Bansilal Ramnath Agarwal Charitable Trust’s

Vishwakarma Institute of Technology
(An Autonomous Institute affiliated to Savitribai Phule Pune University)

Structure & Syllabus of
B. Tech. (Production Engineering)

Pattern ‘D19’
Effective from Academic Year 2019-20

Prepared by: - Board of Studies in Industrial & Production Engineering
<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs/Week)</th>
<th>Examination scheme</th>
<th>Credits</th>
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<td>S1</td>
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<td>PR4003</td>
<td>Die &amp; Mould Design</td>
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<td>#PR4104</td>
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(# Courses in Second semester for those students who do not opt for Semester Internship)
PR4101: PROCESS ENGINEERING

Credits: 04

Teaching Scheme: Theory 3 Hours / Week
Lab: 2 Hours/week

SECTION-1

Process engineering and its functions:- Method of reading and interpreting the part print, Identification of functional surfaces, grouping of related surfaces to be machined, Identification of basic process for processing and sequence of operation from part print,

Geometric dimensioning and tolerance analysis, tolerance stacking, tolerance chart

Work-piece control - Causes of work-piece variations, variables influencing work-piece control, equilibrium theories, mechanical, geometrical and dimensional control,

Basic process operations - principal processes and auxiliary processes, Identification of major, critical, qualifying, re-qualifying and supporting operations. Selection of single or combined operations, Identification of finishing operations, Establishing manufacturing sequence.

SECTION-2

Equipment/machine selection - Factors to be considered in equipment/machine selection, determining machine up and down time. Types of tooling, Factors affecting selection of tooling, use of multi-tooling set-up,

Process Selection - Component of process selection, Factor affecting on process selection decisions, Designing the process (Process flow analysis, Process Re-engineering, Product – Process Mix, Operations Strategy, Capacity utilization,

Capacity Planning - Importance of capacity decisions, Defining and measuring capacity, Dimensions of capacity, Determining capacity requirements, Developing capacity alternatives, Factors determining effective capacity,

Process Sheet Design: Study of the part-print, logical design of process plan, stock preparation, blank size selection with material estimates, Selection of datum surfaces, identification of machining surfaces, dimension and tolerance analysis, selection of machining methods with time estimates and standard time for each operation, Preparation of process picture sheet and operation route sheet for complete manufacturing part.


List of Practicals:
1. Process parameters and machining time determination of lathe operations.
2. Process parameters and machining time determination of milling operations.
3. Study of various systems on capstan and turret lathes
4. Study of various systems on single spindle automatic.
5. Dimensional and tolerance analysis of part print.
7. Identification of locating areas on work piece.
8. Identification of clamping, holding areas on work piece
9. Process sheet design of one component for mass production
10. Process sheet design of one component CNC for batch production
11. Time estimation for assembly using flow charting techniques
12. Determination of processing time, cost for forged and welded components.

**List of Project areas:**
1. Development of process sheet for turned component
2. Development of process sheet for milled component
3. Development of process sheet for cast component
4. Development of process sheet for forged component
5. Development of tool layout and process sheet for turned component on single spindle automat
6. Development of tool layout and process sheet for turned component on capstan and turret lathes.
7. Computer aided process planning
8. Determination and measurement of geometric features of complex part
9. Survey of various process planning softwares
10. Development of process plan using variant software.
11. Development of process plan using generative software

**Text Books:**
2. P. W. Wang, J. Kelly Computer aided process planning-Pearson
3. Nanuasingh, System approach to computer integrated design and manufacturing, Prentice hall

**Reference Books:**
1. H. W. Wage Manufacturing Engineering, McGraw hill
2. Manufacturing catalogues for cutting tools and inspection equipments
3. P. Radhakrishnan, S. Subrmaniyum, V. Raju, CAD\CAM\CIM, New Age International Pvt Ltd
4. K. Hitomi, John Willey Manufacturing Systems Engg-Pearson,

**Course Outcomes:**
The student will be able to –
1. Perform preliminary part print analysis of part
2. Understand concepts of geometric dimensioning and tolerancing in product engineering
3. Classify operations and achieve work piece control for manufacturing of industrial products
4. Manage equipment, tools, gauges, manpower and time economically, required for manufacture of industrial products
5. Select and plan process for manufacturing of industrial products cost effectively
6. Design process sheet for machined component
PR4102::POWDER METALLURGY

Credits: 04  Teaching Scheme: 03 Hrs/Wk

SECTION-1

Historical development, Basic principles of Powder Metallurgy.

**Powder production methods:** Classification of metal powder production methods. Reduction, Atomization & developments in it. Electrolysis etc.

**Characterization of powder and properties** - Production methodology and quality control. Testing of powders. Particle size distribution, surface conditions, purity, flow properties, porosity, true and apparent density, Green compact strength. Preparation of powder: grading, sizing, blending, handling and storage.

**Compaction:** Fundamentals of compaction, presses used, selection of presses, Automation and Handling of powder, tool clearances, Die design principles, wear reclamation, Die and punch materials selection and heat treatment, surface treatment of dies, compact density variations, effect of blending powders, lubricants and lubrication in process. Pressure less powder shaping. Improvement of press tool life


SECTION-2

**Special P. M. Processes:** Special PM processes like Hot Compaction, Iso static pressing, Hot Iso static compaction merits, demerits and typical applications. Powder metal products with polymer blends, Powder roll compaction. P.M. Forging, Powder Extrusion, Powder Injection molding, Hot powder forging, Hot powder extrusion, Comparison between various special PM processes.

Composites & ceramics - Types, Processing, Typical examples, Applications. Production of nano composites with typical applications.

**Secondary Operations & Economics of Powder Metallurgy:**

**Powder Metallurgy Applications**
Production details of common PM structural parts like gears, levers, ratchets, etc. lamp filament and filament support, refractory metal components, electrical contact material, Cemented Carbide tools and wear parts, brakes and clutch lining material, porous bearings and filters, catalytic components etc.
List of Practicals:
1. Study the effect of cold compaction pressure on density
2. Characterization of metal powder
3. Study of effect of sintering temperature on properties.
4. Study of defects in P/M parts
5. Composite manufacturing

List of Project areas:
1. Comparison of P/M part, cast, machined & wrought part.
2. Design die for cold powder compaction for simple P/M parts.
3. Study the effect of various powder characteristics on strength of P/M part.

Text Books:

Reference Books:

Course Outcomes:
The student will be able to –
1. Select most appropriate powder manufacturing technique for cost effective manufacturing of powder component & characterize metal powder.
2. Select & apply different compaction techniques
3. Sintering techniques to obtain near net shape powder metallurgy parts.
4. Understand various special powder metallurgy techniques and secondary operations
5. Understand advantages, limitations and economics of powder metallurgy process
6. Understand typical applications of Powder Metallurgy
PR4104::FINANCIAL MANAGEMENT & ACCOUNTING

Credits: 04
Teaching Scheme: Theory 3 Hours / Week
Lab: 2 Hours/week

SECTION-I


2. Capital Budgeting and ratio Analysis -Ratio Analysis Classification, Ratio Analysis and its limitations. Types of Ratios, Activity Turnover, Profitability, Liquidity, etc., B: Common Size Statement, Index Statement, Capital Budgeting - Nature of Investment decisions; Investment evaluation criteria - Non-DCF& DCF Techniques, PBP, Discounted PBP, PI, ARR, Annual Worth,

3. Working Capital Management - Meaning, significance and types of working capital; calculating operating cycle period and estimation of working capital requirements; sources of working capital, NPV and IRR comparison; Capital rationing. Various committee reports on bank finance; Dimensions of working capital management

SECTION-II


List of Practical:
1. Case study on sources of capital and working capital
2. Case study on assessment of working capital
3. Studying and understanding Financial Statements - Profit and Loss
4. Studying and understanding Financial Statements - Balance sheet
5. Studying and understanding various financial ratios used in practice
6. Studying and understanding various financial ratios for decision making
7. Case study on Analysis of published results of an organisation – Manufacturing
8. Case study on Analysis of published results of an organisation – Service industry
9. Prepare a cost sheet to estimate cost of any product
10. Prepare a cost sheet to estimate cost of any process
11. Case study on use Marginal Costing to determine Break Even Point and profitability
12. Case study on use Marginal Costing to determine profitability

List of Project areas:
1. Budgeting including sources of capital financing
2. Budgeting including sources of working capital finance
3. Preparation of Journal entries, Ledgers
4. Preparation Profit and Loss Account and Balance Sheet
5. Preparation of Balance Sheet
6. Ratio Analysis based on real life data from project on Profit and loss and Balance sheet
7. Compare Analysis of published results of organisations to enable investment decision
8. Apply Product Costing to estimate cost of any process used in practice
9. Apply Service Costing to estimate cost of any process used in practice
10. Apply Process Costing to estimate cost of any process used in practice
11. Apply Standard Costing to estimate cost of any process used in practice
12. Apply Marginal Costing to determine Break Even Point and profitability

Text Books:

Reference Books:
1. Paresh P. Shah, Financial Management, Reprint No. 2 2011, Biztantra, New Delhi,
Course Outcomes:
The student will be able to –
1. Understand and analyze functions of financial management and budgeting, interpret
   financial statements through accounting ratios
2. Understand the concepts of Capital Budgeting and Working Capital management for
   effective financial management
3. Understand the mechanics of financial accounting for preparation of financial statements
   to ascertain the performance and financial position of a business
4. Classify and apply different types of costs and overheads to ascertain costs of a product
   or a process
5. Apply different types of costing methods and techniques according to the suitability for
6. various production processes and services.
7. Develop an ability of decision making about optimum product mix, profit planning, make
   or buy, limiting factors based on marginal costing concept
PR4102::POWDER METALLURGY

Credits: 04
Teaching Scheme: 03 Hrs/Wk

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Production of nano composites with typical applications.


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Reference Books:

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4. Understand various special powder metallurgy techniques and secondary operations
5. Understand advantages, limitations and economics of powder metallurgy process
6. Understand typical applications of Powder Metallurgy
PR4108::MANUFACTURING SYSTEMS

Credits: 04

Teaching Scheme: Th-3 Hrs/Wk+Lab-2 Hrs/Wk

SECTION-I

Hard automation

**Capstan Turret lathes**, SPMs, automats –Single spindle and multi spindle automats, Tool layouts, Cam design Transfer lines, types, work part transfer mechanisms, control of production line, transfer line performance


CONTROL TECHNOLOGIES IN AUTOMATION


SECTION-II

**ROBOTICS**: Components, Configuration, Specifications of Robots Classifications of robots Work envelope, Flexible automation versus Robotic technology, Forward and inverse Kinematics Machine vision system, Applications, DC and AC Servo driving units, encoders, grippers, sensors, programming. Application of robots in machining - Welding - Assembly - Material handling - Loading and unloading - CIM - Hostile and remote environments

**Automatic material handling and inspection**

Automatic material handling and inspection, Automated guided vehicles systems, conveyor systems, automated inspection, Analysis, carousel storage systems, automatic gauging system

**Factory automation, Assembly systems**

Factory automation, Assembly systems, automated assembly, design for automated assembly, vibratory bowl feeders, hopper feeders, rotary disc feeders. Synchronous and non synchronous material transfer, centrifugal, revolving feeders
List of Practicals:
1. Tool layout of Turret lathe
2. Cam design of single spindle automatic
3. Analysis of transfer lines with no internal storage
4. Analysis of AGVs
5. Conveyor system analysis
6. Programming on Robot for loading and unloading of job
7. Assembly line balancing-ranked position weight method
8. Survey of softwares for assembly line balancing
9. Classification and coding problem
10. Production flow analysis problem Cell formation approaches
11. AS/RS design.
12. In process inspection

List of Project areas:
1. Design a mechatronics system- e.g System to accept different type of coins.
2. Mechatronics design of robotic walking machine
3. Mechanism for feeding stock from coil
4. Magazine feeding device
5. Survey of hopper feeding devices
6. Vibratory bowl feeder
7. Survey of chucking devices
8. Survey of turning devices in transfer machines
9. CNC program of a complex part using G and M code
10. CNC program using APT language
11. Trajectory planning of robot arm
12. Programming of robot using language and software like VALII etc.

Text Books:

Reference Books:

Course Outcomes:
The student will be able to –
1. Understand transfer line technology
2. Able to classify jobs according to group technology
3. Study various elements and applications of industrial robots
4. Understand concepts FMS
5. Understand and Analyze performance of automated conveyance and inspection systems
6. Understand principles of automated assembly systems
PR4003::DIE & MOULD DESIGN

Credits: 04
Teaching Scheme: Th-3 Hrs/Wk+Lab-2 Hrs/Wk

SECTION-1

1) **Introduction to Press Working**
Press working terminology, Basic operation, Types of Dies: Simple, compound, progressive, combination and inverted dies

2) **Simple Blanking die design**
Design of Blanking die: Shearing force, press capacity, Methods of reduction of shear force, clearances, die & punch size types of strippers, types of strip layouts, types of strippers, types of stoppers, selection of dowel pins & allen screws. Center of pressure of blank.

3) **Design of Progressive die**
Scrap development layout, Shearing force, press capacity, clearances, die & punch size, selection of strippers, types of strippers, Methods of reduction of shear force in progressive die,, selection of dowel pins & allen screws. Center of pressure of Progressive die.

4) **Types of Presses**
mechanical, hydraulic, pneumatic and their mechanisms, elements of die sets, types of die sets, types of punches

5) **Design of Drawing Dies**
Deep drawing mechanism, Design of deep drawing die: blank size, no of draws, drawing punch and die size, drawing force, press capacity and ironing

6) **Bending Dies**
Types of Bending dies, developed length calculation, bending force, spring back & methods used to overcome it, press brake.

SECTION-2

1) **Forging Die Design**
Design of forging die for multi-impression die-: selection of parting line, drafts, fillet & comer radii, ribs & webs, stock size calculation, Mid ordinate and Simpsons method for odd shape forging stock size calculation, flash & gutter, design of fullering, edging, blocking, finishing impressions, trimming dies, Die block dimensions, die inserts. Rules of Upset forging Upset forging punch and die design.

2) **Plastic manufacturing processes**
Types of plastics, Pastic manufacturing processes: Extrusion, Blow moulding, Thermo forming, Compression and Transfer moulding, Injection moulding: Types of machines and equipment

3) **Injection Mould design**
Selection of plastic material for various parts, Design of mould elements: Cavity, Core, back plates, inserts, and guide pins, guide bushes. Two plate injection mould system, three plate injection mould system, runner less molds, parting lines, split molds, molds for threaded components. Feed system: Designs of various types of runners, gates, balancing of runners, positioning of gates, mould filling patterns etc. Ejection system: Pin ejection, stripper plates, valve ejection, blade ejection, air ejection, etc. Cooling & heating arrangements: Design of cooling channels, layouts etc.
4) Die and Mould Materials: Punch and die materials for sheet metal working operations, Material requirements for Forging dies, Die and moulds material for injection moulding. Die and mould manufacturing techniques and treatment of dies and tools

List of Practical
1. To design Punch and die for simple blank with selection of hardware, stripper & stopper.
2. Drafting of Simple banking die set assembly and strip layout on A1 drawing sheet.
3. To design Punch and die for progressive die with selection of pilot, hardware, stripper & stopper.
4. Drafting of progressive die set assembly and strip layout on A1 drawing sheet.
5. Deep drawing die design: Blank size, no of draws, drawing force and punch and die design.
6. Drafting of deep drawing die set assembly on A1 drawing sheet.
7. To design bending die for bend components.
8. Drafting of bending die on A1 drawing sheet.
9. Forging die design for closed die forging.
10. Drafting of multi impression closed die forging die set on A1 drawing sheet.
11. Upsetting die design for upset forging.
12. Drafting of upset forging die forging die sets on A1 drawing sheet.
13. Injection mould design for the given component.
14. Drafting of injection mould assembly using CAD software. (AutoCAD, CATIA, Pro E)

List of Project areas:
1. Design of simple Blanking die set for sheet metal blanks.
2. Design of Progressive die set for multiple piercing, complicated profile of component.
3. Design of Compound die for washer type components.
4. Design of Combination die for shearing and forming operations together.
6. Design of bending die for bend work pieces.
7. Design of multi impression closed die forging for transmission lever.
8. Injection Mould design for cap of water bag.
9. Sheet metal working simulation.
10. Forging die design simulation.

Text Books:
2. P. C. Sharma, Production Engineering, S. Chand
4. R. G. W. Pye, Injection Mould Design (Design manual for plastic industry), EWP

Reference Books
3. Dr. Surender Kumar, Production Engg. Design (Tool Design), Satya Prakashan
5. Denton and Glanvil Injection mould design fundamentals, Industrial Press, Inc.

Course Outcomes:
Student will be able to
1. Understand mechanism of shearing of sheet metals, elements of dies and equipment.
2. Select and design appropriate die set and equipment for shearing operations of sheet metal.
3. Understand principles of sheet metal forming and design of tools for deep drawing and bending operations.
4. Apply principals of forging operations and design dies for closed die and upset forging.
5. Understand different plastic processing techniques and equipment.
6. Design elements of injection molding dies and understand working of injection machine.
PR4108:: WORLD CLASS MANUFACTURING & INDUSTRY 4.0

Credits: 04

Teaching Scheme: Th-3 Hrs/Wk+Lab-2 Hrs/Wk

SECTION-1

Lean Manufacturing – Definition & Concept. Characteristics of Lean Manufacturing. Concept of MUDA, MURA & MURI, Value Added and NVA activities

Value Stream Mapping – VSM Symbols, Current State and Future State, Kaizen- Types, Format. Kaizen Development,


Set-up Time Reduction: SMED Methodology for Set-up reduction, OTED (One Touch Exchange of Dies), Quick Attachment Devices.


Cellular Manufacturing: Work cell concepts and applications, Work cell design, work cell staffing and equipment issues.

SECTION-2

Japanese Lean Principles: Heijunka (Resource Leveling), Jidoka (Autonomation), Genichi Genbitsu (Go and See)


Visual Management System- , Introduction to 5S: Steps in 5S Methodology, Concept of 1S(Seiri), 2S(Seiton), 3S (Seiso), 4S (Shiketsu), 5S, (Shitsuke). Implementation of 1S & 2S, Visual Displays, Visual Controls


Lean Applications in Service Sector - Logistics, Healthcare

Industry 4.0: Introduction, Globalization and Emerging Issues, The Fourth Revolution, Smart Factories, Drivers and Enablers of Industry 4.0, Cyber Physical Systems, Industrial IoT (IIoT)
List of Practical’s:
1. Waste Identification and Classification -3M of Lean
2. Kaizen preparation- operator or circle level
3. Value Stream Mapping- Current State and Future State ( e-VSM Software )
4. Standardization of processes
5. Design Work Cell as per requirements
6. Design of JIT / Kanban System for manufacturing firm
7. Cellular Manufacturing
8. Design of Single Piece Flow
9. Identification and Reduction TPM Losses
10. Assignment on TPM Performance Measures
11. Assignment on Overall Equipment Effectiveness
12. Autonomous Maintenance -Jishu Hozen
13. Understanding and Implementation of 5S
14. Use of SIPOC Diagram
15. Identification of Bottleneck and constraint classification
16. Application of Theory of Constraints- (Goldratt’s TOC Software)
17. Use of constraint management tools like CRT, FRT, Evaporating Cloud etc
18. Industry 4.O applications

List of Project areas:
1. Value Stream Mapping, ( e-VSM Software )
2. Kaizen Improvement Projects
3. Setup Time Reduction using SMED approach
4. Automotin (Jidoka) and Andon implementation
5. Kanban, JIT feasibility and implementation
6. Group Technology and Cellular Manufacturing
7. TPM- KK Pillar, Overall Equipment Effectiveness,
8. TPM-Pillars- JH and PM
9. TPM Abnormalities
10. 5S Implementation
11. Developing Maintenance Schedule
12. Standardization - Formation of SOP, Work Instructions
13. Theory pf Constraints Applications- (Goldratt’s TOC Software)
14. Lean Applications in Services
15. Industry 4.O applications

Text Books:

Reference Books:
5. Terry Wireman, Total Productive Maintenance, Industrial Press, 2004

Course Outcomes:
The student will be able to –
1. Identify, eliminate and reduce the non-value added activities (wastes) in manufacturing organization
2. Apply the tools and techniques of lean manufacturing to improve productivity in manufacturing organizations
3. Understand the principles and benefits of Toyota Production System philosophy
4. Apply the concept, tools and techniques in TPM philosophy
5. Apply the tools and techniques of constraint management to improve productivity in manufacturing and service organizations
6. Apply the tools and techniques of lean manufacturing to improve productivity in service organizations
PR4011:: OPTIMIZATION TECHNIQUES

Credits: 04  
Teaching Scheme: Th-3 Hrs/Wk+Lab-2 Hrs/Wk

SECTION-1

**Introduction & Formulation of LP Model**  
OR methodology, Definition of OR, Application of OR to engineering and Managerial problems, Features of OR models, Limitation of OR, formulation LPP Models. Definition, mathematical formulation, standard form, solution space, solution – feasible, basic feasible, optimal, infeasible, multiple, optimal, Redundancy, Degeneracy. Graphical and simplex methods. Variants of simplex algorithm – Artificial basis techniques, Big M Method

**Queuing Theory & Simulation**:  

**Game Theory** - Introduction, two - person zero sum game, minimax and maximin principle, saddle point, methods for solving game problems with mixed strategies, Graphical and iterative methods, solving game by LP Method.

SECTION-2

**Integer Programming and Dynamic Programming** - Integer Programming: Branch & bound, cutting plane method, Dynamic Programming: Introduction, application, capital budgeting, different problems solved by dynamic programming

**Decision Making tools & Multi criteria Decision Making Tools**: Decision Tree – Logic. Decision making under risk (EMV criteria) and Decision making under certainty & uncertainty. Goal Programming-Definition, Introduction, Problems. SAW, WPM, TOPSIS, Electrethee, Promethee.

**Replacement Analysis & Non linear Programming methods** - Replacement of capital equipments that deteriorates with time, time value of money (a) remains same (b) changes with constant rates during period. Equipment renewal policy, group and individual replacement. Individual Replacement, Group Replacement Policies, Problems & Non linear Programming methods- Kuhn Tucker, Lagrangian method.

**List of Practicals:**
1. Assignment on Sensitivity Analysis in Linear Programming Problems
2. Assignment on duality
3. Assignment based on queuing theory  
4. Assignment based on Multi stage queuing Model  
5. Assignment based on Game theory- graphical method  
6. Assignment based on Game theory- dominance property  
7. Assignment on Integer programming using branch and bound method  
8. Assignment based on Dynamic programming  
9. Assignment on decision tree and on decision making tools.  
10. Assignment on MCDM  
11. Assignment based on replacement models  
12. Assignment based on Non linear Programming methods

**Project Work:**
1. Queuing theory  
2. Replacement analysis  
3. Linear programming applications  
4. Simulation modeling  
5. Game theory  
6. Goal programming  
7. Integer programming  
8. Dynamic programming  
9. Decision making tree  
10. Non linear programming  
11. Tandem queuing  
12. Monte Carlo Simulation

**Text Books:**

**Reference Books:**

**Course Outcomes:**
The student will be able to –
1. Formulate a linear programming model and solve it optimally  
2. Formulate a real life queuing problem and generate optimal solutions  
3. Simulate various real life problems and generate optimal solutions  
4. Analyze the replacement policies for manufacturing and service sector  
5. Develop integer solution for the real life problem by applying various methods  
6. Divide a complex problem into no of stages and solve it optimally
PR4109:: COMPUTER AIDED ENGINEERING ANALYSIS

Credits: 04  Teaching Scheme: Th-3 Hrs/Wk+Lab-2 Hrs/Wk

SECTION-1

Fundamentals Concepts of FEA

**Introduction** – Brief History of FEM, Finite Element Terminology (nodes, elements, domain, continuum, Degrees of freedom, loads & constraints) General FEM procedure, Applications of FEM in various fields, P & h formulation, Advantages and disadvantages of FEM. Consistent units system. Review of Solid Mechanics Stress equilibrium equations, Strain-Displacement equations, Stress-Strain, Temperature Relations, Plane stress, plane strain and axi-symmetric problems, Strain energy, Total potential energy. Essential and natural boundary conditions Review of Matrix Algebra (Vectors, Matrices, Symmetric banded matrix, Determinants, Inverses), banded skyline solutions. Introduction to solvers (Sparse solver, iterative solver, PCG, block Lanczos). Introduction to different approaches used in FEA such as direct approach, Variational approach, weighted residual, energy approach, Galerkin and Raleigh Ritz approach.

**1D Elements**

Types of 1D elements. Displacement function, Global and local coordinate systems, Order of element, primary and secondary variables, shape functions and its properties. Formulation of elemental stiffness matrix and load vector for spring, bar, beam, truss and Plane frame. Transformation matrix for truss and plane frame, Assembly of global stiffness matrix and load vector, Properties of stiffness matrix, half bandwidth, Boundary conditions elimination method and penalty approach, Symmetric boundary conditions, Stress calculations.

SECTION-2

**2D Elements**

Types of 2D elements, 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. Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), Overview of axi-symmetric elements

**Equations of elasticity**

Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations – Plate and shell elements

**Isoparametric Formulation**

List of Practicals:
1. Introduction to analytical methods
2. Elements and their properties
3. Steps in stress analyses
4. Introduction to analysis software
5. Stress analysis of beams (Cantilever, Simply supported & Fixed ends)
7. Stress analysis of rectangular L bracket
8. Stress analysis of 3D objects
9. 1D FEA Problems
10. 1D FEA Problems
11. 2D FEA Problems
12. 2D FEA Problems
13. 3D FEA Problems
14. 3D FEA Problems
(Meshing Improvement Techniques should be covered during every problem)

Course Project – Industrial Problem
1. Finite Element Analysis Of Composite Leaf Spring For Automotive Vehicle
2. A Project on Modeling And Structural Analysis Of a Cam Shaft
3. A Project on Bending stress and fatigue analysis of connecting rod of Mahindra tractor through finite element method (ANSYS)
4. A Project on Design & Analysis of Coil Spring with different materials for automotive applications
5. Design And Analysis Of Piston By Composite Materials
6. A Project on Finite Element Analysis Of Connecting Rod
7. A Project on FEA Analysis Of Disc Brake
8. Design And Analysis Of New Model Wheel Rim For A Four Wheeler
9. Stresses Analysis Of Helical Gear Using Finite Element Analysis
10. A Project on Design & Analysis of rocker arm
11. Design &Analysis of Fins with Various Configuration
12. Heat transfer enhancement techniques
13. A Project on Design & Analysis of machine tool spindle

Presentations:
1. Sensitivity Analysis
2. Optimized Mesh Density
3. Dynamic Meshing
4. Element Killing
5. New Elements in Element Library
6. Specialty & Difference between different commercial softwares – ABAQUS, ANSYS Mechanical, ANSYS APDL, COMSOL, NASTRAN, LS DYNA, HYPERWORKS, ASTRIX, ADAMS, COSMOS, Sinda
Text Books:

Reference Books:
1. Fagan M. J., Finite Element Analysis, Theory and Practice, Pearson Education Limited
3. S. Moaveni, Finite element analysis, theory and application with Ansys
5. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune

Course Outcomes:
Students will be able to:
1. Understand direct stiffness, Rayleigh-Ritz, Galerkin method to solve engineering problems and outline the requirements for convergence
2. Formulate and Solve axially loaded bar Problems.
3. Formulate and analyze truss and beam problems.
4. Implement the formulation techniques to solve two-dimensional problems using triangle and quadrilateral elements.
5. Formulate and solve Axi-symmetric and heat transfer problems.
6. Use commercial finite element software and understand its structure
PR4107::MECHATRONICS & INDUSTRIAL ROBOTICS

Credits: 04
Teaching Scheme: 3 Hrs/Wk

SECTION-1

1 Mechatronics

2 Basic Concepts in Robotics
Automation and robotics, robot anatomy, robot specifications, Development of industrial Robots and manipulators, basic structure of robots, resolution, accuracy and repeatability. Classification, Configuration of robots, arm and body motions, wrist motions, Mechanical, hydraulic and pneumatic Manipulators

3 Robot Arm Kinematics

4 Static and dynamic analysis of manipulator arm
Statics of planer arm robot, Mass and inertia of links, Lagrangian formulation for equations of motion for serial manipulators.

SECTION-2

1 Robot Grippers
Classification, types, Design consideration, Materials for hostile operation. Cylindrical Cam type; Grippers using pneumatic, Vacuum Grippers, ultrasonic grippers

2 Sensors in Robotics
Vision system: Median filtering, thresholding, discretization, smoothening of binary image. Recognition Procedure. CCD Camera.

3 Robot Drives, Control and Robot Programming

DC servo motors, basic control systems concepts and models, control system analysis, robot activation and feedback components. Positional and velocity actuators. Methods of programming the robot, Languages, Robographics, Introduction to Artificial Intelligence, Hydraulic systems, Power transmission systems, robot joint control design

**List of Practicals:**
1) problems on accuracy, precision and repeatability, resolution
2) Problem on axis rotation by matrix transformation
3) problem on forward kinematics-Cartesian
4) problem on forward kinematics-cylindrical
5) problem on forward kinematics-polar
6) problem on forward kinematics-jointed arm.

**List of Project areas:**
1. Robotic Work Cell Design

**Text Books:**

**Reference Books:**

**Course Outcomes:**
The student will be able to –
1. Understand robot system and Select type of robot for industrial applications
2. Solve direct and inverse kinematic problem for Cartesian, polar, cylindrical and articulated arm robot.
3. Understand concept of static and dynamics of manipulator arm
4. Understand various types of end effectors used in industrial robots.
5. Understand concepts and applications of sensors used in industrial robots.
6. Study and Select appropriate drives and robot programming method for industrial robots.
PR4110:: DATA ANALYTICS

Credits: 4

Teaching Scheme: Theory: 3 Hours / Week
Lab/Project: 2 Hours/Week

SECTION - I

Introduction to Data Science and Analytics

Introduction to Data Science in Python:
Python Core Objects and built-in functions, Number Object and operations, String Object and Operations, List Object and Operations, Tuple Object and operations, Dictionary Object and operations, Set object and operations, Boolean Object and None Object, Different data Structures, data processing Conditional Statements and Loops, UDF Functions and Object Functions, File Handling with Python, Python Modules and Packages, Exceptional Handling and Object-Oriented Python, Python OOPS.

Database System:
Database interaction with Python Creating Database with MYSQL, CRUD Operations, Creating a Database Object. Python MySQL Database Access Disconnecting Database, Data Analytics Tool Spreadsheet, MLTool, BI Tools

SECTION - II

Machine Learning
Data Visualization - Matplotlib, Data Analysis Using Python Modules- Numpy, Pandas,Tableau Machine Learning Algorithms Supervised Learning Regression Linear Regression (Simple and Multiple) Logistic Regression.

Machine Learning Algorithms
Supervised Learning Regression Linear Regression Multiple Linear Regression Bias-Variance Trade-Off

Classification Modelling
Logistic Regression, K-Nearest Neighbors (KNN), Simple Vector Machine (SVM), Decision Trees o Ensemble Methods - Random Forest

Unsupervised Learning Clustering (6 Hours)
K-Means Clustering Hierarchical Clustering DBSCAN
List of Practical: (Use of Excel / R / Python / Minitab / SAS / SPSS/Google Data Studio)
1. Data analysis using Google data studio
2. Data analysis and visualization using Tableau
3. Estimation in Statistics
4. Test of significance for means
5. Test of significance for proportion
6. Test of significance for variance
7. Regression
8. Correlation

List of Project areas:
1. Questionnaire design in Marketing
2. Exploratory Research using secondary data from websites / magazines
3. Exploratory Research using primary data for canteen / hostel / flats
4. Descriptive Research
5. Data analysis in MS Excel
6. Discrete probability distributions in industry
7. Design of field surveys for food apps
8. Methods of sampling
9. Continuous probability distributions in industry
10. Sensex Analysis
11. Brent Crude Analysis
12. Correlation between various sectors
13. Forecasting of values
14. Academic result analysis
15. Developing small tools/programs in R/Python

Text Books:

Reference Books:
1. Levin Richard and Rubin David, Statistics for Management, Prentice Hall of India
4. Paneerselvam R., Design and Analysis of Experiments, Prentice Hall of India
Course Outcomes:
The student will be able to –
1. Explain the nature of research and data requirements
2. Calculate probability by selecting appropriate probability distribution for managerial decisions
3. Estimate confidence interval
4. Perform test of significance for means and proportion
5. Perform test of significance for variance
6. Assess the appropriateness of different kinds of research designs and methodology
PR4074::MAJOR PROJECT-1

Credits: 04

Teaching Scheme: 8 Hr/Wk

The project work could be of the following nature:

1. Manufacturing / Fabrication of a prototype machine including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation.
2. Improvement of existing machine / equipment / process.
3. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for machine tools.
4. Computer aided design, analysis of components such as stress analysis.
5. Problems related to Productivity improvements.
6. Problems related to value engineering.
7. Problems relating to material handling system.
10. Product design and development.
11. Analysis, evaluation and experimental verification of any engineering problem encountered.
13. Quality improvements, In-process Inspection, Online gauging.
15. Time and Motion study, Job evaluation.
16. Ergonomics and safety aspects under industrial environment
17. Management Information System.
18. Market Analysis in conjunction with Production Planning and Control.

OR

Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hitech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Computer based design / analysis or modeling / simulation of product(s), mechanism(s) or system(s) and its validation or comparison with available benchmarks / results. Modelling/simulation of product(s), mechanism(s) or system(s) and its validation or comparison with available benchmarks / results. Design/development and Fabrication of models, machines, and prototypes based on new ideas, robotic and automation systems, Experimental set ups, test rigs/ equipments.

The project work shall be taken up individually or in a group consisting of not more than 4 students.
A report containing maximum 30 pages shall be submitted based on the background, need and scope of the project, project specifications, activities involved in the project and activity plan, study of literature and basic theory, and work completed (if any).

**Guidelines:**

- Report shall be typed or printed.
- Figures and tables shall be on separate pages and attached at respective positions.
- Project title and approval sheets shall be attached at the beginning of the report followed by index and synopsis of the project.
- References shall be mentioned at the end followed by appendices (if any).
- When a group of students is doing a project, names of all the students shall be included on every certified report copy.

Each group of students shall submit two copies of reports to the institute and one copy shall be prepared for each individual student.

**Course Outcomes:**

Students will be able to:

1. Survey literature for problem identification
2. Cultivate the habit of working in a team, communicate effectively and attempt a problem solution in a right approach
3. Correlate the theoretical and experimental/simulations results and draw the proper inferences.
4. Apply engineering knowledge in carrying out project starting from design, drafting, process planning, project management, costing, manufacturing, QC and inspection, down to assembly, testing and evaluation.
5. To practice data collection and analysis using different measurement equipment’s and software packages.
6. Prepare project report as per guideline and present it effectively
PR4086::MAJOR PROJECT-2

Credits: 04

Teaching Scheme:- 8 Hr/Wk

The project work could be of the following nature:

1. Manufacturing /Fabrication of a prototype machine’ including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation.
2. Improvement of existing machine / equipment / process.
3. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for machine tools.
4. Computer aided design, analysis of components such as stress analysis.
5. Problems related to Productivity improvements.
6. Problems related to value engineering.
7. Problems relating to material handling system.
10. Product design and development.
11. Analysis, evaluation and experimental verification of any engineering problem encountered.
13. Quality improvements, In-process Inspection, Online gauging.
15. Time and Motion study, Job evaluation.
16. Ergonomics and safety aspects under industrial environment
17. Management Information System.
18. Market Analysis in conjunction with Production Planning and Control.

OR

Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hitech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Computer based design / analysis or modeling / simulation of product(s), mechanism(s) or system(s) and its validation or comparison with available benchmarks / results. Modelling/simulation of product(s), mechanism(s) or system(s) and its validation or comparison with available benchmarks / results. Design/development and Fabrication of models, machines, and prototypes based on new ideas, robotic and automation systems, Experimental set ups, test rigs/ equipments.

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