ME Sem II / Mech / Choice base / Second half 2018

Paper / Subject Code: 35001 / System Modeling & Analysis.

15/11/2018.

(3 HOURS) **TOTAL MARKS : 80**

N.B. : (1) Attempt any **four** questions.
(2) Assumptions made should be **clearly** stated.
(3) Use log/semi – log paper is permitted.

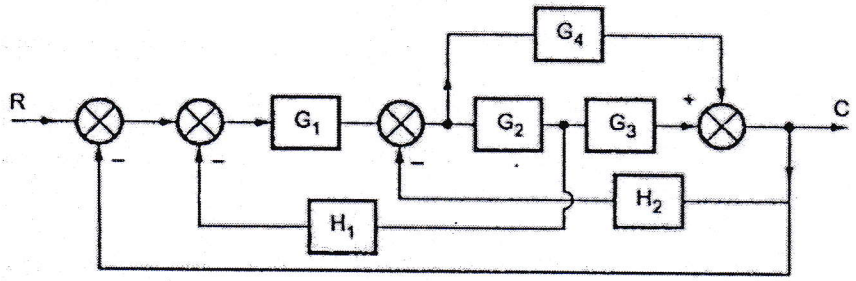
Q.1) (a) Find the transfer function for the following systems represented in state space. (10)

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}-1 & 1 & 0\\ 0 & -1 & 1\\ 0 & 0 & -2\end{bmatrix}[x] + \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}[u]$$

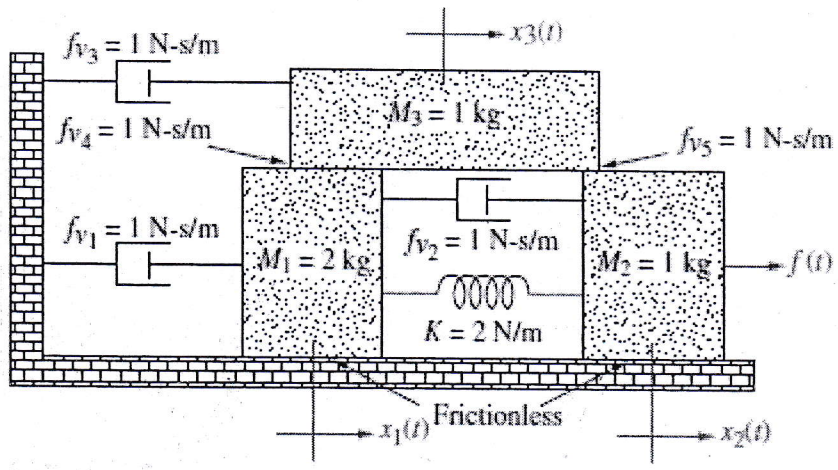
$$[y] = [1 \quad 0 \quad 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

(b) Distinguish between modern control theory and conventional control theoty. Explain state of dynamic system, state variable, state space, state equation and output equation involved in state space modeling (10)

Q.2) (a) Find $\frac{C(s)}{R(s)}$ by Mason's gain formula for system shown below (10)

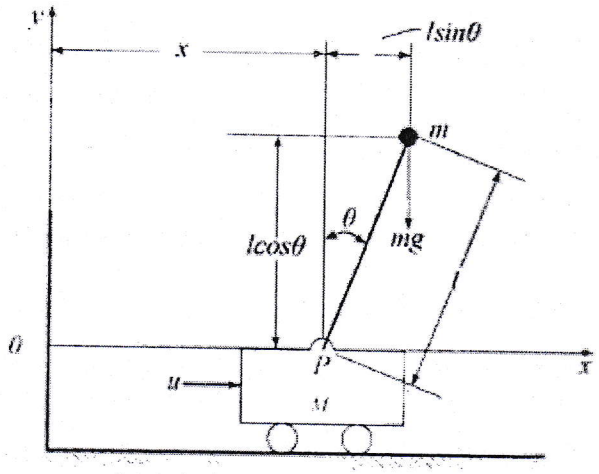


(b) Obtain state space representation of the system shown below where output is $x_3(t)$ (10)



Q.3) (a) Write a note on Lyapunov Stability and modeling via Lyapunov. Also explain any nonlinear modeling technique considering structural and/or material nonlinearity (10)

(b) An inverted pendulum mounted on a motor-driven cart is shown in figure. Assume that the input to the system is the control force u applied to the cart and the two outputs are the angle Θ of the rod from the vertical axis and the position x of the cart. Derive equations of motion and obtain transfer functions of the system shown below. (10)



Q.4) (a) Sketch the Nyquist plot of unity feedback system with (10)

$$G(s) = \frac{k(1+s)}{s(s+0.2s)(s+0.5s)}$$

(b) Sketch the root locus diagram of a control system having H(s)=1 and (10)

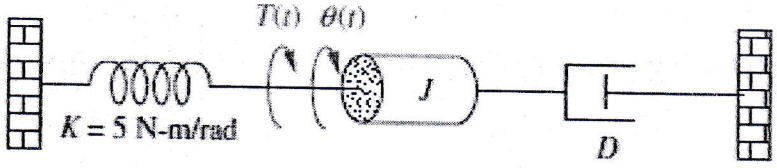
$$G(s) = \frac{k(s+1)}{s(s-1)(s^2+4s+16)}.$$

Comment on stability of the system. Also find the frequency of oscillation.

Q.5) (a) Sketch the bode plot. Determine the gain margin, phase margin, gain crossover frequency and phase crossover frequency for the unity feedback system having open loop transfer function (10)

$$G(s) = \frac{64(s+2)e^{-0.2s}}{s(s+0.5)(s^2+3.2s+64)}.$$

(b) For the system shown in Figure below, find J and D to yield 20% overshoot and a settling time of 2 seconds for a step input of torque T(t). (10)



Q.6) (a) Find the range of k for stability of a unity feedback system. Also find k_{mar} and ω_{mar} (10)

$$G(s) = \frac{k}{s(s+2)(s+4)(s+6)}$$

(b) Consider the liquid-level system shown in Figure below. At steady state, the inflow rate and outflow rate are both $\bar{Q}$ and the flow rate between the tanks is zero. The heads of tanks 1 and 2 are both $\bar{H}$. At t = 0, the inflow rate is changed from $\bar{Q}$ to $\bar{Q} + q$, where q is a small change in the inflow rate. The resulting changes in the heads (h_1 and h_2) and flow rates (q_1 and q_2) are assumed to be small. The capacitances of tanks 1 and 2 are C_1 and C_2 respectively. The resistance of the valve between the tanks is R_1 and that of the outflow valve is R_2. Derive mathematical models for the system when (a) q is the input and h_2 the output, (b) q is the input and q_2 the output, and (c) q is the input and h_1 the output. (10)