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

COURSE CONTENTS

(T.Y. B.Tech. in Mechanical Engineering)

(Under Regulations 2022)

Sardar Patel College of Engineering
Third Year BTech Mechanical Engineering, (Under Regulation-2022)

List of the Courses

PC-BTM501 Heat and Mass Transfer
Course Pre-requisites: PC-BTM305

Course Objectives:

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

1. Identify different mode of heat and mass transfer occurring in thermal system.
2. Analyze steady and transient conduction problem.
3. Learn the fundamentals of convective heat transfer
4. Understand the methods of analyzing a heat exchanger.
5. Learn about basic concept of mass transfer

Course Outcomes:

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

1. Understand different modes of heat transfer and estimate the heat transfer by using classical laws.
2. Apply the knowledge of mathematics, science and heat transfer to develop mathematical models.
3. Analyze heat exchange through radiation.
4. Analyze and evaluate heat transfer in context with conduction, convection and heat exchangers

Course Contents:

Module No.	Details	Hrs.
1	**Basic Concepts:** Understanding generalized energy equation in the mathematical form, Modes of heat transfer, its mechanism and mathematical models.	05
2	**Conduction:** General conduction equation in cartesian, cylindrical and spherical Coordinates (Only use of equations and no derivations) Steady state solution of one-dimensional conduction equation for isotropic materials of various configurations such as plane wall, plane composite wall, cylindrical and spherical composite walls.	08
3	**Transient Conduction:** Lumped capacity method, Distributed parameter treatment.	04
4	**Fundamental of Convection:** Natural and Forced convection, hydrodynamic and thermal boundary layers. Heat transfer coefficient. Effect of various parameters such as physical properties of the fluid, system geometry, fluid flow etc. on heat transfer coefficient. Physical significance of dimensionless numbers such as Nusselt's Number, Grashoffs Number, Prandtl's Number, Reynolds Number and Stanton's Number. Empirical relations for free and forced convection for standard cases.	08
5	**Fundamental of Radiation:** Origin of thermal radiation, Concept of black body and grey body. Emissive power and Emissivity. Basic laws of Radiation: Planck's law, Radiation heat exchange between two black bodies. Electrical network	06

	analogy for radiation heat exchange between two and three grey bodies.	
6	**Heat Exchangers:** Classification of heat exchangers. Logarithmic Mean Temperature Difference, Correction factor and effectiveness of heat exchangers. Effectiveness as a function of Number of Transfer Units and heat capacity ratio. Overall heat transfer coefficient, Fouling factor.	**06**
7	**Mass Transfer:** Mechanism of mass transfer. Importance of mass transfer in engineering. Fick's law of diffusion. Empirical relations for mass transfer, in terms of Sherwood Number, Reynolds Number and Schmidt's number.	**05**

Text Books:

1. Holman, J. P. "Heat transfer, Eighth SI Metric Edition." (2001)
2. Incropera and Dwitt, *Fundamentals of Heat and Mass Transfer,* Wiley India (2010)
3. Kreith, Frank, Raj M. Manglik, and Mark S. Bohn. *Principles of heat transfer* Cengage learning, (2012)
4. Arora C. P. ,*Heat and Mass Transfer*., Dhanpatrai and Co. (2014)
5. Nag P.K.,*Heat and Mass Transfer* , Tata McGraw Hill (2014)
6. Ozisik M.N., *Heat Transfer*, McGraw Hill (2010)
7. Rajput, R. K. "„Heat and Mass Transfer‟, pub." *Tata McGrawhill*(2009).

References:

1) Heat Transfer - Schaums Series - Mc Graw Hill International.
2) Welty, James R. "Engineering heat transfer." *New York, John Wiley and Sons, Inc.*(1974).
3) Hsü, Shao-ti. *Engineering heat transfer*. Van Nostrand, 1963.
4) Eckert and Drake, *Heat and Mass Transfer*, (2010)

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

PC-BTM503 Mechatronics
Course Pre-requisites: Engineering sciences, PC-BTM402

Course Objectives:

- In the recent trend of automation in industry environment has changed rapidly from mechanical to electromechanical. Hence aim is to implement such a mechatronics system in industry to enhance the performance as well as cost, size & power. Such as microcontroller base systems & programmable logic controller base systems.
- Knowledge of systems such as microprocessor, microcontroller, Programable logic controller, Electro-pneumatic& electro hydraulics & other systems such as MATLAB & software's will be useful.

Course Outcomes:

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

1. To explain principles of operation/interfacing of microprocessor, microcontrollers, PLCs, in mechatronics systems
2. To use hydraulic and pneumatic actuation systems for developing circuits for industrial automation and to describe fundamentals of modelling control systems
3. To calculate response of first and second order systems and to explain concepts of frequency response analysis and state space representation of control systems
4. To explain state space representation of control systems

Course Content:

Module No	Details	Hrs.
01	Introduction to Mechatronics, Mechatronics Systems in Factory, Home and Business Applications. Basic Components of Mechatronic Systems, Mechatronics Design process, Objectives.	02
02	Overview of microprocessors and micro-controllers 8051microcontrollers: Functional block diagram and architecture, Instruction set and assembly language programming. Interfacing of: HEX-keyboards, LCD display, ADC, DAC and Stepper motor. Introduction to advanced microcontroller platforms	07
03	Pneumatic and Hydraulic actuation systems: Pneumatic and hydraulic systems. Electro-Pneumatic systems. Electro-Hydraulic systems. Development of circuits for Industrial Automation PLC in Automation: Basic structure, I/O processing. Ladder logic diagram. Selection of PLC.	07
04	Introduction to control systems, open loop and closed loop systems, Mathematical modeling of control systems, concept of transfer function, Block diagram algebra.	06
05	Transient Response Analysis of First and Second orders system, Time domain specifications. Step response of second order system. Classification of control systems according to 'TYPE' of systems, steady-state errors, static error constants, steady state analysis of different type of systems using step, ramp and parabolic inputs. Stability analysis: Introduction to concepts of stability, The Routh and Hurwitz Stability criteria, Relative stability analysis.	08
06	Root locus concepts. Frequency Response Analysis: Frequency domain specifications, Correlation between time and frequency response, Bode Plots.	07
07	State-Space methods, Single degree of freedom, Multi-degree of freedom, Forced response, State Space representation of Control systems. **Matlab programming for control system**	05

Term Work:

1. At least 06 assignments (one on each module).
2. Simulation of Mechatronic System using any open source software.
3. Mini Project on Mechatronics System Design (Maximum 3 students in a group for mini project)

Theory Examination:

1. Question paper will comprise of total seven question, each of 20 Marks
2. Question one will be compulsory and based on maximum part of syllabus.
3. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only five questions need to be solved.

Text books:

1. Uchino, Kenji, and Jayne Giniewicz, eds. Micromechatronics. CRC Press, 2003.
2. Shetty, Devdas, and Richard A. Kolk. Mechatronics System Design, SI Version. Cengage Learning, 2010.
3. Gaonkar, Ramesh S. Microprocessor architecture, programming, and applications with the 8085. Prentice-Hall, Inc., 1995.
4. Nagrath, I. J., and Madan Gopal. Textbook Of Control Systems Engineering (Vtu). New Age International, 2008.
5. Ogata, Katsuhiko, and Yanjuan Yang. "Modern control engineering." (1970): 1.
6. Kenneth, J. Aiyala. "The 8051 Microcontroller, Architecture, programming and applications." (1991).
7. Fawcett, John R. Pneumatic circuits and low cost automation. Brookfield Publishing Co., 1968.
8. Manik D.N., Control Systems, CENGAGE Learning (2012)

References:

1. Horowitz, Paul, and W. Hill. "Art of electronics 2nd edn." (1997).
2. Fundamentals of Pneumatics: Festo Series (2002)
3. Fundamentals of Electro-Pneumatics: Festo Series (2002)
4. Fundamentals of Hydraulics: Festo Series (2002)
5. Fundamentals of Electro-Hydraulics: Festo Series (2002)
6. Mechatronics, H. M. T. "Tata McGraw Hill." New Delhi (1968).
7. Pippenger, John J. Hydraulic valves and controls: selection and application. Marcel Dekker Inc, 1984.
8. . Dukkipati, Rao V. Analysis and design of control systems using MATLAB. New Age International, 2006.

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

PC-BTM512 Dynamics of Machinery
Course Pre-requisites: BTM412

Course Outcomes:

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

1. To examine construction and analyze motion of mechanical subsystems such as dynamometers, governors, gyroscope, gear trains.
2. To analyze static and dynamic balancing of rotor and reciprocating mass systems.
3. To define damped and undamped SDOF vibration system
4. To derive governing equations of motion for damped and undamped vibration systems.

Module no.	Descriptions	hrs
01	Dynamometers–Absorption and transmission dynamometers, Study and analysis of absorption type dynamometer –Proney brake, Rope brake, dynamometers, Study and analysis of transmission type dynamometers. Flywheel: Turning moment diagram, Fluctuation of energy and speed.	**04**
02	Gyroscope: Introduction- Gyroscopic couple and its effect on spinning bodies, Gyroscopic effect on naval ships during steering, pitching and rolling, Ship stabilization with gyroscopic effect. Two wheeler and four wheeler on curved path- effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths, Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft.	**04**
03	Governors: Comparison between governors and flywheel, Types- centrifugal governors, inertia governors, Force analysis of gravity loaded governors– Watt, Porter, Proell, Force analysis of spring loaded governors- Hartnell, hartung, Wilson Hartnell, Force analysis of spring and gravity loaded governor, Performance characteristics of governor stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness, introduction to MEMS based gyroscopes	**04**
04	Gear Trains: Kinematics and dynamic analysis of- simple gear trains, compound gear trains, reverted gear trains, and epi-cyclic gear trains with spur, or bevel gear combination	**04**
05	Basic Concepts of Vibration: Vibration and oscillation, causes and effects of vibrations, Vibration parameters -spring, mass, damper, Damper models, Motion periodic, non-periodic, harmonic, non–harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis, Free Undamped Single Degree of Freedom Vibration System: Longitudinal, transverse, torsional system,	**04**
06	Free Damped Single Degree of Freedom Vibration System: Viscous damped system- underdamped, critically damped, overdamped. Logarithmic decrement. Coulomb's damping. Combined viscous and coulomb's damping. Critical speed of shafts.	**04**
07	Balancing: Static and dynamic balancing of multirotor system, Balancing of reciprocating masses In-line engines, V-engines	**04**

Text Books:

1. Bevan, Thomas. The theory of machines. Pearson Education India, 1944.
2. Rattan, Sarjit S. Theory of machines. Tata McGraw-Hill, 2005.
3. Ballaney, P. L. Theory of machines. Khanna, 1980.
4. Grover, Gopal Krishan. Mechanical Vibrations: MKS System. Nem Chand, 1972.
5. Kelly, S. Graham. "Fundamentals of mechanical vibrations." (1992).
6. Rao, Singiresu S., and Fook Fah Yap. Mechanical vibrations. Vol. 4. New York: Addison-Wesley, 1995.

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

PC-BTM514 Thermal and Fluid Machines
Pre-requisite Courses: Thermodynamics, Fluid Mechanics

Course Objective:

To understand the fundamental concepts, constructional features and applications of various thermal and fluid machinery.

Course Outcome:

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

1. Understand the fundamentals of different thermal and fluid machinery
2. Apply knowledge of thermodynamics and fluid mechanics to study the performance of different thermal and fluid machinery.
3. Analyse, compare and select different thermal and fluid machinery for an application.
4. Evaluate performance of various thermal and fluid machinery.

Course Content:

Module No.	Details	Hrs.
01	**Compressors** Single and multistage reciprocating compressor. Calculation of minimum work, Free air delivered, volumetric efficiency, isothermal and adiabatic efficiency. Roto-dynamic compressor- rotary, axial and centrifugal. Performance characteristics of compressors.	8
02	**Pumps** Classifications- Reciprocating, Centrifugal and Axial flow, Performance characteristics, Series and parallel arrangements.	6
03	**Internal Combustion Engines: Spark Ignition (SI)** Theory of Carburetion, Simple carburetor, various systems of actual Carburetor, Ignition System - Battery and Magnetic Ignition, Electronic Ignition. Combustion phenomenon, knocking, Ignition delay, Petrol Injection -MPFI etc.	8
04	**Internal Combustion Engines: Compression Ignition (CI)** Requirement of fuel injection systems and types of fuel injection, Fuel injection pump, types of nozzles. Necessity of Governor in diesel engines. Combustion phenomenon, Stages of combustion, Delay period, Applications	6
05	**Steam Generators and Steam Turbines:** High pressure steam generator. Constructional and working features, accessories- superheaters, economizers, reheaters, air preheaters. Once through steam generator, control of steam generation. Examples of HP boilers, Flow through steam nozzle, Basic of steam turbine, Classification, compounding of turbine, Impulse turbine-velocity diagram, condition for maximum efficiency. Reaction turbine- velocity diagram, degree of reaction, Parson's turbine. Condition for maximum efficiency.	8
06	**Gas Turbine**: Constructional features, Applications, Open and closed cycle gas turbine, methods to improve efficiency and specific output, Effect of operating variable on thermal efficiency and work ratio.	6
07	**Hydraulic Turbines** Classification, Impulse turbine – Pelton wheel, Reaction turbines- Francis and Kaplan, Performance characteristics.	6

Text Books:

1. Nag, P. K. *Power plant engineering*. Tata McGraw-Hill Education, (Latest edition)..
2. Kothandaraman, C. P., S. Domkundwar, and Anand Domkundwar. *Cource in Thermal Engineering*. Dhanpat Rai & Company (P) Limited, (Latest edition).
3. Yadav, R. "Steam and gas turbine and Power Plant Engineering." (Latest edition).
4. Yahya, S. M. *Turbines compressors and fans*. Tata McGraw-Hill Education, (Latest edition).
5. Lal, Jagdish. *Hydraulic machines*. Metropolitan Book Company, latest ed..
6. Sharma, R. P., and M. L. Mathur. "*Internal Combustion Engine."* Dhanpat Rai & Company (P) Limited, (Latest edition) .
7. Obert, Edward F. "*Internal combustion engines and air pollution."* Intex Educational Pub (Latest edition).
8. Ganesan, V. *Internal combustion engines*. McGraw Hill Education (India) Pvt Ltd,.

References:

1. Sorensen, Harry A. *Principles of Thermodynamics*. Holt, Rinehart and Winston,
2. Eastop, T. D., and A. McConkey. "Applied thermodynamics for engineering technologists,
3. Yunus A Cengel and Michael A. Boles, *Thermodynamics an Engineering Approach*. Tata McGraw-Hill Education.

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

PC-BTM515 Computer Aided Machine Drawing
Course pre-requisites: Engineering Graphics

Course Objective:
In this course students will:

1. Learn to understand drawing, which includes clear spatial visualization of objects and the proficiency in reading and interpreting a wide variety of production drawings.
2. Learn drafting skills depending upon job function, to perform day to day activities i.e. communicating and discussing ideas with supervisors and passing instructions to subordinates also knowledge of computer aided drafting is essential part.

Course Outcome:

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

1. To create and compose engineering drawings for standard machine components on CAD Software.
2. To sketch free hand proportionate illustrative representation of common machine components.
3. To assemble various standard machine components on CAD Software.
4. To plot assembly and detail production drawings with bill of Material.

Course Contents:

Module No.	Details	Hrs.
01	**Solid Geometry:** Intersection of surfaces and Interpenetration of solids- Intersection of prism or cylinder with Prism, cylinder or cone (both solids in simple and offset position only).	03
02	**Free Hand Sketching of:** **Machine elements** such as bolts, nuts, washers, studs, components tapped holes; **Types of Conventional Threads**; V-form and Square form, Conventional representation of assembly of threaded parts in normal and sectional views; **Limits fits and tolerances:** dimensioning with tolerances indicating various types of fit in details and assembly drawings.	02
03	**Details and Assembly Drawing:** Introduction to unit assembly drawing, steps involved in preparing assembly drawing from details and vice versa. **Preparation of details & assembly drawings of** Cotter joints, knuckle joint. **Free Hand sketches of Keys**: sunk, parallel, woodruff, saddle, feather etc.	03
04	**Preparation of Details & Assembly Drawings of:** **Coupling** - simple, muff, flanged, protected flange coupling, Oldham's coupling and universal Coupling. **Bearings**- simple, open, bushed, pedestal, footstep, I.S. conventional representation of ball and roller bearings.	02
05	**Preparation of Details & Assembly Drawings of:** **Belt Pulleys**- V-belt, rope belt, fast and loose pulleys, **Valves** - Air cock, Blow off cock, Steam stop valve, gates valve, globe	02

	valve, non-return valve.	
06	**Preparation of details & assembly drawings of:** **I.C. Engine Parts:** piston, connecting rod, cross head and crankshaft. **Pipe Joints:** flanged joint, spigot and socket joint, stuffing box, expansion joint, union joint.	01
07	**Preparation of details & assembly drawings of:** Jigs & Fixtures, Clapper block, Single tool post, Crane Hook, Lathe & Milling tail stock. Exporting CAD files for 3d printing. Data Management through CAD	01

Text Books:

1. Bhatt, N. D., and V. M. Panchal. Machine Drawing. Charotar, 1991.
2. Dhawan, R. K. Machine Drawing. S. Chand Limited, 1998.

Reference Books:

1. Narayana, K. L., P. Kannaiah, and K. Venkata Reddy. Machine drawing. New Age International, 2009.
2. John, K. C. Textbook of Machine Drawing. PHI Learning Pvt. Ltd., ed.1.

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

PC-BTM551 Heat and Mass Transfer Laboratory
Course Pre-requisites: PC-BTM501

Course Objectives:
Upon successful completion of the course, students should be able to
1. Identify different mode of heat and mass transfer occurring in thermal system,
2. Analyze steady and transient conduction problem,
3. Learn the fundamentals of convective heat transfer,
4. Understand and analyze radiative mode of heat transfer,
5. Understand the methods of analyzing a heat exchanger,
6. Learn about basic concept of mass transfer

Course Outcomes:
Upon successful completion of the course, students should be able to
1. Understand different modes of heat transfer and estimate the total heat transfer
2. Understand design concepts of different heat exchanger equipment
3. Analyze heat exchange through different modes of heat transfer
4. Develop equations for different modes of heat transfer

List of Experiments to be conducted is as follows.
Term work shall consist of minimum **06** experiments and at least one assignment on each module.
1. To find Thermal conductivity and Thermal resistance of composite material.
2. To find the emissivity of given radiating surface.
3. To study Working and construction of Heat pipe.
4. To study heat transfer by Natural convection.
5. To study heat transfer by Forced convection.
6. To study heat transfer from Pin-Fin

Term Work:
The term work will comprise of following
1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ) based on topics mentioned in latest GATE syllabus
4. Oral Examination
5. Mini Presentation on small topic of the syllabus

PC–BTM553 Mechatronics Laboratory
Course Pre-requisites: PC-BTM503

Course Objectives:

- In the recent trend of automation in industry environment has changed very fast from mechanical to electromechanical. Hence aim is to implement such a mechatronics system in industry to enhance the performance as well as cost, size & power. Such as microcontroller base systems & programmable logic controller base systems.
- Knowledge of systems such as microprocessor, microcontroller, Programable logic controller, Electropneumatic & electro hydraulics & other systems such as MATLAB & software's will be useful.

Course Outcomes:

Upon successful completion of the course, students should be able

1. To do interfacing of microprocessor, microcontrollers, PLCs, in mechatronics systems
2. To do programming for Mechatronics system
3. To use hydraulic and pneumatic actuation systems for developing circuits for industrial automation
4. To simulate of control systems using IT tools

Course Contents

List of Experiments to be conducted is as follows.

(At least 6 experiments from the list given below)

1. Study of basic principles of sensing and actuation techniques used in Mechatronics systems
2. Study of Electro-pneumatic Logic Trainer kit, and experiments on Electro-pneumatic circuits
3. Experiments on Ladder programming for Mechatronics system (Bottle filling plant)
4. Experiments using Microcontroller kit Interfacing of HEX-KEYBOARD
5. Experiments using Microcontroller kit Interfacing of LCD Display, ADC, DAC & STEPPER MOTOR
6. Introduction to remote sensing/control
7. Experiments on Control System using MATLAB
8. Experiments on mathematical model using SIMULINK
9. Experiments on DC Servo Position control system

Term Work:

The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ)
4. Oral Examination

PC-BTM562 Dynamics of Machinery Laboratory
Course Pre-requisites: PC-BTM512

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

1. Understand fundamentals involved in working of machines.
2. Understand construction and principle of working of different machine components and sub-assemblies.
3. Provide the necessary tools to systematically synthesize a system and arrive at a critical shapes and dimensions.
4. Provide understanding of vibration systems in mechanical engineering.

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

1. To examine construction and analyze motion of mechanical subsystems such as clutches, breaks, dynamometers, governors, gyroscope, gear trains.
2. To analyze static and dynamic balancing of rotor and reciprocating mass systems.
3. To examine SDOF vibration system
4. To investigate motion for damped and undamped vibration systems.

Course Contents

List of Experiments:

1. Study of Clutches, Brakes and Dynamometers
2. Experiments on Governors and Gyroscope
3. Experimental determination of natural frequency of simple and compound pendulum
4. Experimental determination of natural frequency for longitudinal vibrations of helical springs, and springs in series and parallel.
5. Experimental and theoretical investigation of whirling of shaft (i.e. comparison of experimental and theoretical natural frequency and justification of discrepancy between experiment and theory)
6. Experimental investigation of viscous and coulomb damping, prediction of system parameters (spring stiffness, damping coefficient) from damped oscillations.

Term Work:
The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ) based on topics mentioned in latest GATE syllabus
4. Oral Examination

PC–BTM564 Thermal and Fluid Machine Laboratory
Course Pre-requisites: PC-BTM514

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

- Understand working of compressors.
- Understand working of nozzles and steam turbines.
- Get knowledge about working of steam generators
- Understand performance parameters and working of gas turbines.

Course Outcome:
Upon successful completion of the course, students should be able to
1. To know effect of parameter like delivery pressure on the volumetric efficiency of reciprocating air compressor
2. To understand effect of inlet pressure and back pressure on mass flow rate through C-D Nozzle
3. Get working knowledge of centrifugal pumps, IC Engines-SI &CI
4. To understand torque speed and power speed characteristics of gas reaction turbine.

Course Contents
List of experiments to be performed.

1. Trial on air compressors.
2. Trial on experimental gas turbine
3. Experiment on mass flow rate of air through orifice plate or nozzle.
4. Study of steam turbines.
5. To perform performance test on a centrifugal pimp
6. To perform load test on Pelton and Francis Turbine
7. To perform load test on Petrol Engines.
8. To perform load test on Diesel Engines

Term Work:
The term work will comprise of following
1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ) based on topics mentioned in latest GATE syllabus
4. Oral Examination

PC-BTM565 Computer Aided Machine Drawing Laboratory
Course pre-requisites: Engineering Graphics

Course Objective:
In this course students will:

1. Learn to understand drawing, which includes clear spatial visualization of objects and the proficiency in reading and interpreting a wide variety of production drawings.
2. Learn drafting skills depending upon job function, to perform day to day activities i.e. communicating and discussing ideas with supervisors and passing instructions to subordinates also knowledge of computer aided drafting is essential part.

Course Outcome:

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

1. To create and compose engineering drawings for standard machine components on CAD Software.
2. To sketch free hand proportionate illustrative representation of common machine components.
3. To assemble various standard machine components on CAD Software.
4. To plot assembly and detail production drawings with bill of Material.

Course Contents:

Practical Work based on modules of PC-BTM515 course:

- 1 Sheet on Intersection of curves minimum two problems on CAD software.
- 1 Sheet on free hand sketches of each topic from module 2 and calculating limits, fits and tolerances.
- 1 Sheet on details and assembly drawings of any one topic from module 3
- 1 Sheet on preparation of details and assembly drawings of any one topic from module 4
- 1 Sheet on preparation of assembly of detail drawings of any one topic from module 5
- 1 Sheet on preparation of details of assembly drawings of any one topic from module 6 with fits and tolerances.
- 1 Sheet on preparation of details and assembly drawings of any one topic from module 7 with fits and tolerances and exporting the file for 3d printing.

During practical work, students should be introduced to CAD software features related to collaborative drawing (attach or reference another drawing within a part/assembly drawing), insertion of standard parts using blocks, history-based or feature modelling, parametric modelling, dimensional and geometric constraints.

MC- BT003 Health Safety and Environment
Course pre-requisites: Engineering sciences

Course Objective:

The objective of this course is to sensitize the student to the ever-increasing environment problems and make them aware of the fundamentals of occupational safety and health along with prevailing laws in the world and India.

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

1. explain fundamentals of occupational health and safety and environmental issues
2. describe laws and regulations pertaining to health, safety and environment
3. propose specifications to comply with norms of environment engineering
4. discuss prevention of environmental pollution

Course Content:

Module No.	Details	Hrs.
01	**Introduction to Occupational Safety and Health (OSH)**: Need and Significance, Accidents and Their Effects, Theories of Accident, Roles and Professional Certifications for Safety and Health Professionals, Stress and Safety, Safety and Health Training	**04**
02	The Factories Act Basics and origin of the act, the inspecting staff, health, safety, disclosure of information, Special provisions	**04**
03	**Hazard Assessment, Prevention, and Control:** Mechanical Hazards and Machine Safeguarding, Fire Hazards and Life Safety, Ethics and Safety, Environmental Safety and ISO 14000	**04**
04	**Introduction to Environmental Engineering:** Adverse effects of environment, Types of environmental pollution - Water pollution, Air pollution, Solid waste management, Control Strategies of different environmental problems.	**04**
05	**National Legislation for Environment:** Constitutional provisions for safe-guarding the environment, The Environmental (Protection) Act, The Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, The Wild life (Protection) Act, Forest Act, Biodiversity Act	**04**
06	**International Concerns:** Conventions and Treaties-RAMSAR Convention, CITES, Convention on Biological Diversity, Convention to Combat Desertification, Convention on Climate Change.	**04**
07	**Establishing A Safety-First Corporate Culture** Definition, Importance, what a Safety-First culture looks like, steps for establishing a safety-first corporate culture	**04**

Term Work: Minimum (02) mini projects per student

Text Books:

1. Goetsch, David L. "Occupational Safety and Health for Technologists, Engineers, and." (2011).
2. Krishnaswamy J., Daniels R.J.R., Environmental studies, Wiley India Private Ltd. New Delhi (2009)
3. Basak, Anindita. Environmental studies. Pearson Education India, (2009).
4. Erach Bharucha, Textbook of Environmental Studies, University Press
5. MP Poonia, SC Sharma. Environmental Studies, Khanna Publishing House
6. Rajagopalan, Environmental Studies, Oxford University Press

References:

1. Alli, Benjamin O. "Fundamental principles of occupational health and safety." (2001).
2. Gaur, R. C. Basic environmental engineering. New Age International Pvt Ltd Publishers, (2009).
3. ISO 14001:2004(E) - Environmental management systems Requirements with guidance for use, (2004).

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

VA-BTM591 Reverse Engineering and Product Development
Course Pre-requisites: -

Course Objectives:

- Understand the Reverse Engineering (RE) Methodology
- Disassemble products and specify the interactions between its subsystems and their functionality
- Understand RE applications in software engineering

Course Outcome:

1. Describe the theory in Reverse Engineering
2. Apply the theoretical knowledge in Reverse Engineering Process
3. Formulate 3D model from scanned data
4. Use software & hardware related to Reverse engineering.

Sr. No.	Details	Hrs.
01	Introduction to Reverse Engineering (RE) Technology & Product Development	01
02	Significance of Reverse Engineering Technology in Automotive & Auto component Industries. Barriers to reverse engg.	02
03	Product Development Sequence & Reverse Engineering (RE) Methodology.	02
04	Contact & Non-Contact data acquisition Techniques in Reverse Engineering. Software for Reverse Engg.	03
05	Perform Reverse Engg. Process & techniques through the Digitizing/Scanning methods, Generating CAD model from scanned data, Post processing, triangulation.	02
06	CASE STUDIES on Reverse Engineering in Various fields	02
07	Application of Reverse Engineering in Aerospace & ship hull craft, Medical Life Sciences, Software industry etc.	02

Term Work:
Term work shall consist of class assignments on each module.

Text Books:
W. Wego, (2011). Reverse Engineering Technology of Reinvention, Taylor and Francis Group, LLC International Standard Book Number-13: 978-1-4398-0631-9

Reference Books:
- Practical Reverse Engineering: x86, x64, ARM, Windows Kernel, Reversing Tools, and Obfuscation, Wiley publications
- Reversing: Secrets of Reverse Engineering 1st Edition, by Eldad Eilam

Sardar Patel College of Engineering

Third Year BTech Mechanical Engineering, (Under Regulation-2022)

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

PC-BTM605 Manufacturing Planning and Control
Course pre-requisites: PC-BTM306

Course Objectives:
Basically, this course consists of two streams Production Management and Operation Research.

- After learning this Course, the student will understand the Basic concepts, Principles of Production Management and Operation Research
- The student will learn the various Tools and Techniques like Forecasting techniques, Project Network Analysis Techniques, Production scheduling Techniques in detail and will be position to use them suitably.
- The student will also learn some Case studies of materials management, Purchase Management to reinforce their concepts.

Course Outcomes:

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

1. Describe the Basic concepts, Principles of Production Management and Operation Research
2. Apply the various Tools and Techniques like Forecasting techniques
3. Analyse Project Network and to learn and apply Production scheduling Techniques
4. Examine Cases of materials management, Purchase Management to reinforce their concepts

Course Content:

Module No.	MODULE	HRS
01	**Manufacturing Planning and Control System:** Manufacturing transformation process, Manufacturing as competitive advantage. Manufacturing system – components and types. *Types of products. MPC system overview objectives and functions such as planning routing, scheduling, dispatching and follow up. [Self study]* **Forecasting:** Need for forecasting, Types of forecast. Extrapolative methods- Moving average method, Exponential smoothing method, Forecast errors, Linear trend model. Causal methods- Simple regression analysis.	6
02	**Planning Function**: Capacity planning and Aggregate Planning, Master Production Schedule, Shop floor Control.	6
03	**Planning for Material requirements:** *MRP and MRP II [self study],* Inventory control systems, Economic Order Quantity. Buffer stocks. Purchase and Production type of inventory. Quantity discount.	8
04	Concept of JIT. **Scheduling & Sequencing**: Scheduling concept, Scheduling of processes, Gantt chart, *Job shop scheduling, - Comparison of various methods [self study].* Sequencing of tasks using, Johnson's rule.	6
05	**Project Management**: Concepts of project, planning, monitoring and control, Project management through network analysis, CPM & PERT, *Cost analysis and crashing [self study].*	4

06	**Advanced Concepts In Production Planning I:** Mathematical programming approaches- Linear programming problem, Formulation, Simplex method for maximization and minimization, *Concept of duality [self study]*	6
07	**Advanced Concepts In Production Planning II**: Assignment model, Transportation model. **Simulation:** Need for simulation, Monte Carlo technique, Use of Crystal-Ball Software, Factory Simulation, Use of Big Data to be applied for ERP. Optimization of Supply Chain.	6

Term Work:

- The Term work shall comprise of at least six assignments (Problems and Case Studies) covering different topics of the syllabus.
- Examination (MCQ) based on topics mentioned in latest GATE syllabus

Text Book:

1. Thomas E..Vollmann, William L.. Berry, and D. Clay Whybark.*Manufacturing planning and control systems*. Irwin/McGraw-Hill, 1997.
2. Chary, S. N. *Production and operations management*. Tata McGraw-Hill, 1988.
3. Jhamb L.C., *Modernization of Materials Management*, Everest Publishing House, 1999.
4. Taha, Hamdy A. *Operations Research: An Introduction (For VTU)*. Pearson Education India, 1982.

Reference Books:

1. Buffa E.S., Sarin R.K., *Modern production / Operations management*, Wiley, 1987
2. Telsang, Martand. *Industrial engineering and production management*. S. Chand, 2006.
3. Bewoor A., *Manufacturing Process Planning and System Engineering*, Dream-tech Press, 2009
4. Sharma J.K., *Operation Research*, Macmillan, 2009.
5. Narasimhan, Seetharama L. *Production planning and inventory control*. Pearson College Division, 1995.
6. Wayne W., *Operation Research*, Cengage Learning, 1987
7. Shah R., Soni H., *Operation Research*PHI Learning, 2009
8. Panneerselvam, R. *Research methodology*. PHI Learning Pvt. Ltd., 2014.
9. Ebert R.J., Adams E.E., *Production Operation Research*, PHI Learning, 1986.

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

PC-BTM606 CAD/CAM/CIM
Course Prerequisites: Engineering Drawing, Manufacturing Science

Course Objectives

The general objectives of the course are to enable the students to

- Understand the basic analytical fundamentals that are used to create and manipulate geometric models in computer programs.
- To visualize how the components looks like before its manufacturing or fabrication
- To learn 2D & 3D transformations of the basic entities like line, circle, ellipse etc
- To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc.
- To understand the different types of curves like Bezier curve, B-Spline curve & Graphics Standards
- To understand different Algorithms for optimization of drawing of basic entities
- To understand NC, CNC and DNC technology and Concepts of compute integrated manufacturing (CIM)

Course Outcomes

At the end of the course

1. Students will be able to **explain** the theory in CAD/CAM/CIM
2. Students will be able to **formulate** APT & CNC programs as per the geometry of work piece
3. Students will be able to **solve** analytical problems on Geometrical Transformations, Algorithms, Bezier & B-Spline Curves.
4. Students will be able to **formulate** the programs on Geometrical Transformation Algorithms, Bezier & B-Spline Curves using IT tools like C/C++/MATLAB etc.

Course Contents:

Sr. No.	Details	28Hrs.
01	**INTRODUCTION & ELEMENTS OF INTERACTIVE COMPUTER GRAPHICS** The Design process, Concurrent engineering in Product design & development, CAD System Architecture. Two dimensional computer graphics, vector generation, the windowing transformation, three dimensional Computer graphics, viewing transformation, Line, Circle & Ellipse Algorithm, Visual realism, Hidden line removal & hidden surface removal algorithm, Shading Algorithm.	**04**

02	**TECHNIQUES FOR GEOMETRIC MODELING:** Graphic standards, The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve,NURBS, Jupiter Technology, Parametric representation of line, circle, & ellipse constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature.	**04**
03	**GROUP TECHNOLOGY, CAPP, and CAQC** Introduction to GT, Part Families, parts Classification & Coding, GT Machine cells, Benefits of GT. Introduction to Computer Aided Process Planning (CAPP), Retrieval type Process Planning Systems, Generative type Process Planning Systems, Benefits of CAPP, Artificial Intelligence in CAPP,PFA, Similarity coefficient matrix. Introduction to Computer Aided Quality Control (CAQC), Computers in QC, Contact Inspection methods, Non Contact Inspection methods, Computer Aided Testing, Integration of CAQC with CAD/CAM	**04**
04	**NC, CNC & DNC TECHNOLOGY:** Introduction to NC,CNC & DNC systems along with its advantages & disadvantages, Computer Aided Part Programming, Adaptive Control, CNC programming concepts, Trends & new developments in NC, Part programmers job, functions of a post processor, NC part programming languages, Elements of a APT language, Constructional details of CNC machines, Feedback devices- Velocity & displacement, Flexible Manufacturing System (FMS), Rapid Prototyping	**06**
05	**TRANSFORMATION, MAINPULATION & DATA STORAGE** Basic Coordinate system, 2D & 3D Transformations, Concatenations, Matrix representation, Problems & Object Oriented Programming on Transformations. Data Structures for interactive modeling, Bill of materials from attribute data, The use of Object Orientation & associatively, Engineering Data Management System (EDMS), Relational Data Base for Design, Object Oriented Database, Structured Query Language, Design information Systems.	**05**
06	**COMPUTER INTEGRATED MANUFACTURING** Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio -techno- economic aspects of CIM.	**02**

07	**EMERGING AREAS in CAD/CAM & ITS INTEGRATION SCENARIOS WITH OTHER INFORMATION TECHNOLOGIES** Design for Assembly, Reverse Engineering and Data Capture techniques, Artificial Intelligence in Design & Manufacturing, Representation of Knowledge, and Knowledge base Engineering (KBE). Green Manufacturing, Virtual Manufacturing(VR), Product Life Cycle Management (PLM), CAD-VR Integration, CAD-PLM Integration, Augmented Reality (AR)	**03**

Text Books:

1. "CAD/CAM Computer Aided and Manufacturing" by Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition,PHI
2. "CAD/ CAM , Theory & Practice" by Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
3. "Computer Graphics" by Donald Hearn and M. Pauline Baker, Eastern Economy Edition
4. "CAD/CAM Principles, Practice and Manufacturing Management" by Chris McMahon, Jimmie Browne, Pearson Education
5. "CAD/CAM/CIM" by P. Radhakrishan, S. Subramanyan, V. Raju, New Age International Publishers
6. "CAD/CAM Principles and Applications" by P.N. Rao, Tata McGraw Hill Publications
7. "Principle of Computer Graphics" by William .M. Neumann and Robert .F. Sproul, McGraw Hill Book Co. Singapore.
8. "Computer Graphics & Product Modeling for CAD/CAM" by S.S.Pande, NAROSA Publication
9. David L. Goetsch, Fundamental of CIM technology , Delmar publication
10. David Bedworth, Computer Integrated Design and Manufacturing, McGraw Hill.
11. "CNC Machines" by B.S. Pabla and M. Adithan, New Age International Publishers.
12. "Numerical Control and Computer Aided Manufacturing", T.K. Kundra, P.N. Rao, N.K. Tiwari, Tata McGraw Hill
13. "CNC Technology and Programming", Krar, S., and Gill, A., McGraw Hill publishers
14. "Flexible Manufacturing Systems" by H.K. Shivanand, M.M. Benal, V.Koti, New Age International Publishers
15. "Automation, Production Systems and Computer Integrated Manufacturing ", Groover M.P., Prentice-Hall of India Pvt. Ltd
16. "Mathematical Elements for Computer Graphics", Rogers D F I and Adams J A, McGraw-Hill.

REFERENCE BOOKS

1. "Computer Integrated Manufacturing Hand Book" by Eric Teicholz, Joel N. Orr, *McGraw Hill International Editions*

2. "Computer Integrated Manufacturing- An Introduction with Case Studies" by Paul G. Ranky, *Prentice Hall International*

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

PC-BTM611 Refrigeration and Air Conditioning

Course pre-requisites: Thermodynamics, Fluid Mechanics, Thermal Systems, Heat and Mass Transfer **Course Objectives:**

- Understand fundamentals involved in basic refrigeration and air-conditioning.
- Understand principle of working and construction of air conditioners, refrigerators and other related equipment's.
- Learn about current issues of ODP, TEWI and effects of air-conditioning on global warming.
- Learn about properties of air, summer and winter air conditioning and its heat load estimation with issues related to human comfort.

Course Outcomes:

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

1. Explain the basic refrigeration cycles like vapour compression cycle, vapour absorption cycle, aircraft refrigeration cycles, cascade refrigeration and properties of air.
2. Evaluate the performance of devices working on vapour compression cycle and the vapour absorption cycle.
3. Outline properties of refrigerants, environment friendly refrigerants, properties of air and human comfort.
4. Estimate the cooling / heating load for an air conditioning systems.

Course Content:

Module No.	Details	Hrs.
01	**Introduction to Refrigeration**: Carnot's refrigerator, unit of refrigeration, COP, EER, SEER **Vapour Compression Refrigeration System**: Simple vapour compression cycle, Effect of liquid sub cooling and suction vapor super heating, Use of Liquid vapor heat exchanger (LVHE). Actual VCR cycle, Multi-pressure Systems **Overview of Applications**: House hold refrigerator, Window and Split air conditioners, Air conditioning of Multi-storied buildings, Green Buildings, Heat Pumps.	08
02	**Refrigerants and Components**: Desirable properties of refrigerants, Thermodynamic, Chemical and Physical properties, Designation system for refrigerants. ODP, GWP, TEWI, Secondary refrigerants, natural refrigerants. Types of Compressors, Condensers, Evaporators, Expansion devices, Controls – Safety Controls and Operating Controls	06
03	**Vapour Absorption Refrigeration System**: Ammonia Water, Water/Lithium Bromide system-Single Effect, Double Effect Electrolux refrigeration system, Introduction to Adsorption Refrigeration system	06
04	**Psychrometry:** Psychrometric properties, chart and processes, Bypass factor, ADP, Adiabatic mixing of two air streams, RSHF , RADP, CADP, GSHF, ESHF, Cooling Towers, Types, Approach, Range, Efficiency, Components and maintenance.	06

05	**Cooling Load Estimation**: Cooling Load estimation, Design of summer and winter air-conditioning systems.	06
06	**Air Distribution Systems**: Friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal friction drop methods of duct design, AHU and its components.	06
07	**Human Comfort**: Effective temperature, Comfort chart, Comfort zone, Methods of improving Indoor Air Quality (IAQ), Recent trends in IAQ.	04

Text Books

1. Arora, Chandra Prakash. *Refrigeration and air conditioning*. Tata McGraw-Hill Education, 2000.
2.Dossat, R. J., and Thomas J. Horan. *Principles of refrigeration*, 2002.
3.Stoecker, W. F., and J. W. Jones. *Refrigeration and air conditioning*, Mc GrawHill Book Co, New York, 1982.

References Books

1.Ananthanarayanan, P. N. *Basic refrigeration and air conditioning*. Tata McGraw-Hill Education, 2013.
2.Handbook, A. S. H. R. A. E. "Fundamentals." *American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta* 111 (2001).
3.Handbook, Shan K. Wang, "Handbook of Air Conditioning and Refrigeration", Mc Graw Hill Book Co., New York, 2000.

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

PC-BTM612 Machine Design
Course pre-requisites: PC-BTM302, PC- BTM406, PC-BTM412, PC-BTM415, PC-BTM512

Course Objectives:
The primary objective of this course is

- To analyze the stress and strain on mechanical components; and understand, identify and quantify failure modes for mechanical parts
- To define the detailed design procedure of simple machine elements as well as to apply the effect of different loading on it.
- To understand the detailed design procedure of the different types of joints and the effect of theories of failure on it.
- To understand the analysis of shafts and the effect of theories of failure.

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

1. To formulate and analyze stresses and strains in machine elements subjected to static and fluctuating load conditions
2. To design and evaluate adequacy of standard/custom-built machine elements such as shafts, belts, chains, bolted/welded joints and springs to fulfil desired specifications and satisfy failure criteria
3. To examine and identify role of material selection, manufacturing requirements, aesthetic and ergonomic needs in design of machine elements
4. To demonstrate ability to plan and prescribe design of simple machine elements through engineering drawing and calculation report.

Course Content:

Module No.	Details	Hrs.
01	Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Design Standards, I.S. codes, Preferred Series and numbers. Material properties and their uses in design, Manufacturing considerations in design: tolerances, types of fits, selection of fits, Design considerations of casting and forging. Theories of failures, Factor of safety	04
02	Design against static Loads: Cotter joint, knuckle joint. Power Screw– Design of Screw Presses.	04
03	Design against Fluctuating Loads, Variable stresses: reversed, repeated, fluctuating stresses Fatigue Failure- Static and fatigue stress concentration factors, Endurance limit-estimation of endurance limit Design for finite and infinite life- Soderberg and Goodman design criteria, Fatigue design under combined stresses.	06
04	Design of shaft- power transmitting, power distribution, shafts (excluding crank shaft) under static and fatigue criteria. Keys–Types of Keys and their selection based on shafting condition. Couplings–Classification of coupling. Selection of Standard Bush Pin coupling.	08
05	Design of springs- Helical compression, tension springs under static and variable loads	06

	Construction and design considerations of Leaf springs	
06	Belt and Chain Drives: Design of Belts –Flat and V belt with Pulley construction, timing belts and pulleys, Selection of flat and V belts from manufacturer's catalogue, Introduction to Roller chain, Selection of Standard Roller chains.	06
07	Bolted and Riveted Joints – eccentrically loaded bolted and riveted joints Welded Joints – Design of single transverse, double transverse parallel fillet, eccentrically Loaded welded joint	08

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. At least four A2 size drawing sheets shall be submitted.
3. MCQ based on topics mentioned in latest GATE syllabus

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. Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
3. Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.

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

PC-BTM617 Energy Engineering
Course pre-requisites: PC-BTM305

Course Objectives:
The objective of the course to make the students aware of renewable sources of energy which has huge potential in India. Students are expected learn emerging technology in energy, storage of energy and its audit practices.

Course Outcomes:
Upon successful completion of the course, students should be able to:
CO1: To recognize and understand the concept of sustainability of energy sources and related technology relevant to India,
CO2: Apply and analyse the fundamental to solve some real life applications related energy use for different applications,
CO3: Understand and evaluate the potential of PV, large scale solar and wind, fuel cells and hydrogen energy.
CO4: Learn the need of energy audit and apply the practices energy audit for a give application.

Course Contents:

Module No.	Details	Hrs.
1	**Energy Sources and Sustainability** Concept of sustainability and criteria for sustainable energy. Limits of fossil fuels, Opportunity and limits of Non-fossil energy sources. Vision for Renewable energy and efficiency, Carbon future, global warming and climate change	05
2.	**Fundamentals of Energy Science** Basics of energy, Mechanical, Thermal, Chemical, Solar, Nuclear and Electrical energy	05
3.	**Energy Analysis and Life Cycle Assessment** Principles of Life-Cycle Thinking and Sustainability Analysis, Energy Analysis, Energy monitoring and Energy audit, Economic Analysis of Energy Systems, Environmental analysis of energy	05
4.	**Building and Energy** Energy Efficiency for Buildings – Residential and commercial buildings, Load calculation, Annual cost of heat load management, improving efficiency, Software for building energy analysis, Calculating building energy need, Appliance Efficiency Standards-Energy STAR and Labelling, Green building ratings, Zero Energy Buildings Solar Energy for Buildings-Solar resources, Passive solar heating, Domestic water heating and solar collectors for hot water	08
5.	**Sustainable Electricity** Centralized electric power generation, transmission, distribution and regulations, Distributed generation and management – Energy Storage, Fuel Cells – PEM cells and other promising technologies, Hydrogen Production	07
6.	**Photovoltaic System**	06

	Basic of Semiconductors, PV efficiency, Commercial modules, Design and Sizing of PV system for a demand, Stand alone and Grid connected system, Economics of PV systems	
7.	**Large Scale Renewables-Wind and Solar** Wind resources, Energy from winds, Wind Turbine Technology, Economics of wind power and Environmental impact of winds Concentrating Solar Power Technologies.	06

Term Work / Laboratory Work:

- At least 2 assignments from each module.
- Group Mini-project work

Reference Materials

1. John Randilph and Gilbert M. Masters, "Energy for Sustainability-Technology, Planning, Policy", Island Press
2. Weston, Kenneth C. "*Energy conversion–the ebook*." University of Tulsa (2000).
3. A Culp, Jr "*Principles of Energy Conversion*." 2nd ed., McGraw-Hill, Inc., 1991.
4. Smith, Craig B., and Kelly E. Parmenter. *Energy, Management, Principles: Applications, Benefits, Savings*. Elsevier, 2013.
5. Hamies, *Energy Auditing and Conservation; Methods, Measurements, Management and Case study*, Hemisphere, Washington.
6. Witte, Larry C, *Industrial Energy Management and Utilization*, Hemisphere Publishers, Washington, 1988.
7. John Twidell and Tony Weir, "*Renewable Energy Resources*", John Wiley & Sons,
8. Mukund R Patel, "*Wind and solar powersystem*", CRC Press,
9. Yogi Goswami, D., Kreith, F., and Kreider, J.F., *Principles of Solar Engineering*, Taylor & Francis
10. Sukhatme S.P, "Principles of Solar Energy Collection and Storage", Tata-McGraw Hill

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

Mapping of CO of the course PC-BTM617 with POs/PSOs:

	Program Outcomes (PO)												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	2	-	1	1	-	1	-	-	1	1	-	-
CO2	3	3	3	2	-	1	1	-	1	-	-	1	1	-	-
CO3	3	3	3	2	-	1	1	-	-	-	-	-	1	-	-
CO4	3	3	3	2	-	1	1	-	-	-	-	-	1	-	-

PC-BTM656 CAD/CAM/CIM Laboratory

Course Prerequisites: Engineering Drawing, Manufacturing Science

Course Objectives

The general objectives of the course are to enable the students to

- Understand the basic analytical fundamentals that are used to create and manipulate geometric models in computer programs.
- To visualize how the components looks like before its manufacturing or fabrication
- To learn 2D & 3D transformations of the basic entities like line, circle, ellipse etc
- To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc.
- To understand the different types of curves like Bezier curve, B-Spline curve & Graphics Standards
- To understand different Algorithms for optimization of drawing of basic entities
- To understand NC,CNC and DNC technology and Concepts of computer integrated manufacturing (CIM)
- To understand modern software like ScantoCAD

Course Outcomes

At the end of the course

1. Students will be able to **formulate** the programs on Geometrical Transformation
2. Students will be able to **Implement** various Algorithms for applications of CAD/CAM
3. Students will be able to **Develop** Bezier & B-Spline Curves using IT tools like
4. Students will be able to **Generate** CNC programs for simple components

List of experiments:

1. 3D Modeling & Parametric on Advanced CAD Package
2. Assembly using Advanced CAD Package
3. C++/JAVA Program for DDA Algorithm
4. C++/JAVA Program for Bresenhams Algorithm
5. C++/JAVA Program for Circle Algorithm
6. C++/JAVA Program for Bezier Curves
7. C++/JAVA Program for B-SPline Curves
8. C++/JAVA Program for 2D Transformations
9. C++/JAVA Program for 3D Transformations
10. CNC Programs simulation for simple objects using any Simulation software (3 Programs)

TERM WORK:

- Assignments will be based on each module of theory course
- Miniproject/MCQ

PC-BTM661 Refrigeration and Air Conditioning Laboratory
Course pre-requisite: PC-BTM611

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

- Understand fundamentals involved in refrigeration and air-conditioning
- Understand construction and principle of working of compressors, air conditioners, and refrigerators.
- Learn about current issues of ODP, TEWI and effects of air-conditioning on global warming.
- Learn about air-conditioning processes.

Course Outcomes:

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

1. Know the working of refrigerators, air-conditioners and other equipment's used in HVAC.
2. Know working of various devices used in refrigerators and air conditioners.
3. Know use of refrigerants and importance of human comfort.
4. Calculate COP of refrigerators, heat pumps and air-conditioners.

Course Contents:

Experiments:

1) Experiments to find COP for equipment's like Split air conditioner, domestic refrigerator
2) Experiments on Air and water Heat Pump, Benchtop Cooling Tower
3) Experiments involving the study of humidification dehumidification, heating and cooling, Adiabatic Mixing of two air streams.
4) Visit report- Cold storage plant / ice plant or air-conditioning site visit.

Term Work:

The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Oral Examination
4. MCQ based on topics mentioned in latest GATE syllabus

VA-BTM691 CNC Programming
Course pre-requisites: Manufacturing Science

Course Objectives:

The objective of this course is to:

- Learn working principle of CNC turning and CNC milling machine.
- Learn about different hardware component and systems

Course Outcomes:

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

1. Explain basic construction, hardware components and working of CNC machines.
2. Formulate CNC program using G code and M code and run its simulation.
3. Execute a dry-run cycle before actual execution of CNC program.
4. Modify the CNC program, and its execution for variety of jobs.

Course Content:

Sr. No.	Description	Duration (hrs.)
1	Introduction to CNC Technology, CNC Architecture, Mechanical Elements of CNC Machines, Conveyors Electric Drives & Servomotors Control Elements & Feed Back Devices System Software & PLC	2
2	ATC, APC, Tool Magazine and Tooling for CNC Machines	2
3	Practical on CNC Lathe Machine How G-codes Work	2
4	Practical on CNC Machine How M- codes, Work	2
5	Programming on CNC System for Turning Centre	2
6	Programming on CNC System for Machining Centre	2
7	Practical job Performed on CNC Lathe Machine like Facing, Turning, Grooving, Threading, and Drilling.	2
8	Practical job Performed on CNC milling Machine like plain milling, side milling, pocket milling, Grooving, Threading, and Drilling.	2

Reference Material:

Peter Smid. CNC Setup for Milling and Turning: Mastering CNC Control Systems, Industrial press ***Inc.*****, 2007.**

Term work:

Assignment based on above topics.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

PE-BTM511 Finite Element Methods for Mechanical Engineers
Course pre-requisites: Strength of Materials, Engineering Mathematics

Course Objectives:
1. To explain the finite element method its fundamentals and general steps.
2. To understand the underlying theory, assumptions and modeling issues in FEM.
3. To study the formulation of elemental characteristics matrices.
4. To provide hands on experience using finite element software to model, analyze and design systems of mechanical engineering.

Course Learning Outcomes:

After successful completion of the course the student should be able to
1. Formulate numerical model for a given system.
2. Obtain solution for given problems.
3. Solve mechanical engineering problems using FEA techniques.
4. Carry out FE analysis using commercial software.

Course Content:

Module No.	Details	Hrs.
01	Introduction to FEM- DOF, elements, nodes and interpolation. Brief History. Applications of FEM in various fields. Advantages and disadvantages of FEM. FEA procedure.	3
02	Types of Differential Equations used in various engineering fields, Primary and Secondary Variables and types of Boundary Conditions. Matrix Algebra Matrix operations, Gauss Elimination Method to get inverse of a Matrix.	3
03	Formulation Techniques: Galerkin and other Weighted Residual Methods	6
04	Formulation Techniques: Variational Methods, Reyleigh-Ritz Method	6
05	One dimensional Elements and computational procedures. Bar and Beam element. Stiffness Matrix, Assembly of Stiffness matrix. Loads-mechanical and thermal (temperature DOF). Boundary Conditions.	8
06	Two dimensional elements and computational procedure. Interpolation and shape functions. Three nodded triangular element, four nodded rectangular element, four nodded quadrilateral element, and Isoparametric elements, Numerical Integration and Gauss quadrature, solution to the problem.	8
07	Introduction to 3D Elements	4

Course Project

In course projects, students shall integrate and apply the knowledge gained during the fundamental courses of Mechanical Engineering. The projects will be developed by teams of maximum two students (using any analysis software) and shall consist problem definition, model preparation, appropriate selection of elements, mesh generation, post processing, simulation and validation of results.

Term Work/Practical:

- Term work shall consist of minimum **<u>03</u>** assignments (one on each module)
- Hands on practice on finite element software for 1D and 2D problem.
- Hand on practice of NASA-NASTRAN software for solving FEA problems

Text Books:

1) P. Seshu. *Textbook of Finite Element Analysis*, Prentice Hall, 2003
2) Logan, *Finite Element Method*, CL Engineering, Fifth Edition, 2010.
3) Reddy J. N. *Finite Element Method*, McGraw Hill Education, Third Edition, 2005

References:

1) R.D. Cook. *Concepts & Applications of Finite Element Analysis*.
2) Bathe, K.J., *Finite Element Procedures in Engineering Analysis*, Prentice Hall of India.
3) C.S. Krishnamoorthy. *Finite Elements Analysis*, Tata McGraw Hill
4) S.S. Rao. *The Finite Element Method in Engineering*, 4th Edition, Academic Press, Elsevier
5) Desai and Abel. *Introduction to Finite Elements Methods*, CBS Publication.

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

PE-BTM518 Mechanical Vibrations
Course pre-requisites: Dynamics of Machinery

COURSE OBJECTIVES

1. To develop skill to model a mechanical system as a single or multi-degree of freedom vibration problem.
2. To provide knowledge of analytical and experimental methods of vibration analysis

COURSE OUTCOMES

The student should be able to –
1. Model a physical system using various principles.
2. Estimate response for the given system.
3. Evaluate response for the given system.
4. Justify parameters required for vibration control.

Course Content

Module no.	Description	hrs
1	SDOF Systems – Arbitrary Excitation Single degree of freedom systems-harmonic excitation – An Overview.	**03**
2	Forced single degree of freedom vibration system Analysis of linear and torsional systems subjected to harmonic force and harmonic motion excitation (excluding elastic damper). Force and motion Transmissibility.	06
3	MDOF Systems – Free and Forced Vibrations Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method.	**06**
4	Vibrations of Continuous Systems : Introduction to vibrations of strings, bars, shafts and beams; Mode shapes and natural frequencies.	**06**
5	Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Holzer's method etc.	**06**
6	Equivalent single degree of freedom Vibration system. Conversion of multi –springs, multi masses, multi dampers into a single spring mass and damper with linear or rotational co-ordinate system, vibration isolation	**06**
7	Vibration measuring instruments Principle of seismic instruments, Vibrometer, accelerometer, sensors used in measurement. Introduction to FFT analyzer and fault analysis, Vibration sensors and IoT	**06**

Term work:
Assignment containing numerical problems and case-studies based on above topics

Text Books

1. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, Eighth Edition, 2009
2. Graham Kelly, Fundamentals of Mechanical Vibration, Tata McGraw Hill, 2000
3. P.L. Ballaney, Theory of Machines, Khanna Publishers, Delhi.
4. Rao S. S., Mechanical Vibrations, Pearson, 2018.

Sardar Patel College of Engineering

Third Year BTech Mechanical Engineering, (Under Regulation-2022)

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

PC-BTM519 Solid Mechanics
Course Prerequisites: Mechanics and Strength of Materials

Course Objectives:
The objective of this course is to present the mathematical and physical principles in understanding the linear continuum behavior of solids

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

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

Course contents:

Sr.No.	Description	Duration (hrs)
1	Introduction to Cartesian tensors, Stress: Derivation of Cauchy relations and equilibrium and symmetry equations, principal stresses and directions, True stresses and strains	5
2	Strains: Concept of strain, derivation of small strain tensor and compatibility equations, measurement of strain using strain gauges and rosettes	4
3	Constitutive equations: Generalized Hooke's law, Linear elasticity, Material symmetry; Principle of superposition, Uniqueness theorem, Plane stress and plane strain problems	4
4	Introduction to governing equations in cylindrical and spherical coordinates, axisymmetric problems: Application of theory to thick cylinders, rotating discs	5
5	Torsion of non-circular cross-sections, stress concentration problems, thermo-elasticity, 2-d contact problems	4
6	Solutions using Energy methods, Strain energy, Resilience, proof Resilience, Calculation of stresses due to suddenly applied load, impact load, Strain energy stored due to shear.	3
7	Introduction to material plasticity, strain hardening, the Bauschinger Effect, concept of yield locus and yield surface, Introduction to fracture mechanics	3

Term work:

- Assignment based on above topics and seminars.
- MCQ based on topics mentioned in latest GATE syllabus
- Mini project / seminar based on course content

Recommended Books:

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

Reference Books:

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

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

PE-BTM532 Composite Material Technology
Course pre-requisites: Manufacturing Science, Material Science

Course Objectives:

The objective of this course is to:

- Explain types of composite materials and their applications
- Describe manufacturing processes for composite materials
- Discuss mechanical properties of composites

Course Outcomes:

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

1. Characterization of composite materials and identify its applications to mechanical engineering systems
2. Synthesis of different types of composites
3. Selection of manufacturing processes for composite materials
4. Investigation of mechanical properties of composites

Course contents:

Module no.	Description	Duration (hrs.)
1	**Overview of composite materials** Historical background, Classification based on structure and matrix, Advantages and limitations, industry applications,	06
2	**Composite materials** Reinforcement fibers, whiskers, polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC),	06
3	**Composite Science** Material and microstructure parameters of layered and phased composites, micro and macro approaches to study and prediction of structure property relations.	06
4	**Introduction to micromechanics** Anisotropy of composites, anisotropic elastic constants, failure criteria under multiaxial loading, interlaminar failure mechanism	06
5	**Composite manufacturing processes** Manufacturing of reinforcement fibers and whiskers, preparation of fillers, additives and pigments for PMC, manufacturing of matrix polymers, manufacture of metallic matrices, processing of ceramics, manufacture of foams, honeycombs and adhesives.	06
6	**Composite post processing operation** Machining, cutting, polishing, welding of thermoplastic PMC, bonding, riveting and painting	06
7	**Composite product design** ASTM standards for composites, Material considerations in composite product design, material design of thermal, optical, acoustic, electrical design requirements, design exercise for design of simple structural element such as tension bar and ring, Repair of Composites, Embedded sensors. **ANSYS or ABACUS software for the modelling and analysis of composite material** Case studies on application of the composites	06

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.

Reference Material:

1. K.K. Chawla, Composite Materials – Science & Engineering, Springer-Verlag, New York, 1987.
2. Analysis and Performance of Fiber Composites, Bhagwan D. Agarwal, Lawrence J. Broutman, K. Chandrashekhara, Wiley, 2006
3. Handbook of Composites, George Lubin, Van Nostrand, Reinhold Co., 1982

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

PE-BTM534 Lean and Green Manufacturing
Course pre-requisites: Manufacturing Sciences

Course Objectives-

- To introduce the concepts and practices of Lean and Green
- To make the students aware of Lean and Green assessment tools.
- To enable the students to apply the Lean and Green concepts in various fields.

Course Outcomes-

1. Students will learn the basic concepts of Lean manufacturing
2. Students will be able to explore the wastes in organizations as per the Lean principles
3. Students will be able to develop the New Process using the VSM
4. Students will learn basics of green manufacturing and identify the best practices used in the manufacturing environment

Course Contents:

Module No.	Description	Hrs.
01	**Introduction to Lean and Green Manufacturing** Evolution of Lean; Objectives of lean and Green manufacturing; key principles; implications of lean and Green manufacturing, Concept of Lean; Toyota's foray in Lean;	06
02	**Lean System Design - Value Stream Management** Definition of Value and value stream; Definition of waste - 3 Ms Muda, Mura, Muri - 7 Types of Muda; Value Stream Mapping (VSM) Types; TAKT Time	06
03	**Tools/Techniques/Methodologies/Practices for Lean System Implementation** **(A)Flow Stage:** Work place organization (5S principles); Concept of Kaizen/ continuous improvement; Single Minute Exchange of Die Pokayoke; Prevention & Detection Types; Maintenance - Preventive, Time Based and Condition Based; total productive maintenance; Autonomous Maintenance; Poke Yoke; Process Stability – Losses, 7 Major Losses Reduction-Overall Equipment Effectiveness (OEE) **(B) Pull stage:** **Just In Time Manufacturing (JIT):** Introduction - elements of JIT - uniform production rate - pull versus push method- Kanban system: Types of Kanbans and Practical Application, case studies;	06
04	**Lean and Green Metrics and Assessment** Identify Lean and Green Metrics; Steps involved in Goal Setting; Corporate Goals; Lean Assessment- Framework/Models of Lean and Green assessment, Global Prizes/Awards for sustainable lean and Green implementation.	06
05	**Lean Sustenance** Human Development for sustainable Lean implementation; Involvement of Employees, Cultural Change; Reviews; Recognition; Improving Targets and Benchmarking the best practices; Road map.	06
06	**Applications of Lean and Green in Different Sectors**	06

	Lean and Green New Product Development, Lean Software Development – CMMI Level 4 (Quality Improvement) and Level 5 (Quality Optimization), Lean and Green Construction, Lean Healthcare, Lean in Education system etc. A case study on application of Lean in any sector.	
07	**Reconciling Lean with Other Systems** Lean and Green Manufacturing, Barriers for Green manufacturing , Green Supplier Development, Critical success Factors for Green Manufacturing	06

Term Work:
Assignments based on the above topics.
Case study Preparation [Minimum 2 case studies]

Reference Books:

1. Micheal Wader, “Lean Tools: A Pocket Guide to Implementing Lean Practices”, Productivity and Quality Publishing Pvt Ltd, 2002.
2. Taiichi Ohno, Toyota, “Production System Beyond Large-Scale production”, Productivity Press (India) Pvt.Ltd., 1992.
3. Green Manufacturing: Fundamentals and Applications (Green Energy and Technology) 2012th Edition, by David A. Dornfeld (Editor), Springer Publications
4. Green Manufacturing Processes and Systems, by J. Paulo Davim (Editor), Springer Publications
5. Don Tapping, Tom Luyster and Tom Shuker, “Value Stream Management”
6. Tom Luyster, “Your Lean Future State”
7. Kenichi Sekine, “One-Piece Flow”, Productivity Press, Portland, Oregon, 1992.
8. Mike Rother and Rick Harris, “Creating Continuous Flow”
9. Rick Harris, Chris Harris & Earl Wilson, “Making Materials Flow”
10. Askin R G and Goldberg J B, “Design and Analysis of Lean Production Systems”, John Wiley and Sons Inc., 2003.
11. Alan Robinson, “Continuous Improvement in Operations”, Productivity Press, Portland, Oregon, 1991.
12. Poke - Yoke, "Improving Product Quality by Preventing Defects", Productivity Press, 1992.

Sr. No.	Examination	Module
1	T-1	Module 1 and 2
2	T-2	Module 3 and 4
3	Final Examination	Module 1 to 7

PE-BTM537 Tool Engineering
Course pre-requisites: Manufacturing Sciences

Course Objectives:
The objective of this course is to:

- As a result of having learned this module 1, the students will be able to understand mechanics metal cutting, different factors influencing machining phenomenon, Tool life, Economic consideration for process adoption.
- As a result of having learned this module 2, students will be able to analyze the requirements of tool design for an case and design cutting tools like single point cutting tool, drill, milling cutter etc.
- As a result of having learned this module 3, the students will be able to understand the concept of measurement of forces in machining in different operations. They will also understand the criteria for selection of the cutting fluid.
- As a result of having learned this module 4, the students will be able to get introduced and develop the knowledge and skills for rolling and forming operations.
- As a result of having learned this module 5, the students will understand fundamental of forging process, its mechanism and die design principles.
- As a result of having learned this module 6, the students will develop the knowledge and skills to design press tools for blanking, piercing and non-cutting operations.
- As a result of having learned this module 7, the students will be able to introduce and develop the knowledge related to forming of sheet metal.

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

1. To explain metal cutting principles and important analytical aspects of machining process.
2. To select and design Cutting tools for various machining processes and specify the effects of machining environment on machining mechanism.
3. To explain mechanism of operation for rolling, forging of metal and significance of design of rolling and forging dies.
4. To understand effect and use of different sheet metal forming and working processes for different applications.

Course contents:

Module No.	Description	Duration (hrs.)
1	**Metal cutting fundamentals:** Mechanics of machining – geometry of cutting tools, chip formation, cutting forces and power requirements, wear and tool life, Economics of Metal Cutting parameters affecting machining cost, Tool life for minimum cost max productivity	06
2	**Design of cutting Tools:** Design of cutting Tools Types of tools, Tool geometry, Tool signature, Design of single point cutting tool,	06

	Design of Drill, Reamer, Broach, Milling Cutter	
3	**Characterization of cutting process:** Measurement of cutting Forces, Types of tool dynamometers, Coolants types of coolants, choice of coolants, Effects of coolants on various cutting parameters, cutting fluids, machine-ability	06
4	**Rolling of metals:** Principles of rolling, Characteristic of rolling, Rolling mills and their types, Rolling parameters, Principles of roll pass design, Calculation of design parameters for rolls Forging, Extrusion, Rotary Swaging Processes, types, advantages, limitations and applications.	06
5	**Forging of metals:** Classification of forging processes, open-die forging & spread law, closed die-forging & die design, forging equipments, weight calculation of initial material in forging, forging defects Die Design for drop Forging and press Forging	06
6	**Sheet metal working:** Operations, Introduction of sheet metal working, Press, Classification of presses, Selection of presses, Difference between Hydraulic and Mechanical Press, Types of Cutting operations and non cutting operation, Different elements of die set assembly, Design of dies like simple die, progressive die, compound die, combination die, Bending die, Drawing die, Forming die	06
7	**Sheet metal forming:** Introduction and Classification of Metal Forming Processes, Advantages and Limitations, Stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms, Hot and Cold Working Processes and its effect on Mechanical Properties. **Principle, process parameters, equipment's and application of the following processes:** spinning, stretch forming, plate, V and edge bending, Curling, Ironing, Roll Bending, Metal Spinning. Press brake forming, explosive forming, Hydro forming, electro hydraulic forming, and magnetic pulse forming. High Velocity forming of metals and High energy Rate forming.	06

Recommended Books:

1. 1.S. Kalpakjian & S.R. Schmid, "Manufacturing Engineering and Technology, fourth edition", PEARSON
2. G. Boothroyd & W.A. Knight, " Fundamental of Machining and Machine Tools, third edition", CRC.
3. Milton C. Shaw, "Metal Cutting Principles", OXFORD University Press
4. O.P. Khanna, "A Textbook of Production Technology", Dhanpat Rai Publications
5. Cyril Donaldson, George H. LeCain , Tool Design, TATA McGraw Hill,2012
6. W A J Chapman ,Workshop Technology Part 1,2,&3 , Edward Arnold, 01-Jan-1972
7. B. L. Juneja&Sekhon, Fundamentals of Metal Cutting and Machine Tools, New Age Intl.

8. V.D. Kodgire, “Material Science and Metallurgy”, Everest Publishing House - 25 th. Edition – 2009.
9. HMT Banglore, Tata McGraw-Hill Education, 2001
10. Hajra Choudhary, S.K. and Hajra Choudhary A.K. ,Elements of Workshop Technology, Vol. II, Media Promoters, Mumbai. Shaw, M.C. (2005)
11. Jain R.K. & Gupta S.C."Production Technology " : Khanna Publisher, New Delhi, ; 8th Edition

Practical work:

1. Experiments on given set-up for different tool material, workpiece, cutting conditions, chip morphology study, tool geometry.
2. Industrial visit report (format should be provided by teacher)
3. Seminar presentation on the topic related to any one of the topics.

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

PE-BTM538 Industrial Management and Entrepreneurship
Course pre-requisites: General Engineering and Management

Course Objectives:
The objectives of this course are:

1. To explain and illustrate global principles of Management, principles and techniques of specific domains of management such as Human Resource Management, Engineering Economics, Cost Accounting, Financial Management etc. applicable to an Industry or an Enterprise.
2. To explain and illustrate quantitative tools and techniques in specific functional areas of Management such as Engineering Economics, Cost Accounting, Financial Management etc. applicable to an Industry or an Enterprise.
3. To explain and exemplify scope, potential, procedures, methodology for Enterpreneurship Development and Management of an Enterprise.
4. To explain and illustrate overview, concepts, structure and integration of ERP Systems in an Industry or an Enterprise.

Course Outcomes:

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

1. To understand the Global principles of Management, concepts, functions and techniques of specific domains of Management such as Human Resource Management, Engineering Economics, Cost Accounting, Financial Management etc. applicable to an Industry or an Enterprise.
2. To understand and apply quantitative tools and techniques in specific functional areas of Management such as Engineering Economics, Cost Accounting, Financial Management etc. applicable to an Industry or an Enterprise and thus, evaluate, compare and decide optimum solution of a management problem.
3. To understand and illustrate scope, potential and steps for Enterpreneurship Development and Management of an Enterprise.
4. To understand the overview, concepts, structure and integration of ERP Systems in an Industry or an Enterprise and develop understanding for Role of IT in Industry/ Enterprise for decision making and business management with customer satisfaction.

Course Contents:

Module No.	Details	Hrs.
1.	**Global Principles of Management:** Theory and Practice, Evolution of Management Thought, Management - Social Responsibilty and Ethics. Planning- Objectives, Strategies, Policies and Process, Organization- Structure and Process, Decision Making- Search, Evaluation, Quantitative/Qualitative Analysis and Selection of Alternatives, Programmed and Non-Programmed Decisions. Control- System, Process and Techniques, Role of IT	05
2.	**Human Resource Management:** Importance, Staffing and Selection Function, Managerial Performance Appraisal, Formulation of Career Strategy, Manager Development- Approach, Process and Techniques, Leadership styles,	06

	Motivation and Morale – Significance and Theories, Dynamics of Change Management, Stress Management, Work Groups Management, Management of Organizational Conflicts and Negotiation, Inter Personal Behavior, Transactional Analysis.	
3.	**Engineering Economics and Cost Accounting:** Concepts, Types and Elements of Cost, Depreciation Analysis- Causes and Methods, Break-Even Analysis and its Managerial Applications for Safety Margin, Price Change, Cost Change, etc., Profit-Volume (P/V) Analysis, Marginal Costing, Standard Costing- Significance, Advantages and Limitations, Estimated Cost, Variance Analysis- Types and its Computation. Cost of Production and Cost Curves, Law of Demand and Demand Curve, Law of Supply, Price Determination under Perfect Competition Market Structure, Cost Control and Cost Reduction- Features, Techniques, Difference and Areas of Application	07
4.	**Financial Management:** Concepts, Goals and Key Activities, Valuation Concepts- Time Value of Money, Future and Present Value of a Single Amount or an Annuity, Risk and Return of a Single Asset and Portfolio, Relation between Risk and Return, Capital Budgeting- Process, Basic Principles, Investment Criterion, Net Present Value, Internal Rate of Return, Accounting Rate of Return, Pay Back period, Discounted Pay Back, Profitability Index, Risk Analysis, Sensitivity Analysis, Scenario Analysis, Break-Even Analysis, Financial Statements and Analysis- Balance Sheets, Income Statement, Funds/Cash Flow Statements, Profit and Loss Account, Financial Ratios, Comparative Analysis, Du Pont Analysis. Financial options, Startup Options	07
5.	**Enterpreneuship and Economic Development:** Need, Scope, Philosophy, Alternative Theories, SSI Development- Indian Scenario, Risk Taking, Creativity and Enterpreneurship, Intrapreneuring and Enterpreneurship, Enterprise Launching- Policy Reforms and Government Initiatives, Enterprenual Support Systems, Industrial Reforms and Emerging Opportunities in India, **Product Selection, Market Survey**, Planning a Small-Scale Industry/ Enterprise, Energy Requirement and Utilization, Plant Location and Layout, Project Report Preparation.	06
6.	**Enterpreneurship and Enterprise Management:** Management of a Small Business Firm, **Management of Funds - Capital Structure Planning, Long Term Financing and Working Capital - EBIT-EPS Analysis,** Assessment of Debt Capacity, Financing Choices, Institutional Structure, Direct/Indirect Financial Assistance, Financing Policies, Norms, Schemes, Activities and Procedures, **Project Appraisal,** Export Finance, Sales and Marketing Management, Marketing Problems and Strategies, Quality Management, Pollution Control, Important Labour Laws, Rules for Taxes and Excise Duty, Insurance Coverage, Problems of Sickness of an Enterprise.	06
7.	**Enterprise-wide Resource Planning:** ERP Overview- Concepts and Evolution of ERP Systems, Structure, Critical Components and Architecture of ERP, Best ERP Practices, Overview of Functional Modules like- Manufacturing and Purchase Module, Sales and distribution Module, Finance Module etc.,	05

	Implementation of ERP- Steps involved, Tangible and Intangible benefits, Future of ERP, Challenges in implementation, ERP Audit, ERP Systems in India, Success and failure of ERP Systems in India- Case Studies, Integration of ERP with other ICT such as CRM, PLM, WMS and MES etc.	

Term Work:

1. At least one assignment on each module comprising theoretical concepts and numerical examples.
2. Technical presentations, Group Discussions, Case study presentations on various topics of course contents applicable to management practices in reputed plants, industrial / business organization etc.
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 / CAT Examination.

Assessment: Attendance: 5 Marks, Assignments: 10 Marks, Viva-voce/ MCQ Test:10 Marks.

Term Activity with Industry 4.0 Approach:

1. Industry visit to reputed organization/ industry.
2. Lectures / seminar by experts from industry/ organization of repute.
3. Industry case study: Recent trends and modern management practices viz: Management principles, decision making, HR Management, Motivation and leadership, Financial management, Cot accounting, Enterpreneurship, ERP systems etc. from industry/ plant/ organization of repute.
4. Internship (of one to two weeks) in an industry/ plant / organization of repute.

Text Books :

1. Weihrich Heinz , and Koonz Harold, *Management A Global Perspective*, 10th Edn., McGraw Hill International Edition,1993.
2. Khanna, O.P., *Industrial Engineering and Management*, Dhanpart Rai Publications,
3. Sekaran Uma.,Organisational Behaviour, 2nd Edn.,Tata McGraw Hill Publishing Company Limited, New Delhi, 2004.
4. Mishra Sasmita, *Engineering Economics and Costing*, 2nd Edn., PHI Learning Pvt. Ltd.,Nw Delhi, Eastern Economy Edition, 2014.
5. Chandra Prasanna., *Fundamentals of Financial Management*, 3rd Edn, Tata McGraw Hill Education,New Delhi, 2011.
6. Saini, J.S., and Rathore, B.S., *Enterpreneurship Theory and Practice*, Wheeler Publishing, New Delhi,2001.
7. Brady, J., Monk, E., and Wagner, B., *Concepts in ERP*, Thomson Learning, 2005.

Reference Books:

1.Dr.Shejwalkar, P.C., Dr.Ghanekar Anjali, and Prof. Bhivpathaki , D.P., *Principles and Practice of Management*, 14th edn., Everest Publishing House, 2005.
2.Flippo, Edwin B., *Personnel Management*, Mc Graw Hill, New York, 1984.
3.Ross, S.A., Westerfield, R., and Jordan, B.D., *Fundamentals of Corporate Finance*, Tata McGraw-Hill Education, 2008.

4.Brigham, E.F., and Ehrhardt, M. C., *Financial Management: Theory & Practice*, Cengage Learning, 2013.
5. Drucker, Peter F., *Innovation and Enterprenuership*, Harper Collins India ,2015.
6. Kuratko, Donald F.,*Introduction to Enterpreneurship*, International edn of 8th Revised educational edn., South-Western Educational Publishing,OH, 2009.
7..Leon Alexis, *Enterprise Resource Planning*, McGraw-Hill Education, 2014.

Recommended NPTEL/ Online Lectures / Courses:

1. Economics, Management and Enterpreneurship NPTEL Course Lectures by Prof. Pratap K.J. Mohapatra, IIT Kharagpur https://nptel.ac.in/courses/110/105/110105067/
2. Principles of Human Resource Management NPTEL Course Lectures by Prof. Aradhna Malik, Vinod Gupta School of Management, IIT Kharagpur https://nptel.ac.in/courses/110/105/110105069/
3. Enterprise Systems University of Minnesota Course https://www.coursera.org/lecture/enterprise-systems/1-1b-introduction-to-enterprise-resource-planning-erp-LneSo
4. Concept of Management and Evolution of Management Thought NPTEL Course Lectures by Prof. K.B. Akhilesh, IISc Bangalore https://nptel.ac.in/courses/122/108/122108038/

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

PE-BTM539 Additive Manufacturing
Course Pre-requisites: Applied Physics, Manufacturing Processes, Kinematics of Machinery

Course Objectives:
1. To study the fundamentals of additive manufacturing technologies.
2. To study basic concepts of additive manufacturing and their application in product development.
3. To study different working materials and systems used in additive manufacturing techniques
4. To study layering techniques in additive manufacturing systems

Course Outcomes:
At the end of the course the students shall be able to
1. Describe working principles of additive manufacturing techniques
2. Select proper additive manufacturing techniques for specific technical applications.
3. Select an appropriate material and tools to develop a given product using additive manufacturing machine.
4. Design layering technique for additive manufacturing

Course Content:

Sr. No.	Syllabus	Hrs
1.	**Additive manufacturing (AM)** • Historical Development • Applications: Design, Planning, Manufacturing and Tooling • Applications: Automotive, Jewelry, Bio-Medical and aerospace • Fundamentals of Additive Manufacturing, Design Process • Additive Manufacturing Process Chain	4
2.	**Subsystems of additive manufacturing Machine** • Generalized Subsystems of additive manufacturing machines o Optical System o Mechanical Scanning System o Computer Interfacing hardware, DAQs, Signal Flow, 3D Model to AM Prototype • Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, IDEAs etc.) • Slicing and Scan Path Generation Algorithms • Data Conversion and Transmission • File Formats, IGES, STL • Preprocessing and Post-processing	6
3.	**Liquid Based Additive Manufacturing Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Two Laser System • Micro-stereolithography.	6
4.	**Solid Based Additive Manufacturing Systems** • Materials • LOM (Laminated Object Manufacturing) System	6

	• FDM (Fuse Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Process	
5.	**Powder Based Additive Manufacturing Systems** • Materials • SLS (Selective Laser Sintering) • (3DP) Three-Dimensional Printing • (LENS) Laser Engineered Net Shaping • (MJS) Multiphase Jet Solidification • (EBM) Electron Beam Melting	6
6.	**Advances in Additive Manufacturing Systems and Case Studies** • Advances in RP: Resolution & Accuracy issues, Integrated Hardening Process, Two Photon Process for Micro/Nano Fabrication, Reverse Engineering Process and Applications.	6
7.	Case Study: Wind-Tunnel Testing with RP Models Case Study: Investment Casting with RP Case Study: Fabrication of microlens arrays Case Study: Fabrication of Scaffolds for medical applications	6

Tutorial/Term Work

1. Assignments based on each module.
2. Seminar based on recent advances in the subject
3. At least one Case study
4. Development of slicing and scanning program for additive manufacturing technique

Reference Books:

1. Chua C.K., Leong K.F., and Lim C.S., “Rapid Prototyping Principles and Applications”, World Publishing Co. Pte.Ltd.
2. James O. Hamblen, and Michael D. Furman, “Rapid Prototyping of Digital Systems”, Kluwer
Academic Publishers.
3. Kenneth G. Cooper, “Rapid Prototyping Technology Selection and Application”, 2001, Marcel Dekker Inc, New York.
4. Ali Kamrani, EmadAbouel Nasr, “Rapid Prototyping Theory and Practice”, 2006, Springer Inc.
5. BopayaBidanda, Paulo J. Bartolo, “Virtual Prototyping and Bio Manufacturing in Medical Applications”, 2008, Springer Inc.
6. I. Gibson, D.W. Rosen, and B. Stucker, “Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing”, 2010, Springer Inc.

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

PE-BTM552 Hydraulic Machinery
Course pre-requisites: Fluid Mechanics

Course Objectives:
The objective of this course is to:

- learn the working principle of hydroelectric power plant
- learn about the working principle, construction and parameters of analysis of different hydo-turobomachines,
- learn similarity principle of model and prototype ,
- understand working and construction features of pumping machines- positive displacement and rotodynamic pumps,
- learn about pump and pumping system

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

1. To explain the working of a hydro power plant, different hydro prime movers and pumps,
2. To do simple calculation pertaining to performance of different power generator and pumping system,
3. To analyze hydro turbine / pump for a given application
4. To select hydro turbine / pump for a given application

Course contents:

Module No.	Description	Duration (hrs.)
1	**Hydro Electric Power Plant:** Elements of a hydro power plant, types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Impulse momentum theory. Eulers' equation applied to a turbine, turbine velocities and velocity triangles, expression for work done	03
2	**Impulse Turbine:** Components of a Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge, and efficiency etc., determination of number of buckets. Performance curves	05
3	**Reaction Turbines:** Types of reaction turbines - inward and outward flow, radial mixed and axial; elements of the turbine, estimation of various parameters. Francis Turbine – construction, working and performance, Kaplan Turbine – construction, working and performance,	06
4	**Similarity:** Similarity relations in turbines, definition of unit quantities and specific quantities, selection of turbines. Prediction of results of prototypes from the model test. Cavitation in turbines - causes, effects and remedies, Thoma's cavitation parameter σ. Use of σ Vs specific	04

	speed graphs. Determination of safe height of installation for the turbine. Characteristics of turbines, governing of turbines.	
5	**Pumps:** Introduction, Classification of pumps - positive displacement and non - positive displacement. Positive - Displacement pumps: Types and applications, general features of rotary pumps like gear pumps, vane pumps, screw pumps, etc., General feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram, use of air vessel.	06
6	**Centrifugal Pump:** Types - radial flow, mixed flow and axial flow, Priming of pumps, components of the pump, Euler's equation and velocity triangles, Correction factors for the head, design constant, head constant, flow constant etc., Types of blade profiles, aerofoil theory of axial flow pumps Pressure recuperating devices, Radial thrust and axial thrust and methods used to balance them. Trouble shooting in centrifugal pumps, self priming pumps, submersible pumps, Selection of pumps.	06
7	**Pumping System:** Concept of system and system characteristics, Series and parallel operation of pumps. System curve for branch network. Determination of operating point. Similarity relations and affinity laws, characteristics of pumps. Cavitations and NPSH (NPSHA, NPSHR), Determination of available and required NPSH. Boiler feed pump, Pumping systems in petroleum industries, Application of IoT and Digital twin in hydraulic machines.	06

Hydraulic Machinery Laboratory Experiments

List of Experiments: Any six experiments (at least three from each pump and turbine) from the following list of experiments:

1. Study of hydro-electric power plant.
2. Estimation of Impact of jet
3. Constant head test on Impulse turbine.
4. Constant head test on medium head medium specific speed reaction turbine
5. Constant head test on low head high specific speed reaction turbine
6. Constant speed test on Impulse turbine.
7. Constant speed test on medium head medium specific speed reaction turbine
8. Constant speed test on low head high specific speed reaction turbine
9. Load test on centrifugal pump
10. Constant speed test on centrifugal pump
11. Performance of centrifugal pumps in series and parallel
12. Load test on positive displacement pump.

13. Study of cavitations in hydraulic machines

Term Work:

The term work will comprise of following

1. Journal of laboratory experiments.
2. At least one assignment on each module of the theory course.
3. Examination (MCQ)
4. Oral Examination
5. Case study on system of Hydraulic Machinery

Recommended Books:

1. Lal, Jagdish. *Hydraulic machines*. Metropolitan Book Company, 1961.
2. Vasandani, VP Dr. *Hydraulic Machines: Theory and Design*. Khanna Publishers, 1996.
3. Church, Austin Harris. *Centrifugal pumps and blowers*. Robert E. Krieger, 1972.
4. Rao B.C.S., *Fluid Mechanics and Machinery*, McGraw Hill, 2009.
5. Gupta, S. C. *Fluid mechanics and hydraulic machines*. Pearson Education India, 2006.
6. Douglas J., Gasiorek J., Swaffield J., Jack L., *Fluid Mechanics*, Prentice Hall, 2006.

References:

1. Lazarkiewicz, S. ,Troskolansky AD, *Impeller Pumps*, 1965.
2. Stepanoff, Alexey J. "Centrifugal and axial flow pumps." (1948).
3. Karassik, Igor J., Joseph P. Messina, Charles C. Heald, and Paul Cooper. *Pump handbook*, Vol. 3, McGraw-Hill, 1976.
4. Nechleba, Miroslav. "Hydraulic turbines, their design and equipement." (1957).

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

PE-BTM554 Compressible Fluid Flow
Course pre-requisites: Fluid Mechanics

Course Objectives:
The objective of the course is to make students familiar with the basic behavior of compressible fluids so that they can use this understanding to acquire deeper knowledge in applied domain (high speed flow) and solve simple real-life problems.

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

1. to define the fundamental principles of compressible flows and related terminology, and identify the case of a compressible flow.
2. to describe and explain the basic principles and related mathematical models.
3. to apply the knowledge, perform calculations and solve simple real-life problems.
4. to analyse and design a given system and recommend a better solution after its evaluation.

Course Contents:

Module	Description	Hrs.
1	**Fundamental Concepts:** Concept of compressibility- Ideal gas, speed of sound, Mach number, Governing equations: mass, momentum, energy and entropy equations; Illustrations of few applications where compressible flow study is applicable.	04
2	**One Dimensional Isentropic Flow Through Variable Area**: Isentropic relations; One-D compressible adiabatic duct flow, critical properties; Converging nozzles, choking, converging-diverging nozzles, rocket nozzles;	06
3	**Flow Through Normal Shocks**: Development of shock wave, Governing equations, Prandtle Meyer relation, Property changes across shocks, Tables and charts for normal shock waves	06
4	**Flow Through Oblique Shocks**: Nature of flow, Fundamental relations, Rankine- Hugoniot Equation, Variation of flow parameters, Gas table for oblique shocks;	06
5	**One Dimensional Duct Flow with Heat Transfer** Rayleigh flow and equations, *T-s* diagrams, choked Rayleigh flow;	08
6	**One Dimensional Duct Flow with Friction** Fanno Flow Equation, Choked Fanno Flow, Comparison and Summary of 1-D flows;	06
7	**Wind Tunnel:** Fundamentals of wind tunnels, types of wind tunnels, Design of wind tunnels. Application in compressible flow study;	06

TERM WORK:
Term work shall consist of class assignments on each module.

Recommended Books:

1. Fox and McDonald, "*Introduction to Fluid Mechanics*", John Wiley & Sons, 8ed.
2. Frank M. White, "*Fluid Mechanics*", McGraw Hill, 7ed.
3. John David Anderson, "Modern compressible flow: With historical perspective", McGraw Hill
4. S M Yahya, "Fundamentals of compressible flow", New Age Publication
5. V Babu, "Fundamental of gas dynamics, Wiley
6. Shapiro A H, "The Dynamics And Thermodynamics Of Compressible Fluid Flow", Ronald Press

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

OE-BTM611 Computational Methods
Course pre-requisites: Engineering Mathematics

Course Objectives:

The objective of the course is to equip students with common techniques of numerical computation which is base of several engineering software. This knowledge will help to understand and develop programming skill and use the software more effectively.

Course Outcomes:

Upon completion of this course, students should be able to:

1. to understand and develop a mathematical model for a problem and select an appropriate numerical technique for its solution.
2. to analyze and compare different techniques with reference to errors, convergence and accuracy.
3. to apply the knowledge, perform calculations and solve simple real-life problems.
4. to develop pseudo-code which can be used with available programming resources.

Course Contents:

Module	Description	Hrs.
1.	**Exposure to Numerical Software** Introduction to MATLAB and numerical programming through it, Using EXCEL worksheet in numerical computation.	04
2	**Fundamentals of Modeling and Error**: Fundamentals of mathematical modeling - needs and limitations. Mathematic modeling of simple engineering systems Significance of analytical and numerical methods in engineering analysis. Error analysis; significant figures, accuracy and precision, Error definitions, Round-off and truncation error	04
3	**Numerical Solution of Systems of Linear Algebraic Equation:** Direct Methods: Matrix inversion, Gauss Elimination, LU Decomposition, TDMA Nature of iterative solution, Role of eigen values in convergence, Successive under relaxation, Iterative Methods - Jacobi, Gauss Siedel, Effect of rounding off on iteative solution and ill-conditioned system.	04
4	**Numerical Solution of Systems of Non-linear Equations:** Roots of equations: Bisection, False position, Secant, Newton- Raphson methods. Problems based on real-life application.	04
5	**Numerical Interpolation, Integration and Differentiation:** Developing interpolating polynomial using Direct, Newton's divided difference, Lagrangian, Spline and Aitken's methods. Newton-Cotes Integration Formulas - Trapezoidal rule, Simpson's rule, Finite Difference Methods - Forward difference, Backward difference and Central Difference	04
6	**Numerical Solution of Ordinary Differential Equation:** Single step and multi-step methods. Explicit and Implicit Marching Method, Modified Euler's Method, Runge-Kutta Methods - RK-II and RK-IV,	04

	ODE System: Initial value problem, Boundary value problem, Predictor-corrector methods -Adams Method, Adams-Bashforth-Moulton Method, Milne's Method, Adams- Moulton Method , Stiff ODE System	
7	**Regression Analysis-** Difference between interpolation and Regression. Techniques of regression - Least- square regression Linear regression, non-linear regression and polynomial regression, check of regression analysis.	04

Term Work:

The term work shall comprise of problems and case studies covering different topics taken from course studied in the semester. Assignment shall consist of programmes written in pseudo code, any programming language or MATLAB.

Recommended Books:

1. Sastry, S S. Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.
2. Chapra, Steven and Canale. Numerical methods for engineers. New York: McGraw – Hill, 7ed.
3. Applied numerical analysis : Curtis Gerald

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

OE-BTM613 Entrepreneurship Development and Start Up
Course pre-requisites: General Engineering

Course Objectives:
In this Course Students will:
1. Know different aspects of Entrepreneurships, Business models.
2. Demonstrate the idea generation techniques, Planning of Marketing process, prototyping methods,
3. Apply engineering knowledge to develop prototype of their ideas and innovations.
4. Demonstrate different aspects of Techno-Economic Feasibility, Intellectual Property Rights and Institutional Support for Start-Ups

Course Outcomes:
Upon successful completion of the course, students should be able to:
1. Know different aspects of Entrepreneurships, Business models.
2. Demonstrate the idea generation techniques, Planning of Marketing process, prototyping methods,
3. Apply engineering knowledge to develop prototype of their ideas and innovations.
4. Demonstrate different aspects of Techno-Economic Feasibility, Intellectual Property Rights and Institutional Support for Start-Ups

Module No.	Course Contents	Hrs
1	**Entrepreneurship:** Introduction to Entrepreneurship, Need for Entrepreneurship, Types of Entrepreneurs, Types of Leaders, Entrepreneurship Development.	4
2	**Idea generation & Creativity:** Invention and Innovation, Types of Innovations, Idea Generation techniques: Brain storming. SCAMPER Technique, Morphological Matrix; Evaluation Strategies.	4
3	**Market Research and Planning:** Purpose of market research, Techniques of Market Survey, Procedure of market research and research process, Limitations of Market Survey.	4
4	**Prototyping & Rapid Prototyping:** Roles of Prototyping, Phases of Prototyping**,** Fundamentals of Rapid Prototyping, Benefits of Rapid Prototyping, Classification of Rapid Prototyping,	4
5	**Intellectual Property Rights:** Fundamentals of IPR, Legislations on IPR in INDIA, International Organization and Treaties, Types of IPRs: Patents, Trademarks, Copyrights, Trade Secret	4
6	**Techno-Economic Feasibility Analysis:** Types of Analysis: Economic Feasibility, Marketing Feasibility, Financial Feasibility, Technical Feasibility, Micheal Porter's 5 force analysis, market options, competitive scenarios	4
7	**Institutional & Financial Support for Start-Ups:** Government Policies for small scale industries, Different financial institutions for small scale industries and Incentives by government schemes. International Schemes, Venture Capital, crowdfunding,	4

Term Work/Tutorial:

Tutorials will consist of one Assignment on each module and Case Studies and Roleplays.

Reference Books:

1. "Entrepreneurship Development", S. Anil kumar, New Age International Publishers.
2. "Entrepreneurial Development", S. S. Khanka, S. Chand & Company Ltd.
3. "Entrepreneurship Development", A. Nirjar, Word-Press.
4. "Rapid Prototyping, Principles and Applications", Chua C. K., Leong K. F. and Lim C. S., World Scientific Publishing Company Ltd.
5. Intellectual Property Rights", Neeraj Pandey and Khushdeep Dharni, PHI Learning Pvt. LTd.
6. Intellectual Property Rights, Texts and Cases", Dr. R. Radhakrishnan and Dr. S. Balasubramanium, Excel Books.

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

OE-BTM614 Introduction to Optimization Methods
Course pre-requisites: Engineering Mathematics

Course Objectives:

1. To introduce tools and techniques for optimization to engineering applications
2. To understand the formulation of design equations for engineering systems.
3. To understand algorithms and methods used for optimization

Course Outcomes:

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

1. Explain different approaches to optimize engineering systems.
2. Create programs based on different optimization algorithms using IT tools, such as MATLAB, Python etc.
3. Calculate optimum solution to linear and non-linear problems.
4. Apply the numerical and optimization understanding for finalizing design of engineering systems.

Course content:

M. No	Description	Hrs
1	Need for optimization and historical development, classification and formulation of optimization problem, objective function and constraints, graphical method for two variables	04
2	Calculus based methods, function of single, two and multiple variables, Hessian matrix formulation, Kuhn-Tucker condition	04
3	Linear programming (LP) based methods, standard form of LP problem, simplex algorithm	04
4	Unconstrained multivariate problem solution using Box's evolutionary algorithm, Stochastic methods and Random search algorithms	04
5	Enumerative schemes and Integer programming, integer linear programming, mixed integer programming using Branch and Bound Method, Simulated Annealing	06
6	Evolutionary algorithms, Genetic algorithms, Nature inspired optimization methods – Particle Swarm Optimization (PSO)	04
7	Computational aspects of optimization, Sensitivity analysis, Use of software tools for solving optimization problems	02

Term work:

- Assignments containing numerical problems based on each module.
- Seminar based on recent advances in subject.
- At least one case study based on any one optimization method.
- Mini-project based on course content

Text Books:

1. Rao, Singiresu S., and S. S. Rao. *Engineering optimization: theory and practice*. John Wiley & Sons, 2009.

2. Deb, Kalyanmoy. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.

Reference Books

1. Mital, K.V., 1996. *Optimization methods in operations research and systems analysis*. New Age International.
2. Taha, Hamdy A. *Operations Research: An Introduction (For VTU)*. Pearson Education India, 1982.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

OE-BTM616 Industry 4.0
Course pre-requisites: - CAD, BIM, Sensors, Data base

Course Objectives:

(i) To understand the various industrial revolutions
(ii) To understand the enabling technologies for industry 4.0
(iii) To understand the power of data analytics
(iv) To understand importance of Connectivity
(v) To understand interdisciplinary concept & technology convergence
(vi) To understand New business and Revenue models in light of industry4.0

Course Outcomes:

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

(i) Explain & write basic concepts of industry 4.0
(ii) Identify various enabling technologies of industry4.0.
(iii) Apply theoretical knowledge in practice
(iv) Develop small application using various technologies of industry4.0.

Course Content		
Module No.	**Details**	**Hrs.**
1	**Introduction to Industry 4.0:** Evolution of 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 industry4.0 to Mechanical & Civil engineering.	4
2	**Introduction to Augmented Reality:** Basics of AR, Mixed Reality, Enabling technologies of AR, Marker based & Marker less AR. Software & Hardware of AR, Creating AR experience, Applications of AR in Mechanical & Civil engineering, Challenges	6
3	**Introduction to Virtual Reality:** Basics of VR, Software & Hardware of VR, Challenges, Applications in Mechanical & Civil engineering, Robotic automation & Collaborative robots (COBOTS)	6
4	**Introduction to Artificial Intelligence:** Knowledge Based, Rules based **Introduction to Machine Learning:** Overview of Supervised, Unsupervised & Reinforced learning Algorithms **Introduction to Deep Learning:** Overview of Artificial Neural Network (ANN), Convolutional Neural Network (CNN), AUTOENCODERS Algorithms	6
5	**Introduction to Internet of Things (IOT):** Sensors, IOT Protocols, IOT Platforms, Selection of sensors & IOT Platform, enabling technologies, micro controller, micro processer, Arduino board, Raspberry Pi, Sending Analog Data on Cloud Server, Smart Product Development, Smart Cities, Smart Manufacturing, Smart Logistics etc.	5
6	**Introduction to Big Data Analytics:** Evolution of big data, big data tools, 6V of big data, Basics of big data, HADOOP Ecosystem, HDFS data storage, data processing, RDBMS & NOSQL data base management, Challenges of big data, Sentiment Analytics, Predictive Analytics, Graph Analytics etc.	4
7	**Introduction to Cloud Computing:** Cloud Computing basics, Cloud	5

	deployment models like Software as a Service (SAAS), Platform as a Service (PAAS), Infrastructure as a Service (IAAS), Mobile Computing Virtualization, Technology providers vs. Cloud providers vs. Cloud vendors, Cyber Security Business Issues in industry4.0, Opportunities, Challenges, Skillsets, Startegies	

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. Industry 4.0: Managing The Digital Transformation Book by Alp Ustundag and Emre Cevikcan, Publisher:Springer International Publishing, ISBN:9783319578705, 3319578707
2. Shaping the Fourth Industrial Revolution A Guide to Building a Better World, by Klaus Schwab, Nicholas Davis, Publisher:Penguin Books Limited, ISBN:9780241366394, 0241366399
3. Dieter Uckelmann et.al, “Architecting the Internet of Things”, Springer, 2011
4. Data Analytics : The Complete Beginner's Guide - Step By Step Instructions (The Black Book) Kindle Edition, by Byron Francis
5. The Enterprise Cloud: Best Practices for Transforming Legacy IT, by James Bond
6. Augmented Reality: Principles & Practice Paperback, by Schmalstieg/Hollerer
7. Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, by Tony Parisi, Publisher:O'Reilly Media, ISBN:9781491922781, 1491922788

Reference Books

1. Charalampos Doukas, “Building Internet of Things with the Arduino”, Create space, April 2002
2. Big Data and Analytics 1st Edition, Kindle Edition, by Subhashini Chellappan Seema Acharya
3. Cloud Computing: Concepts, Technology & Architecture, by Richardo Puttini, Thomas Erl, and Zaigham Mahmood
4. Handbook of Augmented Reality, by Borko Furht, Publisher:Springer New York, ISBN:9781461400646, 1461400643

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

OE-BTM617 Digital Twin
Course pre-requisites: CAD, Sensors, Simulation

Course Code	Course Name
OE-BTM617	Digital Twin

Course Objectives

- To understand the fundamentals of industry 4.0 & digital twin
- To understand the enabling technologies for digital twin
- To understand how to build a digital twin
- To study application areas of digital twin
- To understand digital twin as an interdisciplinary technology along with its integration
- To understand New business and Revenue models of digital twin

Course Outcomes

Upon successful completion of the course, students should be able

0. Explain & write basic concepts of digital twin
1. Identify various enabling technologies of digital twin.
2. Apply theoretical knowledge in practice
3. Develop small application using digital twin related software

Course Content

Module No.	Details	Hrs.
1	INDUSTRY 4.0: Introduction to industry 4.0, Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics.	4
2	Evolution of Digital Twins, Introduction to Digital twin, Basic concepts of Digital twins, Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, augmented digital twin, Smart & Connected design, accelerating industry 4.0 using Digital Twin	6
3	Enabling technologies for Digital Twin like Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Big Data Analytics, Internet of Things (IOT), Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Cloud Computing Services (CCS) etc.	6
4	How to build a digital Twin, Steps in building digital twin, integration of IOT & CAD, integration of IOT, BIM data & machine Learning, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms Concurrent engineering & digital twin, digital twin as a smart service to industries.	6
5	Use cases of Digital Twin in Product development, Logistics Manufacturing, Simulation, Predictive Maintenance, Asset Maintenance, Construction industry, Facility Management Architecture, Electrical engineering, digital twin driven power transformer service, Health Care & etc.	5

6	Integration of Digital Twin with Product Life Cycle Management (PLM), Big Data Analytics, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management (SRM), Manufacturing Execution Systems (MES) etc.	4
7	Building New business/Revenue models, developing maturity model of digital twin, Benefits of Digital Twins, Challenges in applying & implementing digital twins Future research areas of digital twin, Careers in Digital twin, Digital Twin Engineer	5

Term Work/ Laboratory

- Journal work shall consist of one assignment on each module
- Seminar
- One Mini Project

Text Books

1. Digital Twin: Possibilities of the new Digital twin technology, Anand Iyer, 2017, 35 Pages
2. Digital Twin Development & Deployment on the Cloud, Ist edition, Nassim Khaled Bibin Pattel Affan Siddiqu, ISBN: 9780128216316, ELSEVIER, pages 592
3. Digital Twin Technologies & Smart Cities, Maryam Farsi, Alireza Daneshkhah, Amin Hosseinian-Far, Hamid Jahankahani, Springer, ISBN 978-3-030-18731-6
4. Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee, ISBN 978-0-12-817630-6, ELSEVIER, pages 257
5. Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj & Preetha Evanjaline, ELSEVIER, pages 257, ISBN 978-0-12-818756-2, ISSN 0065-2458

Reference Books

1. Digital Twin Driven Smart Design by Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, ELSEVIER, ISBN 978-0-12-818918-4, Pages 333
2. Handbook Of Digital Enterprise Systems: Digital Twins, Simulation and Ai, by Wolfgang Kühn, world scientific publishing co., ISBN 978-981-120-073-1, Pages 229.
3. Digital Twin Complete Self-Assesment Guide, 1976302927, 9781976302923sment Guide, Geradus Blokdyk, CreateSpace Independent Publishing Platform, 2017, Pages 120.

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

OE-BTM618 Smart City for Sustainable Development
Course pre-requisites: Basic Science and Mathematics

Course Objective

- To understand the fundamentals of industry 4.0 & smart City
- To understand the technology pillars for smart Cities
- To understand the role of DT in building smart City
- To study applications & various components of Smart Cities
- To understand various IOT Platforms for smart cities
- To understand governance, guidelines for smart Cities
- To understand New business and Revenue models of digital twin

Course Outcomes:

Upon successful completion of the course, students should be able

4. Explain & write basic concepts of Smart City
5. Identify various enabling technologies of Smart City.
6. Select the hardware & software related to smart cities
7. Develop small application using software related to smart city

Course Contents:

Module No.	***Details***	***Hrs.***
1	Introduction to Smart City, concept of smart city, traditional city. Issues & challenges of smart city. Introduction to industry 4.0, Technologies drivers, smart village, Introduction to BIM, BIM Modeling, SCAN to BIM, BIM interoperability	2
2	Components of smart city, smart urban planning, smart waste management, smart resource management, sustainable environment, smart buildings, smart infrastructure, smart Maintenance, smart mobility, smart service, smart people, smart urban energy systems, smart transport system management, smart irrigation system, Smart Traffic lighting system etc. Software and hardware for building smart cities, etc.	6
3	Technologies for Smart Cities, benefits of enabling technologies to smart cities & their framework/architecture etc. Collection, processing & Visualization of smart city data. etc.	6
4	Introduction to DT, role of digital DT in building Smart Cities etc. various steps in building smart cities, significance of DT in smart city creation etc. Enterprise Software integration with smart cities & its benefits.	6
5	Monitoring of smart cities, Internet of Things (IOT) Platforms for Smart City monitoring, framework/architecture etc. Working of IIOT platforms, Benefits of IIOT platforms etc.	4
6	Traditional Governance, Collaborative smart Governance, models, guidelines, challenges of intelligent administration.	2
7	Building New business/Revenue models from Smart Cities, Security & concern areas of smart city	2

Term Work:

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

Reference Materials

1. “Smart Cities, Smart Future: Showcasing Tomorrow” (Wiley and SAS Business Series)
2. Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia
3. Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, “Digital Twin Driven Smart Design”, Elsevier
4. Anil Kumar, “Introduction to Smart Cities”, PEARSON
5. Smart Cities: Introducing Digital Innovation to Cities
6. Juan Carlos Augusto “Handbook of smart cities” , Springer
7. Picon A, “Smart Cities A Spatialised Intelligence”, John Wiley
8. Singh Binti and Parmar Manoj, “Smart City in India”, Taylor & Francis
9. Giffinger, Rudolf, Christian Fertner, Hans Kramar, Robert Kalasek, Nataša Pichler-Milanovic; Evert Meijers "Smart cities – Ranking of European medium-sized cities". Smart Cities. Vienna: Centre of Regional Science
10. "Draft Concept Note on Smart City Scheme". Government of India - Ministry of Urban Development (http://indiansmartcities.in/downloads/CONCEPT_NOTE_-3.12.2014__REVISED_AND_LATEST_.pdf)

PR-BTM698 Project Stage I

Course pre-requisites: Recommended – all courses till semester V

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 solution
2. use knowledge for formulation / fabrication of the desired project
3. analyze the available resources and to select most appropriate one
4. 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 in terms of 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 semester.	**2 (contact) + 6 (self-study)**