Ref. No: Ex/EE/T/314/2018

B.E. ELECTRICAL ENGINEERING THIRD YEAR FIRST SEMESTER - 2018

LINEAR CONTROL SYSTEM
Part-I

Time: Three Hours: Full Marks: 100 (50 Marks for each Part)
Use Separate Answer script for each part

Answer any *three* questions from this part.
Two marks reserved for neat and well-organized answer

1. a) State the difference between a *time invariant control system* and a *time varying control system* with the help of suitable examples. 4+4+8

   b) Explain the following statement: *Use of feedback makes a control system relatively insensitive to internal variations in system parameters.*

   c) Determine the values of K and k of the closed-loop system shown in Fig 1 so that the maximum overshoot in unit step response is 25% and the peak time is 2 sec. Assume that J=1 kg-m^2.

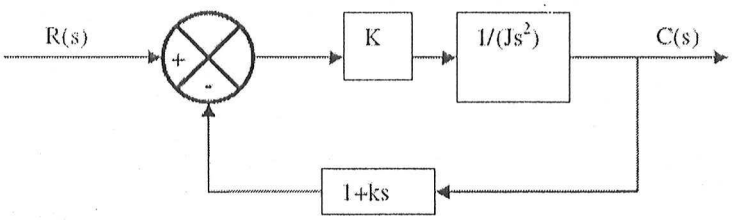

Fig. 1

2. a) For a closed loop unity feedback system with ramp input, justify the following statement: *As type of system increases, the steady state error decreases.* 4+6+6

   b) Given a unity feedback system with forward path transfer function $G(s)=\dfrac{10}{s(s+1)(s+2)}$. Find the position, velocity and acceleration error constants.

   c) The unity feedback system with a forward path transfer function $G(s)=\dfrac{K(s+\alpha)}{(s+\beta)^2}$ is to be designed to meet the following specifications: $e_{ss}\big|_{position} = 0.1\overline{rad}$; Damping ratio = 0.5 and Natural frequency of oscillation = $\sqrt{10}$. Find the values of K, α and β.

3. a) Explain the physical significance of the term *damping ratio* for second order control systems. 4+4+8

   b) State what you understand by the term *sensitivity* of an error sensor. What are its units?

   c) A unity feedback proportional control system has a forward path transfer function

$$G(s)=\frac{10}{s(s+1)}.$$

   If output rate feedback is introduced with feedback transfer function $(1+T_d s)$, what should be the value of T_d to obtain damping ratio of 0.5? What would be the change in the peak overshoot?

4. a) Explain the principle of operation of A.C. Drag Cup Tachogenerator. 4+12

b) The constants for a voltage regulator are given below:

Gain K_A	=	100 V/V
Field resistance	=	200 ohms
Field inductance	=	100 henry
Field constant	=	1 mwb/amp
Armature resistance	=	0.2 ohm
Armature inductance	=	negligible
Speed	=	1000 rpm
EMF constant	=	200 mV/μwb at 1000 rpm
Load current	=	negligible
Feedback factor	=	0.1

Find the general expression for the forward transfer function and the error transfer function. Determine the steady state error voltage to a step input $V_r=V_iu(t)$. Compute this value when $V_i=10$ volts. What is the steady-state output voltage?

5. The transfer function of a plant is given by 16

$$G(s)=\frac{K}{s(s+1)(s+2)}.$$

Design a suitable compensator to meet the following specifications:

a) Velocity constant $K_v \geq 10$ sec^{-1}.

b) Phase margin $\phi_m \geq 35^{\circ}$.

B.E. ELECTRICAL ENGINEERING EXAMINATION, 2018

(Third Year, First Semester)

Linear Control Systems

Part-II

Use separate Answer-script for each part

Time: Three Hours **Full Marks: 100/50√**

Answer Question No. 6 and any Two From the rest

Q6. Answer the following questions. 4x4½=18

i. Establish the relationship between GH-plane and q(s) plane. The symbols carry their usual meanings.

ii. State and explain Hurwitz's stability criterion.

iii. State whether the following statement is correct or not. Justify your answer with necessary derivation.

"A physical system can have infinite number of State Models."

iv. Explain the significance of breakaway/break in points.

Q7a. Plot the Root-Locus for a unity feedback system whose forward path transfer function is as follows. 10+6

$$G(s) = \frac{K(s+2)}{s^2+2s+3},\ K \geq 0$$

Also determine and indicate on the sketch i) number and angles of asymptotes, ii) the centroid, iii) the breakaway point/ points, if any, iv) intersection of the root locus and the asymptotes with the imaginary axis, if

anyv) the range of gain K for which the closed loop system remains stable, vi) any other value that has relevance to the plotting of root locus.

Q7b. Also prove that part of the root locus will describe the locus of a circle. Find out the centre and the radius of the circle.

Q8. For the system described by the following transfer function, sketch the Nyquist plot and ascertain the value of K for which the closed loop system would be stable.

16

$$G(s)H(s)=\frac{K}{s(1+T_1 s)(1+T_2 s)}$$

Q9a.The state model of a third-order system is given below. By means of Routh's criterion, determine the stability of the system. 10

$$\frac{d}{dt}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\-6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}+\begin{bmatrix}0\\0\\1\end{bmatrix}u \ldots and\ y(t)=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}$$

The symbols and notations carry their usual meanings.

Q9b. Find the C/R for the system shown in Fig. P-9b. Assume N=0.

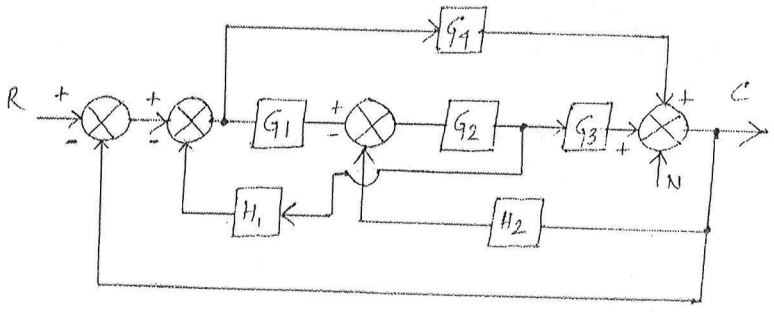

Figure P9b.

06

Q10a. What is a Modal Matrix? With the help of suitable derivation establish the fact that a modal matrix is instrumental for generating a Diagonal System matrix. 3+4

Q10b. Explain how are the Eigenvalues related to the closed loop poles of the system. 3

Q10c. The State equation of a control system is given by

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Obtain the state transition matrix. 6