B.E. Instrumentation Engineering Eighth Semester

IN8043 – Elective – II : Robotic System & Control

P. Pages : 3 **GUG/W/18/2066**

Time : Three Hours Max. Marks : 80

Notes :
1. Same Answer book must be used for each section.
2. All questions carry marks as indicated.
3. Assume suitable data wherever necessary.
4. Diagrams and Chemical equation should be given wherever necessary.
5. Illustrate your answers wherever necessary with the help of neat sketches.

1. a) Define the following terms : **8**

i) Degree – of – freedom

ii) Pose

iii) Kinematics

iv) Dynamics

v) Workspace

vi) Configuration space

vii) State – space

viii) End – effector

b) Find the rotation matrix representing a roll of $\pi/4$ followed by a yaw of $\pi/2$ followed by a pitch of $\pi/2$. **4**

c) Obtain the homogeneous transform for a rotation of 90º about the Z-axis and a displacement of 3 units in the y_0-direction. If H relates frame 0 & 1 and $P^1 = [1 \quad 0 \quad 0]^T$, find P^o. **4**

OR

2. a) Discuss with block diagram the key components involved in the robotic control system. **8**

b) Compare the serial manipulator with parallel manipulator with respect to following points: **8**

i) Kinematic chain

ii) Workspace

iii) Dynamics

iv) Application

3. a) What is the role of manipulator Jacobina matrix in robot kinematics? Justify with an example. **4**

b) Illustrate the co-ordinate frame assignments rules using Denavit – Hartenberg (DH) convention with an suitable example. **4**

c) Derive the Euler – Lagrange equation for one dimensional system. **8**

OR

4. Derive the dynamic model of the two link (RR) planar robotic arm as shown in figure 1, using Euler – Lagrange formulation. **16**

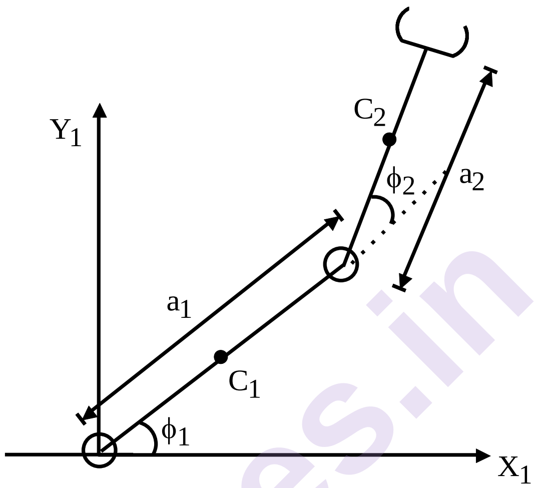

Figure 1. Two-link (RR) Planar robotic arm

Assume zero gravity acting on the robotic arm.

5. a) Discuss the application of inverse dynamics control technique for 'n' link robot manipulator. **8**

b) Carry out the details of PD and PID compensator for trajectory tracking control of robotic manipulator. **8**

OR

6. a) Illustrate the usage of task space inverse dynamics control for robotic manipulator. **8**

b) Derive the transfer function of lumped model of a single link with dc motor actuator employed for torque control of robotic manipulator. **8**

7. a) Distinguish the concept of natural and artificial constraints in motion and force control tasks of a particular robotic application. **8**

b) Given the following tasks, classify the environments as either inertial, capacitive or resistive. **8**

1) Turning a Crank
2) Inserting a peg in a hole
3) Polishing the hood of a car
4) Cutting Cloth

Answer with proper justification.

OR

8. a) Justify the need of task space dynamics & it's role in inverse dynamic control for robotic motion control. **8**

b) Formulate the impedance control scheme to regulate the mechanical impedance for the one – dimensional system shown in figure, consisting of a mass M, on a frictionless surface subject to an environmental force F and control input U. **8**

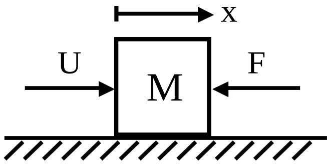

Figure. One-dimensional system

9. a) If $h : R^n \rightarrow R$ be ascalar function and f and g be vector fields on R^n. Then prove the following identify. **6**

$$L_{[f,g]}h = L_f L_g h - L_g L_f h$$

b) Consider the following system, **10**

$$\dot{x}_1 = a\sin(x_2)$$

$$\dot{x}_2 = -x_1^2 + u$$

Using feedback linearization technique, find the value of u in the above system to cancel the nonlinear term $a\sin(x_2)$. Also illustrates the inner and outer loop control architecture for the same system.

OR

10. a) Illustrate the concept of feedback linearization in the context of single – input systems. **8**

b) Define the following terms : **8**

1) Sliding surface

2) Sliding phase

3) Reaching phase

4) Reachability condition.

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