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)

i. Plant

ii. Servo mechanism

iii. System

iv. Controller

b) Distinguish between the following types of Control Systems (4 marks)

i. Linear and Non-linear system

ii. Discrete and Continuous data system

iii. Time variant and Time Invariant system

iv. 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)

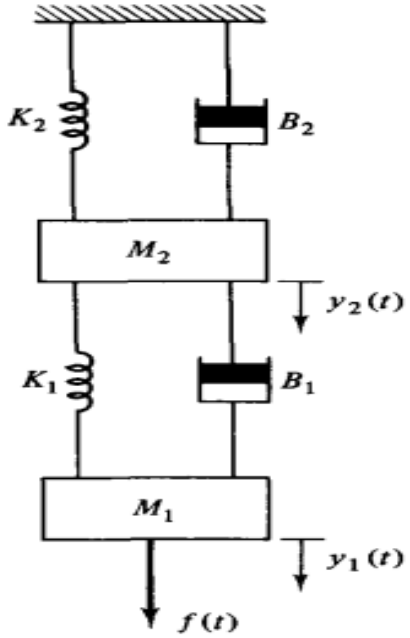

Figure Q 1f)

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.

i. Starting from a well labelled diagram, derive the expressions for the natural frequency and damping constant of the accelerometer (3 marks)

ii. Explain the three damping situations of the elastic sensor (3 marks)

iii. 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).

i. Derive the transfer function by Block Reduction Method (4 marks)

ii. Verify the results in 4ai) above using the Signal Flow Graph Approach (4 marks)

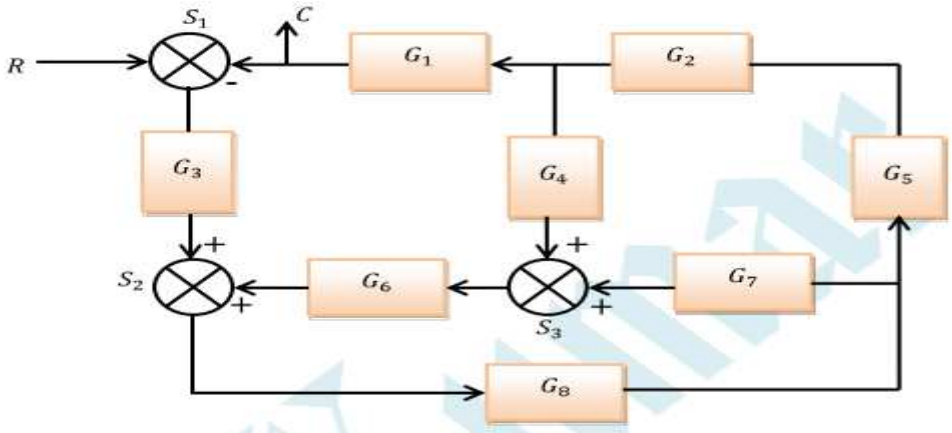

Figure Q4a)

b) A closed loop control system is represented by the Block Diagram shown in Figure Q 4 c).

i. Derive the transfer function by Block Reduction Method (4 marks)

ii. Verify the results in 4ci) above using the Signal Flow Graph Approach (4 marks)

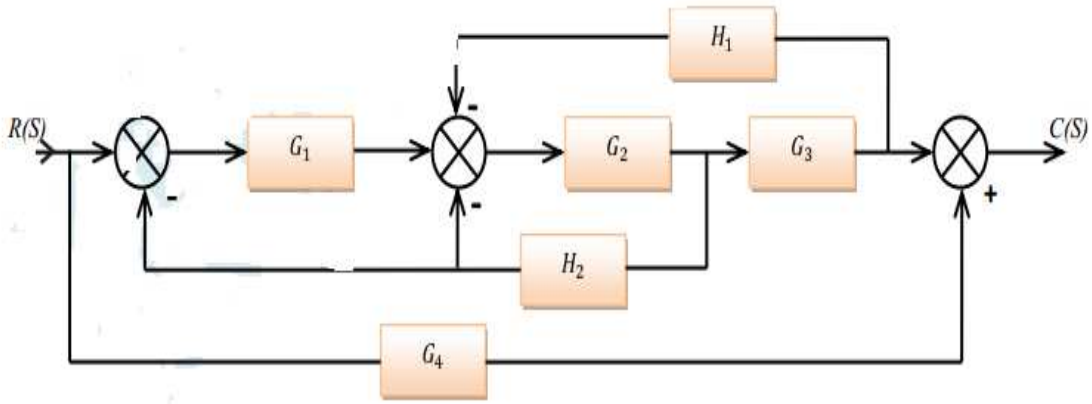

Figure Q3d)

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

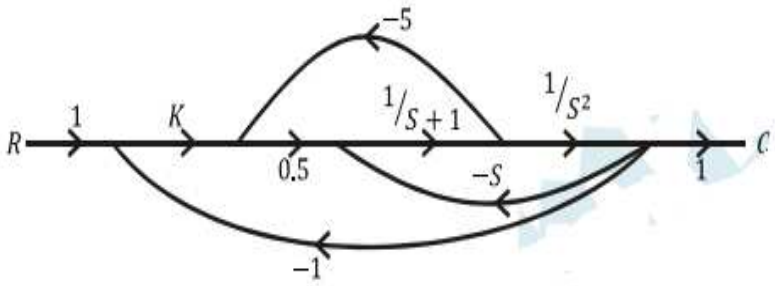

Figure Q4c)

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)

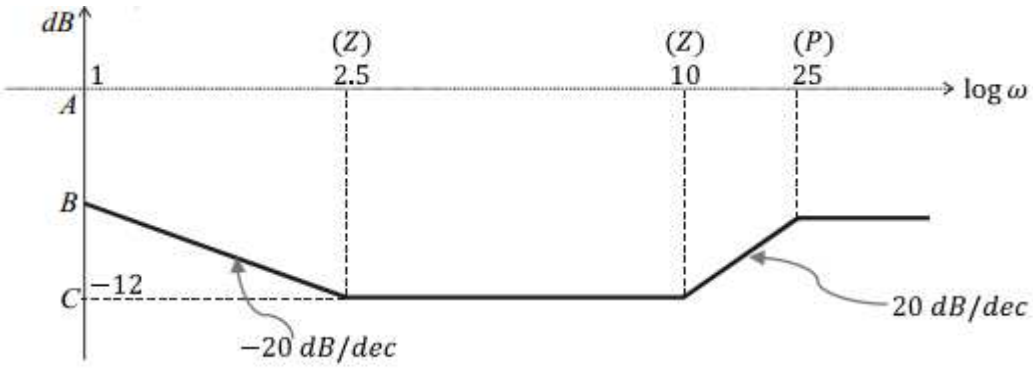

Figure 5a)

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)

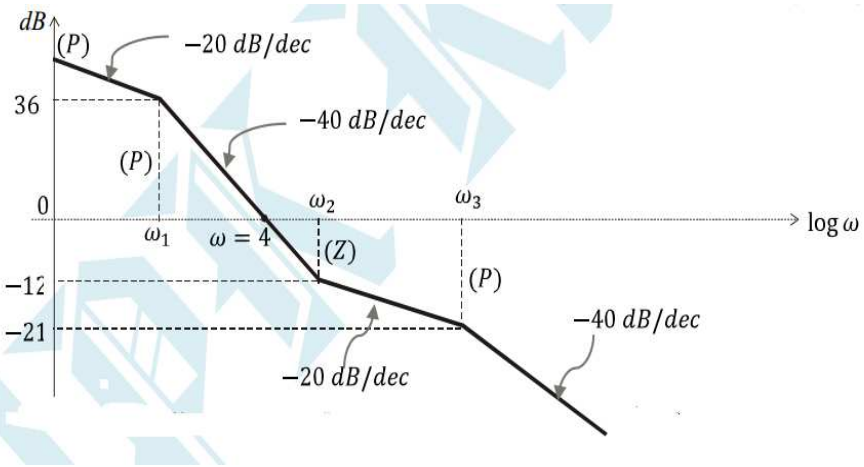

Figure 5c)

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

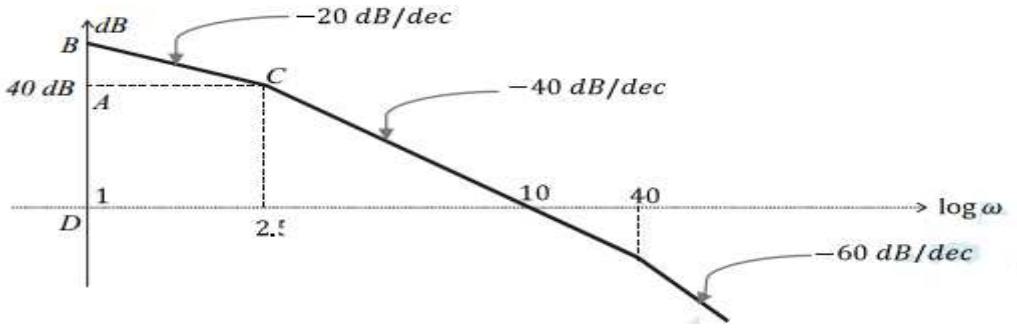

Figure Q 5d)