AUSTRALIAN MARITIME COLLEGE

The Australian Maritime College is an Institute of the University of Tasmania

NATIONAL CENTRE FOR MARITIME ENGINEERING AND HYDRODYNAMICS

CLASS TEST

COURSE:	BE (Ocean Engineering and MOS Engineering)
SUBJECT:	Instrumentation and Process Control
CODE:	JEE326
DURATION:	1 Hour
YEAR:	2
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:
Writing and Drawing Instruments as required
Nonprogrammable personal calculator
"Graph Paper Required" / "No Graph Paper Required"

INSTRUCTIONS TO CANDIDATES

Answer Instructions:	There are three (3) questions. Attempt all questions.
Materials Provided:	Nil
Pass Level:	50%

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) Find poles and zeros of the following transfer functions and mark poles with × and zeros with small circles ⊙ in the s-plane.

i) $H(s) = \dfrac{2s+5}{(3s^2+7s+10)(2s^2+8s+13)}$

ii) $G(s) = \dfrac{s^2+5s+14}{s(s^2+7s+22)}$

[*4 Marks*]

b) A dynamic system is represented by the following differential equation:

$$a\ddot{y} + b\dot{y} + cy = du$$

where y and u are the output and input, respectively, a, b and c are the system parameters.

i) Assuming that all initial conditions are zeros, write the transfer function for the system and find all poles and zeros of the transfer function. Use these numerical values: a = 1, b = 5, c = 6 and d = 2.

[*5 Marks*]

ii) If the input u is a unit step function find the system response y in time domain.

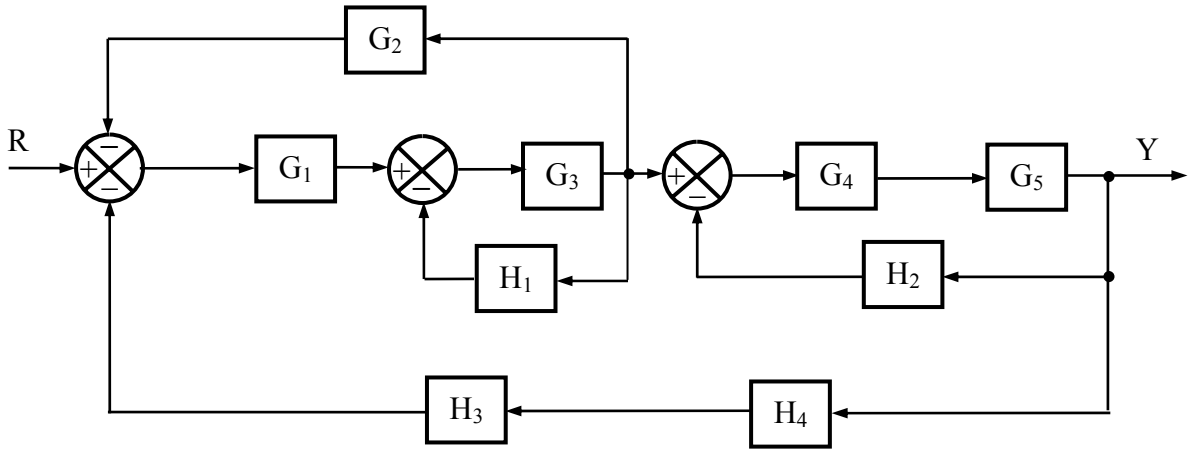
[*4 Marks*]

iii) Find the damping ratio, natural frequency and static sensitivity if y is the output displacement in m and u the input force in N.

[*3 Marks*]

QUESTION 2

Reduce the following block diagram:



[*6 Marks*]

QUESTION 3

Do one of the following problems:

3.1 Vessel (Fluid) System:

A ship has a mass m and resistance C times the forward velocity u(t). If the thrust from the propeller is K times its angular velocity ω(t), determine:

(i) The differential equation and hence the transfer function relating U(s) and ω(s), i.e. G(s) = U(s)/ω(s), assuming that the vessel is initially at rest. Find its poles and zeros.

[*6 Marks*]

When the vessel has the parameters m = $18{,}000 \times 10^3$ kg, C = 150,000 Ns/m, and K = 96,000 Ns/rad, find:

(ii) The time constant and static sensitivity of the system.

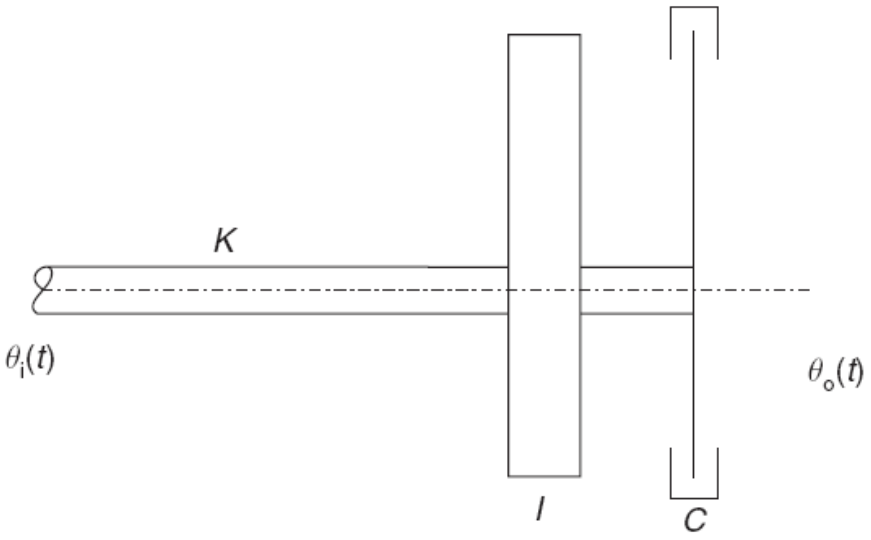
[*2 Marks*]

(iii) If the speed of the vessel is measured by an electronic speed log that has an error of $\pm 0.25\%$. The speed log is connected to a signal conditioning circuit that consists of an amplifier with an error of $\pm 0.35\%$, a voltage-to-current converter with an error $\pm 0.55\%$ and an indicator with an error of $\pm 0.15\%$, calculate the maximum possible error and probable error.

[*2 Marks*]

3.2 Mechanical System:

A torsional spring of stiffness K, a mass of moment of inertia I and a fluid damper with damping coefficient C are connected together as shown in the following figure.



If the angular displacement of the free end of the spring is $\theta_i(t)$ and the angular displacement of the mass and damper is $\theta_o(t)$, find

(i) The differential equation relating $\theta_i(t)$ and $\theta_o(t)$ given that I = 2.5 $kg \cdot m^2$, C = 12.5 $Nm \cdot s/rad$ and K = 250 Nm/rad and hence the transfer function $G(s) = \theta_o(s)/\theta_i(s)$ and its poles and zeros. Assume that the system is initially at rest.

[*6 Marks*]

(ii) The above system is a second-order one, find its damping ratio and natural frequency.

[*2 Marks*]

(iii) If the angular displacement of the free end is measured by a displace transducer that consists of a sensor with K_1 = 1 mV/rad, 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 displacement?

THE END