Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2017

SUBJECT: MECHANICS OF ROBOTIC SYSTEMS [MTE 3102]

REVISED CREDIT SYSTEM
(17/11/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed

1A. For a given 2 link planar RR type manipulator with length of the first link as 2 units and length of second link as 1 unit. It's Jacobian matrices at 3 different configurations (named as J1,J2 and J3) have been given as follows: **07**

$$J1=\begin{matrix}-0.6893 & -0.3420\\ 2.9093 & 0.9397\end{matrix} \quad J2=\begin{matrix}-1.6644 & -0.8192\\ 2.3862 & 0.5736\end{matrix} \text{ and } J3=\begin{matrix}-2.3801 & -0.9659\\ 1.1554 & -0.2588\end{matrix}$$

Calculate joint variables and Cartesian space coordinates for each of these configurations.

1B. With neat sketch, explain different types of joints and different configurations of robot (with work volume, joint notation scheme). **03**

2A. Define pictorially the four parameters in a D-H Table. **04**

2B. Calculate the D-H Table for the Stanford arm as shown in figure Q.2B and derive the forward kinematics for the same.(Assume various parameters). **06**

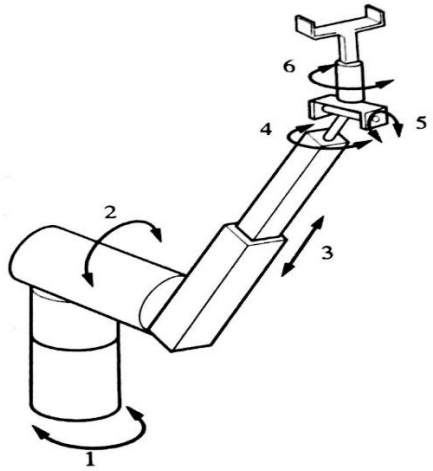

Figure Q.2B

3A Find the inertia tensor of a right cylinder of homogeneous density with respect to a frame with origin at the center of mass of the body. **04**

3B Construct the dynamic equations for the two-link planar manipulator and Discuss each term and elaborate the physical significance of the individual elements of the mass matrix. **06**

4A Elaborate the concept of Model Based Control using flowchart. **03**

4B A fifth order polynomial is used to control the motions of the joints of a robot. Find the coefficients of the fifth order polynomial that allow a joint to go from 0^o to 100^o in 5 seconds, while the initial and final velocities are zero, the initial acceleration and deceleration are 10 and 8 degrees/sec^2 respectively. **04**

4C If there are two reference frames namely {A} , {B} and ${}^B_AX, {}^B_AY, {}^B_AZ$ represents the X,Y and Z axis respectively for frame {A} represented in reference frame {B},Find out the rotation matrix between {A} and {B}. **03**

5A. Obtain the coefficients of a cubic polynomial $\theta(t) = a_0 + a_1 t + a_2 t^2 + a_3 t^3$ if $\theta(0), \dot{\theta}(0), \ddot{\theta}(0)$, and $\theta(t_f)$ are specified. **03**

5B. Assume that we know the transform ${}^A_BT$ in Figure Q.5B, which describes the frame at the manipulator's fingertips relative to the base of the manipulator {B}.The location of tabletop {S} with respect to the manipulator's base is also known. The location of the frame attached to the bolt lying on the table relative to the table frame is also known. Calculate the position and orientation of the bolt relative to the manipulator's hand. **03**

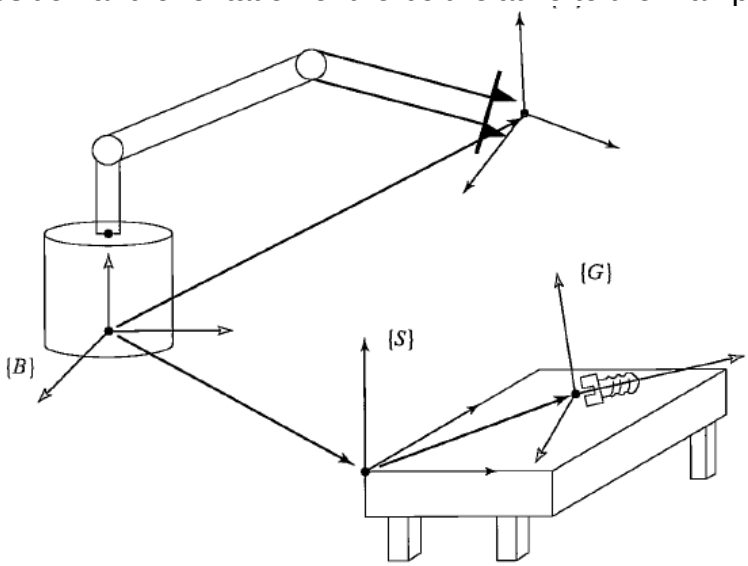

Figure Q.5B

5C Discuss the following robot specifications: **04**

a) Speed of Motion
b) Spatial Resolution
c) Repeatability
d) Accuracy

Appendix:

$$ {}^{i-1}_{i}\boldsymbol{T} = \begin{bmatrix} \boldsymbol{c\theta_i} & \boldsymbol{-s\theta_i} & \boldsymbol{0} & \boldsymbol{a_{i-1}} \\ \boldsymbol{s\theta_i c\alpha_{i-1}} & \boldsymbol{c\theta_i c\alpha_{i-1}} & \boldsymbol{-s\alpha_{i-1}} & \boldsymbol{-s\alpha_{i-1} d_i} \\ \boldsymbol{s\theta_i s\alpha_{i-1}} & \boldsymbol{c\theta_i s\alpha_{i-1}} & \boldsymbol{c\alpha_{i-1}} & \boldsymbol{c\alpha_{i-1} d_i} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{1} \end{bmatrix} $$ (Craig's methods) and

$$ A_{n+1} = \begin{bmatrix} C\theta_{n+1} & -S\theta_{n+1}C\alpha_{n+1} & S\theta_{n+1}S\alpha_{n+1} & a_{n+1}C\theta_{n+1} \\ S\theta_{n+1} & C\theta_{n+1}C\alpha_{n+1} & -C\theta_{n+1}S\alpha_{n+1} & a_{n+1}S\theta_{n+1} \\ 0 & S\alpha_{n+1} & C\alpha_{n+1} & d_{n+1} \\ 0 & 0 & 0 & 1 \end{bmatrix} $$ (Mc Carty's method).