05

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

SPECIAL/SUPPEXAMINATIONS 2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATIONS

FOR THE AWARD OF DIPLOMA IN ENGINEERING

COURSE CODE: DEE 082

COURSE TITLE: CONTROL SYSTEMS

DATE: Thursday 6th Oct, 2022 **TIME:** 8.00a.m – 10.00A.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 4 Printed Pages. Please Turn Over.

Question One

a. Define the following terms as applied in control engineering;

i. Self loop [1 mark]
ii. Path [1 mark]
iii. Sink [1 mark]
iv. Node [1 mark]
v. Locus [1 mark]
vi. Loop gain [1 mark]

b. Develop the Nyquist path for the Type 0 continuous system below. [5 marks]

$$GH = \frac{1}{(s+1)}$$

c. Devise a control system to fill a container with water after it is emptied through a stopcock at the bottom. The system must automatically shut off the water when the container is filled. Use clearly labeled diagram. [2 marks]

d. Construct a signal flow graph for the simple resistance network given in Figure 1d below and find its transfer function using the gain formula. [6 marks]

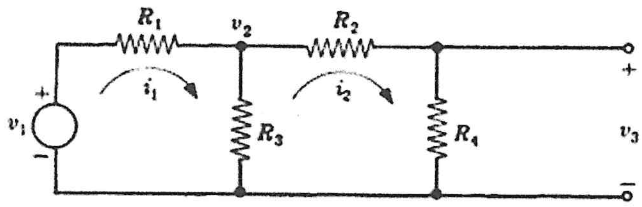


Figure 1d

e. Determine the angle and magnitude of GH(j2) for $GH=k/s(s+2)^2$ hence find the value of k that satisfies $|GH(j2)| = 1$ [5 marks]

f. Give any *six* properties of mapping of P(s) to P(z). [6 marks]

Question Two

a. Determine;

i. The condition under which the Bode magnitude plot for a pair of complex poles has a break at a nonzero, finite value of ω [5 marks]
ii. The frequency at which the peak value occurs [3 marks]

b. Find the angles and centre of, and sketch the asymptotes of [6 marks]

$$GH = \frac{k(s+2)}{(s+1)(s+3+j)(s+3-j)(s+4)}$$

c. Find the breakaway point between 0 and -1for [3 marks]

$$GH = \frac{k}{s(s+1)(s+3)(s+4)}$$

d. Determine the Bode form and Bode gain for the transfer function [3 marks]

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

Question Three

a. Outline the *four* properties of polar plots. [4 marks]

b. Consider the Figure 3b below; find the position, velocity, and acceleration error constants. [6 marks]

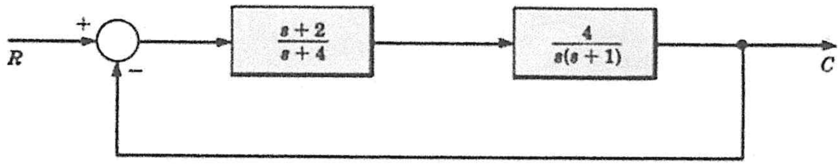
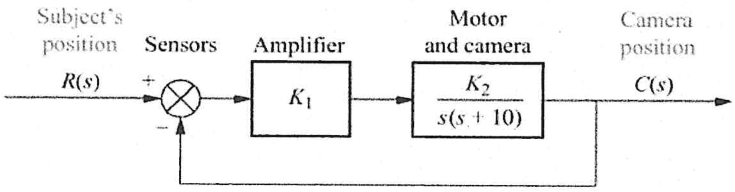


Figure 3b

c. Determine if the following characteristic equation represents a stable system using the Routh stability criterion $S^3 + 4S^2 + 8S + 12 = 0$. [3 marks]

d. Consider the continuous system in Figure below. The design value for the gain factor is K, plot a sketch of the root locus.



[7 marks]

Question Four

a. With the aid of appropriate sketches and equations give any *three* singularity functions used in control systems. [3 marks]

b. Determine the damping ratio ζ, undamped natural frequency ω_n, damping coefficient α, damped natural frequency ω_d, and time constant τ for the following second-order control system; [4 marks]

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 9y = 9u$$

c. Compare the proportional, integral and differential controllers. [3 marks]

d. Construct the polar plot of the Type 1 digital control system with open loop transfer function. [10 marks]

$$GH = \frac{k/4}{(z-1)\left(z-\frac{1}{2}\right)}$$

Question Five

a. Determine the transfer function of the system plotted in the figure 5a below if it has a gain of 9. [4 marks]

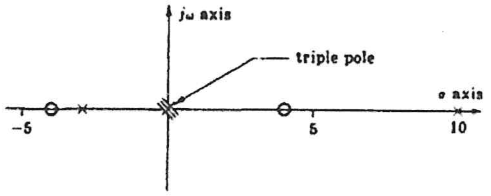


Figure 5a

b. Show that the dB magnitude-phase angle for a pole of order l at the origin of the s-plane $1/(j\omega)^l$ is a straight line parallel to the dB magnitude axis with an abscissa of $-90l^0$ for $\omega \geq 0$. [6 marks]

c. Construct a sketch of the dB magnitude-phase angle plot for the continuous time open loop transfer function [10 marks]

$$GH = \frac{2}{s(1+s)(1+s/3)}$$