II SEMESTER M.TECH. (INDUSTRIAL AUTOMATION AND ROBOTICS, MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, APR/MAY 2017

SUBJECT: ROBOT DYNAMICS AND ANALYSIS [**MTE 5139**]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **Any 5** questions.
- Missing data may be suitable assumed.

1A. Define different types of wheels of mobile robots along with its degrees of freedom. Also for a standard wheel mobile robot the parameters given are as follows: Radius of the wheel is 10cm, Length between the wheels is 50cm, the rate at which is left wheel is spinning with 4 rad/s, and right wheel is spinning with 2 rad/s, $\theta=\pi/4$ Compute velocity in global reference frame. **6**

1B. Write a program using RAPID instructions for tracing a square of 1000mm sides and circle of 500mm Diameter. **4**

2A. How many degrees of freedom does the following mechanism (fig Q.2A) have? **4**

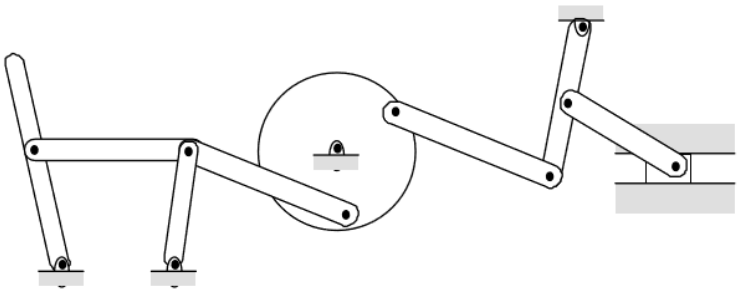

Figure Q.2A

2B. For the 3-joint robot described by the D-H parameters given in the table Q.2B below, compute the complete Jacobian. **6**

Joint	d	a	θ	α

1	0.5	0.8	θ_1	90^0
2	0.2	1.2	θ_2	90^0
3	0	0.15	θ_3	0^0

Table Q.2B

3A. A fifth order polynomial is to be used to control the motions of the joints of a robot in joint. Find the coefficients of the fifth order polynomial that allow a joint to go from 0^o to 120^o in 5 seconds, while the initial and final velocities are zero the initial acceleration and deceleration are 10 degrees/sec^2 **5**

3B. For the given RRRP manipulator is shown in the figure Q.3B.Choose appropriate link reference frame and derive the correspoding D-H paramaters.(Use the Given Fixed frame) **5**

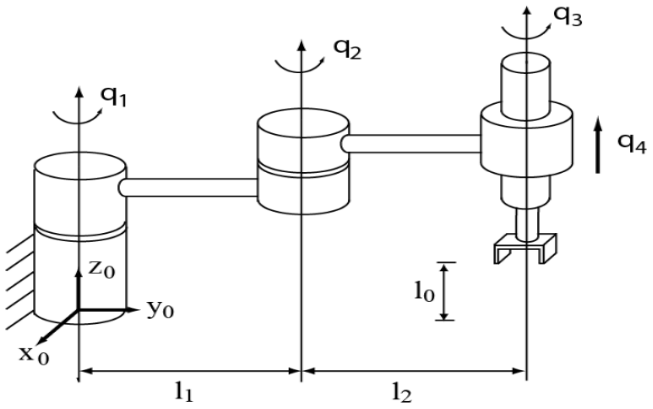

Figure Q.3B

4A. Given a fixed frame [0] and a moving frame [1], we perform the following sequence of rotations on [1]: **3**

1)Rotate frame [1] about the x-axis of frame [0] by a

2)Then rotate about the y-axis of frame [0] by b

3)Then rotate about the z-axis of frame [0] by c

Find the final orientation R with respect for frame [0].

4B. For a spherical configuration the D-H table is given in Table Q.4B: **7**

Link i	α	θ	a	d
1	90	θ_1	0	0
2	-90	θ_2	0	0
3	0	0	0	d_3

Table Q.4B

We desire to move from point A (9, 6, 10) to point B (3, 5, 8) in a straight line. Find the angles of the two joints for each intermediate point and plot the results. (Divide the line into 5 sections).

5. Elaborate the significance of D-H parameters and its role in forward kinematics **10**

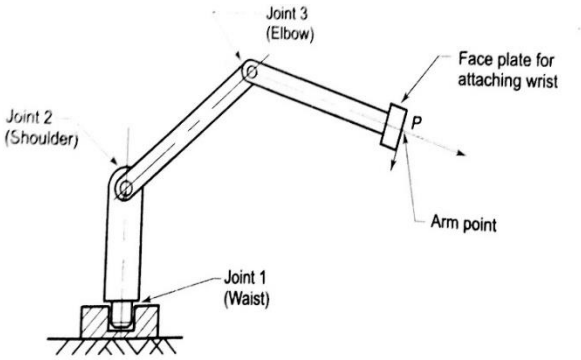

Figure Q.5

For a 3-DOF articulated arm as shown in figure Q.5, determine the joint variable for known position and orientation of the end of the arm point given as.

$$[T_E] = \begin{bmatrix} n_x & s_x & a_x & p_x \\ n_y & s_y & a_y & p_y \\ n_z & s_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

6A Calculate the velocity of the tip of the 2 link planar RR arm manipulator using velocity propagation along the links as showin in figure Q.6A **7**

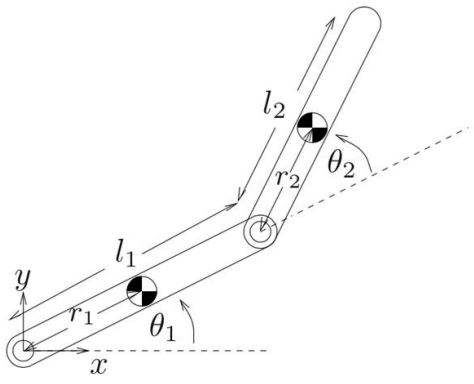

Figure Q.6A

6B A frame B rotated about X axis 90^0,translated about C axis 3 units,translated about B axis 5 units,rotated about Y axis 60^0 and then translated about Z by 4 Units.Find the final location of the pt(10,5,2) attached to the relative frame with respect to the reference frams. **3**

Appendix

$$A_{n+1} = \begin{bmatrix} C\theta_{n+1} & -S\theta_{n+1}C\alpha_{n+1} & S\theta_{n+1}S\alpha_{n+1} & a_{n+1}C\theta_{n+1} \\ S\theta_{n+1} & C\theta_{n+1}C\alpha_{n+1} & -C\theta_{n+1}S\alpha_{n+1} & a_{n+1}S\theta_{n+1} \\ 0 & S\alpha_{n+1} & C\alpha_{n+1} & d_{n+1} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$