DR. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY
LUCKNOW, UTTAR PRADESH

STUDY & EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH. 3rd YEAR

Production Engineering/
Industrial Production Engineering

[Effective from Session: 2020-21]
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### B. Tech Production Engineering/ Industrial Production Engineering

#### Evaluation Scheme

**SEMESTER - V**

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**Total** | 17 | 3 | 8 | 950 | 22 |

*The Mini Project or internship (4 - 5 weeks) conducted during summer break after IV semester and will be assessed during V semester.*

**SEMESTER - VI**

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**Total** | 17 | 3 | 6 | 900 | 21 |
Production Engineering/ Industrial Production Engineering: Departmental electives

Student can choose any elective horizontally from the pool of electives

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Suggested MOOCs

It is suggested that the students may also do the following MOOCs in addition to mandatory courses. This will enhance their learning.

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Control Systems | https://swayam.gov.in/nd1_noc20_cee90/preview | By Prof. C. S. Shankar Ram, IIT Madras |

Introduction to robotics | https://swayam.gov.in/nd1_noc20_de12/preview | By Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan, IIT Madras |

Introduction to Industry 4.0 and Industrial Internet of Things | https://swayam.gov.in/nd1_noc20_cse89/preview | By Prof. Sudip Misra, IIT Kharagpur |

Supply Chain management | https://swayam.gov.in/nd2_cec20_mg11/preview | By Dr. P. Chitramani, Avinashilingam Institute for Home Science and Higher Education for Women |

Work System design | https://swayam.gov.in/nd1_noc20_me70/preview | By Prof. Inderdeeph Singh, IIT Roorkee |

Industrial Safety Engineering | https://swayam.gov.in/nd1_noc20_mg43/preview | By Prof. Jhareswar Maiti, IIT Kharagpur |

Introduction to Composites | https://swayam.gov.in/nd1_noc20_me95/preview | By Prof. Nachiketa Tiwari, IIT Kanpur |

Operation Research | https://swayam.gov.in/nd1_noc20_ma45/preview | By Prof. Kusumdeep, IIT Roorkee |
The students will be able to

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<td>Understand the fundamentals of heat and mass transfer.</td>
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<td>CO-2</td>
<td>Apply the concept of steady and transient heat conduction.</td>
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<td>CO-3</td>
<td>Apply the concept of thermal behavior of fins.</td>
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<tr>
<td>CO-4</td>
<td>Apply the concept of forced and free convection.</td>
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<tr>
<td>CO-5</td>
<td>Apply the concept of radiation for black and non-black bodies.</td>
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<td>CO-6</td>
<td>Conduct thermal analysis of heat exchangers.</td>
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UNIT-1
Introduction to Heat Transfer  
(L-5 Hours)
Introduction of thermodynamics and Heat Transfer, Modes of Heat Transfer: Conduction, convection and radiation, Effect of temperature on thermal conductivity of different types of materials, Introduction to combined heat transfer mechanism, General differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems, Initial and system boundary conditions.

Steady State one-dimensional Heat Conduction  
(L-3 Hours)
Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation, Concept of thermal resistance, Analogy between heat and electricity flow, Thermal contact resistance and over-all heat transfer coefficient, Critical radius of insulation for cylindrical, and spherical bodies.

UNIT-2
Fins  
(L-3 Hours)
Heat transfer through extended surfaces and its classification, Fins of uniform cross-sectional area, Error in measurement of temperature of thermometer wells.

Transient Conduction  
(L-3 Hours)
Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts and their applications.

UNIT-3
Forced Convection  
(L-5 Hours)
Basic concepts: Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Thermal entrance region, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer.

Natural Convection  
(L-5 Hours)
Physical mechanism of natural convection, Buoyant force, Empirical heat transfer relations for natural convection over vertical planes and cylinders, horizontal plates, cylinders and sphere, combined free and
forced convection, Effect of turbulence.

UNIT-4

**Thermal Radiation** *(L-8 Hours)*

Basic concepts of radiation, Radiation properties of surfaces, Black body radiation Planck’s law, Wein’s displacement law, Stefan-Boltzmann law, Kirchhoff’s law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse non-black bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar radiation; Greenhouse effect, Radiation network analysis.

UNIT-5

**Heat Exchanger** *(L-5 Hours)*

Different types of heat exchangers, Fouling factors, Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-number of transfer unit (NTU) method and Compact Heat Exchangers.

**Condensation and Boiling** *(L-3 Hours)*


**Introduction to Mass Transfer** *(L-2 Hours)*


**Reference Books:-**

1. Fundamentals of Heat and Mass Transfer, by Incroperra& DeWitt, John Wiley and Sons
3. Heat Transfer by J.P. Holman, McGraw-Hill
4. Heat and Mass Transfer by Rudramoorthy and Mayilsamy, Pearson Education
5. Heat Transfer by Ghoshdastidar, Oxford University Press
7. Heat Transfer by Venkateshan, Ane Books Pvt Ltd
Subject Code: KME 502  
Strength of Material  
L T P : 3 1 0  
Credits: 4

Course Outcomes: The student will be able to

<table>
<thead>
<tr>
<th>CO</th>
<th>Outcomes</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Understand the concept of stress and strain under different conditions of loading</td>
<td>K2</td>
</tr>
<tr>
<td>CO 2</td>
<td>Determine the principal stresses and strains in structural members</td>
<td>K3</td>
</tr>
<tr>
<td>CO 3</td>
<td>Determine the stresses and strains in the members subjected to axial, bending and torsional loads</td>
<td>K3</td>
</tr>
<tr>
<td>CO 4</td>
<td>Apply the concepts of stresses and strain in solving problems related to springs, column and pressure vessels</td>
<td>K3</td>
</tr>
<tr>
<td>CO 5</td>
<td>Calculate the slope, deflection and buckling of loaded members</td>
<td>K3</td>
</tr>
<tr>
<td>CO 6</td>
<td>Analyze the stresses developed in straight and curved beams of different cross sections</td>
<td>K4</td>
</tr>
</tbody>
</table>

Unit I  
8 Hours

**Compound stress and strains:** Introduction, normal stress and strain, shear stress and strain, stresses on inclines sections, strain energy, impact loads and stresses, state of plane stress, principal stress and strain, maximum shear stress, Mohr’s circle for plane stress, three dimensional states of stress & strain, equilibrium equations, generalized Hook’s law, theories of failure. Thermal Stresses.

Unit II  
8 Hours

**Stresses in Beams:** Pure Bending, normal stresses in beams, shear stresses in beams due to transverse and axial loads, composite beams.

**Deflection of Beams:** Differential equation of the elastic curve, cantilever and simply supported beams, Macaulay’s method, area moment method, fixed and continuous beams

**Torsion:** Torsion, combined bending & torsion of solid & hollow shafts, torsion of thin walled tubes.

Unit III  
8 Hours

**Helical and Leaf Springs:** Deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.

**Columns and Struts:** Buckling and stability, slenderness ratio, combined bending and direct stress, middle third and middle quarter rules, struts with different end conditions, Euler’s theory for pin ended columns, effect of end conditions on column buckling, Ranking Gordon formulae, examples of columns in mechanical equipment and machines.

Unit IV  
8 Hours

**Thin cylinders & spheres:** Introduction, difference between thin walled and thick walled pressure vessels, thin walled spheres and cylinders, hoop and axial stresses and strain, volumetric strain.
Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, compound cylinders, stresses in rotating shaft and cylinders, stresses due to interference fits.

Unit V 8 Hours

Curved Beams: Bending of beams with large initial curvature, position of neutral axis for rectangular, trapezoidal and circular cross sections, stress in crane hooks, stress in circular rings subjected to tension or compression.

Unsymmetrical Bending: Properties of beam cross-section, slope of neutral axis, stress and deflection in unsymmetrical bending, determination of shear center and flexural axis (for symmetry about both axis and about one axis) for I-section and channel section.

Text Books:
2. Strength of Material by Rattan, MC GRAW HILL INDIA

Reference Books:
2. Mechanics of material by Gere, Cengage Learning
7. Introduction to Solid Mechanics by Shames, Pearson
8. Mechanics of material by Pytel, Cengage Learning
10. Strength of Materials by Jindal, Pearson Education
Course Outcomes: The students will be able to

| CO1 | Understand the concept of production system, productivity, facility and process planning in various industries |
| CO2 | Apply the various forecasting and project management techniques |
| CO3 | Apply the concept of break-even analysis, inventory control and resource utilization using queuing theory |
| CO4 | Apply principles of work study and ergonomics for design of work systems |
| CO5 | Formulate mathematical models for optimal solution of industrial problems using linear programming approach |

**Unit-I:**

**Overview of Industrial Engineering:** Types of production systems, concept of productivity, productivity measurement in manufacturing and service organizations, operations strategies, liability and process design.

**Facility location and layout:** Factors affecting facility location; principle of plant layout design, types of plant layout; computer aided layout design techniques; assembly line balancing; materials handling principles, types of material handling systems, methods of process planning, steps in process selection, production equipment and tooling selection, group technology, and flexible manufacturing.

**Unit II:**

**Production Planning and control:** Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master production scheduling; materials requirement planning (MRP) and MRP-II; routing, scheduling and priority dispatching, concept of JIT manufacturing system

**Project Management:** Project network analysis, CPM, PERT and Project crashing.

**Unit III:**

**Engineering economy and Inventory control:** Methods of depreciation; break-even analysis, techniques for evaluation of capital investments, financial statements, time-cost trade-off, resource levelling; Inventory functions, costs, classifications, deterministic inventory models, perpetual and periodic inventory control systems, ABC analysis, and VED analysis.

**Queueing Theory:** Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Classification of Queuing models.

**Unit IV**

**Work System Design:** Taylor’s scientific management, Gilbreths’s contributions; work study: method study, micro-motion study, principles of motion economy; work measurement –time study, work
sampling, standard data, Predetermined motion time system (PMTS); ergonomics; job evaluation, merit rating, incentive schemes, and wage administration.

**Product Design and Development:** Principles of product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, and concurrent engineering.

**Unit V:**
**Operational Analysis:** Formulation of LPP, Graphical solution of LPP, Simplex Method, Sensitivity Analysis, degeneracy and unbound solutions. transportation and assignment models; Optimality test: the stepping stone method and MODI method, simulation.

**Books and References:**
1. Industrial Engineering and Production Management by Martand T Telsang S. Chand Publishing
2. Industrial Engineering and Production Management by M. Mahajan Dhanpat Rai & Co. (P) Limited
3. Industrial Engineering and Management by Ravi Shankar, Galgotia Publications Pvt Ltd
4. Production and Operations Management by Adam, B.E. & Ebert, R.J., PHI
5. Product Design and Manufacturing by Chitale A.V. and Gupta R.C., PHI
6. Operations Research Theory & Applications by J K Sharma, Macmillan India Ltd,
7. Production Systems Analysis and Control by J.L. Riggs, John Wiley & Sons
The students will be able to

<table>
<thead>
<tr>
<th>The students will be able to</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CO1 Apply the concept of conductive heat transfer.</td>
<td>K3</td>
</tr>
<tr>
<td>CO2 Apply empirical correlations for both forced and free convection to determine the value of convection heat transfer coefficient</td>
<td>K3</td>
</tr>
<tr>
<td>CO3 Apply the concept of radiation heat transfer for black and grey body.</td>
<td>K3</td>
</tr>
<tr>
<td>CO4 Analyze the thermal behaviour of parallel or counter flow heat exchangers</td>
<td>K4</td>
</tr>
<tr>
<td>CO5 Conduct thermal analysis of a heat pipe</td>
<td>K4</td>
</tr>
</tbody>
</table>

List of Experiments

Minimum eight experiment of the following
1. To determine thermal conductivity of conductive material(s).
2. To determine thermal conductivity of insulating material(s).
3. To determine heat conduction through lagged pipe.
4. To determine heat transfer through fin under natural convection.
5. To determine the heat transfer Rate and Temperature Distribution for a Pin Fin.
6. Determination of thermal conductivity of different types of fluids.
7. Experiment on Stefan's Law - determination of emissivity, etc.
8. Experiment on convective heat transfer through flat plate solar collector.
9. To compare LMTD and Effectiveness of Parallel and Counter Flow Heat Exchangers.
10. To find the heat transfer coefficient for Forced Convection in a tube.
11. To find the heat transfer coefficient for Free Convection in a tube.
12. To conduct experiments on heat pipe.
13. To study the rates of heat transfer for different materials and geometries.
14. Visit to a Thermal Power Station for practical exposure.
Course outcomes: The students will be able to

<table>
<thead>
<tr>
<th>Course</th>
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<th>Blooms Taxonomy</th>
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<tbody>
<tr>
<td>CO1</td>
<td>Apply conditional statement, loops condition and functions in python program</td>
<td>K3</td>
</tr>
<tr>
<td>CO2</td>
<td>Solve mathematical and mechanical problems using python program</td>
<td>K3</td>
</tr>
<tr>
<td>CO3</td>
<td>Plot various type of chart using python program</td>
<td>K3</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyze the mechanical problem using python program</td>
<td>K4</td>
</tr>
</tbody>
</table>

List of Python Program

1. Write a program to find root of quadratic equation
2. Write a program to find and delete repeating number in Given List
3. Write a program to input and print the element sum of user defined matrix
4. Write a program to input and multiply two different matrices
5. Write a program to compute eigen value and vector of a given 3*3 matrix using NumPy
6. Write a program to find a solution of linear equations in y=mx+c
7. Write a program to draw line using equation y=mx+c
8. Write a program to determine the intersection point of two line.
9. Draw various types of charts using matplotlib
10. Write a program to perform equations of uniform motion of kinematics:
    i. \( v = u + at \)
    ii. \( s = ut + \frac{1}{2}(at^2) \)
    iii. \( v^2 = u^2 - 2as \)
11. Write a menu driven program to perform following properties of thermodynamics as given below:
    i. First Law of thermodynamics ( \( U = Q - W \) ), where \( \Delta U \) is the change in the internal energy. \( Q \) is the heat added to the system, and \( W \) is the work done by the system.
    ii. Efficiency of Heat Engine = \( TH – TC / TH \) where \( TH \& TC \) is the temperature of HOT and COLD Reservoirs.
12. Write the menu program to find the to find the out relationship between stress and strain curve as given below:
    i. Young’s Modulus
    ii. Shear Modulus
    iii. Poisson Ratio
13. Write the program to determine the shear force and bending moment in beams.
14. Write a program to find maxima/minima of functions of two variables and evaluate some real definite and finite integrals.
15. Write a Program to find out unknown magnitude of TB and TD of unknown tension can be obtained from two scalar equations of equilibrium i.e \( EF_x = 0 \) and \( EF_y = 0 \).
16. Write a program to perform interpolation of equally and unequally spaced data.
17. Write a program to calculate total pressure exerted in ideal fluid as equation is given below: \( p + 1/2(pV^2) + \rho gh = \text{constant} \)
Where $P$ is Pressure, $V$ is Velocity of fluid, $\rho$ is density and $h$ is the height of the container.

18. Write a program to find numerical differentiation using Finite differences Method by importing NumPy and plot the numerical values using matplotlib libraries of python.

19. Write a program for Bresenham’s line drawing algorithm.

20. Write a program for geometric transformation of a given object.
The students will be able to

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of Experiment</th>
<th>Outcome</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Familiarization with concept of IoT, Arduino/Raspberry Pi and perform necessary software installation.</td>
<td>Will be able to understand IoT, Arduino/Raspberry Pi, and also able to install software setup of Arduino/Raspberry Pi</td>
<td>K2</td>
</tr>
<tr>
<td>2</td>
<td>To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON/OFF motor.</td>
<td>Able to use relay to control motor and other mechanical devices</td>
<td>K3</td>
</tr>
<tr>
<td>3</td>
<td>To interface sensors* with Arduino/Raspberry Pi and write a program to display sensors data on the computer screen.</td>
<td>Able to retrieve data from sensors and to display it on computer screen</td>
<td>K3</td>
</tr>
<tr>
<td>4</td>
<td>To interface OLED with Arduino/Raspberry Pi and write a program to display sensor data on it.</td>
<td>Able to retrieve data from sensors and to display it on OLED</td>
<td>K4</td>
</tr>
<tr>
<td>5</td>
<td>To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Relay when sensor data is detected.</td>
<td>Able to control relay with help of microcontroller and sensors</td>
<td>K5</td>
</tr>
<tr>
<td>6</td>
<td>To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Solenoid valve when sensor data is detected.</td>
<td>Able to control Solenoid valve with help of microcontroller and sensors</td>
<td>K5</td>
</tr>
<tr>
<td>7</td>
<td>To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Linear Actuator when sensor data is detected.</td>
<td>Able to control linear actuator with help of microcontroller and sensors</td>
<td>K6</td>
</tr>
<tr>
<td>8</td>
<td>To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Starter Motor when sensor data is detected.</td>
<td>Able to control Starter Motor with help of microcontroller and sensors</td>
<td>K6</td>
</tr>
<tr>
<td>9</td>
<td>To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smart phone using Bluetooth.</td>
<td>Able to communicate sensor data from microcontroller to smart phone</td>
<td>K6</td>
</tr>
<tr>
<td>10</td>
<td>To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn Actuators* ON/OFF when message is received from smart phone using Bluetooth.</td>
<td>Able to control actuators using mobile phone through Bluetooth</td>
<td>K6</td>
</tr>
<tr>
<td>11</td>
<td>Write a program on Arduino/Raspberry Pi to</td>
<td>Able to upload status of devices and</td>
<td>K6</td>
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<tr>
<td></td>
<td>Upload Sensor data to thingspeak cloud.</td>
<td>Sensors on web cloud</td>
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<tr>
<td>12</td>
<td>Write a program on Arduino/Raspberry Pi to retrieve sensors data from thingspeak cloud.</td>
<td>Able to retrieve status of devices and sensors from web cloud</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Develop IoT based smart lock system for Motor cycle/Car</td>
<td>Able to develop smart lock system of motor cycle/car</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Develop IoT based Smart water flow system</td>
<td>Able to develop smart water flow system</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Develop IoT based home security system</td>
<td>Able to develop smart home security system</td>
<td></td>
</tr>
</tbody>
</table>

**Components required-**

1. Arduino with cable
2. Raspberry Pi with cable and memory card
3. Node MCU
4. *Sensors*-IR, LDR, DHT11 sensor, Push button, Pressure sensor, Temperature sensor, Vibration, Rotation, Location, Torque, Sound, Weight etc.
5. *Actuators*-LED, Buzzer, Relay Switch, Motors, Motor Drivers, OLED, Display, Linear Actuator, Solenoid Valve, Starter Motor etc.
6. Bluetooth Module, Wi-fi Module, Ethernet Module
7. Smart Phone
8. Computer
9. Power Supply-5V, 12V, 3.3V
10. Internet facility
Semester – V: Departmental Elective – I: Specialization – Manufacturing and Automation

Subject Code: KME 051  |  Computer Integrated Manufacturing  |  L T P : 3 0 0  |  Credits: 3

<table>
<thead>
<tr>
<th>Course Outcome: Student will be able to</th>
<th>Bloom Taxonomy</th>
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</thead>
<tbody>
<tr>
<td>CO 1  Understand the basic concepts of automation, computer numeric control machining</td>
<td>K2</td>
</tr>
<tr>
<td>CO 2  Understand the algorithms of line generation, circle generation, transformation, curve, surface modeling and solid modeling</td>
<td>K2</td>
</tr>
<tr>
<td>CO 3  Understand group technology, computer aided process planning, flexible manufacturing, Industry 4.0, robotics</td>
<td>K2</td>
</tr>
<tr>
<td>CO 4  Understand information system and material handling in CIM environment, rapid prototyping</td>
<td>K2</td>
</tr>
<tr>
<td>CO 5  Apply the algorithms of line &amp; circle generation and geometric transformations</td>
<td>K3</td>
</tr>
<tr>
<td>CO 6  Develop CNC program for simple operations</td>
<td>K3</td>
</tr>
</tbody>
</table>

Unit 1

Unit 2
Principles of Computer Graphics:
Point plotting, drawing of lines, Bresenham’s circle algorithm.

Transformation in Graphics:
2D transformations – rotation, scaling, translation, mirror, reflection, shear – homogeneous transformations – concatenation, 3D transformations.

Curves: Introduction to Hermite cubic splines, Bezier curves, B-spline curves, NURBS

Surface Modeling: Polygon surfaces, Quadric surfaces, Superquadric surfaces and blobby objects

Solid modeling: Boolean set operations, Primitive instancing, Sweep representation, Boundadry representation, Constructive solid geometry,

Unit 3
Computer Aided Manufacturing:

Unit 4
Group Technology: Group technology, Cellular Manufacturing, CAPP – Variant and Generative systems-
Concurrent Engineering and Design for Manufacturing.
**Flexible Manufacturing System:** characteristics – economics and technological justification – planning, installation, operation and evaluation issues – role of group technology and JIT in FMS – typical case studies future prospects, Industry 4.0.

**Robotics:** Classification and specification – drive and controls – sensors - end effectors - grippers- tool handling and work handling – machine vision – robot programming concepts – case studies in assembly. Introduction to Programmable logical controller

**Unit 5**

**Data and information in CIM:** Management information system in CIM environment, MRP – MRP II – ERP - Capacity planning.

**Material handling in CIM environment:** Types – AGVS – AS/RS – Swarf handling and disposal of wastes – single and mixed mode assembly lines – quantitative analysis of assembly systems.

**Rapid prototyping:** Need for rapid prototyping, Basic principles and advantages of RP, General features and classifications of different RP techniques with examples.

**Books and References:**
6. P. Radhakrishnan, - CAD/CAM/CIM, New Age International (P) Ltd., New Delhi
Semester – V: Departmental Elective – I: Specialization – Automation and Industry 4.0

Subject Code: KME 052 | Mechatronics Systems | L T P : 3 0 0 | Credits: 3

Course Outcome: Student will be able to

| CO 1 | Identify key elements of mechatronics and its representation by block diagram. |
| CO 2 | Understand the concept of sensors and use of interfacing systems. |
| CO 3 | Understand the concept and applications of different actuators |
| CO 4 | Illustrate various applications of mechatronic systems. |
| CO 5 | Develop PLC ladder programming and implementation in real life problem. |

Bloom Taxonomy

| K 2 |

Unit I: Mechatronics & Its Scope

Mechatronics System: Introduction to Mechatronic Systems, Evolution, Scope, Application Areas, Basic Elements and Control of Mechatronics systems, Advantages and disadvantages of Mechatronics, Industrial applications of Mechatronics, autotronics, bionics, and avionics and their applications

Control System Concepts: Introduction to Control Systems, Elements of control system, Basic of open and closed loop control with example.

Unit II: Sensor & Transducer

Definition and classification of sensor and transducer, performance terminology, static and dynamic characteristics, Principle of working and application of Inductive Proximity, Capacitive Proximity, Photoelectric, Ultrasonic, Magnetic, Hall Effect, Tactile Sensor, load cell, LVDT and interfacing sensors in Mechatronic system.

UNIT III: ACTUATION SYSTEMS

Fluid Based Actuation: Concept of Hydraulic and Pneumatic Actuation system, Oil and Air preparation unit, Direction Control Valve, Pressure Control Valve, Single and doubly actuated systems, Actuators and Accumulators.

Electrical Actuation Systems: Introduction to Switching devices, Concept of Electro Mechanical Actuation, Solenoids and Solenoid Operated Direction Control Valves, Principle of working of DC and 3 Phase Induction Motor, Stepper motors and Servo Motors with their merits and demerits.

UNIT IV: INDUSTRIAL CONTROLLERS

Programmable Logic Controllers: Basic Structure, Types and Working Principle, Concept of Scan Cycle and Scan Time, IO’s and its Types, Selection Criteria and Applications

Programming Techniques: Ladder diagram – Concept of Contacts and Coil, Latching/ Holding Circuit, Memory Bits, Timers and Counter.

UNIT V: MECHATRONICS APPLICATIONS:

Control of conveyor motor, sorting and packaging unit, pick and place robot, coin counter, operations of bottling plant, domestic washing machine, use of PLC for extending and retracting pneumatic pistons and their different combinations, automatic car park system, engine management system, other applications in manufacturing.
Text Books:
Semester – V: Departmental Elective – V: Specialization – Production Engineering/Industrial Production Engineering

Subject Code: KPI 051 | Advance Manufacturing Science | L T P : 3 0 0 | Credits: 3

Course Outcomes: The students will be able to

| CO-1 | Understand the principles of material removal mechanism of advanced machining processes. |
| CO-2 | Understand the basic concept of advance metal forming processes. |
| CO-3 | Understand the basic concept of advance casting processes. |
| CO-4 | Understand the basic concepts of advance welding process. |
| CO-5 | Understand various hybrid modern manufacturing methods. |

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<td>K2</td>
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</tbody>
</table>

UNIT-1
Introduction (3 Hours)
Types of advanced manufacturing processes, Evolution, need, and classification of advanced machining processes.

Advanced Machining Processes (5 Hours)

UNIT-2
Advanced Machining Processes continued... (7 Hours)
Process principle, Mechanism of material removal, Process Parameters, Process Capabilities, and Applications of Electrochemical machining (ECM), Electro discharge machining (EDM), Electron beam machining (EBM), Laser beam machining (LBM) processes.

UNIT-3
Advanced Metal Forming Processes (6 Hours)
Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming and Contour roll forming.

UNIT-4
Advanced Casting Processes (7 Hours)
Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting.

Advance Welding Processes: Magnetic arc welding, Friction welding, Explosive welding, Ultrasonic welding, Laser welding, Electron beam welding

UNIT-5
Derived and Hybrid Modern manufacturing Methods: Introduction of process like rotary ultrasonic machining , electro stream drilling, shape tube electro machining, wire electro discharge machining,
electro chemical grinding, electro chemical honing, electro chemical deburring and electro chemical spark machining.

Reference Books:-
Course Outcome: Student will be able to

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<tr>
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<tbody>
<tr>
<td>CO 1 Understand the physics of arc welding process and various operating characteristics of welding power source.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 2 Analyse various welding processes and their applications.</td>
<td>K3</td>
</tr>
<tr>
<td>CO 3 Apply the knowledge of welding for repair &amp; maintenance, along with the weldability of different materials.</td>
<td>K3</td>
</tr>
<tr>
<td>CO 4 Apply the concept of quality control and testing of weldments in industrial environment.</td>
<td>K3</td>
</tr>
<tr>
<td>CO 5 Evaluate heat flow in welding and physical metallurgy of weldments.</td>
<td>K4</td>
</tr>
</tbody>
</table>

UNIT-I:
**Introduction**: Introduction to welding, application, classification and process selection criterion. Health & safety in welding.

**Welding Arc**: Physics of welding arc, arc initiation, voltage distribution, arc characteristics, arc efficiency, arc temperatures and arc blow. Mechanism and types of metal transfer.

**Welding Power Sources**: Types of welding power sources, operation characteristics and specifications.

UNIT-II:

**Advances in Welding Processes**: Narrow Gap, Tandem (Twin / Multi Wire) Welding, A-TIG, Hybrid Welding processes, Magnetically impelled arc butt (MIAB) welding, welding automation and robotic applications.

UNIT-III:
**Heat Flow Welding**: Weld thermal cycle, Temperature distribution, Peak temperature; Heat Affected Zone (HAZ), heating, cooling and solidification rates.

**Welding Metallurgy**: Fundamentals of physical metallurgy, Principle of solidification of weld metal, Reactions in weld pool - Gas metal reaction, Slag metal reaction, factors affecting changes in microstructure and mechanical properties of HAZ, Micro and macro structures in weld metal and HAZ

UNIT-IV:
**Repair & Maintenance Welding**: Hardfacing, Cladding, Surfacing, Metallizing processes and Reclamation welding.
**Weldability:** Effects of alloying elements on weldability, carbon equivalent, welding of plain carbon steel, Stainless steel, Cast Iron and Aluminium alloys, Welding of Dissimilar Materials

**UNIT-V:**
**Weld Design:** Types of welds & joints, Welding Symbols, Weld defects and Remedies, Residual Stresses & Distortion, Inspection and testing of welds: Introduction to Non Destructive Techniques; Destructive Techniques - Bulk and Microhardness test, Wear test and types, corrosion test, tensile test, bend test, SEM, EDS and XRD.

**Welding Codes, WPS&PQR:** Introduction to welding codes, ISO, ASME and BIS specifications, Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR), Welding of pipe-lines and pressure vessels.

**Books and References:**
7. Modern Welding Technology by Howard B Cary and Scott Helzer.
8. Welding Handbooks (Vol. I & II)
10. ASME Sec. IX, Boiler and Pressure Vessel Code
Semester – V: Departmental Elective – II: Specialization – Automation and Industry 4.0

Subject Code: KME 056  Programming, Data Structures And Algorithms Using Python  L T P : 3 0 0  Credits: 3

Course Outcome: Student will be able to

| CO 1 | Understand the numbers, math’s function, strings, list, tuples, and dictionaries in python                      | Bloom Taxonomy |
| CO 2 | Apply conditional statement and functions in python                                                         | K2            |
| CO 3 | Apply file handling techniques in python                                                                     | K3            |
| CO 4 | Analyze the graphical demonstration in python                                                              | K3            |
| CO 5 | Apply techniques of Classes and Object Concept in Python                                                   | K3            |

UNIT 1: Introduction (8 Hours)
Introduction to Python, Python IDE’s, Assignment statement, basic types - int, float, complex, bool, Strings, Lists, bytes, byte array, Functions, Loop control statements-break, continue, pass, Anonymous function-filter(), map(), reduce(), more about range().

UNIT 2: Data Structure (7 Hours)
Arrays vs lists, Tuples and dictionaries, Sets, frozenset, Slicing, binary search, Efficiency, Selection Sort, Insertion Sort, Recursion, Mergesort, Quicksort.

UNIT 3: Function and File Handling (8 Hours)
Function definitions, Global scope, nested functions, Lambda Function, List Comprehension, Exception Handling, Standard input and output, Handling files, String functions, pass, del() and None

UNIT 4: Classes and Object (8 Hours)
Generating permutations, Stack, Queue, Circular Queue, Abstract datatypes, classes and objects, Classes and objects in Python, User defined lists, Search trees, Tree, Graph, Hashing

UNIT 5: Algorithm (7 Hours)
Asymptotic Notation – Big-O, Big Omega, Big Theta Notation, Memorization and dynamic programming, Grid paths, longest common subsequence, Matrix multiplication, Algorithms, and programming: simple gcd, improving naive gcd, Euclid’s algorithm for gcd.

Reference Books:
Semester – V: Departmental Elective – II: Specialization – Production Engineering/Industrial Production Engineering

Subject Code: KPI 052 | Quality Assurance & Reliability | L T P : 3 0 0 | Credits: 3

Course Outcomes: The students will be able to

| CO-1 | Acquire basic knowledge of total quality management | K2 |
| CO-2 | Describe and use the modern tools of quality management | K2 |
| CO-3 | Apply statistical quality control concepts in the management of quality control processes in industries | K3 |
| CO-4 | Apply the principles and techniques of Total Quality Management in improving quality practices within an organization | K3 |
| CO-5 | Apply principles and techniques of reliability engineering to predict product and system performance | K3 |
| CO-6 | Apply standard safety procedures in an industrial environment | K3 |

Unit-1:
Quality- Quality: Definition, History, Importance, Cost of Quality, Approaches of Quality Management, Hierarchy of Quality management: Inspection & Test, Quality Control, Quality Assurance, Total Quality Management

Unit-2:

Unit-3:

Unit-4:
Reliability- Definition, Factor of safety and reliability, Reliability analysis procedure; Basic probability theory, Central limit theorem; Functions of random variables, Probability distribution functions, density functions for different types of discrete and continuous variables, mean, mode and median; Failure rate versus time, reliability and hazard functions and different distributions, Estimation of failure rate, Expected residual life, Series, parallel and mixed systems, complex systems, Reliability enhancement.
Unit-5:
Industrial Safety- Introduction, key concepts, terminologies, and safety quantification, safety by design; Hazard identification techniques (e.g., HAZOP, FMEA, etc.); Fault tree and event tree analysis (qualitative & quantitative); Bow-tie and quantitative risk assessment (QRA); Safety function deployment; Safety vs reliability – quantification of basic events (repair to failure, repair-failure-repair, and combined processes); Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets); Human error analysis and safety; Accident investigation and analysis.

Books and References
Subject Code: KME 602  Machine Design  L T P : 3 1 0  Credits: 4

Course Outcomes: The student will be able to

<table>
<thead>
<tr>
<th>Course Outcomes</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1 Recall the basic concepts of Solid Mechanics to understand the subject.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 2 Classify various machine elements based on their functions and applications.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 3 Apply the principles of solid mechanics to machine elements subjected to static and fluctuating loads.</td>
<td>K3</td>
</tr>
<tr>
<td>CO 4 Analyze forces, bending moments, twisting moments and failure causes in various machine elements to be designed.</td>
<td>K4</td>
</tr>
<tr>
<td>CO 5 Design the machine elements to meet the required specification.</td>
<td>K5</td>
</tr>
</tbody>
</table>

Unit I
Introduction
Definition, Design requirements of machine elements, Design procedure, Standards in design, Standards designation of carbon & alloy steels, Selection of preferred sizes, Selection of materials for static and fatigue loads, Design against Static Load

Design against Fluctuating Loads
Cyclic stresses, Fatigue and endurance limit, Stress concentration factor, Stress concentration factor for various machine parts, Design for finite & infinite life, Soderberg, Goodman, Gerber criteria

Unit II
Riveted Joints
Riveting methods, materials, Types of rivet heads, Types of riveted joints, Caulking and Fullering, Failure of riveted joint, Efficiency of riveted joint, Design of boiler joints, Eccentric loaded riveted joint

Welded Joints
Stress relieving of welded joints, Butt Joints, Fillet Joints, Strength of Butt Welds, Strength of parallel fillet welds, Strength of transverse fillet welds

Shafts
Cause of failure in shafts, Materials for shaft, Stresses in shafts, Design of shafts subjected to twisting moment, bending moment and combined twisting and bending moments, Shafts subjected to fatigue loads, Design for rigidity, Keys, Types of keys, Selection of square and flat keys, Strength of sunk key

Unit III
Spur Gears
Tooth forms, System of gear teeth, contact ratio, Standard proportions of gear systems, Interference in involute gears, Backlash, Selection of gear materials, Gear manufacturing methods, Design considerations, Beam strength of gear tooth, Dynamic tooth load, Wear strength of gear tooth, Failure of gear tooth, Design of spur gears, AGMA and Indian standards.

Helical Gears
Terminology, Proportions for helical gears, Force components on a tooth of helical gear, Virtual number of teeth, Beam strength and wear strength of helical gears, Dynamic load on helical gears, Design of helical gears.

Introduction, Classification and Applications of Bevel & Worm Gears

Unit IV
8 Hours

Sliding Contact Bearing

Rolling Contact Bearing
Advantages and disadvantages, Types of ball bearing, Thrust ball bearing, Types of roller bearing, Selection of radial ball bearing, Bearing life, Selection of roller bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing.

Unit V
8 Hours

IC Engine Parts
Selection of type of IC engine, General design considerations, Design of Cylinder and cylinder head; Design of piston, piston ring and gudgeon pin;

Friction Clutches
Clutches, Difference between coupling and clutch, Single plate friction clutch, Torque transmitting capacity, Multi-Disk Clutches, Friction Material

Note: Design data book is allowed in the examination

Text Books:
2. Design of Machine Elements, Sharma and Purohit, PHI.

Reference Books:
5. Machine design, Robert L. Norton, Pearson Education
Subject Code: KME 603  |  Theory of Machines  |  L T P : 3 1 0  |  Credits: 4

Course Outcomes: The students will be able to

| CO1 | Understand the principles of kinematics and dynamics of machines. | K2 |
| CO2 | Calculate the velocity and acceleration for 4-bar and slider crank mechanism | K3 |
| CO3 | Develop cam profile for followers executing various types of motions | K3 |
| CO4 | Apply the concept of gear, gear train and flywheel for power transmission | K3 |
| CO5 | Apply dynamic force analysis for slider crank mechanism and balance rotating & reciprocating masses in machines. | K3 |
| CO6 | Apply the concepts of gyroscope, governors in fluctuation of load and brake & dynamometer in power transmission | K3 |

Unit I
Introduction, mechanisms and machines, kinematics and kinetics, types of links, kinematic pairs and their classification, types of constraint, degrees of freedom of planar mechanism, Grubler’s equation, mechanisms, inversion of four bar chain, slider crank chain and double slider crank chain.

**Velocity analysis:** Introduction, velocity of point in mechanism, relative velocity method, velocities in four bar mechanism, instantaneous center.

**Acceleration analysis:** Introduction, acceleration of a point on a link, acceleration diagram, Corioli’s component of acceleration, crank and slotted lever mechanism.

Unit II
**Cams:** Introduction, classification of cams and followers, cam profiles for knife edge, roller and flat faced followers for uniform velocity, uniform acceleration.

**Gears and gear trains:** Introduction, classification of gears, law of gearing, tooth forms and their comparisons, systems of gear teeth, length of path of contact, contact ratio, minimum number of teeth on gear and pinion to avoid interference, simple, compound, reverted and planetary gear trains, sun and planet gear train.

Unit III
**Force analysis:** Static force analysis of mechanisms, D’Alembert’s Principle, dynamics of rigid link in plane motion, dynamic force analysis of planar mechanisms, piston force and crank effort. Turning moment on crankshaft due to force on piston, Turning moment diagrams for single cylinder double acting steam engine, four stroke IC engine and multi-cylinder engines, Fluctuation of speed, Flywheel.

Unit IV
**Balancing:** Introduction, static balance, dynamic balance, balancing of rotating masses, two plane balancing, graphical and analytical methods, balancing of reciprocating masses, balancing of single cylinder engine.

**Governors:** Introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors. Effort and Power of governor.
Unit V (09 Hours)

**Brakes and dynamometers:** Introduction, Law of friction and types of lubrication, types of brakes, effect of braking on rear and front wheels of a four wheeler, dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer

**Gyroscope:** Space motion of rigid bodies, angular momentum, gyroscopic couples, gyroscopic stabilization, ship stabilization, stability of four wheel and two wheel vehicles moving on curved paths.

**Text / Reference Books**

**Suggested Software**
MechAnalyzer
Course Outcomes: The students will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Explain the design criterion for single and multipoint cutting tools for different machines.</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Design jigs and fixtures with required tolerances and economy.</td>
<td>K3</td>
</tr>
<tr>
<td>CO3</td>
<td>Design the dies for casting and injection moulding processes.</td>
<td>K3</td>
</tr>
<tr>
<td>CO4</td>
<td>Design the dies for casting and injection moulding processes.</td>
<td>K3</td>
</tr>
<tr>
<td>CO5</td>
<td>Select a suitable control system, drives and kinematic mechanism for a machine tool.</td>
<td>K3</td>
</tr>
</tbody>
</table>

Unit-1 Cutting Tools

**Single point Cutting Tools:** Tooling, requirements of a tool designer, general tool design procedure, design of single point lathe tool: design of shank dimension using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry; solid type tool, brazed tip tool, long index able insert, throwaway index able insert types and chip breakers.

**Multi Point Cutting Tool:** Drill bit design of elements like back taper, web thickness, land width, margin, flute length and cross section and selection of tool geometry; design of milling cutter: design of elements like number of teeth and height circular pitch, body thickness, chamfer width, fillet radius and selection of tool geometry.

Unit-2 Jigs and Fixtures

**Jigs & Fixtures:** Tolerance analysis and procedure of designing; the economic calculations, location of the work piece, degree of freedom, references surfaces, resting components, fixture elements for surface concentric and radial locations, clamping of the work-piece, review of cutting forces, principles and methods of clamping; quick clamping devices, standards; guiding elements for tools, gauge for cutter, jig bushes, indexing methods, design of jigs/fixtures/accessories for drilling, milling, turning, broaching, grinding, and welding.

Unit-3 Sheet Metal, Bending and Drawing

**Design of dies:** Simple piercing and blanking process, design of inverted die, compound die, progressive dies, rules for developing stock, strip layouts for progressive dies, types of progressive dies, load centre, analytical and graphical method to determine load centre (i.e. centre of pressure), miscellaneous dies, shaving, horn, cam actuated and precision lamination dies, fine blanking dies, principles - design considerations.

**Bending dies:** Theory of bending, blank development, spring back effect, spring back factor, methods of correction to overcome spring back, types of bending dies, pressure pad dies, forces in bending, construction and working principles, press brake tooling, curling, flanging principles of stretch forming – stretch forming dies.

Unit-4 Die Casting Dies and Injection Moulding

**Design of dies for metal casting:** Casting dies, terminology applicable to process, terminology applicable to dies, alignment of metal flow in hot chamber, horizontal cold chamber and vertical cold chamber
machines, modification for casting of deep core or with limitations of stroke, design for various elements, effect of off-centre cavity layout, necessity of balancing, types of dies, parameters influencing the runner and gate design, ejection mechanism, ejection elements and various locations, die locking mechanism, trimming, types of trim dies and alloys suitable for die making.

**Injection Moulding:** Injection moulding machine and its elements, general configuration of a mould, 2-plate and 3-plate mould, gate, runner, parting surface, ejection system, core and cooling system, introduction to compression die, transfer die, blow moulding dies, extrusion dies, forming and calendaring dies.

**Unit 5: Control, drives and structure**
Machine tool control systems, control systems for speed and feed changing, adaptive control systems, CNC machines.

Kinematics of machine tools, motion transmission, design of hydrostatic, hydrodynamic and antifriction guideways, design of spindles, design of speed gear boxes and feed box, feed drives, stepped and stepless regulations of speed, feed diagram, ray diagrams and design considerations.

Vibration in machine tools, lubrication, rigidity, and reliability in machine tools

**Text Book**

**Reference Books:**
6. Theory and Application of Metal Cutting, by Juneja, Wiley Eastern Ltd
Subject Code: KME 652  
Machine Design Lab  
L T P : 0 0 2  
Credits: 1

Course Outcomes: The student will be able to

| CO-1  | Apply the principles of solid mechanics to design various machine Elements subjected to static and fluctuating loads. | K3 |
| CO-2  | Write computer programs and validate it for the design of different machine elements | K4 |
| CO-3  | Evaluate designed machine elements to check their safety. | K5 |

A  Design of Machine Elements
1. Design a knuckle joint subjected to given tensile load.
2. Design a riveted joint subjected to given eccentric load.
3. Design of shaft subjected to combined constant twisting and bending loads
4. Design a transverse fillet welded joint subjected to given tensile load.
5. Design & select suitable Rolling Contact Bearing for a shaft with given specifications
6. Design a cylinder head of an IC Engine with prescribed parameters.
7. Design of Piston & its parts of an IC Engine

B. Computer Programs for conventional design

**Computer and Language:** Students are required to learn the basics of computer language such as C/C++/MATLAB so that they should be able to write the computer program.

1. Design a pair of Spur Gear with given specifications to determine its various dimensions using Computer Program in C/C++.
2. Design a pair of Helical Gear with given specifications to determine its various dimensions using Computer Program in C/C++.
3. Design of Sliding Contact Bearing with given specifications & determine its various parameters using Computer Program in C/C++.
Subject Code: KME 653  Theory of Machines Lab  L T P : 0 0 2  Credits: 1

The students will be able to:  

<table>
<thead>
<tr>
<th>CO1</th>
<th>Demonstrate various mechanisms, their inversions and brake and clutches in automobiles</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Apply cam-follower mechanism to get desired motion of follower.</td>
<td>K2</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply the concepts of gears and gear train to get desired velocity ratio for power transmission.</td>
<td>K3</td>
</tr>
<tr>
<td>CO4</td>
<td>Apply the concept of governors to control the fuel supply in engine.</td>
<td>K3</td>
</tr>
<tr>
<td>CO5</td>
<td>Determine the balancing load in static and dynamic balancing problem</td>
<td>K3</td>
</tr>
</tbody>
</table>

List of Experiments  
(Minimum eight experiments out of the following)  

**NOTE:** Student has to write computer program in C / C++ / Python and to run to compute the output values for at least ONE experiments.  
1. To study various types of kinematics links, pairs, chains & Mechanisms  
2. To study Whitworth Quick Return Motion Mechanisms, Reciprocating Engine Mechanism, and Oscillating Engine Mechanism  
3. To study of inversions of four bar linkage  
4. To study of inversions of single/double slider crank mechanisms  
5. To study various types of gear (Helical, cross helical, worm, bevel gear) and gear profile (involute and cycloidal) and condition for interference Helical, cross helical, worm, bevel gear  
6. To compute the output velocity in various gear trains  
7. To study gyroscopic effects through models  
8. To determine gyroscopic couple on Motorized Gyroscope  
9. To perform experiment on dead weight type governor to prepare performance characteristic Curves, and to find stability & sensitivity  
10. To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity  
11. To determine whirling speed of shaft theoretically and experimentally  
12. To perform the experiment for static / dynamic balancing  
13. To perform experiment on brake  
14. To perform experiment on clutch  
15. To perform the experiment for static / dynamic balancing.  
16. To perform experiment on longitudinal vibration  
17. To perform experiment on transverse vibration
Subject Code: KME 654  
Tool Design Lab  
L T P : 0 0 2  
Credits: 1

<table>
<thead>
<tr>
<th>Course Outcomes: The students will be able to</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 Analyze the cutting forces in orthogonal machining.</td>
<td>K4</td>
</tr>
<tr>
<td>CO2 Develop a single point cutting tool using tool grinder</td>
<td>K6</td>
</tr>
<tr>
<td>CO3 Develop jig and fixtures for various applications</td>
<td>K6</td>
</tr>
<tr>
<td>CO4 Develop mould for injection moulding/ metal forming</td>
<td>K6</td>
</tr>
<tr>
<td>CO5 Develop die for balking/drawing/bending</td>
<td>K6</td>
</tr>
</tbody>
</table>

List of Experiments: (Minimum eight experiments out of the following)

1. Design and prototype development of angle plate jig.
2. Design and prototype development of milling fixture.
3. Design and prototype development of turning fixture.
4. Design and prototype development of two plate mould.
5. Design of different types of gates used in injection moulding.
6. Design of Two plate moulds for metal forming work.
7. Design of Blanking Die with fixed stripper for a given blank.
8. Design of drawing die for a cylindrical/ rectangular component.
10. Design of 'U' Bending Die for U shape bend.
12. Measurement and analysis of cutting forces in orthogonal turning for different materials at different process parameters.
Unit-I:
Introduction to NDT, DT, advantages & limitations of NDT, classification of NDT methods, Comparison with DT, Terminology, Flaws and Defects. Scope of NDT. Codes, Standards and Certifications in NDT.

Visual Inspection – Equipment used for visual inspection, Borescopes, Application of visual inspection tests in detecting surface defects and their interpretation, advantages & limitations of visual inspection, Visual Inspection in Welding.

Unit-II:
Liquid Penetrant Testing – Principle, Scope, Testing equipment, Advantages, Limitations, types of penetrants and developers, standard testing procedure, Zyglo test, Illustrative examples and interpretation of defects.

Magnetic Particle Inspection – Principle, Scope, Testing equipment, Advantages, Limitations, Application of MPI & standard testing procedure, DC & AC magnetization, Skin Effect, different methods to generate magnetic fields, Illustrative examples and interpretation of defects.

Unit-III:
Radiographic Testing – Introduction to electromagnetic waves and radioactivity, various decays, Attenuation of electromagnetic radiations, Photoelectric effect, coherent scattering and Incoherent scattering, Beam geometry.

X-ray Radiography – Principle, equipment & methodology, applications, source, types of radiations and limitations; γ-ray Radiography – Principle, equipment, γ-ray source & technique; Radiography Image Quality Indicators, Film Processing, advantages of γ-ray radiography over X-ray radiography. Precautions against radiation hazards.

Unit-IV:
Unit-V:
Special NDT Techniques:
Eddy Current Inspection—Introduction, Principle, Methods, scope, Equipment, types of probes, Sensitivity, standard testing procedure, advanced ECT methods, advantages and limitations.

Acoustic Emission Technique—Introduction, Types of AE signal, Principle, Advantages & Limitations, Interpretation of Results, Applications.

Holography, Thermography—Introduction, Principle, advantages, limitations and applications.

Books and References:
7. Practical non destructive testing by Raj, Baldev.
9. ASME Sec. V, boiler and pressure vessel code
Subject Code: KME 062  |  Artificial Intelligence  |  LTP: 3 0 0  |  Credits: 3

Course Outcomes: Students are able to | Bloom's Taxonomy
--- | ---
CO 1  Understand concepts of Artificial Intelligence | K2
CO 2  Solve problem by Search-I & Search-II | K3
CO 3  Understand Knowledge representation | K2
CO 4  Apply concepts of Learning methods | K3
CO 5  Analyse Decision Networks | K4
CO 6  Build planning graphs | K5

Unit 1: (9Hours)

(Recommended lab practice sessions: Games as Search Problems, Alpha-Beta Pruning, State-of-the-Art Game Programs.)

Unit 2: (8Hours)

Unit 3: (9Hours)

Unit 4: (7Hours)
Neural Networks: Learning in Neural Networks, How the Brain Works, Perceptron, Multilayer Feed-Forward Networks, Applications of Neural Networks, Introduction to Learning, Kinds of Learning, Supervised and Unsupervised Learning, Clustering, Reinforcement Learning.


Unit 5: (7Hours)

**Text Book:**

**Reference Books:**
3. E Charniak and D McDermott, “Introduction to Artificial Intelligence”, Pearson Education
4. Dan W. Patterson, “Artificial Intelligence and Expert Systems”, Prentice Hall of India,
Semester – VI: Departmental Elective – III: Specialization – Production Engineering/Industrial Production Engineering

Subject Code: KPI 061  Decision Support & Intelligent System  L T P : 3 0 0  Credits: 3

Course Outcomes: The students will be able to

<table>
<thead>
<tr>
<th>CO-1</th>
<th>Explain the fundamentals of decision support systems, computerized decision aids, expert systems and executive information systems.</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-2</td>
<td>Understand the concept of hybrid support system for decision making</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Understand different components of DSS like Data warehousing, Data mining, modeling and analysis.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4</td>
<td>Understand the basics of Artificial intelligence and expert systems.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5</td>
<td>Examine the uses of various mathematical models, heuristics and simulation as a subsystem of DSS.</td>
<td>K3</td>
</tr>
</tbody>
</table>

UNIT-I:


UNIT-II: Decision Support Systems: Different types of Managerial Decision Problems and the Role of a DSS in solving them, DSS Configurations; Characteristics and Capabilities of DSS; Components of DSS; the Data Management Subsystem.

Modelling and Analysis: Modelling; Classification of Models, Purpose of Modelling, Solution Techniques: Optimization, Heuristics, and Simulation, Desirable features for Models in DSS, Models and Managers Static and Dynamic Models; Certainty, Uncertainty, and Risk; Influence Diagrams; MSS Modelling with Spreadsheets; Decision Analysis of a Few Alternatives.

Decision Support System Development: Introduction to DSS Development; The Traditional System Development Life cycle; Alternative Development Methodologies.

UNIT-III: Knowledge Management
Introduction to Knowledge Management; Organizational Learning and Transformation; Knowledge Management Initiatives; Approaches to Knowledge Management; Information Technology in Knowledge Management.
Knowledge Management Systems Implementation; Roles of People in Knowledge Management; Ensuring Success of Knowledge Management.

UNIT-IV:
**Artificial Intelligence and Expert Systems**: Representation in logic and schemas, semantic networks, production rules and frames, inference techniques – DSS applications.

**Social networking**: package choices- knowledge security, Integrating with web -based and internal operational & support systems, change management, reward systems continuous improvement, Intellectual Property Rights.

UNIT-V:
**Advanced Intelligent Systems**: Machine-Learning Techniques; Case-Based Reasoning; Basic Concept of Neural Computing; Learning in Artificial Neural Networks; Genetic Algorithms Fundamentals; Developing Genetic Algorithm Applications; Fuzzy Logic Fundamentals.

**Intelligent Systems over the Internet**: Web-Based Intelligent Systems; Intelligent Agents: An Overview; Characteristics of Agents; need of Intelligent Agents; Classification and Types of Agents; Internet-Based Software Agents; DSS Agents and Multi-Agents.

**Books and References:**
3. Business Intelligence and Analytics: Systems for Decision Support” by Ramesh Sharda and DursunDelen.
4. Decision Support and Business Intelligence Systems” by Efraim Turban and Ramesh E Sharda.
6. Decision Support, Analytics, and Business Intelligence (Information Systems Collection)” by Daniel J Power.
### B. Tech Production Engineering/ Industrial Production Engineering
Evaluation Scheme
Effective in Session 2021-22 (Yet to Finalized)

#### SEMESTER- VII

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Code</th>
<th>Subject</th>
<th>Periods</th>
<th>Evaluation Scheme</th>
<th>End Semester Total</th>
<th>Credit</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>L  T  P</td>
<td>CT    TA    Total</td>
<td>PS  TE  PE</td>
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<td>Departmental Elective-IV</td>
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<td>Departmental Elective-V</td>
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<td>30 20 50</td>
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<td>6</td>
<td>Mini Project or Internship Assessment*</td>
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<td>8</td>
<td>MOOCs (Essential for Hons. Degree)</td>
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<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The Mini Project or internship (5 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

#### SEMESTER- VIII

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Code</th>
<th>Subject</th>
<th>Periods</th>
<th>Evaluation Scheme</th>
<th>End Semester Total</th>
<th>Credit</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>L  T  P</td>
<td>CT    TA    Total</td>
<td>PS  TE  PE</td>
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<td>HSMC-2/HSMC-1</td>
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<td>2</td>
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<td>3 0 0</td>
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<td>MOOCs (Essential for Hons. Degree)</td>
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</table>
Semester – VII: Departmental Elective – IV: Specializations –

Manufacturing and Automation
Automation and Industry 4.0

Subject Code: KME 071 | Additive manufacturing | L T P : 3 0 0 | Credits: 3

<table>
<thead>
<tr>
<th>Course Outcome: Student will be able to</th>
<th>Bloom Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1 Understanding the basics of additive manufacturing/rapid prototyping and its advantages and disadvantages</td>
<td>K2</td>
</tr>
<tr>
<td>CO 2 Understanding the role of additive manufacturing in the design process and the implications for design.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 3 Understanding the processes used in additive manufacturing for a range of materials and applications</td>
<td>K2</td>
</tr>
<tr>
<td>CO 4 Understand the various software tools, processes and techniques that enable advanced/additive manufacturing and personal fabrication.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 5 Apply knowledge of additive manufacturing for various real-life applications</td>
<td>K3</td>
</tr>
</tbody>
</table>

UNIT I
Introduction
History and Advantages of Additive Manufacturing, Distinction Between Additive Manufacturing and CNC Machining, Types of Additive Manufacturing Technologies, Nomenclature of AM Machines, Direct and Indirect Processes; Prototyping, Manufacturing and Tooling.


UNIT II
Development of Additive Manufacturing Technology
Computer Aided Design Technology, Other Associated Technology, Metal and Hybrid Systems.

Generalized Additive Manufacturing Process Chain; The Eight Steps in Additive Manufacturing, Variation from one AM Machine to Another, Metal System, Maintenance of Equipment, Material Handling Issue, Design of AM.

UNIT III
Additive Manufacturing Processes
Vat Photo polymerization; Materials, Reaction Rates, Photo polymerization Process Modelling, Scan Patterns

Powder Bed Fusion Processes; Material, Powder Fusion Mechanism, Process Parameters and Modeling, powder Handling

Extrusion Based System; Basic principles, plotting and Path Control, Other Systems

Material Jetting; Materials, Material Processing Fundamentals, Material Jetting Machines
Directed Energy Deposition Processes; General DED Process Description, Material Delivery, DED systems, Process Parameters, Processing-Structure-Properties Relationships

UNIT IV: Design & Software Issues
Additive Manufacturing Design and Strategies; Potentials and Resulting Perspectives, AM based New Strategies, Material Design and Quality Aspects for Additive Manufacturing; Material for AM, Engineering Design Rules for AM.

Software Issue for Additive Manufacturing; Introduction, Preparation of CAD Models: The STL file, Problem with STL file, STL files Manipulation, Beyond the STL file, Additional Software to Assist AM

UNIT V
Material Design & Quality Aspects

Applications
Aerospace, Automotive, Manufacturing, Architectural Engineering, Art, Jewellery, Toys, Medical, Biomedical, Dental, Bio-printing, Tissue & Organ Engineering and many others.

Books and References:
Semester – VI: Departmental Elective – IV: Specialization – Production Engineering/ Industrial Production Engineering

Subject Code: KPI 071 Flexible Manufacturing System L T P : 3 0 0 Credits: 3

Course Outcomes: The students will be able to

| CO-1 | Understand the manufacturing systems, flexibility, components of FMS | K2 |
| CO-2 | Understand production, planning, scheduling and simulation of FMS | K2 |
| CO-3 | Understand concepts of group technology and economics issues in the application of FMS | K2 |
| CO-4 | Understand the application of FMS in various operations & involvement of AI in flexible manufacturing system. | K2 |
| CO-5 | Apply the concepts of scheduling and simulation in FMS | K3 |

UNIT-I: Understanding of FMS
Introduction To FMS, Evolution of Manufacturing Systems, objective and Need, Benefits, Components, Types of Flexibility, Merits, Demerits and Applications of Flexibility.

Composition of FMS, CNC machines, robots, automatic storage and retrieval, automatic material handling, computerized control, Hierarchy of Computer Control ,Computer Control of Work Centre and Assembly Lines, FMS Supervisory Computer Control.

UNIT-II: Planning, scheduling and control of flexible manufacturing systems:
Process planning, machine loading, cycle time, machine output vs cycle time, methods to reduce cycle time, machine balancing.

Scheduling, data requirement for scheduling, mater production scheduling, Gantt charts, scheduling rules, scheduling in FMS, Single Product, Single Batch, N–Batch Scheduling Problem, Knowledge Based Scheduling System.

Dispatching, Dispatch activities.

UNIT-III: FMS simulation and data base

Design of FMS: Performance Evaluation of FMS, Analytical model and Simulation model of FMS.

UNIT-IV: Group technology and justification of FMS
Introduction, Matrix Formulation, Mathematical Programming Formulation, Graph Formulation, Knowledge Based System for Group Technology, Economic Justification Of FMS, Implementation issues and maintenance of FMS, Application of Possibility Distributions in FMS Systems Justification.
UNIT-V: Applications of FMS and factory of the future

Books and References:
Semester – VII: Departmental Elective – V: Specialization – Production Engineering/Industrial Production Engineering

Subject Code: KPI 072 | Facility Planning and Design | L T P : 3 0 0 | Credits: 3

Course Outcomes: The students will be able to

<table>
<thead>
<tr>
<th>CO-1</th>
<th>Understand the group technology, Plant Layout, material handling systems, &amp; their constituents</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-2</td>
<td>Understand the various plant layout design algorithms and quantitative models.</td>
<td>K 2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Apply various graphical and computerised layout techniques &amp; algorithms for plant layout development</td>
<td>K 3</td>
</tr>
<tr>
<td>CO-4</td>
<td>Analyse various types of plant layouts, and factors affecting facility location and its layout</td>
<td>K 4</td>
</tr>
<tr>
<td>CO-5</td>
<td>Able to suggest a material handling system for a plant under given constraints</td>
<td>K 4</td>
</tr>
<tr>
<td>CO-6</td>
<td>Development of part families, machine cell formation for implementation of Group Technology and their balancing</td>
<td>K 4</td>
</tr>
<tr>
<td>CO-7</td>
<td>Evaluate different plant layout alternatives within given constraints</td>
<td>K 5</td>
</tr>
</tbody>
</table>

UNIT -I
Factory Planning: Introduction, factors to be considered
Plant Location and Site Selection: Levels of plant location, rural, urban and suburban location of plants, factors influencing the plant location, optimum plant location, location theories.

UNIT -II
Plant Layout: Introduction of production system, scope, objectives, importance, and types of plant layout, characteristics of a good plant layout, factoring affecting plant layout, procedure of developing a plant layout, different graphical and computerised plant layout design techniques, installation and evaluation of plant layout, optimum plant layout.

UNIT -III
Group Technology: Definition, objectives, planning, part families and machine cell formation, evaluation of machine cells, types of GT layout, benefits of GT, implementation of GT.

UNIT -IV
Line Balancing: Definitions, heuristic and analytical methods of balancing the assembly and production line, single and mixed model line balancing, alternatives to line balancing.

UNIT -V
Materials Handling: Definition, scope, objectives, principles, importance, factors in materials handling problem, analysis of materials handling, types and selection of materials handling equipment’s, aids and techniques in materials handling equipment selection. Planning of material flow, advantages of planned material flow, flow planning principles, flow patterns, analysis of material flow.

Recommended Books:
Semester – VII: Departmental Elective – V: Specialization – Manufacturing and Automation

Subject Code: KME 073  |  Mathematical Modeling of Manufacturing Processes  |  L T P : 3 0 0  |  Credits: 3

Course Outcome: Student will be able to  

<table>
<thead>
<tr>
<th>CO</th>
<th>Understand the fundamentals of manufacturing processes, mathematical models and their solutions.</th>
<th>Bloom Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>K2</td>
<td></td>
</tr>
<tr>
<td>CO 2</td>
<td>Understand unconventional and conventional machining, their discrete-time linear and non-linear models with solutions.</td>
<td>K2</td>
</tr>
<tr>
<td>CO 3</td>
<td>Apply the principles of casting, powder metallurgy, coating and additive manufacturing.</td>
<td>K3</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyze the mechanism of heat and mass transfer in welding.</td>
<td>K4</td>
</tr>
<tr>
<td>CO 5</td>
<td>Evaluate microstructure properties and residual stress of different manufacturing processes.</td>
<td>K5</td>
</tr>
</tbody>
</table>

Unit-1: Introduction to Manufacturing processes; Materials Processing; Types and Properties of Engineered Materials; Evaluation of Properties of Manufactured Products; Statistical and data-driven modelling approach; Overview of mathematical modeling, types of mathematical models and methods to solve the same. Physics of manufacturing processes; Solid-state deformation (Elasticity and Plasticity) and residual stresses; solid-state phase transformation and recrystallization; melting and solidification; Coupled Systems.

Unit-2: Conventional machining; Orthogonal cutting; Tool geometry; chip formation; force components; heat generation; tool life; mathematical modelling approach; solution of problems; Introduction to discrete-time linear and non-linear models. Non-conventional machining; Principal and mechanism of different processes; Parametric analysis of heat transfer, material removal, and surface finish.

Unit-3: Metal forming; Mechanics of bulk metal forming; mechanics of sheet metal forming; heat transfer and deformation;

Welding; Fusion welding; Welding-heat source modeling, temperature distribution, effect of surface-active elements, modes of metal transfer in welding; Solid-state welding; Solidification and microstructure; Residual stress and distortion.

Unit-4: Casting and powder metallurgy; Cooling and Solidification; principle of powder metallurgy; Coating and additive manufacturing; Principle of surface and coating technology; Principle and development of additive manufacturing technologies.

Unit-5: Heat treatment; Fundamentals of heat treatment; Evaluation of microstructure properties and residual stress of different manufacturing processes.

Micro/nanoscale manufacturing; Down-scaling of conventional manufacturing processes, Change of properties, Micro-to-nano manufacturing; Packaging, finishing, micro joining and nano joining, micro casting, micro forming, micromachining.
Processing of non-metallic materials; Principle of plastic processing and shaping of plastics, processing of non-metallic bio-materials; Principle of glass and ceramics processing and shaping of glass and ceramics.

Books and References


Related Course’s / Useful Links

1. https://swayam.gov.in/nd1_noc20_hs79/preview
2. https://swayam.gov.in/nd1_noc19_me47/preview
3. https://nptel.ac.in/content/syllabus_pdf/112103273.pdf
4. https://swayam.gov.in/nd1_noc20_ma47/preview
Semester – VII: Departmental Elective – V: Specialization – Automation and Industry 4.0

Course Outcomes: Students are able to

<table>
<thead>
<tr>
<th>CO</th>
<th>Bloom's Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1</td>
<td>Understand machine learning concepts</td>
</tr>
<tr>
<td>CO 2</td>
<td>Apply machine learning algorithms</td>
</tr>
<tr>
<td>CO 3</td>
<td>Solve prediction based problems</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyze machine learning algorithms</td>
</tr>
<tr>
<td>CO 5</td>
<td>Solve real-world machine learning problems</td>
</tr>
</tbody>
</table>

Unit 1: Introduction to Machine Learning

An Introduction to Machine Learning, Types of Machine Learning, and Applications of ML in Mechanical Engineering, Designing a Learning System, Issues in Machine Learning, AI vs. ML, and Essential Math for ML.

Unit 2: Supervised Learning


Unit 3: Unsupervised Learning


Unit 4: Nonparametric estimations & Neural Networks


Unit 5: Predictive Algorithms

Bayesian Estimation, Gaussian Processes, Hidden Markov Models, Model Selection in HMM, Reinforcement Learning: Model-Based Learning, Temporal Difference Learning, Generalization, Real World ML, Choosing an Algorithm, Design and Analysis of ML Experiments.

Text Book:

Reference Book:
2. “Machine Learning for Absolute Beginner’s” A complete guide to master machine learning concepts and create real world ML solutions
**PRODUCTION ENGINEERING/ INDUSTRIAL PRODUCTION ENGINEERING**

**Semester – VII: Departmental Elective – V: Specialization – Production Engineering/ Industrial Production Engineering**

Subject Code: KPI 072  Project Management  L T P : 3 0 0  Credits: 3

<table>
<thead>
<tr>
<th>The students will be able to</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-1 Understand the concepts, applications and advantages of Project Management.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Explain Project organization structure, and leadership quality require for a good project team.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Understand various modern approach to project performance analysis, time value of money, cash flows, payback period, IRR, etc.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Analyze a project using network diagram and project scheduling software.</td>
<td>K4</td>
</tr>
<tr>
<td>CO-5 Create a CPM/PERT network for project scheduling</td>
<td>K6</td>
</tr>
</tbody>
</table>

**UNIT-I:**

**Concepts of project management (PM):** Meaning, definition and characteristics of a project, technical and socio-cultural dimensions; Establishing project and goals, project life cycle phases, project planning and graphic presentation; work breakdown structure, Establishing the project and goals.

**Nature & context of project management:** phases of PM, A framework for PM issues, PM as a conversion process, project environment & complexity.

**UNIT-II:**

**Project organization, culture and leadership:** projects within functional organization; dedicated project/task-force teams; staff, matrix and network organization; choosing appropriate project organization; Organization culture; ten characteristics; cultural dimensions supportive to projects; different traits of a manager and leader; managing project teams; five stage team development model; shared vision; conflicts; rewards; rejuvenating project teams; project stakeholders; concept of project partnering.

**UNIT-III:**

**Project Appraisal & Cost Estimation:** Introduction, technical appraisal, commercial appraisal, economic appraisal, financial appraisal, management appraisal, project risk analysis, components of capital cost of a project, modern approach to project performance analysis, time value of money; cash flows; payback period; Internal rate of return (IRR); cost of capital; NPV; social cost benefit analysis.

**UNIT-IV:**

**Project Planning & Scheduling:** Introduction to PERT &CPM, planning and scheduling networks, time estimation. determination of critical path and its length, expected length of critical path, calculating the project length and variance, event slack and floats, Expected time for activities, PERT &CPM cost accounting systems, lowest cost schedule, crashing of networks, linear programming formulation of event-oriented networks, Line of balance (LOB) technique, Introduction to project scheduling software like overview of MS-project-2000, ProjectLibre, WBS Schedule pro, Smart Draw, etc.
UNIT-V:
**Modification & Extensions of Network Models:** Complexity of project scheduling with limited resources, resource levelling of project schedules, resource allocation in project scheduling - heuristic solution. Precedence networking-examples with algorithm, decision networks, probabilistic models in networks.

**Project Management Software:** Introduction, Advantages of Using Project Management Software, Common Features Available in Most of the Project Management Software, essential requirements of PM software, working on any project management software like Teamwork, Basecamp, Zoho, Proofhub, Celoxis etc

**Books and References:**

1. Project Management by Harvey Maylor, Pearson India.
5. Project Management: A Life Cycle Approach by Kanda, PHI, India.