(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 $\mathbf{90^0}$, followed by a rotation about the o- axis of $\mathbf{30^0}$, 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 $P(1,2,3)^{\mathbf{T}}$ 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.

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

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

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

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

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

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