70

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2021/2022 SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATION ENGINEERING

COURSE CODE: ECE321
COURSE TITLE: CONTROL SYSTEMS I

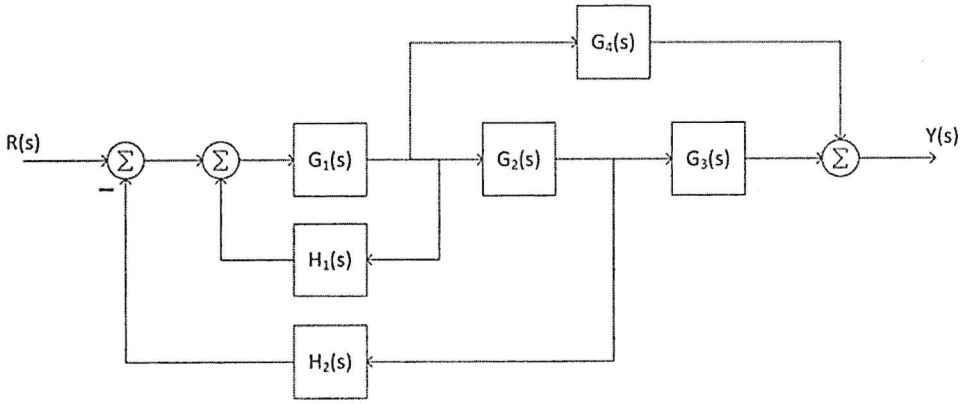
DATE:TUESDAY, APRIL, 26TH, 2022 **TIME: 12:00 – 2:00 PM**

INSTRUCTIONS TO CANDIDATES

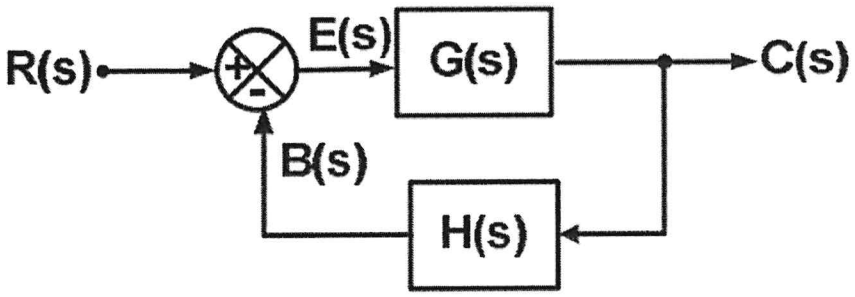
- *This Paper Consists of **FIVE** Questions.*
- *Attempt Question **ONE** and **TWO** other Questions (Do not attempt more than expected).*
- *Allow **ONE** hour for Question **ONE** and another **ONE** hour for **TWO** other Questions.*
- *Question **ONE** carries **30 MARKS** and all other Questions carry **20 MARKS** each.*
- *A **BONUS** will be awarded for clean and well-organized work.*
- *Candidates are reminded to **STRICTLY** adhere to the **Examination Rules and Regulations.***
- ***REQUIRED:** Answer Booklet and Calculator.*

QUESTION ONE (COMPULSORY) (30 MARKS)

1. Explain the following terminologies as applied in control systems
   i. Control system
   ii. Controller
   iii. System
   iv. Feedback Signal **[4 Marks]**
2. Discuss at least 3 classifications of control systems. **[6 Marks]**
3. Differentiate between the necessary condition and sufficient condition for stability in Routh-Hurwitz Stability Criterion. **[4 Marks]**
4. Differentiate between time response and frequency response in control systems. **[4 Marks]**
5. Simplify the block diagram using the block diagram reduction rules and determine the transfer function of the system. **[4 Marks]**



6. Consider a first-order system shown below, show that for unit step signal and unit ramp signal inputs, the unit response, c(t) has both the transient and the steady-state terms and the unit response, c(t) is an exponentially decaying signal for unit impulse input

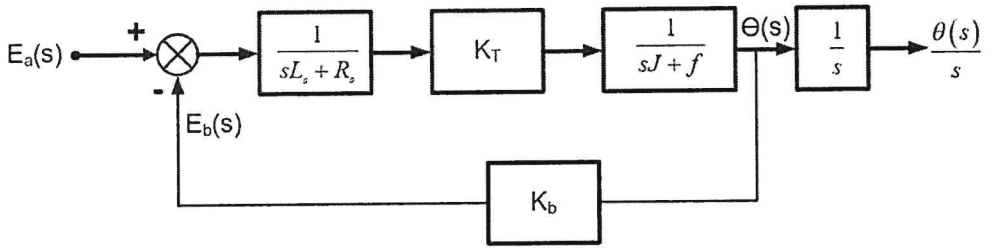


[6 Marks]

7. State if the following closed loop poles are stable or unstable
   i. Closed-loop poles negative and real
   ii. Closed-loop poles complex with negative real parts
   iii. Closed-loop poles positive and real
   iv. Closed-loop poles complex with positive real parts **[2 Marks]**

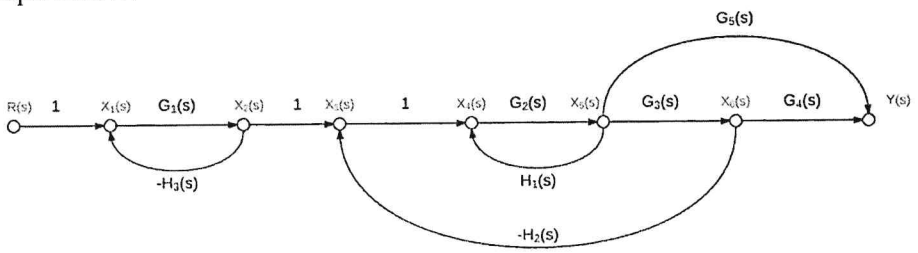
QUESTION TWO (20 MARKS)

1. Highlight at least 4 properties of signal flow graphs **[4 Marks]**
2. The block diagram below presents the armature type speed control of a DC motor, determine the transfer function and represent the block diagram in a signal flow graph.



[6 Marks]

3. Based on Mason's gain formula compute the transfer function from the signal flow graph below.



[4 Marks]

4. In a unity feedback control system, the open loop transfer function is given by

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

Using Routh Hurwitz Criterion, determine the range of K for which the given system is stable. **[6 Marks]**

QUESTION THREE (20 MARKS)

1. Discuss at least 2 types of systems based on stability. **[4 Marks]**
2. Find the steady state error of an input signal $r(t) = \left(5 + 2t + \frac{t^2}{2}\right)u(t)$ of a unity negative feedback control system with.

$$G(s) = \frac{5(s+4)}{s^2(s+1)(s+20)}.$$

[4 Marks]

3. Draw the root-locus of the feedback system whose open-loop transfer functions are given by.

$$G(s)H(s) = \frac{k}{s(s+2)(s+4)}$$

[8 Marks]

4. Discuss the effects of adding a pole or a zero to the root locus of a second- order system. **[4 Marks]**

QUESTION FOUR (20 MARKS)

1. List at least two advantages and disadvantages of static error coefficient method? **[4 Marks]**
2. Consider the system shown in Figure 1 below. To improve the performance of the system feedback is added to this system, which results in Figure 2. Determine the value of K so that the damping ratio of the new system is 0.4. Compare the overshoot, rise time, peak time and settling time and the nominal value of the systems shown in Figures 1 and 2.

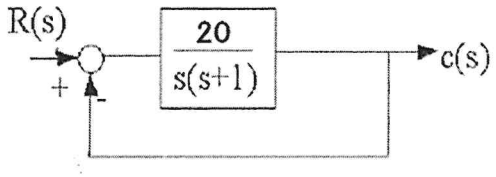


Figure 1

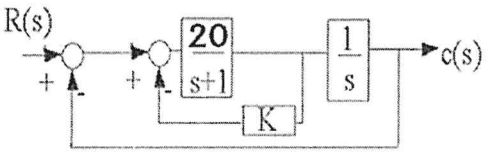


Figure 2

[8 Marks]

3. Draw the Bode magnitude and phase plot of the open-loop transfer function $G(s)H(s)$ and determine gain margin, phase margin and absolute stability if

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

[8 Marks]

QUESTION FIVE (20 MARKS)

1. Using appropriate equations and block diagram, discuss the effect of feedback on the following in control systems.
   i. Overall Gain
   ii. Sensitivity
   iii. Stability
   iv. Noise **[8 Marks]**
2. In a table format contract between open loop and closed loop control systems. **[4 Marks]**
3. Using Nyquist criterion, determine the stability of a feedback system whose open-loop transfer function is given by.

$$G(s)H(s) = \frac{55}{s(s+2)(s+4)}$$

[8 Marks]