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

COURSE CONTENTS

(Final Year B.Tech. in Mechanical Engineering)

(Under Regulations 2022)

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PC-BTM711 Design of Machines and Mechanical Systems
Course pre-requisites: 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 appropriate theory of failure.
- To develop integrated approach for design of mechanical systems.

Course Outcomes*:*

Upon successful completion of the course, students should be able

1. To design and evaluate adequacy of standard/custom-built machine elements such as spur/helical/bevel/worm gears, rolling element/journal bearings, mechanical seals and brakes/clutches to fulfil desired specifications and satisfy failure criteria
2. To discuss design of hydraulic circuits for mechanical systems
3. To integrate knowledge of mechanical engineering to develop design of basic system such as EOT crane and Centrifugal pump
4. To demonstrate 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 No.	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 hydro dynamically 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 Hydraulic Circuits for mechanical systems such as for achieving different machine tool operations	5
06	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	6
07	Introduction to centrifugal pump and positive displacement pump such as gear pump, vane pump, etc. 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

Term Work:

Term 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).
4. **Recommended Data Books**
    a. V. Bhandari, *Machine Design Data Book*, McGraw Hill Education (2017)
    b. Mahadevan K., Reddy K.B. *Design Data Handbook for Mechanical Engineering in SI and Metric Units*, CBS (2013)
    c. *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 Ŭeodos′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	T-I	1,2
2	T-II	3, 4
3	End Sem	1 to 7

PC-BTM714 Industrial Engineering and Project Management
Course pre-requisites: PCC-BTM605

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 tool/techniques are used strategically for the betterment of organization.
4. To understand how it helps in customer focus, innovation, quality management, speeding up the processes and improvement in productivity in an organization.
5. To understand the Life cycle and phases of project management.

Course Outcomes:

Upon successful completion of the course, students should be able

1. To describe the basic concepts in Industrial Engineering & Project Management.
2. To describe the various tools and Techniques in Industrial Engineering & Project Management.
3. To apply the various concepts and Tools in Industrial Engineering & Project 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	**Industrial Engineering:** 1.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, definition and concept of productivity, productivity measures, factors influencing productivity, productivity improvement techniques.	04
2	2. WORK STUDY & ERGONOMICS 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 measurement, steps involved in work measurement, types of elements, time study equipments, performance rating and allowances, computation of standard time, predetermined motion time standards(PMTS), Modern Techniques of Time, work and motion study. Leveraging Industry 4.0	08
3	ERGONOMICS: Definition and objectives of human engineering, man machine systems and their aspects and relationship with productivity, human factors affected by environment, methods to improve work environment. Evaluation of cultural fit on mergers and acquisitions of	-

	business enterprises. System Design (Product and Process Design), Design for X	
4	ADVANCE CONCEPTS IN INDUSTRIAL ENGINEERING Need of computers in industrial engineering, development of integrated systems, sharing of data and information, advantages of integrated systems, principles of integrated system design, MRP-I, MRP-II, JIT,BPR,SCM,EPR, Lean manufacturing, Green Manufacturing, Agile manufacturing, etc.	04
5	**Project Management:** Introduction to Project Management, the triple constraint, Stakeholders, Project Management Knowledge Area, 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 Project Management, Globalization, Outsourcing, and Virtual Teams.	08
6	Project Time Management, Defining and Sequencing Project Activities and Dependencies, Developing Schedule, Gantt Chart, Critical Path Method, Project Uncertainty – PERT, Critical Chain Method, Resource loading and Resource Leveling, Schedule Controlling.	08
7	Project Cost Management, Estimating Techniques, Earned Value Management, Project Quality Management, Planning Quality, Performing Quality Assurance, Quality Control–Tools and Techniques, Project Resource Management, 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 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	10

Term work

1. Assignments based on above modules
2. Seminar based on recent advances in the course
3. At least one Case study conducted at industry
4. Projects on Industrial use tools such as Primavera, Gitlab, MS projects.

Teaching Methods:

1. The course will use the following pedagogical tools:
2. Discussion on concepts and issues on Industrial Engineering and Project Management use of in an organization.
3. Case discussion covering a cross section of gaining strategic advantage by applying Industrial Engineering and Project Management tools and techniques.
4. 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.

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	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

VA-BTM791 Cloud Computing
Course pre-requisites: General knowledge of networking, sensing, databases, programming, and related technology.

Course Objectives:

1. To learn how to use Cloud Services
2. To implement Virtualization
3. To implement Task Scheduling algorithms
4. Apply Map-Reduce concept to applications.
5. To build Private Cloud.
6. Broadly educate to know the impact of engineering on legal and societal issues involved

Course Outcomes:
At the end of course student will be able to

1. Analyze the Cloud computing setup with it's vulnerabilities and applications using different architectures.
2. Design different workflows according to requirements and apply map reduce programming model.
3. Apply and design suitable Virtualization concept, Cloud Resource Management and design scheduling algorithms.
4. Create combinatorial auctions for cloud resources and design scheduling algorithms for computing clouds
5. Assess cloud Storage systems and Cloud security, the risks involved, its impact and develop cloud application
6. Broadly educate to know the impact of engineering on legal and societal issues involved in addressing the security issues of cloud computing.

Course Content:

Module *No*	**Details**	**Hrs.**
01	**1.Cloud Computing** Introduction to cloud computing, Key aspects of CC, Benefits of CC, Cloud system, Services offered by CC, Old IT infrastructure vs. cloud 7. Web 1.0 to 4.0, SAAS, PAAS and IAAS, Public, Private and Hybrid Cloud, Concept of Big Data	04
02	**2.CRM Introduction** Introduction to CRM, Purpose of CRM, Benefits of CRM, CRM metrics CRM technologies, Channels, Customer, Why towards CRM, Salesforce.com and other CR products	04
03	**3.Salesforce Introduction** Introduction to salesforce, salesforce Terminologies, logging into Salesforce, Salesforce user creation , Salesforce navigation term – Home ge , Salesforce navigation term – Records, Salesforce navigation term – Sidebar , Salesforce.com and Force.com, Database.com, Sales Cloud Overview ,Service cloud Overview, Editions of Salesforce, Types of Salesforce sandbox , Salesforce development, Tabs, objects and Fields	04
04	**4.Warehouse App** Create Warehouse App, Custom Objects, Custom fields, Create records, Field types (DT), Tabs, Relationships 1. Master-Detail 2. Lookup 3. Record Format Formulas & Validation 1. Formula 2. Roll Up Summary 3. Improve Validation Rule	04

05	**5.VisualForce** UI Technologies, VF Page, VF Architected, Benefits of VF, VF Inline Editor, MVC Introduction, MVC- Opportunities Tab, VF Key Elements, VF controllers, VF Types Controllers, Expression & Data Binding Versioning, VF Namespaces, Standard vs. Custom ,VF Page compare to controls, Global Variables, VF Page get requests, VF Page post back requests	04
06	7. **Programmatic Logic with Apex** Ways to develop Apps, Install Force.com IDE, Explain Force.com IDE, List variable, Iterate list, Apex trigger, Testing, Adding tests to App, Create Apex Test Class, Adding test Methods, Execute the test, Looking statements	04
07	**7.Other Understandings** Rename standard Tabs, Data Format in SF, How Date DT works, How currency DT works, How Pone DT works, Picklist & Multiselect DT, Change User Language, IE configuration,	04

Term Work:

- 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 Cloud Computing
- Mini Project

TEXT BOOKS:

The Enterprise Cloud: Best Practices for Transforming Legacy IT, by James Bond

REFERENCE BOOKS:

Cloud Computing: Concepts, Technology & Architecture, by Richardo Puttini, Thomas Erl, and Zaigham Mahmood

Course Evaluation Scheme:

Students shall select an Mechanical or any interdisciplinary application & apply concepts of Cloud Computing learned during theory & tutorial/Practical. Following evaluation scheme will be adopted for the evaluation of the course.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PR-BTM798 Project Stage II
Course pre-requisites: Recommended – all courses till semester VI

Course Outcomes:

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

Course content:

Sr.no.	Description	Hrs./week
1	Student shall study the topic of project work and define problem statement. The student shall evolve design and/or do experimental study and/or fabricate engineered device to obtain solution to the identified problem. The student shall prepare a report and shall present a seminar on the basis of work done at the end of semester.	**2 (contact) + 6 (self-study)**

OE-BTM791 Big Data Analytics

Course pre-requisites: General knowledge of networking, sensing, databases, programming, and related technology.

Course Objectives:

1. To provide an overview of an exciting growing field of big data analytics.
2. To introduce the tools required to manage and analyze big data like Hadoop, NoSql MapReduce.
3. To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability
4. To enable students to have skills that will help them to solve complex real-world problems in for decision support.

Course Outcomes:

1. **Understand** the key issues in big data management and its associated applications in intelligent business and scientific computing.
2. **Acquire** fundamental enabling techniques and scalable algorithms like Hadoop, Map Reduce and NO SQL in big data analytics.
3. **Interpret** business models and scientific computing paradigms, and apply software tools for big data analytics.
4. **Achieve** adequate perspectives of big data analytics in various applications like recommender systems, social media applications

Course Content:

Module No	Details	Hrs.
01	**Overview of Big Data** History of big data, its elements, career related knowledge, advantages, disadvantages	04
02	**Technologies for Handling Big Data** Introduction to Hadoop, functioning of Hadoop, Cloud computing (features, advantages, applications) etc	04
03	**Understanding Hadoop Ecosystem** Hadoop and its ecosystem which includes HDFS, MapReduce, YARN, HBase, Hive, Pig, Sqoop, Zookeeper, Flume, Oozie etc.Dig Deep to understand the fundamental of MapReduce and HBase framework of MapReduce and uses of mapreduce.	04
04	**Understanding Big Data Technology Foundations** big data stack i.e. data source layer, ingestion layer, source layer, security layer, visualization layer, visualization approaches etc.Databases and Data Warehouses Databases, polygot persistence and their related introductory knowledge	04
05	**Using Hadoop to store data** HDFS, HBase and their respective ways to store and manage data along with their commands. Learn to Process Data using Map Reduce. This emphasizes on developing simple mapreduce framework and the concepts applied to it.	04

06	**Hadoop YARN Architechture** Background of YARN advantages of YARN, working with YARN, backward compatibility with YARN, YARN Commands, log management etc.Testing and Debugging Map Reduce Applications	04
07	**Learn NoSQL Data Management** NoSQL including document databases, relationships, graph databases, schema less databases, CAP Theorem etc. Exploring Hive, Exploring Pig, Exploring Oozie, Integrating R and Hadoop and Understanding Hive in Detail	04

Term Work:

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

TEXT BOOKS:

1. Data Analytics : The Complete Beginner's Guide - Step By Step Instructions (The Black Book) Kindle Edition, by Byron Francis

REFERENCE BOOKS:

1. Big Data and Analytics 1st Edition, Kindle Edition, by Subhashini Chellappan Seema Acharya

Course Evaluation Scheme:

Students shall select a Mechanical or any interdisciplinary application & apply concepts of Big Data Analytics learned during theory & tutorial/Practical. Following evaluation scheme will be adopted for the evaluation of the course.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM711 Process Equipment Design and Piping Engineering
Course pre-requisites: Machine Design

Course Objectives:
The objective of this course is to:

- Learn reading and interpretation of essential design documents such as P&ID and equipment data sheets.
- Prepare student to obtain sizes of important process equipment and piping components subjected to different types of loading.
- Make students able to handle stress/thermal analysis of pressure and piping components using advanced methods such as finite element method.

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

1. Explain and interpret essential design documents such as PFD, P&ID, Data Sheets and Technical Specifications.
2. Calculate size of major process equipment and piping components using theoretical formulae, rules of international design codes/standards as well as IT tools.
3. Design of pressure vessels, heat exchangers and piping as part of engineering system of process plant.
4. Explain and apply the knowledge of piping engineering such as reading pipe layout, compatibility of materials for service and fabrication, selection of fittings and supports, and features of different international codes associated to piping engineering.

Course contents:

Sr. No.	Description	Duration (hrs.)
1	**Introduction:** Role of process equipment/ piping engineer in industry, organization and working of EPC company, Interpretation of process diagrams such as P&ID, Design codes and standards such as ASME BPVC, ASME B31.1/31.3, IBR, IS2825.	4
2	**Materials of Construction and Fabrication** Material classification and selection of material for various industrial processes, Preparation of Material Ordering Specification Sheets. Review of fabrication, inspection and testing methods.	4
3	**Design of pressure components** such as shell, head, cone for internal pressure loading. Design of cylindrical shells against external pressure; design of stiffener rings.	8
4	**Advanced design topics** such as nozzle reinforcement calculation, bolted flange design, selection of gaskets. Elementary stress analysis of pressure parts using finite element methods.	8
5	**Design of supports** for tall vertical vessels; skirt support subjected to wind and seismic loads. **Elementary heat exchanger design**. Tubesheet thickness calculations, baffle plate design	6

6	**Design of Pipes and Pipe Fittings** Pipe specification, Calculations for pipeline sizing, Pressure drop in pipelines, Design and selection of piping components such as straight pipe and bends.	6
7	**Pipe Supports** Study and selection of various types of pipe supports. Design considerations, supporting span of overhead pipelines. **Piping Flexibility** Introduction to piping flexibility analysis.	6

Term Work:

1. Assignments based on each module
2. Mini project based on design by analysis for a pressure component and piping flexibility analysis.

Recommended Books:

1. Brownell, Lloyd E., and Edwin H. Young. *Process equipment design: vessel design*. John Wiley & Sons, 1959.
2. Harvey, John F., and H. Saunders. "Theory and design of pressure vessels.",Van Nostrand Reinhold Company, 1987.
3. MW Kellogg Co. *Design of Piping Systems*. Wiley, 1961.

Reference Books:

1. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and 2, ASME, 2017.
2. ASME B31.3 Process Piping, ASME, 2016.
3. Mahajan, Kanti K. "Design of process equipment: selected topics.", Pressure Vessel Handbook Pub, 1992.

Term work:

- Assignment based on each module.
- Report of visit to a process industry plant.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM718 Fatigue, Fracture and Failure
Course pre-requisites: Machine Design

Course Objectives

1. To expand student's knowledge in linear-elastic fracture mechanics and the stress analysis of cracked bodies with a focus on metallic structures.
2. To develop student's ability to compute crack-tip stress-intensity factors for two- and three-dimensional cracked bodies of LEFM.
3. To develop student's ability to compute damage due to high-cycle and low-cycle fatigue loading.
4. To introduce students to the techniques for performing failure analysis of engineering components.

Course Outcomes: Learner will be able to…

1. Analyze nature of stresses around a cracked body by applying principles of linear elastic fracture mechanics and compute stress intensity factors.
2. Evaluate design life of components subjected to low- and high-cycle fatigue loading
3. Discuss experimental methods for the determination of fatigue and fracture properties
4. Describe various approaches for performing failure analysis of machine components

Course content:

Sr. No.	Description	Hrs.
1	Introduction, Kinds of failure, modes of fracture failure, brittle and ductile fracture.	**4**
2	Energy Consideration- Introduction, Griffith analysis, energy release rate.	**4**
3	Stress in cracked bodies- Stress intensity factor, determination of SIF, CTOD. J integral- Definition, scope, path independence.	**8**
4	Fatigue- Total lifetime approach, crack initiation, stress-life approach, strain-life approach	**8**
5	Damage tolerant approach, crack growth models, Paris law, Fatigue mechanisms, overview of fatigue analysis using ASME procedure	**8**
6	Experimental methods- introduction, K_{Ic} test technique, J testing, various test specimens, different types of fatigue testing methods	**6**
7	Two to three case studies in engineering failure analysis based on latest technical articles	**4**

Tutorial

1. Assignments on each module
2. Case studies on fatigue, fracture and failure analysis
3. Seminar on recent advances in failure analysis

Recommended Books:

1. Maiti, S. K. Fracture Mechanics: Fundamentals and Applications. Cambridge University Press,2015.
2. Kumar, Prashant, and Kumar Prashant. Elements of fracture mechanics. Tata McGraw-Hill Education, 2009.
3. S. Suresh, Fatigue Of Materials, Cambridge India, 2015
4. Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs. Metal Fatigue in Engineering, Wiley India, 2012
5. Relevant papers from "Engineering Failure Analysis", Elsevier Science Direct Journal

Reference books:

1. Fatigue and Fracture - Understanding the Basics, Edited by F C Campbell, ASM International, 2012.
2. Mechanical Metallurgy, George E Dieter, McGraw Hill Inc., 2017.

Sr. No.	Examination	Module
1.	T-I	1,2
2.	T-II	3,4
3.	End Sem	1 to 7

PE-BTM733 Industrial Robotics
Course pre-requisites: Kinematics and Dynamics of Machines, Mechatronics

Course Objectives:
On successful completion of course, students should able to
1. Understand the anatomy of different ROBOTS
2. Know programming of ROBOTS
3. Develop the ROBOTS in concern with society

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 development of ROBOT
4. To decide social issues & economics of robotic

Course content:

Sr. No.	Details	Hrs.
01	**INTRODUCTION:** Automation & robotics, Robotic System & 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 & Digitising, 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 INTELLGENCE & TASK PLANNING: Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot learning, 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

Term Work:
Term work shall consist of 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, 1981.
3. Groover, Mikell P., Mitchell Weiss, and Roger N. Nagel. *Industrial Robotics: Technology, Programming and Application*. McGraw-Hill Higher Education, 1986.
4. N-Nagy, Francis L. "Robotic engineering: An integrated approach: Richard D. Klafter, Thomas A. Chmielewski and Michael Negin Prentice-Hall International, 1989.

Reference Books:

1. Koren, Yoram, and YoramKoren. *Robotics for engineers*. Vol. 168. New York et al: McGraw-Hill, 1985.
2. Engelberger, Joseph F. *Robotics in practice: management and applications of industrial robots*. Springer Science & Business Media, 2012.
3. Grover, D. J. "Computer integrated manufacturing technology and systems: Ulrich Rembold, Christian Blume and Ruediger Dillmann, Marcel Dekker Inc, Cimarron Road, Monticello, NY 12701, USA (1985)
4. Spong, Mark W., and Mathukumalli Vidyasagar. *Robot dynamics and control*. John Wiley & Sons, 2008.
5. Craig, John J. *Introduction to robotics: mechanics and control*. Vol. 3. Upper Saddle River: Pearson Prentice Hall, 2005.
6. Doebelin, Ernest O., and Dhanesh N. Manik. "Measurement systems: application and design." (2007).
7. Beckwith Thomas, G., and N. Lewis Buck. "Mechanical Measurements." (2008).
8. Ogata, Katsuhiko. "Modern Control Engineering, PHI Learning Pvt." *Ltd., New Delhi, India* (2009).
9. Tzafestas, Spyros G. "Intelligent robotic systems." *Electrical engineering and electronics* (1991).

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM734 Supply Chain Management
Course pre-requisites: Manufacturing Planning and Control

Course Objectives

- To learn to apply tools & techniques of Supply Chain Management in real life industrial environment
- To think logically to design the tailor made new techniques which will enhance the effectiveness of the domain of Supply Chain Management.
- To design Tailor made Supply Chain Management for a typical requirement which will face the new challenges.

Course Outcomes

Upon successful completion of the course, students should be able

1. To describe the various concepts in SCM
2. To apply the various Tools and Techniques of Supply Chain Management in real life industrial environment.
3. To analyse the issues in SCM for a given case.
4. To design Tailor made Supply Chain for a typical requirement which will face the new challenges.

Course content:

Sr. No.	Details	Hrs.
01	**1. INTRODUCTION TO SUPPLY CHAIN MANAGEMENT**: Current Business Scenario, Value Matrix Analysis, Evolution of SCM Function, Theme and Pillars of SCM System, How Supply chain works? Participants in the Supply Chain, Supply chain drivers, Supply chain structure, ToC, Critical Chain, Buffer Management, Digital Supply Chain. Digitalization, Industry 4.0., Simulation of Supply Chain.	04
02	**2.SUPPLY CHAIN OPERATIONS**: 2.1 Planning and Sourcing Demand forecasting, Pricing and Promotional Impacts on demand, CPFR Concepts, CODP Concepts, Consensus Forecasting, Demand and Pricing Optimization 2.2 Making and Delivering Product Design, Production Scheduling, Facility Management, Order Management, Delivery Scheduling, Distribution network design, channels of Distribution, Plant and warehouse location.	07
03	**3. MATERIALS MANAGEMENT IN SUPPLY CHAIN** Scope, importance, classification of materials, Procurement, purchasing policies, vendor development and evaluation, Inventory control systems of stock replenishment, Cost elements New Supply Planning Paradigms, VMI, CMI, Green Channel supply, KM Model of Supplier Partnership, Multi-tier Supplier Partnerships Use of computers for materials function.	06
04	**4. LOGISTICS** Logistics Evolution, 8 wings of Logistics, Distribution Network Systems, Warehousing and Inventory Cross-Docs, Multi-Modal Optimization, Inbound and Outbound handling, Containerization, TPL, FPL, MPL Partnering, Reverse Logistics	06

05	**5.TRANSPORTATION:** Individual Freight and passenger modes, intermodal transportation and third party transportation services, economic social, and political roles of transportation, demand, cost and service characteristics of services, carrier selection and evaluation services, freight rate structure,Private International transportation, Ocean carrier management, port administration and regulation, costing and pricing issues of international transportation, logistics, cost transport mode choice, Dispatch decisions, routing decisions, routing Models, packaging to suit mode of Transport	05
06	**6. SUPPLY CHAIN COORDINATION AND USE OF TECHNOLOGY** The "Bullwhip" Effect, Supply Chain Coordination factors, Collaborative Planning, Forecasting, and Replenishment, supported information systems, E-Business and Supply Chain Integration, SCM systems Vendors, Types of Applications, Optimization Modeling, E-Business and Systems Integrations from ERP to SCM, KM, APS Systems, Further integration to CRM, AI/ML, Industry 4.0 Technologies, Smart Supply Chain, VR/AR, Block chain enabled Supply Chain, Distribution Optimization Case Studies.	07
07	**7.1 MEASURING PERFORMANCE: SUPPLY CHAIN METRICS** Market Performance Categories, Framework for Performance Measurement, Internal Efficiency Metrics, Demand Flexibility Metrics, Product Development Metrics, Benchmarking and SCM SCORE modeling **7.2 TOTAL DISTRIBUTION COST ANALYSIS**	07

Term Work:

Case Study /Course Project: Report of 10 - 15 pages on any topic from syllabus. Term work shall consist of minimum 06 assignments

Text Books:

1. Mohanty, Ph DRP, and Ph DSG Deshmukh. *Supply Chain Management (Theories & Practices)*. John Wiley & Sons, 2005.
2. Altekar, Rahul V. *Supply chain management: Concepts and cases*. PHI Learning Pvt. Ltd., 2005.
3. Shah, Janat. *Supply chain management: Text and Cases*. Pearson Education India, 2009.

Reference Books:

1. Christopher, Martin, and John Gattorna. "Supply chain cost management and value-based pricing." *Industrial marketing management* 34, no. 2, 2005.
2. Wisner, Joel D., Keah-Choon Tan, and G. Keong Leong. *Principles of supply chain management: a balanced approach*. Cengage Learning, 2014.
3. Shapiro, Jeremy. *Modeling the supply chain*. Nelson Education, 2006.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM735 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.	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

Term work: -

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

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	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM752 Computational Fluid Dynamics
Course pre-requisites: Fluid Mechanics

Course Objectives:
To equip students with the fundamental concept of computational fluid dynamics and provide training for basic features of the software ANSYS CFD.

Course Outcomes:
On successful completion of the course students will be able to .

1. To identify the need of modelling and simulation and understand its execution methodology.
2. To define, analyse and interpret a case of thermo-fluid problem.
3. To examine, illustrate and compare the results of different cases under changed boundary conditions.
4. To formulate a problem for its complete CFD analysis.

Course Contents:

Module	Description	Hrs.
1	**CFD Fundamentals:** Modeling and Simulation Computational Fluid Dynamics - its Scope, Application, advantages and disadvantages. Overall methodology of CFD analysis -Preprocessing, Solver, Post processing	04
2	**Mathematical Description of Physical Phenomenon:** Concept of mathematical modeling, Basic conservation equation In differential and Integral form, General thermal and flow boundary condition, Mathematical nature of partial differential equation used in thermo-fluid analysis.	06
3	**Numerical Solution of Linear Algebraic Equation:** Direct Method – Matrix inversion, Gauss Elimination, LU decomposition. Iterative Method- Features of iterative techniques, Jacobi and Gauss Seidel Method, Relaxation method (SUR and SOR). Stability and convergence, Ill-conditioned system of equation and condition number,	06
4	**Numerical Modeling of Heat Conduction:** Steady One and two dimensional Conduction, Unsteady One and two Dimensional Conduction, Stability restrictions,	06
5	**Numerical Modeling of Convection-Diffusion:** Numerical treatment of convective terms- FOU, SOU, QUICK, Power law scheme. Steady One-dimensional and Two Dimensional Convection- Diffusion, Unsteady One-dimensional Convection-Diffusion, Unsteady Two-dimensional Convection-Diffusion	08
6	**Incompressible Fluid Flow:** Governing Equations, Complexities in solving flow problems, Determination	06

	of Pressure for Viscous Flow, SIMPLE, SIMPLER and PISO Algorithm	
7	**Turbulence Modeling:** Introduction to Turbulence Modeling, Basic Theories of Turbulence Reynolds Time-Averaged Equations for Turbulent Flow, Different turbulence models.	06

Term Work:
Term work shall consist of minimum **06 (Six)** assignments/tutorials

Recommended Books:

1. Versteeg H.K. and Malalasekera.W: " An introduction to computational fluid dynamics-The finite volume method", Prentice Hall
2. Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", Hemishphere Publishing Corporation,.
3. Subas, V.Patankar, "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation
4. Muralidhar, K. and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House.
5. Ghoshdasdidar, P.S.,"Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd.

a. Niyogi.P. Laha M.K., Chakrabarty S.K.: "Introduction to Computational Fluid Dynamics". Pearson Education, India.

6. Fletcher, C.A.J."Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer-Verlag

Sr. No.	Examination	Module
1.	**Test – I**	Module 1, 2
2.	**Test – II**	Module 3, 4
3.	**Endsem**	Module 1 to 7

PE-BTM753 Introduction to Cryogenics
Course pre-requisites: Thermodynamics, Heat and Mass Transfer

Course Outcomes:
The objectives of this course are

1. To explain history and developments, principles, scope and applications of Cryogenic Engineering as a science of generation, retention and distribution of extreme low temperature.
2. To explain and illustrate fundamental concepts, properties and principles of behaviour of engineering materials and cryogenic fluids at cryogenic temperatures.
3. To explain and illustrate fundamental concepts and principles of cryogenic insulation, vacuum technology and safety aspects in Cryogenic Engineering.
4. To explain fundamental principles, detailed features of arrangements, operation of various cryogenic cycles for liquefaction of gases and illustrate its applications to evaluate and compare performance parameters of practical cryogenic cycles and liquefactions systems with critical components involved.

Course Outcomes:

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

1. To understand the history and developments, fundamental principles as well as scope and applications of Cryogenic Engineering.
2. To understand fundamental concepts, properties and principles of behavior of engineering materials and cryogenic fluids at cryogenic temperatures and apply them to practical cryogenic systems to evaluate and compare their performance parameters.
3. To understand fundamental concepts and principles of cryogenic insulations, vacuum technology and safety aspects and apply them to practical cryogenic systems to evaluate and compare their performance parameters.
4. To understand fundamental principles, detailed features of arrangements and operations of various cryogenic cycles for liquefaction of gases and apply them to practical cryogenic systems to analyze, evaluate and compare their performance parameters.

Course Contents:

Module No.	Details	Hrs.
1.	**Introduction to Cryogenic Engineering:** • Meaning and definition, Historical background • Progress of Cryogenic Engineering • Scope of Cryogenics and Role of Cryogenic Engineers • Present areas of applications involving Cryogenic Engineering, Principles of Thermodynamics, Heat Transfer, Momentum Transfer, Cooldown etc.	05
2.	**Low Temperature Properties of Engineering Materials** **Properties of solids**: • Mechanical Properties, Thermal Properties, Electrical and Magnetic Properties of solids including metals and non-metals (insulators) • Design considerations, Material selection criterion for Cryogenic Applications **Properties of cryogenic fluids:** • Fluids other than Hydrogen and Helium	06

	• Hydrogen and Helium	
3.	**Gas Liquefaction Systems-I:** • Introduction, System performance parameters • The thermodynamically ideal system • Production of low temperatures: Joule-Thompson effect, Adiabatic expansion • Simple Linde-Hampson system, Precooled Linde- Hampson system, Linde dual pressure system, Cascade system, Claude system, Kapitza system, Heylandt system. Liquefaction systems for LNG Comparison of performance parameters of liquefaction systems	07
4.	**Gas Liquefaction Systems-II** **Liquefaction systems for Neon and Hydrogen:** • Pre-cooled Linde-Hampson system for Neon and Hydrogen, Claude system for Neon and Hydrogen, Helium refrigerated Hydrogen liquefaction system, Ortho-Para Hydrogen conversion **Liquefaction systems for Helium:** • Collins's system, Simon system **Critical components of liquefaction systems:** • Heat Exchangers, Compressors and expanders Effect of Losses for real machines and heat transfer to system on its performance	07
5.	**Cryogenic Insulations:** • Introduction, Heat transfer, Concept of apparent thermal conductivity • Different types of cryogenic insulations: Expanded foam insulations, Gas-filled powders and fibrous insulations, Vacuum insulation, Evacuated powder and fibrous insulations, Opacified-powder insulations, Multilayer insulations • Composite insulation, Adhesives and other materials, Placement of insulation.	06
6.	**Vacuum Technology:** • Importance of vacuum technology in cryogenic engineering,Flow regimes in vacuum systems • Components of vacuum system • Differrent types of vacuum pumps: Mechanical vacuum pumps, Difussion pumps, Ion pumps, Cryopumping, Getters and sorption pumping, Vacuum gauges	06
7.	**Safety Aspects with Cryogenic Systems:** • Introduction, General safety principles, Safety checklist, Physiological hazards, Suitability of materials and construction techniques • Explosions and flammability, Excessive pressure gas • **Special considerations for Hydrogen and Oxygen gas**	05

Term work:

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

2. Technical / Case study presentations on course contents applicable to Cryogenic industry/ Plants/ R & D Institution.
3. Participation in activities such as industry expert lecture/ industry visit etc. organized by faculty for providing the wider exposure to students.
4. At least one MCQ Test based on course contents of GATE Examination.

Assessment: Attendance :5 Marks, Assignment Work:10 Marks, Viva-voce/ MCQTest 10 Marks.

Term Activity with Industry 4.0 Approach

1. Industry visit to Cryogenic plant/ industry / R & Organization of repute.
2. Lectures / seminar by experts from Cryogenic plant/ industry / R & D organization.
3. Internship (of one to two weeks) in a Cryogenic plant/ industry / R & D organization.
4. Case study: Recent developments viz: Gas liquefaction, insulation, vacuum technology etc. from Cryogenic Industry/ Plants/ R & D Institution of repute.

Text Book:

1. Barron, Randall F., *Cryogenic Systems*, 2nd edn,, Oxford University Press, New York, 1985.

Reference Book:

1. Flynn, Thomas M., *Cryogenic Engineering*, 2nd edn, CRC Press, New York, 2005.

Recommended NPTEL/ Online Lectures / Courses

1. Cryogenic Engineering NPTEL Course Lectures by Prof. M.D. Atrey, IIT Bombayhttps://nptel.ac.in/courses/112/101/112101004/

Sr. No.	Examination	Module
1.	**Test – I**	Module 1, 2
2.	**Test – II**	Module 3, 4
3.	**EndSemester**	Module 1 to 7

PE-BTM754 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. To explain, interpret, evaluate and compare cost economics involved in different types of power generation plants and apply for optimum selection of a power generation plant or combination of plants.
2. To explain and compare principles, detailed features of arrangements, operation and advantages of various power genertaion plants and evalaute their performance parameters.
3. To explain and assess impact of power generation technologies on environment and adapt techniques for improving efficiency and reducing the environmental impact.
4. To develop understanding for power generation scenarion in the country with reference to World Power Generation and apply the acquired knowledge to evaluate and compare the performance parameters of different types of power generation plants or their combinations.

Course Contents:

Module No.	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 • Classification of Hydro plants: Run-off River Plant, Storage River Plant, Pumped Storage Plant	06

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

Term work:

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.

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

Term 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.	**Test – I**	Module 1, 2
2.	**Test – II**	Module 3, 4
3.	**EndSemester**	Module 1 to 7

PE-BTM755 Automobile Engineering
Course pre-requisites: I.C. Engine

Course Objectives:

- Automobile engineer must be familiar with this course to know commercial considerations, such as economics, marketing, and sales.
- Students must be familiar with different operations of spark ignition engines and compression ignition engines.
- This syllabus is associated with the engine and includes belt drives, air conditioning, and the starting and charging systems.
- Students must be done analysis of both manual and automatic transmissions, driveshaft design, and four- and all wheel-drive systems.

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

1. To explain knowledge regarding analytical design of the complete motor vehicle, Vehicle Body Engineering and current motor vehicle design.
2. To evaluate the vehicle performance and different losses or resistances occur during driving the vehicle
3. To explain the different mechanisms of the vehicle
4. To design the different vehicles, and the components required

Course Contents:

Module No.	Details	Hrs.
01	**Introduction**: Classification of automobiles. **Automobile power plant**: constructional features of different types of engines used in Automobiles, their characteristics, study of various engine components and their materials. **Vehicle performance**: Tractive force, 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, selection of suitable real axle and gear ratios. **Maintenance and troubleshooting aspects of**: clutches, gearbox, brakes	**08**
02	**Multipoint fuel injection (MPFI) system and Single point fuel injection, electronic fuel injectors**: principal of operations, construction, working and application of temperature sensors, inductive sensors, position sensors, pressure sensors, knock sensors, hot wire and thin film air flow sensors, vortex flow/ turbine fluid sensors, optical sensors, oxygen sensors, light sensors, methanol sensors, and rain sensors. New developments in sensor technology.	**07**
03	**Transmission Systems**: Study of propeller shaft and universal joint, live axle and differential **Steering and front axles**: Steering geometry, Steering requirements, Steering linkages and Steering gears, over Steer and under Steer, cornering power, reversibility of Steering gears, types of front axles their constructions, troubleshooting and remedies.	**06**
04	**Suspension systems**: objects of Suspension, basic requirements, types of Suspension, shock absorbers	**06**

	Wheels and tyres: requirements of Wheels and tyres, constructional features, types of tyres, application to ride and stability, troubleshooting and remedies. **Electrical system**: study of different types of batteries, study of electronic ignition system, study of charging system, study of starting system. **Lighting system**: types of lamps, Energy demands of lighting system, construction and types of head lamps.	
05	**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.	**06**
06	**Vehicle vibration and dynamics**: types of vibration, vibration control, effect of vibration on human body, Driver's comfort and passenger's comfort vehicle vibration with single degree of vibration. **Different accessories used in vehicles**: Electric Horn, Wipers,Fuel pump, power operated windows etc.	**08**
07	**Vehicle maintenance and servicing** :Importance of vehicle maintenance, primitive maintenance, break down maintenance, corrective maintenance, overhaul major and minor, engine and chassis lubrication, types of lubricants. **Recent trends in automobile**: Electronic control module(ECM), Operating modes of ECM (Closed loop and Open Loop), inputs required and output signals from ECM, electronic spark control, air management system, ideal speed control., Introduction to EV design	**07**

List of assignments and experiments:

Assignments and laboratory experiments of (any 8)

1. Study of ignition and charging system.
2. Study of starting system, lighting system and battery.
3. Study of suspension system.
4. Study of basic dimension and vehicle layout.
5. Study of computer control engine.
6. Study of wheels and tiers.
7. Study of vehicle maintenance.
8. Study of different drives.
9. Study of steering system.

Term work :

Term work shall consist of minimum eight experiments, 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	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

PE-BTM756 Renewable Energy Sources and Utilization
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:

Sr. No.	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 and liquid nominated geothermal systems, operational and environmental problems.	03
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,	08

	Sizing of biogas plants, energy plantation. **CHEMICAL ENERGY SOURCES:** Fuel cells-principle, classification, advantage and disadvantage, application and recent development.	

Term work:

Term work shall consist of a selection of any 5 experiments given below:

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	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

OE-BTM712 Introduction to Research Methodology
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

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. No.	Details	Hrs.
01	Definition of research: Research – Definition; Types of Research methods Pure and applied research. Descriptive and explanatory research, Qualitative and quantitative approaches	03
02	Research procedure: Formulating the Research Problem, research design including sample Design, Sample size. Considerations in selecting research problem	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	06
06	Hypothesis tests: z test , F test , t Test, Chi Sq test	06
07	Outcome of research: Preparation of the Report on conclusions reached. Testing validity of research outcomes. Suggestions and recommendations, identifying future scope.	06

Term Work:

Term work shall consist of one assignment on 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	T-I	1,2
2	T-II	3,4
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**

Term Work/Tutorial

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

Recommended 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.

Sr. No.	Examination	Module
4.	T-I	1,2
5.	T-II	3,4
6.	End Sem	1 to 7

OE-BTM718 Fundamentals of AI and Machine Learning
Course pre-requisites: Mathematics, Knowledge of programming language (Python preferred)

Course Objective:
The students after studying these topics should be able to

1. understand applications of Artificial Intelligence and Machine Learning for engineering applications
2. apply suitable algorithms for simple engineering problems

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

1. discuss applications of Artificial Intelligence for engineering problem solving
2. apply fundamental concepts in machine learning and select machine learning algorithms for engineering problem solving
3. compose computer code for solving problems using machine learning algorithms
4. explain advanced machine learning concepts such as Neural Network, Reinforcement Learning.

Course Content:

Module No.	Details	Hrs.
01	Fundamental Concepts of AI, Agents, Environments, General Model, Problem Solving Techniques, uninformed search techniques, Heuristic search	2
02	Knowledge representation, Propositional and predicate calculus	1
03	Introduction to Machine Learning Learning algorithm: Supervised and Unsupervised Learning, Linear, multivariate regression, overfitting/underfitting and regularization, Training/Testing/Validation datasets, Model evaluation metrics, Feature reduction and Principal Component Analysis (PCA)	6
04	Classification Algorithms: Logistic regression, Naive Bayes, Instance based learning: K-Nearest Neighbors (KNN) classifiers, Support Vector Machine, Kernel function and Kernel SVM, Decision trees	6
05	Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network	5
06	Clustering: k-means, DBSCAN and hierarchical clustering	4
07	Collaborative filtering-based recommendation, Introduction to Reinforcement Learning	4

Term Work/Laboratory:

- Journal work shall consist of e-folder with computer code for solution to problems based on each module.
- Seminar
- Mini-project

Text Books:

1. Tom Mitchell, Machine Learning, First Edition, McGraw- Hill (1997).
2. Stuart Russel and Peter Norvig, Artificial Intelligence – A modern approach, Pearson (2015)
3. Ethem Alpaydin, Introduction to Machine Learning, PHI (2015).
4. Gopal M., Applied Machine Learning, McGraw Hill (2018)

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

OE-BTM719 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.

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

Term Work Point Distribution: (total 25 marks).

- 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	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

OE-BTM721 Generative Design
Prerequisite: CAD, BIM, MACHINE LEARNING, FEA

Course Objectives:

- To understand the fundamentals of generative design
- To understand the enabling technologies for generative design
- To understand how to develop generative design
- To study application areas of generative design
- To understand generative design as an interdisciplinary technology
- To understand, how ML & DL can be used in generative design
- To understand, how evolutionary & genetic algorithms help generate multiple design solutions

Course Outcomes: Students will demonstrate the ability to

- Explain & write basic concepts of generative design
- Identify various enabling technologies of generative design.
- Apply theoretical knowledge in practice
- 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

Term Work

Term Work/ Laboratory

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	T-I	1, 2
2	T-II	3 & 4
3	End Sem	1 to 7

OE-BTM717 Introduction to Augmented Reality
Course pre-requisites: General knowledge of CAD Modelling

Course Objectives:
Upon successful completion of the course, students will be

- Explore the basic concepts of Augmented Reality.
- They are also able to design & develop AR application.

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

Term Work:

- 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

REFERENCE BOOKS:

1. Tobias Höllerer, Dieter Schmalstieg, Augmented Reality: Principles and Practice

Sr. No.	Examination	Module
1.	**Test – I**	Module 1, 2
2.	**Test – II**	Module 3, 4
3.	**Endsem**	Module 1 to 7