of Experiments

1. Test on Hydraulic Vane pump and plotting performance characteristics
2. Following experiments to be done on hydraulic trainer (any 3)
    a. Regenerative circuit
    b. Speed control circuits (Meter in, Meter Out and Bleed off)
    c. Sequencing circuit
    d. Traverse and feed circuit.
3. Following experiments to be done on pneumatic trainer
    a. Automatic reciprocating circuit.
    b. Speed control circuit.
    c. Pneumatic circuit involving Shuttle valve/ Quick exhaust valve
4. Design of Hydraulic or Pneumatic circuit using simulation software.
5. Simulation of Transfer functions using MATLAB .
6. Measurement of Temperature: Thermocouple, Thermistor & RTD and their comparative analysis (estimation of sensitivity)
7. Data interpretation using PID controller for industrial cooling system
8. PLC Control system: -Ladder logic Implementation on real time system

Text Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Fluid Power with application	Esposito A,	Prentice Hall	
2.	Oil Hydraulic system- Principle and maintenance	Majumdar S.R,	Tata McGraw Hill	
3.	Hydraulics and Pneumatics	Stewart H. L	Taraporewala Publication	
4.	Mechatronics, Electronics control system in mechanical and electrical engineering	William Bolton	Pearson	
5.	Mechatronics: Integrated mechanical electronic systems	K.P.Ramachandran, G.K.Vijayaraghavan, M.S. Balasundaram	Wiley Publication	
6.	Control system principles and design	M.Gopal	Mc-Grawhill	

Reference Books

Sr. No.	Title of Book	Authors	Publication House	Accession No
1.	Industrial Hydraulics	Pipenger J.J	McGraw Hill	
2.	Industrial Fluid Power	Pinches	Prentice Hall	
3.	Process Control instrumental technology	C.D.Johnson	Prentice Hall	
4.	Mechatronics-Principle concepts and applications	Mahalik	Tata Mc-Grawhill publications.	

SEMINAR AND TECHNICAL COMMUNICATION SKILLS (ME310)

Teaching Scheme		Examination Scheme	
Lectures:	- Hrs. / Week	**CIA**	-
Practical:	4 Hrs./ Week	**End Sem Exam:**	-
		OR	25 Marks
Credits:	**2**	**Total:**	25 Marks

==========

Prerequisite Course: (if Any)

==========

Course Objectives:

1. To make survey on selected topics related to issues of science in society.
2. To study scientific literatures.
3. To collect relevant information from collected literature.
4. To compile the information and present and communicate it effectively

Course Outcomes (COs): At the end of the course, learner will be able to

COs	Course Outcomes	Blooms Taxonomy	
		Level	**Descriptor**
CO1	Study various research papers to understand existing and recent technology	2	Understand
CO2	Identify various promising and new cutting edge technologies	2	Understand
CO3	Prepare detailed technical report interpreting the results.	3	Apply
CO4	Make effective communication through an oral presentation and draw solid conclusion	4	Analyse

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	0	3	3	3	1	0	-	3	-	-	-
CO2	3	3	2	1	3	3	3	-	-	0	-	1	-	-	-
CO3	-	-	1	-	-	-	-	3	3	3	-	1	-	-	-
CO4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-

Course Content

Guidelines

- Each student will select a topic in the area of Mechanical Engineering and Technology preferably keeping track with recent technological trends and development beyond scope of syllabus avoiding repetition in consecutive years.
- **The topic must be selected in consultation with the Institute guide by referring atleast 3 research paper from following sources.**
- Each student will make a seminar presentation using audio/visual aids for a duration of 20-25 minutes and submit the seminar report prepared in prescribed format
- Active participation at classmate seminars is essential.

Guidelines for Assessment

- Panel of staff members along with a guide would be assessing the seminar work based on these parameters-Topic, Contents and Presentation, regularity, Punctuality and Timely Completion, Question and Answers, Report, Paper presentation/Publication, Attendance and Active Participation.

Internal Evaluation

Review 1	Attendance Till review:5 Topic Finalization and Research paper selection:10 Marks Presentation 1 with literature survey:10 Marks
Review II	Attendance Till review:5 Report Preparation:10 Marks Presentation 2:10 Marks

Recommended Format of the Seminar Report

- · Title Page with Title of the topic, Name of the candidate with Exam Seat Number / Roll Number, Name of the Guide, Name of the Department, Institution and Year and University
- Seminar Approval Sheet/Certificate
- Abstract and Keywords
- Acknowledgements
- Table of Contents, List of Figures, List of Tables and Nomenclature
- Chapters Covering topic of discussion- Introduction with section including organization of the report, Literature Survey/Details of design/technology/Analytical and/or experimental work, if any/ …..,Discussions and Conclusions ,Bibliography/References
- Plagiarism Check report
- Report Documentation page

Resources for Journals

Sr.	Package	No. of Journals	SUBJECT COVERED	Go to URL
1	IEEE	180	Computer/Electrical/ E &Com Engg / & related disciplines	https://ieeexplore.ieee.org/browse/periodicals/title
2	A S C E	38	Civil Engineering & Structural Engineering	https://ascelibrary.org/journals
3	ASME	32	Mechanical Engineering &	https://asmedigitalcollection.asme.org/
			Mechatronics Engineering	
4	Elsevier	275	Computer/Electrical/ E &Com engg/ Mechatronics Mech/ Civil/ Structural Aerospace/ Manufactur	http://www.sciencedirect.com
	Science Direct			https://www.sciencedirect.com/browse/journals-and-books
5	Knimbus Platform	1267	MBA-Management	https://sanjivanicoe.knimbus.com/user#/home
6	EBSCO –e book Business Collection	22,577	MBA-Management	http://search.ebscohost.com/
7	National Digital Library		Institutional Membership	http://ndl.iitkgp.ac.in
8	Springer E Book	2015	All Branch	https://link.springer.com/
9	IEI-Journal of the Institution of Engineers	5	GO to URL	www.ieindia.org.in
	For All	Series A	Login ID= LI1003710	Password coelib10
		Series B	LI1003727	coelib27
		Series C	LI1003733	coelib33
		Series D	LI1003745	coelib45
		Series E	Same	Same
	NPTEL Videos	–	All Branches(on-line & off-line database)	192.168.81.100/NPTELhttps://nptel.ac.in/
				http://onlinecources.nptel.ac.in/

Corporate Readiness (HS311)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hrs/Week	**Continuous Assessment: 50 Marks**
Tutorial: --- Hr/Week	**In-Sem Exam: --**
	End-Sem Exam: --
Credits: 02	**Total: 50 Marks**

Prerequisite Course: (Verbal and Non-verbal communication)

Course Objectives:

1. To develop clarity in the exploration process of student career and to match his skills and interests with a chosen career path.

2. To develop required aptitude skills.

3. To design the functional and chronological resume.

4. To demonstrate the importance of critical thinking ability and expression in group discussions

5. To prepare students for the various professional interviews.

6. To develop different soft skills necessary to get success in their profession.

Course Outcomes (COs):

After successful completion of the course, student will be able to:

Course Outcome (s)		Bloom's Taxonomy	
		Level	**Descriptor**
CO1	Remember placement processes of various organizations and modern job search approach.	**BTL 1**	
CO2	Understand Industry Specific skill set with a view to design an Ideal Resume.	**BTL 2**	
CO3	Apply the knowledge of GD & Presentation Skill during Industry Assessments for Placement/Internship/Industry Training/Higher Studies/Competitive Exams etc.	**BTL 3**	
CO4	Analyse and apply the critical thinking ability as required during Aptitude/Technical Tests.	**BTL 4**	

CO5	Evaluate Technical/General Dataset to interpret insights in it.	**BTL 5**	
CO6	Create an ideal personality that fits Industry requirement.	**BTL 6**	

Mapping of Course Outcomes to Program Outcomes (POs) & Program Specific Outcomes (PSOs):																
	PO 1	PO 2	PO 3	PO4	PO 5	PO6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	--	--	--	--	--	--	--	02	00	02	01	01	--	--	--	--
CO2	--	--	--	--	--	--	--	02	03	03	03	01	--	--	--	--
CO3	--	--	--	--	--	--	--	01	03	03	02	01	--	--	--	--
CO4	01	01	--	--	--	--	--	--	--	01	01	--	--	--	--	--
CO5	01	01	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CO6	--	--	--	--	--	--	--	02	03	03	02	03	--	--	--	--

Course Contents			
UNIT-I	Placement Awareness	**Hrs.**	**Cos**
	Discussion over Different Companies for recruitment, their eligibility criteria and placement procedures. Discussion over Different Competition organised by companies & other platforms, Revision and Assessment of Verbal reasoning.	05 Hrs.	CO1
UNIT-II	Resume Writing	**Hrs.**	**CO**
	Keywords, resume examples for industry, professional font, active language, important achievements, Proofread and edit. Innovative resume building- video resume.	03 Hrs.	CO2
UNIT-III	Group Discussion and Presentation skills	**Hrs.**	**CO**
	Why GDs are implemented commonly, Aspects which make up a Group Discussion, Tips on group discussion, do's and don'ts of GD and Presentation skills.	04 Hrs.	CO3
UNIT-IV	Logical Reasoning I	**Hrs.**	**CO**
	Coding and Decoding (Visual Reasoning and series), Statement & Conclusions (Syllogisms), Relationships (Analogy), Data arrangements, Crypt arithmetic.	05 Hrs.	CO4

UNIT-V	Logical Reasoning II	**Hrs.**	**CO**
	Data Interpretation & Data Sufficiency, Blood relation and dices, Clocks and Calendar, Direction sense and cubes, Logical connectives.	06 Hrs.	CO5
UNIT-VI	Preparation for Job Interviews	**Hrs.**	**CO**
	Prepare for Different Types of Job Interviews, Most Common Interview Questions, Prepare for Best Practices before & after the Job Interview, Expected Technical Questions, Strategic Questions at the end of the Job Interview.	03 Hrs.	CO6

Text Books:

[T1]. A Modern Approach to Verbal & Non-Verbal Reasoning by R.S. Agarwal.

[T2]. Reasoning verbal and Non-Verbal by B. S. Sijwali.
[T3]. Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs by Sheetal Desarda.

References:

[R1]. Shortcuts in Reasoning (Verbal, Non-Verbal, Analytical).

[R2]. Analytical Reasoning by M. K. Panday.
[R3]. Logical and analytical reasoning by K. Gupta.

[R4]. Multi-dimensional reasoning by Mishra & Kumar Dr. Lal.

E- Books :

[1].https://themech.in/quantitative-aptitude-and-logical-reasoning-books/

[2].https://www.thelocalhub.in/2021/01/reasoning-competitive-exams-pdf.html

E-learning Resources/MOOCs/ NPTEL Course Links:

[1]. https://www.practiceaptitudetests.com/non-verbal-reasoning-tests/

[2]. https://www.educationquizzes.com/11-plus/non-verbal-reasoning/

[3].

https://www.livecareer.com/resume/examples/web-development/e-learning-developer

[4]. https://novoresume.com/career-blog/how-to-write-a-resume-guide
[5]. https://www.coursera.org/projects/preparation-for-job-interviews
[6]. https://www.coursera.org/learn/resume-writing