



MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EMM 415: CONTROL ENGINEERING I

DATE: 20/5/2019

TIME: 8.30-10.30 AM

INSTRUCTIONS

Answer Question ONE and any other TWO Questions.

Make your answers Exact and concise

QUESTION ONE (30 MARKS)

- a) Define the following terms as used in Control Engineering (2 marks)
- Plant
 - Servo mechanism
 - System
 - Controller
- b) Distinguish between the following types of Control Systems (4 marks)
- Linear and Non-linear system
 - Discrete and Continuous data system
 - Time variant and Time Invariant system
 - Adaptive and Optimal control system
- c) Distinguish between Open Loop and Closed Loop systems and state three applications of each in Mechanical and Manufacturing Engineering (4 marks)

- d) Discuss the Force-Voltage Analogy of the Mechanical Rotating System (3 marks)
- e) State any Four features of the Transfer Function (2 marks)
- f) A Mechanical System is shown in Figure Q 1f)

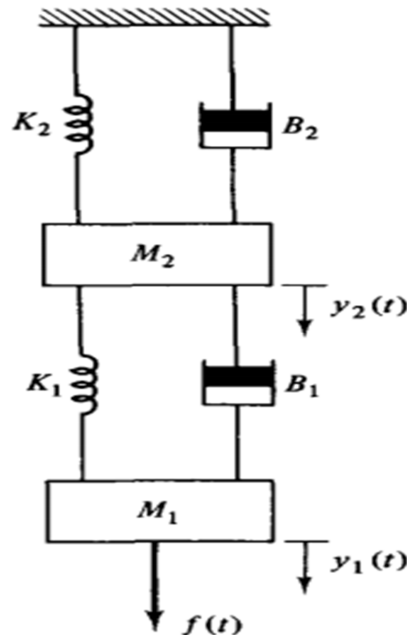


Figure Q 1f)

- i. By defining the respective *State Variables*, write the Differential Equations of the system hence Draw the *State Diagram* (Signal Flow Graph) (6 marks)
 - ii. Using the *Mason's Gain Formula*, determine the *Transfer Functions* of the System from the State Diagram in Figure Q 1 f) above (3 marks)
- g) Discuss the factors to consider when choosing a *Controller Design Software* for a Mechanical and Manufacturing firm (6 marks)

QUESTION TWO (20 MARKS)

- a) From the first principles, determine the output resistance expression, $R(t)$ of a Resistance Thermometer when a sinusoidal input temperature, $T(t) = T \sin \omega t$, is applied when the system transfer function is given by

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

All symbols carry the usual meaning (7 marks)

- b) An elastic sensor consists of a spring Kx , a damper $C \frac{dx}{dt}$ and a mass $m \left(\frac{dx}{dt} \right)^2$. In this case, x is the displacement of the system due to the force $F(t)$ applied on the mass.
- Starting from a well labelled diagram, derive the expressions for the natural frequency and damping constant of the accelerometer (3 marks)
 - Explain the three damping situations of the elastic sensor (3 marks)
 - Derive the expression of the displacement with respect to time when a *unit step force* is applied (7 marks)

QUESTION THREE (20MARKS)

- a) Determine and Sketch the Root Locus defined by each of the following Characteristic Equations
- $(i) S(S + 2) + K(S + 4) = 0$ (3 marks)
 - $(ii) S(S + 4)(S^2 + 4S + 20) + K = 0$ (6 marks)
- b) Determine and Sketch the *Root Locus* defined by the following Characteristic Equation (11 marks)

$$S(S + 5)(S + 6)(S^2 + 2S + 2) + K(S + 3) = 0$$

QUESTION FOUR (20MARKS)

- a) A closed loop control system is represented by the Block Diagram shown in Figure Q 4a).
- Derive the transfer function by Block Reduction Method (4 marks)
 - Verify the results in 4ai) above using the Signal Flow Graph Approach (4 marks)

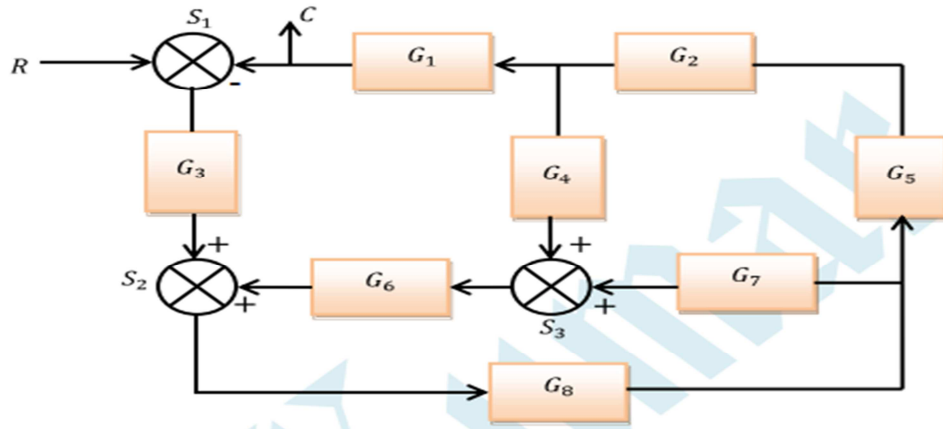


Figure Q4a)

- b) A closed loop control system is represented by the Block Diagram shown in Figure Q 4 c).
- Derive the transfer function by Block Reduction Method (4 marks)
 - Verify the results in 4ci) above using the Signal Flow Graph Approach (4 marks)

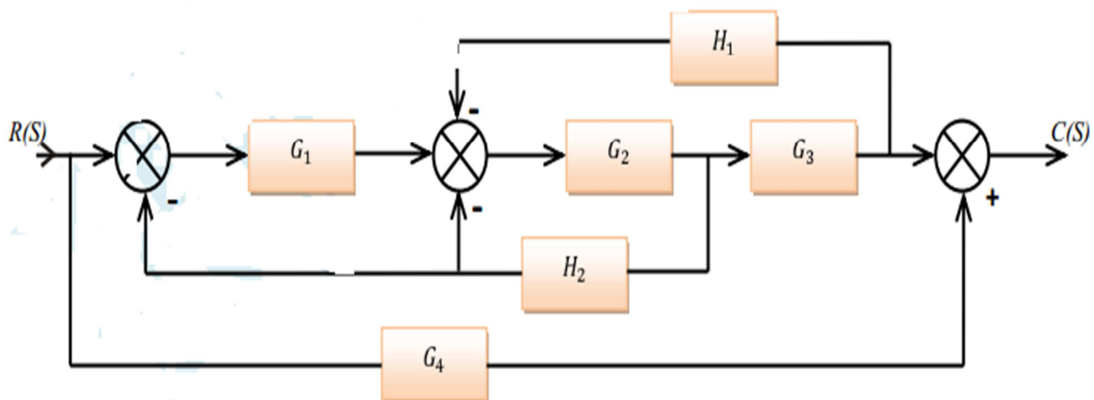


Figure Q3d)

- c) Determine the restrictions on K for which the system represented by the SFG in Figure Q4c) is stable (4 marks)

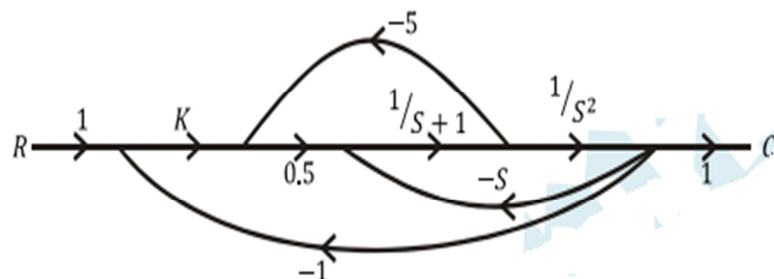


Figure Q4c)

QUESTION FIVE (20MARKS)

- a) A Control System is defined by the Bode Plot Shown in Figure .Q 5 a) .Derive the Open-Loop Transfer Function of the System (5 marks)

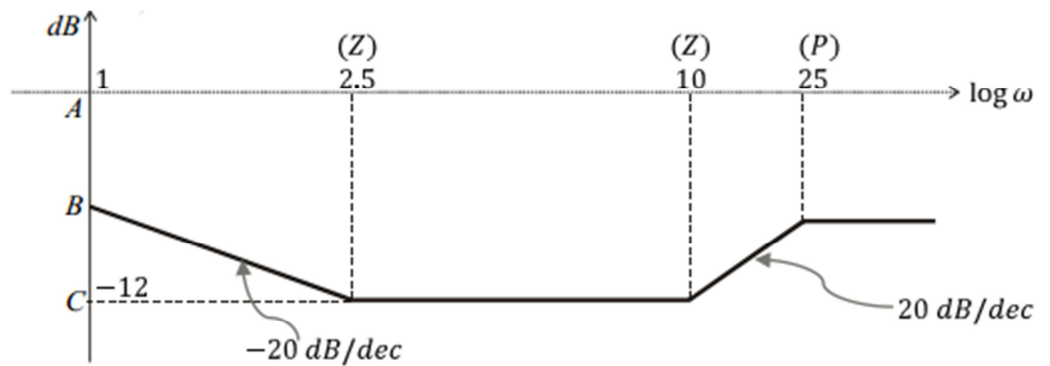


Figure 5a)

- b) Determine and sketch the Bode Magnitude Plot for the transfer function given by (5 marks)

$$G(s) = \frac{200(s + 20)}{s(2s + 1)(s + 40)}$$

- c) A Control System is defined by the Bode Plot Shown in Figure .Q 5 c) .Derive the Open-Loop Transfer Function of the System (5 marks)

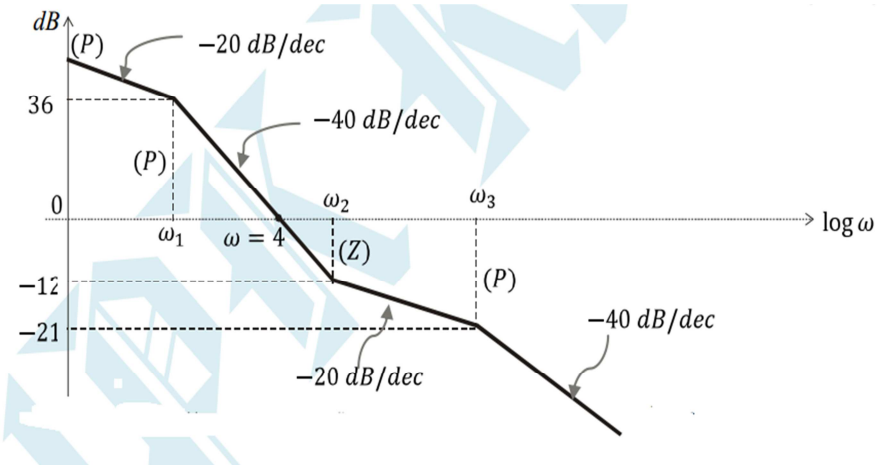


Figure 5c)

- d) Determine the Transfer Function of a Control System whose *Bode Plot Approximation* is shown in Figure 5 d) (5 marks)

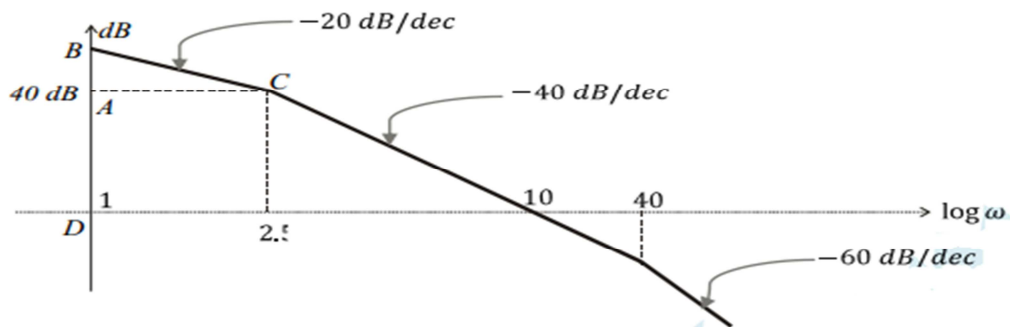


Figure Q 5d)