Bachelor of Technology

(B Tech)

6th Semester

Detailed Syllabus of

2022-2026 Batch

Department of

Mechanical Engineering

NIST Institute of Science and Technology,

Pallur Hills, Berhampur, 761008, Odisha

SIXTH SEMESTER					
Theory					
Sl. No.	**Category**	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	BSC	**22CM6BS01T**	Optimization Engineering	3-1-0	4
2	PCC	**22ME6PC01T**	Design of Machine Elements	3-0-0	3
3	PCC	**22ME6PC02T**	Fluid Machinery and Components	3-0-0	3
4	PEC	**22ME6PE01T/** **22ME6PE02T/** **22ME6PE03T/** **22ME6PE04T**	Finite Element Methods; Mechanical Vibration; Tribology; CAD/CAM	3-0-0	3
5	PEC	**22ME6PE05T/** **22ME6PE06T/** **22ME6PE07T/** **22ME6PE08T**	Compressive Flow and Gas Dynamics; Computational Fluid Dynamics Industrial Automation and control Total Quality Management	3-0-0	3
6	OEC	**Open Elective – 3 (for Non-ME Students)**			
		22ME6OE01T **22ME6OE02T**	Introduction to Hybrid Vehicle Industry 4.0	3-0-0	3
Total Credit (Theory)					**19**
Practical					
1	PCC	**22ME6PC01L**	Design of Machine Elements Lab.	0-0-2	1
2	PCC	**22ME6PC02L**	Fluid Machinery and Components Lab	0-0-2	1
3	HSMC	**22CM6HS01L**	Business Communication and Interview Skills Lab.	0-0-4	2

4	PSI	**22CM6PS01L**	Lab Based Project	0-0-4	2
5	PSI	**22CM6PS01L**	Pre-placement training	0-0-4	2
Total Credit (Practical)					**8**
Total Semester Credit					**27**

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PC01T	Design of Machine Elements	3- 0- 0	3

Course Objectivess:

1 To understand procedure of machine design and develop an ability to apply it for simple component design by using design data hand book.

2 Find out the forces in welded and riveted joints and formulate design solution for size of weld and size of rivet
3 Determine forces on transmission shaft and design of transmission shaft
4 Design different type of bearing and its application.
5 Proficient in design of helical and leaf spring

Syllabus:

Module - I **[9 Hours]**

Mechanical Engineering Design: Introduction to design procedure, Design synethesis and analysis, Aesthetic and ergonomic consideration in design, Manufacturing consideration in design, Stages in design, Code andStandardization, Interchangeability, Preferred numbers, Fits and Tolerances, Engineering materials: Ferrous, Non-ferrous, Non-metals, design requirements – properties of materials, Material selection, Use of Data books.

Fundamentals of Machine Design: Types of load, Modes of failure, factor of safety concepts, Theories of Failure, concept and mitigation of stress concentration, Fatigue failure and curve, endurance limit and factors affecting it, Notch sensitivity, Goodman, Gerber and Soderberg criteria..

Module – II **[9 Hours]**

Design of Keys, Shaft and Couplings: Classification of keys and pins, Design of keys and pins, Design of shafts: based on strength, torsional rigidity and fluctuating load, ASME code for shaft design, Design of couplings: Rigid coupling, Flexible coupling.

Module – III **[13 Hours]**

Design of Joints: Rivets, welds and threaded fasteners based on different types of loading, Boiler joints, cotter joints and knuckle joints.

Bearings: Types and selection of ball and roller bearings, Dynamic and static load ratings, Bearing life, Design of sliding contact bearings, Journal bearing, foot step bearing.

Module – IV **[9 Hours]**

Design of Mechanical Springs: Types of helical springs, Design of Helical springs, bulking of spring, spring surge, end condition of springs, Design of leaf springs: nipping.

Text Books:

1 Design of Machine Elements, V. B. Bhandari, TMH, 4th edition, 2017
2 Mechanical Engineering Design, Joseph E. Shigley McGraw-Hill, 3rd edition, 2009

Reference Books:

1 Design Of Machine Members, Alex Valance V.I Doughtie, McGraw-Hill, 3rd edition, 1951
2 Fundamentals of Machine design, Rechard M. Phelan, TMH, 3rd edition, 1970
3 Machine Design, V. L. Maleev and J. B. Hartman, Scranton: International Textbook Co.,3rd edition, 1954
4 Machine Design, Robert L. Norton, Pearson, 5th edition, 2014
5 Machine Design, Black & Adams, Mc Graw-Hill, 3rd edition, 1968

Online Resources:

1 Online course on "Machine Design-1" by Prof. G. Chakraborty and Prof. B. Maiti, Prof. S.K. Roychowdhury , IIT Kharagpur available on NPTEL at https://nptel.ac.in/courses/112/105/112105125/
2 Video course on "Machine Design-1" by Prof. G. Chakraborty and Prof. B. Maiti, Prof. S.K. Roychowdhury , IIT Kharagpur available on NPTEL at https://nptel.ac.in/courses/112/105/112105124/

Course Outcomes:

At the end of the course, the students will be able to:

1 Identify basic requirements of machine elements and select materials for engineering design.
2 Design keys, cotters and knuckle joints including riveted, bolted and welded joints.
3 Design the shafts and analyze the buclkling of columns.

4 Develop capability to analyze different type of bearings and its selection for engineering applications.

5 To analyze and design mechanical springs.

Course Code:	Course Name :	L-T-P	Credit
22ME6PC02T	Fluid Machinery and Components	3- 0- 0	3

Course Objective:

1. Know about gas turbine and air craft engine.

2. Gaining knowledge about reciprocating compressor and gas turbine.
3. Do the performance analysis of different turbines
4. Evaluate the performance analysis of different types of pumps
5. Know about machinery components of fluid machinery

Syllabus:

Module-I: Gas Turbine and Air Craft Propulsion **10 Hrs**

Gas Turbines: Introduction, Open and closed cycle gas turbines, Analysis of practical gas turbine cycle.

Air Craft Propulsion: Analysis of Turbo Jet, Turbo Prop, Turbo fan & Ram jet engines.

Module-II: Reciprocating Air Compressors **10 Hrs**

Introduction (Uses of compressed air), The reciprocating cycle neglecting and considering clearance volume, Volumetric efficiency and its effect on compressor performance, Limitations of single stage compression, Multistage compression and intercooling, Optimum intercooler pressure, Performance and design calculations of reciprocating compressors, Air motors.

Module-III: Hydraulics Turbine **10 Hrs**

Hydraulic turbines: Classification, Impulse and Reaction turbine; Tangential, Radial and axial turbine. Impulse turbine, Pelton wheel, bucket dimensions, number of buckets in pelton wheel, efficiency and performance curves.

Reaction Turbines: Francis turbine and Kaplan turbine, velocity triangle and efficiencies, performance curve. Function of draft tube.

Module-IV: Hydraulics Pump **10 Hrs**

Centrifugal Pump: constructional features, vane shape, velocity triangles, Efficiencies, Multi stage centrifugal pumps, Pump Characteristic, NPSH.

Reciprocating pumps: Reciprocating Pump, Working principle, Discharge, work done and power requirement, Slip, Indicator diagram.

Working principle of Centrifugal compressor, axial compressor, Radial Compressor, Fan and Blower,

Course Outcomes:

1 Able to explain about gas turbine and air craft engine
2 Explain about reciprocating compressor and gas turbine
3 Able to evaluate performance analysis of different turbines
4 Evaluate the performance analysis of different types of pumps

Text Books:

1. Basic and Applied Thermodynamics, P.K.Nag, 2nd Ed, TMH.
2. Fluid Mechanics, Y A Cengel, TMH
3. Fluid Mechanics and Machinery, CSP Ojha and P.N. Chandramouli, Oxford University Press
4. Fluid Machinery- https://archive.nptel.ac.in/courses/112/104/112104117/

Referrence Books:

1. Fundamentals of Thermodynamics by Sonntag, Borgnakke, Van Wylen, John Wiley & Sons
2. Introduction to Fluid Mechanics, Fox, McDonald, Willey Publications 5. Fluid Mechanics by Kundu, Elsevier

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE01T	Finite Element Methods	3- 0- 0	3

Course Objectives:

1 Understanding with the Finite Element Analysis fundamentals.

2 Introduce basic aspects like discretization, interpolation, boundary conditions etc…

3 Formulate the design problems into FEA (Axi-symmetric problems).

4 Solve the heat transfer and fluid flow problems using FEM concept.

5 Use of different FEM software for solving engineering problems

Syllabus:

Module – I **[10 hours]**

Introduction to Finite Element Method: General description of the finite element method. Boundary conditions: homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.

Module – II **[10hours]**

Interpolation Models: Simplex, complex and multiplex elements, linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for 1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 8), 2D Isoperimetric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads

Module – III **[10 hours]**

Numerical Problems: Solution for displacement, stress and strain in 1D straight bar, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to point loads.

Module – IV **[10 hours]**

Heat Transfer and Fluid Flow: Basic equations of heat transfer: Energy balance equation, 1D finite element formulation using variational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Flow through a porous medium, Flow through pipes of uniform and stepped sections.

Text Books:

1 Finite Elements in Engineering, T.R.Chandraputla and A.D.Belegundu, PHI, 4th edition, 2011
2 The Finite Element Method – Its Basis & Fundamentals, Zienkiewicz, Taylor and Zhu, Elsevier, 6th edition, 2013

Reference books:

1 Introduction to Finite Element Method, A numerical method for Engineering Analysis, C.Desai and J.F.Abel, CBS publishers, 2005.
2 Introduction to Finite Element Method, J.N.Reddy, TMH Publications, 4th edition, 2020.
3 Numerical Methods in Finite Element Analysis, K.J.Bathe and E.L.Wilson, PHI, 2nd edition, 2014.
4 Concepts & Applications of Finite Element Analysis,Cook, D.S.Malkus&M.E.Plesha, Wiley, 4th edition, 2001.
5 The Finite Element Method in Engineering, S. S. Rao, Elsevier, 5th edition, 2010.
6 A First Course in the Finite Element Method, D.L.Logan, Cengage Learning, 5th edition, 2010.

Online Resources:

1 Online course on “Finite Element Method” by Prof. P.M.Dixit, IISc Kanpur available on NPTEL at https://nptel.ac.in/courses/112/104/112104116/

2 Video course on "Finite Element Method" by Prof. C.S. Upadhyay and Prof. U.N Gaitonde, IIT Kanpur available on NPTEL at https://nptel.ac.in/courses/112/104/112104115/

Course Outcomes:

1 To understand Formulation of elemental stiffness matrix and load vector for Plane stress/strain such as Linear Strain Rectangle (LSR), Constant Strain Triangles (CST), Pascal's triangle, primary and secondary variables, properties of shape functions.

2 To use 1-D and 2D element stiffness matrices and load vectors from various methods to solve for displacements and stresses calculations.

3 To understand steady state heat transfer formulation of 1D element conduction and Predict finite element equations for axi-symmetric bodies.

4 Students will do job as a CAE Engineer in industry and understand and solve complex problem using different CAE software's.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE02T	Mechanical Vibration	3- 0- 0	3

Course Objectives:

1 Understand the basic concepts and behavior of vibrations in machines.
2 Understand the fundamental to Mechanical Free Undamped and damped Vibration and review single degree of freedom.
3 Understand the determination of frequencies and other parameters in forced vibration systems
4 To conversant for development of differential equation or equation of motion for nonlinear vibrating system.
5 To Set up and solve eigenvalue problems for determining natural frequencies and mode shapes for continuous system.

Syllabus:

Module – I **[12 Hours]**

Introduction & Importance of Mechanical Vibration: Brief history of Mechanical Vibration, Types of Vibration, Simple Harmonic Motion (S.H.M.), and Principle of superposition applied to S.H.M., Beats, Fourier analysis, and Concept of degree of freedom for different vibrating systems.

Undamped and Damped Free Vibration of Single Degree Freedom Systems: Modeling of Vibrating Systems, Evaluation of natural frequency – differential equation, Energy & Rayleigh's methods, Equivalent systems.

Different types of damping, Equivalent viscous damping, structural damping, Evaluation of damping using free and forced Vibration technique, Concept of critical damping and its importance, study of vibration response of viscous damped systems for cases of under damping, critical damping and over damping, Logarithmic decrement.

Module – II **[9 Hours]**

Forced Vibration of Single Degree Freedom Systems: Steady state solution with viscous damping due to harmonic force, Reciprocating and rotating unbalance mass, vibration isolation and transmissibility due to harmonic force excitation and support motion. Vibration measuring

instruments – vibrometer and accelerometer. Whirling of shaft with single disc and without damping, Concept of critical speed and its effect on the rotating shaft.

Module – III **[9 Hours]**

Undamped Vibration of Two Degree Freedom Systems: Free vibration of spring coupled and mass coupled systems, Longitudinal, Torsional and transverse vibration of two degree freedom systems, influence coefficient technique, Undamped vibration Absorber.

Module – IV **[9 Hours]**

Introduction to Multi-Degree Freedom Systems: Normal mode vibration, Co-ordinate coupling-close coupled and far coupled systems, Orthogonality of mode shapes, Methods of matrix iteration, Holzer's method and Stodola method. Torsional vibration of two, three and multi-rotor systems. Dunkerley's lower bound approximate method.

Continuous Systems: Vibration of strings, longitudinal vibration of rods, Torsional vibration of rods, Transverse vibration of Euler-beams.

Text Books:

1 Theory of Vibration with Applications, W. T. Thomson and Marie Dillon Dahleh, Pearson Education, 5th edition, 2007.
2 Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4th edition, 2003

Reference Books:

1 Mechanical Vibrations, V. P. Singh, Dhanpat Rai & company Pvt. Ltd. 3rd edition, 2006
2 Elements of Vibration Analysis, Leonard Meirovitch, TMH Publications, Special Indian edition, 2007
3 Mechanical Vibrations, S. Graham Kelly, Schaum's outline series, TMH Publications, Special Indian edition, 2007

Online Resources:

1 Video course on "Introduction to Mechanical Vibration" by Prof. Anil Kumar , IIT Rookee available on NPTEL at https://nptel.ac.in/courses/112/107/112107212/

Course Outcomes:

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

1 Explain the concepts of mechanical vibrations and undamped vibrations and also develop the mathematical model of damped vibrations.
2 Demonstrate the response of Forced Vibrations for single degree of freedom system.
3 Describe the concept of vibration in undamped two degree of freedom systems.
4 Discuss the Multi-degree of freedom and continuous vibration systems

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE03T	Tribology	3- 0- 0	3

Course Objectives:

1 Understand the concept of tribology for applying lubrication in bearings and other machine elements.
2 Design the tribological systems consisting bearings.
3 Apply modern technologies of surface texturing for performance improvements of bearings
4 Derive governing equations of all types of bearings using knowledge of fluid mechanics.
5 Solve General Reynolds equation for lubrication problems using FDM.

Syllabus:

Module – I **[10 Hours]**

Function and Requirements of Lubrication System: Lubricant and lubrication, Types of bearings, properties and testing of lubricants, Basic equations: Generalized Reynolds equation, Flow and Shear Stress, Energy equation, Equation of state

Module – II **[10 Hours]**

Hydro Dynamic Lubrication: Mechanism of pressure development and load carrying capacity, Plane-slider bearing, Idealized slider bearing with a pivoted shoe, Step bearing, Idealized journal bearing. – Infinitely long journal bearing, Petroffs equation for a lightly loaded bearing, narrow bearing.

Module – III **[10 Hours]**

Oil Flow and Thermal Equilibrium: Heat transfer analysis of Hydrostatic Bearing: Principles, Component of hydrostatic lubrication, Hydrostatic circular thrust bearing, calculation of pressure, load carrying capacity, flow rate, power loss in bearing due to friction.

Module – IV **[12 Hours]**

Lubrication in Bearing: Concept of gas lubricated bearing, Concept of Elasto-hydrodynamic lubrication, Design and selection of anti-fiction bearing, types of bearings

Friction and Wear of Metals: Theories of friction, surface contaminants, Effect of sliding speed on friction, Classification and mechanism of wear, Wear resistant materials.

Text Books:

1 Introduction to Tribology of Bearing, B. C. Majumdar, S. Chand & Co, 2010.

2 Fundamentals of Tribology, S. K. Basu, A. N. Sengupta, B. B. Ahuja, PHI, 1st edition, 2006.

Reference Books:

1 Basic Lubrication Theory, A. Cameron, John Wiley & sons, 2nd edition, 1977.

2 Theory and Practice of Lubrication for Engineers, D. Fuller, New York company, 3rd edition 1998

3 Principles and Applications of Tribology, D. F. Moore and D. W. Hopkins,Amsterdam: Pergamon press, 2013.

Online Resources:

1 Online course on "Tribology" by Dr. Harish Hirani, IIT Delhi available on NPTEL at https://nptel.ac.in/courses/112/102/112102015/

2 Video course on "Tribology" by Dr. Harish Hirani, IIT Delhi available on NPTEL at Kanpur available on NPTEL at https://nptel.ac.in/courses/112/102/112102014/

Course Outcomes:

At the end of the course, a student should be able to:

1 Explain the basic concepts of bearing friction, lubrication and describe the hydro-dynamics lubrication system.

2 Analysis of heat transfer and power loss in bearing.

3 Demonstrate the gas lubrication in bearings.

4 Study the phenomenon of Friction and wear metals.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE04T	CAD/CAM	3- 0- 0	3

Course Objectives:

The objective of the course is to enable students to:

1 Provide basic foundation in computer aided design / manufacturing.
2 Get acquainted with the basic CAD software designed for geometric modeling.
3 Learn working principles of NC machines CNC control and part programming.
4 Understand CNC programming using M-code and G-code.
5 Understand concept of different advanced manufacturing systems like CNC, DNC, CIMS, lean manufacturing etc…

Syllabus:

Module – I **[8 Hours]**

CAD: Need of machine design, use of computer, computer fundamentals, computer aided design process, CAD configuration, and CAD tools, advantage and disadvantage of CAD, CAD and CAM integration.

Newer Techniques of CAD: Adaptive control- definition, meaning, block diagram, sources of variability and applications.

Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications

Module – II **[8 Hours]**

Computer Graphics Software and Database: Configuration, Graphics Packages, Constructing the Geometry, Transformations of geometry, Database structure and content, Wire frame versus solid modeling, Constraint– Based modeling, Geometric commands, Display control commands, Editing.

CAM: Numerical Control, Numerical Control elements, NC Coordinate system, NC motion control system, Manual and Computer Aided programming, the APT language, Miscellaneous Functions, Advanced part-programming methods.

Module – III **[8 Hours]**

CNC Part Programming: Definition and importance of various, positions like machine zero, home position, and work piece zero and program zero, G and M codes for turning and milling-

meaning and applications of important codes. Practice of simple and complex part programming in turning and milling.

Module – IV **[8 Hours]**

Comparison of Conventional NC, NC Technology: CNC, DNC, Combined DNC/ CNC system, Adaptive control manufacturing systems, Computer Integrated Manufacturing system, Machine Tools and related equipment, Materials Handling system: AGV, Robots, Lean manufacturing.

Test Books:

1 M. P. Groover, W. E. Zimmer, CAD/CAM: computer aided design and manufacturing, Prentice Hall, 1st edition, 2011.

2 I. Zeid, CAD / CAM Problem & Practice, TMH Publications, 3rd edition, 2001.

Reference Books:

1. P. N. Rao, CAD/CAM Principles & Applications, TMH Publications, 3rd edition, 2010.
2. A. M. Kuthe, Computer Graphics Including CAD, AutoCAD & C, S. Chand Publications, 1st edition, 2005

Online Resources:

1 Online course on "Computer Aided Design and Manufacturing" by Prof. Anoop Chawla, IIT Delhi available on NPTEL at https://nptel.ac.in/courses/112/102/112102101/

2 Online course on "Computer Aided Design and Manufacturing" by Prof. P.V. Madhusdan Rao, IIT Delhi available on NPTEL at https://nptel.ac.in/courses/112/102/112102103/

3 Video course on "Computer Aided Design and Manufacturing" by Prof. Anoop Chawla, Prof. P. V. Madhusdan Rao, IIT Delhi available on NPTEL at Kanpur available on NPTEL at https://nptel.ac.in/courses/112/102/112102101/

Course Outcomes:

After successful completion of this course student should be able to:

1 Describe basic concepts of CAD with its application in recent technology.
2 Explain the concept of geometrical transformation, database and its application.
3 Demonstrate a basic and advanced understanding of numerical controlled (NC) programming strategies and CNC program using M-code and G-codes for specific applications.
4 Describe the different advanced manufacturing systems.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE05T	Compressive Flow and Gas Dynamics	3- 0- 0	3

Course Objectives:

1 Conservation laws, propagation of disturbances, isentropic flow, compressible flow in ducts with area changes.
2 Normal and oblique shock waves and applications, Prandtl-Meyer flow and applications,
3 Flow characteristics of variable flow in a nozzle can be determine,

4 Simple flows such as Fanno flow and Rayleigh flow with applications to nozzles, and propulsion related concepts.

5 The method of characteristics will be described in one dimensional unsteady isentropic flow.

Syllabus:

Module-I **[10 hours]**

Fundamentals of compressible flow: Ideal gas relationship, The adiabatic energy equation, Mach number and its significance, Mach waves, Mach cone and Mach angle, static and stagnation states, relationship between stagnation temperature, pressure, density and enthalpy in terms of Mach number, stagnation velocity of sound, reference speeds, various regions of flow, Effect of Mach number on compressibility, Area velocity relationship

Module-II **[10 hours]**

One Dimensional Isentropic flow: General features of isentropic flow, performance curve, Comparison of adiabatic and isentropic process, One dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers, operation of nozzles under varying pressure ratio, mass flow rate in nozzles, critical properties and choking, area ratio as function of Mach number, Impulse function, non-dimensional mass flow rate in terms of pressure ratio, area ratio and Mach number, Working charts and gas tables, Application of Isentropic flow

Module-III **[10 hours]**

Normal shock Waves: Development of shock wave, Thickness of shock wave, governing equations, Strength of shock waves, Prandtl-Mayer relation, Rankine-Hugoniot relation, Mach number in the downstream of normal shock, variation of flow parameters across the normal shock, normal shock in Fanno and Rayleigh flows, impossibility of a rarefaction shock, supersonic diffusers, supersonic pitot tube

Module-IV **[12 hours]**

Flow in constant area duct with friction (Fanno flow): Fanno curve and Fanno flow equations, solution of Fanno flow equations, variation of flow properties, variation of Mach no. with duct length, isothermal flow in constant area duct with friction, tables and charts for Fanno flow, Experimental friction coefficients.

Flow in constant area duct with heat transfer (Rayleigh flow): Simple heating relation of a perfect gas, Rayleigh curve and Rayleigh flow equations, variations of flow properties, maximum heat transfer, tables and charts for Rayleigh flow

Text Books:

1 Fundamental of Compressible flow With Aircraft And Rocket Propulsion, S. M. Yahya, New age international Publication, 6th edition, 2018
2 Fundamentals of compressible fluid dynamics, P. Balachandran, PHI Learning Pvt. Ltd., 2006
3 The dynamics and thermodynamics of Compressible fluid low Volume-I, Ascher H. Shapiro, Wiley, 1st edition, 1991
4 Gas Dynamics, E. Rathakrishnan, PHI Learning Pvt. Ltd, 7th edition, 2020
5 Compressible Fluid Flow, P. H. Oosthuizen and W. E. Carscallen, NY, McGraw-Hill, 1st edition 1997.

Reference Books:

1 Elements of Gas Dynamics, H. W. Liepmann, and A. Roshko, Dover Pub, 1st edition 2001
2 Compressible Fluid Flow, M. A. Saad, Upper Saddle River, NJ: Prentice-Hall, 2nd edition, 1993.
3 Viscous Fluid Flow , F. M. White, New York: McGraw-Hill, 2nd edition, 1991.

Online Resources:

1 Online course on “Gas Dynamics” by Dr. Vinayak Kulkarni, IIT Guwahati available on NPTEL at https://nptel.ac.in/courses/112/103/112103021/
2 Video course on “Gas Dynamics” by Prof. A. Sameen, IIT Madras available on NPTEL at Kanpur available on NPTEL at https://nptel.ac.in/courses/112/106/112106196/

Course Outcomes:

1 Understand the basic concept of Gas Dynamics.
2 Realize gas flow under various conditions and its impact in design considerations
3 The importance of fluid flow and its effect on subsonic and supersonic flow
4 Correlate fundamentals of Gas Dynamics with various mechanical systems

Course Code:	Course Name:	L-T-P	Credit
22ME6OE06T	Computational Fluid Dynamics	3- 0- 0	3

Course Objectives:

1 Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems
2 Provide the essential numerical background for solving the partial differential equations governing the fluid flow

3 To know the solution methods for Inviscid Burger's equation.

4 Understand the numerical technique for convection- diffusion problems

5 Develop students' skills of using a commercial software package

Syllabus:

Module – I **[10 hours]**

Basics of computational fluid dynamics (CFD): Introduction to one dimensional (1-D) computation: finite difference methods (FDM)-finite element method (FEM)-finite volume method (FVM). Solution of discretised equations, the tri-diagonal matrix algorithm (Thomas algorithm for 1-D case) the finite volume method for diffusion problems, finite volume method for 1-D steady state diffusion, worked examples: 1-D steady state diffusion

Module – II **[10 hours]**

Inviscid Burger's equation: Burger's equation, numerical and Analytical solution of 1-D Burger's equation, Stability and convergence analysis.

Module – III **[10 hours]**

Convection-diffusion problems: Introduction, steady one dimensional convection and diffusion, the central difference scheme, assessment of the central difference scheme for convection-diffusion problems, the upwind difference scheme, assessment of the upwind difference scheme, the hybrid difference scheme, assessment of the hybrid difference scheme, the power-law scheme, higher order difference schemes for convection-diffusion problems, quadratic upwind difference scheme: the quick scheme.

Module – IV **[12 hours]**

Unsteady Flows: Introduction, 1-D unsteady heat conduction, Explicit scheme, Crank-Nicolson scheme, the fully implicit scheme, illustrative examples

Implicit method for 2D & 3D problems: Discretisation of transient convection-diffusion equation, worked example of transient convection-diffusion using QUICK scheme.

Text Books:

1 An Introduction to Computational Fluid Dynamics- The Finite Volume Method, Longman Scientific & Technical. Versteeg, H. K., Malalasekera W, PHI; 2nd Edition, 2007.

2 Numerical Heat Transfer & Fluid Flow, Suhas V. Patenkar, CRC Press, 1st edition, 1980.

Reference Books:

1 Computational Fluid Flow and Heat Transfer, by Muralidhar, K. and Sundararajan, T., Norosa Publishing House, N. Delhi, Alpha Science International Ltd; 2nd Edition, 2003

2 Computational Fluid Mechanics and Heat Transfer, by Anderson, D. A. Jr, McGraw-Hill, CRC Press; 3rd edition, 2012.

3 Computational Methods for Fluid Dynamics, by Ferziger J. H. and Peric M., Springer, 2002.

Online Recourses:

1 Video course on "Computational Fluid Dynamics" by Prof. K. M. Singh, IIT Roorkee, available on NPTEL at https://nptel.ac.in/courses/112107080.

2 Video course on "Computational Fluid Dynamics" by Prof. Sreenivas Jayanti, IIT Madras, available on NPTEL at https://nptel.ac.in/courses/112105045

Course Outcomes:

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

1. Develop mathematical models for flow phenomena.
2. Analyze mathematical and computational methods for fluid flow and heat transfer simulations.
3. Solve computational problems related to fluid flows and heat transfer.
4. Evaluate the grid sensitivity and analyze the accuracy of a numerical solution.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE07T	Industrial Automation and Control	3- 0- 0	3

Course Objectives:

1 To understand the importance of automation in the of field machine tool based manufacturing.

2 To get the knowledge of data acquisition and control in industrial environments, issues encountered and ways to mitigate them, ensuring reliability by redundancy.

3 To get the knowledge of various elements of manufacturing automation – sensors, drives and their control, pneumatics, hydraulics and CNC

4 To understand the concepts of automation using robots, automation of material handling using computer based tools, use of computation to model and simulate the process to reduce in-process inventory.

5 To get the knowledge of various off-the shelf automation systems hardware and communication protocols to automate processes at minimized cost.

Syllabus:

Module-I: **[8 hours]**

Introduction: Evolution of Industry 4.0 and requirement of plant automation, Types of plant automation: fixed, programmable and flexible. Level of automation, Different systems for Industrial automation: PLC, HMI, SCADA, DCS and Drives. Advantages and challenges in factory automation. Characteristics of measurement systems (accuracy, precision, repeatability, range, scaling, level).

Module-II: **[8 hours]**

Data acquisition and Control: Analog and digital data acquisition (ADC/DAC), Control system : linear and adaptive feedback control systems, feed forward control ratio, adaptive control, PID algorithm: parameters and tuning. Basics of comparator circuitry (Opamp, Gain). Transmission and logging of measured data (analog vs digital, RF/EM interference). Cloud infrastructure for industrial automation and control (comparison of latency, redundancy, reliability and availability, cost).

Module-III: **[8 hours]**

Plant automation and Process control:

FMS, Sequence control, Scan control, RRL program, Electric drives (types, functions, characteristics, four quadrant operation), Pulse Width Modulation, Flow control valves, AC and DC drive controls. Variable Frequency Drives, Direct torque control, linear and rotary actuators, Industrial hydraulic and pneumatic circuit.

Module-IV: **[8 hours]**

Robotic automation: Commercial robotic platforms (Configuration, degrees of freedom, application area), Robotic Process Automation (RPA), training of robots, Process route modeling, Optimization techniques, Introduction to process simulation software (Anylogic, GFDL, FlexSim, Siemens PLM, Simio etc.)

Automated Material handling: Assembly, Flexible fixturing.; Sorting, grading and labeling systems; Computer vision systems for material tracking and quality control (multispectral vision), basic algorithms for object detection and classification in images and videos. Types of sensors for material tracking. Queuing system and in-process inventory. JIT scheduling (introduction only).

Text Books:

1 Automation, Production Systems, and Computer-integrated Manufacturing, Mikell P. Groover, PHI Publications, 4th edition, 2016.

2 Manufacturing – Engineering and Technology, Serope Kalpakjian and Steven R. Schmid, Pearson Publications, 7th edition, 2013.

Reference Books:

1 Computer control of manufacturing system, Yoram Koren, Mc Graw Hill India,1st edition, 2007.

2 CAD/CAM : Theory & Practice, Ibrahim Zeid, Mc Graw Hill Education, 2nd edition. 2009.

Online Resources:

1 Online course on “Mechatronics and Manufacturing Automation” by Dr. Shrikrishna N. Joshi, IIT Guwahati available on NPTEL at https://nptel.ac.in/courses/112/103/112103174/

2 Video course on "Mechatronics and Manufacturing Automation" by Dr. Shrikrishna N. Joshi, IIT Guwahati available on NPTEL at https://nptel.ac.in/courses/112/103/112103293/

3 Video course on "Manufacturing Automation" by Prof. Sounak Kumar Choudhury, IIT Kanpur available on NPTEL at https://nptel.ac.in/courses/112/104/112104288/

Course Outcomes:

Upon completion of this course, the students:

1 A comprehensive picture of computer-based automation of manufacturing operations.

2 Will be familiar with various automation technologies in manufacturing and implement various control and automation method in process industries.

3 Will be able to apply PLC programming and implement it on PLC kits

4 Will be able to design and implement electro-pneumatic/hydraulic solutions for automated systems.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PE08T	Total Quality Management	3- 0- 0	3

Course Objectives:

1. Understand the historical perspective of quality management, basics of feedback-based quality assessment and control.

2. Learn about principles, tools and techniques for TQM implementation in an organization.
3. Learn about traditional and modern tools for quality control of product or service delivery.
4. Learn techniques to implement TQM at workplace (production or services based).
5. Learn about quality certifications for product, production, environment and personnel.

Syllabus:

Module-I: **[10 hours]**

Introduction: Definition of quality, need for quality, product quality and service quality; Evolution of quality, Quality statements, Customer perception of quality, customer orientation & satisfaction, customer complaints, customer retention; costs to quality. Basic concepts of TQM, TQM framework. Barriers to TQM

Module-II: **[10 hours]**

TQM Principles: Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCA cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection. Six sigma- concepts, methodology. POKA YOKE

Module-III: **[10 hours]**

Total Quality Management Tools and Techniques: Process capability, Six sigma, Reliability concepts: definition, reliability of series and parallel systems, product life characteristics curve.

Module-IV: **[10 hours]**

Quality Systems: Standardization and benchmarking. Need for ISO 9000, ISO 9001-9008; ISO 14000 - concepts, requirements and benefits.

Text Books:

1. Total Quality Management, D. H. Besterfield, et al., Pearson Education Asia, 3rd edition, 2006.

2. The management and Control of Quality, J. R. Evans and W. M. Lindsay, Cengage Learning, 8th edition, 1st Indian edition, 2012.

Reference Books:

1. Total Quality Management, B. Janakiraman and R. K. Gopal, Prentice Hall India, 1st edition, 2006.
2. Total Quality Management, L. Suganthi and A. Samuel, Prentice Hall India Pvt. Ltd., 2006.

Online Resources:

1. Online course on "Total Quality Management" by Prof. Raghunandan Sengupta, IIT Kanpur available on NPTEL at https://nptel.ac.in/courses/110/104/110104080/

Course Outcomes:

Upon completion of this course, the students will get:

1. Implement TQM in industries
2. Manage quality improvement teams
3. Will develop thinking towards Quality systems.
4. Will know about customer satisfaction and better cost management.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6OE01T	Introduction to Hybrid Vehicle	3- 0- 0	3

Course Objectives

1. Understand the basic functional components of modern vehicles and the necessity for different degrees of hybridization.
2. Analyze suitable drive systems for electric and hybrid electric vehicles.

3. Learn about electric propulsion units and design considerations for EVs and hybrids.
4. Discuss energy storage technologies used in hybrid electric vehicles and explore energy management strategies.

Syllabus:

Module-I: Basics of Hybrid Vehicles [08 Hours]

Introduction to conventional and electric vehicles, need for hybrid vehicles (societal and environmental impacts), challenges of hybrid vehicles, comparison of conventional, hybrid, and electric vehicles, degrees of hybridization (Micro, Mild, Full, and Plug-in hybrids), overview of hybrid vehicle architectures (Series, Parallel, and Series-Parallel configurations).

Module-II: Vehicle Dynamics and Drive-trains [10 Hours]

Motion and dynamics equations for vehicles, Forces acting on a vehicle, Resistance to motion (rolling resistance, air resistance and gradient resistance), Basics of vehicle performance, vehicle power source characterization, transmission characteristics, Overview of drive-train systems (IC engine-based, electric motor-based, and hybrid drive-trains), IP rating of drive train, Design Considerations for EV Chassis and Body**.**

Module-III: Energy Storage Systems in Hybrid Vehicles [10 Hours]

Battery technology (Lead-acid and Li-ion), Battery charge-discharge characteristics and lifecycle analysis, Battery Management System, Fuel cells, Supercapacitors and flywheels (Working principles, advantages, and limitations), Hybrid energy storage systems (Combining batteries, fuel cells, and capacitors), Regenerative braking.

Module-IV: Energy Management Strategies and Infrastructure [10 Hours]

Introduction to energy management strategies in hybrid vehicles, classification and comparison of different energy management strategies, implementation issues of energy management strategies, challenges in battery charging / swapping infrastructure, Case Studies: Design of a Series-Parallel Hybrid Vehicle and Plug-in Hybrid Electric Vehicle.

Text Books:

1 Electric and Hybrid Vehicles: Design Fundamentals, I. Husain, CRC Press, 2nd edition, 2010.
2 Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 3rd edition, 2018.
3 Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley, 2nd edition, 2012.

Reference Books:

1 Vehicular Electric Power Systems, A. Emadi, M. Ehsani and Jihn M. Miller, CRC Press, 1st edition, 2003.
2 Electric Vehicles: Prospects and Challenges, James Larminie and John Lowry, Wiley, 2nd edition, 2012.
3 Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Sheldon S. Williamson, Springer, 2013.

Online Resources:

6 Online course on "Introduction to Hybrid and Electric Vehicles" by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati available on NPTEL at https://nptel.ac.in/courses/108/103/108103009/

7 **Video Course on "Electric Vehicles" by Prof. Amit Kumar Jain, IIT Delhi available on NPTEL at https://nptel.ac.in/courses/108/102/108102121/**

Course Outcomes:

After completing the course, students will be able to:

1. Describe the evolution, need and key differences between conventional, hybrid, and electric vehicles.
2. Analyze vehicle dynamics, drive-train configurations, and power flow in hybrid systems.
3. Evaluate energy storage systems like batteries, fuel cells, and super capacitors in hybrid vehicles.

4. Apply energy management strategies and design solutions for hybrid vehicle case studies.

Course Code:	Course Name:	L-T-P:	Credit:
22ME6OE02T	Industry 4.0	3:0:0	3

Course Objectives:

1 The current manufacturing industries and businesses are moving from the third industrial revolution of computers and automation to the fourth where automation becomes even smarter fueled by data analytic and artificial intelligence.

2 This course is designed to offer learners an introduction to the use of the Internet and Digital technology for better manufacturing and business.

3 Learners will gain deep insights into how smartness is being harnessed from data and appreciate what needs to be done to overcome some of the challenges.

Syllabus:

Module -I **[10 Hours]**

Introduction: The Fourth Industrial Revolution, Difference between conventional automation and Industry 4.0, Case Studies: Health, Agriculture, Manufacturing.

Industry 4.0 and its components: Internet of Things (IoT) & Industrial Internet of Things (IIoT), Internet of Services, Value chains in manufacturing companies, Digital Twins.

Module - II **[10 Hours]**

Digital Manufacturing and Design: Cyber Physical Systems and Next Generation sensors, Collaborative Platform and Product Life-cycle Management, Robotics and Automation.

Module - III **[10 Hours]**

Industrial IoT: Cloud Computing, Big Data Analytic, AI & ML, Virtual and Augmented Reality, Block-chain.

Module - IV **[10 Hours]**

Challenges & Opportunities in Industry 4.0: A Digital Strategy alongside Resource Scarcity, Standards and Data security, Financing conditions, availability of skilled workers, Comprehensive broadband infra- structure, Legal framework, protection of corporate data, liability, handling personal data.

Text Books:

1. D. Pyo, J. Hwang, and Y. Yoon, Tech Trends of the 4th Industrial Revolution, Mercury Learning & Information publisher, 2021.
2. Bruno S. Sergi, Elena G. Popkova, Aleksei V. Bogoviz, and Tatiana N. Litvinova Understanding Industry 4.0: AI, the Internet of Things, and the Future of Work, Pub: Emerald Publishing Limited, 2019

Reference Books:

1. S. Misra, A. Mukherjee, and A. Roy, Introduction to IoT. Cambridge University Press, 1st Edition, 2021.
2. Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, Emerging Technologies for Health, and Medicine: Virtual Reality, Augmented Reality, Artificial Intelligence, Internet of Things, Robotics, Industry 4.0, John Wiley publisher, 2018.
3. **Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress Berkeley publisher, CA 1st Edition, 2016.**

Course Outcomes:

On completion of the course, learner will be able to

1. Understand the key components and enablers of Industry 4.0 Technology and Appreciate

the smartness in Smart Factories, smart products, and smart Services.

2. Outline Smart Factory technologies and their role in an Industry 4.0 world.
3. Outline IoT technology and scope of implementing IoT in Industries and businesses and comprehend distributed cyber-physical and digital manufacturing system.
4. Demonstrate the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits

Course Code:	Course Name:	L-T-P	Credit
22ME6PC01L	Design of Machine Elements Lab	0- 0- 2	1

Course Objectives:

1. To understand design concept and expand the skill to design machine component.
2. To acquire a skill of design and drafting of standard welded and riveted joint.
3. To understand procedure of machine design and develop an ability to apply it for Cotter Joint Design and Knuckle Joint Design etc. and determine resisting areas against failure.
4. Design and Analysis of shaft subjected to direct and combined loading.
5. To acquire a skill of design and drafting the Bolted joint, Coupling, spring and bearing.

Syllabus:

1. Design of any one working model related to Design of machine elements i.e., Module I and II.
2. Design of any one working model related to Design of machine elements i.e., Module III and IV.
3. Design & drawing of Riveted joint
4. Design and drawing of Cotter joint
5. Design and drawing of Knuckle joint
6. Design of shafts subjected to combined loading
7. Design and drawing of Flange coupling
8. Design of spring
9. Design of bearing

Course Outcomes:

1. Be able to apply design knowledge for Design of Cotter Joint and Knuckle Joint etc and formulate the design procedure and acquire skill of finding resisting areas against failure.
2. Develop Logical and Analytical ability to design of Shaft subjected to direct and combined loading.

3. Be able to apply skill of design and drafting for standard welded and riveted joint as per ISO standard.
4. Develop Logical and Analytical ability to apply Knowledge for design of Shaft subjected to direct and combined loading
5. Able to apply design procedure for designing the Coupling, spring and bearing.

Course Code:	**Course Name:**	**L-T-P**	**Credit**
22ME6PC02L	Fluid Machinery and Components Lab	3- 0- 0	2

Syllabus:

List of the Experiments:

1. Experiments on impact of Jets
2. Experiments on performance of Pelton Turbine
3. Experiments on performance of Francis Turbine

4. Experiments on performance of Kaplan Turbine
5. Experiments on performance of centrifugal pump
6. Experiments on performance of reciprocating pump
7. Performance evaluation of Gas Turbine
8. Experiments on performance of Gear pump
9. Study about turbine blades and its profiles
10. Study on wind tunnel

Course Outcomes:

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

1. Explain about the impact of jet to a plate
2. Evaluate performance of different turbines
3. Able to explain working principle of pump and turbine
4. Test the performance of pumps
5. Analyzes the flow through aerodynamic profiles

Course Code: PSI	Course Code 22CM6HS01L	Course Name: Business Communication and Skills for Interview	L-T-P: 0-0-4	Credit: 2

This is an activity based course that has been specifically designed to cater to the needs of the Pre-Final Year (6th Semester) students. This course will aim at preparing and facilitating the students for the Interview and its related activities. There will be ten labs, all of which deal with various aspects and stages of Interview.

Syllabus:

LAB 1 : Ice breaking, Professional Introduction

LAB 2 : Professional Introduction, Professional Ethics

LAB 3 : Non-verbal aspects in an Interview/a G.D./Meeting, Business/Professional Etiquette

LAB 4 : Team Management Skills

LAB 5 : Leadership and Managerial Skills

LAB 6 : Time and Stress Management

LAB 7 : Present yourself in the context of your dream company

LAB 8 : Present yourself in the context of your dream company (contd…)

LAB 9 : Basics of drafting a Job Application and Resume (Fundamental differences between CV/Resume/Bio-data)

LAB 10: Summarizing (Reviewing Final Resume and Job Application of students)

Course Code PSI	Course Code 22CM6PS01L	Course Name: Lab Based Project/	L-T-P: 0-0-4	Credit 2

Course Objectives:

1 Understand the concept of doing research project
2 Software tool can be used for doing research
3 Understand the working of Automation
4 Material behavior easily understand
5 Alternative energy and its need will be understand

Syllabus:

1 Modeling using any CAD Software
2 Analysis physical phenomenon using ANSYS
3 CNC Milling
4 CNC Lathe
5 3D Scanning
6 3D Printing
7 Wear Measurement
8 Micro-Structure Analysis
9 Wind-tunnel
10 Bio-gas Generation
11 Vapour Absorption Refrigeration System Analysis
12 Solar Collector

Course Outcomes:

1 Basic knowledge about research will be gain
2 Get knowledge on software analysis tools
3 Automation machine tool concept will be gain
4 Gaining micro-structure behavior of composite material
5 Thermal energy knowledge able to enhance