SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Draft Syllabus of Semester V & VI of B.E. (Mechanical Engineering)

SEMESTER: VI

Program:	**B.E. Mechanical Engineering**	**Semester:**	**VI**
Course:	**Design of Machine Element (PCC-I)**	**Code:**	**6ME231PC**

Lecture	**Tutorial**	**Hours**	**Credit**	**TA**	**CT-I**	**CT-II**	**Th. Exam**	**Total**
3	**0**	**3**	**3**	**40**	**30**	**30**	**60**	**100**

Methods of Internal Evaluation (TA): Class Tests, Assignments, Quiz, Class Attendance, etc.

Course Objectives:

1. To understand the basic principles of machine design including stresses, factor of safety and design procedures.
2. To study the design and analysis of machine elements such as riveted joints, welded joints, hooks and clamps.
3. To develop knowledge about springs and power screws and their design for different loading conditions.
4. To understand the design of shafts and bearings used in mechanical systems.
5. To learn the design principles of gears and antifriction bearings for power transmission in machines**.**

After completion of the course, the student will be able to:

CO	**Course Outcomes**	**BT level**
CO-1	Explain the design process and calculate stresses in basic machine components like beams, hooks, clamps, riveted and welded joints.	L2 , L3
CO-2	Analyze and design springs and power screws considering stresses, efficiency and safety.	L4 ,L6
CO-3	Design shafts and journal bearings for different loading conditions and lubrication requirements.	L6
CO-4	Design spur and helical gears and select suitable gears for power transmission systems.	L6
CO-5	Select appropriate antifriction bearings and evaluate their life and performance in mechanical applications.	L5

SYLLABUS

UNIT I:

a) Meaning of design, Phases of design, Simple stresses, factor of safety, Torsional stress, bending stresses in straight & curved beams, its applications, Hooks, C-clamps.
b) **Riveted Joint:** Strength and failure of Riveted joints, eccentrically loaded riveted joints
c) **Welded joints**: Strength, of transverse & parallel fillet welded section. Welded joints subjected to bending and torsional moment. (10 Hours)

UNIT II:

a) **Design of Helical springs-** Types of springs stresses in helical springs, Wahl's stress factor, Buckling & surge, tension spring and leaf spring.
b) **Design of power screw**- Torque required to raise and lower loads, efficiency, overhauling & self-locking of screw, ACME threads, stresses in power screw.
c) **Belt Drive** : **Flat Belt** – Material, Slip, type of drives, numerical based on design **V-Belts** – Introduction, construction of belt, numerical based on design (10 Hours)

UNIT III:

a) **Design of Shaft** – Subjected to twisting, bending & combined twisting & bending loads, based on rigidity**.**
b) **Journal bearing:** Lubrication, selection of lubrication, design procedure & numerical. (10 Hours)

UNIT IV:

a) **Design of Gear**: Classification of gears, Selection of type of gears, Standard system of gear tooth, Design of spur gear .Helical gear – Classification face width, formative teeth number, strength and design of gear.
b) **Antifriction bearing**: Types of bearing, construction, life of bearings, selection of bearings. (10 Hours)

Text Books:

1. Machine Design by Dr. P.C. Sharma & Dr. D. K. Agrawal, Katsons Publications Ltd.
2. Design of Machine Element by V.B.Bhandari , Tata McGrow Hill.
3. Machine Design, R.S. Khurmi, J.K. gupta, Eurasia Publications, New Delhi.
4. Machine Design data book by Mahadevan

Reference Books:

1. Shigley's Mechanical Engineering Design – by Richard G. Budynas & J. Keith Nisbett
2. Machine Design: An Integrated Approach – by Robert L. Norton
3. Machine Design – by Robert L. Norton.

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Program:	B. E. Mechanical Engineering	Semester:	VI
Course:	Metrology and Quality Control (PCC-II)	Code:	6ME232PC

Lecture	Tutorial	Hours	Credit	TA	CT-I	CT-II	Th. Exam	Total
3	0	3	3	40	30	30	60	100

Methods of Teacher Assessment (TA): Class Tests, Assignments, Class Attendance, Quiz

Course Objectives:

- **CO1:** Understand the fundamentals of metrology, standards of measurement, calibration, and their role in quality control.
- **CO2:** Apply linear, angular, and dimensional measurement techniques using instruments, comparators, and CMM.
- **CO3:** Comprehend limits, fits, tolerances, and gauges used in manufacturing and quality inspection.
- **CO4:** Analyse quality characteristics, variable and attribute data, and basic statistical tools for quality assessment.
- **CO5:** Construct and interpret control charts, evaluate process capability, and participate in quality circles.
- **CO6:** Explain and evaluate TQM principles and Six Sigma methodology for quality management and process improvement.

CO No.	Course Outcome (After completion of the course, the student will be able to:)	Bloom's Level
CO1	Explain the fundamentals of metrology, measurement standards, and calibration for ensuring precision, accuracy, and quality in engineering applications.	Understand (Level 2)
CO2	Demonstrate the use of linear, angular, and coordinate measuring instruments, including Vernier calipers, micrometers, sine bars, comparators, and CMM.	Apply (Level 3)
CO3	Classify and select appropriate limits, fits, tolerances, and gauges for manufacturing and quality inspection processes.	Understand / Apply (Level 2–3)
CO4	Analyze quality characteristics and measurement data using statistical tools, and interpret results for quality control.	Analyze (Level 4)
CO5	Construct and interpret control charts for variables and attributes, calculate process capability, and participate in quality improvement initiatives like quality circles.	Apply / Analyze (Level 3–4)
CO6	Explain and evaluate TQM principles and Six Sigma methodology (DMAIC, sigma levels, DPMO) and assess their applications in organizational quality improvement.	Understand / Evaluate (Level 2–5)

SYLLABUS:

UNIT I: Fundamentals of Metrology (6 Lectures)

- Introduction: definition, scope, and applications
- Standards of measurement: international, primary, secondary, and working standards
- Accuracy, precision, repeatability, and reproducibility
- Calibration: definition, purpose, and procedure
- Role of metrology in quality control

UNIT II: Standards, Limits & Gauges (6 Lectures)

- Standards of measurement: line, end, wavelength
- Limits, allowance, and tolerances; types of tolerances
- Fits and classification: clearance fit, transition fit, interference fit
- Hole basis and shaft basis systems
- Types of gauges: plug, ring, snap gauges

- Concept of interchangeability

UNIT III: Dimensional Measurement and Coordinate Metrology (6 Lectures)

- Linear measurement: Vernier callipers, micrometer, slip gauges
- Angular measurement: sine bars, clinometers
- Comparators: types, principles, and applications of mechanical comparators
- Introduction to Coordinate Measuring Machine (CMM)
- Advantages and applications of CMM in precision engineering

UNIT IV: Quality Concepts & Statistics (6 Lectures)

- Quality concepts: quality of design and conformance, quality characteristics
- Cost and value of quality, inspection, and quality assurance
- Basic statistics for quality: variable and attribute data, frequency distribution, mean, median, mode, range, standard deviation

UNIT V: Statistical Quality Control (6 Lectures)

- Population and normal distribution
- Causes of variation: assignable and chance causes
- Control charts for variables and attributes; comparison
- Numerical problems: $\bar{X}$ and R charts, p-chart, np-chart, c-chart
- Concept of process capability, precision, accuracy
- Quality circles: concept, objectives, and benefits

UNIT VI: Quality Management (6 Lectures)

- Concept and objectives of TQM
- Principles of TQM: customer focus, continuous improvement, leadership, employee involvement, process approach, fact-based decision making
- Introduction to Six Sigma: concept, sigma levels, DPMO
- DMAIC methodology: Define, Measure, Analyze, Improve, Control
- Roles in Six Sigma: Champion, Black Belt, Green Belt
- Benefits and industrial applications of Six Sigma

Text Books:

1. Raghuwanshi, B.S. & Mittal, V.K. **–** *Metrology and Quality Control* (S. Chand or equivalent edition)
2. Jain, R.K. **–** *Engineering Metrology* (Khanna Publishers)
3. Montgomery, D.C. **–** *Introduction to Statistical Quality Control* (John Wiley & Sons)
4. Besterfield, D.H., et al. – *Total Quality Management* (Pearson Education)
5. Pyzdek, T. & Keller, P. **–** *The Six Sigma Handbook* (McGraw-Hill Education)

Reference Books:

1. Raghuwanshi, B. S. – *Engineering Metrology*, Khanna Publishers.
2. Juran, J.M. & Godfrey, A.B. – *Juran's Quality Handbook* (McGraw-Hill)
3. Gulati, R. – *Metrology for Engineers* (Standard Publishers)
4. T. Eschmann – *Coordinate Measuring Machines and Industrial Metrology*
5. Doebelin, E.O. – *Measurement*
6. *Systems: Application and Design* (McGraw-Hill)
7. P.N. Rao – *Advanced Metrology and Precision Engineering*

NPTEL Web Videos / Online Learning Resources:

1. General concepts and definitions in metrology- https://www.nptelprep.in/courses/112104250/videos
2. Standards of measurement, "https://www.nptelprep.in/courses/112104250/videos"
3. Introduction to measurement and metrology- https://www.nptelprep.in/courses/112104250/videos
4. Role of instruments in measurement system - https://www.nptelprep.in/courses/112104250/videos
5. Introduction to measurement and metrology- https://www.nptelprep.in/courses/112104250/videos

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Program:	**B. E. Mechanical Engineering**	Semester:	**VI**
Course:	**Hydraulic Machines** (PCC-III)	Code:	**6ME233PC**

Lecture	Tutorial	Hours	Credits	IE (CT-I/II/TA)	End Semester Th.Exam. (ESE)	Total	Exam. Duration
3	0	3	3	40	60	100	3 Hrs

Methods of Teacher Assessment (TA): Class Tests, Assignments. Quiz Class, Attendance, etc.

Course Objectives:

1) To get fundamentals of the hydroelectric power plant.
2) To Study operation, working principle & performance characteristics of hydraulic turbines
3) To Study operation, working principle & performance characteristics of centrifugal pump, reciprocating pump and other hydraulic pumps.
4) To study the behavior of compressible fluid flow
5) To study different hydrostatic and hydro kinematics industrial applications

After completion of the course, the student will be able to:

COs	Course Outcomes	BT Level
CO-1	Demonstrate the working principle and characteristics of impulse and reaction turbines.	L2
CO-2	Utilize the knowledge of centrifugal pump for specific applications	L3
CO-3	Reveal the importance of Computational Fluid Dynamics (CFD) in fluid flow systems.	L2
CO-4	Apply the knowledge of Positive Displacement Pumps for specific engineering applications.	L3
CO-5	Solve the elementary treatment on compressible fluid flow	L3
CO-6	Understand the concept of hydrostatic and hydro kinetic system.	L2

SYLLABUS

Unit I: Hydraulic Turbines:
Theory of impulse and reaction turbines, Pelton, Francis and Kaplan turbines, their construction, classification, analysis and characteristics. Governing of turbines, Numerical on turbines. Introduction to draft tube, its working principle and types of draft tubes. (8 Hrs)

UNIT-II: Centrifugal pumps:
Basic Theory, classification, construction, operation, characteristics, multistage, NPSH and cavitation in pumps. Numerical on centrifugal pumps. (8 Hrs)

UNIT-III: Computational Fluid Dynamics (CFD) and other Pumps:
Introduction to CFD, necessity, limitations, philosophy behind CFD, CFD methodology, CFD applications in research and industry. Comparison between CFD and Experimental Fluid Dynamics (EFD). Basic theory, Construction, working principle and applications of (a) Axial flow pump (b) Air lift pump. (c) Jet Pump. (d) Hydraulic Ram pump (8 Hrs)

UNIT-IV: Positive Displacement Pumps:
Reciprocating Pump theory, construction, working and performance characteristics. Slip of reciprocating pump, indicator diagram for ideal reciprocating pump. Effect of acceleration head and friction on ID. Comparison of centrifugal and reciprocating pumps. Numerical on reciprocating pumps. Basic theory, construction, working performance of rotary pumps, gear pumps, screw pumps, vane pumps and lobe pumps. (8 Hrs)

UNIT-V: Compressible Fluid Flow:
Perfect gas relationship, Bernoulli's equation for compressible fluid flow, Isothermal and isotropic flows, Derivation for speed of sound wave, match number, Sonic, Subsonic and Supersonic flows, match cone, shock waves. Numerical on Compressible fluid flows. (8 Hrs)

UNIT-VI: Hydrostatic and Hydro-kinetic systems:
Basic theory, construction, types, working principle and applications of (a) Hydraulic accumulator, (b) (c) Hydraulic intensifier, (d) Hydraulic press, (e) Hydraulic crane, (f) Hydraulic lift, (g) Hydraulic coupling, (h) Hydraulic torque converter. (8 Hrs)

Books Recommended:
Text Books:

1) A Text of Fluid Mechanics and Hydraulic Machines, R. K .Bansal, Laxmi Publication(P) Ltd, Delhi
2) A Text of Fluid Mechanics and Hydraulic Machines, Er. R.K.Rajput, S.Chand and Co., Dehli
3) Hydraulics and Fluid Mechanics, Modi and Seth, Standard Book House, Delhi.

4) Fluid Mechanics- Fundamentals and applications, Yunus A Sengel and John M. Cimbala, Tata Mc-Graw Hill Education Pvt. Ltd. New Delhi.
5) Fluid Mechanics and Machinery, C.S.P.Ojha, Oxford University Press (Published in India)

Reference Books:

1) Fluid Mechanics: with Engineering Applications, (SI Metric) Ed. R.L.Daugherty, J.B Franzini, Mc-Graw Hill pub.
2) Fluid Mechanics: problems and solutions, Joseph H Spurk, Springer Pub.

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Program:	**B.E. Mechanical Engineering**	**Semester:**	**VI**
Course:	**Internal Combustion Engine (PEC-II)**	**Code:**	**6ME234PE**

Lecture	**Tutorial**	**Hours**	**Credit**	**TA**	**CT-I**	**CT-II**	**Th. Exam**	**Total**
3	**0**	**3**	**3**	**40**	**30**	**30**	**60**	**100**

Methods of Internal Evaluation (TA): Class Tests, Assignments, Quiz, Class Attendance, etc.

Course Objectives:

1. Understand the working principles, classification and thermodynamic cycles of IC engines used in transportation and power generation.
2. Explain the properties of fuels, alternative fuels and modern fuel injection systems used in SI and CI engines.
3. Analyze combustion phenomena in spark ignition engines, including knock, flame propagation and combustion chamber design.
4. Evaluate combustion processes in compression ignition engines, including delay period, diesel knock and fuel injection characteristics.
5. Determine engine performance parameters and analyze methods for improving engine power and efficiency through supercharging, turbocharging and performance testing.
6. Understand engine emissions, environmental regulations.

After completion of the course, the student will be able to:

CO	**Course outcome**	**BT level**
CO-1	Explain the working principles, classification and thermodynamic cycles of internal combustion engines.	L2
CO-2	Compare conventional and alternative fuels and describe modern fuel supply and fuel injection systems used in SI and CI engines.	L4, L5
CO-3	Analyze combustion processes in spark ignition engines and evaluate factors affecting engine knock and combustion efficiency	L4
CO-4	Interpret combustion phenomena in compression ignition engines, including delay period, diesel knock and combustion chamber design.	L2
CO-5	Evaluate performance parameters of IC engines and analyze techniques such as supercharging and turbocharging for improving engine performance.	L3, L5
CO-6	Identify major pollutants from IC engines and explain emission control technologies.	L1

SYLLABUS

UNIT I: Fundamentals of Internal Combustion Engines and Thermodynamic Cycles:

Introduction to internal combustion engines. Classification of IC engines based on fuel, ignition method, cooling and applications. Construction and working of two-stroke and four-stroke engines. Engine components and terminology. Air standard cycles: Otto cycle, Diesel cycle, Dual cycle and Atkinson cycle. Comparison of air standard cycles. Fuel–air cycle and actual engine cycle. Major losses in IC engines and factors affecting engine efficiency. (6 Hours)

UNIT II: Fuels and Modern Fuel Supply Systems:

Conventional fuels for IC engines: gasoline and diesel. Fuel properties, Rating of fuel and requirements for SI and CI engines. Fuel additives and limitations of fossil fuels. Alternative fuels: CNG, LNG, LPG, biodiesel, ethanol blends, hydrogen fuel.

Fuel supply systems in IC engines: carburetor systems and electronic fuel injection systems. Single-point and multi-point fuel injection systems. Gasoline direct injection (GDI). Diesel fuel injection systems, including mechanical fuel pumps (Bosch type) and common rail direct injection (CRDI), Multi-point fuel injection systems. Fuel injectors, spray characteristics, electronic control units (ECU), sensors, and actuators. (6 Hours)

UNIT III: Combustion in Spark Ignition (SI) Engines:

Stages of combustion in SI engines. Flame propagation and factors affecting flame speed. Normal and abnormal combustion. Detonation and pre-ignition. Factors responsible for detonation and its effects on engine performance. Octane rating of fuels and methods of improving octane number. Knock control methods. Combustion chamber requirements for SI engines. Types of combustion chambers and their advantages and limitations. (6 Hours)

UNIT IV: Combustion in Compression Ignition (CI) Engines:
Stages of combustion in CI engines. Ignition delay period and factors affecting the delay period. Diesel knock and its effects. Cetane rating of fuels and methods of improving the cetane number. Fuel atomization and spray formation. Combustion chamber requirements for CI engines. Methods of generating turbulence in CI engines. Types of combustion chambers used in diesel engines. (6 Hours)

UNIT V: Engine Performance and Power Enhancement:
Performance parameters of IC engines: indicated power, brake power, mechanical efficiency, thermal efficiency and specific fuel consumption. Heat balance sheet and excess air calculation. Methods of determining friction power: Morse test, Willans line method and motoring test.
Power enhancement techniques: supercharging and turbocharging. Intercooling. Advantages and limitations of supercharging and turbocharging. (6 Hours)

UNIT VI: Engine Emissions:
Engine emissions: carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter and greenhouse gases. Effects of engine pollutants on the environment and human health. Methods for emission control. Exhaust after-treatment technologies: catalytic converter, EGR, diesel particulate filter (DPF), selective catalytic reduction (SCR).
Emission regulations: BIS and EURO emission norms, Bharat Stage emission standards. (6 Hours)

Recommended Text Books:

1. Internal Combustion Engines – M. L. Mathur and R. P. Sharma, Dhanpat Rai Publications.
2. Internal Combustion Engines – V. Ganesan, Tata McGraw-Hill. FOURTH EDITION.

Reference Books:

1. Internal Combustion Engine Fundamentals – John B. Heywood, McGraw-Hill.
2. Internal Combustion Engines and Air Pollution – Edward F. Obert.
3. Engineering Fundamentals of the Internal Combustion Engine – Willard W. Pulkrabek.

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Course Code	Course Title	L	T	P	C
Programme Elective Core II	Computer Aided Manufacturing (6ME234PE)	03	00	00	3

Course Prerequisites:
1. Knowledge of mechanical engineering drawing and part design.
2. Knowledge machining processes and machines.

Course Learning Objectives:
1. To understand the concept of NC and CNC Machines.
2. To understand the working of DDA
3. To demonstrate the skill of the part programming of NC/CNC Machines.

Course Outcomes: At the end of course, students will be able to –
1. Understand the basics construction and working of NC Machines.
2. Understand the basics principle of working and construction and working of CNC Machines.
3. Understand the working of DDA and software interpolator also knows the types of motion control.
4. Able to do the manual part programming and APT programming of NC/CNC machines.
5. Understand the concept and architecture in Direct Numerical Control systems.
6. Understand the concept and use of adaptive control in Machining with CNC.

Unit	Computer Aided Manufacturing	L
UNIT I	Numerical control (NC): Fundamentals of NC, merits and demerits of NC, classification of NC systems, basic components of N C systems. NC tape and coding, control units, features of machine tools and system devices	07
UNIT II	Computer Numerical Control CNC: Problems in conventional NC, CNC controller technology, computer numerical control, designing CNC systems. NC/CNC machine tools: Types and features	06
UNIT III	DDA integrator, DDA hardware interpolator, software interpolators, reference word interpolator, point to point, straight line and contouring Controls in CNCs.	06
UNIT IV	NC/CNC part programming: Introduction, computer-aided part programming (APT), CNC part programming	07
UNIT V	Direct numerical control (DNC), Types of DNC Systems. combined DNC/CNC systems. Difference Between CNC & DNC systems.	06
UNIT VI	Adaptive control: ACC and ACO systems, optimization of AC. Benefits off AC in Machining. Problems in implementing Generative AC.	06

Text Books:

1. Mikell P. Groover- Automation, Production Systems and CAD/CAM-Prentice-Hall of India pvt. Ltd.
2. Kundar T.K., Rao P.N., Tewari N.K.- Numerical control and computer aided manufacturing; Tata McGraw Hill.
3. M. Aditham & B.S. Pabla, CNC Machines- New Age International.

Reference Books:

1. Yoram Koren- Computer control of manufacturing, McGraw Hill.
2. D. Kochan- CAM Development in computer integrated manufacturing- Springer Verlag, Berlin

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Course Code	Course Title	L	T	P	C
Professional Elective Course PEC-II	Tool Design (6ME234PE)				

Course Pre-requisites:

1. Knowledge of mechanical engineering drawing.
2. Knowledge machining processes and machines.

Course Learning Objectives:

1. Develop the design of single and multi-point cutting tools.
2. Develop the design of multipoint tools like twist drills, reamers, broach and milling cutters & press working dies like punching, blanking and drawing.
3. Analyze the real time problems of work holding by designing jigs and fixtures.

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

1.To study the basic geometries of different cutting tools, chip formation mechanism, tool force analysis etc. in metal cutting.
2. To understand the design and operation of various types of Jigs and Fixtures.
3. To develop a graphical design of a jig or fixture suitable to the requirements of a work-piece.
4.To understand the theory of metal cutting and how to estimate the required force and clearance amount in sheet metal cutting and forming operations.
5.To study construction and working of various types of dies used for different press working operations.
6. To study the steps in designing and drawing of different cutting, drawing and forming dies for press working.

Unit	Tool Design	L
UNIT I	Single Point cutting Tool: Shear angle, shear strain, velocity relations, un-deformed chip thickness, Merchant's circle, energy relations, nomenclature, single point cutting tool design, recommended speed, feed and depth of cut Form tools. Graphical approach of circular form tool design.	07
UNIT II	Jig & Fixture Design: Economics, principles of locations, types of locations, prevention of jamming, problems of chip & dust in location, use of dowels. Redundant location, Principles of clamping, types of clamps, power clamping, Tool guiding & tool setting, types of drill Jigs & fixtures	06
UNIT III	Jig & Fixture Design: Design of Plate, Channel, Box, Turnover and Post type Drill Jigs. Design of Turning, Milling, Fixture, Broaching, Assembly & Welding Fixtures.	06
UNIT IV	Multi-point Cutting Tools: Types, Geometric elements and forces in various tools like Twist drills & Reamers, Circular Broaches, Milling Cutters, Taps and Dies, Gear shaper cutter & Gear Hobs.	07
UNIT V	Press tools: Classification of presses, Theory of sheet metal cutting, clearance, cutting force calculations, Methods of reducing cutting forces, Centre of pressure & its significance, Classification of press working operations, Theory of bending, spring back action in metals, drawing fundamentals, calculation of drawing & bending forces, planning for cupping operation, Stock layout.	06
UNIT VI	Design of Press working Tools: Types of die construction, function & nomenclature of die components, Cutting Dies Blanking & Punching, Forming Dies-Forming, Drawing and Bending etc. Design of Compound, Combination and progressive dies Miscellaneous dies-Horn die, Cam-action die, Rubber & Building die, Suppress die.	06

Text Books:

1. Tool Design - Cyril Donaldson (Tata Mc-graw Hill)
2. Jigs & Fixtures - P.H.Joshi (Tata Mc-graw Hill)
3. Fundamentals of Metal Cutting & M/c Tools - Juneja (New Age International).
4. Fundamentals of Tool Design - A.Kumar (Dhanpatrai & Sons).

Reference Books:

1. Metal Cutting Theory & Cutting Tool Design- Arshinov (Mir Publications)
2. Tool Design - ASTME (ASTME)
3. Jigs and Fixture- Grantt.

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Program:	**B.E. Mechanical Engineering**	Semester:	**VI**
Course:	**Computational Fluid Dynamics** (Program Elective Course-III)	Code:	**6ME235PE**

Lecture	Tutorial	Hours	Credits	IE (CT-I/II/TA)	End Semester Th.Exam. (ESE)	Total	Exam. Duration
3	0	3	3	40	60	100	3 Hrs

Methods of Teacher Assessment (TA): Class Tests, Assignments. Quiz Class, Attendance, etc.

Course Objectives:

1. To numerically solve governing partial differential equations for physical problems in fluid mechanics and heat transfer.
2. To analyze different mathematical model and computational methods for transport process.
3. To study and apply discretization method and schemes and analyze its effects on the accuracy of numerical solution and computational time.
4. To demonstrate the ability to use modern CFD software tools.

After completion of the course, the student will be able to:

COs	Course Outcome	BT Level
CO-1	Understand the governing partial differential equations of fluid flow and heat transfer problems.	L2
CO-2	Understand the different mathematical models and computational methods for fluid flow analysis.	L2
CO-3	Apply the discretization methods to solve fluid flow and heat transfer problems.	L3
CO-4	Understand and apply the CFD schemes for the respective fluid flow/transport phenomena problem.	L3
CO-5	Apply the knowledge of turbulence modelling for solving fluid flow and heat transfer problems.	L3
CO-6	Demonstrate the ability to use modern CFD software tools.	L3

SYLLABUS

Unit I: Governing Equations and PDEs:
Introduction, Importance and applications of CFD, Discussion on Governing equations of fluid dynamics, Continuity Equation, Momentum Equation, Energy Equation, Parabolic, elliptic and hyperbolic Partial differential equations, Boundary and Initial conditions, Overview on Finite Difference Method (FDM), Finite Element Method (FEM) and Finite Volume Method (FVM), Overview on Numerical Methods. **(10 Hrs)**

Unit II: Finite Difference Method & Explicit and Implicit approach:
Discussion on Finite Difference Method, Taylor series, Simple and General method for first and second accuracy (derivations), Explicit Approach and Implicit Approach for solving the equations, Numerical Methods: Direct Method and Iterative Method. **(8 Hrs)**

Unit III: Finite Volume Method:
Introduction and Importance of FVM, Steps involved in FVM analysis, 1D steady state diffusion problem, 1D unsteady state diffusion problem, stability, consistency and Convergence, Difference between FDM and FVM approach. **(8 Hrs)**

Unit IV: Grid Generation (Meshing)
Importance of grid generation, grid generation methods and types of grid, grid independence study, Stretched Grid, Elliptic and Adaptive grids, Study of Numerical solution on flow field using QUICK (Quadratic Upstream Interpolation for Convective Kinematics) algorithm and SIMPLE (Semi-implicit method for pressure linked equation) algorithm. **(8 Hrs)**

UnitV: Turbulence Model: Introduction to Turbulence models, Reynolds Averaged Navior stokes equations

(RANS), Two equation K-epsilon model, Two equation K-epsilon model and SST model. **(8 Hrs)**

Unit VI: CFD software Utility:

CFD Softwares and applications, CFD Software: Open FOAM and ANSYS, CFD Software: FLUENT & STAR CCM plus, Application of mentioned software for solving fluid flow and heat transfer analysis problems like Double pipe heat exchanger heat transfer analysis using (CFD)FLUENT, CFD analysis of fluid flow in T-junction pipe, CFD analysis of heat transfer in 2D flat plate (conduction), External flow analysis over Airfoil or Cylinder. **(8 Hrs)**

BOOKS RECOMMENDED:

Text Books:

1. Computational fluid mechanics and heat transfer, Anderson D., Tannehil J.C., & Pletcher R.H. CRC Press (2016).
2. Numerical Heat Transfer and fluid flow, Suhas Patankar, Taylor & Francis (2018)
3. Introduction to Computational Fluid Dynamics, Anil W. Date, Cambridge University Press.
4. Computer Simulation of flow and heat transfer, P.S. Ghoshdastidar, Tata McGraw Hill
5. Heat Transfer, S.P.Sukhatme, Universities Press(India)Ltd.

Reference Books:

1. Introduction to Computational Fluid Dynamics: The Finite Volume Method , H.K. Versteeg & W. Malalasekara , Pearson Education 2008
2. Computational Fluid Flow and heat transfer, K. Murlidhar & T. Sundarajan, Alpha Science International 2003
3. Computational Fluid Dynamics, T. J. Chuung, Cambridge University press 2010
4. Introduction to Computational Fluid Dynamics, Prodip Niyogi, S.K. Chakrbarty, M.K. Saha, Pearson Education 2005

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Program:	B. Tech. (Mechanical Engineering)	Semester:	VI
Course:	Project Management	Code:	6ME235PE

Lecture	Tutorial	Hours	Credit
3	-	3	3

Course Objectives:

To provide fundamental knowledge of project management principles including project initiation, planning, and control, and to develop an understanding of project organization, feasibility analysis, and performance monitoring required for successful execution of engineering projects.

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

CO	Course Outcomes	BT Level
CO-1	Explain the basic concepts of project management, project life cycle, and the role of a project manager.	L2
CO-2	Describe the process of project planning including scope, feasibility study, and project organization.	L2
CO-3	Discuss the methods of project control including schedule, cost, quality, and project evaluation.	L2

UNIT-I: **Introduction**

Characteristics of a project types of projects, Project Management, Body of Knowledge (PMBOK), role of project manager and his qualities, project organization and benefits, idea generation, needs of society, import substitution, project lifecycle, project charter, project sponsor. (6 Hrs)

UNIT II: **Project Planning**

Customer needs, stake holder concept, project scope, feasibility study and report, baseline plan, SWOT analysis, project organization structure and hierarchy, project teams, formation, attitude and aptitude. (6 Hrs)

UNIT III: **Project Control**

Project scope, project change request, and control of schedule, resources, cost and quality, project communications, channels, means, meetings, project reports, project audits Project evaluation, project close-out reports, guidelines, audit reports, maintenance and shutdown projects, plant turn- around and brief introduction to replacement analysis. (6 Hrs)

Text Books:

1. Kamaraju Ramakrishna, "Essentials of Project Management", PHI Learning, New Delhi, 2010.

Reference Books:

1. Prasanna Chandra, "Projects - Planning, analysis, selection, implementation and review", Tata McGraw-Hill, New Delhi, 2010.
2. Chitkara, "Construction Project Management", Tata McGraw- Hill, New Delhi.

MOOCs Links and additional reading, learning, video material:

1. **Project Planning & Control** :
(https://onlinecourses.nptel.ac.in/noc19_ce30/preview)

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Course Code	Course Title	L	T	P	C
Open Elective Core II	Product Design and Development (6ME235PE)	03	00	00	3

Course Pre-requisites:

1. Basic Knowledge of Machine design
2. Basic Knowledge of manufacturing processes

Course Learning Objectives:

1. To study modern product design and product development processes
2. To learn and explain the concept of Industrial design and robust design concepts.
3. To learn the concept of Design for manufacture and assembly.
4. To study the legal factors, social issues, engineering ethics related to product design.

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

1. Understand the Product Design and Development Process, as a means to manage the development of an idea from concept through to production.
2. Understand the customer requirements in product design.
3. Apply structural approach to concept generation, concept selection and concept testing.
4. Identify various aspects of design such as industrial design, design for manufacture, assembly, and product architecture.
5. Understand the various principles and technologies used for the preparation of prototype models of products.
6. Apply the legal factors, social issues, engineering ethics related to intellectual property rights.

Subject: Industrial Product Design

Unit	Product Design and Development	L
UNIT I	**Introduction:** Characteristics of Successful Product Development, Challenges of Product Development, **Development processes:** Generic and concurrent Product Development Process, Product Development Process Flows	06
UNIT II	**Customer Needs:** Importance, process of identification of customer needs **Product Specifications:** Establishing Target Specifications, Setting the Final Specifications	06
UNIT III	**Concept Generation:** Structured Approach for concept generation- A Five Step Method **Concept Selection:** Methodology, Concept Screening, Concept Scoring. **Concept Testing:** Steps in concept testing	07
UNIT IV	**Product Architecture:** Implications of the Architecture, Establishing the Architecture, Types of Product Architecture- Modular and Integral **Industrial Design:** Need for Industrial Design, The Industrial Design Process	07
UNIT V	**Design for Manufacturing:** Suitability of the manufacturing processes such as casting, forging, rolling, press working, machining, plastic moulding.	06
UNIT VI	**New Approaches in product design:** Computer Aided Product Design and Development process. **Prototyping:** Concept and importance of Prototyping, Rapid Prototyping	06

Text Books:

1. Product Design and Development, Karl T. Ulrich, Steven D. Eppinger ISBN 978-0-07- 802906-6 TATA McGraw-Hill Education
2. Rapid Prototyping, Amitabha Ghosh, Affiliated East-West Press Pvt. Ltd.

Reference Books:

1. Product Design for Manufacture and Assembly, Geoffrey Boothroyd, Peter Dewhurst, Winston Knight ISBN: 0-8247-0584-X
2. Selection and Use of Engineering Material, J.A. Charles, F.A.A. Crane, J.A.G. Furness ISBN:-13:978-81-312-0173-2 Elsevier Publishers

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Program:	**B.E. Mechanical Engineering**	**Semester:**	**VI**
Course:	**Design of Machine Element Lab. (PCC-I)**	**Code:**	**6ME236PL**

Practical	**Hours**	**Credit**	**Practical Evaluation**		**Total**
			INT	**EXT**	
2	2	1	25	25	50

Course Objectives

1. To understand the design procedure of machine elements used in mechanical systems.
2. To develop the ability to apply theoretical knowledge for designing mechanical components.
3. To learn drawing and dimensioning of machine elements according to design calculations.
4. To understand the working principles and applications of various machine components like joints, springs, shafts, and bearings.
5. To develop skills in preparing detailed design and assembly drawings of machine elements.

Course Outcomes: After completion of this practical course, students will be able to:

CO1	Design and draw mechanical joints such as cotter joint, knuckle joint, and riveted joints based on given load conditions.
CO2	Design and prepare drawings of power transmission and lifting devices such as screw jack and couplings.
CO3	Design machine components like helical springs and shafts considering various loading conditions.
CO4	Design and draw journal bearings (Plummer block type) and understand their working and applications.
CO5	Prepare design calculations and drawings of IC engine components such as connecting rod and flywheel.

Practical Term Work:

At least six exercises based on the following:

1. Design of Cotter or Knuckle joint.
2. Design & drawing of screw jack.
3. Design & drawing of Riveted joints.
4. Design & drawing of Helical Spring
5. Design of shaft on the basis of various loading.
6. Design and drawing of coupling (any one type).

7. Design and drawing of Journal Bearing (Plumber Block Type).
8. Design and drawing of connecting rod in IC Engine.
9. Design and drawing of Flywheel.

Practical Examination: Note: Practical examination shall consist of viva voce/performance based on the above syllabus and practical work.

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Program:	**B. E. Mechanical Engineering**	Semester:	**VI**
Course:	**Metrology and Quality Control Lab (PCC-II)**	Code:	**S6ME237PL**

Practical	Hours	Credit	Practical Evaluation		Total
			INT	EXT	
2	2	1	25	25	50

Course Objectives (Lab / Practical):

CO1: Develop practical skills in measuring linear and angular dimensions of mechanical components using precision and non-precision measuring instruments.
CO2: Provide hands-on experience in the measurement and inspection of gears, screw threads, cutting tool geometries, and surface characteristics using standard metrology equipment.
CO3: Introduce students to statistical techniques for quality data analysis and enable the preparation of variable and attribute control charts for process monitoring.
CO4: Familiarize students with modern quality improvement methodologies, including the application of Six Sigma through the DMAIC approach.
CO5: Strengthen understanding of inspection, measurement standards, tolerances, and quality control principles through systematic laboratory practice.

Course Outcomes (After Completion of Lab Practical's)

CO1: Measure linear and angular dimensions of mechanical components using precision and non- precision instruments such as Vernier calliper, micrometer, sine bar and clinometer.
CO2: Inspect and evaluate gears, screw threads, surface characteristics, and single-point cutting tool geometries using standard metrology instruments including gear tooth Vernier, floating carriage micrometer, optical flat, profile projector, and tool maker's microscope.
CO3: Perform statistical analysis of quality data by calculating mean, median, mode, range, and standard deviation for process evaluation.
CO4: Construct and interpret variable and attribute control charts ($\bar{X}$–R, p-chart, np-chart, c-chart) for effective process monitoring and quality control.
CO5: Apply the principles of Six Sigma using the DMAIC methodology to analyze defects and recommend improvements in manufacturing processes.

Practical's: At least six from the below list:

1. Determination of Linear dimensions of a given specimen/ part using Precision/Non-Precision Measuring instruments.
2. Measurement of angular dimensions using sine bar/ clinometer/ bevel protractor.
3. Statistical Analysis of Quality Data Using Mean, Median, Mode, Range and Standard Deviation.
4. Preparation of Variable Control Charts for the given lot of sample.
5. Preparation of Attribute Control Charts for the given lot of sample.
6. Study of Six Sigma DMAIC Methodology to Reduce Defects in a Manufacturing Process
7. Measurement of Gear Tooth Thickness by Gear Tooth Vernier Calliper.
8. Measurement of Screw Thread Element by Floating Carriage Micrometer.
9. Testing of Surfaces by using Optical Flat.
10. Measurements of various angles of single point cutting tool by using Profile Projector and Tool Maker's Microscope.

Practical Examination:

Note: Practical examination shall consist of viva voce/performance based on the above syllabus and practical work.

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Program:	B.E. Mechanical Engineering	Semester:	VI
Course:	Hydraulic Machines (PCC-III)	Code:	6ME238PL

Practical	Hours	Credit	Practical Evaluation		Total
			INT	EXT	
2	2	1	25	25	50

List of Practical's:

At least SIX practicals based on the following:

1) Trial/ Study of Pelton Wheel (Turbine)
2) Trial/ Study of Francis Turbine
3) Trial/ Study of Kaplan Turbine
4) Trial/ Study of Centrifugal Pump
5) Trial/ Study of Reciprocating Pump
6) Trial/ Study of Axial flow pump
7) Trial/ Study of Hydraulic ram pump
8) Trial/ Study of Multistage centrifugal pump
9) Trial/ Study of Special pumps Air lift pump/ Jet pump
10) Trial/ Study of Gear pump
11) Any one practical based on CFD software. (CFD simulation of fluid flow analysis in T-pipe)

Practical Examination:

Note : Practical examination shall consist of viva voce/performance based on the above syllabus and practical work.

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Program	B.E. Mechanical Engineering	Semester	VI
Course	MDM-V: Non-Conventional Energy Sources	Code	6ME239M

Lecture	Tutorial	Hours	Credit	TA	CT-I	CT-II	Th.Exam	Total
2	0	0	2	10	5	5	30	50

Method of Teacher Assessment (TA): Class Tests, Assignments, Quiz, Class Attendance, etc.

Course Objectives:

To understand the basic concept of Sustainable Energy e.g. Solar Energy, P-V Cell, Geothermal Energy, Tidal Energy, Ocean Thermal Energy Conversion, Wind Energy, Biomass Energy Conversion

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

CO	Course Outcomes	BT Level
CO 1	Understand the basic concept of Sustainable energy, Sources and its importance, radiation transmission through covers and solar energy collections, the basic concept of Solar energy utilization and storage.	L2
CO 2	Understand the basic concept of Geothermal energy, energy from ocean.	L2
CO 3	Understand the basic concept of energy from Wind and biomass.	L2

UNIT I:

Introduction: -Sustainable energy. Need of sustainable energy sources, Overview of Global and Indian Energy Scenario.

Solar Radiation: Types of Solar radiation, Measurement of solar radiation using Pyrheliometer, Pyranometer and Sunshine Recorder.

Solar Collectors:- classifications of collectors, construction and working.

Solar Energy Storage & Utilization: Methods of storage, Applications of solar energy in heating, cooling, pumping, power production, distillation, drying, etc.

Solar Photo voltaic cells: Principle, Construction and Working (8Hrs)

UNIT II:

Geothermal Energy Resources: Hot Dry Rock system, Vapour dominated, liquid dominated, flash steam, binary fluid concept of power generation.

Tidal Power:-Types of tidal plants such as single and two basin plants, operation of tidal power plant.

Ocean thermal energy conversion system:- Construction and working of OTEC systems (8Hrs)

UNIT III:

Wind Power: Introduction, Principles of wind energy conversion, Operation, Wind speed data, Site selection, Types of wind mills, Applications.

Biomass Energy Resources: Mechanism of green plant photosynthesis. Solar energy plantation,

Biogas-Types of biogas plants, factors affecting production rates. Introductionto bio-diesel and ethanol as alternative fuels, properties of bio-fuel. (8 Hrs)

BOOKS RECOMMENDED:

Text Books:

1. Solar Energy; S.P. Sukhatme; TMH.
2. Non-Conventional Energy Sources; G.D. Rai; Khanna Publications.
3. Non-Conventional Energy Sources; B. H. Khan.

Reference Books:

1. Treatise on Solar Energy; H.P. Garg; John Wiley & Sons.
2. Renewable Energy Conversion, Transmission and Storage; Bent Sorensen; Elsevier Publication.
3. Renewable Energy; Godfrey Boyle; Oxford University Press, Mumbai.
4. Renewable Energy Sources and Emerging Technology; D.P. Kothari, K.C. Singal, RakeshRanjan; PHI.

MOOC Links:

Renewable Energy Engineering: Solar, Wing, Biomass Energy Systems:
https://archive.nptel.ac.in/courses/103/103/103103206/
Non Conventional Energy Sources: https://archive.nptel.ac.in/courses/121/106/121106014/
Hydro and Renewable Energy: https://nptel.ac.in/courses/109107397

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Program:	**B. E. Mechanical Engineering**	**Semester:**	**VI**
Course:	**Design Analysis and Simulation Lab**	**Code:**	**6ME240VS**

Lecture	**Practical**	**Tutorial**	**Hours**	**Credit**	**TA**	**CT-I**	**CT-II**	**Practical Evaluation**		**Total**
								Internal	**External**	
1	2	0	3	2	----	----	-----	50	-----	50

Methods of Teacher Assessment (TA): Attendance – 10%, Lab Performance – 60% , Viva – 20%, Lab Record.- 10% (30% Theory orientation, 70% Practical)

Course Objectives:

- **CO1:** To introduce students to CAD-based modeling and simulation tools.
- **CO2:** To perform basic structural, thermal and motion analysis.
- **CO3:** To Identify failure-prone regions.
- **CO4:** To interpret simulation results for design improvement.
- **CO5:** To develop industry-relevant CAE skills.

After completion of the course, the student will be able to:

1. Perform analytical stress calculation
2. Conduct structural, thermal & modal analysis.
3. Validate and improve mechanical design.
4. Prepare professional engineering reports.
5. Employability in CAD/CAE industries.

CO No.	**Course Outcome (After completion of the course, the student will be able to:)**	**Bloom's Level**
CO1	Understand the concepts of part drawings and assembly of various mechanical parts. Understand the concepts of surface and assembly modeling	Understand (Level 2)
CO2	Understand the concepts of surface and assembly modeling, use of various analytical tools like ANSYS, CATIA, ABAQUS, etc., for design problems	Apply (Level 3)
CO3	Solve displacements, stress, and reactions in a 2D bar, 3D bar, beam, and truss elements.	Understand / Apply (Level 2–3)
CO4	Understand the steady state heat transfer analysis of plane and Axi-symmetric components.	Analyze / Evaluate (Level 4-5)
CO5	Students Validate and optimize mechanical components, Compare analytical and FEM results Prepare professional CAE documentation.	Apply / Analyze (Level 3–4)

SYLLABUS:

Unit I: Engineering design cycle, Difference between Design & Design Analysis, Importance of validation before manufacturing, Failure modes (ductile, brittle, fatigue), and Factor of Safety concept Design process flow: Problem → Concept → modeling → Analysis → Optimization → Validation. Types of design:- Safe design, Economic design, Optimized design. Factor of Safety. Failure theories - Maximum principal stress theory, Maximum shear stress theory, Distortion energy theory (Von-Mises). (5 Hours)

Unit II: Analytical stress calculation, Bending stress, Torsion equation, Error percentage calculation, Design validation approach. Load case identification, Boundary condition selection, Stress concentration. Thermal stresses, Temperature-induced deformation, Introduction to CAD & CAE Environment, CAD modeling workflow, importing geometry to CAE, Pre-processing overview. (5 Hours)

Unit III: Types of finite elements, Mesh density and convergence, Mesh quality parameters. Material property assignment, Boundary condition application, Load cases, Solver setup Kinematic simulation, Displacement, velocity, acceleration plots, Prepare engineering validation reports. (5 Hours)

List of Practical's to be conducted in LAB:

1. 3D Modeling of Mechanical Bracket
2. Mesh Generation & Quality Check
3. Static Structural Analysis of Cantilever Beam
4. Stress Analysis of Connecting Rod
5. Steady-State Thermal Analysis of Fin
6. Modal Analysis of Beam
7. Motion Simulation of Slider-Crank Mechanism.
8. Mini Project: Design & Simulation of a Mechanical Component

Software Use –

1. CATIA V5-6R2023 (Any Updated Version)
2. Creo Parametric (Any Updated Version)
3. SOLIDWORKS (Any Updated Version)
4. ANSYS Workbench 2022 R1/R2 (Any Updated Version)
5. Fusion 360 (Free Available on Auto Desk Website - https://www.autodesk.com/in/education/edu-software/fusion)
6. Virtual Labs At IIT Bombay –
   - https://fab-coep.vlabs.ac.in/
   - https://mp-dei.vlabs.ac.in/List%20of%20experiments.html
   - https://3dp-dei.vlabs.ac.in/List%20of%20experiments.html

Text Books:

1. Machine Design By R.S. Khurmi and J.K. Gupta.. S. Chand Publishing.
2. A Textbook of Strength of Materials: (in S.I. Units)by R.K. Bansal, Laxmi Publications.
3. Introduction to Machine Design by V.B Bhandari. McGraw Hill Education India,
4. Introduction to Finite Elements in Engineering by Tirupathi R.Chandrupatla and Ashok Belegundu.
5. Finite Element Analysis Theory And Application With ANSYS Edition 3 rd Publisher Pearson India, ISBN-10 : 8131760642, ISBN-13 : 978-8131760642
6. CATIA V5-6R2024 for Designers, 22nd Edition, CADCIM Technologies, USA, Prof. Sham Tickoo, Purdue University Northwest, USA **ISBN** 978-1-64057-294-2
   (Download free - CATIA V5-6R2024 for Designers Book By Prof. Sham Tickoo and CADCIM Technologies)
7. Creo Parametric 12.4 for Designers with Videos, 11th Edition, CADCIM Technologies, USA, Prof. Sham Tickoo, Purdue University Northwest, USA **ISBN** 978-1-64057-275-1.
   (Download free - Creo Parametric 12.4 for Designers with Videos Book By Prof. Sham Tickoo and CADCIM Technologies)
8. SOLIDWORKS 2025 for Designers, 23rd Edition, CADCIM Technologies, USA, Prof. Sham Tickoo, Purdue University Northwest, USA, **ISBN**978-1-64057-296-6
   (Download free - SOLIDWORKS 2025 for Designers Book By Prof. Sham Tickoo and CADCIM Technologies)
9. ANSYS Workbench 2025 R1: A Tutorial Approach, 8th Edition, CADCIM Technologies, USA, Prof. Sham Tickoo, Purdue University Northwest, USA, **ISBN**978-1-64057-350-5.
   (Download free - ANSYS Workbench 2025 R1: A Tutorial Approach Book By Prof. Sham Tickoo and CADCIM Technologies

Reference Books:

1. Computer Aided Design and Manufacturing by M.Groover and E.Zimmers.
2. Applied Finite Element Analysis with SolidWorks Simulation, 4th edition Dr. Cyrus Raoufi, *British Columbia Institute of Technology* CYRA Engineering Services Inc., 2021.
   ISBN: 97810991949885; Language: English
3. Finite Element Modeling and Simulation with ANSYS Workbench" (2nd Ed.) by Xiaolin Chen and Yijun Liu
4. CATIA V5 Design Fundamentals - 2nd Edition: A Step by Step Guide by Jaecheol Koh

5. CATIA v5 Advanced Parametric and Hybrid 3D Design - First edition published 2023 by CRC Press 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742.

NPTEL Web Videos / Online Learning Resources:

1. Finite Element Method – https://onlinecourses.nptel.ac.in/noc26_ce42/preview
2. Basics of Finite Element Analysis - II - Course https://onlinecourses.nptel.ac.in/noc26_me37/preview
3. Finite Element Analysis and Constitutive Modelling in Geomechanics - https://onlinecourses.nptel.ac.in/noc26_ce69/preview
4. Finite Element Method in Thermal Engineering. https://onlinecourses.nptel.ac.in/noc26_me96/preview
5. Modelling And Simulation Of Dynamic Systems. https://onlinecourses.nptel.ac.in/noc26_me84/preview

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