M.E. PRODUCTION ENGINEERING
FIRST YEAR, FIRST SEMESTER EXAM 2024

AUTOMATION OF PRODUCTION SYSTEMS

Time: Three hours Full Marks 100

Answer any FIVE questions
All parts of a question (a, b etc.) must be answered at one place.

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1. What is CIM? Explain different element of CIM system with the help of suitable diagram. Differentiate between automation and CIM.

   4+10+6

2. (a) What are the general requirements for selection of part feeder?
   (b) Derive the limiting conditions for forward and backward sliding and show them graphically. Show that for forward conveying
   $$\tan\varphi > \frac{\tan\theta}{\mu^2}$$
   Where θ is track angle and Φ is vibration angle.

   6+14

3. What is the function of an orienting device? What are the differences between in-bowl and out-of-bowl tooling? With the help of neat sketch describe the orienting mechanism for screw and cup-shaped parts in vibratory bowl feeder.

   3+3+14

4. (a) Discuss different types of feed track used for delivering parts to workhead.
   (b) Give one example of simple escapement cum part placing mechanism with figure.
   (c) Discuss ratchet escapement, slide escapement and gate escapement with neat sketches.

   4+4+12

5. (a)Explain on-off control with help of an example? What are its disadvantages?

(b) Consider the gear train used in servo systems shown in Fig. 6(b). In this system, a load is driven by a motor through the gear train. Assuming that the stiffness of the shafts of the gear train is infinite (there is neither backlash nor elastic deformation) and that the number of teeth on each gear is proportional to the radius of the gear, obtain the equivalent moment of inertia and equivalent viscous-friction coefficient referred to the motor shaft.

In Fig. 6(b) the numbers of teeth on gears 1,2,3 and 4 are N_1, N_2, N_3, and N_4, respectively. The angular displacements of shafts 1,2 and 3 are θ_1, θ_2 and θ_3,, respectively. Thus, $\theta_2/\theta_1 = N_1/N_2$ and $\theta_3/\theta_2 = N_3/N_4$. The moment of inertia and viscous-friction coefficient of each gear train component are denoted by J_1, b_1; $J2$, b_2 and J_3, b_3; respectively. (J_3 and b_3 include the moment of inertia and friction of the load.)

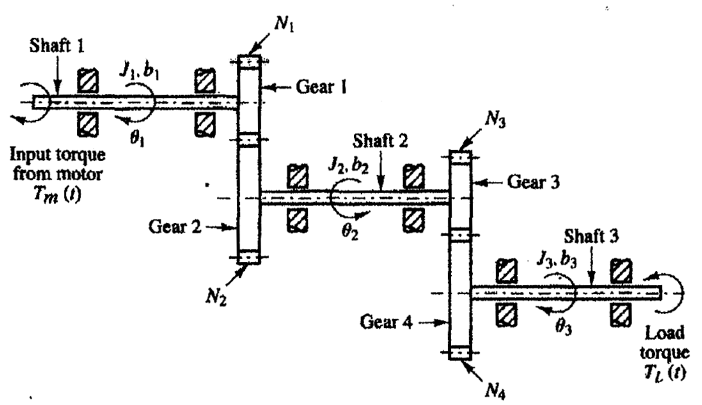

Fig. 6(b)

(c) Consider an electrical circuit consisting of a $1M\Omega$ resistance in series with a $2\mu F$ capacitance. Determine how the voltage across the capacitor will vary with time (also show the response curve) when,

i) at a time t=0 the circuit is subject to a voltage of $6V$.

ii) at a time t=0 the circuit is subject to a ramp voltage of $4t$ volt, i.e., the voltage increases uniformly at the rate of $4V$ every 1 sec.

4+10+6

6. (a) The closed loop transfer function of a second order system is given by

$$\frac{C(S)}{R(S)} = \frac{w_n^2}{s^2 + 2\lambda w_n s + w_n^2}$$

Where, w_n = undamped natural frequency of the system

λ = damping ratio of the system.

Find out the unit step response when the system is critically damped.

(b) Obtain the closed loop transfer function for the positional servo system shown in Fig. 7(b). Assume that the input and output of the system are the input shaft position and output shaft position, respectively. Assume the following numerical values for system constants

r = angular displacement of the reference input shaft, radians.

c = angular displacement of output shaft, radians

θ = angular displacement of the motor shaft, radians

k_p = gain of the potentiometric error detector = $24/\pi$ v/rad

k_v = amplifier gain = 10 v/v

e_a = armature voltage, v

e_b = back emf, v

Ra = armature resistance = 0.2 Ω

La = armature winding inductance = negligible

i_a = armature winding current, A

k_b= back emf constant = $7\text{x}10^{-3}$ v-sec/rad

k_t = motor torque constant = $7\text{x}10^{-3}$ N-m/A

J_m= moment of inertia of the motor referred to the motor shaft = $1\text{x}10^{-5}$ kgm^2

b_m= viscous-friction coefficient of the motor referred to the motor shaft = negligible

J_L = moment of inertia of the load referred to the output shaft = $4.4\text{x}10^{-3}$ kg-m^2

b_L=viscous-friction coefficient of the load referred to the output shaft=$4\text{x}10^{-2}$ N-m/rad/sec

n = gear ratio N_1/N_2 = 1/10.

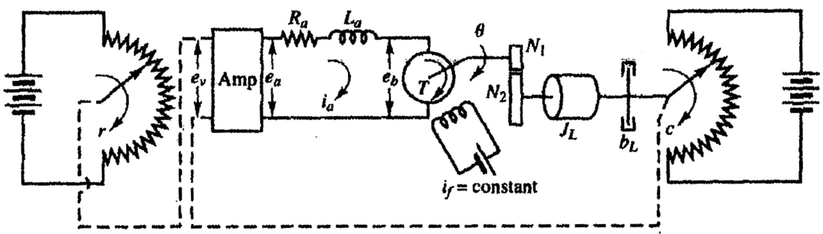

Fig. 7(b)

6+14

7. (a) What are the advantages of PID control over proportional control?
   (b) Draw an op-amp controller circuit that may be used as PID controller and find out the transfer function of the controller and also determine the proportional, integral and derivative gain of the controller.

5+15