UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING

MAIN EXAMINATION MAY 2008

TITLE OF PAPER: **LINEAR SYSTEMS**

COURSE CODE: **E352**

TIME ALLOWED: **THREE** HOURS

INSTRUCTIONS:

1. Answer question **one** and any other **three** questions.
2. Question one carries 40 marks.
3. Questions 2, 3, 4, and 5 carry 20 marks each.
4. Marks for different sections are shown in the right-hand margin

This paper has 6 pages including this page.

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Question 1

(a) Is the system shown in Figure 1A linear? Show how you derive your conclusion.

(5 marks)

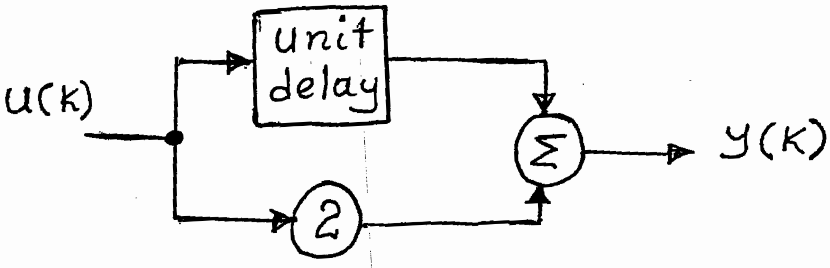

Figure 1A

(b) The output, y, and input, x, of a device are related by

$$y = x + 1.4x^3$$

obtain a linearized model for two operating points x_o=1 and x_o=2. (6 marks)

(c) For the mechanical system shown in Figure 1C determine the transfer function $\dfrac{Y(s)}{U(s)}$

(15 marks)

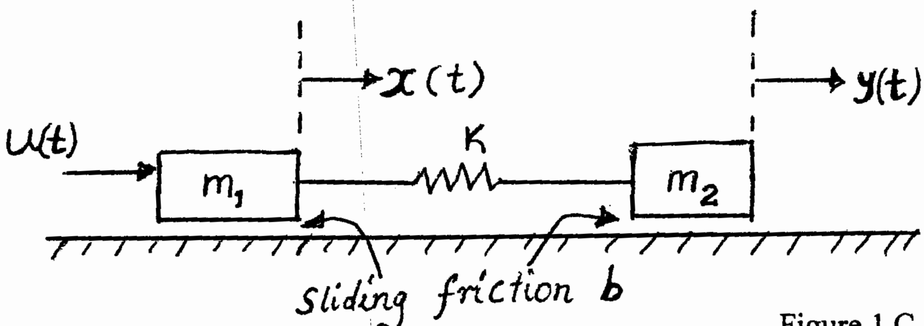

Figure 1 C

(d) The transfer function of a linear system is $\dfrac{Y(s)}{R(s)} = \dfrac{10(s+6)}{s^2+7s+12}$.

If r(t) is a unit step input, determine
(i) the response y(t)
(ii) the rise time, and
(iii) the settling time. (14 marks)

Question 2

Use Mason's gain rule to find the transfer function of the system shown in Figure 2

(20 marks)

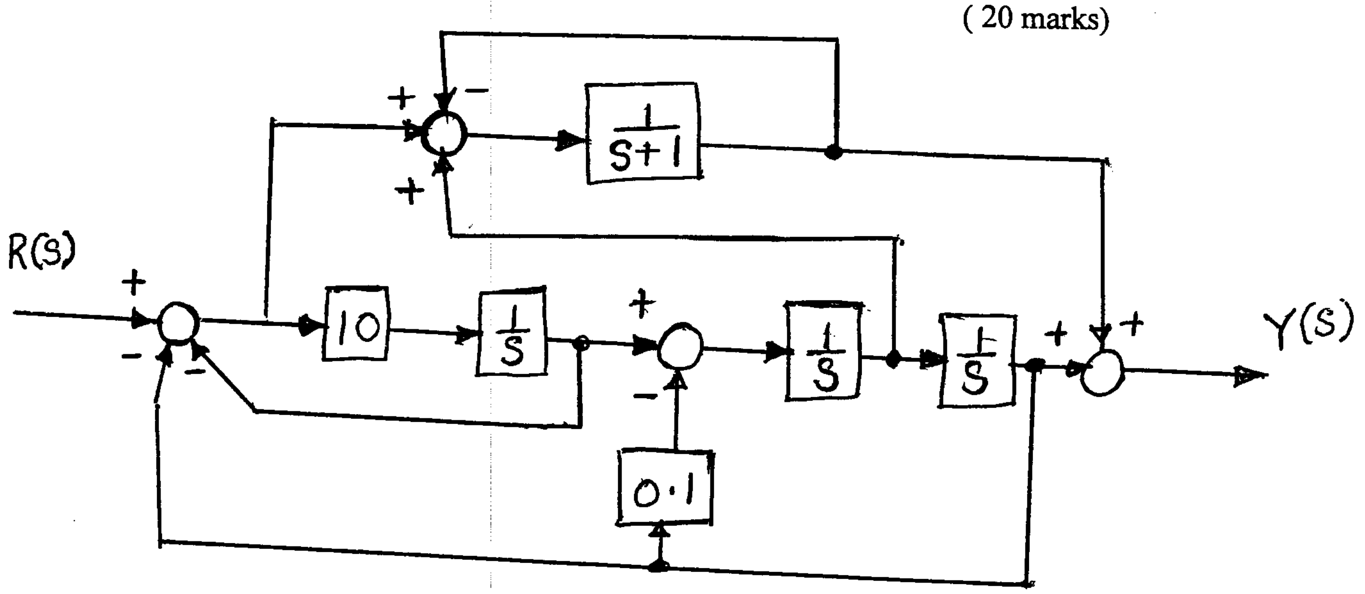

Figure 2

Question 3

The linear system shown in Figure 1 can be represented by equations of the form

$$\dot{x} = Ax + Bu$$

$$y = Cx$$

Determine the matrices ***A, B,*** and ***C***. [20 marks]

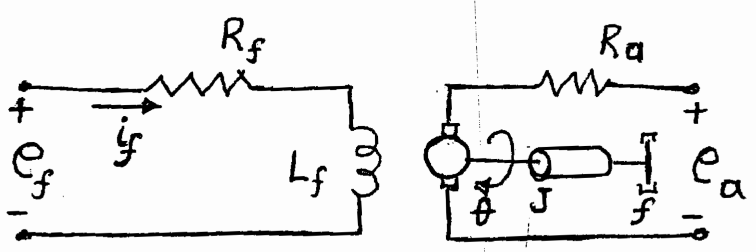

Figure 1

where $T = K_2 i_f$ with K_2 being a constant
θ = angular displacement of the motor shaft
e_f = field voltage
i_a = armature current and it is a constant

Note: The state variables are defined as follows $i_f = x_1$ and $\omega = x_2$.
The field voltage is the input and the angular velocity of the motor shaft $\omega = d\theta/dt$ is the output .

Question 4

Obtain state variable equations, using phase variable format only, for a linear system whose transfer function is $\dfrac{Y(s)}{R(s)} = \dfrac{8s^3 + 10s + 210}{s^4 + 19s^3 + 7s^2 + 30s}$. [20 marks]

Question 5

For pendulum oscillator Figure 5, the torque on the mass is given by $T = MgL\sin\theta$

(a) determine the linear approximation using the equilibrium condition for the mass

[10 marks]

(b) determine the range of θ for which the approximation is within 1% of the actual nonlinear pendulum.

[10 marks]

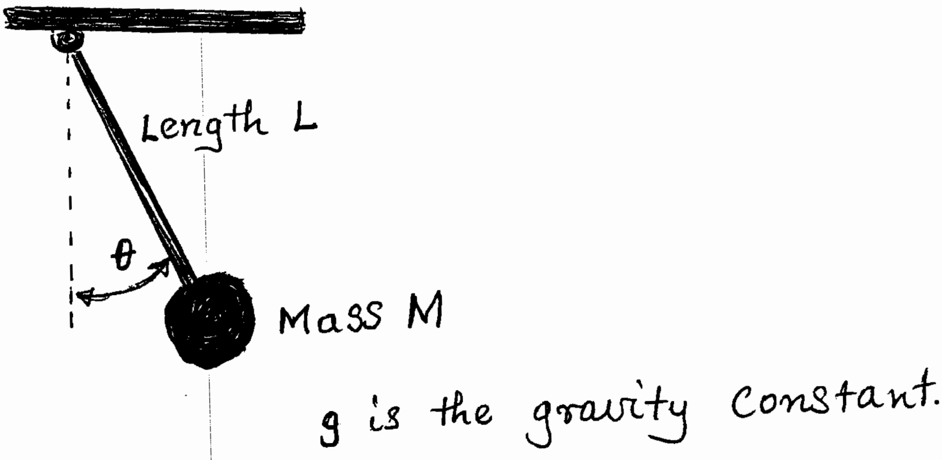

Figure 5