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)

Year: 2018-19

Sardar Patel College of Engineering, Andheri (West), Mumbai 400058
Year: 2018-19

List of Courses

PCC-BTM501 Heat and Mass Transfer

Course Pre-requisites: PCC-BTM305

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 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 Content:

Module No	Details	Hrs.
Module 01	**Basic Concepts:** Understanding generalized energy equation in the mathematical form, Identifying the mode of heat transfer in a thermal system. Modes of heat transfer, its mechanism and mathematical models.	03
Module 02	**Conduction:** General conduction equation in cartesian, cylindrical and spherical coordinates 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. Critical thickness of insulation and its importance. Extended surfaces.	07
Module 03	**Transient Conduction:** Lumped capacity method, Distributed parameter treatment, Use of transient temperature chart, Semi infinite solids.	03
Module 04	**Fundamental of Convection:** Natural and Forced convection, hydrodynamic and thermal boundary layers. Similarity between velocity profile and temperature profile. 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, Grashoff s Number, Prandtl's Number, Reynolds Number and Stanton's Number. Principle of dimensional analysis. Application of dimensional analysis to Convection for finding heat transfer coefficient.	10

	Empirical relations and their use for forced internal and external convection under standard boundary condition for circular and non-circular duct. Empirical relations for free convection for standard cases.	
Module 05	**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, Kirchoff s law, Stefan-Boltzman law, Wien's.-.displacement law and Lambert's Cosine law. Intensity of Radiation Radiosity. Radiation heat exchange between two black bodies. Electrical network analogy for radiation heat exchange between two and three grey bodies. Shape factor for simple geometries. Properties of shape factor.	07
Module 06	**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.	07
Module 07	**Mass Transfer:** Mechanism of mass transfer. Importance of mass transfer in engineering. Fick's law of diffusion. Steady State diffusion of gases and liquids through plane, cylindrical and spherical walls. Equimolal diffusion. Isothermal evaporation of water into air. Convective mass transfer and mass transfer coefficient. 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

PCC-BTM502 Theory of Machine -II
Course Pre-requisites: BTM402, PCC-BTM402

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 mechical engineering.

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 clutches, breaks, 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.

Course Content:

Module No.	Details	Hrs.
01	**Clutches:** Positive clutches, friction clutches, Friction Clutches-Analysis of frictional torque, power transmission. Power loss in Friction in single plate, multiple plate clutch, and cone clutch, Centrifugal Clutches-construction, working **Brakes:**Type of Brakes, Analysis of Block brakes –external and internal, Band brake-simple and differential, Band and block brake simple and differential, Braking of vehicles front wheels, rear wheels, all wheels on level and, transmission, epicyclic, torsion dynamometers, Froude hydraulic dynamometer. **Dynamometers**–Absorption and transmission dynamometers, Study and analysis of absorption type dynamometer –Proney brake, Rope brake, dynamometers, Study and analysis of transmission type dynamometers.	12
02	**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 governors-stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness.	7
03	**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.	5
04	**Gear Trains:** Kinematics and dynamic analysis of- simple gear trains, compound gear trains, reverted gear trains, and epi-cyclic gear trains with spur	5

	or bevel gear combination.	
05	**Basic Concepts of Vibration:** Vibration and oscillation, causes and effects of vibrations, Vibration parameters -spring, mass, damper, Damper models, Motion- periodic, nonperiodic, harmonic, non–harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis.	3
06	**Free Undamped Single Degree of Freedom Vibration System:** Longitudinal, transverse, torsional system, Methods for formulation of differential equations by Newton, Energy, Lagrangian (Rayleigh's method), Effect of spring's mass and shaft inertia on natural frequency, Effect of flexible bearings on natural frequency **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.	7
07	**Balancing:** Static and dynamic balancing of multirotor system, Balancing of reciprocating masses In-line engines, V-engines (excluding radial engines)	3

Term Work / Laboratory Work:
Journal work shall consist of experiments (at least 06) and assignments (one on each Module).

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.

Reference Books:

1. Norton, Robert L. *Design of machinery: an introduction to the synthesis and analysis of mechanisms and machines*. McGraw-Hill Professional, 2004.
2. Ghosh A., Malik A., *Theory of Mechanisms and Machines*, West Press Pvt. Ltd., New Delhi (2014)
3. Green, Walter George. *Theory of machines*. Blackie, 1962.
4. Srinivas J., *Mechanics & Dynamics of Machinery*, Scitech, 2001.
5. Waldron, Kenneth J., Gary L. Kinzel, and Sunil K. Agrawal.*Kinematics, dynamics, and design of machinery*. John Wiley & Sons, 2016.
6. Hahn, Brian, and Daniel Valentine. *Essential MATLAB for engineers and scientists*. Newnes, 2007.

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

PCC-BTM503 Mechatronics

Course Pre-requisites: Engineering sciences, PCC-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, 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 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.
Module 01	Introduction to Mechatronics, Mechatronics Systems in Factory, Home and Business Applications. Basic Components of Mechatronic Systems, Mechatronics Design process, Objectives.	02
Module 02	Overview of microprocessors and micro-controllers 8051microcontrollers: Functional block diagram and architecture, Interfacing of: HEX-keyboards, LCD display, ADC, DAC and Stepper motor	07
Module 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
Module 04	Introduction to control systems, open loop and closed loop systems, Mathematical modeling of control systems, concept of transfer function, Block diagram algebra, State space modeling, Process control systems, ON-OFF control, P-I-D Control. Control system components: servomotor, stepper motors.	06
Module 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	08

	analysis: Introduction to concepts of stability, The Routh and Hurwitz Stability criteria, Relative stability analysis.	
Module 06	Root locus concepts. Frequency Response Analysis: Frequency domain specifications, Correlation between time and frequency response, Polar Plots, Bode Plots.	07
Module 07	State-Space methods, Single degree of freedom, Multi-degree of freedom, Forced response, State Space representation of Control systems	05

Term Work:
At least 06 assignments (one on each module).

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 Company, 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

PCC-BTM504 Thermal Systems
Course pre-requisites: PCC-BTM305

Course Objective:
The students after studying this course should be able to
- Understand fundamentals involved in compressor technology and power generation.
- Understand working of Compressors, turbine, steam generators and condensers.
- Carry out basic calculation involving compressor, turbine, condensers and steam generators.
- Understand performance parameters of compressors and turbines.

Course Outcome:
Upon successful completion of the course, students should be able to
1. apply knowledge of thermodynamics and fluid mechanics to study the performance of different types of compressors.
2. do simple calculations on the performance of compressors.
3. get knowledge about working of different types of steam generators, turbines and condensers.
4. do simple calculations on the performance of steam turbines and gas turbines.

Course Content:

Module No.	Details	Hrs.
01	**Introduction to thermal systems:** Basic principles of steam power cycle – Carnot cycle, rankine cycle; Equipments and accessories of thermal power plant.	3
02	**Reciprocating Compressors**: Single stage reciprocating compressor- neglecting clearance. Multistaging of compressors. Two stage air compressors, Perfect inter-cooling. Ideal inter cooler pressure. Minimum work, Free air delivered, volumetric efficiency, isothermal and adiabatic efficiency. Effect of clearance volume on F.A.D and volumetric efficiency, Work, power and efficiency calculations.	8
03	**Rotodynamic Compressor:** Energy conversion in rotodynamic machines, Rotary, centrifugal and axial compressor; Surging, chocking and stalling, Multi-staging, performance parameters and characteristics.	5
04	**Steam Generator**: 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, Boiler performance. Boiler efficiency. Fluidized bed system in steam generation. Use of nuclear energy in steam generation and power production.	08
05	**Steam Condensers:** Need of condenser, Elements of condensing plant, Types of condensers, surface and evaporative condenser. Partial pressure, effect of air leakage, vacuum efficiency, Air pump capacity, Cooling tower and associated calculations.	4
06	**Steam Turbines:** 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.	7

07	**Gas Turbine**: Application of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration. Effect of operating variable on thermal efficiency and work ratio.	7

Text Books:

1. Nag, P. K. *Power plant engineering*. Tata McGraw-Hill Education, 2002.
2. Kothandaraman, C. P., S. Domkundwar, and Anand Domkundwar. *Cource in Thermal Engineering*. Dhanpat Rai & Company (P) Limited, 2010.
3. Yadav, R. "steam and gas turbine and Power Plant Engineering." (2009)
4. Yadav, R. "Thermodynamics and Heat Engines." *Allahabad: Central Publishing House* (2001).
5. Yahya, S. M. *Turbines compressors and fans*. Tata McGraw-Hill Education, 2010.

References:

1. Sorensen, Harry A. *Principles of Thermodynamics*. Holt, Rinehart and Winston, 1961.
2. Eastop, T. D., and A. McConkey. "Applied thermodynamics for engineering technologists, 1996.
3. Yunus A Cengel and Michael A. Boles, *Thermodynamics an Engineering Approach*. Tata McGraw-Hill Education, 2014.

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

PCC-BTM505 Hydraulic Machinery
Course Prerequisite: PCC-BTM403, PCC-BTM453

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 of pumping machines- reciprocating and centrifugal,
- 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.	04
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	06
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 speed graphs. Determination of safe height of installation for the turbine. Characteristics of turbines, governing of turbines.	06

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.	06

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 equipment." (1957).

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

PCC-BTM506 Numerical Methods
Course Prerequisite: Engineering Mathematics

Course Objectives:

1. To understand the fundaments of numerical computation.
2. To learn the common numerical techniques for basic tools of mathematical.
3. To apply numerical techniques to solve simple real-life problems.

Course Outcomes:

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

1. understand the basic concept of modelling, numerical computation and associated errors.
2. apply numerical techniques of common mathematical tools to solve real life problem.
3. analyze and compare different techniques with reference to errors, convergence and accuracy.
4. demonstrate potential to develop code which can be used with available programming resources.

Course Contents:

Module	Description	Hrs.
1	**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
2	**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.	06
3	**Numerical Solution of Systems of Non-linear Equations:** Roots of equations: Bisection, False position, Secant, Newton- Raphson methods. Problems based on real-life application.	06
4	**Numerical Integration and Differentiation:** Newton-Cotes Integration Formulas - Trapezoidal rule, Simpson's rule, Finite Difference Methods - Forward difference, Backward difference and Central Difference	06
5	**Numerical Solution of Ordinary Differential Equation:** Explicit and Implicit Marching Method, Modified Euler's Method, Runge-Kutta Methods - RK-II and RK-IV, 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	08
6	**Curve Fitting;** Regression - Least- square regression	06

	Interpolation - Newton's divided difference polynomials, Lagrange's polynomials, Spline interpolation;	
7	**Use of Code / Software for Numerical Techniques:** Using Excel / MATLAB / Pseudo -Code to solve engineering problems.	06

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

PCC-BTM551 Heat and Mass Transfer Laboratory
Course Pre-requisites: PCC-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
7. To determine the Critical Heat flux.

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

PCC-BTM552 Theory of Machine-II Laboratory
Course Pre-requisites: PCC-BTM502

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 mechical 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)
4. Oral Examination

PCC–BTM553 Mechatronics Laboratory
Course Pre-requisites: PCC-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

PCC–BTM554 Thermal Systems Laboratory
Course Pre-requisites: PCC-BTM504

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 steam generators and its accessories
4. To understand torque speed and power speed characteristics of gas reaction turbine.

Course Contents

Any six experiments out of listed below.

- Trial on air compressors.
- Trial on experimental gas turbine
- Experiment on mass flow rate of air through orifice plate or nozzle.
- Study of steam turbines.
- Study of boilers mountings and accessories
- Study of experiments on heat balance sheet of boiler.
- Study of experiments on calorific value at constant pressure and constant volume.
- Determination of dryness fraction

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

PCC-BTM555 Hydraulic Machinery Laboratory
Course pre-requisites: PCC-BTM403, PCC-BTM453

Course Objectives:

1. To demonstrate working of hydraulic turbines
2. To demonstrate working of hydraulic pumps
3. To study performance and operating characteristics of turbines
4. To study performance characteristics of pumps

Course Outcomes:

On successful completion of the course learner should be able to

1. Identify the different types of hydraulic turbines and pumps
2. obtain performance characteristics of turbines
3. obtain operating characteristics of turbines
4. obtain pump and system characteristics

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.

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

VAC-BTM525 Compliant Mechanisms
Prerequisites: PCC-BTM402

Course Objectives:

1. To develop the student's understanding on compliant mechanisms
2. To develop the student understands of the working of compliant mechanisms
3. To develop student to understand analysis of compliant mechanism.

Course Outcomes:

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

1. Explain working of complaint mechanisms
2. Distinguish the difference between conventional and compliant mechanisms
3. analyse compliant mechanisms for displacement
4. design basic compliant XY scanning mechanisms

Course Content:

Module No.	Description	Hrs.
1	**Introduction** - Definition of compliant mechanisms - Advantages and disadvantages of compliant mechanisms Nomenclature and Diagrams	**2**
2	**Fexibility and Deflection** - Linear vs. nonlinear deflections - Stiffness, strength, and flexibility - Materials choice - Linear elastic deflections - Large-deflection analysis	**2**
3	**Analysis of Flexure Mechanisms in the Intermediate Displacement Range** Modeling Geometric Nonlinearities in Beam Flexures Beam Constraint Model Case Study: Parallelogram Flexure Mechanism	**1**
4	**Modeling of Large Deflection Members** Equations of Bending for Large Deflections Solving the Nonlinear Equations of Bending Examples-- Fixed-Pinned Beam, Fixed-Guided Beam (Bistable Mechanism)	**2**
5	**Pseudo-Rigid-Body Model** - Introduction - Pseudo-rigid-body models for flexible segments - Pseudo-Rigid-Body Models for Planar Beams Modeling of Mechanisms	**2**
6	**Complaint Mechanism Synthesis** - Rigid-body replacement - Synthesis through Freedom and Constraint Topologies	**2**

	- Synthesis through Topology Optimization	
7	**Case Studies:** 1. Compliant mechanism in microsterolithography 2. Spiral Shaped flexural bearing for compressor of cryocooler 3. Flexural based mechanisms in machine tools	**2**

Recommended References:

1. Handbook of Compliant Mechanisms by Larry L. Howell and Brian M. Olsen, John Wiley & Sons.
2. Compliant Mechanisms by Nicolae Lobontiu, CRC press
3. Compliant Mechanisms by Larry L. Howell, John Wiley & Sons, Inc. ISBN 0-471-38478-X
4. Thesis "Synthesis and analysis of parallel Kinematic XY flexure mechanisms**"** by Shorya Awtar, Doctoral Reseach at MIT.
5. Flexures: Elements of Elastic Mechanisms, S. T. Smith, CRC press

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

VAC-BTM526 Digital Manufacturing
Course Pre-requisites: Conversant with 3D Modelling software like CATIA/PRO-E, Knowledge of Layout, Simulation etc.

Course Objectives:
The students will be able to grasp the basic idea of digital manufacturing. The students will be able to create the virtual environment & simulate the same. They will also understand the robotic simulation and insert virtual manikins & avatars

Course Outcomes:
1. Describe the theory related to Digital Manufacturing
2. Create Virtual Environments of any facility like shopfloor etc.
3. Demonstrate the technology for new applications
4. Compare digital & Actual Layout

Course Content:

Sr. No.	Details	Hrs.
Module 01	**FUNDAMENTALS OF DIGITAL MANUFACTURING:** Definition of digital manufacturing, Architecture of Digital Manufacturing System. Role of Digital Mnufacturing in Automotive & Auto Component Industries	02
Module 02	**DIGITAL FACTORY AND VIRTUAL MANUFACTURING:** Introduction, Scope, Methods and Tools Used in Virtual Manufacturing, Benefits. Virtual factory simulation.	02
Module 03	**HARDWARE & SOFTWARE** Hardware & software technologies used in Digital Manufacturing, Conversion of CAD Model to VR Model	02
Module 04	**VIRTUAL REALITY AND VIRTUAL ENVIRONMENTS:** The historical development of VR: Flight simulation, Virtual environments, Requirements for VR, benefits of Virtual reality. Creation of Virtual Environments, 3D Factory & simulation	02
Module 05	**VIRTUAL COMMISSIONING** Virtual Commissioning, Validation	02
Module 06	**R&D** Research & Development status of Digital Manufacturing	02
Module 07	**Research & Development Status of Digital Manufacturing** Bionic Manufacturing, Holonic Manufacturing, Biological Manufacturing	02

TERM WORK:

- Assignments Based on each Module and or Practicals based on any Digital Manufacturing software

Text Books:

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", Springer, 2005

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

VAC-BTM528 Knowledge Based Engineering
Course Pre-requisites: Any one programming language

Course Objectives:
Students will be able to understand the basics of Knowledge Based Engineering (KBE). They will be able to represent the knowledge on the form of logic & rules & will further apply the knowledge to develop the application

Course Outcomes:

1. Describe the concepts of KBE
2. Apply the theory concepts to an application
3. Convert information in the form of logic & rules
4. Develop an application using KBE concepts

Course Content:

Sr. No.	Details	Hrs.
Module 01	What is knowledge Based Engineering (KBE). Organizational challenges & Value addition	02
Module 02	Elements of Knowledge Based System, Knowledge Representation, Knowledge representation methods.	02
Module 03	Knowledge Representation Issues: Representations And Mappings, Approaches To Knowledge Representation. knowledge Based Engineering (KBE), KBE Methodology	02
Module 04	Knowledge Base integration, Knowledge Based Engineering in CAD, Product Development, Computer Aided Process Planning (CAPP), KBE & Product Life Cycle Management (PLM)	02
Module 05	CASE STUDIES & Applications of knowledge Based Engineering (KBE) in Design, Manufacturing & other fields	02
Module 06	Business Challenges, Programming tools & skills	02
Module 07	Future of knowledge Based Engineering (KBE)	02

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

Text Books:

1. "Artificial Intelligence" -By Elaine Rich And Kevin Knight (2nd Edition) Tata Mcgraw-Hill
2. Artificial Intelligence: A Modern Approach, Stuart Russel, Peter Norvig, PHI
3. Introduction to Prolog Programming By Carl Townsend.

4. "PROLOG Programming For Artificial Intelligence" -By Ivan Bratko(Addison-Wesley)
5. "Programming with PROLOG" –By Klocksin and Mellish

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

VAC-BTM529 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 Engg. Process
3. Formulate 3D model from scanned data
4. Use software & hardware related to Reverse engg.

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

PRACTICAL:
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

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

VAC-BTM530 Introduction to Aerodynamics
Course Pre-requisites: Thermodynamics (PCC-BTM305), Fluid Mechanics (PCC-BTM403)

Course Objective:
- Learn about standard atmosphere.
- Learn about flow without friction and its applications.
- Learn about viscous flow and boundary layer phenomena.
- Learn about aerodynamics of airfoils, wings and bodies like cylinder and spheres.

Course Outcome:
Upon successful completion of the course, students should be able to
1. have knowledge of inviscid flow and its measurement systems,
2. understand viscous flow and boundary layer,
3. apply knowledge of viscous flow phenomenon to airfoils and wings,
4. have a knowledge of aerodynamics of cylinders and spheres.

Course Content

Module No.	Description	Hrs.
1.	**The standard Atmosphere**: The standard atmosphere, Absolute altitude, Geometric altitude, Geopotential altitude, Hydrostatic equation, Construction of standard atmosphere, Definition of pressure, temperature and temperature altitudes.	1
2.	**Inviscid Flow:** Flow with no friction, Continuity equation, Momentum equation, Energy equation, Equation for isentropic flow.	2
3	**Applications:** Speed of sound, Low speed subsonic wind tunnels, Measurement of airspeed in incompressible, compressible and supersonic flow.	2
4	**Viscous Flow:** Flow with friction, Boundary layer concept, laminar and turbulent boundary layer, Transition from laminar to turbulent flow, Flow separation.	2
5	**Airfoils:** Nomenclature, Aerodynamic coefficients, Experimental data, Obtaining lift coefficients from pressure coefficient, Compressibility corrections, Critical Mach number, Drag-divergence number, supersonic speeds, Lift, Wave drag.	3
6	**Wings:** Finite wing, Induced drag, Change in lift slope, Swept wings, Flaps,	2
7	**Aerodynamics of bodies:** Aerodynamics of Cylinders and spheres, Circulation and Kutta-Joukowsky theorem.	2

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

Recommended books:
1. John D Anderson Jr. Introduction to flight, McGraw-Hill, New York, 5th Edition.
2. John D Anderson Jr. Fundamentals of Aerodynamics, McGraw-Hill, New York 5th Edition.
3. E. L. Houghton and P. W. Carpenter, Aerodynamics for Engineering students, Elsevier, 6th Edition.

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

PCC-BTM601 Refrigeration and Air Conditioning
Course pre-requisites: PCC-BTM305, PCC-BTM504

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.
- Learn about current issues of ODP, TEWI and effects of air-conditioning on global warming.
- Learn about heat load estimation of air conditioning system and issues related to human comfort.

Course Outcomes:

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

1. Understand basic refrigeration cycles like vapour compression cycle, vapour absorption cycle, aircraft refrigeration cycles, refrigeration and air properties.
2. Apply knowledge of working of various cycles mentioned in 1 to evaluate performance of devices working on it.
3. Know about properties of refrigerants, environment friendly refrigerants, properties of air and human comfort.
4. Calculate the cooling / heating load for air conditioning system.

Course Content:

Module No.	Details	Hrs.
01	Introduction to Refrigeration Carnot refrigerator, unit of refrigeration, COP, EER Vapor Compression Refrigeration System • Simple vapor 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 • Aircraft Refrigeration	10
02	Components • Desirable properties of refrigerants, Thermodynamic, Chemical and Physical properties, Designation system for refrigerants. ODP, GWP, TEWI, Secondary refrigerants • Types of Compressors, Condensers, Evaporators, Expansion devices, Controls – Safety Controls and Operating Controls • Cooling Towers, Types, Approach, Range, Efficiency, Components and maintenance	06

03	Psychrometry • Psychrometric properties, chart and processes. • Bypass factor, ADP, Adiabatic mixing of two air streams • RSHF, RADP, CADP, GSHF, ESHF	08
04	• Cooling Load estimation, Design of summer and winter air-conditioning systems.	06
05	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. • Air Filters, Fans and blowers.	06
06	Human Comfort- • Effective temperature, Comfort chart, Comfort zone, • Methods of improving Indoor Air Quality(IAQ) • Sick Building Syndrome	03
07	Vapor Absorption Refrigeration. • Ammonia Water • Water/Lithium Bromide system-Single Effect, Double Effect Electrolux refrigeration system	05

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

PCC-BTM602 Machine Design–I
Course pre-requisites: PCC-BTM302, PCC- BTM304, PCC-BTM402

Course Objectives:
The primary objective of this course is

- To develop an ability to apply knowledge of mathematics and engineering related to different machine parts.
- To analyze the stress and strain on mechanical components; and understand, identify and quantify failure modes for mechanical parts
- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
- To develop an ability to identify, formulate, and solve engineering problems.
- To understand the detailed design procedure of springs as well as the effect of stresses 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.
- To understand the theory behind the selection of material for the different machine parts.

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 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, Design stresses, Principle Stresses Design Standards, I.S. codes, Preferred Series and numbers.	04
02	Design against static Loads: Cotter joint, knuckle joint. Power Screw– Design of Screw Presses along with the Frame.	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	06

	Design for finite and infinite life- Soderberg and Goodman design criteria, Fatigue design under combined stresses.	
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 Design of Laminated Springs.	06
06	Design of Belts –Flat and V belt with Pulley construction, timing belts and pulleys, Selection of Standard Roller chains.	08
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	06

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. Assignments

Text Books:

1. Bhandari, V. B. *Design of machine elements*. Tata McGraw-Hill Education, 2010.
2. Shigley, Joseph E., Charles R. Mischke, and Richard G. Budynas. *Mechanical engineering design*. McGraw-Hill,, 2004.
3. Robert, L. Norton. "Machine Design An Integrated Approach." (2006).
4. **Recommended Data Books**
    a. V. Bhandari, *Machine Design Data Book*, McGraw Hill Education (2017)
    b. Mahadevan K., Reddy K.B. *Design Data Handbook for Mechanical Engineering in SI and Metric Units*, CBS (2013)
    c. *PSG Design Data Book*, PSG College, Coimbatore (2012)

Reference Books:

1. Spottes, M.F.,Terry E. S., and Lee E.H. *Design of machine elements*. Vol. 2. Pearson Education India, 2004.
2. 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

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

PCC-BTM604 Internal Combustion Engine
Course pre-requisites: PCC-BTM305

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

- Understand fundamentals involved in internal engine combustion technology.
- Understand construction and working principle of different types of engines and able to calculate work done and various efficiencies.
- Test the performance of IC engines and plot their characteristics curves.

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

1. Describe the constructional details and thermodynamics of I. C. Engine
2. Apply the knowledge for testing and analyzing the engine performance parameters
3. Analyze engine performance, fuel properties, and exhaust constituents of S I and C I Engine
4. Evaluate the requirements of a modern Engine for better economy and emissions

Course Content:

Module No.	Details	Hrs.
01	Constructional Features of Reciprocating I.C. Engines: Four stroke and two stroke engines. **Types of engines** - Stationary, Automotive, and Marine engines. Comparative study of Two stroke and Four stroke engines ifferent methods of Scavenging and scavenging blowers. Cycle Analysis of I.C. Engines: Variable specific heat and its effect on Air Standard Cycles, Fuel Air Cycles. Dissociation and other losses. Actual cycles.	**04**
02	Carburetion - Theory of Carburetion, Simple carburetor, various systems of actual Carburetor, Types of Carburetors. Ignition System - Battery and Magnetic Ignition Systems. Electronic Ignition System. Combustion: Combustion phenomenon in S.I. Engines, Ignition delay, Velocity of flame propagation, pressure - crank angle diagram, detonation, factors affecting combustion and detonation, types of combustion chambers. Petrol Injection - MPFI etc.	**08**
03	**C. I. Engines:** Requirement of Fuel Injection Systems, Types of fuel injection system viz. Common rail, individual pump, distributor and unit injector systems. High pressure fuel injection pump, Types of Nozzles. Necessity of Governor in Diesel engines, Governor characteristics. **Combustion:** Combustion phenomenon in C.I. Engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers.	**10**

04	Supercharging /Turbo charging: Objectives of Supercharging / Turbo charging. Effect of Supercharging / Turbo charging on power output and efficiency of the engine. Methods of Supercharging / Turbo charging. Types of Superchargers / Turbochargers SA Limit of Supercharging / Turbo charging. Performance Characteristics of S.I. & C.I. Engines Effect of load and speed on mechanical, indicated, brake thermal and volumetric efficiencies. Brake mean effective pressure and Brake specific fuel consumption, Heat balance test. Method of determining indicated power of the engine.	**08**
05	Exhaust Gas Analysis and Air Pollution: Necessity of exhaust gas analysis. Constituents of exhaust gas, Orsat apparatus for carrying out exhaust gas analysis. Different methods of determining Air/Fuel ratio. Fuels of I.C. Engines: Requirement of fuels. Classification of hydrocarbon fuels. Physical and Chemical properties of fuels. Rating of Fuels - Octane No., Cetane No. & Performance No. Determination of Octane and Cetane Nos.	**04**
06	Engine Lubrication: Types of lubricants used in I.C. Engines. Properties of Lubricants. SAE Ratings of Lubricants. Types of Lubrication Systems. Engine Cooling: Systems of Cooling - Air, Water-cooling. General arrangements.	**04**
07	Non-Conventional fuels for I.C. Engines. CNG, LPG, Hydrogen, Bio- fuels, alcohol etc. Air Pollution due to engine exhaust. Pollution control devices and EURO standards. Introduction to Stratified Charge and Wankel engines. Recent developments in I. C. Engines	**04**

Term Work / Laboratory Work:
At least 2 assignments from each module.

Text Books:

1. Sharma, R. P., and M. L. Mathur. "Internal Combustion Engine." (1980).
2. Obert, Edward F. "Internal combustion engines and air pollution." (1973).
3. Domkundwar, V. M. "A course in internal combustion engines."*Dhanpat Rai and CO.(P) Ltd* (2000).
4. Ganesan, V. *Internal combustion engines*. McGraw Hill Education (India) Pvt Ltd, 2012.

References:

1. Stone, Richard. *Introduction to internal combustion engines*. (1999).
2. Beohar S.L., *Internal Combustion Engine*,
3. Gill, Paul W., James H. Smith, and Eugene Ziurys.*Fundamentals of Internal Combustion Engines*. United States Naval Institute, 1952.
4. Heldt, Peter Martin. *High-speed combustion engines: design, production, tests*. Chilton Co., 1956.
5. Morse, Frederick T. *Power plant engineering*. Van Nostrand, 1963.
6. Maleev, Vladimir Leonidas. *Internal-combustion engines: theory and design*. 1945.
7. Taylor, Charles Fayette, and Edward Story Taylor. *The internal-combustion engine*. Vol. 1. International Textbook Co., 1961.
8. Heywood, J. B. "Internal combustion engine fundamentals/John B. Heywood."

(1988).
9. Thipse, S. S. *Internal Combustion Engines*. Jaico, 2010.
10. Willard, W. Pulkrabek. *Engineering fundamentals of the internal combustion engine*. Prentice Hall. New Jersey (2004).

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

PCC-BTM605 Manufacturing Planning and Control
Course pre-requisites: PCC-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,	6

	Gantt chart, *Job shop scheduling, - Comparison of various methods [self study]*. Sequencing of tasks using, Johnson's rule.	
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.	6

Term Work:
The Term work shall comprise of at least six assignments (Problems and Case Studies) covering different topics of the 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

PCC-BTM651 Refrigeration and Air Conditioning Laboratory
Course pre-requisite: PCC-BTM601

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:

List of Experiments to be conducted is as follows. (At least 6 experiments to be performed)

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

PCC-BTM654 Internal Combustion Engine Laboratory
Course pre-requisites: PCC-BTM604

Course Objectives:

The students after studying these topics should be able to

- Understand fundamentals involved in internal engine combustion technology.
- Understand construction and working principle of different types of engines and able to calculate work done and various efficiencies.
- Test the performance of IC engines and plot their characteristics curves.

Course Outcomes:

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

1. Describe the constructional details of I. C. Engine
2. Apply the knowledge for testing and analyzing the engine performance parameters
3. Analyze engine performance, fuel properties, and exhaust constituents of S I and C I Engine
4. Evaluate the requirements of a modern engine for better economy and emissions

Course Contents

List of Experiments to be conducted is as follows.

1) Study of carburetor.
2) Study of ignition system.
3) Study of fuel injection system.
4) Morse Test on petrol engine.
5) Speed Test on petrol or/and diesel engine.
6) Load Test on diesel engine (engines).
7) Heat Balance test on diesel or petrol engines.
8) Experimental determination of Air fuel ratio.
9) Exhaust Gas/Smoke analysis of S.I. / C.I. engines
10) Effect of Supercharging on Performance Characteristics of an engine.

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

VAC-BTM625 Introduction to Micro Electro Mechanical Systems
Course pre-requisites: Engineering sciences

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

Course Outcomes: Learner will be able to…
1. Select appropriate sensors and actuators for a given MEMS application.
2. Select a micro-fabrication technique for a specific MEMS fabrication process.
3. Model and simulate a given MEMS system
4. Design MEMS

Course content:

Sr.No.	Description	Hrs.
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	2
2	**Sensors and Actuators in Micro-domain** • Concept of Sensors & Actuators, • Sensing & Actuation Principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors.	2
3	**Fabrication Methods** Microfabrication Methods (VLSI Techniques) • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques.	2
4	**3D High Aspect Ratio Fabrication Techniques** • LIGA, • AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography etc	2
5	**Modelling and Simulation Techniques** • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis.	1
6	**Characterization Techniques** Topography Methods (Optical, Electrical and Mechanical Methods) • Microscopy, STM (Scanning Tunneling Microscopes),	2

	• SEM (Scanning Electron Microscopes),SPM (Scanning ProbeMicroscopes), AFM (Atomic Force Microscopes) Mechanical Structure Analysis	
7	**Introduction to Advances of MEMS and Nanotechnology** • CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, • Nano-mechanical Systems (NEMS), • Domestic and Industrial Applications of nanotechnology • Social and Ethical Implications of nanotechnology in Society	**2**

Recommended Books:

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

Sr. No.	Examination	Module
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

VAC-BTM627 Product Lifecycle Management (M)
Course Prerequisites: Knowledge of CAD

Course Objectives-

- Provide insight of PLM
- Understand technologies enabling PLM
- Understand the integration scenarios of PLM
- Understand the workflow processes involved in PLM
- Understand the concept of PLM enabled Concurrent Engineering.

Course Outcomes-

- Describe the basic concepts of PLM
- Apply the theory knowledge in practice
- Compare PLM with Concurrent Engineering
- Discuss integration of PLM with other ICT systems
-

Course Contents:

Sr. No.	Description	Hrs.
Module 01	**INTRODUCTION** Product Data Management (PDM), Definition of PLM, Need to migrate to PLM, Benefits, and Concept of Product Life Cycle, Components of PLM, Evolution of PLM, Significance of PLM in Indian industries.	02
Module 02	**FRAMEWORK OF PLM.** Process oriented framework, PLM & Concurrent Engineering, Product Data and Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision,	02
Module 03	**TECHNOLOGIES ENABLING PLM** Jupiter Technology, Computer Aided Design (CAD), Computer Aided Engineering(CAE), ALIAS, DFA, Virtual Reality etc.	02
Module 04	**Components of PLM:** Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration), Information authoring tools (e.g., MCAD, ECAD, and technical publishing) etc.	02
Module 05	**Knowledge Management in PLM** Managing knowledge in PLM, Intellectual Property rights (IPR), Decision making, slicing and dicing of data, Document Management, Product Configurators	02
Module 06	**Implementation Issues of PLM** Implementation Process, Challenges in implementation, Legacy system integration, Management Approach, implementation status in industries.	02
Module 07	**PLM Integration** PLM+CRM Integration, PLM+MES integration, PLM+ERP integration, Multi CAD integration	02

Term Work:

- Assignments based on each Module
- Case study based on Industry with Presentation

Recommended Books:

Text Books:

- Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
- Antti Saaksvuori, Anselmi Immonen , Product Life Cycle Management - Springer, 1st Edition (Nov.5, 2003)
- Stark, John, . Product Lifecycle Management: Paradigm for 21st Century Product Realization, Springer-Verlag, 2004. ISBN 1852338105
- Kari Ulrich and Steven D. Eppinger, Product Design & Development, McGraw Hill International Edns, 1999.

References

- Relevant recent technical articles, research papers, key note addresses, etc.

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

VAC-BTM628 Advanced Heat Transfer
Course pre-requisites: PCC-BTM501

Course Objectives:
Upon successful completion of the course, students should be able to
1. Understand modes of heat transfer in Forced and Natural convection,
2. Analyze steady and transient conduction problems,
3. Learn the fundamentals of Laminar and Turbulent boundary condition,
4. Learn and use of boiling and condensation principles in design of equipment,
5. Understand the methods of analyzing heat exchangers,

Course Outcomes:
Upon successful completion of the course, students should be able to
1. Understand different modes of heat transfer and estimate heat transfer by using conduction and convection laws.
2. Apply the knowledge of mathematics, science, and heat transfer to develop the basic understanding of designing of heat exchanger equipment.
3. Use of New technology of heat transfer in design of heat pipe and other thermal equipment.
4. Analyze and evaluate heat transfer in context with conduction, convection, and heat exchangers.

Course Content:

Module No	Details	Hrs.
01	Steady and unsteady heat transfer.	02
02	Flow inside Ducts. Laminar and turbulent boundary condition	02
03	Natural convection and forced convection: Practical applications.	02
04	Advance Heat exchanger like Helical coil heat exchanger Spiral coil heat exchanger, plate heat exchanger, Micro channel heat exchanger. • Construction • working	02
05	Heat pipe: Construction and working principle.	02
06	Boiling and condensation: Types and applications.	02
07	Pressure drop calculation and heat transfer calculations in heat exchangers.	02

Term work:
At least two assignments from each module.

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-1	Module 1 and 2
2	T-2	Module 3 and 4
3	Final Examination	Module 1 to 7

VAC-BTM629 Lean and Green Manufacturing
Course pre-requisites: PCC-BTM306

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:

Sr. No.	Description	Hrs.
01	**Module I: 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;	01
02	**Module II: 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	01
03	**Module III: 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;	04
04	**Module IV: 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.	02
05	**Module V: Lean Sustenance** Human Development for sustainable Lean implementation; Involvement of Employees, Cultural Change; Reviews; Recognition; Improving Targets and Benchmarking the best practices; Road map.	02

06	**Module VI: Applications of Lean and Green in Different Sectors** 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.	01
07	**Module VII: Reconciling Lean with Other Systems** Lean and Green Manufacturing, Barriers for Green manufacturing , Green Supplier Development, Critical success Factors for Green Manufacturing	01

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

VAC-BTM631 Introduction to Computer Integrated Manufacturing
Course pre-requisites: PCC-BTM306

Course Objectives:

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

1. Understand the basic Manufacturing models and Metrics.
2. To identified Elements of an automated system – Levels of Automation.
3. To create Logical steps in Computer Aided Process Planning.
4. To understand the cellular manufacturing.
5. to understand the component and application of flexible manufacturing system (FMS) and automated guided vehicle system (AGVS)
6. To understand industrial robotics and application in manufacturing.

Course Outcomes:

Upon successful completion of the course, students should be able

1. Describe the Basic concepts, and application of Computer Integrated Manufacturing.
2. To create different Logical steps in Computer Aided Process Planning according to different manufacturing requirement.
3. Analysis of automated flow line & line balancing.
4. To apply industrial robotics in various manufacturing process.

Course Content:

Module No.	Details	Hrs.
1.	INTRODUCTION Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control- Introduction to CAD/CAM – Concurrent Engineering-CIM concepts – Computerised elements of CIM system – Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance – Simple problems – Manufacturing Control – Simple Problems – Basic Elements of an Automated system – Levels of Automation – Lean Production and Just-In-Time Production	6
2.	PRODUCTION PLANNING AND CONTROL AND COMPUTERISED PROCESS PLANNING Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control-Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) - Simple Problems.	6
3.	CELLULAR MANUFACTURING Group Technology(GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing	8

	– Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems	
4.	FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDED VEHICLE SYSTEM (AGVS) Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.	6
5.	ANALYSIS OF AUTOMATED FLOW LINE & LINE BALANCING General terminology and analysis, Analysis of Tranfer Line without storage upper bound approach, lower bound approach and problems, Analysis of Transfer lines with storage buffer, Effect of storage, buffer capacity with simple problem, Partial automation-with numerical problems, flow lines with more than two stages, Manual Assembly lines, line balancing problem.	8
6.	CNC MACHINING CENTERS Introduction to CNC, elements of CNC, CNC machining centers, part programming, and fundamental steps involved in development of part programming for milling and turning.	5
7.	INDUSTRIAL ROBOTICS Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.	6

Term Work:
Assignments based on the above topics.

Texts/References:

1. Groover, M. P., Automation production systems, and computer-integrated manufacturing, second edition, Prentice-Hall of India, New Delhi, 2001.
2. Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.

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

VAC-BTM632 Introduction to Augmented Reality (AR)

Course Prerequisite: General knowledge of CAD Modelling

Course Objectives:-

- To understand usefulness of Augmented Reality in education & other areas of research
- To have hands on Augmented Reality software.
- To develop applications of AR using AR software.

Course Outcomes:

After successful completion of the course student should be able to

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

Course Content:

Module No	Details	Hrs.
Module 01	**Introduction** History of AR, Basics of Augmented Reality, Architecture/Framework, Various applications of AR in Automotive & Auto Component industries, Construction Management, Education etc. AR Browsers, Marker & Marker less AR	02
Module 02	**Enabling Technologies of Augmented Reality** Mobile, Camera, Cloud Computing, Unity, AR with Google Sketch up	02
Module 03	**Remote Maintenance/Training using AR** Architecture, Benefits, Challenges	02
Module 04	**Lighting and Illumination Issues in AR** Conversion of CAD Model to AR Model	02
Module 05	**HOLOLENS INTERFACE** Understanding the HoloLens prerequisites, such as setting up the environment and so on. building holographic apps and run the apps in the HoloLens device or **HoloLens Emulator** .	02
Module 06	**Integration of AR** Integration with IOT. Integrating with CRM, New market Opportunities of AR, Business models, Revenue models & AR in Other Fields**.**	02
Module 07	**Challenges & Opportunities of AR** New business markets in AR, Technological challenges faced by AR	02

Term Work:

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

TEXT BOOKS:

- Augmented Reality: Principles & Practice Paperback, by Schmalstieg/Hollerer

Augmented Reality (AR) Course Evaluation Scheme:

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

Test 1: 20% (Theory paper)
Test 2: 20% (Theory paper)
In-semester evaluation: 60%

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

VAC-BTM633 Introduction to AI and Machine Learning
Course Pre-requisites: Mathematics, Knowledge of programming language (Python preferred),

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

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

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

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

Course Content:

Module No.	Details	Hrs.
01	Artificial Intelligence, Intelligent agents, types of learning, steps involved in problem solving using Machine Learning	2
02	Linear regression, Decision trees, overfitting	2
03	Instance based learning, Feature reduction, Collaborative filtering-based recommendation	2
04	Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM	2
05	Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network	2
06	Clustering: k-means, adaptive hierarchical clustering	2
07	Introduction to Reinforcement Learning	2

Term Work/Laboratory:

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

Text Books:

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

4. Gopal M., Applied Machine Learning, McGraw Hill (2018)

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

VAC-BTM634 Non-Destructive Testing (NDT)
Course Pre-requisites: PCC-BTM306

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

1. Understand different types of non-destructive testing methods.
2. discuss industrial applications of non-destructive testing.
3. explain use of equipment of non-destructive testing
4. suggest appropriate non-destructive testing methods for specific industrial situation.

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

1. describe different types of non-destructive testing methods.
2. explain industrial applications of non-destructive testing and use of international standards such as ASQ, ASME, and ANSI.
3. select appropriate non-destructive testing method for industrial scenario
4. perform simple non-destructive testing procedures.

Course Content:

Module No.	Details	Hrs.
01	**Introduction to NDT** NDT Versus destructive testing, various types of manufacturing defects, different non-destructive testing methods with their relative advantages and limitations, industrial applications of NDT	2
02	**Visual Testing (VT)** Aided and unaided visual inspection, advantages and limitations of VT, qualification and certification requirements for VT, inspection tools for VT, direct and remote VT	1
03	**Liquid Penetrant Testing (PT)** principles of working for visible and fluorescent PT, preparation/pre-cleaning of test objects prior to beginning the inspection, steps in conduct of PT testing, interpretation and evaluation of the indications	2
04	**Magnetic Particle Testing (MT)** Principles of Magnetic Particle Testing, magnetization and its types, types of magnetizing current, methods of demagnetization, dry and wet MT, portable, mobile and stationery equipment for MT, interpretation and evaluation of indications, differentiate between surface and subsurface indications.	2
05	**Ultrasonic Testing (UT)** Basic principles of ultrasonic testing, equipment for UT, different types of transducers, importance of calibration in UT, basic testing procedure, straight beam and angle beam testing, different scans (A-scan, B-scan and C-scan)	3

06	**Radiography Testing (RT)** Basic principles of radiographic testing, advantages and the limitations of RT, x-ray, gamma ray and their sources, equipment and procedure for RT, film processing and interpretation, computed and digital radiography	3
07	**Eddy Current Testing (ET)** Basic principles of eddy current Testing, generation of eddy currents, eddy current sensing elements, probes, instrumentation, procedure for RT and interpretation of test	1

Term Work / Laboratory Work:
Journal work shall consist of experiments (at least 05) and assignments (one on each Module).

List of Experiments

1. Experiment on VT
2. Experiment on PT
3. Experiment on MT
4. Experiment on UT
5. Demonstration of RT by site visit to industry
6. Demonstration of ET by site visit to industry

Text Books:

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010

Reference Books:

1. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005
3. Charles, J. Hellier, "Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.
4. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

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