KENYATTA UNIVERSITY

EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PETROLEUM ENGINEERING

EPL 407: CONTROL ENGINEERING I

1ST SEMESTER 2022/2023 TIME: 2 Hours

INSTRUCTIONS:

Attempt Question **ONE** and any other **TWO** questions.

QUESTION ONE (COMPULSORY)[30 MARKS]

a) Define the following terms as used in control systems
   i. Transfer function
   ii. Characteristic equation **(2 mks)**

b) A system has the open loop transfer function

$$G(s) = \frac{s+4}{s^2+3s+4}$$

Obtain and sketch the location of its open loop poles and zeros. **(2 mks)**

c) The impulse response of a system is $\sin 3t$. Determine the response of the system when subjected to a unit step input **(4 mks)**

d) A unity feedback system has the open loop transfer function

$$G(s) = \frac{100}{s(s+5)}$$

Determine its peak overshoot, rise time, peak time and settling time given 2% tolerance hence sketch its response **(6 mks)**

e) For the block diagram of Figure Q1 e) and given that $R(s) = 0$, determine the transfer function $\frac{C(s)}{R(s)}$ **(6 mks)**

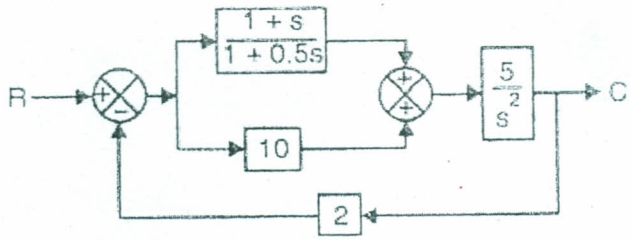

Figure Q1 e)

f) Obtain the transfer function for the signal flow graph of Figure Q1 f). **(6 mks)**

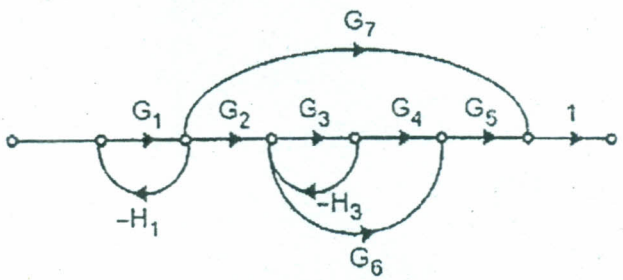

Figure Q1 f)

g) Test for the stability of a control system with the characteristic equation given below, using the Routh stability criterion

$$s^4 + 2s^3 + 10s^2 + 10s + 5 = 0$$ **(4 mks)**

QUESTION TWO [20 MARKS]

a) Explain the concept of stability in control systems **(2 mks)**

b) A unity feedback system has the open loop transfer function

$$\frac{C(s)}{R(s)} = \frac{k}{s(s+10)(s^2+4s+5)}$$

Determine the range of k for the closed loop system to be stable **(6 mks)**

c) For the unity feedback control system with

$$G(s) = \frac{15}{s(s+3)(s+5)}$$

Draw the bode plots **(12 mks)**

QUESTION THREE [20 MARKS]

a) Explain, with aid of sketches and mathematical expressions, the following standard test inputs used in control systems
   i. Step input
   ii. Ramp input **(2 mks)**

b) Explain the relationship between impulse response and the transfer function of a control system **(2 mks)**

c) A unity feedback system has the open loop transfer function

$$\frac{C(s)}{R(s)} = \frac{s+4}{s^2+3s+4}$$

Determine the response of the system when subjected to a unit step input **(8 mks)**

d) Model, using block diagram representation, the electrical circuit of Figure Q3 d), as a feedback system with $V_I(s)$ and $V_O(s)$ as the input and output respectively and use it to determine the transfer function of the circuit **(8 mks)**

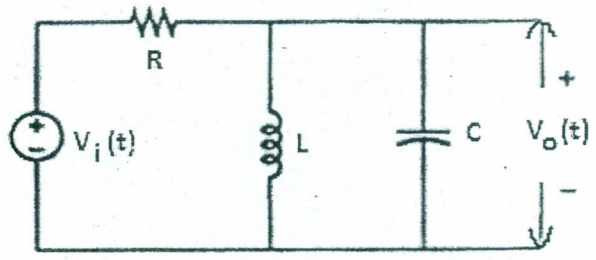

Figure Q3 d)

QUESTION FOUR [20 MARKS]

a) Define the following terms as used in frequency domain analysis
   i. Resonant frequency
   ii. Peak response
   iii. Bandwidth **(3 mks)**

b) For a second order system with unity feedback has its open loop transfer function given by

$$G(s) = \frac{200}{s(s+8)}$$

Determine its resonant frequency, resonant peak and bandwidth **(7 mks)**

h) Sketch the root locus diagram of a unity feedback control system with the open loop transfer function **(10 mks)**

$$G(s) = \frac{k(s+4)}{s(s^2+6s+13)}$$

QUESTION FIVE [20 MARKS]

a) Draw the standard block diagram of a closed loop system and derive the expression for its closed loop transfer function **(6 mks)**

b) The closed loop transfer function of a system is given by

$$\frac{Y(s)}{R(s)} = \frac{s+1}{s^2+4s+4}$$

The feedback elements consist of a resistor in series with a capacitor. Determine the values of the resistor and capacitor given that the frequency of operation of the system is 50 Hz **(6 mks)**

c) Obtain the mathematical model of the mechanical systems of Figure Q5 c) and use it to determine its electrical equivalent using the Force-current analogy **(8 mks)**

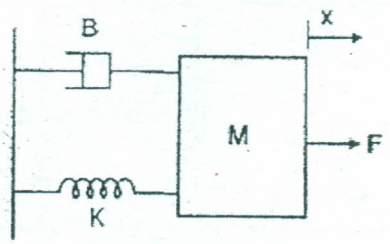

Figure Q5 c)