PP I

TECHNICAL UNIVERSITY OF MOMBASA

School of Pure & Applied Sciences

Department of Mathematics & Physics

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS

EEE 4351: CONTROL ENGINEERING II.

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: APRIL 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; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) With the aid of diagrams explain the following
   i) Cascade compensator
   ii) Feedback compensator
   iii) Series – Parallel compensator

[9 marks]

b) Derive the transfer function of the PID controller of Figure Q1a

[14 marks]

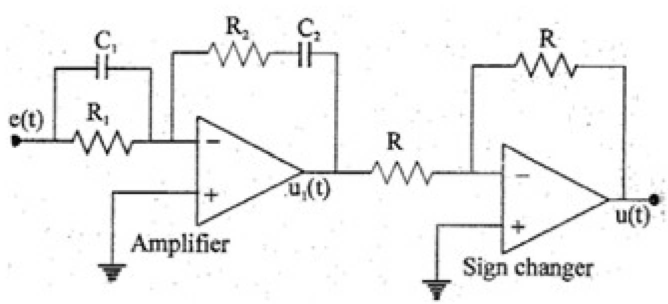

Figure Q1a

c) For the RLC in figureQ2a write down the state equations when
   i) The state variables are v_2(t) and $\dot{v}_2$
   ii) The state variables are v_2(t) and i(t)

[7 marks]

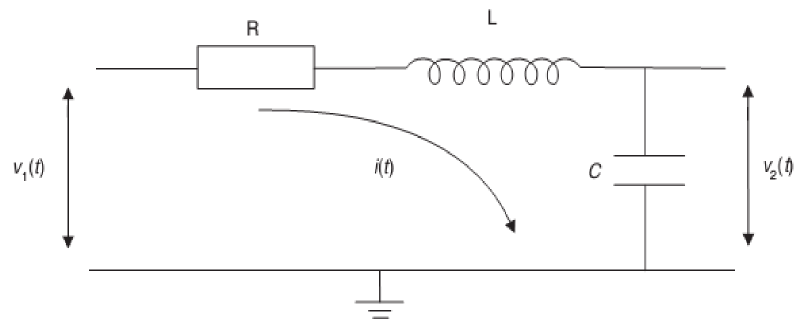

Figure Q1c

Question TWO

a) For the electrical phase lead network of figure Q1a,

i) Derive the transfer function $E_o(s)/E_i(s)$

ii) Show that the phase lead angle is a maximum at a frequency given by $\omega_m=\sqrt{\left(\frac{1}{\tau}\right)\left(\frac{1}{\alpha\tau}\right)}$ where $\omega_{c1} = 1/\tau$ and $\omega_{c2} = 1/\alpha\tau$ are the corner frequencies of the phase lead compensator.

[12 marks]

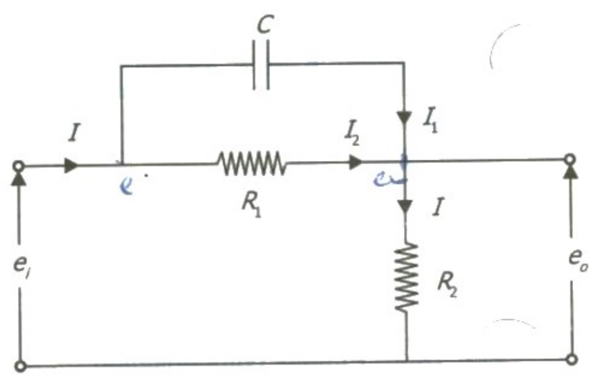

Figure Q1a

b) Outline Four effects of lead compensation on a system

[8 marks]

Question THREE

a) Given the transfer function of the system as

$$\frac{Y(s)}{U(s)}=\frac{b_o s^3+b_1 s^2+b_2 s+b_3}{s^3+a_1 s^2+a_2 s+a_3}$$

i) Derive the state model in observable canonical form

ii) Draw the block diagram

[15 marks]

b) For Figure Q2b given that the motor inductance is negligible, the motor constant K_m = 10, the back electromagnetic force constant is K_b = 0.0706, the motor friction is negligible. The motor and valve inertia J = 0.006, and the area of the tank is 50m^2. The motor is controlled by the armature current i_a. Take $x_1 = h$, $x_2 = \theta$ and $x_3 = d\theta/dt$, assuming $q_i = 80\theta$, where θ

is the shaft angle and that the output flow is $q_o = 50h(t)$. Determine the state space representation for the system.

[5marks]

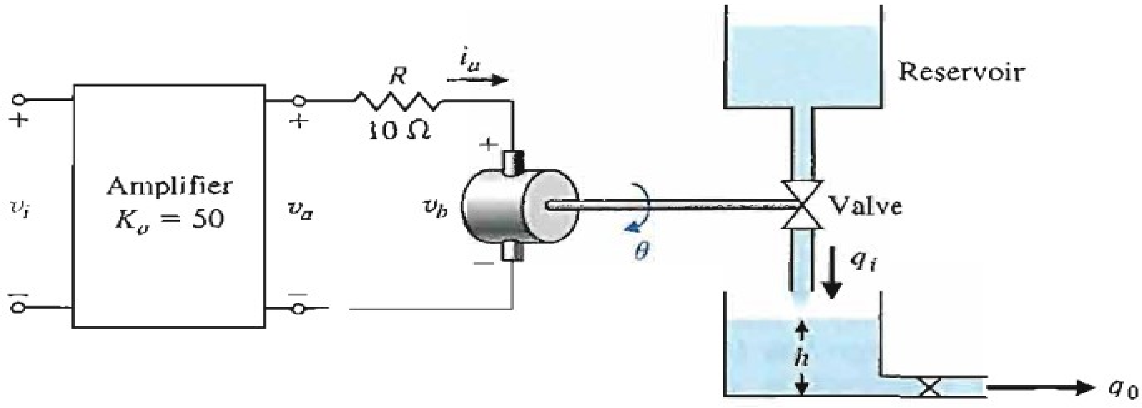

Figure Q2b

Question FOUR

a) Derive the state space equation for the armature controlled DC motor of Figure Q4a

[13 marks]

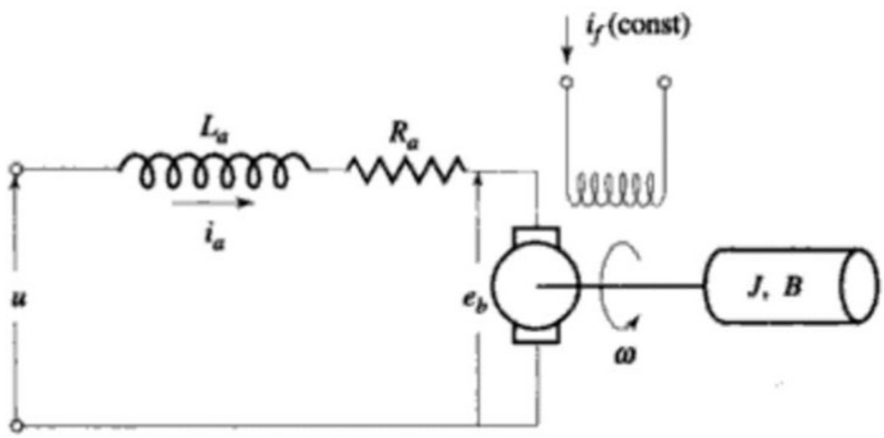

Figure 4a

b) Obtain the time response of the following system:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

where $u(t)$ is the unit-step function occurring at $t = 0$, or $u(t) = 1(t)$

[7 marks]

Question FIVE

a) Explain why Derivative controllers cannot be applied alone in a control system.

[8 marks]

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]