Bharatiya Vidya Bhavan's
SARDAR PATEL COLLEGE OF ENGINEERING
(Government Aided Autonomous Institute under Mumbai University)
Andheri (W) Mumbai - 400058

Bachelor of Technology

Mechanical Engineering Program

Regulation -2023

Course Contents

Final Year of Mechanical Engineering

Semester – VII & VIII

Academic Year – 2026-27

List of Courses

PC-BTM701 Design of Machines and Mechanical Systems

Course pre-requisites: Elements of Machine Design

Course Objectives:

The objectives of this course are

- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
- To apply the detailed design procedure of the different types of machine elements and select the appropriate theory of failure.
- To develop an integrated approach for the design of mechanical systems.

Course Outcomes*:*

Upon successful completion of the course, students should be able

1. To design and evaluate the adequacy of standard/custom-built machine elements such as spur/helical/bevel/worm gears, rolling element/journal bearings, and mechanical seals to fulfil desired specifications and satisfy failure criteria
2. To Analyze, design, and evaluate brakes and clutches based on functional requirements and strength considerations
3. To integrate the knowledge of mechanical engineering to develop the design of basic systems such as EOT cranes and centrifugal pump
4. To demonstrate an ability to design and evaluate a complex mechanical system to meet real-life needs with appropriate considerations such as economic, environmental, social, ethical, manufacturability, sustainability, health, safety, legal and cultural

Course content:

Module	Details	Hrs.
01	Design of spur, helical, bevels and worm gears	10
02	Selection of rolling contact bearings based on constant /Variable Load and speed conditions (includes deep groove ball bearing and cylindrical roller bearing)	4
03	Design of hydrodynamically lubricated bearings (Self-contained) Selection of Mechanical Seals	5
04	Design of Brakes: Disk, shoe and drum type. Design of lever arm Design of clutches: Single and multi-plate with springs, pressure and friction plate selection	6
05	Design of EOT crane system: Snatch Block assembly, Rope drum assembly, Overhead travelling mechanism assembly, application of mechatronics, sensors and IOT concepts in system design of EOT crane. Machine design application of generative design concept for machine element.	6
06	Introduction to positive displacement pump such as gear pump, vane pump, etc. Design of gear pump, vane pump and lobe pump	5
07	Design of main components of centrifugal pump - Motor selection, Suction and delivery pipe, Impeller, Impeller shaft, Volute casing. Application of mechatronics, sensors and IOT concepts in system design of centrifugal pump.	6

Internal assessment:

Internal assessment work shall comprise of

1) Exercises on the above topics in the form of design calculations with sketches and or drawings.
2) Examination (MCQ) based on topics mentioned in latest GATE syllabus
3) Design and detailed assembly drawing(digital) on A2 size for minimum **two** design problems
4) Course project*

***Course Projects-** There will be course projects where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Two to Four students and will consist of design of any systems having min. 5 to 6 components.

Text Books

1. Bhandari, V. B. *Design of machine elements*. Tata McGraw-Hill Education, 2010.
2. Shigley, Joseph E., Charles R. Mischke, and Richard G. Budynas. *Mechanical engineering design*. McGraw-Hill,, 2004.
3. Robert, L. Norton. "Machine Design An Integrated Approach." (2006).

Recommended Data Books

1. V. Bhandari, *Machine Design Data Book*, McGraw Hill Education (2017)
2. Mahadevan K., Reddy K.B. *Design Data Handbook for Mechanical Engineering in SI and Metric Units*, CBS (2013)
3. *PSG Design Data Book*, PSG College, Coimbatore (2012)

Reference Books

1. Spottes, M.F.,Terry E. S., and Lee E.H. *Design of machine elements*. Vol. 2. Pearson Education India, 2004.
2. Maitra, Gitin M. *Handbook of gear design*. Tata McGraw-Hill Education, 1994.
3. Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
4. Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
5. PATIL, SP. *Mechanical System Design,* JAICO students Ed., 2014.
6. Rudenko, Nikola Ďeodos′evich, and Nikolaĭ Feodos′evich Rudenko. *Materials handling equipment*. Peace Pubs., 1964.
7. Sahu G.K., *Pumps*, New Age International, 2000

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PC-BTM702 Industrial Engineering, Project and Finance Management

Course pre-requisites: -- Industrial Engineering and Management

Course Objectives:

1. To understand knowledge areas and tool – techniques for efficient Industrial Engineering & Project Management.
2. Understand the role of Industrial Engineering & Project Management in an organization.
3. Develop an insight as to how Industrial Engineering & Project Management tools/techniques are used strategically for the betterment of the organization.
4. To understand how it helps in customer focus, innovation, quality management, speeding up the processes and improvement in productivity in an organization.

Course Outcomes:

Upon successful completion of the course, students should be able

1. To describe the basic concepts in Industrial Engineering, Project and Finance Management,
2. To describe the various tools and Techniques in Industrial Engineering, Project and Finance Management,
3. To apply the various concepts and Tools in Industrial Engineering, Project and Finance Management for Industrial cases,
4. To investigate the factors for improving the process and Managing the Project successfully.

Course Content:

Module No	Details	Hrs
1	**<u>Industrial Engineering:</u>** INTRODUCTION TO INDUSTRIAL ENGINEERING Introduction to Industrial Engineering, history and contribution to industrial engineering by Researchers, industrial engineering approach, techniques of industrial engineering, objectives of industrial engineering, system approach and industrial engineering, **Productivity Improvement:** Definition and concept of productivity, productivity measures, factors influencing productivity, productivity improvement techniques. Numerical on productivity improvement	04
2	METHOD AND TIME STUDY **Work Study**: Definition and objectives, importance and advantages, work-study procedure. **Method Study:** Definition and objectives, scope and steps involved in method study, job selection, recording techniques, critical examination, development and selection of improved method, motion economy principles, installation and maintenance of proposed method. **Work Measurement:** Definition and objectives, techniques of work	04

	measurement, steps involved in work measurement, types of elements, time study equipment, performance rating and allowances, computation of standard time, predetermined motion time standards (PMTS) **Modern Techniques:** Modern Techniques of Time, work and motion study, Application of MOST, Leveraging Industry 4.0	
3	SYSTEM EXCELLENCE APPROACHES: System Design (Product and Process Design), Design for X :Design for Ergonomics, Design for Assembly, Design for Manufacturing, Design for Service, Design for Sustainability, Design for Supply Chain , Design for Transportation, Design for Six Sigma Business Process Reengineering, Supply Chain Management, Enterprise Resource Planning, Lean Concepts, Green Manufacturing, Agile manufacturing, Value Engineering, Total Productive Maintenance, TQM, Kaizen, Zero Defect, Six Sigma, Industry 4.0 enabled business processes	4
4	ENTREPRENEURSHIP Introduction to entrepreneurship, Factors influencing entrepreneurship, Types of entrepreneurs, Creativity, Decision-making and Problem-Solving, Financial assistance by different agencies, Project Report Preparation	4
5	**Project Management:** INTRODUCTION TO PROJECT MANAGEMENT: Project Management Scenario in the world, the triple constraint, Stakeholders, Project Management Knowledge Areas, Project Management Processes Tools and techniques, Role of a Project Manager, job description, Suggested Skills, Importance of people and leadership skills. Project Management to the Mechanical Engineering context, Organizational Structure, Project Life Cycle, Phases and Nature of Mechanical Engineering Projects, Trends affecting Mechanical Engineering Projects, Globalization, Outsourcing, and Virtual Teams.	04
6	FINANCE MANAGEMENT FOR PROJECT: Funding Institutions for Engineering Projects, Financial Analysis and Planning, The Time Value of Money, Risk and Return: Portfolio Theory and Asset Pricing Models, Estimation of Project Cash Flows, Project Cost Management, Estimating Techniques, Earned Value Management,	08
7	PROJECT MANAGEMENT KNOWLEDGE AREAS: Project Crashing, Project Quality Management, Planning Quality, Performing Quality Assurance, Quality Control–Tools and Techniques, Project Resource Management, Project Resource Allocation and Resource smoothing, Development of Human Resource Plan, Project Organizational Chart and Responsibility Assignment, Multi-project Scheduling and Resource Allocation, Project Communication Management, Identifying Stakeholders, Planning Communication, Project Risk Management, Identifying Risks; Common Sources	10

	of Risk in Mechanical Engineering Projects, Qualitative Risk Analysis: Probability and Impact Matrix, Quantitative Risk Analysis: Decision Trees, Planning Risk Response, Project Procurement Management, Planning and conducting procurement	

Internal assessment criterion:

1. Assignments based on the above modules
2. Entrepreneurship Project Report Preparation
3. At least one Case study conducted at industry
4. Use of tools such as Primavera and MS projects for the above project.

Teaching Methods:

The course will use the following pedagogical tools:

1. Discussion on concepts and issues on Industrial Engineering and Project Management use in an organization.
2. Case discussion covering a cross-section of gaining a strategic advantage by applying Industrial Engineering and Project Management tools and techniques.
3. Projects/ Assignments/ Quizzes/ Class participation etc.

Text books:

1. Weihrich, Heinz, and Harold Koontz. Management: A global perspective. Tata McGraw-Hill, 2005.
2. Niebel, Benjamin W. Freivalds, Andris Benjamin W. Niebel, and AndrisFreivalds. Methods, standards, and work design. 2003.
3. Mundel, Marvin Everett. Improving productivity and effectiveness. Englewood Cliffs, NJ: Prentice-Hall, 1983.
4. Chase, Richard B., and Nicholas J. Aquilano. Production and operation management. R d Irwin, 1973.
5. Barnes, Ralph M. "Motion and time study ." (1949).
6. Sham H.S., Work Study and Ergonomics, Dhanpatrai & Sons, 2000.
7. Meredith, Jack R., and Samuel J. Mantel Jr. Project management: a managerial approach. John Wiley & Sons, 2011.
8. Lewis, James P. Project Planning, Scheduling & Control, 4E. McGraw-Hill Pub. Co., 2005.
9. Financial Management: Theory and Practice by Prasanna Chandra , Mc Graw Hill Publications

Reference book

1. Larson, Erik W., and Clifford F. Gray. "Project management: The managerial process." (2011).
2. I.L.O. Introduction to Work Study, I.L.O., 1986.
3. Meredith, Jack R., and Samuel J. Mantel Jr. Project management: a managerial approach. John Wiley & Sons, 2011.

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM711 Industrial Robotics

Course pre-requisites: Kinematics and Dynamics of Machines, Mechatronics

Course Objectives:
On successful completion of the course, students should be able to
1. Understand the anatomy of different ROBOTS
2. Know the programming of ROBOTS
3. Develop the ROBOTS in concern with society
4. Evaluate the application of robotics in manufacturing systems, robotic cell design

Course Outcome:
Upon successful completion of the course, students should be able
1. To describe the basic anatomy of ROBOT
2. To explain programming in ROBOTICS
3. To apply knowledge for the development of ROBOT
4. To decide on social issues & economics of robotic

Course Content:

Module	Details	Hrs.
01	**INTRODUCTION:** Automation & robotics, Robotic Systems & Anatomy Classification, Future Prospects DRIVES: Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators, Power Transmission Systems. ROBOT & ITS PERIPHERALS: End Effecters -types, Mechanical & other grippers, Tool as end effecter SENSORS: Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Uses Vision Systems - Equipment	6
02	MACHINE VISION: Introduction, Low level & High-level vision, Sensing & Digitizing, Image processing & analysis, Segmentation, Edge detection, Object description & recognition, Interpretation, Applications	6
03	PROGRAMMING FOR ROBOTS: Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot.	6
04	ROBOT KINEMATICS: Forward, Reverse& Homogeneous Transformations, Manipulator Path Control, Robot Dynamics.	6
05	ROOT INTELLIGENCE & TASK PLANNING: Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem-solving, Robot learning, and Robot task planning.	6

06	ROBOTIC APPLICATION IN MANUFACTURING: Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors, Robotic Cell Design & Control.	6
07	SOCIAL ISSUES & ECONOMICS OF ROBOTICS	6

Internal assessment criterion:

Internal assesment shall consist of a minimum **06** assignments, at least one on each module, programming of robots

Text Books

1. Ramamurti, Viswanatha. *Computer aided design in mechanical engineering*. New Delhi: Tata McGraw-Hill, 1987.
2. Paul, Richard P. *Robot manipulators: mathematics, programming, and control: the computer control of robot manipulators*. Richard Paul.
3. Groover, Mikell P., Mitchell Weiss, and Roger N. Nagel. *Industrial Robotics: Technology, Programming and Application*. McGraw-Hill Higher Education.
4. N-Nagy, Francis L. "Robotic engineering: An integrated approach: Richard D. Klafter, Thomas A. Chmielewski and Michael Negin Prentice-Hall International.

Reference Books:

1. Koren, Yoram, and YoramKoren. *Robotics for engineers*. Vol. 168. New York et al: McGraw-Hill.
2. Engelberger, Joseph F. *Robotics in practice: management and applications of industrial robots*. Springer Science & Business Media.
3. Grover, D. J. "Computer integrated manufacturing technology and systems: Ulrich Rembold, Christian Blume and Ruediger Dillmann, Marcel Dekker Inc, Cimarron Road, Monticello, NY USA.
4. Spong, Mark W., and Mathukumalli Vidyasagar. *Robot dynamics and control*. John Wiley & Sons.
5. Craig, John J. *Introduction to robotics: mechanics and control*. Vol. 3. Upper Saddle River: Pearson Prentice Hall.
6. Doebelin, Ernest O., and Dhanesh N. Manik. "Measurement systems: application and design."
7. Beckwith Thomas, G., and N. Lewis Buck. "Mechanical Measurements."
8. Ogata, Katsuhiko. "Modern Control Engineering, PHI Learning Pvt." *Ltd., New Delhi, India*
9. Tzafestas, Spyros G. "Intelligent robotic systems." *Electrical engineering and electronics*

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM712 Renewable Energy Applications

Course pre-requisites: Thermal Systems

Course Objectives:

To understand the importance of renewable energy and its utilization to satisfy the ever increasing thermal and electrical energy needs of humankind. At the same time be aware of the environmental aspects of these resources.

Course Outcomes:

Upon successful completion of the course, students should be able

1. To apply the fundamental knowledge of heat transfer and fluid mechanics for harnessing renewable energy sources like solar, wind and other sources.
2. To calculate and analyze energy production from liquid flat plate collectors, concentrated collectors, photovoltaic cells and wind energy.
3. To identify and select appropriate renewable energy technology to meet the demand.
4. To identify techniques in extraction and utilization of ocean and geothermal energy.

Course contents:

Module	Description	Hrs.
1	**ENERGY REQUIREMENT - OF INDIA AND THE WORLD:** 06 Present energy scenario, conventional energy sources- World's Production and reserves, India's production and reserves. Demand side management of energy. Need and role of renewable energy.	6
2	**SOLAR ENERGY I:** Terrestrial and extra-terrestrial solar radiation. Instruments for measurement of solar radiation. Flat plate collector, Use of selective coatings to enhance performance. Solar thermal power system, Solar energy storage, Solar refrigeration and air-conditioning. Economics of Solar systems.	10
3	**SOLAR ENERGY II:** Photovoltaic energy conversion, solar cells, Selection of PV system to match application.	03
4	**WIND ENERGY:** History, principle of wind power, Betz model. Wind maps, Site selection for wind farms. Wind mills- Design parameters of components, Electrical Power Generation Subsystem. Operational issues, Newer designs of windmills. Application of wind energy.	06
5	**SMALL HYDRO-POWER: P**rospects of small hydropower, mini and micro power systems, hydropower conversion devices-Turbine, status of mini and micro hydel in India. **OCEAN ENERGY:** Types of ocean energy sources, OTEC cycles closed and open. Comparison with normal thermal power cycles. Ocean waves-wave motion, Wave energy conversion devices. Tidal Power- Formation and causes of tides, site selection, turbines selection.	08
6	**GEOTHERMAL ENERGY:** History and future, origin and types of geothermal energy regions, dry rock and hot Aquifer analysis, vapor dominated	03

	and liquid nominated geothermal systems, operational and environmental problems.	
7	**BIOMASS ENERGY:** Various forms of biomass as a potential energy 08 source, , Bio-fuel production processes, Gasifiers, principle, construction and design, Types of bio gas plants individual and community biogas plants, Sizing of biogas plants, energy plantation. **CHEMICAL ENERGY SOURCES:** Fuel cells-principle, classification, advantage and disadvantage, application and recent development.	08

Course activities shall comprise of:

1. Measuring solar radiation using Pyranometer.
2. Measuring length of shadow and comparing with calculated length with reasons for difference.
3. Performance of solar liquid flat plate collector, plotting in Hottel Whillier Bliss format.
4. Use of Box type cooker and compare with concentrating type Sievert Cooker.
5. Solar PV panel-characteristics.
6. Measuring performance of Wind Turbine available in SPCE.
7. Survey of energy use in households

And a mini project involving fabrication of working model of device to extract energy of the wind or wave energy.

Recommended Books:

Text Books:

1. Sukhatme, K., and Suhas P. Sukhatme. *Solar energy: principles of thermal collection and storage*. Tata McGraw-Hill Education, 1996.
2. Tiwari, Gopal Nath. *Solar energy: fundamentals, design, modelling and applications*. Alpha Science Int'l Ltd., 2002.
3. G.D. Rai, Non-conventional Energy Sources. Khanna Publishers.

References

1. Kishore, V. V. N., ed. Renewable energy engineering and technology: principles and practice. The Energy and Resources Institute (TERI), 2010.
2. Boyle, Godfrey. Renewable Energy: Power for a Sustainable. Oxford University Press, USA, 1996.
3. Twidell, John, and Tony Weir. Renewable energy resources. Routledge, 2015.
4. Goswami, D. Yogi, and Frank Kreith, eds. Handbook of energy efficiency and renewable energy. Crc Press, 2007.
5. Tripathi A.K., Multiple Choice Questions on Renewable Energy, 2001.

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM713 Welding Process and Welding Technology

Course pre-requisites: Manufacturing Sciences

Course Objectives:

The main objectives of the course are

- To introduce the students to the different type of welding and their application.
- To develop an ability to identify, formulate, and solve different type of welding problems.
- To understand the theory behind the selection of filler material for the different welding structure.

Course Outcomes:

At the end of the course the students shall be able to

1. Identify and apply which type of welding method is required for different material and structure.
2. Design the different weld structure and use of welding standard in design.
3. Analyse heat flow and cooling rate in welding.
4. Explain the power source, welding fluxes and coating required while welding.

Course Content

Module No	Details	Hrs
1	Evolution of welding; classification of welding processes; application of welding.	03
2	Design principles of welded structures, Welding symbols, standards and codes. Introduction to corrosion prevention.	06
3	Welding methods – shielded metal arc welding, gas tungsten arc welding, gas metal arc welding, flux cored arc welding, submerged arc welding,	08
4	plasma arc welding, electroslag welding, electrogas welding, arc stud welding, synergic and pulsed welding, friction welding, Oxy-fuel gas welding, resistance welding, brazing, soldering.	05
5	Types of power source and their characteristics; Physics of welding arc – characteristics of arc, mode of metal transfer, forces acting on a molten droplet.	08
6	Welding fluxes and coatings - type and classification; Study and analysis of heat flow, cooling rates, models for welding heat sources.	06
7	Testing of welds, types of defect, causes and remedies of defect; NDT of welded joints; fracture and fatigue of welded structures, welding metallurgy, heat treatment of welds, effect of alloying materials., Smart Welding Technologies. Sensors and robots used in welding. Robotic welding, Underwater welding, Welding in space.	06

Internal assessment criterion:

At least 20 (twenty) solved problems/ case studies based on the above syllabus as per the module weightage shall be submitted as Internal assesment.

Textbooks/References:

[1] O'Brien, Welding Handbook: Welding Processes, Part 1, Vol. 2, AWS, 2004.
[2] J. F. Lancaster, The Physics of welding, Pergamon, 1986.
[3] R. W. Messler, Principles of Welding, John Wiley and Sons, 1999.
[4] O. Grong, Metallurgical modelling of welding, 2nd Ed, IOM Publication, 1997.
[5] V.M. Radhakrishnan, Welding technology and design, New age, 2002.
[6] J. A. Goldak, Computational welding mechanics, Springer, 2005.
[7] L.E Lindgren, Computational welding mechanics, Woodhead Publishing Limited2007.
[8] Welding handbook by AWS(American Welding Society)

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM714 Power Plant Engineering

Course pre-requisites: Thermodynamics, Thermal Systems

Course Objectives:

The objectives of this course are:

1. To explain cost economics involved in different types of power generation plants.
2. To explain fundamental principles, detailed features of arrangements, operation and evaluate performance parameters of various power genertaion plants and their combinations.
3. To explain impact of power generation plants on environment and methods/ technologies adapted for improving efficiency and reducing the environmental impact.
4. To develop understanding for the national and global power generation scenarion and to analyse a power generation system.

Course Outcomes:

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

1. **Analyze** the cost economics associated with various power generation plants and **evaluate** suitable power generation systems or combinations of plants for optimum power production.
2. **Explain** the operating principles, constructional features, arrangements, and advantages of different power generation plants, and **evaluate** their performance parameters for effective power generation.
3. **Assess** the environmental impacts of different power generation technologies and **recommend** appropriate measures to enhance efficiency and minimize environmental effects.
4. **Interpret** the national and global power generation scenario and **compare and evaluate** the performance characteristics of different power generation plants and integrated power systems.

Course Contents:

Module	Details	Hrs.
1.	**Economics of Power Plants:** ● Load curve, load duration curve, various factors. ● Effect of fluctuating load on operation and design of the plant, Methods of meeting fluctuating load, Selection of the generating equipment, load sharing, ● Cost of electrical energy and Tariff methods. ● Performance and operating characteristics of Power Plants. ● Power Generation: Global and Indian Scenarion.	06
2.	**Hydro Power Plants:** ● Rainfall, Runoff and its measurement, Hydrograph, Flow Duration Curve, Mass Curve and Reservoir Storage Capacity	06

	● Classification of Hydro plants: Run-off River Plant, Storage River Plant, Pumped Storage Plant	
3.	**Fluidized Bed Combustion:** ● Regimes of Combustion ● Circulating and Pressurized Fluidized Bed Combustion (FBC) system ● Fluidized Bed Boilers-Features and Classification ● Control of Nitrogen oxides	06
4.	**Nuclear Power Plants:** ● Introduction to Nuclear Engineering: Radioactive Decay, Half Life, Fission, Fusion, Nuclear materials ● Thermal Fission Reactors and Power Plants: PWR, BWR, Liquid Metal Reactors, Fast Breeder Reactors, Reactor Control	06
5.	**Diesel Power Plants:** ● General Layout, Systems, Advantages and Disadvantages, Applications **Gas Turbine (GT) Power Plants:** ● Types, Modifications, Performance Parameters and Comparison for: Open Cycle, Closed Cycle and Semi-closed Cycle GT plants ● Gas Turbine Material, Fuels, Applications ● Current Scenario and Future Scope for GT Power Plants	06
6.	**Combined Cycle Power Generation:** ● Thermodynamics of Combined Cycle Plants ● GT-ST combinations and plant operation, Cogeneration, Mixed Cycle Power Generation, Benefits ● Combined Power Generation Base Load and Peak Load Plants ● Combination and Co-ordination of different types of Power Plants	06
7.	**Environmental Impact of Power Plants** **Social and Economic Issues of Power Plants:** ● Thermal pollution, Air Pollution ● Greenhouse effect, Acid precipitation – Acid Rain and Acid Snow, Dry deposition and acid fog **Thermal Power Plants:** ● Coal storage, In-plant handling of coal, ● Ash handling systems, Dust collectors. Flue Gas Desulphurization (FGD), Electrostatic precipitator (ESP). **Nuclear Power Plants:** Nuclear Radiations, Disposal of radioactive waste	06

Course activities shall comprise of:

1. At least one assignment on each module comprising theoretical concepts and numerical examples.

2. Participation in activities such as industry expert lecture/ industry visit etc. organized by faculty for providing the wider exposure to students.
3. Technical / Case study presentations on course contents with application on power plants.
4. At least one MCQ Test based on course contents of GATE Examination.

Internal Assessment Criterion:
Assessment: Attendance – 5 Marks, Assignment- 10 Marks, Viva-voce/ MCQ Test – 10 Marks

Internal Assessment Activity with Industry 4.0 Approach:
1. Industry visit to Thermal/ Gas Turbine / Diesel/ Nuclear Power Plant / allied industry.
2. Lectures/seminar by experts from thermal based industry/ plant/ R & D organization.
3. Internship (of one to two weeks) in a thermal industry/ plant of repute.
4. Case study: Practices of operation, waste heat recovery, efficiency enhancement, operation and maintenance, pollution control etc. from thermal power plant/ R & D organization.

Text Books:

1. Nag, P. K., *Power Plant Engineering*. Tata McGraw-Hill Education, 2002.
2. Ei-Wakil, M.M, *Power Plant Technology*, McGraw Hill, 2016, (https://engineeringstudymaterial.net/ebook/power-plant-technology)
3. Domkundwar, A. S., *Power Plant Engineering*,Dhanpat Raj & Sons, India, 2000.
4. Sharma, P. C. *Power Plant Engineering*. SK Kataria and Sons, 2009.
5. Rajput, R. K., *Power Plant Engineering*, Laxmi Publication (P) Ltd, 1995.
6. Dr, Yadav, R., *Steam and Gas Turbines and Power Plant Engineering*, Central Publishing House, 7th Revised edn., 2012.

Reference Books:

1.Morse, Frederick T., *Power plant engineering*, Van Nostrand, 1963.
2. Potter, Philip J. *Power plant theory and design*. Ronald Press Company, 1959.
3. Weisman, Joel, and Eckart Roy. *Modern Power Plant Engineering*,1985.
4. Bennet, John Donald and ThomsonJames Robert,*The Elements of Nuclear Power*,1989.
5. Elliott, Thomas C., *Standard Handbook of Power Plant Engineering*, 1989.

Recommended NPTEL/ Online Lectures / Courses :
1. Power Plant Engineering NPTEL Course Lectures by Prof. Ravi Kumar, IIT Roorkee https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-me10/
2. Fundamentals of Nuclear Power Generation NPTEL Course Lectures by Prof. Dipankar N. Basu, IIT Guwahati https://nptel.ac.in/courses/112/103/112103243/

Sr. No.	Examination	Module
1	Mid Term	1 to 3

2	**IE**	**1 to 7**
3	**End Sem**	**1 to 7**

PE-BTM715 Automobile Engineering

Course pre-requisites: Engineering materials, IC engine, Dynamics

Course Objectives:

- To introduce students to the fundamentals of automobile systems, vehicle performance, steering, suspension, braking, electrical systems, and body design.
- To develop basic understanding of automotive powertrain, chassis design, vehicle dynamics, and recent trends in electric vehicle technology.

Course Outcomes:

Upon successful completion of the course, students should be able

1. Explain the basic automobile systems, vehicle performance parameters, and air-standard cycle analysis.
2. Analyze steering, suspension, power transmission, and braking systems used in automobiles.
3. Describe automobile electrical systems, accessories, body design, chassis, and frame structures.
4. Understand recent trends in automobiles, including electric vehicle design, battery thermal management, and EV powertrain systems.

Course Contents:

Module No.	Details	Hrs.
01	**Introduction**: Overview of automobiles, Classification of automobiles, Brief introduction to all sub systems of automobiles. Air standard cycles performance analysis and their relative comparison. **Vehicle performance**: Tractive force Vs Vehicle speed, resistance to motion of the Vehicle–Rolling and gradient resistance, power requirement for acceleration and gradeability, maximum acceleration for front wheel drive – Rear wheel drive – four wheel drive Vehicles,	**08**
02	**Steering System:** Functions, Fifth wheel Steering system, four wheel Steering system (Ackerman steering geometry), Classification of steering system, Steering Column Assembly and components, Manual Assist Steering, Power Assist Steering and its classes, Kinematics of Bicycle model: Vehicle trajectory, Wheel Alignment and its parameters, special features of steering column, Under steer and Over steer	**07**
03	**Suspension systems**: Objectives of Suspension, basic requirements, types of Suspension, Function, Challenges, Different dependent and independent suspension system & Components, Analysis of suspension system, **Automobile Power Train**: Requirements of automotive power train, Ideal Prime mover characteristic, Components of Clutch and its characteristics, Construction of Gear Box, Gear ratio,	**06**

	synchronous and unsynchronous transmission, Realization of power transmission in manual mode, Forces acting on vehicle, Intermediate gear ratio, Tractive force	
04	**Brake System:** Desirable requirements, Evolution of brake, Functional grouping of braking system, Components of brake system, Disk and drum brake performance, reliability, brake fade, friction material sensitivity, Hydraulic brake, Air brake and its detailed circuit components and working, Hydraulic oil, Dynamic load transfer and static load transfer in braking and acceleration.	**06**
05	**Electrical system:** Automobile electrical system includes Starting system, charging system, Ignition system and lighting system, Accessories include Horn and Mobile charging system **Automobile accessories:** Wipers system and its operation control, mechanism of drive in wipers, Flashing lamp system, Electric circuit, Windows regulator and its types, Speedometer, Odometer, Horn system.	**06**
06	**Vehicle Body Design**: importance of body design, material for body constructions–styling forms–coach and bus body style, layouts of passenger cars, bus and Truck bodies. Aerodynamic drag–aerodynamic lifts , pitching moments, side force, yawing moments and Rolling moments. **Basic dimensions**: geometrical relations to driver seat, dimensions of foot and pedal control, passenger seats, vehicle dimensions and visibility. **Chassis types and structure types**: open semi integral pedal and integral Bus structures. **Frames**: function and types, loads on frames, load distribution of structure.	**08**
07	**Recent trends in Automobile**: Electric Vehicle design, Battery Design and its thermal management system, Power train of EV, Dynamics of EV, Maintenance aspects of EV.	**07**

Course activities shall comprise of:

Course activities shall consist of a minimum of eight experiments and assignments.

Text Books:

1. Singh, Kirpal. *Automobile engineering*. Standard publishers, 1994.
2. Giri, N. K. *Automobile mechanics*. 2013.
3. Banga, T. R., and Natthana Siṃha. *A textbook on Automobile Engineering*. Khanna Publ., 1987.
4. Steed W., *Principle of vehicle dynamics*
5. Gupta, R. B. "Automobile engineering." *Satya Prakashan* (1993).

References:

1. Reyat H.S., *The Automobile*, S.Chand and Co., 2004.
2. Pawlowski, Janusz, and Guy Tidbury. *Vehicle body engineering*. Business Books, 1969.
3. King, Dick H. *Computerized engine controls*. Delmar Publishers Inc., 1990.
4. Crouse, William H., and William Harry Crouse. *Automotive mechanics*. Tata McGraw-Hill Education, 1982.

5. Garrett, Thomas Kenneth, Kenneth Newton, and William Steeds. *Motor vehicle*. Butterworth-Heinemann, 2000.

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTM701 Financial Planning and Wealth Management

Course pre-requisites : Financial Planning and Wealth Management

Course Objectives:

The objectives of this course are:

1. To develop financial literacy and understanding of personal finance, investing, insurance, taxation, and retirement planning.
2. To apply concepts of saving, investing, compounding, and time value of money to achieve short-term and long-term financial goals.
3. To analyze various investment avenues, including equities, debt instruments, mutual funds, ETFs, gold, real estate, and retirement schemes, for effective wealth creation and portfolio diversification.
4. To equip students with practical financial planning skills for wealth creation and informed financial decision-making.

Course Outcome:

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

1. Explain the fundamentals of personal finance, financial planning, investment instruments, taxation, and insurance concepts.
2. Apply financial calculations and tools for budgeting, investment planning, loan analysis, and retirement planning.
3. Analyze financial products, market indicators, and investment opportunities using basic financial parameters and risk-return concepts.
4. Demonstrate informed financial decision-making skills for personal wealth creation and long-term financial sustainability.

Course Content:

Module	Details	Hrs.
01	**Foundations of Personal Finance** Introduction to personal finance, financial planning, and financial independence; Concepts of saving, investing, time value of money, compounding, inflation, and purchasing power; Budgeting, personal cash flow management, saving habits, and emergency fund planning; Financial goal setting, goal-based investing, and common financial mistakes; Practical exercises on budgeting, SIP growth, and basic financial planning.	5

02	**Banking, Credit and Taxation** Indian banking system, digital banking, deposits, credit score, loans, and EMI concepts. Basics of income tax, tax slabs, tax-saving instruments, and responsible financial practices. Practical exercises on EMI and tax calculations.	5
03	**Investment Fundamentals** Risk and return concepts, asset classes, and principles of wealth creation. Equity, debt, gold, real estate, SIP, lump sum investing, and compounding concepts. Goal-based investing, inflation-adjusted returns, and basic portfolio planning. Practical exercises on investment and SIP calculations.	6
04	**Stock Market and Mutual Funds** Introduction to stock markets, stock indices, mutual funds, ETFs, and index investing. Financial parameters including PE, EPS, ROE, CAGR, and basics of fundamental analysis. nvestment behavior, market risks, and common investing mistakes. Practical exercises on company and mutual fund analysis.	8
05	**Insurance and Risk Management** Basics of life, health, and general insurance, term insurance, and investment-linked insurance products. Risk management principles, financial protection, and emergency financial planning. Practical exercises on insurance need analysis and risk assessment.	4
06	**Retirement Planning and Financial Independence** Retirement planning concepts, pension systems, EPF, PPF, NPS, and passive income strategies. Financial independence, SWP, retirement corpus estimation, and long-term wealth sustainability. Practical exercises on retirement and financial planning calculations.	4
07	**Financial Tools and Real-Life Applications** Use of Excel and financial tools for budgeting, investment analysis, CAGR, and XIRR calculations. Portfolio tracking, financial fraud awareness, and practical financial decision-making. Case studies and practical exercises on personal financial planning.	4

Internal assessment criterion:

Internal assessment work shall consist of one assignment for each module, including case studies on topics like intelligent design, breakthrough innovation, etc.

Text Books:

1. Prasanna Chandra, *Investment Analysis and Portfolio Management*, 6th Edition, McGraw Hill Education, 2021.
2. H. S. Shylaja and M. S. Ramesh, *Personal Finance: A Practical Approach*, McGraw Hill Education, 2020.
3. Sanjay Tolani and R. Srinivasan, *Financial Planning and Wealth Management*, McGraw Hill Education, 2019.
4. Monika Halan, *Let's Talk Money: You've Worked Hard for It, Now Make It Work for You*, Harper Business, 2018.
5. Robert T. Kiyosaki and Sharon L. Lechter, *Rich Dad Poor Dad*, Plata Publishing, 2017.

Reference Books:

1. Monika Halan. '*Let's Talk Money: You've Worked Hard for It, Now Make It Work for You*.' HarperCollins India.
2. Morgan Housel, 'The Psychology of Money: Timeless Lessons on Wealth, Greed, and Happiness', Harriman House
3. Parikh, Parag. *Value Investing and Behavioral Finance: Insights into Indian Stock Market Realities.* Tata McGraw-Hill Education.

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

IC-BT01 Research Methodology and Ethics

Course pre-requisites: General Engineering, Communication Skills

Course Objectives:

1. To learn research methodology
2. To learn research methodology tools and techniques
3. To learn research report writing
4. To develop the skill required for preparing technical research report, presenting research outcomes effectively , and practicing ethical standards in research

Course Outcomes:

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

1. understand the basics of Research Methodology
2. understand the Tools and techniques in Research Methodology
3. use the knowledge of data collection methods
4. write the research report

Course Contents:

Module.	Details	Hrs.
01	Research – definition; types of research methods, pure and applied research. descriptive and explanatory research, qualitative and quantitative approaches,	03
02	Research procedure: Considerations in selecting the research problem Formulating the problem statement, Research design - sample size.	06
03	Literature survey- Guidelines for literature survey	06
04	Data collection methods- Interview, experimental methods, case study, questionnaire design	09
05	Regression Equation and Curve fitting, Multivariate analysis, and Hypothesis tests: z test, F test, t-test, Chi Sq test, Validity of research outcomes. Suggestions and recommendations, Identifying future scope	06
06	Writing research reports – Chapters, paragraphs, sentences, figures, tables, charts, references, etc., Presentation of experimental setup, models, result analysis and conclusion	06
07	Research and publication ethics – Common unethical practices, Plagiarism, Predatory journals and Others.	06

Internal assessment criterion:

Internal assessment criterion shall consist of one assignment for each module, including case studies on topics like intelligent design, breakthrough innovation, etc.

Text Books:

1. Kothari C R, Research Methodology, Wiley Eastern
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PR-BTM701 Project

Course pre-requisites: All fundamental courses of the mechanical engineering

Course Objective:
The objective of the field project is to integrate theory with practices in society or industries. Students will be able to understand and work on real-world challenges and issues. It can be used to learn, investigate, analyze, and conclude to develop a solution to a problem, which may be a local technical, social problem or industrial problem. The field project may be extended to a major project with the additional scope of the problem. It can be a group work.

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

1. integrate the knowledge of the fundamentals of subjects to search the related literature and devise solutions,
2. use knowledge for formulation/fabrication of the desired project,
3. analyze the available resources and select the most appropriate one,
4. apply principles of ethics and standards, skill of presentation and communication techniques.

Course content:

Sr.no.	Description	Hrs./week
1	Students should visit industries and social institutes/organizations and understand their systems. They can pick up a live problem, if any, or identify an existing system that can be analyzed for a better technical solution. If it is a group project, the work must be distributed among the group members. The work may involve- data collection, analysis, and inferencing. The student shall prepare an interim report and shall present a seminar on the work done at the end of the semester.	2

MI- BT024 Minor-4

The course content of all Minors offered by the institute during an academic year is provided separately. Students are advised to visit the list of Minors to see the details of the associated courses and their course contents.

PE-BTM8xxx Professional Elective-IV

The department will recommend a list of NPTEL/SAWAYAM courses and PE before the commencement of the academic year or offered in online mode.

PE-BTM811 Engineering Simulation Techniques

Course pre-requisites: CAD, BIM, FEA

Course Objectives:
The primary objective of this course is

1. To understand the evolution from traditional FEA/CFD toward AI-enhanced intelligent simulation systems.
2. To explore how intermediate node-level data can be transformed into predictive intelligence using AI/ML.
3. To introduce data driven frameworks integrating physics-based and data-driven models.
4. To enable students to develop simulation-driven predictive engineering workflows. Expose students to next-generation intelligent engineering systems used in Industry 4.0 and Industry 5.0.

Course Outcomes:
Upon successful completion of the course, students should be able

1. Explain the limitations of traditional FEA/CFD approaches and the emergence of intelligent simulation systems using AI and data driven systems.
2. Analyze intermediate node-level simulation data and identify its predictive significance in engineering systems.
3. Apply AI/ML techniques such as CNNs, LSTMs, Autoencoders, and PINNs to engineering simulation datasets.
4. Evaluate intelligent simulation approaches for fault prediction, adaptive monitoring, and real-time engineering decision-making.

Course Content:

Module	Details	Hrs.
1	**Evolution of Engineering Simulation** Fundamentals of FEA and CFD, Traditional simulation workflows, Solver convergence and iterative computation, Limitations of extreme-condition analysis, Evolution toward intelligent simulation systems, Introduction to Digital Engineering and Industry 4.0	4
2	**Simulation Intelligence** Nature of intermediate solver data, Stress evolution and convergence histories, Temporal and spatial behavior in simulations, Hidden	6

	information in node-level datasets, significance of intermediate data, Predictive significance of transient simulation behavior	
3	**AI and Machine Learning for Simulation Engineering** Fundamentals of AI/ML for engineering systems, CNNs for spatial simulation pattern recognition, LSTMs/RNNs for temporal simulation evolution, Autoencoders and PCA for dimensionality reduction, Introduction to Physics-Informed Neural Networks (PINNs)	6
4	**Intelligent data driven simulation systems** Concepts and architecture of data driven systems, Physics-based vs data-driven systems, Hybrid data driven system frameworks, Real-time synchronization with physical systems, Sensor integration and IoT-enabled simulation, Adaptive and self-learning engineering systems	6
5	**Predictive Engineering Analytics** AI-driven anomaly detection, Predictive maintenance using simulation intelligence, Failure forecasting and condition monitoring, Sensitivity analysis and what-if prediction, Reduced Order Models (ROMs), AI-assisted surrogate simulation models	5
6	**Intelligent Simulation Applications** Intelligent structural analysis, Smart thermal systems, AI-enhanced CFD applications, Data driven systems for manufacturing, Aerospace, automotive, and energy case studies, Real-time simulation for autonomous engineering systems	4
7	**Future of Simulation Engineering** Generative AI in engineering simulation, Agentic AI for autonomous engineering decisions, Cloud and edge simulation systems, XR/VR-enabled simulation visualization, Ethical and industrial implications, Careers in intelligent simulation and Digital Engineering	5
Internal Assessment Criterion		
Course activities shall comprised of: 1. Journal work shall consist of one assignment on each module 2. Seminar 3. One Mini Project		

Text Books
1. Machine Learning in Engineering – Sunila Gollapudi 2. Artificial Intelligence for Engineers – Piero Molino 3. Finite Element Procedures – Klaus-Jürgen Bathe 4. Computational Fluid Dynamics – John D. Anderson
Reference Books
1. Physics-Informed Machine Learning – Karniadakis 2. Deep Learning – Ian Goodfellow 3. AI Applications in Manufacturing – Springer 4. Digital Engineering for Industry 4.0 – Elsevier

Sr. No.	Examination	Module
1	Mid Term	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM812 Intelligent CAD CAM Systems

Course pre-requisites: Manufacturing Processes, CNC

Course Objectives:

1. To explore the application of AIML, DL, GenAI, and Agentic AI in CAD/CAM.
2. To understand the role of virtual real time systems, extended reality, and cloud-edge computing in next-gen manufacturing.
3. To enable students to design, simulate, and optimize intelligent CAD/CAM workflows.
4. To introduce future professional directions in AI-augmented product design and smart manufacturing systems.

Course Outcomes:

Upon successful completion of the course, students should be able

1. Understand the evolution and fundamentals of CAD/CAM systems and how Artificial Intelligence and emerging technologies
2. Apply AI and Machine Learning techniques such as knowledge-based systems, neural networks, and optimization algorithms to automate design and manufacturing decision-making.
3. Develop intelligent CAD models using parametric, generative, or feature-based design methods integrated with AI-based tools and digital workflows
4. Analyze data from CAM processes and sensor-integrated machines to enable adaptive control, predictive maintenance, and process optimization.

Course Content

Module	Details	Hrs.
1	**AI Foundations for CAD/CAM** Role of AI, ML, DL, and GenAI in CAD/CAM., Data-driven design: supervised & unsupervised learning for geometry and design optimization, Agentic AI: autonomous systems in design and manufacturing, Case studies: AI-assisted CAD tools	4
2	**AI in Geometric and Solid Modeling** Feature extraction & recognition using ML/DL, GenAI for geometry creation, generative design, and topology optimization, Intelligent 3D modeling:	6

	parametric + AI-driven shape adaptation. Neural implicit representations for 3D models	
3	**Intelligent Process Planning & Quality Control** AI-enabled Computer-Aided Process Planning (CAPP). Predictive quality analytics with ML/DL. Computer vision in quality control and defect detection. Agent-based decision support in process planning.	6
4	**Smart CNC and Intelligent Manufacturing Systems** AI-driven CNC optimization: adaptive machining using ML. Digital twins of CNC machines for predictive maintenance. Agentic AI for shop floor scheduling and decision-making. Cloud-CNC and edge computing in manufacturing execution.	6
5	**Data-Driven Transformations & Knowledge Management** Knowledge graphs in CAD/CAM, NoSQL, Big Data & AI integration for design data, Semantic design databases with intelligent retrieval, Blockchain in design-data security & traceability.	5
6	**Digital Twin and Extended Reality in CAD/CAM** Process digital twins for CAD/CAM workflows, Virtual Manufacturing with AI integration. AR/VR/MR applications in design validation & training, Cloud & IoT-enabled CAD/CAM ecosystems.	4
7	**Emerging Professional Applications & Future Directions** AI in sustainable and green manufacturing., Multi-agent AI for supply chain-integrated CAD/CAM, GenAI-driven reverse engineering, Ethical & socio-technical aspects of AI in design & manufacturing, Career pathways in AI-driven CAD/CAM.	5

Internal Assessment Criterion:

Internal Assessment/ Laboratory

1. Journal work shall consist of one assignment on each module
2. Seminar
3. One Mini Project

Text Books

1. CAD/CAM: Computer-Aided Design and Manufacturing – Mikell P. Groover & Emory W. Zimmers, PHI.
2. CAD/CAM: Theory and Practice – Ibrahim Zeid, McGraw Hill.

3. Artificial Intelligence for Engineers – Piero Molino & Chip Huyen.
4. Generative Deep Learning – David Foster, O'Reilly.
5. Digital Twin Driven Smart Manufacturing – Fei Tao, Ang Liu, Tianliang Hu.

Reference Books

6. Artificial Intelligence for Design and Manufacturing – D.T. Pham & E.E. Dimov.
7. Machine Learning Applications in Manufacturing – J. Lee, Springer.
8. Generative Design: Visualize, Program, and Create with JavaScript – Hartmut Bohnacker et al.
9. Cognitive Manufacturing: AI Applications in Industry 4.0 – IBM Research.
10. Extended Reality in Manufacturing – Springer Series on XR & Industry 4.0.
11. Recent Journals & Case Studies – CIRP Annals, Journal of Manufacturing Systems, IEEE Transactions on Industrial Informatics.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

PE-BTM813 Non-traditional Machining Processes

Course pre-requisites: Manufacturing Processes

Course Objectives:

1. To understand the fundamentals of conventional and non-conventional manufacturing processes and their industrial applications.
2. To study the principles, classifications, and applications of unconventional machining processes and advanced machining systems.
3. To understand the principles, techniques, and applications of unconventional joining processes and advanced joining technologies.
4. To explore the principles, methods, and industrial applications of unconventional forming processes.

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

1. Apply the principles of mechanical, chemical, and electrochemical energy in the selection and implementation of unconventional machining processes.
2. Analyze and apply explosive energy, high-energy beam technologies, water jet, electromagnetic, electrical discharge, and explosive energy-based techniques in unconventional joining and forming processes.
3. Develop mathematical models and analyze the performance of various unconventional machining processes for process evaluation and optimization.
4. Assess industrial requirements, sustainability considerations, and environmental aspects to select appropriate unconventional manufacturing processes for modern engineering applications.

Course Content

Module	Details	Hrs.
1	Need for non-traditional machining methods-Classification of modern machining processes – considerations in process selection. Materials, Applications. Ultrasonic machining – Elements of the process, mechanics of metal removal process parameters, economic considerations, applications and limitations, recent development.	4
2	Abrasive jet machining, Water jet machining and abrasive water jet machine: Basic principles, equipments, process variables, mechanics of metal removal, MRR, application and limitations.	6
3	Electro – chemical processes : Fundamentals of electro chemical machining, electrochemical grinding, electro chemical honing and deburring process, metal removal rate in ECM, Tool design, Surface finish and accuracy economic aspects	6

	of ECM – Simple problems for estimation of metal removal rate. Fundamentals of chemical, machining, advantages and applications.	
4	Thermal metal removal processes : General Principle and applications of Electric Discharge Machining, Electric Discharge Grinding and electric discharge wire cutting processes – Power circuits for EDM, Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, methods surface finish and machining accuracy, characteristics of spark eroded surface and machine tool selection. Wire EDM, principle, applications.	6
5	Generation and control of electron beam for machining, theory of electron beam machining, comparison of thermal and non-thermal processes –General Principle and application of laser beam machining – thermal features, cutting speed and accuracy of cut.	5
6	Application of plasma for machining, metal removal mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries. Chemical machining-principle- maskants –etchants-applications.	4
7	Sustainable and Green Non-Traditional Machining – Eco-friendly dielectrics, minimum energy machining, recycling of process media, environmental and safety aspects. Industrial case studies in aerospace, biomedical, electronics, automotive, and precision engineering.	5

Course activities shall comprise of:

- At least one assignment on each module comprising theoretical concepts and numerical examples.
- Participation in activities such as industry expert lecture/ industry visit etc. organized by faculty for providing the wider exposure to students.
- Technical / Case study presentations on course contents with application on different Non-traditional Machining Processes.
- At least one MCQ Test based on course contents of GATE Examination.

Internal Assessment Criterion:

Internal Assessment

Assessment: Attendance – 5 Marks, Assignment- 10 Marks, Viva-voce/ MCQ Test – 10 Marks

Text Books

1. Jain, V. K., *Advanced Machining Processes*, Allied Publishers Pvt. Ltd., New Delhi, First Edition, 2009.
2. Groover, M. P., *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, John Wiley & Sons, 7th Edition, 2023.

3. Davim, J. P. (Ed.), *Sustainable Manufacturing*, ISTE Ltd. and John Wiley & Sons, First Edition, 2010.

Reference Books

1. Benedict. G.F. "Nontraditional Manufacturing Processes", Marcel Dekker Inc., New York, 1987.
2. Mc Geough, "Advanced Methods of Machining", Chapman and Hall, London, 1998.
3. Paul De Garmo, J.T.Black, and Ronald. A.Kohser, "Material and Processes in Manufacturing" Prentice Hall of India Pvt. Ltd., 8thEdition, New Delhi , 2001.
4. Dornfeld, D. A., *Green Manufacturing: Fundamentals and Applications*, Springer Science & Business Media, 2013.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTxxx Open Elective – II

The department will recommend a list of NPTEL/SAWAYAM courses as OE before the commencement of the academic year or offered in online mode.

OE-BTM801 AI-Enabled Research Methodology

Course Pre-requisites: General Engineering, Communication Skills, Basic Computer Programming

Course Objectives:

1. To understand modern research methodologies and scientific inquiry.
2. To apply AI, GenAI and Agentic AI tools in research activities.
3. To perform data analytics, machine learning and Python-based research workflows.
4. To utilize GenAI and Agentic AI for scientific discovery and communication.

Course Outcomes:

1. Understand research methodology and AI-enabled research processes.
2. Conduct AI-assisted literature reviews and identify research gaps.
3. Apply Python programming and data analytics in research.
4. Develop ML/DL models for engineering research applications.

Course Contents:

Module No.	Details	Hrs.
01	Foundations of Research Methodology: Definition and purpose of research; Types of research; Qualitative and Quantitative research; Research process framework; Research problem identification; Research objectives and hypothesis formulation; Design thinking for research; AI-augmented research lifecycle.	06
02	AI-Assisted Literature Review and Research Discovery: Literature survey and review; Systematic Literature Review (SLR); PRISMA framework; Bibliometric analysis; Citation network analysis; Research gap identification; AI-assisted literature discovery.	06
03	Python Programming for Research: Variables, data types, loops and functions; Data structures; NumPy and Pandas; Data visualization using Matplotlib; Statistical analysis; Research dataset handling; Development of Python programs for research applications.	08
04	Data Collection, Data Preparation and Research Analytics: Survey design; Questionnaire design; Interviews; Case studies; Experimental methods; IoT and sensor data; Data cleaning; Missing values; Data normalization; Outlier detection; Feature selection; Redundant data identification; Exploratory data analysis.	08
05	Machine Learning for Engineering Research: AI and ML fundamentals; Machine learning workflow; Training, validation and testing; Supervised learning (Linear Regression, Logistic Regression, Decision Trees, Random Forest, SVM); Unsupervised learning (K-Means, Hierarchical Clustering, PCA); Reinforcement learning concepts; Model evaluation metrics; Python implementation.	08
06	Deep Learning, Generative AI and Agentic AI for Research: Artificial Neural Networks; CNN; RNN; Transformers and Large Language Models; Prompt engineering; Retrieval Augmented Generation (RAG); Agentic AI; Multi-agent research systems; Autonomous literature review; AI-assisted knowledge discovery and scientific writing.	06

07	Research Validation, Scientific Communication and Ethics: Regression and curve fitting; Hypothesis testing (Z-test, t-test, F-test, Chi-square test); Research report writing; Technical papers; Journal publications; Impact factor and quartile rankings; Research ethics; Plagiarism; Responsible AI; Reproducible research; Future scope and recommendations.	06

Internal Assessment Criterion:

Course activities shall consist of:

1. Journal work shall consist of one assignment on each module
2. Seminar
3. One Mini Project

Text Books

1.C.R. Kothari and Gaurav Garg, *Research Methodology: Methods and Techniques*, 4th Edition, New Age International Publishers, 2019.

2. Wes McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter*, 3rd Edition, O'Reilly Media, 2022.

3. Aurelien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*, 3rd Edition, O'Reilly Media, 2022.

4.Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, 2016.

5.Brett Lantz, *Machine Learning with R: Expert Techniques for Predictive Modeling*, 3rd Edition, Packt Publishing, 2019.

Reference Books

1. John W. Creswell and J. David Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 6th Edition, SAGE Publications, 2023.

2. Barbara Kitchenham and Stuart Charters, *Guidelines for Performing Systematic Literature Reviews in Software Engineering*, EBSE Technical Report, 2007.

3. R. S. Pressman and Bruce R. Maxim, *Software Engineering: A Practitioner's Approach*, 9th Edition, McGraw-Hill Education, 2019. (For systematic review and research practices)

4.Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd Edition, Springer, 2009.

5. Christopher M. Bishop and Hugh Bishop, *Deep Learning: Foundations and Concepts*, Springer, 2024.

6.Nielsen, Michael A., *Neural Networks and Deep Learning*, Determination Press, 2015.

7. P. W. Taylor and J. S. Taylor, *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*, University Science Book

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTM802 Value Engineering

Course pre-requisites: General

Engineering Course Objectives:

1. To understand and analyse the theory and methodology of Value Engineering with the Guidelines
2. To understand the step by step application of the technique to the current industrial problems.
3. To provide the knowledge about Value engineering Principles, the various models and implementation method, which are adopted in the industries.
4. To develop creativity and innovation skills using various idea-generation and evaluation methodologies.

Course Outcomes:

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

1. To understand the concepts of value engineering, identify the advantages, applications.
2. To analyze the function, approach of function and evaluation of function. Determine the worth and value.
3. Appraise the value engineering operation in maintenance and repair activities.
4. To improve management skill

Course Content

Module No.	Course content	Hours
1	What is Value Engineering, Myths on Value Engineering, History of Value Engineering. Why Value Engineering. Understanding Value and different types of Values, Introduction of Function and its importance in Value creation	04
2	Identifying Functions and Job Plan Methodology, Projects identification and Techniques	04
3	Function Analysis System Technique. (FAST) with exercises, Function – Cost – Worth. (FCW)	04
4	Team building and its Role in success of projects, Creativity & Innovation. Different methodologies for Ideas generation	04
5	Evaluation of Ideas and various Techniques, Implementation of Ideas and Logical conclusions of projects	04
6	Hands on practice on Implementation of Projects by students	04
7	Value engineering Projects in Construction Industry, Manufacturing Industry and Service Industries	04

Internal Assessment Criterion:

- Case study presentation: 15 marks
- Group Discussion: 05 marks
- Attendance: 05 marks

Text Book:

1. Anil Kumar Mukhopadhyaya, "Value Engineering: Concepts Techniques and applications", SAGE Publications 2010

References:

1. Alphonse Dell'Isola, "Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations", R S Means Co., 1997.
2. Richard Park, "Value Engineering: A Plan for Invention", St. Lucie Press, 1999.
3. Del L. Younker, "Value Engineering analysis and methodology", Marcel Dekker Inc, New York, 2004.
4. Miles, L.D., "Techniques of Value Analysis and Engineering", McGraw Hill second Edition, 1989.
5. Khanna, O.P., "Industrial Engineering and Management", DhanpatRai& Sons, 1993.
6. Anil Kumar Mukhopadhyaya, "Value Engineering Mastermind: From concept to Value Engineering Certification", SAGE Publications, 2003.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE BTM803 Solar and Wind Technology

Course pre-requisites: Engineering sciences

Course Objective:

1. To introduce the fundamentals of solar and wind energy systems and develop skills to assess, design, and analyze renewable power generation systems.
2. To understand the fundamentals of solar radiation, solar thermal energy, solar photovoltaic systems, and wind energy conversion technologies for renewable power generation.
3. To analyze the design, performance, and operational characteristics of standalone and grid-connected solar PV systems, solar thermal power plants, and wind energy systems under different climatic and operating conditions.
4. To develop the ability to estimate solar radiation, evaluate renewable energy system performance, and utilize computational tools such as PVSyst and Tonatiuh for modeling and performance analysis.

Course Outcomes:

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

1. Explain solar radiation, Sun-Earth geometry, and solar measurement methods.
2. Estimate solar radiation and analyze solar thermal power systems.
3. Design and evaluate standalone and grid-connected solar PV systems.
4. Analyze wind turbines, wind farms, and wind energy conversion systems.

Course Content:

Module No.	Details	Hrs.
01	**Module-1** Introduction to power generation, Global and Indian scenario, an overview of current technologies available for power generation. Physics of propagation of solar radiation from the sun to earth. Sun-Earth Geometry, Extra-Terrestrial and Terrestrial Radiation, Solar energy measuring instruments	06
02	**Module-2** Estimation of solar radiation under different climatic conditions, Estimation of total radiation. Solar Thermal Power Generation, Fundamentals of Solar thermal energy conversion, solar thermal based power plant design and analysis (flat plate and concentrator)	06
03	**Module-3** Solar Photovoltaic Power Generation Fundamentals of Solar photovoltaic energy conversion, Solar PV power plant design, Performance analysis of standalone and grid connected PV systems.	06
04	**Module-4** PV standalone system components, Standalone PV-system design. Components of grid-connected PV system, solar power plant design and performance analysis. Analysis of systems/case study using Tonatiuh and PVSyst computational tool	06
05	**Module-5** Introduction to wind turbine, Turbine types and terms, classification and analysis of different components, Theory, design and analysis of wind turbines (horizontal axis and vertical axis) and wind farms	06

06	**Module-6** Physics of wind energy conversion system, Linear momentum and basic theory, Energy extraction, Axial force on turbines, Torque, Drag machines. Dynamic matching, Optimal rotation rate; tip-speed ratio, Extensions of linear momentum theory..	**06**
07	**Module-7** Blade element theory. Characteristics of the wind, Basic meteorological data and wind speed time series, Variation with heigh, Power extraction by a turbine, Electricity generation, Classification of electricity systems using wind power, Electricity generation for utility grids: wind farms, Individual machines and integrated systems	**06**

Internal Assessment Criterion:
Minimum One assignment on each module.

Text Books:

1. John Twidell and Tony Weir. " Renewable Energy Resources." (2006).
2. Wind and Solar Power Systems: Design, Analysis, and Operation by Mukund R. Patel
3. Duffie, J. A., & Beckman, W. A., *Solar Engineering of Thermal Processes*, 5th Edition, John Wiley & Sons, 2020.
4. Manwell, J. F., McGowan, J. G., & Rogers, A. L., *Wind Energy Explained: Theory, Design and Application*, 3rd Edition, John Wiley & Sons, 2024.
5. Sukhatme, S. P., Nayak, J. K., & Baredar, P., *Solar Energy: Principles of Thermal Collection and Storage*, 5th Edition, McGraw Hill Education, 2023.

References:

1. "Wind Power Technology" by Joshua Earnest
2. "Solar PV and Wind Energy Conversion Systems (Green Energy and Technology)" by S Sumathi and L Ashok Kumar
3. Masters, G. M., Renewable and Efficient Electric Power Systems, 3rd Edition, John Wiley & Sons, 2013.
4. Boyle, G. (Ed.), Renewable Energy: Power for a Sustainable Future, 4th Edition, Oxford University Press, 2022.
5. Kalogirou, S. A., Solar Energy Engineering: Processes and Systems, 3rd Edition, Academic Press (Elsevier), 2020.
6. Ackermann, T. (Ed.), Wind Power in Power Systems, 3rd Edition, John Wiley & Sons, 2024.
7. Twidell, J., & Weir, T., Renewable Energy Resources, 4th Edition, Routledge, 2021.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTM804 Generative Design

Prerequisite: CAD, BIM, MACHINE LEARNING, FEA

Course Objectives:

1. To understand the fundamentals of generative design
2. To understand generative design as an interdisciplinary technology
3. To understand, how ML & DL can be used in generative design
4. To understand, how evolutionary & genetic algorithms help generate multiple design solutions

Course Outcomes:

Students will demonstrate the ability to

1. Explain & write basic concepts of generative design
2. Identify various enabling technologies of generative design.
3. Apply theoretical knowledge in practice
4. Develop multiple design solutions using related software

Module	Details	Hours
1	**Introduction to Industry 4.0:** Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics & enabling technologies of industry 4.0, Relevance of GE in INDUSTRY4.0	4
2	**Overview of Generative Design (GE):** Introduction to Generative Design,, Components of GE, Significance of GE in Mechanical & Civil Engineering structures & components, Enabling Technologies, Generative Design Framework, CAD & BIM models in GE, CAD & FEA integration, Additive Manufacturing	6
3	**Artificial Intelligence:** Overview of AI, Rule based design **Machine Learning based Design Generation:** Overview of Supervised, Unsupervised & Reinforced learning Algorithms for Generative Design **Deep Neural Design Generation:** Artificial Neural Network (ANN), Convolutional Neural Network (CNN), Auto Encoders & Decoders for Generative Design (GE) & Generative Adversarial Networks (GAN)	6
4	**Topology Optimization:** Problem Formulation, Design Parameterization, Structural Optimization, Sensitivity Analysis, Algorithms for solving problems & implementation, Convergence of solution, Optimal solution	6

5	**Evolutionary & Genetic Algorithms:** Biological evolution, Fitness evaluation, Selection, Crossover/recombination, mutation, next generation, evolutionary strategies, overview of Genetic & evolutionary programming	5
6	**CASE STUDIES on Generative Design for Mechanical & Civil Engineering.** Defining Generative Objects, Defining Obstacle regions, Defining Preserve regions, Selecting load, Selecting Manufacturing method, solving generative study, viewing generative outcomes. FEA Analysis of multiple design solutions for various results like stress, deformation etc.	6
7	**Benefits & Applications:** benefits & applications of Generative Design in Mechanical & Civil Engineering, Future Scope. New Business & Revenue models.	3

Internal Assessment Criterion:

1. Journal work shall consist of one assignment on each module
2. Seminar
3. One Mini Project

Text Books

1. "Topology Optimization: Theory, Methods, and Applications" by Bendsoe and Sigmund
2. “Generative Design” Visualize, Program, and Create with JavaScript in P5.js by Benedikt Gross, Hartmut Bohnacker, Julia Laub, Claudius Lazzeroni · 2018, ISBN: 9781616897840, 1616897848, Publisher: Princeton Architectural Press
3. “Generative Design: Form-finding Techniques in Architecture” , By Asterios Agkathidis · 2016, Publisher:Laurence King Publishing, ISBN: 9781780676913
4. “Deep Learning with Python” by François Chollet,
5. “Introduction to evolutionary computing” by Agoston E Eibe, Publisher:Springer Berlin Heidelberg, ISBN:9783662448748, 3662448742
6. “Genetic algorithms in search, optimization, and machine learning” Book by David E. Goldberg.
7. Python Machine Learning, Machine Learning and Deep Learning with Python, Scikit-learn, and TensorFlow 2, 3rd Edition By Sebastian Raschka, Vahid Mirjalili · 2019,
ISBN:9781789958294, 1789958296, Publisher:Packt Publishing

Reference Books

1. "A Hands-On Introduction to Topology Optimization" by Amir M. Mirzendehdel and Krishnan Suresh "Homogenization and Structural Topology Optimization: Theory, Practice and Software" by Behrooz Hassani and Ernest Hinton.
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, by Aurelien Geron, ISBN-10 : 1492032646, Publisher : O'Reilly Media; 2nd edition (October 15, 2019)

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTM805 Introduction to Augmented Reality

Course pre-requisites: General knowledge of CAD Modelling

Course Objectives:

Upon successful completion of the course, students will be

1. To understand the fundamentals, architecture, enabling technologies, and hardware components of Augmented Reality (AR) systems.
2. To analyze the applications of Augmented Reality in engineering, manufacturing, education, maintenance, logistics, and other industrial domains.
3. To develop the ability to create and deploy AR models by converting CAD models, addressing lighting and tracking issues, and utilizing AR development platforms and tools.
4. To apply Augmented Reality concepts by integrating AR with emerging technologies such as IoT and evaluating the challenges, opportunities, and business applications of AR solutions.

Course Outcomes:

After successful completion of the course student should be able to

1. Describe the theory related to Augmented Reality
2. Apply theoretical knowledge of AR in practice
3. Select the hardware & software for different applications.
4. Develop interactive augmented reality applications for both PC based mobile devices using a variety of novel input devices

Course Content:

Module No	Details	Hrs.
01	**Introduction** History of AR, Basics of Augmented Reality, Architecture/Framework, Marker & Marker less AR	06
02	**Enabling Technologies of Augmented Reality** Mobile, Camera, webcam, Cloud Computing, Unity, SDK, Augment, display of digital content, tracking, registration, recognition, rendering etc.	06
03	**Applications of AR in Industries & Education** Remote Maintainence, Product Development, Logistics, NDT, Architecture, civil building works & training, Manufacturing resource planning, Sales & marketing, Assembly, education etc.	06
04	**Lighting and Illumination Issues in AR** Conversion of CAD Model to AR Model	06
05	**Hardware** HOLOLENS INTERFACE	06
06	**Integration scenarios of AR with other IT Technologies** IOT+ AR Integration	06
07	**Challenges & Opportunities of AR** New business & Revenue models, Technological challenges faced by AR	06

Internal Assessment Criterion:

- It consists of **at least one** tutorial and/or assignments and/or hands-on excercises from each module of the curriculum mentioned for the course.
- One Presentation / Seminar related to AR
- Mini Project

TEXTBOOKS:

1. Cawood , Augmented Reality A Practical Guide Paperback – 2008
2. Schmalstieg, D., & Höllerer, T., *Augmented Reality: Principles and Practice*, 2nd Edition, Addison-Wesley Professional, 2024.
3. Carmigniani, J., & Furht, B. (Eds.), *Handbook of Augmented Reality*, Springer, 2011.
4. Greg Kipper & Joseph Rampolla, *Augmented Reality: An Emerging Technologies Guide to AR*, Syngress (Elsevier), 2013.

REFERENCE BOOKS:

1. Tobias Höllerer, Dieter Schmalstieg, Augmented Reality: Principles and Practice
5. Alan B. Craig, *Understanding Augmented Reality: Concepts and Applications*, Morgan Kaufmann (Elsevier), 2013.
6. Dieter Schmalstieg & Tobias Höllerer, *Augmented Reality: Principles and Practice*, Addison-Wesley Professional, 2016.
7. Burdea, G. C., & Coiffet, P., *Virtual Reality Technology*, 2nd Edition, John Wiley & Sons, 2003.
8. Jason Jerald, *The VR Book: Human-Centered Design for Virtual Reality*, Association for Computing Machinery (ACM), 2016.
9. Steven M. LaValle, *Virtual Reality*, Cambridge University Press, 2017.
1.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

OE-BTM714 Introduction to Micro Electro Mechanical Systems

Course pre-requisites: Engineering sciences

Course Objectives

1. To introduce basic concepts of MEMS and its applications.
2. To introduce sensors and actuators in Micro-domain.
3. To study modelling and simulation techniques for various applications.
4. Apply knowledge of micro fabrication techniques and applications to the design and manufacturing of an MEMS device or a micro system

Course Outcomes: Learner will be able to…

1. Select appropriate sensors and actuators for a given MEMS application.
2. Select a micro-fabrication technique for a specific MEMS fabrication process.
3. Model and simulate a given MEMS system
4. Design MEMS

Course content:

Sr.No.	Description	Hrs.
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	6
2	**Sensors and Actuators in Micro-domain** • Concept of Sensors & Actuators, • Sensing & Actuation Principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors.	6
3	**Fabrication Methods** Microfabrication Methods (VLSI Techniques) • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques.	6
4	**3D High Aspect Ratio Fabrication Techniques** • LIGA, • AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography etc	6

5	**Modelling and Simulation Techniques** • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis.	**6**
6	**Characterization Techniques** Topography Methods (Optical, Electrical and Mechanical Methods) • Microscopy, STM (Scanning Tunneling Microscopes),	**6**
	• SEM (Scanning Electron Microscopes),SPM (Scanning ProbeMicroscopes), AFM (Atomic Force Microscopes) Mechanical Structure Analysis	
7	**Introduction to Advances of MEMS and Nanotechnology** • CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, • Nano-mechanical Systems (NEMS), • Domestic and Industrial Applications of nanotechnology • Social and Ethical Implications of nanotechnology in Society	**6**

Internal Assessment Criterion:

1. Assignments on each module
2. Case studies on applications of Micro-electromechanical Systems
3. Seminar on recent advances in Micro-electromechanical Systems
4. Exercises on layout of Integrated circuits on L-Edit software

Text Books:

1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim "Microsensors MEMS and Smart devices", John Wiley and sons, Ltd.
2. NadimMulaf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House.
3. NicolaeLobontiu and Ephrahim Garcia, "Mechanics of Microelectromechanical systems", Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, "Silicon Processing for the VLSI era Volume -1 Technology", Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and sons Ltd.
6. Bhushan, "Springer Handbook of Nanotechnology", Springer Inc.

Reference Books:

1. Nadim Maluf and Kirt Williams, "An Introduction to Microelectromechanical Systems Engineering", Artech House.
2. Nicolae Lobontiu and Ephrahim Garcia, "Mechanics of Microelectromechanical Systems", Kluwer Academic Publishers.
3. Stanley Wolf and Richard N. Tauber, "Silicon Processing for the VLSI Era, Volume 1: Process Technology", Lattice Press.
4. Vijay K. Varadan, K. J. Vinoy and S. Gopalakrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley & Sons Ltd.
5. Bharat Bhushan, "Springer Handbook of Nanotechnology", Springer.

6. Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology", CRC Press.

Sr. No.	Examination	Module
1	Mid Sem	1 to 3
2	IE	1 to 7
3	End Sem	1 to 7

AE-BTM801 to 803 Ability Enhancement

It is a 1 credit course with a minimum of 14 hours. Any course on a modern Indian language can be completed either online or offline mode.
The institute shall offer at least one course for the same during the vacation after Semester VII.

CC-BTM801 Co-Curricular

- The students can earn credits through courses such as Health and Wellness, education sports, and fitness.
- The students can earn credits through Cultural Activities, NSS/Green Club activities or Fine/ Applied/ Visual/ Performing Arts.
- The evaluation for a Co-curricular course/ activity shall be defined by the course instructor or activity evaluator.
- The assessment for 100 points will be carried out throughout the semester, and the grade Pass/ No pass will be awarded, which will not be considered for CPI calculation.

PR-BTM801 Work Based Project

Course pre-requisites: All fundamental courses of the mechanical engineering

Course Objective:
The objective of the work based project is to integrate theory with practices in society or industries. Students will be able to understand and work on real-world challenges and issues. It can be used to learn, investigate, analyze, and conclude to develop a solution to a problem, which may be a local technical, social problem or industrial problem. The field project may be extended to a major project with the additional scope of the problem. It can be a group work.

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

1. integrate the knowledge of the fundamentals of subjects to search the related literature and devise solutions,
2. use knowledge for formulation/fabrication of the desired project,
3. analyze the available resources and select the most appropriate one,
4. apply principles of ethics and standards, skill of presentation and communication techniques.