B.E.-Instrumentation Engineering Sem VIII

IN8043 - Elective-II: Robotic System and Control

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. Due credit will be given to neatness and adequate dimensions.
- 4. Assume suitable data wherever necessary.
- 1. a) State the laws of robotics.

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b) Compare revolute joint with prismatic joint.

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c) Verify that a positive rotation of θ about the Y_0 – axis is the same as a negative rotation of θ about the Y_1 – axis, if frame – 0 is related to frame – 1 by a rotation of π about the Z_0 – axis.

OR

2. a) Define robot. Discuss the types of robots based on their application in automation industry.

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b) Obtain the rotation matrix, $R_{Y,\theta}$ for a rotation of θ about the Y – axis in 3 – dimensional space.

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3. a) Draw and justify the Denavit – Hartenberg (DH) frames for the SCARA manipulator.

b) Show that the dynamic model of the regular pendulum system shown in below figure 1 is

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$$\ddot{\theta} = \frac{-g}{\ell} \sin \theta$$

where, ℓ is the length of pendulum, m is the mass of the tip of the pendulum, θ is the angle between pendulum and vertical Y – axis and g is the gravity term.

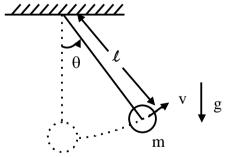


Figure 1: Regular Pendulum system.

OR

4. a) Derive the forward Kinematic equation for articulated manipulator using DH – convention.

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b) Describe the general expressions for Kinematic and potential energy for 'n' link robotic manipulator.

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5. a) Carryout the details of the computed torque control for trajectory tracking of robotic manipulator.

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

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- 6. Discuss the design of PD control for robotic manipulator using Lyapunov approach. 8 a)
 - b) Discuss the role of actuator dynamics in robot control system. 8
- 7. Formulate the impedance control scheme to regulate the mechanical impedance for the a) one-dimensional system shown in figure -2, consisting of a Mass M, on a frictionless surface subject to an environmental force F and control input u.

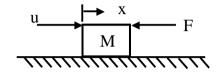


Figure -2: one - dimensional system.

b) Describe the natural and artificial constraints associated with the task of turning a crank. Sketch the compliance frame.

OR

- 8. Discuss the role of force and impedance control in robotic motion control system. a)
 - Classify the environments as either Inertial, capacitive or resistive for following tasks. 8 b)
 - Turning a crank

9.

- ii) Inserting a peg in a hole
- iii) Polishing the hood of a car
- iv) Cutting cloth
- Answer with proper justification.
- Illustrate the concept of sliding mode control as a robust control. Discuss the two major a) steps in the design of sliding mode control for nonlinear uncertain system.
 - Illustrate the concept of feedback linearization in the context of single-input systems. b)

OR

10. Consider the following system, a)

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

$$\dot{\mathbf{x}}_2 = -\mathbf{x}_1^2 + \mathbf{u}$$

using feedback linearization technique, find the values of u in the above system to cancel the non-linear term a $\sin (x_2)$. Also illustrate the inner and outer loop control architecture for the same.

b)

Compute the lie-brackets of vector fields
$$f(x)$$
 & $g(x)$ on R^3 given as
$$f(x) = \begin{bmatrix} x_2 \\ \sin x_1 \\ x_3^2 + x_1 \end{bmatrix}, \ g(x) = \begin{bmatrix} 0 \\ x_2^2 \\ 0 \end{bmatrix}$$

and denoted by [f, g]
