JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

MOOC End Term Examination- 2025

B.Tech-VII Semester (CSE/IT/ECE/CE/BT/BI)

COURSE CODE(CREDITS): 25B2WEC604 (3) MAX. MARKS: 70

COURSE NAME: INDUSTRIAL ROBOTICS THEORIES FOR IMPLEMENTATION

COURSE INSTRUCTORS: Dr Emjee Puthooran MAX. TIME: 3 Hours

Note: (a)All questions are compulsory.
(b)Marks are indicated against each question in square brackets.
(c) The candidate is allowed to make Suitable numeric assumptions wherever required for solving problems
(d) Assume standard industrial 6-DOF articulated robot wherever required unless specified.
(e) Draw neat sketches wherever necessary.

Q.No	Question	Marks
Q1	Define a robot as per ISO 8373 standard and differentiate between serial and parallel robots with one industrial example each.	2
Q2	Compare the working principle and typical industrial applications of Stepper motor vs BLDC servo motor.	3
Q3	Explain the significance of "Repeatability" and "Accuracy" in industrial robots with a sketch showing the difference.	3
Q4	Write the general form of a 4×4 Homogeneous Transformation Matrix (HTM) and state what each block represents.	3
Q5	What is a kinematic singularity? Give one practical situation in a 6-DOF industrial robot where elbow singularity occurs.	3
Q6	(a) A manufacturer's datasheet of a DC servo motor lists: Rated torque = 2.5 Nm, Peak torque = 7.5 Nm, Rated speed = 3000 rpm, Rotor inertia = 4.2×10^{-4} kg-m², Voltage constant Ke = 0.085 V/(rad/s). Calculate the maximum acceleration the motor can achieve at peak torque (ignore load inertia). Show all steps. (4) (b) Why do modern industrial robots prefer AC synchronous servo motors over DC motors? List three technical reasons. (2) (c) What is "back-drivability" of an actuator? Which actuator among DC, stepper, and BLDC is least back-drivable and why? (4)	10
Q7	(a) For a force-torque sensor mounted on the robot wrist, explain the terms "resolution", "hysteresis", and "crosstalk" with reference to its datasheet. (5) (b) An inductive proximity sensor has sensing distance of 8 mm for mild steel target. How does the effective sensing distance change for aluminium and stainless steel targets? Explain the correction factors typically used. (5)	10

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<tr><td>Q8</td><td>(a) Explain the complete steps of "Mastering" an industrial 6-axis robot using the pulse-count method and calibration marks. Why is mastering necessary after a gearbox replacement? (6)
(b) Describe the "4-Point TCP Calibration" method with a sketch. Why is it preferred over the 3-point method in industry? (6)</td><td>12</td></tr>
<tr><td>Q9</td><td>A 3-DOF planar RRR manipulator has link lengths $a_1 = 400$ mm, $a_2 = 300$ mm, $a_3 = 200$ mm. The DH parameters are:
<table>
<tr><th>i</th><th>α_{i-1}</th><th>a_{i-1}</th><th>d_i</th><th>θ_i</th></tr>
<tr><td>1</td><td>0°</td><td>0</td><td>0</td><td>θ_1</td></tr>
<tr><td>2</td><td>0°</td><td>400</td><td>0</td><td>θ_2</td></tr>
<tr><td>3</td><td>0°</td><td>300</td><td>0</td><td>θ_3</td></tr>
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(a) Derive the forward kinematics equations and write the position of the end-effector (x, y) in terms of θ_1, θ_2, θ_3. (5)
(b) Compute the 3×3 Jacobian matrix (linear velocity part only) in terms of joint angles. (4)
(c) At configuration $\theta_1 = 30°$, $\theta_2 = 60°$, $\theta_3 = -90°$, is the manipulator in singularity? Justify mathematically. (3)</td><td>12</td></tr>
<tr><td>Q10</td><td>(a) A workpiece is to be calibrated using the Indirect method on an industrial robot. List the step-by-step procedure and state the advantage of this method over the Direct method. (6)
(b) Explain how a linear rail (7th axis) is synchronized with a 6-axis robot. What parameters must be defined in the robot controller for perfect coordination? (6)</td><td>12</td></tr>
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