ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA
DEPARTMENT OF MECHANICAL ENGINEERING

SECOND SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 310 – Control Systems (3 Units)

CLASS: 300 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer **Question 1** and any other **THREE** questions

Date: July, 2018

Question 1

a) Briefly answer the following questions:

i. What are the twin goals of Control System Engineering?

ii. Give two (2) advantages of Feedback Control Systems.

iii. Give two (2) disadvantages of Feedback Control Systems.

b) Many luxury automobiles have thermostatically controlled air-conditioning systems for comfort of the passengers. Sketch a block diagram of an air-conditioning system where the driver sets the desired interior temperature on a dashboard panel. Identify the function of each element of the thermostatically controlled cooling system.

c) In the past, control systems used human operator as part of a closed-loop control system. Sketch the block diagram of the valve control system shown in Figure 1-1.

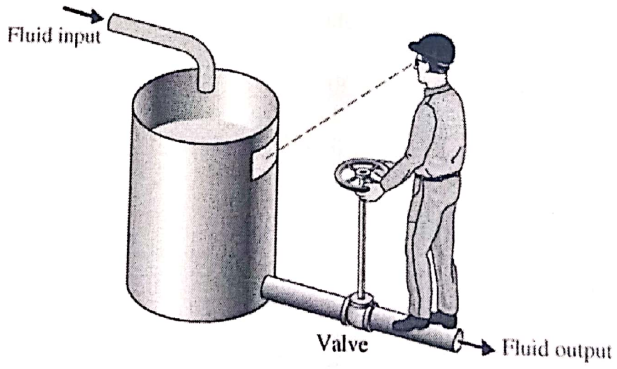

Figure 1-1: Manual control of water level

d) The student-teacher learning process is inherently a feedback process intended to reduce the system error to a minimum. Construct a feedback model of the learning process and identify each block of the system.

e) Simplify the block diagram shown in Figure 1-2. Obtain the transfer function relating $C(s)$ and $R(s)$.

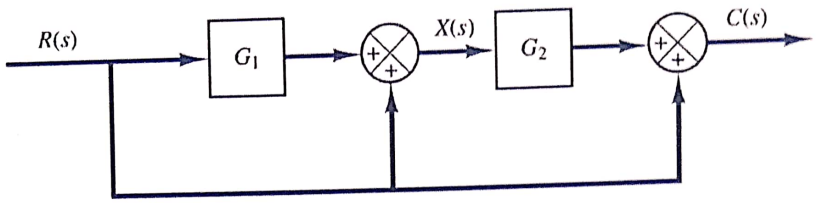

Figure 1-2: Block diagram

Question 2

a) Briefly answer the following questions:

i. What is a transducer?

ii. Give two (2) types of transducers.

iii. Give two (2) characteristics of transducers.

b) Simplify the block diagram shown in Figure 2-1. Obtain the transfer function relating Y and R.

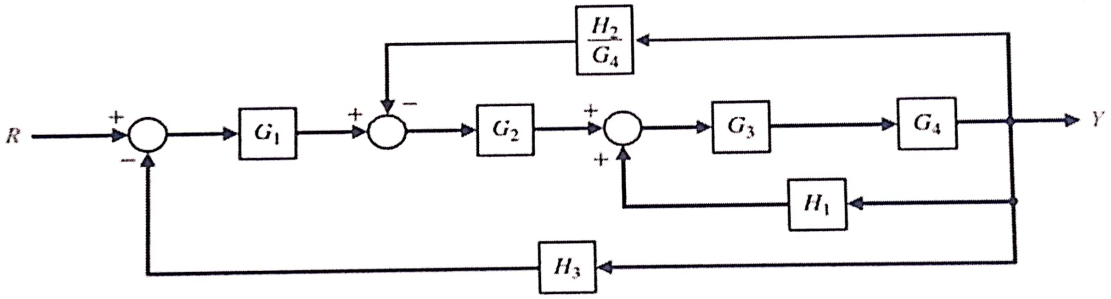

Figure 2-1: Block diagram of a system

Question 3

a) Briefly answer the following questions:

i. Draw and label a diagram showing constituents of mechatronics.

ii. List four (4) key elements of mechatronics.

b) Figure 3-1 shows a block diagram with input $R(s)$, output $Y(s)$, and disturbance $T_d(s)$. Obtain,

i. Output due to $R(s)$

ii. Output due to $T_d(s)$

iii. Total output.

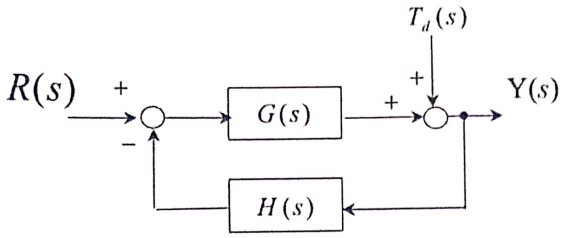

Figure 3-1: Block diagram of a system with input, output, and disturbance

c) Obtain an expression for the sensitivity of the system represented by the block diagram shown in Figure 3-2.

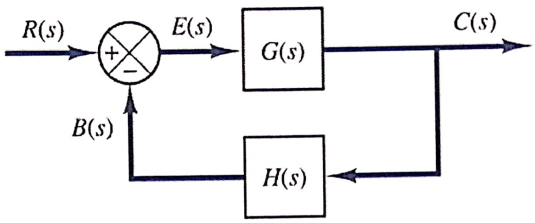

Figure 3-2: Block diagram of a simple feedback system

Question 4

a) Given that Figure 4-1 describes the transient response of a 2nd-Order system, briefly define (***using equations only***) the following terms:

i. Rise time

ii. Peak time

iii. Maximum (percentage) overshoot

iv. Settling time

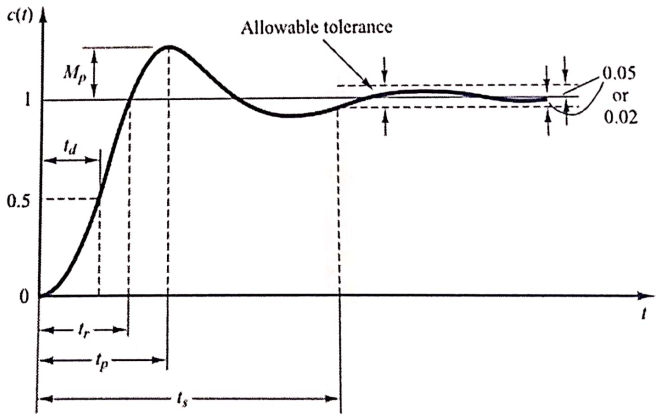

Figure 4-1: Block diagram of a simple feedback system

b) Consider the system subjected to unit-step input (refer to Figure 4-2), where ζ=0.62 and ω_n=4.95rad/s. Obtain,

i. the rise time t_r.
ii. the peak time t_p.
iii. the maximum overshoot M_p.
iv. the settling time t_s.

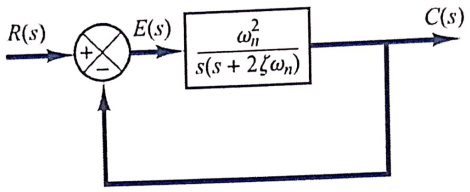

Figure 4-2: Block diagram of a 2nd-Order system

c) Obtain the poles and zeros of the system shown in Figure 4-2.

Question 5

a) A system's characteristic equation is shown below:

$$2s^5 + 3s^4 + 2s^3 + s^2 + 2s + 2 = 0$$

Determine (*using Routh Hurwitz criterion*),

i. the stability of the system.
ii. the number of roots with real parts.

b) Consider the polynomial of a system given below:

$$s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$$

Show (*using Routh Hurwitz criterion*),

i. that the system is unstable.
ii. that there are two (2) roots with real parts.

Question 6

a) The block diagram of a control system is shown in Figure 6-1.

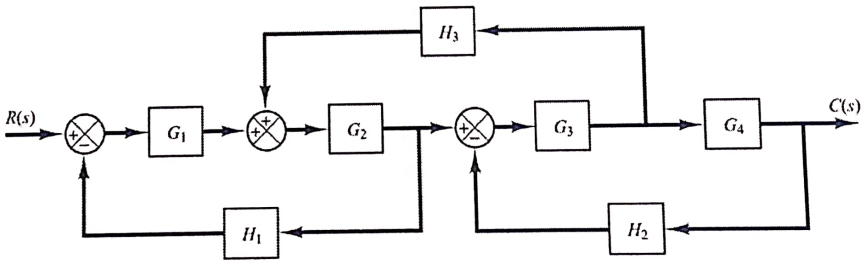

Figure 6-1: Block diagram of a control system

Answer the following questions:

i. Simplify the block diagram.
ii. Obtain the closed-loop transfer function C(s)/R(s).

b) Given that a system is defined as

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

Answer the following questions:

i. Obtain expressions for the real and imaginary parts of $G(i\omega)$
ii. Draw the Nyquist plot of the system