TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY (ELECTRICAL & ELECTRONIC ENGINEERING)

EEE 4402: CONTROL ENGINEERING II

END OF SEMESTER EXAMINATION

SERIES: MARCH 2025

TIME: 2 HOURS

DATE: MARCH 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of five Questions; Attempt **Question One (compulsory)** and any other Two Questions.

Do not write on the question paper.

Question ONE

a) For the lead compensator circuit of Figure Q1a determine:

i) the transfer function

ii) the expression for the magnitude M and phase angle ϕ

iii) the expression for the maximum value of frequency

iv) Sine ϕ_m

v) Pole zero plot

vi) Sketch the polar plot

vii) Sketch the Bode plot

[20 marks]

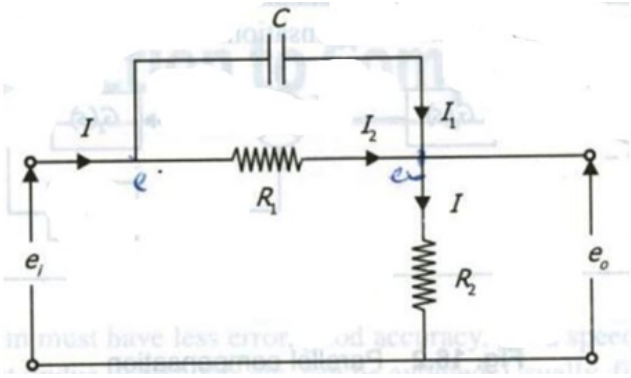

Figure Q1a

b) Obtain the z transform of

$$X(z) = \frac{z(z+2)}{(z-1)^2}$$

[8 marks]

c) State any two types of compensators

[2 marks]

Question TWO

(a) Derive the overall transfer function for the PI controller of Figure Q2a and show the expression for

i) Proportional gain K_p

ii) Integral time T_i

[10 marks]

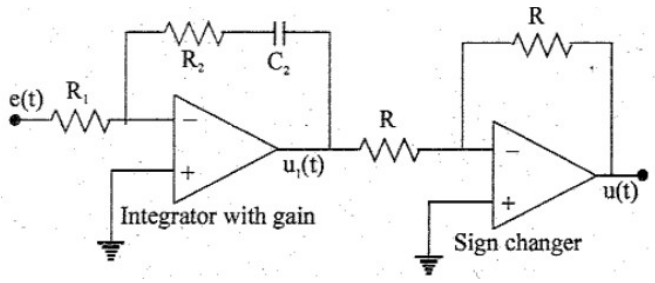

Figure Q2a

(b) The *PI*-controller of Figure Q2a, is used in the system of Figure Q2b, determine the effect of the controller when connected in series with the system whose transfer function:

$$G(s) = \frac{\omega_n^2}{s(s+2\xi\omega_n)}$$

[10 marks]

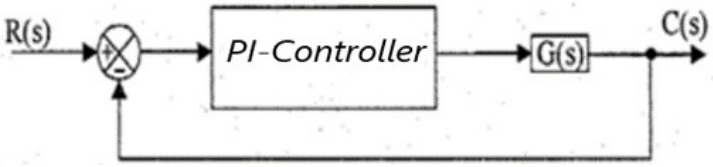

Figure $Q2b$

Question THREE

a) Obtain the z transform of

$$X(z) = \frac{z(z+2)}{(z-1)^2}$$

[8 marks]

b) Determine the output x(k) for the difference equation

$$x(k+2) - 1.3679x(k+1) + 0.3679x(k) = 0.3679u(k+1) + 0.2642u(k)$$

where $x(k)$ is the output and $x(k) = 0$ for $k \leq 0$ and where $u(k)$ is the input given by

$$u(k) = 0, \quad k < 0$$

$$u(0) = 1$$

$$u(1) = 0.2142$$

$$u(2) = -0\ 2142$$
$$u(k) = 0, \quad k = 3,4,5,\ldots$$

[12 marks]

Question FOUR

Figure Q4 is a closed loop system where a PID controller is used to control the direction of ship. The disturbance (e.g. due to the wind) affects the system. The input reference signal r(t) is a constant

a) Design a control system such that the closed loop response to a unit step disturbance decays fast (e.g. the settling time T_s is 2 or 3 seconds with 2% final value tolerance) and the damping of the system is satisfactory.

[12marks]

b) Choose the position of the poles so that the closed loop system has a pair of dominant poles

[2 marks]

c) Determine the time response of the system to a unit step disturbance and to a unit step input reference signal

[6 marks]

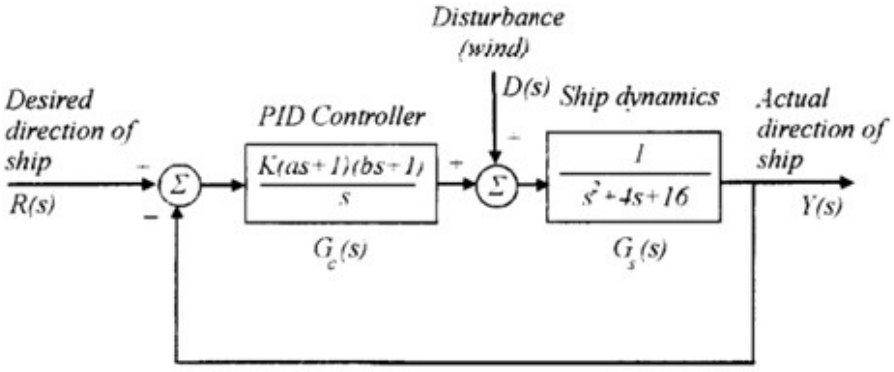

Figure Q4

Question FIVE

a) Assuming a sampling period T of 1 sec, determine the z transform of the curve in Figure Q2b

[8 marks]

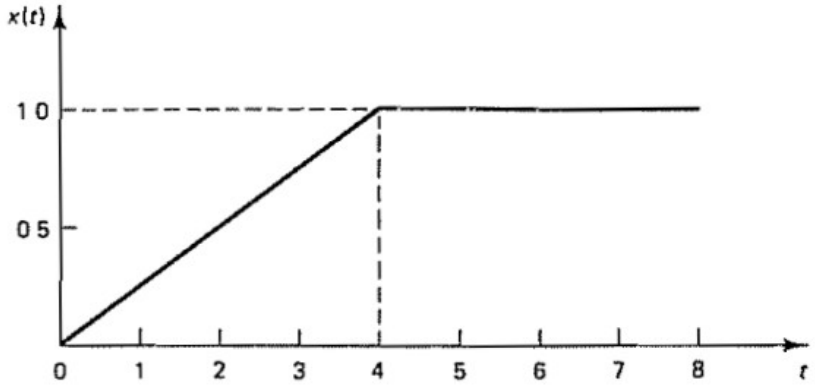

Figure Q2b

b) With the aid of mathematical analysis, describe the effects of a *PI* controller when applied to a standard second order control system

[12 marks]