Q/K/TY

Reg. No: 24BECE0[illegible]

VIT
Vellore Institute of Technology

Final Assessment Test – November 2025

Course: BECE312L - Robotics and Automation

Class NBR(s): 3465 / 3467 / 3468

Time: Three Hours

Slot: A1+TA1

Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

COs	CO Statements
CO1	Classify robots and summaries their role in diverse applications
CO2	Infer the working of basic electric, electronic, and other types of drives required in robots.
CO3	Distinguish and interpret the sensors for various applications in robotics and automation.
CO4	Determine the mathematical model of robotic systems and analyse their kinematic behaviour.
CO5	Design robots for varied working environments encompassing all types of motions across different paths and diverse trajectories.
CO6	Apply the ideas in performing various robotic tasks for contemporary industry standards using suitable programming skills.

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions

(100 Marks)

1. State the laws of robotics. Which performance specifications according to you should be the primary determining factors desired for an industrial robot? Elaborate with a suitable example on how these factors play pivotal role in an industrial robot. **[5] CO1 BL2**

2. The Yamaha YK-XC robot and the symbolic representation showing a portion of its workspace is depicted in Figure 1a & 1b. Brief the configuration of the manipulator and highlight its advantages and drawbacks. Also, specify an example application for this robot configuration. **[5] CO1 BL2**

Fig.1a

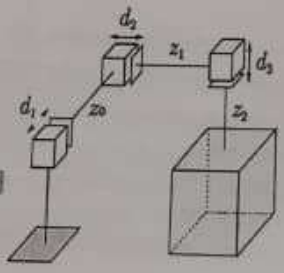

Fig.1b

3. With a neat sketches, explain the construction and working principle of variable reluctance, permanent magnet and hybrid stepper motors. Highlight the comparison among the above-mentioned stepper motor types with advantages. [10] CO2 BL2

4. What is the role of end-effector in robotic arms? How do the end-effectors acheive the sense of touch? With neat diagrams, explain the sensing mechanism of PVDF, Capacitive and Resistive type tactile sensors. [10] CO3 BL2

5. Consider a 5×5 grayscale image represented by the following intensity values [5] CO3 BL3

$$I = \begin{bmatrix} 52 & 55 & 61 & 59 & 58 \\ 54 & 60 & 62 & 63 & 65 \\ 53 & 58 & 120 & 122 & 125 \\ 50 & 57 & 121 & 123 & 127 \\ 49 & 55 & 119 & 118 & 124 \end{bmatrix}$$

Considering a segmentation technique that considers use of seed points, perform one full region-growing iteration and determine which pixels belong to the segmented region. Use the following conditions:

- Seed point $S(3,3)$
- Growth threshold $T = 5$
- 8-connectivity criterion

6. For the schematic figure as shown in Figure 2, determine the following parameters. [5] CO3 BL3

a) Centroid; b) Minimum aspect ratio; c) Thinness; d) Compactness

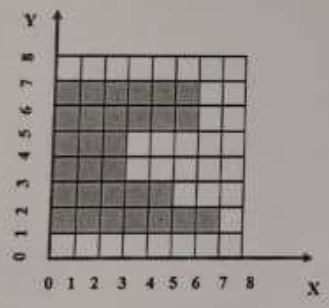

Fig. 2

7. Determine the rotational matrix for the Euler rotation XZX for a combination for angles $\theta_1, \theta_2, \theta_3$. Also sketch the associated frame diagram. [10] CO4 BL3

8. Consider the following rotation matrix R: [10] CO4 BL4

$$R = \begin{bmatrix} 0 & A & B \\ C & D & -0.354 \\ E & 0.612 & F \end{bmatrix}$$

Let R be a 3×3 real Rotational matrix whose entries contain the six unknowns A, B, C, D, E, F.

(a) Find out the missing elements provided the condition the ratio of B and D is 2 and B > 0

(b) Using the values obtained in (a), assemble the full 3 × 3 matrix R and verify all the properties of R within some rounding errors.

9.(a) A manipulator with 3 DoF having all revolute joints has the coordinate frames shown in Figure 3 assigned to each link. Determine the A1, A2 and A3 matrices. Also find the resultant Homogeneous Transformation Matrix (HTM) for the same. **[10] CO4 B**

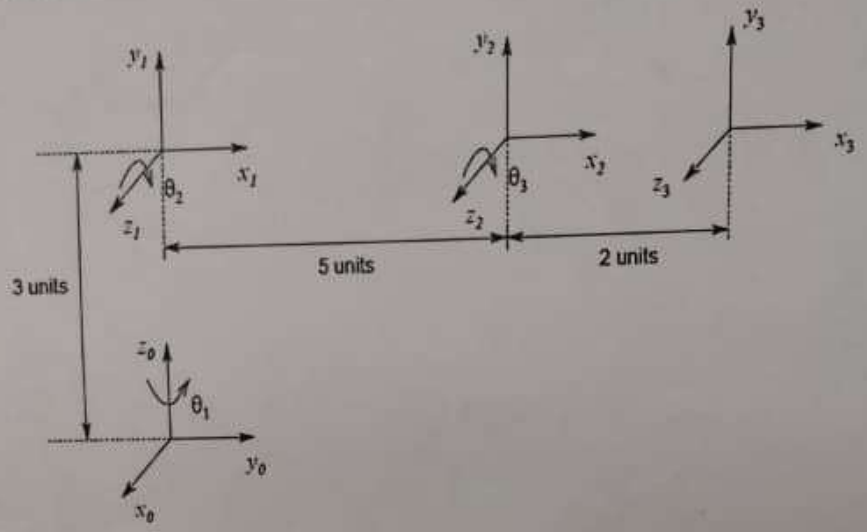

Fig. 3

OR

9.(b) Figure 4 depicts the forward kinematic diagram of a manipulator. Sketch the frame and fix the DH table. **[10] CO4**

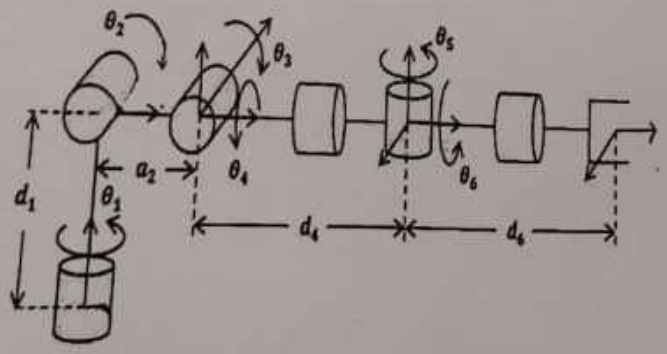

Fig. 4

10.(a) A rotary joint of an industrial manipulator moves from an initial position of 10° to a final position of 50°. The link attached to this joint starts from rest, completes the motion smoothly in 4 seconds, and comes to rest at the final position. Determine a third-order polynomial trajectory function that satisfies the given boundary conditions. Also, sketch the position and velocity profiles of the joint over the given time interval. **[10] CO5**

OR

10.(b)	Explain the requirement of a parabolic blend in the linear trajectory function of path planning with suitable diagrams. Draw the velocity and acceleration curves with respect to the linear trajectory with the blend. Find the expression for angular velocity at the linear region of the trajectory function.	[10]	CO5	BL4
11.	In an automobile manufacturing unit, a robotic vision system is deployed to detect defects in painted car body panels moving on a conveyor belt. The robot must identify panels with paint defects, such as scratches or uneven coating, and remove them from the production line. Write a pseudocode that uses image processing, and make the decision to discard the defective panel from the conveyor.	[10]	CO6	BL5
12.	Explain the role of industrial robots in manufacturing automation. Discuss with suitable examples how robots are employed in welding, painting, and assembly operations. Highlight the advantages of using robots over human labor in terms of precision, productivity, and safety. Illustrate your answer with neat sketches or block diagrams showing a typical industrial robotic setup for one of these applications.	[10]	CO6	BL3

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