AUSTRALIAN MARITIME COLLEGE

DIVISION OF ACADEMIC AND RESEARCH

EXAMINATION

COURSE:	BE (OE, MOS)
SUBJECT:	Instrumentation and Process Control
CODE:	E07 267
DURATION:	3 Hour
YEAR:	2007
SEMESTER:	2
EXAMINER/S:	Hung Nguyen

MOBILE PHONES AND ELECTRONIC DICTIONARIES ARE STRICTLY PROHIBITED IN THE EXAMINATION VENUE
STUDENTS ARE PERMITTED TO BRING THE FOLLOWING ITEMS INTO THIS EXAMINATION:
Non-programmable calculator
Formulae sheets without annotation
"Graph Paper Required" / "No Graph Paper Required"

INSTRUCTIONS TO CANDIDATES

Answer Instructions:	There are six (6) questions. Attempt all questions. You should read the questions very carefully before answering in order to avoid misunderstanding. There are a total of 70 marks available in this examination. Marks follow each question.
Materials Provided:	Nil
Pass Level:	You are required to achieve over 50% of the possible marks for this examination.

Note:

In order to ensure that the examiner is aware of your entire examination returns, please ensure that:

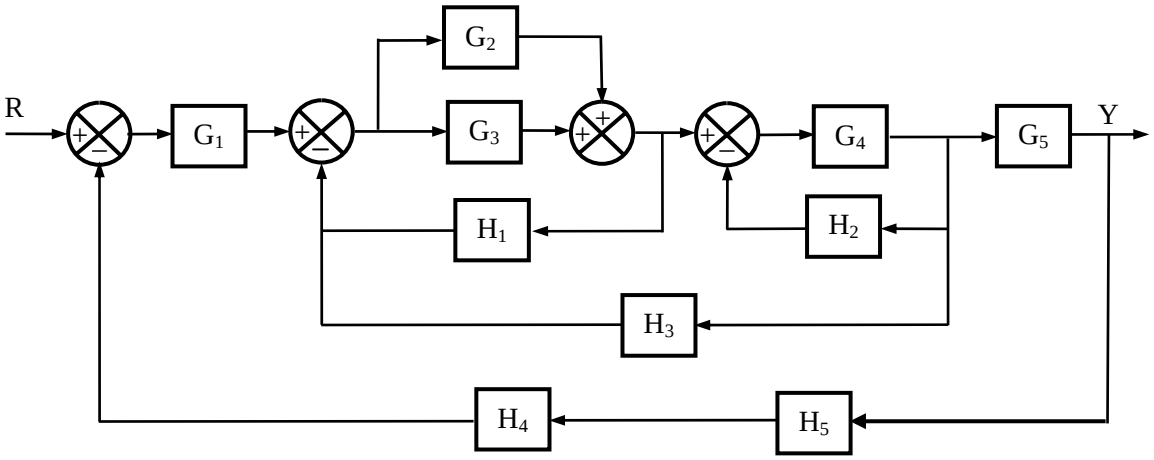
- *Your student I.D. number is entered clearly and legibly on all examination answer booklets that you use.*
- *You indicate which questions are answered in each booklet.*
- *All answer booklets are sequentially numbered in the box provided on the front page of each booklet.*
- *The total number of booklets that you use is also indicated in the box provided on the front page of each booklet.*

QUESTION 1

(a) Draw a block diagram to present a closed-loop (feedback) control system that consists of a plant with the transfer function (tf) of $G_p(s)$, a measurement element with the tf of H(s), a comparison element and an actuator with the tf of $G_a(s)$. Name the signals and state the functions for each element in the system. Write the open-loop transfer function and total feedback transfer function of the whole system.

[8 Marks]

(b) Reduce the following block diagram:



[6 Marks]

QUESTION 2

Dynamics of a process system is represented by the following differential equation:

$$\ddot{y} + 4\dot{y} + 13y = 5u$$

where y is the output and u is the input.

(a) Write a transfer function for Y(s)/U(s) with zero initial conditions and find possible poles and zeros of the transfer function.

[4 Marks]

(b) Find the system response in time domain if a step input applies.

[4 Marks]

(c) Find the steady state error if:

i) a unit step input applies

ii) a unit ramp input applies

[4 Marks]

QUESTION 3

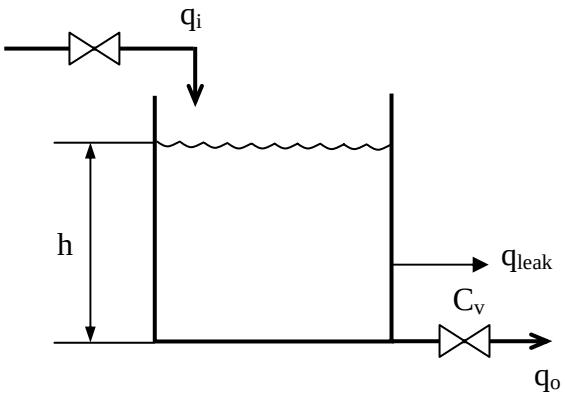
A simple surge tank with a fixed valve on the outflow line is illustrated in the following figure. The tank has the diameter of 1 m. If the outflow rate q_o is proportional to the liquid height, i.e. $q_o = C_v h$ (C_v = 2 l/min/m), and the liquid density is constant ($\rho = 1000$ kg/m^3) write a differential for the relationship between the output level h (m) and inflow rate q_i (600 l/min) with the assumption that the process is initially empty.

i) Write the transfer function $G(s) = H(s)/Q_i(s)$ and find its poles and zeros.

[6 Marks]

ii) Find time constant and static sensitivity of the system.

[2 Marks]



iii) If the liquid level is measured by a level transducer that consists of a level sensor (resistance type) with K_1 = 1 mV/cm, an amplifier with K_2 = 100 V/V and a voltage-to-current converter with K_3 = 2 mA/V, calculate the overall sensitivity. If the transducer reading is 10 mA, what is the liquid level?

[2 Marks]

iv) It is assumed that because of corrosion the tank has a leak at one third of the height of the tank level from the bottom as shown in the above figure and the leak flow rate is approximated by $q_{leak} = 0.5 \times h$ (l/min), find a new transfer function and its zeros and poles for the system. What is the time constant of the system?

[4 Marks]

QUESTION 4

Describe a type of level transducer that can be used for the system in Question 3. You may use simple sketches, formulas and/or block diagrams to illustrate your answers.

[8 Marks]

QUESTION 5

Describe a type of actuator that can be used for the system in Question 3. You may use simple sketches, formulas and/or block diagrams to illustrate your answers.

[8 Marks]

QUESTION 6

(a) State the principles of a PID controller. You may use mathematical equations, sketches and block diagram to illustrate your answers.

[8 Marks]

(b) Consider the tank system in Question 3. The relationship between the tank level and the inlet flow rate is expressed by the following equation

$$Ah' + C_v h = q_i$$

Assuming that the liquid level is kept stable by a PID controller and an actuator with the transfer function of $G_a(s) = K_v$, a current-to-pressure converter with the transfer function of $G_{IP}(s) = K_{IP}$ is used to supply enough energy for the actuator and the liquid level is measured by a level transducer with the transfer function of $H(s) = K_m$:

(i) Draw a block diagram for the whole system;

[4 Marks]

(ii) Write the total feedback (closed-loop) transfer function for the system.

[4 Marks]