



Name :

Roll No. :

Invigilator's Signature :

CS/B.Tech(ME)/SEM-1/ME-102/2009-10

2009

MECHATRONICS SYSTEMS DYNAMICS

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

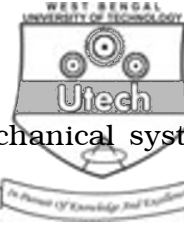
Answer any *five* question at least two from **Group A**.

GROUP – A

1. a) Determine the transfer function $V_o(s)$ to $V_i(s)$ for the network shown below : 7

Fig. 1

CS/B.Tech(ME)/SEM-1/ME-102/2009-10



- b) Obtain the transfer function of the mechanical system shown below between x_1 and f (Fig. 2).

Fig. 2

2. a) Obtain the transfer function of field controlled DC motor between applied field voltage and angular displacement.
- b) Obtain the unit step response of the following system :

$$\frac{C(S)}{R(S)} = \frac{10}{S^2 + 2S + 10} \quad 7$$



3. a) The open loop transfer function of a system with unity feedback gain is given by

$$G(S) = \frac{20}{S^2 + 5S + 6} .$$

Determine the damping ratio, maximum overshoot, rise time and peak time. 7

- b) The moment of inertia J_m and the co-efficient of viscous friction f_m for a field controlled *dc* servomotor are $5 \times 10^{-4} \text{ kg-m}^2$ and $12.5 \times 10^{-4} \text{ Nm / (rad/s)}$. Take motor torque constant k_f being 2.5 Nm / A . Determine the transfer function relating angular speed of the shaft and field current. Draw the block diagram. 7

GROUP – B

4. a) Define rigid body. 2



- b) A mechanical system consisting of spring, mass and damper is shown in Fig. 3. The system is initially at rest and the displacement x is measured from the equilibrium position. Assume that mass $m = 1$ kg, damping co-efficient $b = N - s/m$ and spring constant $k = 100 N / m$. Obtain the response of the system when $10 N$ of force (a step input) is applied to the mass m . 12

Fig. 3

5. a) Define ideal damper. 3
- b) An optical scanner used reading bar codes is shown in Fig. 4. As the mirror rotates, a friction force is developed



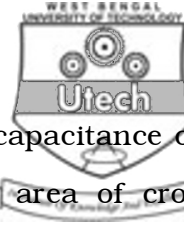
which is proportional to its angular speed. The friction constant b is equal to 0.04 N.S./rad and the moment of inertia J is equal to 0.1 kg m^2 . The output variable is the velocity $\omega (t)$.

- i) Obtain the differential equation of motion of the motor. 3
- ii) Find the response $\omega (t)$ of the system when the input torque $T (t)$ is an unit step function and the initial velocity at $t = 0$ is equal to 0.5 rad/s . The unit step function is defined as 8

$$u_s (t) = 0 \text{ for } t \leq 0$$

$$= 1 \text{ for } t > 0$$

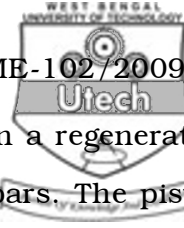
Fig. 4



6. a) Derive an expression showing that the capacitance of a tank containing liquid is related with area of cross-section of the tank and liquid mass density. 4
- b) A two capacity liquid flow system (Fig. 5) has time constants $(R_1 C_1 \text{ and } R_2 C_2)$ of 600 and 1800 seconds respectively. The liquid is water and $R_2 = 3.2 \times 10^6 \text{ N-S / m}^5$. Find the transfer function relating ' h_2 ' and inflow rate ' m '. 10

Fig. 5

7. a) How do a simple pressure relief and compound relief valve differ in operation ? 3
- b) Explain the role of an unloading valve in a hydraulic circuit with two pumps (one a high pressure low flow pump and the other a low pressure high flow one). 6



- c) A double acting cylinder is hooked up in a regenerative circuit. The relief value setting is 105 bars. The piston area is 130 cm^2 and the rod area is 65 cm^2 . If the pump flow is $0.0016 \text{ m}^3/\text{s}$, find the cylinder speed for the (i) extending stroke (ii) retracting stroke. 5
8. a) Discuss the working principle of a torque motor and how it controls the flow through the servo valve ? 4
- b) Discuss the principle of operation of a lubricator in a pneumatic system. 4
- c) Two pneumatic cylinders are to be sequentially operated. Draw the pneumatic circuit and explain its working principle. 6
-