# DEPARTMENT OF MECHANICAL ENGINEERING

## M TECH. (CAD/CAM)

### SCHEME OF INSTRUCTION AND EXAMINATION

(with effect from 2015-16 academic year)

## I – SEMESTER

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Course title</th>
<th>Scheme of Instruction</th>
<th>Scheme of Examination</th>
<th>Total</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CADM 1.1</td>
<td>Computer Graphics</td>
<td>4 -- 4 4 3 70 30 100 4</td>
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<td>CADM 1.2</td>
<td>Integrated Computer Aided Design</td>
<td>4 -- 4 3 70 30 100 4</td>
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<td>CADM 1.3</td>
<td>CNC &amp; APT Programming</td>
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<td>CADM 1.5</td>
<td>Elective Subject 1</td>
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<tr>
<td></td>
<td>A) Advanced Optimization Techniques</td>
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<td>B) Advanced Numerical Methods</td>
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<td>C) Advanced Tool Design</td>
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<td>CADM 1.6</td>
<td>A) Design of Hydraulic and Pneumatic Systems</td>
<td>4 -- 4 3 70 30 100 4</td>
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<td>B) Advanced Design</td>
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<td>C) Competitive Manufacturing Systems</td>
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Note: The viva-voce for the labs / seminars shall be held with the course instructor/ faculty member and an external examiner nominated by the university from any academic institution / industry / R & D organization.
# II – SEMESTER

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<tr>
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### III – SEMESTER

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<td>Dissertation (Preliminary)</td>
<td>Viva-voce</td>
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**Note:** The Dissertation shall be evaluated through Viva–Voce examination by a committee with HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 30,30, and 40 percent by the members respectively.

### IV – SEMESTER

<table>
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<td>Dissertation (Final)</td>
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**Note:** The Dissertation shall be evaluated through Defence and Viva–Voce examination by a committee with an External Examiner nominated by University, HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 20, 20, 20, and 40 percent by the members respectively.
CADM 1.1 COMPUTER GRAPHICS

Periods per week : 4
Examination (Theory): 3hrs.
Examination : 70 ; Sessionals : 30
Credits : 4

Geometry and line generation: Line segments, Pixels and frame buffers, Bresenham's algorithms: line, circle, ellipse generation.


Polygons: Polygons representation, An inside test, Filling polygons, Filling with a pattern.
Transformations: Scaling transformations, Reflection and zooming, Rotation, Homogeneous coordinates and translation, Rotation about an arbitrary point.

Segments: The segment table, Segment creation, Closing a segment, Deleting a segment.
Windowing and clipping: The viewing transformation, Clipping, The clipping of polygons, Generalized clipping.

Three dimensions: 3D geometry, 3D primitives, 3D transformations, Parallel projection, Perspective projection, Isometric projections, Viewing parameters, Special projections.

Light, color and shading: Point-source illumination, Shading algorithms, Shadows, Color models.

Curves and fractals: Curve generation, Interpolation, B splines, Curved surface patches, Bezier curves, Fractals, Fractal lines, Fractal surfaces.

References:
CADM 1.2 INTEGRATED COMPUTER AIDED DESIGN

Periods per week: 4
Examination: 70; Sessionals: 30
Examination (Theory): 3hrs.
Credits: 4


Geometric modeling: Geometric modeling techniques - Multiple view 2D input, Wire frame geometry, Surface models, Geometric entities - Curves and Surfaces, Solid modelers, Feature recognition.

Computer aided drafting: AutoCAD tools, 3D model building using solid primitives and boolean operations, 3D model building using extrusion, Editing tools, Multiple views: Orthogonal, Isometric.

Visual realism: Shading solids, Coloring, Color models, Using interface for shading and coloring.
Graphic aids: Geometric modifiers, Naming scheme, Layers, Grids, Groups, Dragging and rubber banding.

Computer animation: Conventional animation, Computer animation - Entertainment animation, Engineering animation, Animation types, Animation techniques.
Mechanical assembly: Assembly modeling, Part modeling, Mating conditions, Generation of assembling sequences, Precedence diagram, Liaison-sequence analysis.

Mechanical tolerancing: Tolerance concepts, Geometric tolerancing, Types of geometric tolerances, Location tolerances, Drafting practices in dimensioning and tolerancing, Tolerance analysis.


References:
1. CAD/CAM Theory and Practice by Ibrahim Zeid.
CADM 1.3 CNC AND APT PROGRAMMING

Periods per week : 4          Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.            Credits : 4

Introduction: NC, DNC, CNC, Programmed Automations, Machine control unit, Part program, NC tooling.

NC machine tools: Nomenclature of NC machine axes, Types of NC machine tools, Machining centres, Automatic tool changes (ATC), Turning centres.

Machine control unit & tooling: Functions of MCU, NC actuation systems, Part program to command signal, MCU organization, Computerized numerical control, Transducers for NC machine tools, Tooling for NC machining centres and NC turning machines, Tool presetting.


Computer aided part programming: NC languages: APT, NELAPT, EXAPT, GNC, VNC, Preprocessor, Post processor.


References:
Introduction, Transformations and kinematics: Historical development, A sense of mechanisms, Robotic systems, Classification of robots, Position, orientation and location of a rigid body, Mechanics of robot manipulators. Objectives, Homogeneous coordinates, Homogeneous transformations, Coordinate reference frames, Some properties of transformation matrices, Homogeneous transformations and the manipulator: The position of the manipulator in space, Moving the base of the manipulator via transformations, Moving the tool position and orientation.


Jacobian analysis of serial manipulators: Differential kinematics of a rigid body, Differential kinematics of serial manipulators, Screw coordinates and screw systems, Manipulator Jacobian matrix.

Trajectory generation: General considerations in path description and generation, Joint space schemes, Cartesian space schemes, Geometric problems with Cartesian paths, Path generation at run time, Description of paths, Planning paths using the dynamic model, Collision-free path planning.

Robot Programming: Robot languages: AL, AML, RAIL, RPL, VAL, Demonstration of points in space: Continuous path (CP), Via points (VP), Programmed points (PP).

Text Book:
1. Robot Analysis - The Mechanics of Serial and Parallel Manipulators by Lung-Wen Tsai, John Wiley & Sons, Inc.

References:
INTRODUCTION: Statement of an optimization problem, Engineering Applications, Classification of optimization problems


Stochastic programming (S.P): Basics concepts of probability theory, stochastic linear programming

Unconventional optimization techniques: Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, A.N.N, Simulated Annealing

References:
1. Operations Research- Principles and Practice, Ravindran, Phillips and Solberg, John Wiely
5. Genetic Algorithms - In Search, Optimization and Machine Learning by David E. Goldberg, Addison-Wesley Longman (Singapore) Pvt. Ltd.
CADM1.5 Elective – I
B) ADVANCED NUMERICAL METHODS

Periods per week : 4  Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.  Credits : 4


Ordinary differential equations RungeKutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.


Finite difference methods for elliptic equations laplace and poisson’s equations in a rectangular region: Five point finite difference schemes, Leibmann’s iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.


References :
CADM1.5 Elective – I
C) ADVANCED TOOL DESIGN

Periods per week : 4
Examination (Theory): 3hrs.
Examination : 70 ; Sessionals : 30
Credits : 4


PERIODS REFERENCES:
2. E.G.Hoffman,” Jig and Fixture Design”, Thomson Asia Pvt Ltd, Singapore, 2004
CADM1.6 Elective – II
A) DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS

Periods per week : 4
Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.
Credits : 4

Oil hydraulic systems and hydraulic actuators  Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics.

Control and regulation elements  Pressure - direction and flow control valves - relief valves, non-return and safety valves - actuation systems.


Pneumatic systems and circuits  Pneumatic fundamentals - control elements, position and pressure sensing - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods - step counter method - compound circuit design - combination circuit design.

Installation, maintenance and special circuits  Pneumatic equipments- selection of components - design calculations – application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

References :
CADM1.6 Elective – II  
B) ADVANCED DESIGN

Periods per week: 4  
Examination: 70; Sessionals: 30  
Examination (Theory): 3hrs.  
Credits: 4

Design philosophy: Design process, Problem formation, Introduction to product design, Various design models-Sligle model, Asimov model and Norton model, Need analysis, Strength considerations -standardization. Creativity, Creative techniques, Material selections, Notches and stress concentration, design for safety and Reliability

Failure theories: Static failure theories, Distortion energy theory, Maximum shear stress theory, Coulomb-Mohr’s theory, Modified Mohr’s theory, Fracture mechanics theory. Fatigue failure theories, Fatigue mechanisms, Fatigue failure models, Fatigue failure criteria, Methods to reduce fatigue, Design for fatigue, Modified Goodman Diagram, Gerber method, Soderberg line, Surface failure models. Lubrication, friction and wear

Product Design: Product strategies, Product value, Product planning, product specifications, concept generation, concept selection, concept testing.

Design for manufacturing: Forging design, Casting design, Design process for non metallic parts, Plastics, Rubber, Ceramic, Wood, Glass parts.


References:  
Manufacturing in a competitive environment

Group technology & flexible manufacturing systems

Computer software, simulation and database of FMS

Lean Manufacturing

Just in time

Text books:

References:
CADM 1.7 CAD LAB

Periods per week : 3

Examination: 50
Sessionals : 50
Credits : 2

List of Experiments:

2D and 3D modelling and assembly modelling using modelling packages like AutoCAD, AutoDesk Mechanical desktop, Pro-Engineer, IDEAS.

Linear and non-linear static and dynamic analysis using any FEA package ANSYS / CAEFEM / NASTRAN.

CADM 1.8 SEMINAR -I

Periods per week : 3

Examination: 50
Sessionals : 50
Credits : 2
CADM 2.1 COMPUTER INTEGRATED MANUFACTURING

Periods per week: 4  
Examination: 70; Sessionals: 30  
Examination (Theory): 3hrs.  
Credits: 4

Introduction: Scope of computer integrated manufacturing, Product cycle, Production automation.

Group technology: Role of group technology in CAD/CAM integration, Methods for developing part families, Classification and coding, Examples of coding systems, Facility design using group technology, Economics of group technology.


Integrative manufacturing planning and control: Role of integrative manufacturing in CAD/CAM integration, Overview of production control - Forecasting, Master production schedule, Capacity planning, M.R.P., Order release, Shop-floor control, Quality assurance, Planning and control systems, Cellular manufacturing, JIT manufacturing philosophy.

Computer aided quality control: Terminology in quality control, Contact inspection methods, Noncontact inspection methods, Computer aided testing, Integration of CAQC with CAD/CAM.

Computer integrated manufacturing systems: Types of manufacturing systems, Machine tools and related equipment, Material handling systems, Computer control systems, FMS.

References:
CADM 2.2 MECHATRONICS

Periods per week : 4
Examination (Theory): 3hrs.
Examination : 70 ; Sessionals: 30
Credits: 4

Mechatronics system design: Introduction to Mechatronics: What is mechatronics, Integrated design issues in mechatronics, Mechatronics key elements, the mechatronics design process, Advanced approaches in mechatronics.

Modelling and simulation of physical systems: Simulation and block diagrams, Analogies and impedance diagrams, Electrical systems, Mechanical translational systems, Mechanical rotational systems, Electromechanical coupling, Fluid systems.


Signals, systems and controls: Introduction to signals, systems and controls, System representation, Linearization of nonlinear systems, Time delays.

Real time interfacing: Introduction, Elements of a data acquisition and control system, Overview of the I/O process, Installation of the I/O card and software.

Advanced applications in mechatronics: Sensors for condition monitoring, Mechatronic control in automated manufacturing, Artificial intelligence in mechatronics, Microsensors in mechatronics.

Text Books:

References:
CADM 2.3 FLEXIBLE MANUFACTURING SYSTEMS

Periods per week: 4
Examination: 70; Sessionals: 30
Credits: 4

Introduction: The economic justification of FMS, The basic components of FMS and their integration in the data processing system, The concept of the 'total system'.

Management decisions during FMS project planning, design and implementation: Designing the FMS, Data processing design, FMS project and software documentation.

Artificial intelligence in the design of FMS: LISP, PROLOG, Expert systems, Expert systems in FMS design and control, Integrative aspects of AI languages.

Distributed processing in FMS: Introduction to database management systems (DBMS) and their application in CAD/CAM and FMS, Distributed systems in FMS.

Distributed tool databases in FMS: The distributed tool data structure with a general purpose tool description facility, Implementation of the FMS tool data base, Application possibilities of the FMS tool database.

FMS database for clamping devices and fixtures: The FMS clamping device and fixture database, The analysis and calculation of pallet alignment and work mounting errors, Mating surface description methods for automated design and robotised assembly, Application of industrial robots in FMS, The application of automated guided vehicle (AGV) systems.

Coordinate measuring machines in computer integrated systems: Overview of coordinate measuring machine, Contact and non-contact inspection principles, Part programming coordinate measuring machines, In-cycle gauging.

References:
CADM 2.4 VISION SYSTEMS AND IMAGE PROCESSING

Periods per week : 4
Examination (Theory): 3hrs.
Examination : 70 ; Sessionals : 30
Credits : 4


Spatial domain techniques - Convolution, Correlation. Frequency domain operations - Fast Fourier transforms, FFT, DFT, Investigation of spectra. Hough transform

Image enhancement, Filtering, Restoration, Histogram equalisation, Segmentation, Region growing.

Image compression - Edge detection - Thresholding - Spatial smoothing - Boundary and Region representation - Shape features - Scene matching and detection - Image classification.

References:
2. Robot Vision by Prof. Alan Pugh (Editor), IFS Ltd., U.K.
CADM2.5 Elective – III

A) ADVANCED FINITE ELEMENT ANALYSIS

Periods per week: 4
Examination: 70 ; Sessionals: 30
Examination (Theory): 3hrs.
Credits: 4


Element shape functions - Some general families of C continuity, curved, isoparametric elements and numerical integration. Some applications of isoparametric elements in two-and-three dimensional stress analysis.

Bending of thin plates - A C continuity problem. Non-conforming elements, substitute shape functions, reduced integration and similar useful tricks. Lagrangian constraints in energy principles of elasticity, complete field and interface variables (Hybrid method).

Shells as an assembly of elements, axisymmetric shells, semi-analytical finite element processes - Use of orthogonal functions, shells as a special case of 3-D analysis. Steady-state field problems - Heat conduction, electric and magnetic potentials, field flow, etc.

The time domain, semi-descritization of field and dynamic problems and analytical solution procedures. Finite element approximation to initial value - Transient problems.

References:
3. Concepts and Applications of Finite Element Analysis by Cook, R.D.
4. Applied Finite Element Analysis by Segerland, L.J.
CADM 2.5 Elective – III
B) NEURAL NETWORKS AND FUZZY TECHNIQUES

Periods per week : 4         Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.          Credits : 4


Neural dynamics-I: Activations and signals, Neurons as functions, Signal monotonicity, Biological activations and signals, Neuron fields, Neuronal dynamical systems, Common signal functions, Pulse-coded signal functions.


Fuzzy associative memories: Fuzzy systems as between-cube mappings, Fuzzy and neural function estimators, Fuzzy Hebb FAMs, Adaptive FAMs: Product-space clustering in FAM cells. Applications in design and structural analysis.

References:
1. Neural Networks & Fuzzy Systems by Bark Kosko, PHI Published in 1994
4. Fundamentals of Artificial Neural Networks by Mohamad H Hassoum. PHI.
5. Fuzzy Set Theory & its Application by J. Zimmerman Allied Published Ltd.
CADM 2.5 Elective – III
C) CONCURRENT ENGINEERING

Periods per week : 4          Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.      Credits : 4

Introduction: Concurrent design of products and systems - Product design - Fabrication and assembly system design - designing production systems for robustness and structure.

Strategic approach and technical aspects of product design: Steps in the strategic approach to product design - Comparison to other product design methods - Assembly sequence generation - Choosing a good assembly sequence - Tolerances and their relation to assembly - Design for material handling and part mating - Creation and evaluation of testing strategies.

Basic issues in manufacturing system design: System design procedure - Design factors - Intangibles - Assembly resource alternatives - Task assignment - Tools and tool changing - Part feeding alternatives - Material handling alternatives - Floor layout and system architecture alternatives.

Assembly workstation design: Strategic issues - Technical issues analysis.

Design of automated fabrication systems: Objectives of modern fabrication system design - System design methodology - Preliminary system feasibility study - Perform detailed work content analysis - Define alternative fabrication configurations - Configuration design and layout - Human resource considerations - Evaluate technical performance of solution.

Case studies: Automobile air conditioning module - Robot assembly of automobile rear axles.

Reference:
A) SIGNAL ANALYSIS AND CONDITION MONITORING


Practical analysis of transients: Analysis as a periodic signal. Analysis by repeated playback (constant bandwidth). Analysis by repeated playback (variable bandwidth).


References:
2. Frequency Analysis by R.B. Randall.
CADM 2.6 Elective - IV
B) ADDITIVE MANUFACTURING


Other additive manufacturing systems: Three dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.

References:
CADM 2.6 Elective - IV
C) METROLOGY AND NON DESTRUCTIVE TESTING

Periods per week : 4  Examination : 70 ; Sessionals : 30
Examination (Theory): 3hrs.  Credits : 4


Statistical Quality Control Data presentation - Statistical measures and tools - Process capability - Confidence and tolerance limits - Control charts for variables and for fraction defectives - Theory of probability - Sampling - ABC standard - Reliability and life testing.

RADIO GRAPHER Sources of ray-x-ray production - properties of d and x rays - film characteristics - exposure charts - contrasts - operational characteristics of x ray equipment - applications.

Ultrasonic and acoustic emission techniquesProduction of ultrasonic waves - different types of waves - general characteristics of waves - pulse echo method - A, B, C scans - Principles of acoustic emission techniques - Advantages and limitations - Instrumentation - applications.

References:
CADM 2.7 CAM LAB

Periods per week : 3
Examination: 50 Sessionals : 50
Credits : 2

Manual and computer assisted part programming exercises on CNC machine tools.

Surface generation, Tool selection, NC code generation and Tool path simulation for turning and milling operations using CAM packages like CATIA, Gibbs CAM, Master CAM.

Robot programming off-line and on-line.
1. a) Explain the Bresenham’s algorithm for generating a circle and discuss about its advantages.
b) Explain about the graphic primitives for display-file structure.

2. a) Explain an algorithm for filling a polygon with a pattern.
b) Develop a combined transformation matrix to reflect the given object about a line passing through the point \((x_p, y_p)\) and having a slope \(lm\).

3. a) Explain the procedure for creating and closing a segment.
b) Explain about the generalized clipping.

4. a) Derive the combined transformation matrix to rotate the given 3-D object about an axis passing through the points \((x_a, y_a, z_a)\) and \((x_b, y_b, z_b)\).
b) Explain transformation for perspective projection.

5. a) Explain the Painter’s algorithm with a suitable example.
b) Explain about any one shading algorithm.

6. a) Given the algorithm to generate the Bezier curve for the four given points.
b) What is fractal? How thy are useful in generating lines and surfaces?

7. a) Write short note on 3-D homogeneous transformations.
b) Explain the procedure to represent a surface patch in a CAD model.

8. Write short notes on:
a) Pixels and frame buffers.
b) Inside test.
c) Scaling transformation.
d) Curve fitting and curve fairing technique.
1. a) What is CAD and what are its applications and benefits?
b) What are the hardware requirements of a Design workstation? Explain.

2. a) What is geometric modeling? Compare and contrast the various modeling techniques.
b) How are solid modelers categorized? Explain the generic architecture of any solid modeler. Name some popular solid modelers.
c) Create the CSG model of the solid shown in the figure 1.

3. a) What is shading? How is the shading of CSG model achieved? Explain any one shading algorithm for solids.
b) What do you understand by the term geometric modifier? Explain. Give some examples where layering concepts are useful.

4. a) What is animation? Compare and contrast the conventional animation and computer animation. Write a brief note on animation techniques.
b) Explain the procedure involved in animating a four bar linkage.

5. a) Generate the assembly tree and the precedence diagram for the assembly shown in the figure 2. Count the number of all possible assembly sequences to create the assembly.
b) What are the various techniques to generate all assembly sequences for a mechanical component? Explain Liaison sequence analysis.

6. a) What is geometric tolerancing? What are the types of geometric tolerances? How is it different from conventional tolerancing? Give a list of ANSI symbols for geometric tolerances?
   b) Fig.3 shows a part design with assigned tolerances. Use the arithmetic method to calculate the tolerance information for the axial dimension F of the outside surface shown.

7. a) Derive the principal moments of inertia of an object given its moments about a coordinate system.
   b) The geometry of an object is given in the following figure. Calculate the mass properties of the object assuming a density of 801.2 N/m³.
8. Write short notes on any FOUR of the following:
   a) Rubber banding and dragging
   b) Rendering a 3-D solid model
   c) Boolean operations, extrusion with AutoCAD
   d) Tolerance analysis
   e) Properties of composite objects
1. a) What is NC? What are the major advantages of CNC machine tool compared to its conventional counterpart?
   b) How do you designate the coordinate axes for a CNC lathe? Show them diagrammatically on a rough sketch of a lathe.

2. a) How BCD system differs from Binary system? Explain how the eight track tape coding is specified in ISO and EIA.
   b) Explain important features of a CNC machining centre.

3. a) What is the function of a Transducer in CNC? Explain any one type of a Transducer.
   b) Explain the function of MCU and explain its organization to perform its functions.

4. Prepare manual part program for machining the component with 4 holes of 10 mm diameter on 60 mm p.c.d. as shown in Fig.1 using ISO code. Do not use G41 or G42.

5. Prepare manual part programming for turning the component shown in Fig.2 on CNC lathe using ISO code. Assume the tool tip radius is 2 mm.

6. a) Give any six circle definitions in APT geometry.
b) Write APT geometry to define lines and circles shown in Fig.3.

![Fig. 3](image)

7. Prepare NC program in APT for machining the contour shown in Fig.4 with two passes one with rough-cut and other with finish cut.

![Fig. 4](image)

8. Write short notes on any FOUR of the following:
   i) Servo system
   ii) Presenting tools
   iii) Tab sequential format
   iv) MATRIX definition in APT
   v) INTOL and OUTTOL commands
   vi) Post processor
1. a) Write about the historical development of Robot manipulators.
   b) Write about the classification of Robots.
2. a) Explain the different ways by which the orientation of a rigid body can be described with respect to the fixed frame.
   b) What is the resultant rotation matrix for a rotation of 60º about the fixed X-axis, followed by a rotation of 45º about the Y-axis, followed by rotation of 30º about the Z-axis. For the above rotations find the direction of the screw axis and angle of rotation.
3. Figure-1 shows the schematic diagram of the Scorbot robot. In the diagram, the second, third and fourth joint axes are parallel to one another and point into the paper at points A, B, and P respectively. The first joint axis points up vertically, and the fifth joint axis intersects the fourth perpendicularly. The D-H parameters are as given under. Find the overall transformation matrix for the robot.

<table>
<thead>
<tr>
<th>Joint i</th>
<th>$\alpha_i$</th>
<th>$a_i$</th>
<th>$d_i$</th>
<th>$\theta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$-\pi/2$</td>
<td>10</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>15</td>
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<td>45</td>
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<tr>
<td>4</td>
<td>$-\pi/2$</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>70</td>
</tr>
</tbody>
</table>

4. a) How do you classify parallel manipulators?
   b) Figure-2 shows the schematic diagram of planar 2-d.o.f. five-bar manipulator that is constructed with one
prismatic and four revolute joints. Find the end effector position \( \mathbf{q} \) as function of the two input joint variables, \( d_1 \) and \( \theta_2 \).

5. a) What is a Jacobian?
   b) Derive the conventional Jacobian of a planar 2-d.o.f. manipulator shown in Figure-3.

6. a) A single-link robot with a rotary joint is motionless at \( \theta = 15^\circ \). It is desired to move the joint in a smooth manner to \( \theta = 75^\circ \) in 3 seconds. Find the coefficients of a cubic which accomplishes this motion and brings the manipulator to rest at the goal. Plot the position, velocity, and acceleration of the joint as a function of time.
   b) What is collision-free path planning?

7. Write about any Robot Language providing a sampling of the important features and statements.

8. Write short notes on any THREE of the following:
   a) Homogeneous Transformation Matrix.
   b) Method of successive crew displacements.
   c) Planning paths using the dynamic model.
   d) Demonstration of points in space.
1. a) What is arithmetic – geometric inequality?

b) Minimize the following function:

\[ f(X) = \frac{1}{2} x_1^2 + x_2 + \frac{2}{3} x_1^{-1} x_2^{-1} \]

2. a) Explain the problem of Dimensionality in Dynamic programming.

b) Maximize \( f(x_1, x_2) = 50x_1 + 100x_2 \)

Subjected to

\[
\begin{align*}
10x_1 + 5x_2 & \leq 2500 \\
4x_1 + 10x_2 & \leq 2000 \\
x_1 + 1.5x_2 & \leq 450 \\
x_1 & \geq 0, \quad x_2 \geq 0
\end{align*}
\]

3. Solve the following problem using Bala’s method.

Minimize \( f = 3x_1 + 2x_2 + x_3 + x_4 \)

Subjected to

\[
\begin{align*}
x_2x_3 + x_4 & \leq 1 \\
2x_1 + x_2x_3 + x_4 & \geq 3 \\
x_i &= 0 \text{ or } 1, \quad i = 1,2,3,4.
\end{align*}
\]

4. A contractor plans to use four tractors to work on a project in a remote area. The probability of a tractor functioning for a year without a breakdown is known to be 82%. If \( X \) denotes the number of tractors operating at the end of a year, determine the probability mass and distribution function of \( X \) and also find the expected value and the standard deviation of the number of tractors operating at the end of one year.

5. Find the minimum of

\[
\begin{align*}
f_1 &= x_1^2 + x_2^2 \\
f_2 &= (x_1 - 2)^2 + x_2^2
\end{align*}
\]

Subject to

\[ x_1 - x_2 - 1 \leq 0 \]
6. a) Construct the objective function to be used in GAs for a minimization problem with mixed equality and inequality constraints.

   b) Consider the following two strings denoting the vector $X_1$ and $X_2$

   $X_1$: \{1 0 0 0 1 0 1 1 0 1\}
   $X_2$: \{0 1 1 1 1 0 1 1 0\}

   Find the result of crossover at location 2. Also, determine the decimal value of the variable before and after crossover if each string denotes a vector of two variables.

7. a) What is a sigmoid function? How it is affected by weighted sum of inputs, explain.

   b) How is a neuron modeled in neural network-based model, explain with one example.

8. Explain any Three of the following.
   a) Simulated Annealing Algorithm
   b) Continuous Dynamic programming
   c) Branch – and - Bound method
   d) Complementary Geometric programming
1. a) What is need analysis?
   b) Explain different design specifications with suitable examples.
2. a) Explain different stages of product life cycle. Illustrate with a suitable example.
   b) Briefly enumerate the advantages of standardization.
3. a) Explain Von Mises stress.
   b) For the bicycle pedal arm assembly as shown in Fig. 1 with rider applied force of 1500 N at the pedal, determine the Von Mises stress in the 15 mm dia pedal arm. The pedal attaches to the arm with a 12 mm thread. Find the Von Mises stress in the screw. Find the safety factor against static failure if the material has $S_y = 350$ MPa.

4. a) Explain the mechanism of fatigue failure.
   b) Explain various factors affecting fatigue life of a component.
5. a) Explain the design considerations for casting process with examples.
   b) Briefly explain design process for non-metallic parts.
6. a) Explain the conventional breakeven chart.
   b) What is manufacturability? Describe its significance in design for manufacturing.
7. a) What is creativity?
   b) Explain the various creative techniques.
8. Write any FOUR of the following:
   a) Shigley model of design.
   b) Fracture mechanics theory of failures.
   c) Stress concentration factors.
   d) Design for reliability.
   e) Material selection concepts.