Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

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

END SEMESTER EXAMINATIONS, APRIL 2017

SUBJECT: ROBOT DYNAMICS AND ANALYSIS [MTE 5139]

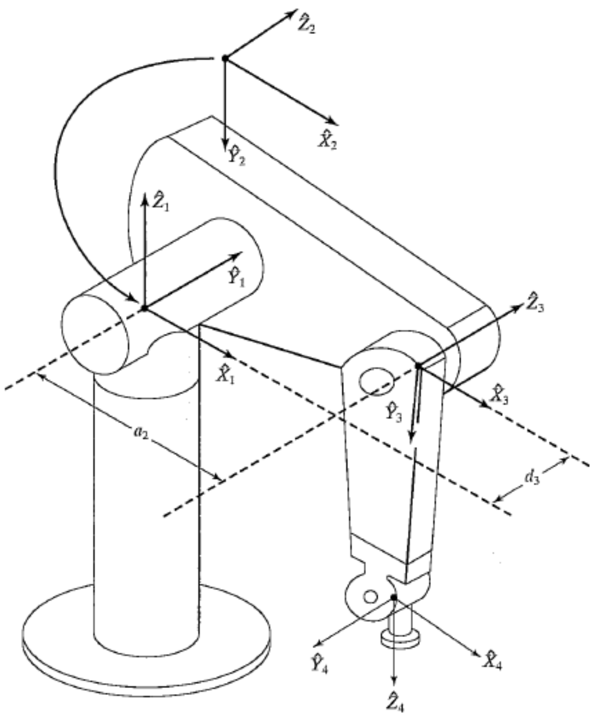
(23/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Define pictorially the four parameters in a D-H Table. Calculate the D-H Table for the PUMA 560 as shown in Figure Q.1A and derive the forward kinematics for the same.(Assume various parameters). **07**



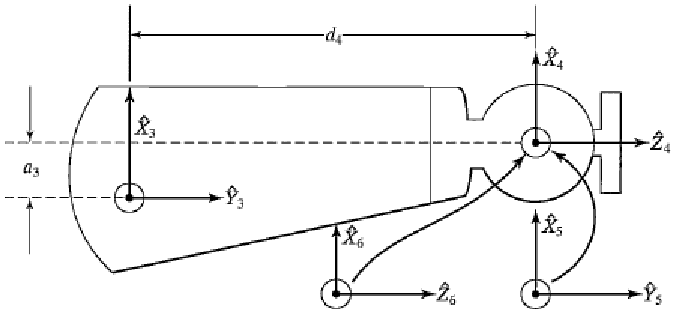


Figure Q.1A

1B. 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**

2A. Write down the general form of EoF (equation of motion) for multi body system. What does each of the components represents? Deduce the same using Lagrangian Formulation. **05**

2B. Deduce the equation of motion for two link planar manipulator Figure Q.2B **05**

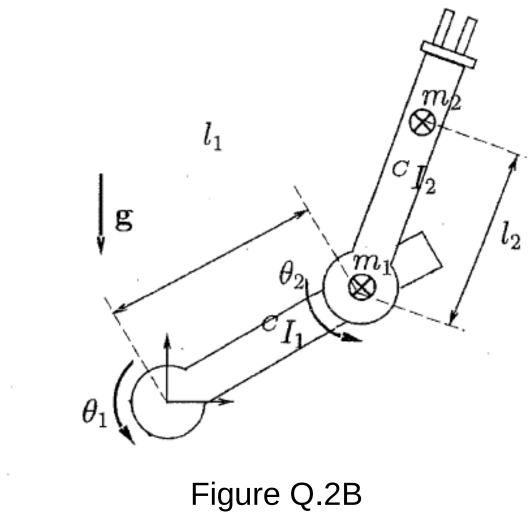


Figure Q.2B

3A. Figure Q.3A shows a two-link planar arm with rotary joints. For this arm, the
second link is half as long as the first—that is, $l_1 = 2l_2$. The joint range limits in degrees are **04**

$$0 < \theta_1 < 180$$
$$-90 < \theta_2 < 180$$

Sketch the approximate reachable workspace (an area) of the tip of link 2.

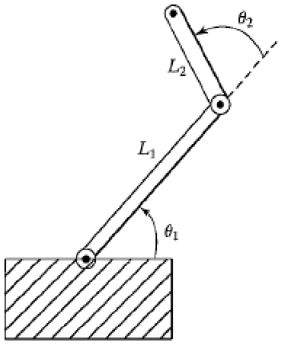


Figure Q.3A

3B. If the parameters of the system in Figure Q3B are in m = 1, b = 1, and k = 1, find the gains k_p, k_v for a position-regulation control law that results in the system's being critically damped with a closed-loop stiffness of 16.0. **04**

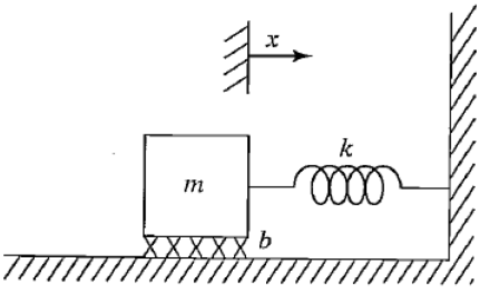


Figure Q3B

3C. Draw a block diagram for a position regulator system **02**

4A. Write down the forward kinematic equation for two link planar manipulator and derive the inverse kinematic expression algebraically. For the same manipulator length of the first link is 2 units and length of second link is 1 unit. It's Jacobian matrixes 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.

4B. With neat sketch, explain different types of joints and different configurations of robot (with work volume, joint notation scheme). **03**

5A. Draw the block diagram for Hybrid position/force controller for a general manipulator. **05**

5B. Illustrate the methodology for deriving inverse kinematics solution for two link planar manipulator (RR). **03**

5C. 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. **02**