

- (a) Gravity and loads
 - (b) Software
 - (c) Power supply
 - (d) Noise
- 1-f. Lagrange's equations are based on (CO3, K1) 1
- (a) Energy methods
 - (b) Newton's laws
 - (c) Kirchoff's laws
 - (d) Cost analysis
- 1-g. Trajectory planning defines (CO4, K1) 1
- (a) Path and timing of motion
 - (b) Robot cost
 - (c) Payload type
 - (d) Factory layout
- 1-h. Circular interpolation is required for (CO4, K1) 1
- (a) Arc welding
 - (b) Pick and place
 - (c) Inspection
 - (d) Gripping
- 1-i. Textual programming languages for robots include (CO5, K1) 1
- (a) SQL
 - (b) CNC G-code
 - (c) HTML
 - (d) VAL, RAPID
- 1-j. Subroutines in programming improve (CO5, K1) 1
- (a) Decoration
 - (b) Noise
 - (c) Cost
 - (d) Modularity

2. Attempt all parts:-

- 2.a. List major types of industrial robots. (CO1, K1) 2
- 2.b. Define dexterity in robotic systems. (CO2, K2) 2
- 2.c. List assumptions in robot dynamics modeling. (CO3, K1) 2
- 2.d. Define machine vision in robotics. (CO4, K2) 2
- 2.e. List flow control operations in robot programming. (CO5, K1) 2

SECTION-B 30

3. Attempt all parts:-

3.a. Answer any one of the following:-

- 3.a.(i) Explain evolution of robots in industry. (CO1, K2) 6
- 3.a.(ii) Evaluate role of peripheral devices in robotics. (CO1, K2) 6

3.b. Answer any one of the following:-	
3.b.(i) Explain the different parameters used in D-H matrix in kinematic modeling. (CO2, K3)	6
3.b.(ii) Examine effect of singularity on inverse kinematics. (CO2, K2)	6
3.c. Answer any one of the following:-	
3.c.(i) A manipulator droops under its own weight. Apply gravity compensation principles to suggest how counterbalance springs or control torques can correct this. (CO3, K3)	6
3.c.(ii) Describe how the inertia matrix of a robotic manipulator is formulated, explaining the steps involved in deriving it during dynamic modeling. (CO3,K3)	6
3.d. Answer any one of the following:-	
3.d.(i) Discuss the various constraints that must be considered during robot trajectory planning. (CO4, K3)	6
3.d.(ii) How is machine vision used in bin-picking applications? Highlight its role in object detection, pose estimation, part localization, and guiding robotic manipulators for accurate picking. (CO4, K3)	6
3.e. Answer any one of the following:-	
3.e.(i) Discuss the different structure and syntax of robot programs. (CO5, K3)	6
3.e.(ii) Explain the core architecture and design philosophy of the Robot Operating System (ROS). (CO5, K3)	6
SECTION-C	50
4. Answer any <u>one</u> of the following:-	
4-a. A company wants to install robot for bike assembly line. Explain selection procedure for robots for this. (CO1, K3)	10
4-b. Explain role of robot controllers and adaptive control system in robotics. (CO1, K3)	10
5. Answer any <u>one</u> of the following:-	
5-a. A robot rotates 60° about Z, then translates 0.4 m along X, then rotates 30° about X. Apply geometric transformations to compute the final pose matrix. (CO2, K3)	10
5-b. Define the concept of workspace in robotics. Describe the various types of work envelopes used in industrial robot applications. (CO2, K3)	10
6. Answer any <u>one</u> of the following:-	
6-a. For a 2-link planar arm, apply Lagrange's method to calculate kinetic energy using given joint velocities. (CO3, K3)	10
6-b. Evaluate the key torque control strategies used in robotic manipulators. (CO3, K2)	10
7. Answer any <u>one</u> of the following:-	
7-a. A robot moves from joint position $(10^\circ, 20^\circ)$ to $(40^\circ, 60^\circ)$. Apply linear interpolation to compute intermediate values at 50% motion. (CO4, K3)	10
7-b. Discuss the role of vision-guided robots in industrial automation. (CO4, K3)	10
8. Answer any <u>one</u> of the following:-	
8-a. Analyze flow control and logical operations in robot programs. (CO5, K3)	10
8-b. Evaluate process of deploying ROS applications to physical robots. (CO5, K2)	10