(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS 2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATIONS

FOR DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE CODE: DEE 074

COURSE TITLE: CONTROL SYSTEMS I

DATE: Friday 22nd April, 2022 **TIME:** 3.00 p.m – 5.00 p.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

Question 1

a. Define the following control system terminologies

- Plant(1mk)
- Controller (1mk)
- Stability (2mk)

b. With the aid of block diagrams differentiate between open loop control system and closed loop system.(4mks)

c. Derive the transfer function of a basic control system shown in Fig 1 below (4mks)

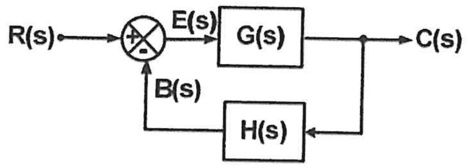

Figure 1

d. A unity feedback system has the plant transfer function

$$G_1 = \frac{C(s)}{M(s)} = \frac{10}{s(s+2)}$$

A proportional controller is employed to control the dynamics of the system.The controller characteristics are given by

$$m(t) = e(t) + K_D \frac{de(t)}{dt}$$

where e(t) is the error Determine

i. The damping factor and the undamped natural frequency when K_D=0(4mks)

ii. The value of K_D so that the damping factor is increased to 0.8 (4mks)

e. Obtain the pole-zero map of the following transfer function (3mks)

$$G(s) = \frac{(s-2)(s+2+j4)(s+2-j4)}{(s-3)(s-4)(s-5)(s+1+j5)(s+1-j5)}$$

f. Find stability of the following system given by

$$B(s) = s^3 + 2s^2 + 3s + 10$$

using Routh-Hurwitz stability criterion.(3mks)

g. Draw the polar plot for the open loop transfer function $G(s)H(s) = \frac{20}{s(s+5)}$ (4mks)

Question 2

a. Define rise time and maximum peak overshoot(2mks)

b. A single degree of freedom spring-mass-damper system has the following data: spring stiffness 20 kN/m; mass 0.05 kg; damping coefficient 20 N-s/m. Determine

   a) undamped natural frequency in rad/s and Hz(4mks)

   b) damping factor(2mk)

   c) damped natural frequency in rad/s and Hz.(4mk)

   If the above system is given an initial displacement of 0.1 m, trace the phasor of the system for three cycles of free vibration.

c. A second-order system has a damping factor of 0.3 (underdamped system) and an un-damped natural frequency of 10 rad/s. Keeping the damping factor the same, if the un-damped natural frequency is changed to 20 rad/s, locate the new poles of the system? What can you say about the response of the new system?(4mks)

d. Find the transfer function of the following Spring-mass-damper as shown in Fig 2 below(4mks)

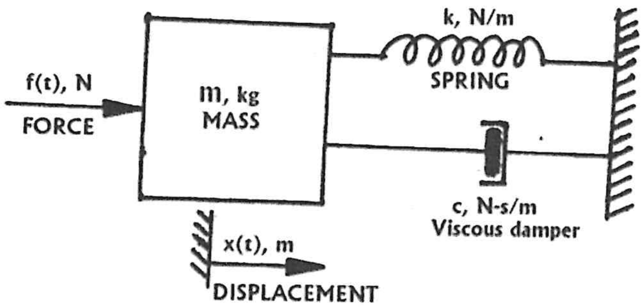

Figure 2

Question 3

a. A unity negative feedback system has the open loop transfer function $G(s) = \frac{K}{s(s+1)(s+3)}$. Calculate the value of gain $K > 0$ at which the root locus crosses the imaginary axis.(3mks)

b. Draw root locus of feedback system whose open loop transfer system is $G(s)H(s) = \frac{K}{s(s+5)}$ (7mks)

c. A unity negative feedback system has an open loop transfer function $G(s) = \frac{K}{s(s+12)}$.Calculate the gain K for the system to have a damping ratio of 0.4(4mks)

d. A unity feedback is shown in the following Fig 3

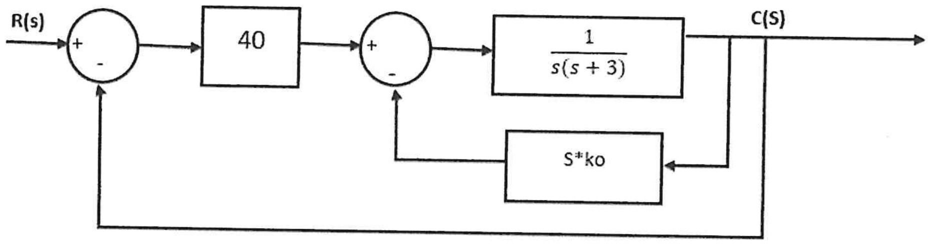

Figure 3

i. In absence of derivative feedback controller ($K_0 = 0$) Find ζ and ω_n(3mks)

ii. Find K_0 if ζ is modified to 0.6 by use of controller(3mks)

Question 4

a. Define phase margin and gain margin (2mks)

b. Draw a Nyquist plot for $G(s) = \frac{1}{s^2(1+s)(1+3s)}$ and determine the stability of the system (10mks)

c. The Fig 4 below shows PD controller used for a system.

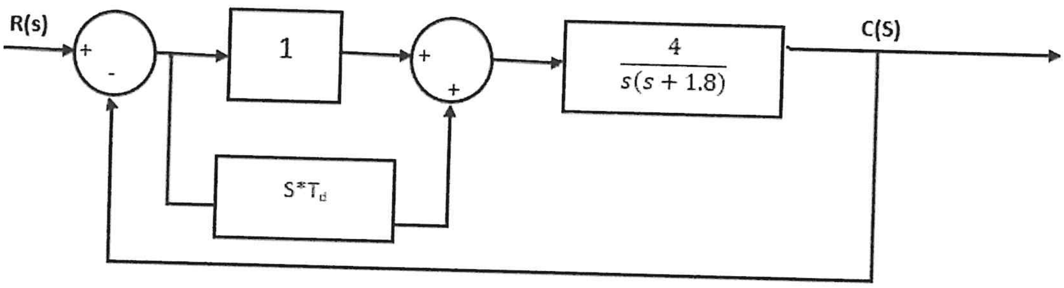

Figure 4

Determine the value of T_d so that the the system will be critically damped.Calculate its settling time(4mks)

d. Calculate the phase margin(in degrees) of the system $G(s) = \frac{10}{s(s+10)}$ (4mks)

Question 5

a. Define Transfer function (2mks)

b. Find the overall transfer function of the system given in Fig 5 below using Mason's gain formula(8mks).

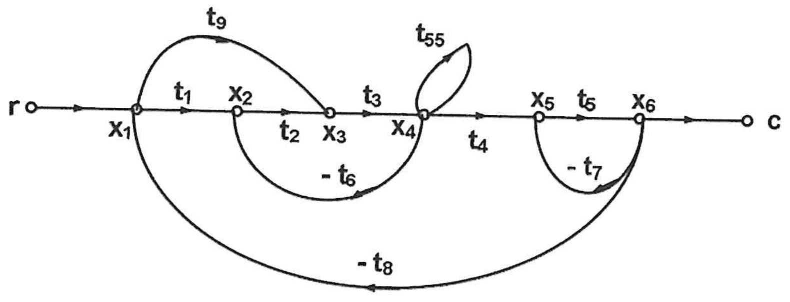

Figure 5

c. Draw bode plot for the system $G(s) = \frac{10}{s(1+0.4s)(1+0.1s)}$ (10mks)