VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

(Revision 2018)

For

Final Year

of

Four Year Undergraduate Programmes Leading to

Bachelor of Technology (B Tech) Degree in Mechanical Engineering

Implemented from the batch admitted in Academic Year 2018-19

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Bachelor of Technology (B Tech)
In

102 Mechanical Engineering

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

Vision

To establish global leadership in the field of Technology and develop competent human resources for providing service to society

Mission

To provide students with comprehensive knowledge of principles of engineering with a multi-disciplinary approach that is challenging.

To create an intellectually stimulating environment for research, scholarship, creativity, innovation and professional activity.

To foster relationship with other leading institutes of learning and research, alumni and industries in order to contribute to National and International development.

B. Tech. Mechanical Engineering

Program Educational Objectives (PEOs)

1. To attain Analytical, Experimental and Computational expertise in Mathematics, Applied Sciences and Core Engineering subject domain.
2. To discharge responsibilities towards society by achieving high standards of professionalism, leadership and ethical behavior.
3. To comprehend the need for higher studies and lifelong learning so as to remain in competitive and sustainable environment.

Program Outcomes (POs)

PO1: Apply knowledge of mathematics, science and engineering to design, analyze and evaluate mechanical components & complex systems.

PO2: Analyze problems of mechanical engineering including design thermal and manufacturing industrial systems.

PO3: Design, implement, and evaluate mechanical systems and processes considering public health, safety, cultural, societal and environmental issues.

PO4: Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.

PO5: Apply recent techniques, skills, knowledge and computer based methods & tools to solve mechanical problems.

PO6: Analyze the local and global impact of modern technologies on individual organizations, society and culture.

PO7: Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco-friendly environment.

PO8: Exhibit responsibility in professional, ethical, legal and social issues.

PO9: Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goal.

PO10: Effective written and verbal communication on complex engineering activities and exhibit leadership qualities.

PO11: Apply management principles to manage projects in multidisciplinary environment.

PO12: Pursue life-long and independent learning as a means to enhance knowledge and skills.

Program Specific Outcomes (PSOs)

Our Graduate should be able to apply principles of Mechanical Engineering to:

1. Specify, manufacture, test, operate and document basic mechanical systems and processes.
2. Analyse, design, develop and implement advanced mechanical systems and processes.
3. Select solutions to the mechanical engineering problems based on ethics, sustainability and long term benefits to society.

SEM-VII

	Course Code	Course Name	Hr/Week			Credits	TA	IST	ESE	ESE hours
			L	T	P					
1	R4ME4001T	Finite Element Method	2	0	0	2	20	20	60	3
	R4ME4001P	Finite Element Method Laboratory	0	0	2	1	60% CIE+40%ESE			
2	R4ME4002S	Design of Mechanical Systems	3	1	0	4	20	20	60	3
3	R4ME4003S	Operations Management	3	0	0	3	20	20	60	3
4		Program Elective 2	3	0	0	3	20	20	60	3
		Program Elective 2 Lab	0	0	2	1	60% CIE+40%ESE			
5		Open Elective 2	3	0	0	3	20	20	60	3
6	R4ME4004D	Project –I	0	0	4	2	60% CIE+40%ESE			
7	R4ME4005D	Presentation on work carried out on Internship	0	0	4	2	60% CIE+40%ESE			
TOTAL			14	1	12	21				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, M**ST**: Mid Semester Tests, **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

Semester VII List of Program Elective 2:

S. No	Course code	Course Title
1.	R4ME4101T	Automobile Engineering
	R4ME4101P	Automobile Engineering Laboratory
2.	R4ME4102T	Rapid Product Development
	R4ME4102P	Rapid Product Development Laboratory
3.	R4ME4103T	Renewable Energy
	R4ME4103P	Renewable Energy Laboratory
4.	R4ME4104T	Composite Materials and Manufacturing
	R4ME4104P	Composite Materials and Manufacturing Laboratory
5.	R4ME4105T	Internet of Things
	R4ME4105P	Internet of Things Laboratory
6.	R4ME4106T	Data Science and Data Analytics
	R4ME4106P	Data Science and Data Analytics Laboratory

Semester VII List of Open Elective 2:

S. No	Course code	Course Title
1.	R4ME4601S	Nano Technology
2.	R4ME4602S	Energy Conservation and Management
3.	R4ME4603S	Total Quality Management

SEM-VIII

	Course Code	Course Name	Hr/Week			Credits	TA	IST	ESE	ESE hours
			L	T	P					
1	R4ME4006T	Mechatronics	3	0	0	3	20	20	60	3
	R4ME4006P	Mechatronics Laboratory	0	0	2	1	60% CIE+40%ESE			
2	R4ME4007T	Refrigeration and Air-Conditioning	3	0	0	3	20	20	60	3
	R4ME4007P	Refrigeration and Air-Conditioning Laboratory	0	0	2	1	60% CIE+40%ESE			
3		Program Elective 3	3	1	0	4	20	20	60	3
4		Program Elective 4	3	1	0	4	20	20	60	3
5	R4ME4008D	Project –II	0	0	8	4				
TOTAL			12	2	12	20				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, M**ST**: Mid Semester Tests, **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

Semester VIII List of Program Elective 3:

S. No	Course code	Course Title
1.	R4ME4107S	Supply Chain Management
2.	R4ME4108S	Gas Dynamics & Jet Propulsion
3.	R4ME4109S	Reliability Engineering
4.	R4ME4110S	Design of Experiments
5.	R4ME4111S	Failure Analysis and Design
6.	R4ME4112S	Solid Mechanics
7.	R4ME4113S	Power Plant Engineering

Semester VIII List of Program Elective 4:

S. No	Course code	Course Title
1.	R4ME4114S	Process Planning and Cost Estimation
2.	R4ME4115S	Micro and Nano Manufacturing
3.	R4ME4116S	Tribology
4.	R4ME4117S	Piping Engineering
5.	R4ME4118S	Design Thinking
6.	R4ME4119S	Product Design and Life Cycle Management
7.	R4ME4120S	Pressure Vessel Design

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4001T**	
Course Title	**Finite Element Method**	
Prerequisites	**Machine Design, Mechanical Vibrations, Heat Transfer**	

COURSE OUTCOMES:

The student should be able to

1. Explain basic ideas related to finite element method.
2. Formulate one and two dimensional problems using FEM for structural and thermal engineering problems.
3. Apply FEM to solve boundary value problems.

Course Contents

Introduction to Finite Element Method (FEM)

Basic concept of finite element method, Problem classification, Introduction of elements, nodes and dof, Example applications, Discretization, Stiffness matrix and boundary conditions, Introduction to elasticity, Plane Stress and Plain strain.

FEM Formulations

Vibrational method-Weighted residual method, Rayleigh-Ritz method, Virtual work method. Shape functions, Elemental matrix.

One Dimensional FEM

Element matrices, bar element (two-noded, and three-noded), Truss element, Frame elements, One dimensional heat transfer problem, Convergence of FE solutions.

Two Dimensional FEM

Three-noded triangular element, Six-noded triangular element, Four-noded quadrilateral element, Natural coordinates, Isoparametric Formulation, Numerical Integration.

Vibration Analysis using Finite Elements

Equations of motion, Bar vibration, Beam vibration.

Introduction to Three Dimensional and Non Linear FEM

Basic ideas and equations from two dimensions to three dimensional analysis, Geometric and material non-linearity, Examples of problems.

Text Books

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Element in Engineering, Pearson, Fourth Edition, 2012.
2. P. Seshu, Textbook of Finite Element Analysis, PHI Learning Pvt. Limited, 2012.
3. R. D. Cook, D. S. Malkus, M. E. Pleasha and R. J. Witt, Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Fourth Edition, 2005.

Recommended Reading

1. J.N. Reddy, An Introduction to the Finite Element Method, McGraw Hill Book Co., Third Edition, 2016.
2. C. S. Desai and J. F. Abel, Introduction to the Finite Element Method, CBS Publishers, New Delhi, 2005.
1. Desai and Abel, Finite Element Method, Introduction to FEM
2. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, Butterworth and Heinmann, Fifth Edition, 2000.
3. K. J. Bathe, Finite Element Procedures, Prentice Hall, 2006.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4001P**	
Course Title	**Finite Element Method Laboratory**	
Prerequisites	**Machine Design, Mechanical Vibrations, Heat Transfer**	

COURSE OUTCOMES

The student should be able to -

1. Formulate numerical model for a given system.
2. Obtain Solutions for boundary value problems.
3. Solve mechanical engineering problems using FEA techniques.

Course Contents

Use of a FEM package

Solve the following problems using a commercial software like Ansys, (to practice the tasks like modeling, mesh generation, simulation, solution, interpretation of results and discussion)

1. Static analysis of truss.
2. Steady state thermal analysis of a composite wall.
3. Static analysis using beam element.
4. Static Analysis of axisymmetric element.
5. Stress of a mechanical component like plate, spanner etc. plane stress/plane strain conditions.
6. Modal analysis of a mechanical component.

Recommended Reading

1. Paleti Shrinivas, Krisha Chaitnay Sambana, Rajesh Kumar Datti, Finite Element Analysis using Ansys 11.0, Prentice Hall, 2010
2. Saeed Moaveni, Finite Element Analysis Theory and Applications with ANSYS, Prentice Hall, Third Edition, 2007
3. Y. Nakasone and S. Yoshimoto, Engineering Analysis with ANSYS Software, Butterworth-Heinemann, 2007
4. Erdogan Madenci, Ibrahim Guven, The finite element method and applications in Engineering using Ansys, Springer, Third Edition, 2007
5. N.S. Gokhale, S S Deshpande, S.V. Bedekar and A.N. Thite, Practical Finite Element Analysis, Finite to Infinite, First Edition, 2008
6. Reference Manual of Hypermesh Software
7. Online Tutorial of HyperMesh Software.
8. Tutorial of Ansys Software.

Text Books

1. Chandrupatla, Belegundu , Introduction to FEM in Engineering, Prentice Hall, Fourth Edition, 2011
2. Logan, Finite Element Method, CL Engineering, Fifth Edition, 2010
3. P. Seshu, Textbook of FEAnalysis, Prentice Hall, 2003

Recommended Reading

1. Rao S. S., FEM in Engg., Butterworth-Heinemann, Fifth Edition, 2010
2. Reddy J. N., Finite Element Method, McGraw-Hill Education, Third Edition, 2005
3. Segerlind, Applied Finite Element Analysis, John Wiley, Second Edition, 2005
4. Akin J. Edward, FEA for undergraduates, Academic Press, 1987

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4002S**	
Course Title	**Design of Mechanical Systems**	
Prerequisites	**Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

1. Design various sub-systems of crane, pump and conveyors.
2. Design single and multispeed gear boxes.
3. Select suitable bearing for a given application.

Course Contents

Design of Gears and gear box

Design of spur, helical, bevels and worm gears using strength and wear, Derive Lewis equation, AGMA standards, Design of single speed gear box consisting of spur and helical gear pair, gear box housing layout and housing design (Maximum two stages), Design of gear box (multi speed) for machine tool applications(Maximum three stages and twelve speeds)

Design of Bearings

Basic terminology in Rolling Contact bearings, Selection of rolling contact bearings based on constant /Variable Load & speed conditions. Design of hydro dynamically lubricated bearings. Introduction to hydro Static bearings. Selection of Mechanical Seals

Design of Cranes

Classification, Criteria for selection. Types of cranes and their Layouts. Design of Hoisting Mechanism of Overhead crane.

Design of components of Gear Pump (External)

Classification, Working Principle, Construction. Design of External Gear Pump: Motor selection, Gears, Cover and casing. Bolts.

Design of components of Conveyors

Classification, Merits and Demerits. Design of Belt Conveyor: Belt, Roller Assembly, Drum & Drum Shaft, Bearings. Motor selection. Take-up arrangements.

Text Books

1. S.N. Trikha, Machine Design Exercises, Khanna Publishers
2. N. Rudenko, Material Handling Equipment, Peace Publication

Reference Books

1. M. F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Elesevier, 5th Edition, 2017
2. Spivakosky & Dyachkov, Conveying Machines Vol.2, Mir Publishers, Moscow, 1985
3. Anthony Esposito, Fluid power with applications, Prentice Hall, Seventh Edition, 2008
4. Indian Standards- IS: 807, IS: 3443, IS: 3777, IS: 3815, IS: 3973
5. Vickers Industrial Hydraulic Manual, 2013
6. CMTI : Machine Tool Design Handbook, Tata Mc-graw Hill, 2012
7. Design data - Data Book for Engineers, PSG, Coimbatore, 2012
8. Alexandrov M.P., Materials Handling Equipment, MIR Publishers, Moscow, 1981
9. N. K. Mehta, Machine Tool Design, Tata McGraw-Hill Education, Third Edition, 2012

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester -VII*
Course Code	**R4ME4003S**	
Course Title	**Operations Management**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Demonstrate the variations in MPC system for different types of organizations.
2. Outline the processes from forecasting to sales and to use the different production planning techniques
3. Apply the different operations research techniques to solve MPC related problems
4. Evaluate the inventory control decisions

Course Contents

Manufacturing Planning and control System

Manufacturing–transformation process, Manufacturing as competitive advantage. Manufacturing system – components and types. Overview of manufacturing systems and various issues related with MPC. MPC system overview objectives and functions such as planning routing, scheduling, dispatching and follow up.

Forecasting

Need for forecasting, types of forecast. Extrapolative methods- Moving average method, Exponential smoothing method, Forecast errors, Linear trend model. Causal methods - Simple regression analysis.

Planning Functions

Capacity planning and aggregate planning, Master production schedule, Shop floor Control. MRP, MRP II and Concept of JIT.

Scheduling & Sequencing

Scheduling concept, Scheduling of processes, Gantt chart, job shop scheduling, Comparison of various methods, Sequencing of tasks using, Johnson‘s rule.

Project Management

Concepts of project planning, monitoring and control, Project management through network analysis, CPM & PERT. Project leveling and smoothing. Cost analysis and Crashing.

Inventory Management

Inventory control, purpose of holding stock, effect of demand on inventories, ordering procedures. Two bin system -Ordering cycle system-Determination of Economic order quantity and economic lot size-ABC analysis-Recorder procedure-Introduction to computer integrated production planning systems. Assembly Line Balancing

Operation Research Techniques in MPC

Mathematical programming approaches- Linear programming problem, Formulation, Simplex method, concept of duality. Assignment models, Transportation model. Need for simulation, Monte Carlo technique. Theory of constraints. Sequencing problems.

Text Books

1. Krajewski, L. J., Ritzman, L. P. and Malhotra, M. K., Operations Management, Prentice Hall, New Delhi, 2009
2. Ebert, J and Adams, D.J., Production/Operations Management, Prentice Hall of India, New Delhi, 2007
3. Thomas Vollmann, William Berry, Manufacturing planning and control Systems, McGraw Hill Education, Fifth Edition, 2004
4. Premkumar Gupta and Hira, Operation Research, S. Chand Company Ltd., New Delhi, 2007.
5. Jay Heizer, Barry Render, Jagadeesh Rajashekhar. Operation Management, Person Publication, 3rd Edition, 2011.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4101T**	
Course Title	**Automobile Engineering**	
Prerequisites	**Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

1. Outline the structure of the automobile.
2. Formulate steering, braking and suspension systems.
3. Select a suitable conventional and automatic transmission system.
4. Identify the usage of Electrical vehicles/Hybrid electric vehicle and power plants.

Course Contents

Vehicle classifications and specifications

Introduction: Current Scenario of the global automobile industry and future challenges in vehicle manufacturing.

Vehicle classifications and specifications: Frames, Chassis Layout and constructional details. power plant locations and drive.

Axles, Steering System, Wheels and Tyres

Axles: Types of front axles and their constructions, Purpose and materials.

Steering System: Steering geometry, Steering requirements, Steering linkages and steering gears, over steer and under steer, Cornering power, Reversibility of steering gears.

Wheels and Tyres: Wheels construction, alloy wheel, wheel balancing, types of tyres, construction, materials, factors affecting tyre life.

Brakes

Requirement of brakes, Classification of brakes, Mechanical, Hydraulic, Pneumatic, Electro and vacuum brakes, Disc brakes, Weight transfer during braking and braking efficiency, braking of vehicle front wheel, Rear wheel and four wheel brakes, Introduction to antilock braking system and EBD (Electronic Brake force Distribution).

Suspension

Objectives of suspension, Basic requirements, Springs-Leaf and Coil springs, Air suspension and its features, Independent suspension, Sprung and un-sprung mass, Pitching, Rolling and bouncing, Shock absorbers.

Transmission and drive line

Requirements of clutches, Types of clutches and clutch materials, Fluid coupling- Gear box-types, Automatic Transmission, Continuously Variable Transmission (CVT), Propeller Shafts, Overdrive, final drive and differential.

Electrical System, Electric and Hybrid Electric Vehicles

Batteries: Principles and construction of Lead acid battery, characteristics of battery, rating, capacity and efficiency of batteries.

Electric Vehicle: Introduction, layout construction and working.

Hybrid Electric Vehicles: Introduction, types, hybridization factor. Challenges and future scope of EVs and HEVs.

Text Books

1. Kirpal Singh, Automobile Engineering, Vol. 1&2 Standard Publications.
2. N.K. Giri, Mechanics, Khanna Publishers, New Delhi, 8th Edition
3. C. P. Nakra, Basic Automobile Engineering, Dhanpat Rai Publishing Company.
4. P. S. Kohali, Automobile Electrical Equipment, Tata McGraw Hill Publication.

Reference books

1. William H. Crouse, Automotive Mechanics, Tata McGraw-Hill., 10th edition
2. J. Reimpell H. Stoll, J.W. Betzler, The Automotive Chassis, SAE International Publication.
3. Newton, Steed and Garrot, Motor Vehicles, Butterworth London, 13th Edition
4. SAE Manuals and Standards.
5. Joseph Heitner, Automotive Mechanics, C. B. S. Publishers and Distributers.
6. R. B.Gupta, Automobile Engineering, Satya Publication.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4101P**	
Course Title	**Automobile Engineering Laboratory**	
Prerequisites	**Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

1. Understand the structure of the automobile.
2. Analyze the transmission systems, wheels and tyres.
3. Study of different automotive systems

Course Contents

1. Study of the following automotive systems

a. Chassis Layout,
b. Steering systems.
c. Drum and disc brakes.
d. Suspension systems.
e. Different types of clutches.
f. Gear Boxes.
g. Transmission systems.
h. Wiring layout.

2. Experimental study of the following systems

a. Spark ignition systems.
b. Differential gear boxes.
c. Clutch systems.
d. Gear boxes.
e. Power steering.
f. Pneumatic Braking System.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4102T**	
Course Title	**Rapid Product Development**	
Prerequisites	**Computer Aided Design/Computer Aided Manufacturing**	

COURSE OUTCOMES

The student should be able to –

1. Evaluate various existing Product Development processes
2. Design various Virtual Simulations techniques for industrial applications
3. Analyze existing Rapid Prototyping and Rapid Manufacturing Processes
4. Develop methods and materials for the modern manufacturing industry.

Course Contents

Product development

Essentials of Good Product Development, Influencing Factors of This Era, Types of Businesses, Product & Its classification, Product Cycle, An Overview of Rapid Product Development (RPD)

Virtual Reality

Definition of VR , Features of VR, Real time Response, Optimization of the Rendering Process, Technologies used in VR, Stereo Displays, Interactions in VR, Tracking based interaction, Data Generation for VR, Haptic Rendering, Applications of VR, Simulation in VR, Augmented Reality AR.

Rapid Prototyping

Rapid Prototyping Definition, Principle of RP, Comparison of CNC and RP, RP Processes like, Laminated Object Manufacturing(LOM), Fused Deposition Modeling (FDM), Stereo-lithography Apparatus(SLA), Photo-masking or Solid Ground Curing (SGC), Objects, Perfactory, Selective Laser Sintering (SLS), 3DPrinting (3DP), Applications/ Case studies/ Advantages, Important Issues in RP.

Rapid Tooling

Types of approaches: Layered Manufacturing and Material Translation, Need for Rapid Tooling & Metallic/ Ceramic Prototyping, Conformal Cooling Channels, Various types of tools- Metallic and Non-metallic tools, Direct and Indirect Methods of Rapid Tooling.

Reverse Engineering

Need for Reverse Engineering, Digitizing Methods and its Principles, Types measurements, Contact & Non-contact Types, Coordinate Measuring Machine (CMM), Capture devices, Sensors, Scanning Methods, 3D scanners, Data representation, Data processing and manipulation techniques. Applications

Polyhedral Modeling

Introduction, STL Format, Possible Defects in STL Files, Polyhedral B-Rep Kernel, Repairing STL Files, Repairing Missing Faces, Repairing Flipped Faces, Slicing and Other Operations, Feature Recognition from STL Files, Curvatures of Polyhedral Objects

Rapid Manufacturing

Introduction to Rapid Prototyping, Definition of Rapid Manufacturing, Roadmap to Rapid Manufacturing, Comparison of Various Processes for Rapid Manufacturing of Metallic Objects, Rapid Manufacturing of Polymeric Objects, Rapid Casting, other RM Processes like Hybrid Layered Manufacturing, Material Translation using Segmented Object Manufacturing. Applications such as dental implants etc.

Text Books

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 1997
2. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies: from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996
3. Peter D. Hilton and Paul F. Jacobs (Editors), Rapid Tooling: Technologies and Industrial Applications, Marcel Dekker, 2000
4. Karunakaran K.P., Rapid Product Development & Manufacturing, Proceedings of CEP workshops, 2010

Recommended Reading

1. Eliyahu M. Goldratt, The Goal, Lionheart Publishing, 1993,
2. Bill Gates with Collins Hemingway, Business @ the Speed of Thought with Digital Nervous System, Tata McGraw-Hill, 1999

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4102P**	
Course Title	**Rapid Product Development Laboratory**	
Prerequisites	**Computer Aided Design/Computer Aided Manufacturing**	

COURSE OUTCOMES

The student should be able to –

1. Create 3 D Models
2. Build STL file from 3D Models
3. Build Rapid Prototyping Parts
4. Apply surface finish enhancement techniques on FDM parts

Course Contents

Creating 3D Models

Create 3 D Models both part and surface modeling techniques using CAD software.

Build the stl file

Working on 'stl' file formats, details of 'stl' files, converting 3D Model file into 'stl' file format.

Building Parts on Rapid Prototyping Machine

Introduction to existing Rapid Prototyping Machine, working on RP machine control software, Importing CAD model in the form of stl file. Build the parts using 'FDM' RP Machine.

Apply surface finish techniques on FDM Parts

Apply hand finishing techniques, chemical treatment techniques to improve surface finish of FDM parts

Checking dimensional stability of RP parts

Introduction to existing CMM machine. Working on Coordinate Measuring Machine (CMM) to check the dimensional stability of FDM parts.

Text Books

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 1997
2. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies: from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996
3. Peter D. Hilton and Paul F. Jacobs (Editors), Rapid Tooling: Technologies and Industrial Applications, Marcel Dekker, 2000
4. Karunakaran K.P., Rapid Product Development & Manufacturing, Proceedings of CEP workshops, 2010

Recommended Reading

1. Eliyahu M. Goldratt, The Goal, Lionheart Publishing, 1993,
2. Bill Gates with Collins Hemingway, Business @ the Speed of Thought with Digital Nervous System, Tata McGraw-Hill, 1999

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4103T**	
Course Title	**Renewable Energy**	
Prerequisites	**Thermodynamics, Fluid Machinery**	

COURSE OUTCOMES

The student should be able to –

1. Demonstrate and design solar energy systems.
2. Demonstrate and design wind energy systems
3. Demonstrate and design other renewable energy systems
4. Suggest integrated energy approach and sustainable energy policies

Course Contents

Overview of conventional power plants & need for renewables

Present energy scenario, world's production and reserves, India's production and reserves, load curve, load duration curve, load factor, demand factor, capacity factor, diversity factor, etc.,

Global energy crisis, challenge of climate change, need for renewable.

Solar energy

Solar radiation-terrestrial and extra-terrestrial, extra instrument. energy potential of sun, simple flat plate collector, selective casting. application of LFPC, performance, analysis of LFPC. concentrating collectors, solar ponds, solar distillators, solar satellite power system, solar cooker, solar air heaters, solar dryers, photo voltaic direct energy conversion, solar cells, solar thermal power system, solar energy storage.

Wind energy

History, principle of wind power, betz model, wind mills-horizontal and vertical axis, horizontal axis wind turbines and their components. operation, recent developments & their site's characteristics. vertical axis-Magnus effect, Madaras & Darrieus turbine. application of wind energy.

Ocean energy

Types of ocean energy sources, ocean temperature differences. otfc cycles-closed, ocean waves-wave motion, energy power from waves. wave energy conversion device. tidal power-formation and causes of tides, power from tides, tidal power devices.

Biomass energy

Various forms of biomass as a potential energy source, energy plantation. biofuel production processes, bio gas plants, gassifiers, principle construction & design of gassifiers , individual & community bio and gobar plants, types of gobar gas plant.

Geothermal energy

History and future, origin & type of geothermal energy regions, dry rock & hot acquifier analysis, vapour dominated and liquid nominated geothermal systems, operational and environmental problems.

Integrated approach towards energy planning and policies

Integrated approach for energy planning, energy policies of states and the country, SEU model

Text Books

1. S. P. Sukhatme, Solar Energy, McGraw-Hill Education, Third Edition, 2009
2. John W. Twidell and A.D. Weir, Renewable Energy Source, ELBS Publication
3. G.D. Rai, Non-Conventional Energy Sources, Khanna publishers, 2004

Recommended Reading

1. B. S. Magal, Solar Energy, Tata Mc-Graw Hill, 2000

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4103P**	
Course Title	**Renewable Energy**	
Prerequisites	**Thermodynamics, Fluid Machinery**	

COURSE OUTCOMES

The student should be able to –

1. Analyze the performance of solar devices.
2. Evaluate the energy requirement of a system.

List of Experiments

1. Power calculation on PV module for different tracking angle
2. Thermal performance analysis of compound parabolic collector system
3. Experimentation on various solar equipments and its working principle (Solar Pyranometer, Solar Albedometer, Solar Tracker, Wind Anemometer, Thermal Gun, Hygrometer etc.)
4. Experimentation on Solar Water Heating System
5. Experimentation on Solar Parabolic Dish system
6. Experimentation on Solar water Pumping System

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4104T**	
Course Title	**Composite Materials**	
Prerequisites	**Material Science**	

COURSE OUTCOMES

The student should be able to –

1. Identify the properties of fiber and matrix materials used in composites.
2. Select an appropriate manufacturing process for composite parts.
3. Analyze fiber composites based on the constituent properties.
4. Create and design engineering structures with fiber reinforced -composites.
5. To study nanocomposites processing and properties

Course Contents

Introduction to Composites

Material selection in design, Types of composite materials, general characteristics of composite materials, applications of composites

Constituents of Composite Materials

Reinforcement and fillers: glass fibers, carbon fibers, organic fibers, boron fibers, natural fibers, ceramic fibers Matrix: thermoset matrix and thermoplastic matrix, metal matrix materials, ceramic matrix materials

Manufacturing of Composites

Bag-molding, compression molding, pultrusion, filament winding, liquid composite molding, metal matrix composite manufacturing, ceramic matrix composite manufacturing, selection of manufacturing method

Mechanics of Fiber Reinforced Composite Materials

Fiber matrix interaction, micromechanics of composite materials, Laminate Analysis, Failure theories for composite materials

Characterization of Fiber Reinforced Composite Materials

Static mechanical properties, fatigue properties, impact properties, methods of characterization of fiber-matrix interphase, quality inspection methods, different ASTM standards

Fracture and Fatigue of Fiber Reinforced Composite Materials

Failure of composites, delamination in composites, modes of fracture, composite damage mechanics, S-N diagram for composite materials

Polymeric Nanocomposite Materials

Introduction to nanomaterials, nanoplatelete/nanoparticles/nanofibers reinforced composites, CNT/Graphene reinforced composites, challenges in processing of nanocomposites, prediction of properties of nanocomposites, applications of nanocomposites

Text Books

1. P.K. Mallick, Fiber-Reinforced Composites: Materials, Manufacturing, and Design, Third Edition, CRC Press, 2007
2. K. K. Chawla, Composite Materials: Science and Engineering, Springer, 2012

Recommended Reading

1. Bryan Harris, Engineering Composite Materials, The Institute of Materials, Landon
2. Hussain, Farzana, et al., Review article: polymer-matrix nanocomposites, processing, manufacturing, and application: an overview. Journal of composite materials 40.17, 2006: 1511-1575
3. M. Ashby, Material Selection in Mechanical Design, 4th Edition, Elsevier, 2010

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4104P**	
Course Title	**Composite Materials Laboratory**	
Prerequisites	**Material Science**	

COURSE OUTCOMES

The student should be able to –

1. Develop composite manufacturing process for the given part
2. Evaluate the performance of composite structure
3. Design the optimal composite structure

List of experiments

1. Resin Preparation and cure cycle
2. Manufacture of composite material using hand layup process
3. Manufacture of natural fibers composite materials
4. Open mold composite manufacturing process
5. Vacuum assisted resin transfer molding process
6. Manufacture of sandwich composite
7. Testing of polymeric composite materials
8. Finite element analysis of composite materials
9. Design optimization of composite structure
10. Manufacture of electrospun nanofibers reinforced composites

Text Books

1. P.K. Mallick, Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007
2. K. K. Chawla, Composite Materials: Science and Engineering, Springer, Third Edition, 2012

Recommended Reading

1. Bryan Harris, Engineering Composite Materials, The Institute of Materials, Landon
2. Hussain, Farzana, et al., Review article: polymer-matrix nanocomposites, processing, manufacturing, and application: an overview. Journal of composite materials 40.17, 2006: 1511-1575
3. M. Ashby, Material Selection in Mechanical Design, Elsevier, Fourth Edition, 2010

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4105T**	
Course Title	**Internet of Things**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Understand fundamentals and usage of the term "Internet of the Things" in different Context.
2. Analyze the key components that make up an IoT system: Signals, Sensors, Actuators, Interfaces
3. Compose Networking and apply the knowledge / skills acquired to build and test IoT system
4. Evaluate the role of cloud computing and data analytics in IoT system. Evaluate various existing Product Development processes

Course Contents

IoT Introduction and Fundamentals

IoT definitions & Fundamentals: overview, potential & challenges Applications where IoT can be deployed, Benefits/challenges of deploying an IoT, IoT components: Sensors, front-end electronics (amplifiers, filtering, and digitization), digital signal processing, data transmission, choice of channel (wired/wireless), back-end data analysis. Introduction to programming.

Signals, Sensors, Actuators, Interfaces

Sensors: types, signal types, shape, strength and Sensor Network, Sensor non-idealities: Sensitivity and offset drift, noise, minimum detectable signal, non- linearity, Read-out circuits: Instrumentation-amplifier, SNR definition, noise-bandwidth-power tradeoff, Power/energy considerations, Basic signal processing (filtering, quantization, computation, storage)

Networking and Cloud Computing in IoT

Review of Communication Networks, Challenges in Networking of IoT Nodes, range, bandwidth, Machine-to-Machine (M2M) Communications and Medium Access Control (MAC) Protocols for M2M Communications, Basics of 5G Cellular Networks and 5G IoT Communications, Low-Power Wide Area Networks (LPWAN), Wireless communication for IoT: channel models, power budgets, data rates, Cloud computing platform (open source) and local setup of such environment, user interfaces, Security and Privacy in The Internet of things

Data Analysis for IoT applications

Statistics relevant to large data, Data Handling and Analytics, Linear regression, Basics of clustering, classification, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Applications to Mechanical Industries

Text Books

1. B K Tripathy, J Anuradha, Internet of Things (IOT): Technologies, Applications, Challenges and Solutions, CRC Press
2. Pethuru Raj and Anupama C Raman, The Internet of Things, Enabling Technologies, Platforms, and use cases, CRC press
3. Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach

Recommended Reading

1. Rajkumar Buyya and Amir Vahid Dastjerdi, Internet of things: Principles and Paradigms, Elsevier (Morgan Kaufmann)
2. Adeel Javed, Building Arduino projects for the Internet of Things, Apress

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4105P**	
Course Title	**Internet of Things Laboratory**	
Prerequisites		

Course Contents

Set of experiments (using Arduino/Raspberry Pi/DSPs/custom board)
Integration of Sensors and Actuators with Arduino
Identify a hardware/software platform that is open-source with flexibility and students have some prior exposure (either in a microprocessor or embedded systems lab).
Suggestion: Thingsboard and Arduino
Experiment involving a microcontroller with wireless enabled peripheral – Interfacing of sensors, communicating data to a local server, fusion at the server, sending actuator signals from the server (2 to 3 experiments)

At least one mini-project focused on realizing practical IoT applications related to Mechanical / Mechtronics / Automation / Robotics industry/Case studies in: Sensor body-area- network, Control of a smart home, Smart Vehicles, Smart Manufacturing & Smart Factory

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4106T**	
Course Title	**Data Science and Data Analytics**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Demonstrate understanding of the mathematical foundations needed for data science.
2. Collect, explore, clean, munge and manipulate data.
3. Implement models such as k-nearest Neighbors, Naive Bayes, linear and logistic regression, decision trees, neural networks and clustering.
4. Build data science applications using Python based toolkits.

Course Contents

Introduction to Data Science

Concept of Data Science, Why/When/What, application in real scenarios.

Programming Tools for Data Science

Basics of Python (file handling, case-folding, spell check, split, strip, Regex, find, replace, etc.), Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK, Visualizing Data: Bar Charts, Line Charts, Scatterplots, Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction

Mathematical Foundations

Linear Algebra: Vectors, Matrices, Multivariate calculus, Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation, Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem, Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P-hacking, Bayesian Inference, Optimization: Unconstrained, Constrained, KKT conditions

Machine Learning

Overview of Machine learning concepts – Bias/variance, overfitting and train/test splits. Types of Machine learning – Supervised, Unsupervised, Semi-supervised. Classification and Regression algorithms-Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees and induction rules, Hidden Markov Models, Metrics, Introduction to Bayes Theorem, Linear Regression-model assumptions, Regularization (lasso, ridge, elastic net) from both the statistical and Bayesian inference viewpoint, Analysis of Time Series, Bagging and Boosting (to balance bias and variance) and random forest, Neural Networks-Learning And Generalization, Overview of Deep Learning, Unsupervised learning: KMeans and Hierarchical clustering, Reinforcement learning

Case Studies of Data Science Applications and Project

Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis, etc.

Text Books

1. Joel Grus, Data Science from Scratch: First principles with Python, O'Reilly Media
2. Aurelien Geron, Hands on Machine Learning with Scikit-Learn and Tensor flow: Concepts, Tools and Techniques to build Intelligent Systems, First Edition, O'Reilly Media
3. V.K.Jain, Data Sciences, Khanna Publishing House, Delhi
4. Jeeva Jose, Machine Learning, Khanna Publishing House, Delhi
5. Rajiv Chopra, Machine Learning, Khanna Publishing House, Delhi

Recommended Reading

1. V.K.Jain, Big Data and Hadoop, Khanna Publishing House, Delhi
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press
3. Jiawei Han and Jian Pei, Data Mining Concepts and Techniques, Third Edition, Morgan Kaufmann Publishers

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4106P**	
Course Title	**Data Science and Data Analytics Laboratory**	
Prerequisites		

LIST OF PRACTICALS

1. Write a programme in Python to predict the class of the flower based on available attributes.
2. Write a programme in Python to predict if a loan will get approved or not.
3. Write a programme in Python to predict the traffic on a new mode of transport.
4. Write a programme in Python to predict the class of user.
5. Write a programme in Python to identify the tweets which are hate tweets and which are not.
6. Write a programme in Python to predict the age of the actors.
7. Mini project to predict the time taken to solve a problem given the current status of the user.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4601S**	
Course Title	**Nanotechnology**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Analyze the effect of nanoscale on properties of materials.
2. Synthesize the nanomaterials using different processing methods.
3. Characterize the properties of nanomaterials.
4. Apply nanoscale phenomena to design the nanostructures and devices.

Course Contents

Fundamentals of nanotechnology

What is nanotechnology? Scaling laws, size dependent properties, Nanoscale Materials-zero dimensional, one dimensional, two dimensional materials, nanomaterials terminology, nanomaterials in nature, Potential impacts of nanotechnology- Healthcare, materials, environment, energy, defense etc.

Review of chemical and physical principles

Chemical Principles-Bonding and hybridization, Intermolecular forces, Dispersion forces, van der waal's forces, hydrogen bonding

Physical Principles- Crystal structures, quantum mechanics, density of states

Thermodynamics- Laws of thermodynamics, enthalpy, entropy, free energy

Bio-chemical – block polymers, biomolecules (carbohydrates, proteins, lipids, and nucleic acids)

Synthesis of nanomaterials

Bottom up processes-Vapor Phase Deposition, Molecular Beam Epitaxy, Liquid Phase methods, Colloidal methods, Sol-Gels, Pulse-Laser Deposition (PLD), Magnetron Sputtering, Self Assembly

Top Down processes – Ball Milling, Machining, Lithography, Nanoimprint Lithography, Dip-Pen Lithography, Wet Bulk Micromachining, E-Beam lithography, Electrospinning

Characterization methods

Scanning Tunnelling Microscope (STM), Scanning Electron Microscope (SEM), Trasmission Electron Microscope (TEM), Helium Ion Microscope (HIM), Atomic Force Microscope (AFM) X-ray Diffraction, Raman Spectrometry, Fourier Transform Infrared Spectrometry

Applications of nanotechnology

Healthcare and medicine- Drug delivery, Tissue engineering, Biosensors, diagnostics Electronics- Semi-conductor nanowires, nano-transisters, quantum dots, flexible displays Energy - Photovoltaics, Nanocrystals, die sensitized solar cells, hydrogen fuel cells

Structural materials- carbon nanotubes, graphene, polymeric nanocomposites

Text Books

1. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.
2. G. L. Hornyak, Fundamentals of Nanotechnology, CRC Press, 2008

Recommended Reading

1. Bharat Bhushan, Handbook of Nanotechnology, Springer, 2007
2. A. Sengupta, Introduction to Nano: Basics to Nanoscience and Nanotechnology, Springer, 2015

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4602S**	
Course Title	**Energy Conservation and Management**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Illustrate the current energy scenario, challenge of climate change & peak oil, importance of energy conservation and need for alternative energy resources.
2. Examine various parameters in energy systems and energy auditing.
3. Apply Energy Planning and forecasting techniques for performing energy analysis.
4. Integrate energy economics and relevance of sound energy policies for sustainable development.

Course Contents

Introduction

Energy Scenario-world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries - an overview. Peak oil. Challenge of climate change - Energy conservation and energy efficiency – needs and advantages.

Pollution from energy generation

Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, nuclear fuel cycle, radioactive wastes – treatment and disposal- Environmental pollution limits guidelines for thermal power plant pollution control- Environmental emissions from extraction, conversion, transport and utilization of fossil fuels- Green house effect- Global warming.

Energy auditing

Energy Conservation Act 2001. Energy auditing - Definition, need, types of energy audit methodologies, barriers. Role, Duties and responsibilities of energy managers and auditors. Energy audit questionnaire. Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, optimizing the input energy requirements; Fuel & energy substitution.

Energy conservation

Energy Efficiency in relevant utilities

Mechanical/Thermal – Boilers, Steam System, Furnaces, Insulation and Refractories, Cogeneration, Waste Heat Recovery, Heat Exchangers

Electrical – Electrical Systems, Electric motors, Compressed air system, HVAC and refrigeration system, Fans and Blowers, Pumps and pumping system, Cooling Tower, Lighting system, Diesel/Natural Gas Power generating system

Civil – Energy Conservation in buildings and ECBC
Textile – Textile industry

Energy economics

Investment - need, appraisal and criteria, financial analysis techniques - break even analysis-simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.

Energy forecasting

Energy forecasting techniques - Energy demand – supply balancing, Energy models, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India.

Energy policies

National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy- Carbon Trading- Renewable Energy Certification – CDM. The Sustainable Energy Utility (SEU) Model.

Text Books:

1. General Aspects of Energy management and Audit, Guide book for energy manager and energy auditor, Bureau of energy efficiency
2. Energy Efficiency in Thermal Utilities, Guide book for energy manager and energy auditor, Bureau of energy efficiency
3. Energy Efficiency in Electrical Utilities, Guide book for energy manager and energy auditor, Bureau of energy efficiency
4. Energy Performance Assessment for Equipment and Utility Systems, Guide book for energy manager and energy auditor, Bureau of energy efficiency

Additional Reading:

1. YP Abbi and Shashank Jain, Handbook on Energy Audit and Environment Management, TERI Publications, 2009.
2. Steve Doty, Wayne C. Turner, Energy Management Handbook
3. Jason Houck, Wilson Rickerson, The Sustainable Energy Utility (SEU) Model for Energy Service Delivery, http://online.sagepub.com

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R4ME4603S**	
Course Title	**Total Quality Management**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Apply basic tools of TQM for achieving overall quality in organization
2. Develop a strategy for implementing TQM in an organization.
3. Implement the quality control tools for industrial problem
4. Analyze the voice of the customer for product/service development.
5. Evaluate the impact of quality on economic performance and long-term business success of an organization

Course Contents

Basic TQM Concepts

Introduction, Development of the Importance of Quality Management, Quality and Public, Factors Affecting Quality, Total Quality Management: Introduction and Principles.

TQM Philosophies and Principles

Approach to Quality: Deming, Juran, Crosby, Kaizen, Shigeo Shingo, Ishikawa, Taguchi. Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

Concept of Quality Circles

Objective, Process of Operation of Quality Circles, Using the Concept, Fish Bone, Application in Organization.

Six Sigma

Deviation and Standard Deviation, Phases and Defective Units of Six Sigma, Its Importance, Overview of Master Black and Green Belt

Leadership

Definition, Characteristics of Quality Leaders, Leadership Concepts, Role of TQM Leaders

Customer Satisfaction

Introduction, Customer Perception of Quality, Feedback, Service Quality, Customer Retention

Performance Measures

Quality Costs, Basic Concepts, Performance Measure Presentation, Appraisal Cost Category,

Collection and Reporting, Analysis, Deming Prize

Tools and Techniques

Pareto and Process Flow Diagram Check Sheets and Histograms, Control Charts, Quality Management Systems, Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

Case Studies

Changing Company Culture, Xerox Corporation – Using TQM as a Competitive Strategy, Motorola's Secret to TQC, Motorola's Quest for Quality

Text Books

1. Dale H. Besterfield, Total Quality Management, Pearson, Third Edition, 2011
2. N, Logothetis, Managing of Total Quality, Prentice Hall of India Private Limited, First Edition, 1992
3. J. Bicheno and M. R Gopalan, A Management Guide to Quality and Productivity, Wiley Dreamtech, New Delhi
4. Janakiraman, B and Gopal, R.K, Total Quality Management – Text and Cases, Prentice Hall (India) Pvt. Ltd., 2006

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VIII***
Course Code	**R4ME4006T**	
Course Title	**Mechatronics**	
Prerequisites	**Mechanical Measurements**	

COURSE OUTCOMES

The student should be able to –

1. Build low cost automation circuits
2. Prepare the assembly programs in 8085µp for various applications.
3. Use of programmable logical controllers.
4. Apply the assembly programming in 8051µc for interfacing.

Course Contents

Introduction to Sensors, Transducers and Actuators

Principle, working and applications of-Limit switches, proximity switches like inductive, capacitive and optical (deflecting and through beam type), Thumb wheel switches magnetic reed switches, Optical encoders-displacement measurement, rotary, incremental, opto-couplers. Introduction to LCA circuits, Construction of LCA circuits,

Actuator – solenoids – on-off applications, latching, triggering.

Types of relays – solid state

8085 Microprocessor

Architecture, Pin configuration, working of microprocessor and applications. Introduction to ICs used for interfacing such as – Programmable peripheral devices, memory, keyboard, display – LCD, LED, I/O device, ADC, DAC etc. Assembly programming, stack and subroutine (CALL, RET, PUSH, POP).

Programmable Logic Controller (PLC)

Introduction, PLC definition, PLC block diagram, Difference between relay panel and PLC, power supply, input/output modules (analog, digital) concepts of sink/source, set/reset, latch/unlatch, advantages and disadvantages, installation, troubleshooting and maintenance. Ladder diagrams and sequence listing, large process ladder diagram construction, flowcharting as a programming method, Basic PLC functions

Register basics, timer functions, counter functions

8051 Microcontroller

Architecture, Pin configuration, working of microprocessor, and applications.

Assembly language programming - Jump, Loop, Call instructions.

Addressing modes - Arithmetic, Logic Instructions & programs.

I/O port programming - LCD, ADC, DAC, STEPPER MOTOR, DC MOTOR interfacing.

Text Books:

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Sixth Edition, 2013

2. Muhammad Ali Mazidi, The 8051 microcontroller & embedded systems, Pearson Education, Second Edition, 2005

Recommended Reading

1. NIIT Programmable Logic Control – Principles and Applications. Prentice Hall of India, 2004
2. Kolk R.A. and Shetty D., Mechatronics systems design, Vikas Publishing, New Delhi, Second Edition, 2010
3. Mahalik N.P., Mechatronics principles, concepts and applications, Tata McGraw Hill Publishing, First Edition, 2003
4. J.R. Fawcett, Pneumatic circuits, Trade & Technical Press, Fourth Edition, 1980

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4006P**	
Course Title	**Mechatronics Laboratory**	
Prerequisites	**Mechanical Measurements**	

COURSE OUTCOMES

The student should be able to –

1. Design basic pneumatic circuits.
2. Formulate and execute the assembly programs in 8085µp.
3. Interface 8051µc for different applications.

List of Experiments

1. Experiments on Pneumatic Kit
   a. Actuation of Single acting cylinder.
   b. Actuation of Double acting cylinder.
   c. Actuation of cascading pneumatic circuit.
2. Experiment on the Logic gates trainer
3. Assembly programming on 8085 µp kit
   a. Introduction to8085 µp.
   b. Assembly programming for arithmatic operations on 8085 µp.
   c. Assembly programming for logical operations on 8085 µp.
4. Interfacing with 8051 µc.
   a. Interfacing of 8051 µc with LCD.
   b. Interfacing of 8051 µc with DAC.
   c. Interfacing of 8051 µc with ADC.
   d. Interfacing of 8051 µc with stepper motor.
   e. Interfacing of 8051 µc with DC motor.

Text Books:

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Sixth Edition, 2013
2. Muhammad Ali Mazidi, The 8051 microcontroller & embedded systems, Pearson Education, Second Edition, 2005

Recommended Reading

1. NIIT Programmable Logic Control – Principles and Applications. Prentice Hall of India, 2004
2. Kolk R.A. and Shetty D., Mechatronics systems design, Vikas Publishing, New Delhi, Second Edition, 2010
3. Mahalik N.P., Mechatronics principles, concepts and applications, Tata McGraw Hill Publishing, First Edition, 2003

4. J.R. Fawcett, Pneumatic circuits, Trade & Technical Press, Fourth Edition, 1980

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4007T**	
Course Title	**Refrigeration and Air Conditioning**	
Prerequisites	**Thermodynamics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Analyze the basic cycles of Air Refrigeration
2. Evaluate the performance of Vapour Compression Refrigeration cycle.
3. Analyze the Vapour absorption and other advanced refrigeration cycles.
4. Analyse various Psychrometric Processes and their applications.
5. Provide the remedial actions for the harmful effects of refrigerants on environment.

Course Contents

Basic Refrigeration Systems

Definition of Refrigeration, Reversed Carnot Cycle, Reversed Joule Cycle or Bell Coleman cycle, Refrigerator, Heat Pump, Performance parameters like Tonnes of Refrigeration (TR), Coefficient of Performance (COP), kW (power) per TR, TR per kW etc.

Application of various Air Standard Refrigeration cycles used for cooling Aircraft cabins. Comparisons.

Vapour Compression Refrigeration Systems

Components of Vapor Compression Refrigeration cycle, Use of Pressure-Enthalpy charts, Effect of condenser pressure, evaporator pressure, subcooling and superheating on COP, Performance analysis and optimisation of vapour compression cycle, Multistaging, Cascade Refrigeration, introduction to air / LNG liquefaction.

Introduction to air-cooled and water cooled chiller packages.

Advanced Refrigeration Systems

Binary mixtures, Construction of Enthalpy-Concentration Charts, Basic processes of binary mixtures, Rectification Column, Theoretical Vapour Absorption Refrigeration cycle, Ammonia-Water (NH_3 - H_2O) system, Lithium Bromide-Water (LiBr-H_2O) system.

Electrolux Refrigeration, Thermo-electric Refrigeration, Waste Heat Refrigeration, Cogeneration Refrigeration, Magnetic Refrigeration, Triple Fluid Refrigeration System , Steam Jet Refrigeration.

Psychrometry and Air Conditioning Processes

Definition of Air Conditioning, Psychrometry – Properties of moist air.Theoretical Analysis, Construction and use of Psychrometric Charts.

Psychrometric processes – Adiabatic mixing, Sensible heating / cooling, Humidification / Dehumidification, Bypass Factor, Apparatus Dew Point (ADP). Types of Sensible Heat Factors (SHF) like Room SHF, Grand SHF, effective SHF

Heating / Cooling Load Calculations, Comfort Air Conditioning- Effective Temperature, Comfort Charts, Comfort Zone, Summer / Winter A.C., Year Round A.C., Room and Split Air-conditioners, Package and ductable air-conditioners, Central A.C., Air handling unit & Duct Design. Air quality.

Introduction to Variable Refrigerant Flow system.

Refrigerants

Refrigerants & their nomenclature, types and properties, alternate refrigerants, Ozone Depletion Potential (ODP) & Global Warming Potential (GWP), Montreal Protocol & Kyoto Protocol.

Text Books

1. Arora & Domkundwar, Course in Refrigeration & Air-Conditioning, Dhanpat Rai Publications, 8th Edition, 2013.
2. Manohar Prasad, Refrigeration & Air-Conditioning, New Age Intl. Publications, 3rd Edition, 2010.
3. C. P. Arora, Refrigeration & Air-Conditioning, Tata McGraw Hill, 3rd Edition, 2004.

Recommended Reading

1. ASHRAE Handbook, 2013 Edition.
2. Threlkeld, Thermal Environmental Engineering, Prentice-Hall Inc, 3rd Edition, 1998.
3. W. P. Jones, Air Conditioning Engineering, Butterworth-Heinemann, Fifth Edition, 2000.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VIII***
Course Code	**R4ME4007P**	
Course Title	**Refrigeration and Air Conditioning Laboratory**	
Prerequisites	**Thermodynamics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Evaluate the performance of a simple Vapour Compression Refrigeration system
2. Optimise the performance of a Vapour Compression Refrigeration system
3. Analyze the performance of a Thermoelectric Heat Pump
4. Evaluate the Psychrometric properties of moist air.
5. Evaluate the performance of Psychrometric processes for Air Conditioning systems.

List of Experiments (any 5)

1. Test on Water Cooler
2. Performance Tests (minimum 2) on the Refrigeration Tutor
3. Test on Thermoelectric Heat Pump
4. Test to evaluate Psychrometric Properties of moist air
5. Performance Tests (minimum 2) on Air-conditioning Tutor
6. Visit to a Refrigeration and Air-conditioning plant or Industry

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4107S**	
Course Title	**Supply Chain Management**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Evaluate the supply chain networks
2. Estimate the total cost of different logistic modes
3. Evaluate various performance measures of supply chain management
4. Obtain solutions for a variety of warehouse problems
5. Integrate the supply chain using the IT solution.

Course Contents

Introduction to Supply Chain

Understanding the supply chain, stages and decision phases of supply chain, Process view of supply chain, Supply chain flows, Competitive and supply chain strategies, Achieving and expanding strategic scope, Drivers of supply chain performance, Measuring performance of supply chain, Framework for structuring drivers, Roles of facilities, inventory, transportation facilities, information, sourcing and pricing in supply chain, Obstacles to achieving fit, Value chains, Sustainable and green manufacturing and linkage with supply chains.

Designing the Supply Chain Distribution Networks

Factors affecting distribution networks, applications to business, network design in supply chain and uncertain environments, Network optimization models, Gravity location models, Network optimization models, Evaluation of network designs, Forecasting demands in supply chains, Aggregate planning and managing variability. Managing inventory in supply chain. Optimal level of product availability.

Logistics for Supply Chains

Introduction of logistics, Logistics cost analysis, Total cost analysis, Principles of logistics costing, Customer profitability analysis,Direct product profitability, Cost drivers and activity-based costing

Warehouse and Transport Management

Concept of strategic storage, Warehouse functionality, Warehouse operating principles, Developing warehouse resources, Material handling and packaging in warehouses, Transportation Management, Transport functionality and principles, Transport infrastructure, Transport economics and Pricing. Transport decision making.

IT in Supply Chain

IT framework, Customer Relationship Management (CRM), internal Supply chain management, Supplier Relationship Management (SRM) and Transaction Management, Lack

of supply chain coordination and the Bullwhip effect, Obstacle to Coordination, Risk Management in IT, Vendor managed inventory-3PL-4PL, Reverse logistics: Reasons, Role, Activities, RFID systems: Components, Applications, Implementation, Lean supply chain, Implementation of Six Sigma in supply chain, Green supply chain. Use of GPS and GPRS systems.

Decision Support Models of Supply Chain Management

Decision support systems in supply chains, Transportation Systems, Warehouse Design, Distribution Policies, Transshipment etc.

Text Books

1. Sunil Chopra, Peter Meindl and D. V. Kalra, Supply Chain Management Strategy, Planning, and operations, Pearson, Sixth Edition, 2016
2. Martin Christopher, Logistics and Supply Chain Management, Pearson, Fifth Edition, 2016
3. Ammer D.S. Taraporawala, Materials Management & Purchasing
4. David Simchi Levi, Philip Kaminsky and Edith Smichi Levi, Designing & Managing Supply chain, McGraw Hill Higher Education, 1999

Recommended Reading

1. Robert B Handfield, Ernest L Nicholas, Supply Chain Redesign: Transforming Supply Chains into Integrated Value Systems, Financial Times/ Prentice Hall, 2002
2. Coyle, Bardi, Langley, The Management of Business Logistics: A Supply Chain Perspective, South-Western, Seventh Edition, 2002

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4108S**	
Course Title	**Gas Dynamics and Jet Propulsion**	
Prerequisites	**Thermodynamics, Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Analyze one -dimensional steady compressible flow.
2. Analyze the conditions for flow through a normal shock, oblique shock and Prandtl-Meyer expansion wave.
3. Solve an unsteady one-dimensional flow problem numerically.
4. Apply gas dynamics principles to jet and space propulsion systems

Course Contents

Basic concepts

Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Acoustic speed and Mach number, Governing equations for compressible flows.

One-dimensional compressible flow

One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine-Hugonoit equations, Rayleigh flow (constant area frictionless flow with heat transfer), Fanno flow (constant area adiabatic flow with friction), Crocco's theorem, Gas tables.

Quasi-one dimensional flows

Governing equations, Area velocity relations, Isentropic flow through variable-area ducts, Convergent-divergent (or De Laval) nozzles, Over-expanded and under-expanded nozzles, Diffusers.

Unsteady wave motions

Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic theory, Incident and reflected waves, Piston analogy, Finite compression waves, Shock tube relations, Method of Characteristics.

Two-dimensional flows

Oblique shock wave and its governing equations, θ-B-M relations, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.

Introduction to numerical techniques in inviscid Gas Dynamics

Classical finite difference procedures; Application to one-dimensional unsteady flows.

Jet Propulsion

Theory of jet propulsion, thrust equation, thrust power and propulsive efficiency, Operating principle and cycle analysis of ramjet, turbojet, turbofan and turboprop engines.

Types of rocket engines, propellants & feeding systems, ignition and combustion, theory of rocket propulsion, performance study, staging, terminal and characteristic velocity, space flights

Text Books

1. J.D. Anderson, Modern Compressible Flow with Historical Perspective, Third Edition, McGraw-Hill, 2003
2. P.H. Oosthuizen and W.E. Carscallen, Compressible Fluid Flow, McGraw-Hill, 1997

Additional Reading

1. H.W. Liepmann and A Roshko, Elements of Gas Dynamics, Dover, 2003
2. Ascher H. Shapiro, Dynamics and Thermodynamics of Compressible Fluid Flow (volumes I and II), John Wiley & Sons, 1977
3. P. G. Hill and C.R. Peterson, Mechanics and Thermodynamics of Propulsion, Pearson, 1991
4. H.S. Mukunda, Understanding Aerospace Chemical Propulsion, Interline Publishing, 2004.
5. Sutton G. P. and Biblarj O., Rocket propulsion elements, John Wiley, Seventh Edition, 2001.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4109S**	
Course Title	**Reliability Engineering**	
Prerequisites	**Mathematics for Mechanical Engineering I and II**	

COURSE OUTCOMES

The student should be able to –

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Course Contents

Probability

Probability theory: Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem.

Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance.

Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.

Acceptance sampling: Lot by lot sampling- types, probability of acceptance in single plan, double, multiple sampling technique, OC curves, producer risk and consumer risk, AQL, LTPD, AOQL concepts. Standard sampling plan for AQL & LTPD, use of standard sampling plans

Reliability

Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve.

Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions.

Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.

System Reliability

System Reliability: System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.

Reliability Improvement: Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis.

System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.

Maintainability and Availability

Maintainability and Availability: System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.

Failure Mode, Effects and Criticality Analysis: Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis

Text Books

1. L.S. Srinath, Reliability Engineering, Affiliated East-Wast Press (P) Ltd., 2008.
2. Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill.

Recommended Reading

1. B.S. Dhillion, C. Singh, Engineering Reliability, John Wiley & Sons, 1980.
2. Douglas. C. Montgomery, Introduction to statistical quality control 5^{th} edition, John Wiley 2001
3. P.D.T. Conor, Practical Reliability Engg., John Wiley & Sons, 1985.
4. K.C. Kapur, L.R. Lamberson, Reliability in Engineering Design, John Wiley & Sons.
5. Murray R. Spiegel, Probability and Statistics, Tata McGraw-Hill Publishing Co. Ltd.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VIII***
Course Code	**R4ME4110S**	
Course Title	**Design of Experiments**	
Prerequisites	**Mathematics of Mechanical Engineers-I & II**	

COURSE OUTCOMES

The student should be able to –

1. Apply re-engineering practices.
2. Employ reverse engineering process
3. Carry out design of experiments & Taguchi method
4. Demonstrate robust design principles

Course Contents

Uncertainty, Statistical Tools and Techniques of handling Uncertainty

The Mystique of Probability, Idea of a Random Variable, Hypothesis Testing, Comparing Two Population, Cause-Effect Models and Regression, "Cause" Factor, F-Statistic , The Mean Sum of Squares

Design Processes

Re-engineering, Reverse Engineering of Design, Concurrent Engineering

Design of Experiment

One-Factor Designed Experiment, ANOVA Helps Compare Variability, Factor Effects are Statistically Significant, Sum of Squares and the F-Test

Taguchi Method

Design Achieving Quality—Taguchi's Seven Points Optimized Design, Reduces R&D, Production, and Lifetime Cost. Taguchi's Definition of Quality, Causes Performance, Prevention by Quality Design Steps in Designing Performance into a Product Functional Design, Parametric Design, Additivity, the Response table

Signal to Noise Ratio

Selecting Factors for Taguchi Experiments Seek Robustness One Should Measure Performance by S/N Ratios, S/N Ratio in Optimization, OA as the Experiment Matrix, Axiomatic Approach to Design Orthogonal Arrays , Control and Noise Factors: The Ishikawa Diagram, Optimized Design , Testing for Additivity, The Optimization Strategy, Taguchi's Two Steps to On-Target Performance with Minimum Variability

Process/ Product Optimization

Passive Network filter, Formal Statement of the Design Problem, Robust Design Formulation of the Problem, Data Analysis and Estimation of Effects , Effects of the Design Parameters, The Process for Manufacturing Optical Filters , Control Parameters and the OA Performance Measurements and the S/N Ratio Minimizing log10 (s2), Variability of Thickness.

Robust Design

Re-Statement of the Multiple Objective Design Optimization, Target Performance Requirements as Explicit Constraints , Constraints Present in the Filter Design , Seeking Pareto-Optimal Design, Monte Carlo Evaluation of S/N Ratios, Necessary Mathematical Tools, Developing a Multiple Regression Model, Rationale of the Constrained Robust Design Approach, Application of the Constrained Approach to Real, Discussion of the Constrained Design Optimization

Loss function and Design Tolerances

Loss to Society is More Than Defective Goods, Determining Manufacturing Tolerances, Loss Functions for Mass-Produced Items

Text Books

1. Tapan P. Bagchi, Taguchi Method Explained, PHI, New Delhi, First Edition, 1993
2. Suh Nam P., The Principles of Design, Oxford university Press, NY, First Edition, 1990
3. Hammer Michel, Champy J., Re-engineering the Corporation, Harper Business, 2006

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4111S**	
Course Title	**Failure Analysis and Design**	
Prerequisites	**Machine Design**	

COURSE OUTCOMES

The student should be able to -

1. Apply appropriate theory of failure.
2. Differentiate between ductile and brittle fracture.
3. Apply the knowledge of fatigue, creep and fracture mechanics.
4. Carry out preliminary failure analysis of mechanical failures

Course Contents

Fundamentals

Concept of damage, failure and failure analysis, Damage tolerance in design, relooking theories of failure.

Fracture

Type of fracture, Theoretical cohesive strength of metals, Griffith theory of brittle fracture, fracture of single crystals, Brittle fracture, Ductile fracture, Notch effects, Fracture under combined stresses.

Fatigue Failure

Stress cycle, S-N curve, Description of fatigue fractured parts, Phases of fatigue fracture, Fatigue crack propagation, Effects of metallurgical variables, Temperature, Stress concentration, Size and surface factors, Fatigue under combined stresses, Paris law.

Creep Failure

Creep curve, Structural changes and mechanisms during creep, Activation energy for steady-state creep, Fracture at elevated temperature.

Elementary Fracture Mechanics

Damage tolerance, Strain energy release rate, Stress intensity factor, Fracture toughness, Plane strain toughness testing, Crack-opening displacement, J- Integral, R-curves.

Failure Analysis

Purpose of fracture based assessment, Assessment of fracture by observation, Comparison between different fractured parts undergoing various type of fracture.

Text Books

1. Kumar P., Mechanics of Fracture, Wheeler Publishing Company, 1998
2. Maiti S. K., Fracture Mechanics, Cambridge University Press, 2015
3. Simha K. R. Y., Fracture Mechanics for Modern Engineering Design, University Press, 2001
4. Dieter G.E., Mechanical Metallurgy, McGraw Hill, Third Edition, 1986

Recommended Reading

1. Rolfe S.T. and Barson, J.M., Fracture and Fatigue Control Structures, Prentice Hall
2. Ulpi D. J, Understanding How Components Fail, ASM International, Third Edition, 2013
3. Sors L., Fatigue Design of Machine Components, Pergamon Press.
3. Anderson T.L., Fracture Mechanics-fundamental and applications, CRC Press, Third Edition, 2005

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4112S**	
Course Title	**Solid Mechanics**	
Prerequisites	**Strength of Materials, Material Science**	

COURSE OUTCOMES

The student should be able to -

1. Describe stresses and strains as tensors
2. Explain the deformation behavior of solids under different types of loading
3. Derive mathematical solutions for deformation behavior of simple geometries
4. Discuss solutions using potentials and energy methods

Course contents

Introduction to Cartesian tensors, Strains

Concept of strain, derivation of small strain tensor and compatibility, Stress: Derivation of Cauchy relations and equilibrium and symmetry equations, principal stresses and directions

Constitutive equations

Generalized Hooke's law, Linear elasticity, Material symmetry; Boundary Value Problems: concepts of uniqueness and superposition

Plane stress and plane strain problems

Introduction to governing equations in cylindrical and spherical coordinates, axisymmetric problems

Application of theory to thick cylinders, rotating discs, torsion of non circular cross-sections, stress concentration problems, thermo-elasticity, 2-dcontact problems

Solutions using potentials, Energy methods, Strain energy, Resilience, proof Resilience, Calculation of stresses due to suddenly applied load, impact load, Strain energy stored due to shear.

Introduction to material plasticity, Yield Locus, Yield Surface for Three-Dimensional Stress, Tresca Yield Condition

Text Books

1. Srinath L. S., Advanced Mechanics of Solids, McGraw Hill, 2017
2. G. T. Mase, R. E. Smelser and G. E. Mase, Continuum Mechanics for Engineers, CRC Press Third Edition, 2004
3. Schmidt R.J. and Boresi A.P. Advanced Mechanics of Materials, Wiley, 2009

Recommended Reading

1. Y. C. Fung, Foundations of Solid Mechanics, Prentice Hall International, 1965
2. Lawrence. E. Malvern, Introduction to Mechanics of a Continuous Medium, Prentice Hall International, 1969

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4113S**	
Course Title	**Power Plant Engineering**	
Prerequisites	**Thermodynamics, Fluid Machinery**	

COURSE OUTCOMES

The student should be able to –

1. Examine present energy scenario of the world and of India with reference to global energy challenges.
2. Evaluate performance and operating characteristics of power plants.
3. Assess the environmental impact of power plants.

Course Contents

Energy requirement and selection of power plants

Present energy scenario, world's production and reserves, India's production and reserves, load curve, load duration curve, load factor, demand factor, capacity factor, diversity factor, etc., effect of fluctuating load on operation and design of power plant, methods of meeting, fluctuating load, base load plant, peak load plant, load sharing, selection of generating equipment, cost of electrical energy, fixed cost and operating cost, tariff methods, performance and operating characteristics of power plant.

Thermal power plant

Introduction to various power plants, thermal power plants layout, working and site selection, coal storage and transportation system, ash disposal and handling system.

Diesel Power Plant

General layout of diesel power plant, fuel, cooling, lubrication and starting system of diesel power plant.

Gas Turbine Power plant

Performance of gas turbine power plant, Series flow, parallel flow gas turbine plant, Gas turbine combustion chamber, Free piston engine plant, Combined gas turbine-steam turbine plant, Repowering.

Nuclear power plant

Radioactive decay, half time, types of nuclear reaction, nuclear material, nuclear reactor, boiling water reactor pressurized water reactor, heavy water CANDU reactor, gas cooled reactor, liquid metal fast breeder reactor, reactor control.

Basics of hydro power plant

Rainfall, run off & it's measurement, hydrograph, flow duration curve, mass curve & reservoir storage capacity, Classification of Hydro plants, Run of river plant, Storage river plant, Essential feature of hydro plant, Pumped storage plant.

Hydro-power: - principle of hydro power, prospects of small hydro power, mini & micro power system, hydro power conversion device- turbine, status in India.

Environmental impact of conventional power plant & need for renewables

Harmful effects of power plant pollutants, greenhouse effect, acid rain, air pollution & its control, thermal pollution & its control, disposal of nuclear waste, global energy crisis, challenge of climate change, need for alternate energy sources.

Text Books

1. Domkundwar, Arora, Power Plant Engineering, Dhanpat Rai and Co.
2. R.K. Rajput, A textbook of Power Plant Engineering, Laxmi Publications, Fifth edition, 2016

Recommended Reading

1. Wakil, Power Plant Engineering, McGraw-Hill Higher Education, 2002
2. P.J. Plotter, Power Plant Theory and Design, Second Edition
3. Bennat, Thomson, The Elements of Nuclear Power Plant, Longman, Third Edition, 1989
4. ASME Journal of Engineering for Power
5. Morse, Power Plant Engineering

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4114S**	
Course Title	**Process Planning and Cost Estimation**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Use the concepts of process planning
2. Estimate the machining time for various processes
3. Implement the depreciation, replacement analysis for industrial problem
4. Cost estimation for various products manufactured with the help of different manufacturing processes

Course Contents

Introduction of Process Planning

Methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection Process planning activities- process parameter calculation for various production processes, selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, economics of process planning, case studies

Introduction to Cost Estimation

Importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labor cost, material cost, allocation of overhead charges, causes of depreciation, methods of calculating depreciation, breakeven analysis and equipment replacement analysis.

Machining Time Estimation

Importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding.

Production Costs

Different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost and estimation of machining cost.

Text Books

1. Peter Scalon, Process Planning, Design/ Manufacture Interface, Elsevier Sci. & Tech. 2002.
2. Ostwaal P.F. and Munez J., Manufacturing Processes and Systems, 9th Edition, John Wiley, 1998.

3. Chitale A.V. and Gupta R.C., Product Design and Manufacturing, 2nd Edition, Prentice Hall, 2002.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester -VIII*
Course Code	**R4ME4115S**	
Course Title	**Micro and Nano-Manufacturing**	
Prerequisites	**Manufacturing Processes**	

Course Outcomes

The student should be able to –

1. To give awareness of different techniques used in micro and nano manufacturing
2. To introduce Non - conventional micro - nano manufacturing and finishing approaches
3. To know different techniques used in Micro Joining and the metrology tools in micro and nano manufacturing.

Course Content

MEMS

Introduction to Micro products and MEMS devices. Precision engineering.
Micro-electromechanical systems – merits and applications, Micro phenomenon in Electro-photography – applications.

Bulk Micro machining Processes

Micromachining: macro milling and micro drilling. Introduction to Bulk micromachining, Surface micromachining steps. Laser technology in micro manufacturing- Practical Lasers, application of technology fundamentals. Micro drilling – process, tools and applications. Micro turning- process, tools and applications, Diamond Micro turning – process, tools and applications. Micro milling and Micro grinding – process, tools and applications. Micro extrusion- process and applications. Abrasive Jet Micro Machining, WAJMM. Micro EDM, Micro WEDM, Micro EBM – Process principle, description and applications. Micro ECM, Micro LBM - Process principle, description and applications. Focused ion beams - Principle and applications.

Laser Micro welding

Description and applications, defects. Electron Beam Micro-welding – description and applications. Introduction to micro and nano measurement, defining the scale, uncertainty.

Nano- Plastic forming and Roller Imprinting

Introduction to Non - conventional micro - nano manufacturing. Process, principle and applications. Introduction to Nanofabrication, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp). Manipulative techniques – process principle, applications

Introduction to Micro-energy and chemical system (MECS)

Space Micro-propulsion, e-Beam Nanolithography – important techniques, Introduction to Nanotechnology

Carbon Nano-tubes

Properties and structures, Molecular Logic Gates and Nano level Biosensors – applications

Micro and Nano Finishing Processes

Magnetorheological Finishing (MRF) processes, Magnetorheological abrasive flow finishing processes (MRAFF) – process principle and applications. Force analysis of MRAFF process, Magnetorheological Jet finishing processes Working principle and polishing performance of MR Jet Machine. Nanofinishing – finishing operations. Elastic Emission Machining (EEM) – machine description, applications. Chemical Mechanical Polishing (CMP) – Schematic diagram, principle and applications.

Carbon Nano-tubes

Introduction to Carbon nano materials – CN Tubes; properties and applications, CN Tube Transistors – Description only, CVD/PVD and LIGA processes.

Scanning Electron Microscopy

Description, principle 1 Scanning White-light Interferometry – Principle and application. Optical Microscopy – description, application. Scanning Probe Microscopy, scanning tunneling microscopy description, application. Confocal Microscopy - description, application. Introduction to On-Machine Metrology. Micro instrumentation – applications, Micro Mechatronics,

Text Books

1. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006.
2. Nitaigour Premchand Mahalik, Micro-manufacturing and Nanotechnology, Springer Publications, 2006.
3. V.K. Jain, Micro-manufacturing Processes, CRC Press, 2012.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4116S**	
Course Title	**Tribology**	
Prerequisites	**Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

1. Apply friction/lubrication mechanism to the practical engineering problem.
2. Justify the use of metallic and non-metallic materials.
3. Design mechanical components against wear.
4. Employ different methods to reduce the friction for engineering surface

Course Contents

Introduction

Introduction to tribology
History of tribology
Tribology definition.
Tribology in design- bearing material its properties and construction Tribological design of oil seals and gasket.
Tribology in industry (Maintenance).
Lubrication-Definition, basic modes of lubrication, properties of lubricants, additives, EP lubricants, Recycling of used oil, oil conservation, oil emulsion.
Bearing Terminology-Types of Sliding contact, rolling contact bearings.
Comparison between sliding and rolling contact bearing.

Friction

Friction- Introduction, laws of friction, Friction classification, causes of friction.
Theories of dry friction.
Friction measurement.
Stick-slip motion and friction instabilities.

Wear

Types of wear and basic mechanism of wear. Wear properties of friction and anti-friction metallic and nonmetallic materials, experimental techniques in evaluation of materials. Design of mechanical components against wear. Design of friction surfaces used in clutches and brakes.

Lubrication and Lubricants

1. Importance of Lubrication.
2. Boundary Lubrication.
3. Mixed Lubrication.
4. Full Fluid Film Lubrication ; Hydrodynamic
5. Elastohydrodynamic lubrication.

6. Types & Properties of Lubricants.
7. Lubricants Additives.

Hydrodynamic Lubrication and Bearing Design

Theory of hydrodynamic lubrication, mechanism of pressure development in oil film.Two dimensional Reynold‘s equation and its limitations, Petroff`s equation.
Hydrodynamic thrust bearing-Introduction, types.
Flat plate thrust bearing-Pressure equation, load, centre of pressure, frictional force equation.
hydrodynamic lubrication: design of plain fixed pad and tilting pad, slider bearing for steady and varying –loads. Full and partial journal bearing of infinite length, design of journal bearing for steady loads and varying loads. Introduction to design of hydrostatic and Aerostatic bearings. Thrust and radial.

Elastohydrodyanamic Lubrication

Elasto-hydrodynamic lubrication-Principle and applications to rolling contact bearings, cams and gears.

Rolling Contact Bearing

Static and dynamic load capacity, left rating, selection of rolling contact bearing for different applications.

Text Books

1. Cameron A., Basic Lubrication Theory, Wiley Eastern Ltd.
2. Mujumdar B. C., Introduction to Tribology and Bearings, S. Chand and Company Ltd. New Delhi.
3. Andras Z. Szeri, Fluid film lubrication theory & design, 1st Edition, 2005
4. J. Bhatia, Advances in industrial Tribology

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4117S**	
Course Title	**Piping Engineering**	
Prerequisites	**Design of Machine Elements, Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Prepare piping system layout.
2. Design piping system as per the requirement.
3. Apply various national and international standards.

Course Contents

Introduction

Scope of Piping, Code and Standards, Mechanical Design Fundamentals, Mechanical design of piping system, Wall thickness, Piping size selection, Piping elements and specialties, Pipe representation, Welded and flanged fittings.

Piping system layout and drawing

Piping layout, Equipment Layout, Process Piping Layout, Pipe flow sheets, plan and isometric representation of piping system, plot plan

Pipe Supports

Load on structural supports, supporting structures on pipelines, pipe supports – design considerations, platforms and ladders, foundations, supporting span of overhead pipelines, stiffening ribs, flexible hanger support.

Valves and Auxiliaries

Valve material and method of construction, Pressure drop in valves, valve size, type of valves, fittings, Pressure relief devices, Design of pressure relief system.

Mechanical Piping Design

Nominal pipe size, Pipe sizing by internal diameter, Choosing the final pipe size, Piping drawings, Piping stress design, Internal or external fluid pressure stresses, expansion effect and compensation methods.

Stress analysis

Type of loads, code compliance, thermal effects, fatigue loads, flexibility analysis and introduction to dynamic analysis, softwares for stress analysis.

Text Books

1. G K Sahu, Handbook of piping design, New Age international publisher, Second Edition, 2009
2. Sabin Crocker, Piping Handbook, McGraw Hill Publication, Fifth Edition, 1968
3. Ed. Bausbacher and Roger Hunt, Process Plant Layout and Piping Design, Pearson Prentice Hall, 1993

Recommended Reading

1. Mohinder L. Nayyar, Piping Handbook, MccGrawHill, Seventh Edition, 1999
2. ASME Piping Code B 31 (Power piping) and 33 (Process piping)
3. Pipe Supports, Catalog PH-82A NHK Spring Co. Limited, Yokohoma, JAPAN

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VIII*
Course Code	**R4ME4118S**	
Course Title	**Design Thinking**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Understand the concept that drives design thinking.
2. Translate the customer needs into product specifications.
3. Learn the techniques for creating ideas.
4. Develop the ability to create and test prototypes.

Course Contents

Introduction to Design thinking

Phases of design thinking: Empathize, Define, Ideate, Prototype, Test, Roots of design thinking, Human Centered Design: Methods and Approaches

Understanding the need

Knowing Your Users, Identifying Needs of Customers, Designing with Empathy, Methods for Empathetic Design, Designing for Diversity & Inclusion

Ideation

Ideation Techniques, Tools for Fostering Creativity, Evaluation of Ideas, Immersive Learning Exercises

Prototyping & Testing

Proof of Concept, Minimum Value Proposition Designing, Tooling and Building, Learning from Failed Designs

Product Development

New Product Development Processes, Design for Products & Services, Sustainability through Design, Thinking Lean & Agile Product/ Service Design

Applications of Design Thinking

Case Studies on application of design thinking in different field such as health care, consumer products, solving social problems etc.

Text Books

1. Michael G Luchs, Design Thinking by John Wiley & Sons Inc., 2016
2. Gravin Ambrose, Design Thinking, AVA Publishing
3. Tim Brown, Change by Design, Harper Collins E-books

Recommended Reading

1. Christian Mueller-Roterberg, Hand book of Design Thinking, Kindle Direct Publishing ISBN: 978-1790435371
2. Ulrich, Karl T., Design: Creation of Artifacts in Society, 2011, https://ssrn.com/abstract=1951106 or http://dx.doi.org/10.2139/ssrn.1951106

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VIII***
Course Code	**R4ME4119S**	
Course Title	**Product Design and Life Cycle Management**	
Prerequisites	**Material Science, Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

6. Select the appropriate product design and development process for a given applications
7. Analyze the voice of the customer for product/service development.
8. Develop a strategy for concept generation, concept selection, concept testing.
9. Implement the procedure for reserving intellectual property
10. Understand the PLM system for industrial problem.

Course Contents

Basics of Product Design

Characteristics of Successful Product Development, Designs and Develops Products, Duration and Cost of Product Development, The Challenges of Product Development.

Development processes & Organization

Conceptual Design: generation, selection and embodiment of concept

Development Processes and Organizations: The Product Development Process, Concept Development: The Front-End Process

Opportunity Identification: Types of Opportunities, Tournament Structure of Opportunity Identification, Opportunity Identification Process

Process planning: The Product Planning Process

Identifying Customer Needs, Product Specifications.

Concept Generation: The Activity of Concept Generation, A Five-Step Method.

Concept Selection: Concept Selection Is an Integral Part of the Product Development Process; All Teams Use Some Method for Choosing a Concept, Overview of Methodology.

Concept Testing

Industrial Design & IPR

Introduction to Industrial Design, Design for Environment, Design for Manufacturing, Robust design.

Patents and Intellectual Property: Overview of Patents, Utility Patents, Preparing a Disclosure Product Lifecycle Management: Introduction, fundamental, benefit of PLM system, Challenges of product management in manufacturing industry.

Text Books

1. Karl T Ulrich, Steven D Eppinger, Product Design & Development, Tata McGrawhill New Delhi, 2003

2. David G Ullman, The Mechanical Design Process, McGraw-Hill Inc Singapore, 1992

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R4ME4120S**	
Course Title	**Pressure Vessel Design**	
Prerequisites	**Design of Machine Elements**	

COURSE OUTCOMES

The student should be able to –

1. Apply ASME code to design vessel for internal and external pressure.
2. Design/Select Nozzles and Flanges for the given conditions.
3. Design vessel for wind and seismic loads.
4. Analyze the requirements of transportation, Testing and erections.

Course Contents

Introduction to Pressure vessel

Classification, Components, Types of shell, Types of supports, nozzles, attachments, Procedure for pressure vessel design, Fabrication methods, Review of various country wide Pressure vessel codes

Theory of Pressure Vessel

Types of Design methods, various failure modes, stress evaluation, loads, stress theories, stiffener rings, stresses in various components.

Material of Construction

Selection of material for Pressure vessel, ASME Material codes for Pressure Vessel.

Design for Internal Pressure

Thickness calculation of various components subjected to internal pressure.

Design for External Pressure

Thickness calculation of various components subjected to External pressure.

Other requirements of Pressure vessel

Understanding Requirements of Part UG, UW, UCS of ASME Sec VIII Div 1

Nozzles and Bolted Flange design

Types of openings, size of opening, nozzle reinforcement, Need of flanges, types of flanges, design considerations

Design for Wind/ Seismic loads

Design codes and practices, Load cases, comparison, steps in wind and seismic load calculations, effects of wind and seismic loads

Evaluation of Pressure Vessel for various conditions

Saddle design, design of Lifting attachments, types of transportation, Hydro test

Creep and fatigue in Pressure vessel

Creep: Phenomenon, Creep Behaviour, Governing Parameters, Creep Testing, Design Considerations

Fatigue: Background, Phenomenon, fatigue behaviour, design considerations

Text Books

1. Somnath Chattopadhyay, Pressure vessels design and practice, CRC Press, Third Edition, 2004
2. John F Harvey, Theory & Design of Pressure Vessels, Van Nostrand Reinhold Company Ltd, Fifteenth Edition

Recommended Reading

1. Vincent A. Carucci, Overview of pressure vessel design, ASME International
2. Brownell and Young, Process equipment design, Wiley, 2009
3. N K Roy, Review of code for pressure vessels, IS 2825 as compared to ASME/BS/ADMerkblatter, Journal for Process Equipment & Piping Technology, Vol 1, No 1, June 1994
4. A special report : Worldwide pressure vessel codes, Hydrocarbon Processing, Dec 1978.
5. ASME Section VIII Div-1, 2 & 3, 2010, Addenda 2011a.
6. H. Bednar, Pressure Vessel Design Handbook, Krieger Publishing Company, Second Edition, 1990
7. Dennis Moss, Pressure Vessel Design Manual, Butterworth-Heinemann, Fourth Edition, 2013