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020401

May 2026

B. Tech. (RAI) (Fourth Semester)

Kinematics of Robots (RAU-202-V)

Time : 3 *Hours*] [*Maximum Marks* : 75

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other.

Part A

1. (a) Define a kinematic pair and give one example. 1.5

(b) What is a homogeneous transformation matrix ? 1.5

(c) Define inverse kinematics of a manipulator. 1.5

(d) What do PUMA and SCARA stand for ? 1.5

(e) What is meant by the Euler equation of motion for rigid bodies ? 1.5

(f) What is meant by robot payload ? 1.5

(g) Define module of a gear. 1.5

(h) What is meant by velocity propagation ? 1.5

(i) Define singularity in robots. 1.5

(j) What is meant by Jacobian singularity ? 1.5

Part B

2. Describe the inversions of the slider-crank mechanism and their practical applications. Explain in detail the working of the quick return motion mechanism. 15

3. (a) A cylindrical robot has the following joint parameters :

(i) Radial extension = 0.5 m

(ii) Vertical displacement = 0.4 m

(iii) Rotation about vertical axis = 60°.

Determine the position coordinates of the end effector in Cartesian coordinates. 5

(b) A point in coordinate frame A has coordinates (2, 3, 4). Frame B is translated relative to frame A by (1, 2, 3) and rotated 90° about the Z-axis. Determine the coordinates of the point in frame B using homogeneous transformation. 10

4. A special 3-DOF spraying robot has been designed as shown. The reset position is when the arms are horizontal : 15

(i) Assign the coordinate frames based on the D-H representation.

(ii) Fill out the parameters table.

(iii) Write all the A matrices.

(iv) Write the UTH matrix in terms of the A matrices.

5. (a) The hand frame of a 5-DOF robot, its instantaneous numerical Jacobian and a set of differential motions are given. The robot has a 2RP2R configuration. Find the new location of the hand after the differential motion :

$$T_6 = \begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 0 & -1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$J = \begin{bmatrix} 3 & 0 & 0 & 0 & 0 \\ -2 & 0 & 1 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} d\theta_1 \\ d\theta_2 \\ d\theta_3 \\ d\theta_4 \\ d\theta_5 \end{bmatrix} = \begin{bmatrix} 0.1 \\ -0.1 \\ 0.05 \\ 0.1 \\ 0 \end{bmatrix}$$

10

(b) What is difference between a differential operator and Jacobian ? How to relate them ? **5**

6. (a) Name *five* robots developed in India and briefly explain their application areas. **10**

(b) Name the different types of gears and briefly describe their application areas. **5**

7. Derive the equations of motion for the 2-DOF system as shown below, using Lagarangian mechanics : **15**

