(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE CODE: DEE 082

COURSE TITLE: CONTROL SYSTEMS II

DATE: Tuesday 19th April, 2022 **TIME:** 8.00 A.m – 10.00 A.m

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

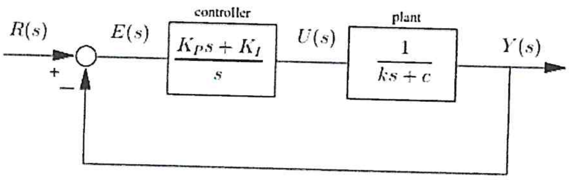
This Paper Consists of 3 Printed Pages. Please Turn Over.

Question One [30 Marks]

a. Define the following terms as used in signal flow graphs.
   i. Path [1 mark]
   ii. Node [1 mark]
   iii. Branch [1 mark]
   iv. Gain [1 mark]
   v. Loop [1 mark]

b. With the aid of a relevant diagram provide the circuit analysis for the Lag-Lead compensator.
[2 marks]

c. Consider the system shown below. Given that k = 1, c = 1 and the time constant $\tau = 0.2$, find the PI controller gains such that $\zeta = 0.7071$.
[5 marks]



d. A PID controller is inserted in series with a system having a transfer function below. The system has unity feedback. Find the gain constants of the PID controller required to locate the closed-loop poles at $s = -50$, $s = -4 \pm j5$.
[6 marks]

$$G(s) = \frac{10}{(s+1)(s+2)}$$

a. Design a lag compensator for the system to meet the following specifications: $K_v = 5$ $\sec^{-1}$, Phase margin at least 40^0, Gain margin at least 10dB
[12 marks]

$$G(s) = \frac{1}{s(s+1)(0.5s+1)}$$

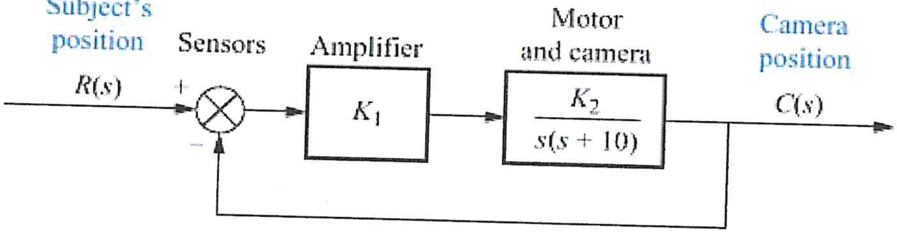
The gain and phase of $G(j\omega)$ at certain frequencies is given below:

Frequency ω (rad/sec)	0.004	0.02	0.04	0.2	0.4	2	4
Gain (dB)	48	34	28	14	7	-16	-31
Phase (degrees)	-90	-92	-93	-107	-123	-198	-229

Question Two [20 Marks]

a. List the *four* general effects of lead compensation in Nyquist system design.
[2 marks]

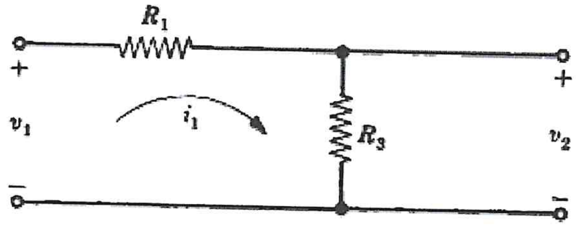
b. Consider the continuous system below in the figure below. Showing all steps followed you are required to construct the root locus hence predict the stability of the closed-loop system.
[8 marks]



c. Construct the db magnitude-phase angle plot for the continuous-time open-loop transfer function $GH = \frac{2}{s(1+s)(1+s/3)}$.
[10 marks]

Question Three [20 Marks]

a. Two identical networks, simple voltage dividers, of the form given in the figure below are to be cascaded and used as the control elements in the forward loop of a control system. Develop its signal flow graph and work out the transfer function [10 marks]



b. Construct the dB magnitude-phase angle plot for the open-loop transfer function [10 marks]

$$GH = \frac{4(s+0.5)}{s^2(s^2+2s+4)}$$

Question Four [20 Marks]

a. Find the Nyquist Stability Plot for $GH(s) = 1/s(s-1)$ and comment on its stability. [5 marks]

b. Determine the value of the gain factor K for which the system with the open-loop transfer $GH = \frac{K}{s(s+2)(s+4)}$ has closed-loop poles with a damping ratio $\xi = 0.5$ [6 marks]

c. Obtain the phase and gain margins of the system shown in Figure 4c for the two cases where $K = 10$ and $K = 100$. [9 marks]

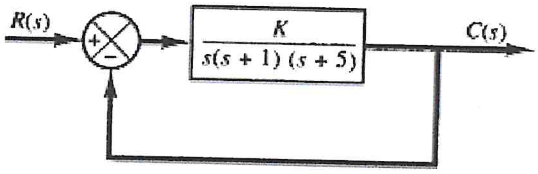


Figure 4c

Question Five [20 Marks]

a. Compute the values of $P(s) = 1/(s^2+1)$ for $s_1 = 2$, $s_2 = j4$, and $s_3 = 2 + j4$. [3 marks]

b. Map the imaginary axis in the s-plane onto the P(s)-plane, using the mapping function $P(s) = s^2$. [5 marks]

c. Design a compensator for the system below such that the static Velocity Error Constant $K_v = 20\ \text{sec}^{-1}$, the Phase Margin is at least 45^0 and the Gain Margin at least 10dB. [12 marks]

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

The gain and phase of $G(j\omega)$ at certain frequencies is tabulated below:

Frequency ω (rad/sec)	0.01	0.05	0.1	0.5	1	5	10	50	100
Gain (dB)	6	32	26	12	5	-17	-28	-56	-68
Phase (degrees)	-90	-91	-93	-104	-117	-158	-169	-178	-179