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

Third 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.

SEMESTER-V

	Course Code	Course Name	Hr/Week			Credits	TA	IST	ESE	ESE hours
			L	T	P					
1	R4ME3001T	Dynamics of Machinery	3	0	0	3	20	20	60	3
	R4ME3001P	Dynamics of Machinery Laboratory	0	0	2	1	60% CIE+40%ESE			
2	R4ME3002T	Fluid Machinery	3	0	0	3	20	20	60	3
	R4ME3002P	Fluid Machinery Laboratory	0	0	2	1	60% CIE+40%ESE			
3	R4ME3003T	Manufacturing Science & Tooling	3	0	0	3	20	20	60	3
	R4ME3003P	Manufacturing Science & Tooling Laboratory	0	0	2	1	60% CIE+40%ESE			
4	R4ME3004T	Heat Transfer	3	0	0	3	20	20	60	3
	R4ME3004P	Heat Transfer Laboratory	0	0	2	1	60% CIE+40%ESE			
5	R4ME3005S	Industrial Engineering & Management	3	0	0	3	20	20	60	3
6	R4HM3001L	Professional Communication Skills Laboratory	1	0	2	2	60% CIE+40%ESE			
TOTAL			16	0	10	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-VI

	Course Code	Course Name	Hr/Week			Credits	TA	IST	ESE	ESE hours
			L	T	P					
1	R4ME3006S	Machine Design	3	0	0	3	20	20	60	3
2	R4ME3007T	CAD/CAM	3	0	0	3	20	20	60	3
	R4ME3007P	CAD/CAM Laboratory	0	0	2	1	60% CIE+40%ESE			
3	R4ME3008T	Internal Combustion Engines	3	0	0	3	20	20	60	3
	R4ME3008P	Internal Combustion Engines Laboratory	0	0	2	1	60% CIE+40%ESE			
4	R4ME3009T	Mechanical Vibrations	2	0	0	2	20	20	60	3
	R4ME3009P	Mechanical Vibrations Laboratory	0	0	2	1	60% CIE+40%ESE			
5		Program Elective 1	3	0	0	3	20	20	60	3
		Program Elective 1 Laboratory	0	0	2	1	60% CIE+40%ESE			
6		Open Elective 1	3	0	0	3	20	20	60	3
7	R4ME3010A	Innovation and Entrepreneurship	2	0	0	P/NP	100% CIE			
TOTAL			19	0	8	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 VI List of Program Elective 1:

S. No	Course code	Course Title
1.	R4ME3101T	Computational Fluid Dynamics
2.	R4ME3102T	Robotics
3.	R4ME3103T	MEMS and Microflows

Semester VI List of Open Elective 1:

S. No	Course code	Course Title
1.	R4ME3601S	Optimization and Decision Sciences

Minimum six weeks mandatory internship in industry/research Institute after 6th Semester

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3001T**	
Course Title	**Dynamics Of Machinery**	
Prerequisites	**Kinematics of Machinery**	

COURSE OUTCOMES

Upon successful completion of the course, students should be able to -

1. Apply the knowledge of flywheel, governor and gyroscope for the field applications
2. Recognize the different types of bakes and calculate their capacity.
3. Calculate the transmission ratio for various gearing mechanism.
4. Perform static and dynamics force analysis for machine components.

Course contents

Flywheel

Turning moment diagram, Fluctuation of speed, fluctuation in energy, function of flywheel estimating inertia of flywheel

Governors

Comparison between governors and flywheel, Types-centrifugal governors, inertia governors. Force analysis of gravity loaded governors- Watt. Porter. Proell Force analysis of spring loaded governors- Harnell, Hartung, Wilson Hartnell Force analysis of spring gravity loaded governor. Performance characteristics of governors- stability, isochronism, Hunting, governor effort and governor power, coefficient of insensitiveness.

Gyroscope

Introduction Gyroscopic couple and its effect on spinning bodies. Gyroscopic effect on naval ships during steering, pitching and rolling. Ship stabilization with gyroscopic effect. Two wheeler and four wheeler on curved path– effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths. Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft.

Brakes and Dynamometers

Types of Brakes, Analysis of Block Brakes- external and internal. Band Brake simple and differential. Band and block brake- simple and differential Braking of vehicles- front wheels, rear wheels, all wheels on level and inclined roads. Types of dynamometers- Absorption and transmission dynamometers. Study and analysis of absorption type dynamometer- Proney brake, Rope brake dynamometer. Study and analysis of transmission type dynamometers- Belt transmission Epicyclic torsion dynamometers.

Gear Trains

Kinematics and dynamic analysis of – simple gear trains, compound gear trains, reverted gear trains, Epicyclic gear trains with spur or bevel gear combination.

Static and Dynamic Force Analysis

Static and dynamic force analysis in slider crank mechanism neglecting mass of connecting rod and crank. Static force analysis in gears-spur, bevel, helical worm and worm gear. Static and dynamic force analysis – in linkage mechanism (upto – 4 links) by virtual work method. Dynamic equivalent system to convert rigid body to two mass system with and without correction couple.

Introduction to Dynamics of rigid bodies

Definition of inertia quantities, inertia tensor, ellipsoid of inertia.

Text Books

1. Farazdak Haideri, Dynamics of Machinery, Nirali Publications, Pune, Thirteenth Edition, 2016
2. Thomas Bevan, Theory of Machines, C.B.S. Publishers, Third Edition, 2005
3. S.S.Rattan, Theory of Machines, McGraw-Hill Education (India) Private Limited, Fourth Edition, 2014

Recommended Reading

1. R. Norton, Kinematics and Dynamics of Machinery, McGraw-Hill Education (India) Private Limited, 1980
2. A.Ghosh and A.Malik, Theory of Mechanism and Machines, Affiliated East –West Press Pvt. Ltd., New Delhi, 2008
3. John J. Uicker Jr , Gordon R. Pennock , Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford Press, Fifth Edition
4. J.Hannah and R.C.Stephens, Mechanics of Machines-Elementary Theory and Examples, Butterworth-Heinemann, Fourth Edition, 1984
5. Thomas Cane, Dynamics-Theory and Applications, McGraw Hill, First Edition

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3001P**	
Course Title	**Dynamics Of Machinery Laboratory**	
Prerequisites	**Kinematics of Machinery**	

COURSE OUTCOMES

Upon successful completion of the course, students should be able to -

1. Examine the experimental behaviour of various applications like governors, gyroscope, etc.
2. Select a brake/dynamometer for a need.
3. Calculate the transmission ratio for various gearing mechanism.

List of Experiments

1. Performance Characteristics of Porter Governors
2. Performance Characteristics of Proell Governor
3. Determine gyroscopic couple on Motorized Gyroscope.
4. Study of Brakes
5. Measure braking torque of Dynamometer
6. Study of Gear Trains
7. Determination of centre of gravity/moment of inertia of connecting rod.
8. Experimental determination of Corioli's acceleration.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3002T**	
Course Title	**Fluid Machinery**	
Prerequisites	**Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Analyze the performance of hydraulic turbines
2. Analyze the performance of pumps
3. Analyze the performance of compressors
4. Select the pump/compressor/turbine for a given application

Course Contents

Basic Principles

Introduction, Classification of Fluid Machines, The Linear-Momentum Equation: Force on fixed and moving Vanes, The Angular- Momentum Principle: The Euler Turbomachinery Equation, The Euler and Bernoulli Equations, Velocity Diagrams

Hydraulic Turbines

Hydro Electric Power Plants: Classification, Components of Hydro Electric Power Plants, Classification of Hydraulic Turbines, Pelton/Francis/Kaplan Turbines – Main Components and their Functions, Velocity Triangles, Force and Power, Losses and Efficiencies, Design of Component Parts, Draft Tube Analysis, Cavitation, Thoma's Cavitation parameter, Performance Characteristics, Model Testing and Similarity, Governing, Selection of Turbines

Pumps

Classification of Pumps: Positive & Non Positive Displacement Pumps, Types and Applications, Centrifugal Pumps – Introduction, Pump Construction, Components and their Functions, Materials Commonly Used, Terminology Used: Manometric Head, Total Static Head etc., Euler's Head, Theoretical Characteristics, Efficiencies, Hydraulic Performance, Losses: (Leakage, Disk Friction, Mechanical)System Characteristics, Operating Point, Duty Point, Performance Characteristics, Pumps in Series and Parallel, NPSH & Cavitation – NPSH(A) and NPSH (R), Selection of Pumps, Axial Thrust & Radial Thrust, Operation and Maintenance of Pumps, Field Troubles, Model Testing, Pump Testing – Procedure, Tolerances Allowed (reference to IS codes)

Reciprocating Pumps – Components, Working, Types, Work done, Indicator diagram, Effects of Acceleration of Piston, Air vessels, Rotary Pumps – Gear Pumps, Vane Pumps & Piston Pumps, Construction and Working, Performance Characteristics

Compressors

Introduction: Applications of Compressed Air, Classification of Air-Compressors,

Centrifugal Compressors and Fans – Principle of Operation, Work done and Pressure rise, The Diffuser, Compressibility Effects, Non Dimensional Quantities, Compressor Characteristics

Axial Flow Compressors and Fans– Introduction, Compressor Stage, Reaction Ratio, Stage Loading, Lift and Drag Coefficients, Blade Cascades, Blade Efficiency and Stage Efficiency, Three-dimensional Flow, Multistage Performance, Axial Compressor Characteristics, Introduction to Gas Turbines

Reciprocating Compressors – Reciprocating Air Compressors: With Clearance, without clearance, Single-acting, Double-acting, Single stage, Multistage, Minimum Work Conditions, intercooling free air delivered, Volumetric Efficiency, Isothermal and Adiabatic Efficiency, Comparison for merits and demerits

Text Books

1. S.K.Som, G.Biswas, Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw-Hill Education, Third Edition, 2013
2. A. J. Stepanoff, Centrifugal and Axial Flow Pumps, John Wiley & Sons, Inc., Second Edition, 1993
3. A. T. Sayers, Hydraulic and compressible flow turbomachines, McGraw-Hill, 1990

Recommended Reading

1. Miroslav Nechleba, Hydraulic Turbines, ARTIA Prague
2. S. M. Yahya, Turbines Compressors and Fans, Tata McGraw-Hill, Fourth Edition, 2002
3. David Japikse, Nicholas C. Baines, Introduction to Turbomachinery, Concepts ETI, Inc. and Oxford University Press, 1997
4. HIH Saravanamuttoo, GFC Rogers, H Cohen, Gas Turbine Theory, Pearson Education, Sixth Edition, 2008
5. Igor J Karassik & Roy Carter, Centrifugal Pumps, McGraw-Hill, Second Edition, 1998
6. George F. Round, Incompressible Flow Turbomachines, Elsevier, Butterworth and Heinmann, 2004
7. S. L. Dixon and C. A. Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier, Sixth Edition, 2010

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3002P**	
Course Title	**Fluid Machinery Laboratory**	
Prerequisites	**Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Test the fluid machines for their Performance
2. Evaluate the Performance of Fluid Machines
3. Analyse the Performance Characteristic of Turbines, Pumps and Compressors

List of Experiments: [any 10]

1. Impact of Jet
2. Constant head characteristics of Pelton Turbine
3. Constant speed characteristics of Pelton Turbine
4. Constant head characteristics of Francis/Kaplan Turbine
5. Constant speed characteristics of Francis/Kaplan Turbine
6. Performance Characteristics of Centrifugal Pump with Iso- Efficiency curves
7. Performance Characteristics of Reciprocating Pump
8. Performance Characteristics of Gear Pump
9. Pumps in Series and Parallel
10. Characteristics of centrifugal blower
11. Cavitation
12. Water Hammer & Pipe Surge

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3003T**	
Course Title	**Manufacturing Science and Tooling**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Illustrate the use of various tools used in industries to manufacture the component.
2. Identify effect of various parameters on tool life.
3. Select appropriate machining process depending upon desired output characteristics
4. Optimize cost of component manufacturing.

Course Contents

Tool Geometry

Tool signature of single point cutting tools – ASA, ORS, MRS and NRS systems. Tool geometry of drills, reamers, milling cutters, broaches, gear hobs.

Tool Wear, Tool Life and Machinability

Tool wear – types, mechanisms and measurement. Tool life equations. Effect of machining parameters on tool life.Machinability criteria and its measurement. Coolants – functions, types, selection, effect on cutting forces, tool life and surface finish.

Metal Cutting Theory

Features of commonly used machining processes and machining parameters. High Speed Machining. Cutting Tools types, materials, properties and tool geometry. Mechanism of chip formation, Orthogonal and Oblique cutting, Chip flow direction in turning, shaping, drilling and milling with force analysis. Temperature in cutting and Cutting Fluids.

Economics of Machining

Costs associated with machining operations. Calculation of optimum cutting for minimum cost and maximum production rate. Product design considerations in machining. Process planning, make/buy decisions, automated process planning, concurrent engineering.

Sheet Metal Working

Press – Types, classifications, operations, specifications and selection. Press tool components, Types of Dies – Piercing, Blanking, Progressive, Compound and Combination, Cutting Action in shearing of metals in Press Tool operations, Effect of clearance, Cutting force calculations, Methods of reducing cutting forces, Blanking and Piercing Die Design, Design principles of Bending Dies.

Jigs and Fixtures

Parts, Construction, Types and operations on Jigs and Fixtures. Principles of Jigs and Fixture design location, clamping, clearance, stability and handling. Design of Jigs and Fixture of simple components.

Non-Conventional Machining-I (Mechanical and Chemical Processes)

Introduction, Classification, Principle, Working and Applications of Chemical Machining, Electrochemical Machining, Abrasive Jet Machining, Ultrasonic Machining.

Non-Conventional Machining-II (Electrical and Thermal Processes)

Principle, Working and Applications of Electric Discharge Machining, Electron Beam Machining, Ion Beam Machining, Plasma Arch Machining, Laser Machining- Cutting and Welding

Superfinishing Processes: Lapping, Honing, and polishing. Advanced super finishing processes.

Micromachining Processes: Micromanufacturing- Overview, Diamond Micromanufacturing, High Resolution Lithography, LIGA Process, Self-Assembly, etc.

Additive Manufacturing

Fundamentals of Prototyping, liquid and solid based additive manufacturing systems. Powder based additive manufacturing. Additive manufacturing machines; data formats and softwares. Applications and future trends in additive manufacturing.

Text Books

1. M.P. Groover, Fundamental of Modern Manufacturing: Materials, Processes and Systems. John Wiley and Sons, Fifth Edition, 2012
2. Chapman, Workshop technology vol. I,II & III, Edward Arnold Publication Ltd., London
3. Manufacturing Engineering & Technology, S. Kalpakjian and S. R. Schmid, Fourth Edition; Prentice Hall, 2001.
4. S.K. Hajra Choudhari, Workshop Technology, Vol. I & II, Media Promoters & Publishers, Mumbai.
5. Hoffman, Introduction to Jigs and Fixtures, Galgotia Publishers, Fifth Edition, 2008

Recommended Reading

1. HMT Hand book, Production Technology, Tata McGraw Hill Education Private Limited, 2001
2. P. C. Sharma, Production Engineering, Khanna Publications, Eighth Revised Edition, 1999
3. S. E. Rusinoff, Manufacturing Processes, Times India Press, Reprint Edition, 1962
4. Doyle, Manufacturing Processes and Materials for engineers, Prentice Hall of India Press
5. S. K. Basu, Fundamentals of Tool Design, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Frank W. Liou, Rapid Prototyping & Engineering Applications, CRC Press, Taylor & Francis Group, 2011

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3003T**	
Course Title	**Manufacturing Science and Tooling Laboratory**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Develop skills in precision turning, shaping, milling and grinding work.
2. Detect the difficulties encountered during manufacturing and assembly.
3. Evaluate overall dimensions of part and precisely manufacture products for desired function
4. Relate manufacturing theory to practice through laboratory experiments

Job: Students will design a small product which has a specific functionality. It is expected that at least 04 manufacturing processes should be required to completely manufacture the part. Student will prepare operation sheet, process picture as well calculate theoretical time required for completion of part.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3004T**	
Course Title	**Heat Transfer**	
Prerequisites	**Mathematics for Mechanical Engineers– I & II, Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Apply the major theories, approaches and methodologies used in Heat Transfer.
2. Derive mathematical model for each mode of heat transfer.
3. Analyze different heat exchangers and fins.
4. Employ numerical techniques to solve Heat transfer problems in conduction, convection and radiation.

Course Contents

Introduction and Modes of Heat Transfer

Importance of heat transfer in engineering, basic modes and fundamental laws of heat transfer, applications in industry such as nuclear, mechanical, electrical, electronics, chemical, metallurgy and MEMS engineering.

Conduction

Mechanism of hear transfer by Conduction, Fourier's three dimensional differential equation for conduction with heat generation, for unsteady state; in Cartesian co-ordinates.

Solution of Fourier's equation for one-dimensional steady state Conduction through isotropic materials of various configurations such as plane wall, cylinder and sphere, composite wall, composite cylinders and composite spheres. (For cylindrical and spherical walls, derivation of Fourier's three-dimensional equation is NOT included.)

Thermal Insulation-insulating materials, Critical thickness of insulation. Extended surfaces, Solutions for heat transfer through rectangular fins. Types of fins and their applications.

Effectiveness and efficiency of fins. Unsteady state Conduction – Bodies with no internal resistance, thermocouples, Bodies with finite internal resistance-Use of Heisler charts.

Convection

Mechanism of heat transfer by convection – Free convection and Forced convection.

Hydrodynamic and thermal boundary layers, Similarity between velocity profile and temperature profile. Relation between the hydrodynamic and thermal boundary layer,

Convective heat transfer coefficient (film coefficient), Effect of various parameters such as physical properties of the fluid, system geometry, fluid flow etc. on heat transfer coefficient.

Application of dimensional analysis to convective heat transfer. Empirical relations for free convection and forced convection, Physical significance of dimensionless numbers such as

Nusselts Number, Grashoffs Number, Prandtls Number, Reynolds Number and Stanton Number. Reynolds analogy between momentum and heat transfer, Condensation and Boiling.

Heat Exchangers

Classification of heat exchangers. Applications, Overall heat transfer coefficient, Fouling factor, pressure drop in fluids across heat exchangers. Logarithmic Mean Temperature Difference in parallel flow, counter flow and cross flow heat exchangers, Multi pass heat exchangers. Effectiveness of a heat exchanger- Relation for the effectiveness in terms of Number of Transfer Units.

Radiation

Mechanism of heat transfer by Radiation. Concept of black body and grey body. Emissive power and Emissivity.

Basic laws of Radiation: Planck's law, Kirchhoff's law, Stefan- Boltzmann law, Wien's displacement law and Lambert's Cosine law, Intensity of Radiation. Shape factors for simple geometrical shapes. Radiosity and Irradiation. Radiation heat exchange between two black bodies. Electrical network analogy.

Text Books

1. J. P. Holman, Heat Transfer, McGraw Hill Companies, Tenth Edition, 2009
2. R. K. Rajput, Heat and Mass Transfer, S. Chand & Company Ltd., Revised Edition, 2008
3. M. M. Rathore, Engineering Heat and Mass Transfer, University Science Press, Third Edition, 2015

Recommended Reading

1. Yunus A. Cengel, Heat Transfer: A Practical Approach, McGraw Hill International Edition, Second, 2002.
2. Eckert and Drake, Heat and Mass Transfer, Second Revised Edition, 1959
3. Ozisik, Heat Transfer, McGraw Hill, 1985.
4. Incropera and Dewitt, Heat Transfer, John Willey and Sons, 2002.
5. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India, 2009
6. A.F. Mills and V. Ganesan, Heat Transfer, Pearson Education, 2009
7. Sukhatme S. P., Heat transfer, McGraw Hill, 1985
8. Adrian Bejan, Convection Heat Transfer, Wiley-Interscience, Second Edition 1994
9. P.K. Nag Heat and Mass Transfer, Third Edition, McGraw Hill International, 2011

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3004P**	
Course Title	**Heat Transfer Laboratory**	
Prerequisites	**Mathematics for Mechanical Engineers– I & II, Fluid Mechanics**	

COURSE OUTCOMES

The student should be able to –

1. Compare various heat transfer phenomenon of conduction, convection and radiation using experimentation.
2. Investigate the performance of different heat exchangers and fins.

List of Experiments

1. To determine the thermal conductivity of a Metal Rod
2. To determine the thermal conductivity of an Insulating material
3. To determine the thermal conductivity and thermal resistance of a composite slab
4. To determine the convective heat transfer coefficient -'h' for
    a. Free convection
    b. Forced convection
5. To determine experimentally the value of Stefan-Boltzmann constant
6. To determine the emissivity of a circular disc.
7. To determine LMTD & overall heat transfer coefficient 'U' for ' a tube in tube ' type of heat exchangers for-
    a. Parallel flow conditions
    b. Counter flow conditions
8. To examine the phenomenon of Boiling and Condensation
9. To compare heat exchangers (shell and tube, concentric tube, tube-in-tube and plate type heat exchanger) using computerized interface.
10. To determine heat transfer coefficient and heat transfer rate of pin fin arrangement.
11. Assignment or Mini project on coding based numerical methods in heat flow devices using Python/ Matlab/ISRO-FEAST /Ansys workbench.
12. Assignment or Mini project on real life problem, bio-heat transfer, solar thermal, jet cooling and/or industrial heat exchanger problem considering probabilistic decision making and multi-disciplinary based numerical optimization of heat transfer equipment's.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4ME3005S**	
Course Title	**Industrial Engineering and Management**	
Prerequisites	**Mathematics for Mechanical Engineers-II**	

COURSE OUTCOMES

The student should be able to –

1. Examine various organizational behaviors
2. Apply statistical techniques for inspection
3. Apply work study principles for different case studies
4. Optimize resources with the use of ERP technology.

Course Contents

Introduction

Introduction to industrial engineering, history and contribution to industrial engineering, industrial engineering approach, techniques of industrial engineering, objectives of industrial engineering, system approach and industrial engineering.

Organization Structure and Behavior

Definition, Need, Types, Hierarchy, Functional matrix relationship, Responsibility, Authority delegation, Span of control, Recent developments (Lean, network, virtual, SBU'S), Theories of motivations and leadership

Industrial Acts

Introduction, necessity of industrial acts, Indian boiler act 1923, the Indian factories act 1948, the minimum wage act 1948, The industrial disputes act1947**.**

Work Study &Time study

Definition and Objectives, Work content – Basic work content, Total work content – Ineffective time method of their reduction, Method study; Definition – Objectives and basic procedure – Different techniques used in method improvement – Process chart symbol – Process chart for operator or Material process chart – Process chart for assemblies, Flow diagram – analysis and critical examination of operations and development of improved methods, Man machine chart, Multiple activity chart, Use of micromotion and memotion study, Work measurements, Significance and procedures of work measurements, Techniques of time study; Steps in making time study – Selection of operator, Breakup of an operation into elements, Different timing method – Recording time study data – Form used, Different rating practices , Normal time, Different types of allowances, Standard time.

Facility Planning

Objectives and scope, location of facilities, types of layouts, layout design techniques, assembly line balancing, and computer packages for layout analysis. Quantitative methods of Plant layout: CRAFT and CORELAP, Relationship diagrams.

Statistics in Industrial Engineering

Control chart techniques, Quality characteristics, trial control limits, revised control limits of mean, range and standard deviation chart, state of control, control chart for moving average and run chart, Control charts of attributes – Control chart for fraction defectives (p), Control chart for number of defectives (np), Control for number of defects (c), Control charts for number of defects per unit (u). Concept of variation, central tendency theorem, acceptance sampling.

Enterprise Resource Planning

ERP- Conceptual overview, Critical components, Structure, Evolution and Architecture of ERP, Best Practices and Business process reengineering issues in ERP, ERP- Overview of functional modules

(i) Manufacturing and Purchase Module: A functional overview

(ii) Finance Module-A functional overview

(iii) Sales & Distribution Module-A functional Overview

ERP-Implementation methodologies, Success and failure cases, ERP Audit, Future of ERP, ERP systems in India, Introduction to ERP software.

Lean Manufacturing, Six Sigma.

Text Books

1. Heinz Weihrich, Harold, Koontz, Management A Global Perspective, McGraw-Hill Education, Tenth edition, 1994
2. R. Panneerselvam, Production and Operations Management, PHI Learning, Third Edition, 2012
3. Martand Telsang, Industrial Engineering and Production Management, S. Chand, Second Edition, 2006
4. Banga and Sharma, Industrial Engineering and Production Management, Khanna publishers
5. Dr. B. Kumar, Industrial Engineering and Management, Khanna Publishers
6. Work study, International Labour Organisation (ILO)
7. Gang A. Langenwalter, ERP and Beyond Integrating Your Entire organization, The St. Lucas Press/ Apics Series on Resources management, 1999

Recommended Reading

1. Harold Amrine, John Ritchey, Moodie, Kmec, Manufacturing Organisation and Management, Pearson, Sixth Edition, 2004
2. J.L. Riggs, Production System, Planning, Analysis and Control, Wiley, 3rd edition
3. International Journal of Business Performance Management.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – V*
Course Code	**R4HM3001L**	
Course Title	**Professional Communication Skills Laboratory**	
Prerequisites	**Business English**	

COURSE OUTCOMES

The student should be able to -

1. Apply the principles and practices of business communication for communicating in a professional environment.
2. Design a technical document with correctness of language, appropriate vocabulary and style.
3. Display competence in oral and visual communication.
4. Demonstrate capabilities for self -assessment and development.

Course Contents

Basics of Business Communication

a. Concept and meaning of communication
b. Verbal and non-verbal communication
c. barriers to the process of communication
d. Channels of communication
e. Role of communication in the age of information technology

Technical Writing

a. Technical writing process
b. Style and organization in technical writing
c. Objectivity, clarity, precision as defining features of technical communication
d. Language and format of various types of business letters, reports; proposals, e-mails, minutes of meeting, research paper

Self Development & Assessment

a. Time Management
b. Perception & Attitude
c. Personal Goal Setting
d. Emotional Intelligence
e. Team work
f. Creativity

Spoken Communication

a. Public Speaking
b. Group Discussion
c. Presentation
d. Interviews
e. None verbal Communication

f. Using Visual Aids

Business Ethics & Etiquettes

a. Business & Corporate Ethics
b. Social and Business Etiquettes
c. Interview Etiquettes

Text Books

1. Hory Sankar Mukerjee, Business Communication, Oxford University Press, Second Edition, 2016
2. Ashraf Rizvi, Effective Technical Communication, Tata McGraw-Hill Education, Second Edition, 2017
3. Meenakshi Raman, Prakash Singh, Business Communication, Oxford University Press, Second Edition, 2012

Recommended Reading

1. E.H. McGrath, Basic Managerial Skills for All, PHI Learning Pvt Ltd, Ninth Edition, 2011
2. R. Subramanian, Professional Ethics, Oxford University Press, Second Edition, 2017
3. *https://learnenglish.britishcouncil.org/en/english-grammar*

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3006S**	
Course Title	**Design of Machine Elements**	
Prerequisites	**Strength of Materials, Dynamics of Machinery**	

COURSE OUTCOMES:

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

1. Use various standards and other considerations in design.
2. Apply a suitable theory of failure.
3. Design of clutches and flexible drives.
4. Design machine elements subjected to static and dynamics loads.

Course contents

Basics of Machine Design

Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics considerations in design, Material properties and their uses in design, Design for manufacturing, types of fits, selection of fits, Design for assembly. National and International standards used in design. Modes of failures, Factor of safety, Design stresses, Theories of failure, Preferred Series and Numbers. Green/ Lean Design concepts.

Design against static loads

Design of machine elements like Cotter joint, knuckle joint, strap end connecting rod.

Bolted and welded joints concentric and eccentric loading.

Power screws and its applications. Introduction to Re-circulating ball screw.

Design of springs

Helical compression, tension springs under static load, Laminated springs.

Clutches

Type of Clutches, Analysis of clutches, design of clutch friction clutch.

Design against fluctuating Load

Fatigue failure, Variable stresses, reversed, repeated, fluctuating stresses, Static and fatigue stress concentration factors. Estimation of endurance limit.

Design for finite and infinite life. Soderberg and Goodman design criteria.

Fatigue design under combined stresses.

Design of shaft, Key selection, rigid and flexible couplings.

Design of bolted joint subjected to internal pressure

Design of Helical spring subjected to variable loads.

Flexible curvature drive

Flat belt, V-belt, Rope, Selection of Roller Chain drive.

Text Books

1. V.B.Bhandari, Design of Machine Elements, Tata McGraw-Hill Education, Third Edition, 2010
2. J.E.Shigley, Mechanical Engineering Design, McGraw Hill, Sixth Edition, 2001
3. Merhyle Franklin Spotts, Terry E. Shoup, Lee EmreyHornberger, Design of Machine Elements, Pearson/Prentice Hall, Eighth Edition, 2004

Recommended Reading

1. Robert L. Norton, Machine Design- An Integrated Approach, Pearson Education Asia, Fifth Edition, 2013
2. M. F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Elesevier, 5th Edition, 2017
3. D N Reshetov, Machine Design, Mir Publishers
4. Black Adams, Machine Design, McGraw Hill, Third Edition
5. Hawrock, Jacobson, Fundamental of Machine Elements, McGraw Hill, Third Edition, 2014
6. V.M. Faires, Design of Machine Elements, The Macmillan Co., Fourth Edition
7. P. Orlov, Fundamentals of Machine Design, Mir Publishers,
8. Design Data Book, PSG, 2012
9. Design Data Book, Mahadevan, CBS Publishers and Distributors Pvt Ltd, Fourth Edition, 2013

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VI***
Course Code	**R4ME3007T**	
Course Title	**Computer Aided Design/Computer Aided Manufacturing**	
Prerequisites	**Computer programming and problem solving, Machine Drawing**	

COURSE OUTCOMES

The student should be able to –

1. Construct and transform geometric objects.
2. Employ various techniques of geometric modeling.
3. Develop Part programs for NC-CNC Machines
4. To select and apply additive manufacturing technique
5. To understand automation integration concepts in manufacturing

Course Contents

Overview of CAD/CAM

Product life cycle & CAD/CAM, Design process

Computer Graphics

Scan conversion: - line, circle, ellipse.

Transformations: 2D and 3D Transformations (Translation, Rotation, Scaling, Reflection).

Projections-Taxonomy of projection, parallel projection (orthographic- Iso, di, tri-metric projections, oblique –cabinet, cavalier projections)

Geometric Modeling

Curves – Introduction, Analytical curves (Line, circle, ellipse, parabola, hyperbola), Synthetic curves (Hermite Cubic Spline, Bezier, B-Spline Curve)

Surfaces – Introduction, Surface representation, Analytic surfaces, Synthetic Surfaces, Hermite bicubic, Bezier, B-Spline, Coons patch surface, Applications in freeform surfaces

Solids - Introduction, Geometry and Topology, Solid Representation, Boundary Representation, Euler's equation, Constructive Solid Geometry (CSG), Boolean operation for CSG

Computer Numeric Control of Machine Tools

Introduction to Computer Aided Manufacturing (CAM), Coordinate system, Working principal of CNC, Turning Centers, Machining Centers, Steps in developing CNC part program, Manual Part Programming-Machining Center programming, turning center programming, Tool and geometric compensations, subroutine and Do loop using canned cycle, APT language programming , CNC program generation from CAD models

CAD/CAM Applications

Additive Manufacturing: Introduction, additive manufacturing processes (SLA, LOM, SLS, FDM, 3D printing), Working principle, features, models & specification of process, application, advantages and disadvantages, Rapid Tooling and STL format.

Group Technology**:** Introduction, Coding Methods, Concepts of Computer Integrated Manufacturing (CIM) and Computer Aided Process Planning (CAPP), Variant & Generative methods of CAPP, advantages of CAPP.

Flexible Manufacturing System: Introduction to FMS - concepts, advantages, components of FMS.

Robotics: Introduction to robotics, Classification of robots, robot anatomy, Point to point and continuous path robotic systems, Joints, End Effectors, Grippers - Mechanical, Magnetic and Pneumatic, Applications.

Text Books

1. Ibrahim Zeid, R. Sivasubramanian, CAD/CAM-Theory & Practice, Tata McGraw Hill Publications, Special Indian Edition, 2009
2. Roger & Adams, Mathematical elements for computer graphics, McGraw Hill Education, 2nd Edition, 2017
3. Mikell P Groover, Automation Production systems, Computer Integrated Manufacturing, Prentice Hall, 1987

Recommended Reading

1. P.N. Rao, CAD/CAM Principles and Applications, Tata McGraw Hill Publications, Third Edition, 2010
2. Foley Van Dam, Computer Graphics: Principles and Practice, Third Edition, 2013
3. David F. Rogers, Procedural Elements for computer graphics, Second Edition,
4. Hans B. Kief ,T. Frederick Waters, Computer Numerical Control, Glemcoe, 1992
5. Zhigang Xiang, Roy Plastock, Computer Graphics, Schaum Outlines, Second Edition

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VI***
Course Code	**R4ME3007P**	
Course Title	**Computer Aided Design/Computer Aided Manufacturing Laboratory**	
Prerequisites	**Computer programming and problem solving, Machine Drawing**	

COURSE OUTCOMES

The student should be able to -

1. Apply scan conversion techniques to generate and transform geometric entities
2. Develop part models and assemblies using CAD software
2. Develop Part programs for NC -CNC Machines manually and using Cam software

Course Contents

Scan Conversion (Programming)

- LINE-by DDA, Bresenham algorithm; CIRCLE - Bresenham
- 2D transformations of any geometry - Translation, Rotation, Scaling, Reflection, shearing
- Curves – Hermite, Bezier, B-Spline

Part and Assembly Modeling

- Component and assembly modeling of mechanical components and assemblies (CATIA/Pro-E/Solidworks or similar)

Computer Aided Manufacturing (CAM)

- Part programming and job making on CNC milling, turning trainers
- Demonstration of part programming on 5-axis CNC Machine
- Demonstration on Rapid Prototyping Machine (FDM)
- Demonstration on Coordinate Measuring Machine (CMM)
- Toolpath generation using CAM software

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3008T**	
Course Title	**Internal Combustion Engines**	
Prerequisites	**Thermodynamics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Undertake the cycle analysis of SI engines.
2. Undertake the cycle analysis of CI engines.
3. Evaluate the performance of naturally aspirated and supercharged engines.
4. Undertake the cycle analysis of Gas Turbines.
5. Suggest methods to minimize the environmental hazards caused by I.C.Engines

Course Contents

Classification of I.C. Engines

Four stroke and two stroke engines. Classification based on other parameters. Applications.

Cycle Analysis of I.C. Engines

Air standard cycles, Fuel air cycles, Actual working cycles, Valve timing diagrams.

Fuels of I.C. Engines

Physical and Chemical properties of fuels. Rating of Fuels- Octane No, Cetane No. & Performance No. Alternate fuels for I.C. Engines (Only introduction).

Engine Lubrication and Cooling

Types and Applications

S.I. Engines

Fuel Metering - Theory of Carburetion. Various systems in actual Carburettor. Types of Carburettors, Petrol Injection- Advantages, MPFI systems

Ignition System – Battery and Magneto Ignition Systems, Electronic Ignition Systems

Combustion in S.I. Engines- Pressure - crank angle diagram, Stages of combustion, Ignition Delay, Flame Propagation, Afterburning.

Abnormal Combustion – Auto ignition, Effects of auto ignition, factors affecting combustion and auto ignition/detonation, Control of abnormal combustion.

Principles involved in combustion chamber design, Types of combustion chambers used in S.I. engines.

C.I. Engines

Fuel Injection Systems - Types of fuel injection systems, Types of Nozzles. Necessity of governors in Diesel engines.

Combustion- Pressure–Crank angle diagram, combustion phenomenon in C.I. Engines, Stages of combustion, delay period, Abnormal combustion, Knocking, Factors affecting combustion and knocking. Types of combustion chambers used in C.I. engines.

Supercharging/Turbo charging

Objectives of Supercharging, Effect of Supercharging / Turbo charging on power output and efficiency of an engine. Methods of Supercharging, Types of Superchargers / Turbochargers. Limits of Supercharging.

Performance Characteristics of S.I. & C.I. Engines

Heat transfer in an engine, Losses, Unit air charge/ volumetric efficiency, Indicated efficiency, Mechanical efficiency, Brake thermal efficiency, Effect of load and speed on indicated, mechanical, brake thermal & volumetric efficiencies. Torque, Mean Effective Pressure, Specific Fuel consumption (Indicated and Brake parameters for all of these), Heat balance for an engine. Methods of determining indicated power of the engine.

Air Pollution due to I.C. Engines

Air/Fuel Ratio with the help of exhaust gas analysis, various pollutants and sources of pollution in the engine. Pollution control devices, EURO standards/ Bharat Standards.

Recent Developments in I.C. Engines

Introduction to CNG, LPG, Stratified Charge and Wankel engines. Other significant developments

Gas Turbines

Ideal Cycles and their analysis: Simple, Regenerative, Reheat cycles and Combined cycles.
Component efficiencies, Pressure loss, Incomplete combustion, Cycle efficiency, Performance of actual cycles
Applications and Future Development of Gas Turbines.

Text Books

1. E.F. Obert, Internal Combustion Engines, Harper and Row, 1973
2. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill, Fourth Edition, 2012
3. Gas Turbines- V. Ganesan, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Recommended Reading

1. Richard Stone, Internal Combustion Engines, Palgrave publications, Third Edition, 1999
2. John Heywood, Internal Combustion Engines, Tata McGraw Hill, 2011
3. Willard Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, PHI Learning Pvt. Ltd. Second Edition
4. Collin Ferguson, Allan Kirkpatrick, Internal Combustion Engines: Applied Thermosciences, John Wiley and Sons, Third Edition, 2015

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3008P**	
Course Title	**Internal Combustion Engines Laboratory**	
Prerequisites	**Thermodynamics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Identify various components of SI and CI engines
2. Perform tests on SI & CI Engines
3. Prepare heat balance sheet for CI engine

List of Experiments

Perform at least seven experiments out of the following.

1. Dismantle an I.C. engine
2. Conduct a Load test on an S.I. engine
3. Perform a Speed test on an S.I. engine
4. Conduct a Load test on a single cylinder C.I. engine
5. Conduct a Load test on a multi-cylinder C.I. engine
6. Prepare Heat balance sheet on a C.I. engine
7. Perform Load test on a turbocharged engine
8. Identify subsystems in Carburettors by assembling or dismantling.
9. Assemble Battery Ignition System and compare it with Magneto Ignition System
10. Dismantle a Fuel Injection system for CI engine.

Seminar- Report / Presentation based on relevant current developments in the field

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3009T**	
Course Title	**Mechanical Vibrations**	
Prerequisites	**Dynamics of Machinery**	

COURSE OUTCOMES:

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

1. Analyse single degree of freedom systems.
2. Analyse multidegree of freedom problems.
3. Evaluate parameters required for balancing of system.

Course contents

Basics of Vibration

Basic concepts of vibrations, causes and effects of vibrations. Classification of Vibrations, Vibration parameters- spring, mass, damper. Degree of freedom, static equilibrium position.

Free vibration of single degree of freedom system

Free body diagram method, Equivalent system methods, Free vibration of undamped system, Free vibration of system with viscous damping and coulomb damping. Effect of spring inertia on natural frequency.

Forced vibration of single degree of freedom system

Response of linear and torsional systems subjected to harmonic force and harmonic motion excitation (excluding elastic damper). Force and motion Transmissibility.

Balancing

Theory of balancing. Static and Dynamics balancing, Balancing of rotary masses. Balancing of Reciprocating masses, balancing of In-line Engines, V Engines

Introduction to Multi degree of freedom Vibration systems & Acoustics

Comparison with one degree of system, Equations of motion, introduction to acoustics and its applications

Text Books

1. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, Eighth Edition, 2009
2. Graham Kelly, Fundamentals of Mechanical Vibration, Tata McGraw Hill, 2000
3. P.L. Ballaney, Theory of Machines, Khanna Publishers, Delhi.

Recommended Reading

1. S. S. Rao, Mechanical Vibrations, Pearson Education, Fourth edition, 2009
2. P.Srinivasan, Mechanical Vibration Analysis, Tata McGraw Hill, 1982
3. Den, Chambil, Hinckle, Mechanical Vibrations
4. J.P. Den Hartog, Mechanical Vibrations, McGraw hill Book Company Inc.

5. Leonard Meirovitch, Elements of Vibration Analysis, Tata McGraw Hill, Special Indian Edition, 2007
6. Grahm Kelly, Mechanical Vibrations, Schaum's outline series, Tata McGraw Hill, Special Edition, 2007
7. William Seto, Mechanical Vibrations, Schaum's outline series-McGraw Hill
8. J.S.Rao, K.Gupta, Theory and Practice of mechanical vibrations, New Age International Publications
9. W.T. Thomson, Theory of vibrations with applications, CBS Publishers, Delhi, 2003

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3009P**	
Course Title	**Mechanical Vibrations Laboratory**	
Prerequisites	**Dynamics of Machinery**	

COURSE OUTCOMES:

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

1. Evaluate response for single degree of freedom system.
2. Evaluate response for multi degree of freedom system.
3. Evaluate parameters required for balancing of system.

List of Experiments

1. Experimental prediction of unknown mass and stiffness.
2. Experimental investigation of longitudinal vibrations of helical springs connected in series and parallel
3. Experimental prediction of damping constant of a given fluid.
4. Experimental prediction of radius of gyration for a given bar using Bi-Filar suspension.
5. Experimental investigation of Transverse vibrations of beam (Dunkerley's Rule Expt.)
6. Experimental Investigation of Static and dynamic Balancing of multi-rotor system.
7. Vibration analysis of mechanical system using codes.
8. Experimental prediction of natural frequencies, and nodal points for two-rotor vibratory system
9. Experimental prediction of frequency of whirling of shaft.
10. Prediction of spectral response of vibrating machine using FFT Analyser.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3101T**	
Course Title	**Computational Fluid Dynamics**	
Prerequisites	**Fluid Mechanics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Analyze methodologies used in CFD.
2. Apply finite volume method to heat transfer and fluid flow problems.
3. Develop computer codes for simulation of heat transfer and fluid flow problems.

Course Contents

Fundamentals of CFD

Overview of CFD, need, Advantages of CFD, Numerical vs. Analytical vs. Experimental, Applications of CFD, CFD methodology, grid independence, Verification and validation

Governing equations of mass, momentum and energy

Derivation, Discussion of physical meanings and presentation of forms particularly suitable to CFD, Boundary Conditions – Dirichlet, Neumann, Robbins, initial conditions, mathematical behavior of partial differential equations – Elliptic, parabolic & hyperbolic equations, impact on CFD

Discretisation methods

Introduction to Finite Difference Method, Finite Volume Method, Finite Element Method. Concepts of Convergence, consistency, stability. Solution of discretised equations, Direct methods and iterative methods, Tri Diagonal Matrix Algorithm, iterative convergence

Finite volume method for diffusion problems (Conduction)

Steady state one dimensional heat conduction with or without heat generation, Dirichlet, Neumann, and Robins type boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction-Explicit, Crank-Nicolson, Implicit schemes, stability of solutions, two dimensional steady and unsteady heat conduction. Gauss-Seidal point by point and line by line TDMA methods.

Finite volume method for Convection-diffusion problems

One dimensional convection-diffusion- Advection schemes-Central, first order upwind, exponential, hybrid, power law, Second order upwind, QUICK etc., Conservativeness, boundedness, transportiveness, False diffusion, Extension to two dimensional steady and unsteady convection – diffusion

Solution algorithms for pressure velocity coupling

Staggered grids and co-located grids, SIMPLE, SIMPLER, SIMPLEC, PISO algorithms, unsteady flows

Turbulence modeling

Turbulence, Reynolds Averaged Navier-Stokes (RANS) equations, introduction to turbulence modeling - DNS, LES, k-ε , k-ω, RSM models

Introduction to Grid Generation

Structured and Unstructured Grids, General transformations of the equations, body fitted coordinate systems, Algebraic and Elliptic Methods, multi block structured grids, adaptive grids

Text Books

8. S V Patankar, Numerical Heat Transfer and Fluid Flow, ANE BOOKS-NEW DELHI, Special Indian Edition, 2017
9. H K Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Pearson Education, Second Indian Edition, 2010

Recommended Reading

1. John. D. Anderson, Jr., Computational Fluid Dynamics - The basics with applications, McGraw-Hill, Indian Edition, 2017
2. Atul Sharma, Introduction to Computational Fluid Dynamics –Development, Application and Analysis, Ane-books Pvt. Ltd., 2017
3. Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Elsevier, Third Edition, 2018
4. A.W. Date, Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005
5. Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer, Third Edition, 2008

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3101P**	
Course Title	**Computational Fluid Dynamics Laboratory**	
Prerequisites	**Fluid Mechanics, Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Develop computer codes for simulation of heat transfer and fluid flow problems.
2. Implement CFD process by using CFD software.
3. Interpret data obtained from the numerical solution

List of Experiments

Development of computer codes

1. To develop computer codes for steady state one dimensional heat conduction with or without heat generation, different boundary conditions, Multi-solid heat conduction, Non-linear Heat conduction, Unsteady heat conduction, two dimensional steady and unsteady heat conduction, comparison with analytical solution
2. To develop computer codes for one dimensional convection-diffusion problem to implement various advection schemes like - Central, first order upwind, hybrid, power law, Second order upwind, QUICK etc., two dimensional steady and unsteady convection – diffusion, comparison with analytical solution
3. To develop computer codes for implementation of pressure velocity couplings like SIMPLE for benchmark problems like Lid driven cavity, backward facing step etc., comparison with analytical/numerical solution.

Project

A small group of 2/3 students will use CFD software (commercial/open source) for solution of a problem (sample problems given in the list, however students can select their own project topic) and present their results.

1. Flow between two parallel plates (laminar/turbulent) (with or without heat transfer)
2. Flow in pipe (laminar/turbulent)
3. Boundary layer on a flat plate
4. Flow in a bend
5. Flow over an aerofoil
6. Convection in a pipe (laminar/turbulent)
7. Flow past a cylinder
8. Flow over backward facing step (laminar/turbulent)
9. Flow over Ahmed body
10. Fluid flow and heat transfer in a wavy channel
11. Lid driven cavity

12. Flow over pick-up truck
13. Cooling electronic components in a computer

Recommended Reading

1. Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Elsevier, Second Edition, 2012
2. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
3. https://www.openfoam.com/documentation/

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3102T**	
Course Title	**ROBOTICS**	
Prerequisites	**Mathematics for Mechanical Engineers I and II, Kinematics of Machinery, Mechanical Measurements**	

COURSE OUTCOMES

The student should be able to –

1. Identify various Robotic systems
2. Perform calculations of Robot kinematics and Robot dynamics
3. Apply various methods of Robot vision and Trajectory planning
4. Implement programming for Robot

Course Contents

Introduction

Automation & Robotics, Robotic System & Anatomy, Classification, Robot languages, Robot Applications, Future prospectus

Drives

Different types of drives used in robot systems, Basic control system concepts & models, Various control system, Robot activation & feedback components, position & velocity sensors, Actuators, Timer belts, Power transmission systems.

Robot and its peripherals

End effectors- types, Mechanical & other grippers, Tool as end effecter, Sensors: Sensors in robotics, Tactile sensors, Proximity and Range sensors, Sensor based system, User vision systems-equipment.

Robotic Transformations

Transformation matrix for robot arm

Robot kinematics

DH algorithm for Forward and Inverse Kinematics of Robots

Robot Dynamics

Static Force Analysis of robots, Dynamic equations for multiple degree of freedom of Robots, Transformations of Forces and Moments between Coordinate Frames.

Robot Vision

Introduction, Low level & high level vision, Sensing & digitizing, Image processing & analysis

Trajectory Planning

Basics of trajectory planning, Joint-Space Trajectory Planning, Cartesian Space Trajectory planning, Continuous Trajectory Recording.

Programming for robots

Methods, Robot program as a path in space, Motion interpolation, Level & task level language, Robot Languages, Programming in suitable languages, Characteristics of robot.

Customize the robotic systems

Customize robotic systems for the various industrial applications such as Material transfer, Machine loading & unloading, Processing operations, Assembly & inspections, Robotic cell design & control with the consideration of social & economic issues of robotics.

Text Books

1. Robert J. Schilling , Fundamentals of Robotics, Pearson Prentice Hall, 1990
2. Saeed B. Niku, Introduction to Robotics, Wiley, Second Edition, 2010
3. Ashitava Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006

Recommended Reading

1. John Craig, Robotics, Pearson, Third Edition, 2008
2. R.P. Paul, Robot manipulators : Mathematics, programming & control, 1981
3. Groover and Zimmers, Industrial Robotics, Tata McGraw-Hill Education, 1986
4. Yoram Koren, Robotics of engineers, McGraw-Hill. 1985
5. J. F. Engelberger, Robotics in practice, Amacom, 1980
6. Ulrich Rembolds and Christian Blume, Computer integrated manufacturing technology & systems,
7. Ernest Doebelin, Measurement systems, McGraw Hill Higher Education, Fifth Edition, 2003
8. Richard D. Klafter, Thomas A. Chmielewski, Michael Negin, Robotic Engineering: An integrated approach,
9. Spyros G. Tzafestas, Intelligent Robotic Systems, New York/Basel: Marcel Dekker, 1991

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3102P**	
Course Title	**Robotics Laboratory**	
Prerequisites	**Mathematics for Mechanical Engineers I and II, Kinematics of Machinery, Mechanical Measurements**	

COURSE OUTCOMES

The student should be able to –

1. Investigate problems of direct and inverse kinematics
2. Implement programming for 5 axis robot manipulator
3. Build the robotic systems for simple operations

List of Practicals

I. Problems on transformation matrices using computer programming

II. Validating Direct and Inverse Kinematics analysis problems using Robotics simulation software such as "Robo Analyser"

III. Programming using 5 Axis robot manipulator for
- Pick and Place Operations Continuous path operations

IV. Micro Controller Programming using "Arduino" platform
- To build line follower robot
- To build wireless robot

REFERENCES

1. "Intellitek" 5 axis robot manual
2. Robot analyser software built in help (online)
3. Arduino robot controller built in help (online)

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3103T**	
Course Title	**MEMS and Microflows**	
Prerequisites	**Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Analyze various heat transport processes with understanding of solution approximation.
2. Identify mechanism of momentum and energy transport.
3. Apply transport phenomenon in liquid and gases flow.
4. Examine gas and liquid micorconvection and nanoflows .

Course Contents

MEMS and Microflows

Introduction to MEMS and application in mechanical and electronics industry. Heat flow through microdevices and cooling technology using microchannels. Glimpses of Microsystems; scaling effects.

Basic concepts of design of MEMS devices and processes

Micro electro mechanical systems (MEMS), devices and technologies. MEMS fabrication using VLSI technology: lithography, chemical etching, Plasma etching, oxidation, chemical vapour deposition (CVD), surface micromachining, LIGA technology, MEMS fabrication using laser micromachining, Electro Discharge and Electro Chemical micromachining (EDM and ECM). Silicon wafer processing.

Multiphysics analysis of flow through MEMS devices

Review of Heat flow Governing equations: Continuty, momentum, energy and heat flow mechanism. Fluid flow behavior in microdevices with scaling effects like rarefaction and non rarefaction. Applicability of Continuum Assumptions for Microflows. Gas and liquid microconvection and molecular modelling. Momentum transport Navier-Stokes Equations and Mechanisms of heat transport energy equation. Physical mechnism due to varition in thrmophysical properties in different liquid and gases.

Industrial application of microflows and nanoflows phenomenon

Integration of microsystems and microelectronics. Microchannel Cooling of ICs and High Heat Flux Device with Low Reynolds flow and high Reynolds laminar flow. Applications to various industrial problems like ISRO Space Technology, radar, missile launching, gas turbine cooling, Nuclear, Chemical, Heat Exchanger, Elecrtical etc. various research methods and writing computer program of solution for solving momentum, heat and mass transfer problems. Properties at nanoscale. CNT (Carbon Nano Tubes) Applications. Nano-mechanical Systems (NEMS), Domestic and Industrial Applications of nanotechnology in electronics and packaging and scope of research in microconvection.

Text Books

1. Adams M. Thomas, Introductory MEMS: Fabrication and Applications, First Edition, Heritage Publishers
2. George Karniadakis and Ali Beskok, Microflows and Nanoflows: Fundamentals and Simulation
3. J.R.Wilty, R.W.Wilson, and C.W.Wicks, Fundamentals of Momentum Heat and Mass Transfer, John Wiley, New York, Second Edition, 1973

Recommended Reading

1. N Mahalik, Fundamentals of MEMS, McGraw Hill Education, 2017.
2. R. Bird, W.E. Stewart, and E.N. Lightfoot, Transport Phenomena, John Wiley & Sons, New York, Second Edition, 2002
3. W. M. Kays and M. E. Crawford, Convective Heat and Mass Transfer, John Wiley & Sons, Third Edition, 1993

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3103P**	
Course Title	**MEMS and Microflows Laboratory**	
Prerequisites	**Heat Transfer**	

COURSE OUTCOMES

The student should be able to –

1. Examine various heat transfer phenomenon and heat and mass transport mechanism.
2. Analyze various solution approximation using heat flow governing equations.
3. Determine momentum and energy flux in 1D/2D flow using FEAST VSSC ISRO software.

List of Practicals

1. Introduction to FEAST VSSC ISRO software and Fluent Software and to understand heat transfer module in FEAST/Fluent.
2. To apply boundary condition and to determine transport properties in 1-D low Reynolds laminar flow using Fluent software.
3. To apply boundary condition and to determine transport properties in 1-D and high Reynolds turbulent flow using Fluent software.
4. To determine and analyze effect of transport properties on macro and microflows using Fluent software.
5. Determine momentum flux in 2-D laminar flow in space applications using FEAST VSSC ISRO software.
6. Experimentation on finding heat flux and heat transport on flat or circular plate with continuous impingement of jet flow using jet impingment technology.
7. Experimentation on finding heat flux and heat transport on circular plate with pulsation impingement of jet flow.
8. Every student (group) develops a proposal for a microsystem and cooling technology.

Text Books

1. W.J.Thomson, Introduction to Transport Phenomena, Pearson Education Asia, New Delhi, 2001
2. J.R.Wilty, R.W.Wilson, and C.W.Wicks, Fundamentals of Momentum Heat and Mass Transfer, John Wiley, New York, Second Edition, 1973

Recommended Reading

1. R. Bird, W.E. Stewart, and E.N. Lightfoot, Transport Phenomena, John Wiley & Sons, New York, Second Edition, 2002

2. Stewart , Warren E, Transport theory, 1924
3. Chapman and T. G. Cowling, The Mathematical Theory of Non-Uniform Gases, Cambridge University Press, Third Edition, 1970
4. W. M. Kays and M. E. Crawford, Convective Heat and Mass Transfer, John Wiley & Sons, Third Edition, 1993

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3601S**	
Course Title	**Optimization and Decision Science**	
Prerequisites	**Mathematics of Engineers-I & II**	

COURSE OUTCOMES

The student should be able to –

1. Employ basic knowledge of optimization and choose appropriate optimization technique for engineering applications.
2. Use single and multivariable optimization as well as linear programming tools for constrained as well as unconstrained problems.
3. Apply Multi-attribute decision-making approaches in engineering problems solving.
4. Solve decision-making problems using utility theory and outranking methods.

Course Contents

Basics of Optimization

Introduction to optimization, Engineering Applications of Optimization, Statement of Optimization Problem, Design Vector, Design Constraints, Constraint Surface, Objective Function, objective function surfaces.

Classical Optimization Techniques

Single variable optimization, Multivariable optimization without constraints, Multivariable Optimization with equality constraints, Multivariable Optimization with inequality constraints.

Linear Programming: Simplex Method

Introduction, Standard form of a linear programming problem, geometry of linear programming problems, definitions and theorems, solution of a system of linear simultaneous equations, pivotal reduction of a general system of equations, motivation to the simplex method, simplex algorithm.

Multi-attribute Decision-Making

Introduction, Simple Additive Weighing Method, Weighted Product Method, Analytic Hierarchy Process, Problems on engineering applications.

Utility Theory Methods of optimization

Introduction, Utility Additive Method, Multi-objective optimization on the basis of Ratio Analysis, Engineering problems.

Outranking Methods for optimization

Introduction of outranking comparison, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), Compromise Ranking Method: Vlse Kriterijumska Optimizacija I Kompromisno Resenje(VIKOR) as applications to solve engineering problems.

TEXT BOOKS

1. Singiresu S. Rao, Engineering Optimization: Theory and Practice by John Wiley and Sons, 4th Edition, 2009.
2. R. Venkata Rao, Decision Making in the Engineering Environment, Using Graph Theory and Fuzzy Multiple Attribute Decision Making, Springer, 2010.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VI*
Course Code	**R4ME3010A**	
Course Title	**Innovation and Entrepreneurship**	
Prerequisites		

Course Contents

Introduction to Entrepreneurship

Evolution of entrepreneurship from economic theory. Managerial and entrepreneurial competencies. Entrepreneurial growth and development. Concept and Definitions: Entrepreneur & Entrepreneurship, Entrepreneurship and Economic Development, A Typology of Entrepreneurs.

Creativity and Innovation

Creativity and Innovation: Concepts Shifting Composition of the Economy Purposeful Innovation & the 7 Sources of Innovative Opportunity, The Innovation Process.

Innovative Strategies: Strategies that aim at introducing an innovation. Innovation & entrepreneurship: Can they work together? Planning -incompatible with Innovation & entrepreneurship. Factor Affecting Entrepreneurial Growth: Economic, Non-Economic Factors, EDP Programmes, Entrepreneurial Training

Entrepreneurial Motivation

Need for continuous learning & relearning Acquiring Technological Innovation Entrepreneurial motivation (nAch story) Achievement Motivation in Real life. Case Study. Entrepreneurial Competencies: The Entrepreneur's Role, Task and Personality - Entrepreneurial Skills: creativity, problem solving, decision making, communication, leadership quality, self – analysis, personal efficacy, culture & values, risk-taking behaviour, technology backup.

International Entrepreneurship

Concepts and Nature of International Entrepreneurship. The changing International environment. Ethics and International Entrepreneurship. Strategic Issues in International Entrepreneurship.

Problem Identification and Problem Solving

Problem Identification. Problem solving. Innovation and Diversification.

Small Enterprises and Enterprise Launching Formalities

Definition of Small Scale, Rationale; Objective; Scope; Role of SME in Economic Development of India, SME; Registration, NOC from Pollution Boar, Machinery and Equipment Selection.

Project Report Preparation

Specimen of Project Report; Project Planning and Scheduling using Networking Techniques, Methods of Project Appraisal - economic viability and market feasibility, requirements of financial institutions, projected financial statement preparation.

Entry strategies

New product, Franchising, Partial Momentum, Sponsorship and Acquisition. Intellectual Property Creation and Protection.

Case Studies

Diagnostic case studies of successful / unsuccessful entrepreneurs, key variables explaining success /failures, industrial sickness, industrial reconstruction, technology obsolescence, technology, transfer

Text Books

1. Martin M.J., Managing Innovation and Entrepreneurship in Technology based Firm, John Wiley, 1994
2. Ettlie J.E., Managing Technology Innovation, John Wiley & Sons, 2000
3. Drucker P. F., The Discipline of Innovation, Harvard Business Review, May, (originally published 1985, May-June, 63(3), 67-72.1, 2000
4. Christensen C. M. and Raynor, M. E., The Innovator's Solution: Creating and Sustaining Successful Growth, Boston, MA: Harvard Business School Press, 2003
5. Drucker P. F., Innovation and Entrepreneurship, New York: Harper, 1985
6. Harvard Business Review on Innovation (Collection of articles), Harvard Business School Press, 2001
7. Harvard Business Review on Entrepreneurship (Collection of articles), Harvard Business School Press, 1999
8. Rogers, E.M., Diffusion of Innovations, Fifth Edition, New York: Simon and Schuster, 2003