UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.Tech. Mechatronics **Semester – V**
Subject (Course): Robotics & Control **Max. Marks : 100**
Course Code : MEEL 333 **Duration : 3 Hrs**
No. of page/s: 03

Note: 1.) Section A has five questions of 4 marks each.

2.) Section B has four questions of 10 marks each.

3.) Section C has three questions of 20 marks each.

4.) All the questions in Section A and Section B are compulsory. Attempt any two questions from section C.

5.) Assume any missing data.

SECTION A

Q.1: Differentiate between hybrid and impedance control techniques.

Q.2: Differentiate between forward and inverse kinematics.

Q.3: What is the purpose of a wrist? What is its typical degrees-of-freedom in an industrial robot?

Q.4: Prove the following:

a) det(**Q**) = 1

b) $\mathbf{Q}^{-1} = \mathbf{Q}^T$

where, **Q** = rotation matrix.

Q.5: What are the different subsystems of a robotic system?

SECTION B

Q.6: A joint drive system consists of a DC servomotor with total inertia of 0.02 kg-m^2 and bearing friction of 0.5 N/s and a gearbox with gear ratio of 32. The link inertia is 5 kg-m^2 and the link bearing friction is 2 N/s. Determine the effective inertia (J_{eff}) and effective damping (B_{eff}) for the joint. Assume all shafts are rigid and massless. If the transfer function of above system is given by:

$$G(s) = \frac{1}{J_{eff} s^2 + B_{eff} s + 1}$$

determine the natural frequency, damping ratio, and the time response of the system for a unit step input.

Q.7: Consider the mass-spring-damper system shown in Fig.1. Design a control system for regulating the position of mass, using a

a) proportional derivative (PD) control strategy.

(b) partitioned proportional derivative (PPD) control strategy.

Give the control system block diagram and the mathematical model for the control system.

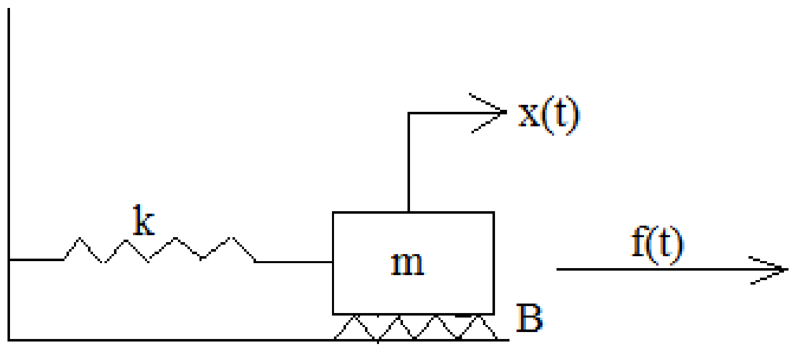

Fig.1: A mass-spring-damper system (Figure for Q.7)

Q.8: For the 2-DOF planar manipulator shown in Fig. 2, determine the joint displacements for known position and orientation of the end of the arm point using inverse kinematics analysis.

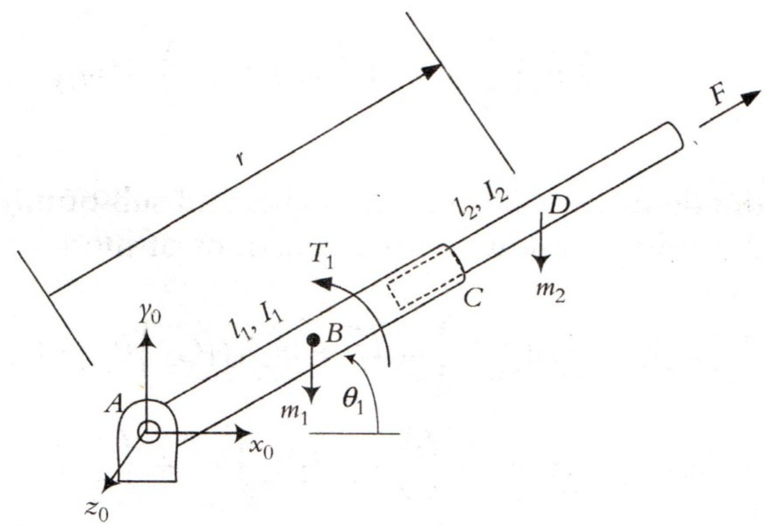

Fig.2: A 2-DOF planar manipulator (Figure for Q.8)

Q.9: Derive the velocity relationship and differential motion relationship between the joint coordinates and tip coordinates of a planar 2-DOF articulated manipulator arm. Comment on your results.

SECTION C

Q.10: The trajectory between two points is divided into two segments and two-cubic polynomial interpolation is to be used. The boundary conditions that the polynomials must satisfy are:

(i) position constraints at start, lift-off, set-down and goal positions, and

(ii) continuity of velocity and acceleration at all the path points.

Determine the polynomial for each segment. Give the general expressions.

Q.11: a) It is required to unscrew a screw from an electricity panel board with the help of a screw-driver attached at the end-effector of a robot. Describe the natural and artificial constraints for this control task.

b) Model the contact between the screw and screw-driver using a single degree of freedom mass-spring system to implement a hybrid control strategy.

Q.12: a) It is required to scrap paint from a glass pane with the help of a scrapping tool attached at the end-effector of a robot. Describe the natural and artificial constraints for this control task.

b) Model the contact between the scrapping tool and glass pane using a single degree of freedom mass-spring system to implement a hybrid control strategy.