(*University of Choice*)

**MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)**

MAIN CAMPUS

**UNIVERSITY EXAMINATIONS**
**2021/2022 ACADEMIC YEAR**

**FOURTH YEAR FIRST SEMESTER EXAMINATIONS**

**FOR THE DEGREE**
**OF**
**BACHELOR OF SCIENCE IN MECHANICAL AND INDUSTRIAL ENGINEERING**

**COURSE CODE:** MIE 453
**COURSE TITLE:** CONTROL ENGINEERING

**DATE: MONDAY, APRIL 25TH, 2022** **TIME: 3.00PM-5.00PM**

**INSTRUCTIONS TO CANDIDATES**

Question ONE (1) is compulsory
Answer Any Other THREE (3) questions

TIME: 3 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 6 Printed Pages. Please Turn Over.

Q1. (a) (i) Name the two forms of representation of the open loop transfer function in time response analysis of control systems. (1 mks).

(ii) State Mason's gain formula. (2mks)

(iii) State the three necessary conditions for stability. (3mks)

(iv) In general. State the two concepts of stability and the systems where the two concepts are equal. (2mks)

(b) Consider the network in Fig.1.1 Obtain the relation between the applied voltage and current in the form of:

(i) Differential equation (2 mks)
(ii) Transfer function. (2 mks)

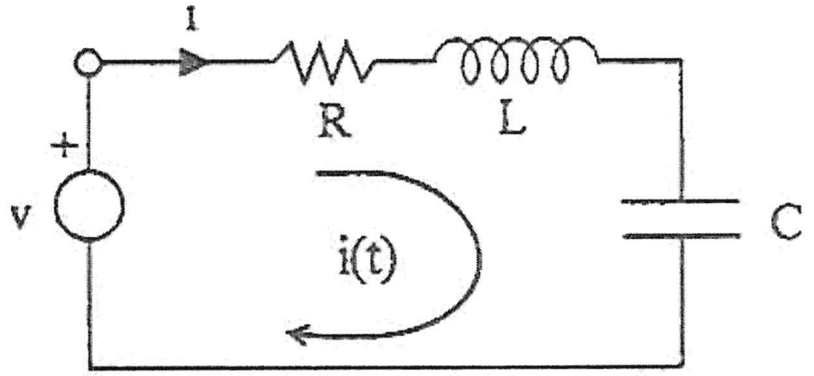


Fig.1.1

(c) Determine whether the time constant for the characteristic equation given below is greater than 1 sec. (2 mks).

$$\mathbf{D(s) = S^4 + 6S^3 + 14S^2 + 16S + 8}$$

(d) Name the four standard test signals that the control system is subjected to. (2 mks)

(e) (i) Consider a first order feedback system fig.1.2 subjected to a unit step input R(s)= $\frac{1}{s}$ where G(s)= $\frac{1}{\tau s}$. Derive c (t) and plot c (t) vs time and explain its response. (4 mks)

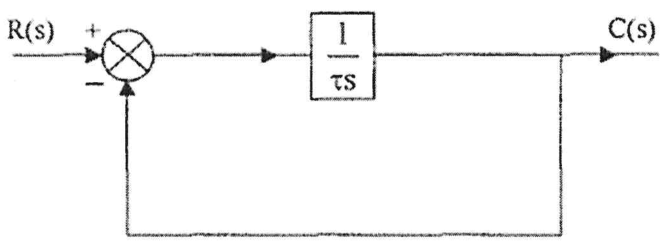


Fig.1.2

(ii) For the system under consideration in fig.1.2 derive the steady state error e(t) of the system and explain its implication on the system.(3 mks).

(f) For the open loop system in Fig. 1.3 (a) find the percentage change in the steady state value of C(s) for a unit step input and for a 10% change in K. (3 mks)

(g) For the closed loop system in Fig. 1.3 (b), find the percentage change in the steady state value of C(s) for a unit step input for the same increase in the value of K. (4 mks)

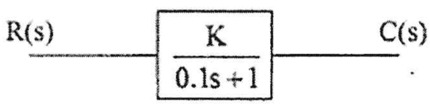


Fig. 1.3 (a) Open loop system

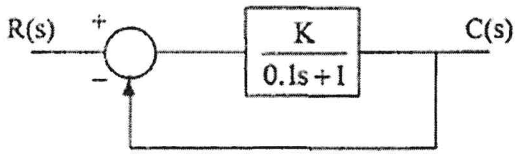


Fig. 1.3 (b) Closed loop system

Q2. (a) State the advantages and disadvantages of open and closed loop systems. (6 mks)

(b) Find the overall transfer function of the system shown in Fig.2.1 using the block diagram reduction technique. (7 mks)

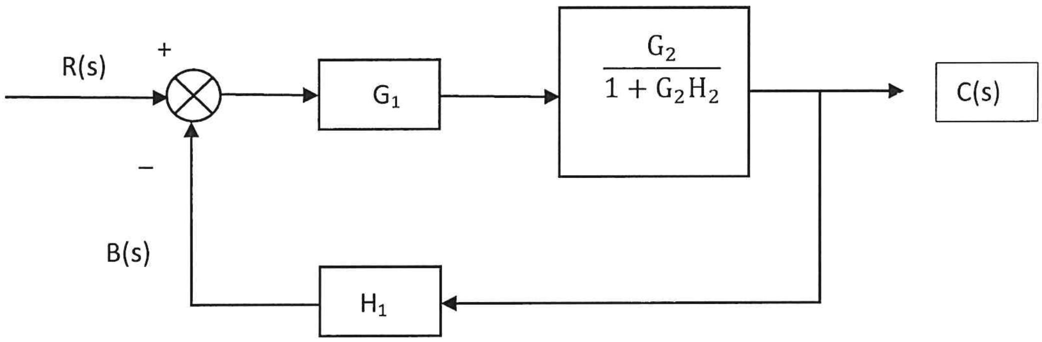


Fig.2.1

(c) Draw the signal flow graph and find the transfer function for the network in Fig. 2.2 using Mason's gain formula (7 mks)

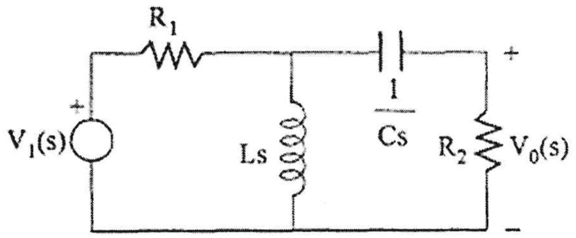


Fig.2.2

Q3. (a) Explain the difference between Routh Hurwitz and Nyquist Stability criterion (2 mks).

(b) Using Routh Hurwitz Criterion determine whether the characteristic equation indicated below is stable and indicate the number of roots in the right half of s-plane. (2 mks).

$$\mathbf{D(s) = S^4 + 2S^3 + S^2 + 4S + 2 = 0}$$

(c) Comment on the stability of the system with the following characteristic equation. (10 mks).

$$D(s) = S^6 + S^5 + 7S^4 + 6S^3 + 31S^2 + 25S + 25$$

(d) Consider a mechanical translational system in Fig 3.1. Derive its differential equation and transfer function. (6 mks).

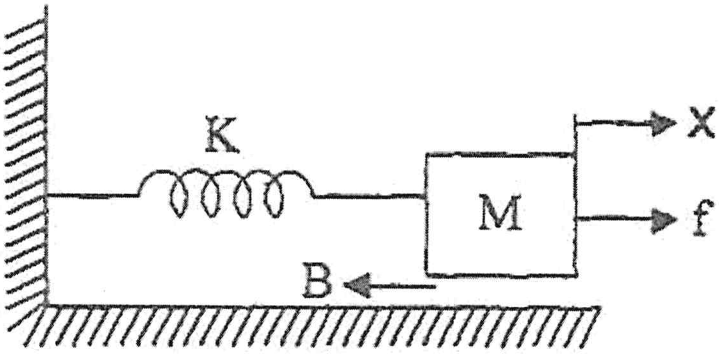


Fig.3.1

Q4. Sketch the root locus of the system with loop transfer function. (20 mks).

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

Q5. Consider a system

$$G_c(s) = \frac{K_v}{s(s+1)}$$

The specifications are:

$e_{ss}$ for a velocity input should be less than 0.1.

Phase margin should be greater than $40^{\circ}$.

Determine:

(i) The value of $K_{v.}$ (1mk)

(ii) Draw the Bode for the value of $K_{v.}$ ( 10 mks)

(iii) The gain cross over frequency. (2 mks).

(iv) Phase margin of uncompensated system. (2 mks)

(v) Phase lead, assuming $\Phi_{\epsilon}$ is $8^{o}$ . (2 mks)

(vi) $\alpha$ of the phase lead network. (3mks)