Question Paper

Exam Date & Time: 28-Nov-2019 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
END SEMESTER THEORY EXAMINATION - NOVEMBER/ DECEMBER 2019
IV SEMESTER B.Sc.(Applied Sciences)in Engg.
Dynamics Of Systems [ME 244]

Marks: 100 **Duration: 180 mins.**

Answer any FIVE full Questions.
Missing data, if any, may be suitably assumed

1) A) Define corner frequency with respect to frequency domain analysis. Determine the magnitude and phase using bode plot analysis for the open loop transfer function (10)

$$G(s) = \frac{e^{-0.2s}}{s(s+2)(s+8)}$$

B) With the help of a neat diagram, derive the transfer function for an armature controlled DC servo motor. (10)

2) A) Sketch the Nyquist plot for an open loop transfer function of a system which is defined as: (12)

$$G(s)H(s) = \frac{K(4s+1)}{s(s-1)}$$

Also compute the range of K for which the system is stable.

B) For a system which is subjected to a step of 1 volt, the open loop transfer function is given by (8)

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

Find a) Time to first maximum b) Time to first minimum c) Time to second maximum d) Time to second minimum

3) A) Describe any four disadvantages of the classical LTI approaches which are overcome by the use of state space approach. Obtain the state space model for the following transfer function using phase variables. (12)

$$\frac{Y(s)}{U(s)} = \frac{s^2 + 3s + 4}{s^3 + 2s^2 + 3s + 2}$$

B) Derive the expression for the response of an over damped second order system for a (8) unit step input and draw its response.

4) A) With mathematical expressions, describe the behavior of four test signals used in time domain analysis. (4)

B) What is damping ratio with respect to a second order system? Describe the effect of damping ratio on the performance of a second order system by considering the characteristic equation. (6)

C) For the electrical system shown in fig. 4(c), (10)
i) Write down the differential equations describing the electrical system.
ii) Draw the equivalent mechanical analogous system and rotational analogous system.
iii) Write the differential equations for mechanical translational and rotational system.

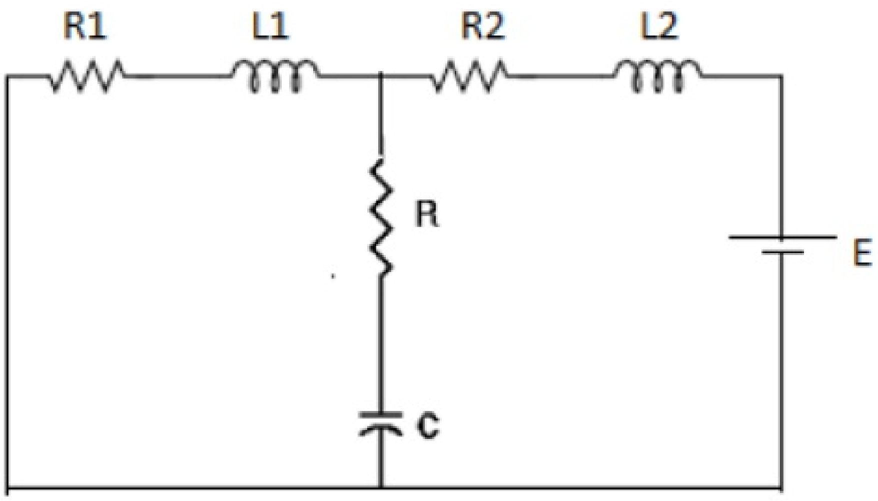

Fig 4(c)

5) A) Define Controllability and Observability. Evaluate both for the following parameters of the state space model: (10)

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 8 \\ 4 \\ 0 \end{bmatrix} \quad C = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix}$$

B) Write the conditions for Bounded Input Bounded Output (BIBO) stability. For the characteristic equation given below, calculate the number of roots lying on the right hand side of the s-plane and comment on the stability of the system using the R-H stability criterion. (10)

$$s^7 + 9s^6 + 24s^5 + 24s^4 + 24s^3 + 24s^2 + 23s + 15 = 0$$

6) A) For the mechanical rotational system shown in fig. 6(a), (12)
Draw equivalent mechanical network and with free body diagrams, write down the differential equations describing the system.
Draw analogous electrical network based on force current analogy and write down the analogous electrical equations.

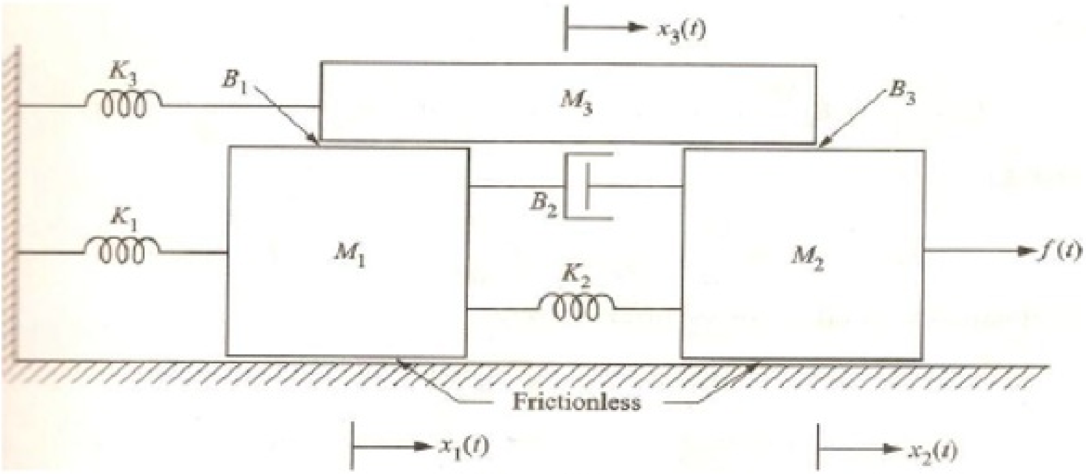

Fig 6(a)

B) Define steady state error and write its mathematical expression. Consider a unity feedback system with a closed loop transfer function (8)

$$M(s) = C(s) / R(s) = \frac{Ks+b}{s^2+as+b}$$

Determine open loop transfer function G(s). Show that the steady state error for a unit ramp input is given by (a - K)/b.

7) A) Consider a system defined by $\dot{X}$=Ax+Bu, where, (16)

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using the state-feedback control **u = -Kx**, it is desired to have closed loop poles at -2-4j,-2+4j and -10 respectively. Determine the state-feedback gain matrix K. Verify the result by using Ackerman's formula.

B) Differentiate between open loop system and closed loop system with an example. (4)

8) A) What is the need of controller in control systems? With neat sketches, explain proportional plus integral (PI), proportional plus derivative (PD) and proportional integral derivative (PID) controllers (8)

B) Sketch the root locus for the open loop transfer function of a unity feedback system given by: (12)

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

Also, determine K for damping ratio of 0.5 from the root locus.

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