

(3 Hours)

[Total Marks: 80]

N.B. : 1) Question No. 1 is Compulsory.

2) Attempt **any THREE** from remaining questions.

3) Assume suitable data if necessary.

- Q1 a) Define Robotics and Explain its classification. 05
- b) Describe Robot Reference Frames. 05
- c) Describe Robot Kinematics. 05
- d) Explain various Robot Applications. 05
- Q.2 a) A frame F was rotated about the y- axis 90° , followed by a rotation about the o- axis of 30° , followed by a translation of 5 units along the n- axis , and finally a translation of 4 units along the x- axis. Find the total transformation matrix. 10
- b) Describe D-H Representation of Forward Kinematic equations of robots. 10
- Q.3 a) A frame B has translated a differential amount of Trans (0.01, 0.05, 0.03) Units. Find its new location and orientation. 10

$$B = \begin{bmatrix} 0.707 & 0 & -0.707 & 5 \\ 0 & 1 & 0 & 4 \\ 0.707 & 0 & 0.707 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Find the new location of point $P(1,2,3)^T$ relative to the reference frame

- b) Explain Inverse Jacobian in detail. 10
- Q.4 a) An object is subjected to the following forces and moments relative to the reference frame. Attached to the object is a frame, which describes the orientation and the location of the object. Find the equivalent forces 10

and torques acting on the object relative to the current frame.

$$B = \begin{bmatrix} 0.707 & 0.707 & 0 & 2 \\ 0 & 0 & 1 & 5 \\ 0.707 & -0.707 & 0 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$F^T = [10, 0, 5, 12, 20, 0]_{N, N.m}$$

- b) Find the effect of differential motion of **0.1 rad** about y-axis followed by 10
a differential translation of **[0.1, 0, 0.2]** on the given frame B.

$$B = \begin{bmatrix} 0 & 0 & 1 & 10 \\ 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Q.5 a) Explain BUG1, BUG2 and Tangent BUG algorithms and compare them in brief. 10

b) Explain the concept of robot motion planning. 10

Q.6 Write short notes on any **TWO** 20

- 1) Generalized Voronoi Diagrams
- 2) Wave-Front Planner algorithm with example
- 3) Trapezoidal Decomposition with example
