Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent institution of MAHE, Manipal)

IV SEMESTER B.TECH. (OPEN ELECTIVE)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: INTRODUCTION TO ROBOTICS [MTE 3283]

(30/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A Assume that we know the transform ${}^{A}_{B}T$ in Figure Q.1A below, which describes the frame at the manipulator's fingertips {T} relative to the base of the manipulator, {B}, where the tabletop is located in space relative to the manipulator's base (because we have a description of the frame {S} that is attached to the table as shown, T), and that we know the location of the frame attached to the bolt lying on the table relative to the table frame—that is, Calculate the position and orientation of the bolt relative to the manipulator's hand, ${}^{T}_{G}T$. **03**

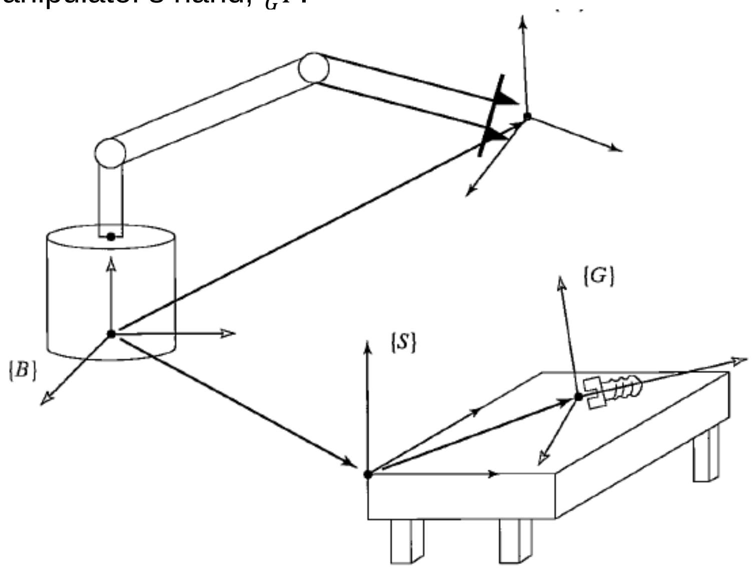

Figure Q.1A.

1B 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**

1C 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 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**

2A. Determine the homogeneous transformation matrix to represent the following sequence of operations. **03**

a) Rotation of 60˚ about OX axis.
b) Translation of 4 units along OX axis.
c) Translation of -6units along OC axis.
d) Rotation of 30˚ about OB axis.

2B. Write down the forward kinematic equation for two link planar manipulator and derive the inverse kinematic formulation for the same. For the same manipulator length of the first link is 2 units and length of second link is 1 unit. It's Jacobian matrices at 3 different configuration (named as J1,J2 and J3) have been given as follows: **07**

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

Calculate joint variables and Cartesian space coordinates for each of this configuration.

3A. Find the inertia tensor for the rectangular body of uniform density ρ with respect to the coordinate system shown in Figure Q3A.(l=2,w=2,h=1). **04**

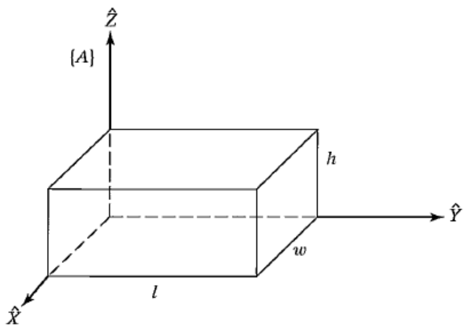

Figure Q.3A

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. Write the difference between the following: **04**

i. Forwards Vs Inverse Kinematics
ii. Forwards Vs Inverse Dynamics

4C. If there are two reference frame {A} and {B} and ${}^{B}_{A}X$, ${}^{B}_{A}Y$, ${}^{B}_{A}Z$ 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. Define pictorially the four parameters in a D-H Table. Calculate the D-H Table for the PUMA 560 as shown in Figure Q.5A and derive the forward kinematics for the same.(Assume various parameters). **07**

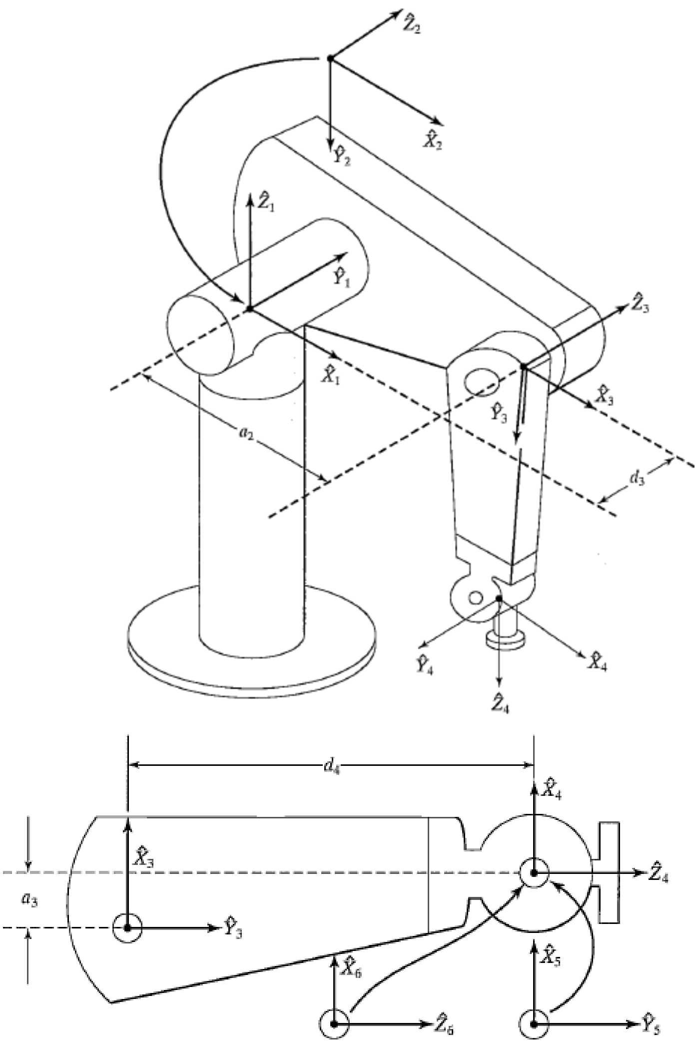

Figure Q.5A

5B. Sketch the workspace for two link planar manipulator. **03**