ROLL NO. ________________

Code: AE61/AE109 **Subject: CONTROL ENGINEERING**

AMIETE – ET (Current & New Scheme)

Time: 3 Hours **DECEMBER 2018** **Max. Marks: 100**

PLEASE WRITE YOUR ROLL NO. AT THE SPACE PROVIDED ON EACH PAGE IMMEDIATELY AFTER RECEIVING THE QUESTION PAPER.

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q.1 must be written in the space provided for it in the answer book supplied and nowhere else.**
- **The answer sheet for the Q.1 will be collected by the invigilator after 45 minutes of the commencement of the examination.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or the best alternative in the following: (2×10)

a. A system is represented by the differential equation

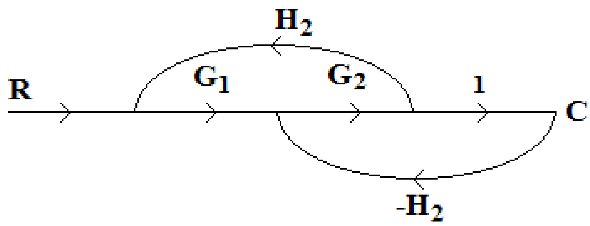
$$M\frac{d^2x}{dt^2} + F\frac{dx}{dt} + K_{OL} = u(t)$$

The transfer function relating X(s) & U(s) is

(A) $\frac{M}{Ms^2 + Fs + K}$ **(B)** $\frac{F}{Ms^2 + Fs + K}$

(C) $\frac{K}{Ms^2 + Fs + K}$ **(D)** $\frac{1}{Ms^2 + Fs + K}$

b. The overall transfer function for the SFG given below is:



(A) $\frac{G_1G_2}{1 - G_1G_2H_1 + G_2H_2}$ **(B)** $\frac{G_1G_2}{1 + G_1G_2H_1 + G_2H_2}$

(C) $\frac{G_1G_2}{1 - G_1G_2H_1 - G_2H_2}$ **(D)** $\frac{G_1G_2}{1 + G_1G_2H_1 + G_2H_1}$

c. The error detector element in a control system gives

(A) Sum of reference signal & feedback signal
(B) Sum of reference signal & error signal
(C) Difference of reference signal & feedback signal
(D) Difference of reference signal & output signal

d. Which of the following transfer function will have greatest maximum overshoot

(A) $\frac{2}{s^2 + 2s + 9}$ **(B)** $\frac{16}{s^2 + 2s + 16}$

(C) $\frac{25}{s^2 + 2s + 25}$ **(D)** $\frac{36}{s^2 + 2s + 36}$

e. The impulse response of the system $\frac{C(s)}{R(s)} = \frac{8}{s(s+2)(s+4)}$ is

(A) $C(t) = 2 - e^{-2t} + e^{-4t}$
(B) $C(t) = 1 + 2e^{-2t} - 4e^{-4t}$
(C) $C(t) = 1 - 2e^{-2t} + e^{-4t}$
(D) $C(t) = 2 + e^{-2t} - 4e^{-4t}$

f. With reference to the following characteristic equation of a feedback control system. The centroid of the root locus plot is
$s^3 + 2s^2 + Ks + K = 0$

(A) 0.5
(B) –0.5
(C) –1
(D) 1

g. For the system having open loop transfer function

$$G(s)H(s) = \frac{70}{s(s+2)(s+5)}$$

the GM is

(A) 2 db
(B) 5 db
(C) 7 db
(D) 0 db

h. The initial slope of the Bode plot for a type 2 system intersects 0 db axis at

(A) $\omega = 0$
(B) $\omega = K$
(C) $\omega = \sqrt{K}$
(D) $\omega = K^2$

i. The transfer function

$$G_c(s) = \frac{1 + R_2C_2s}{1 + (R_1 + R_2)C_2s}$$ represents

(A) Lead Network
(B) Lay Network
(C) Lay-lead Network
(D) Feedback Network

j. The characteristic equation for a system having static equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \text{ is}$$

(A) $s^2 + 5s + 8 = 0$
(B) $s^2 + 4s + 3 = 0$
(C) $s^2 + 4s + 5 = 0$
(D) $s^2 + 4s + 2 = 0$

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. A torque controller uses a split field motor for position control. The error detector gain is 10 V per radian error and the amplifier transconductance is 100 mA/V. The motor torque constant is 5×10^{-4} Nm/mA. The moment of inertia and the coefficient of viscous friction at the motor shaft are respectively 1.25×10^{-5} kg-m^2 and 5×10^{-4} Nm/(rad/sec). The motor is coupled to the load through a gear having a ratio 20:1. Draw the block diagram of the system showing the transfer function of each block and determine the overall transfer function relating the output and input. **(10)**

b. Draw the mechanical circuit diagram for the system shown in figure1 and write system equations. **(6)**

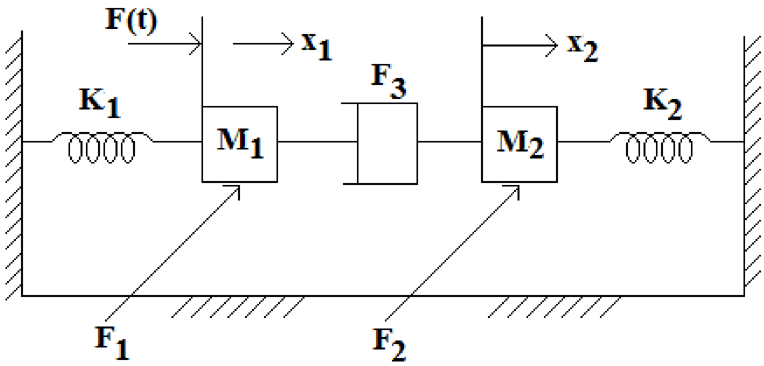


Figure 1

Q.3 a. Determine the transfer function C/R from the block diagram shown in Figure 2. **(8)**

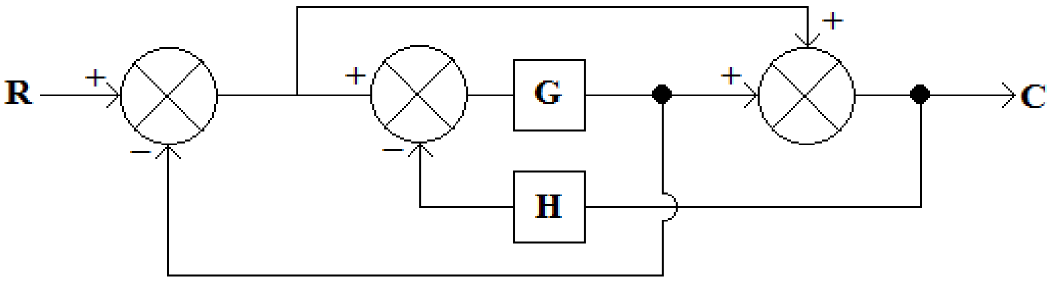


Figure 2

b. Draw the signal flow graph and determine the overall transfer function using Mason's gain formula for the block diagram shown in figure 3. **(8)**

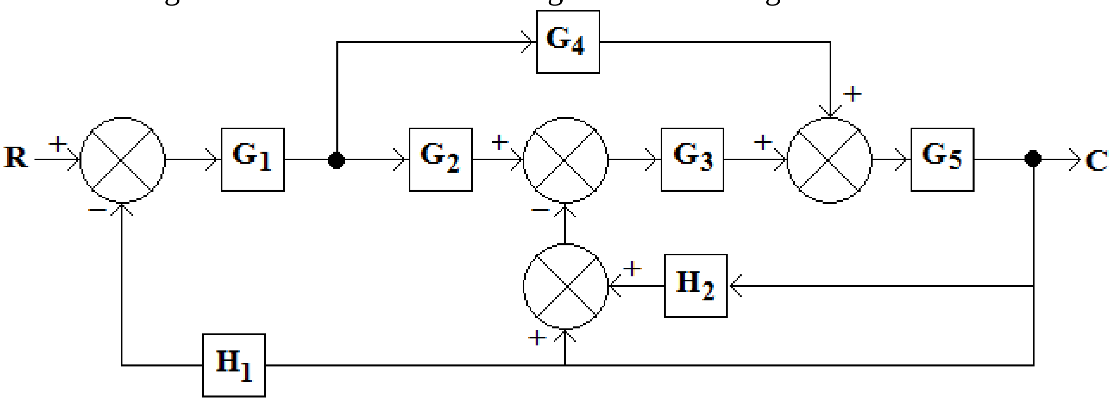


Figure 3

Q.4 a. Differentiate between open loop and closed loop systems. **(4)**

b. Discuss the effects of feedback on control systems. **(8)**

c. Write a short note on hydraulic system with suitable diagrams. **(4)**

Q.5 a. The forward path transfer function of a unity feedback control system is given by

$$G(s) = \frac{20}{(s+1)(s+5)}$$

Determine the characteristic equation of the system, ω_n, damping ratio, ω_d, t_p, m_p, the time at which the first undershoot occurs, the time period of oscillations and the number of cycles completed before reaching the steady state. **(10)**

b. Determine the stability range of K for a system having characteristic equation $s^4 + 2s^3 + 10s^2 + (K - 10)s + K = 0$ **(6)**

Q.6 a. Enumerate the procedure of construction of root Loci plots. **(8)**

b. Draw the root locus diagram for the open loop transfer function of a unity feedback control system given as

$$G(s) = \frac{K}{s(s+6)^2}$$

Determine the value of centroid and the frequency at which the root locus branches cross the imaginary axis. **(8)**

Q.7 a. The open loop transfer function of a unity feedback control system is given as

$$G(s) = \frac{Ke^{-0.5s}}{(0.5s+1)}$$

(i) Plot the asymptotic Bode plot for K=1
(ii) Determine the limiting value of K for stability **(8)**

b. A unit step input is applied to a unity feedback control system whose open loop transfer function is given by

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

Determine the values of K & T given that maximum overshoot M_p=26% and resonant frequency is ω_r= 8 rad/sec. Calculate the resonant Peak M_r, Gain crossover frequency and Phase Margin. **(8)**

Q.8 The open loop transfer function of a unity feedback control system is given by $G(s) = \frac{K}{s(s+2)}$. The system is to have 25% maximum overshoot and peak time 1.0 second. Using feedback compensation method determine the value of K and tachometer feedback constant K_t. **(16)**

Q.9 a. Obtain the time response of the system **(8)**

$$\dot{X} = Ax, \text{ where } A = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix} \text{ given } X(0) = [1 \;\; 1]^T \text{ and } Y = [1 \;\; -1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

b. Check for controllability and observability of a system having following coefficient matrices. **(8)**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} \quad \text{and } C^T = \begin{bmatrix} 10 \\ 5 \\ 1 \end{bmatrix}$$