AUSTRALIAN MARITIME COLLEGE

FACULTY OF MARITIME TRANSPORT AND ENGINEERING

EXAMINATION

SUBJECT:	**Instrumentation and Process Control**
CODE:	**E07 267**
DATE:	**7 November 2003**
DAY:	**Friday**
START TIME:	**0900**
END TIME:	**1200**
COURSE:	**Bachelor of Engineering (Ocean Engineering)** **Bachelor of Engineering (Marine & Offshore Systems)**
EXAMINER:	**H Nguyen**

No materials allowed except the following:

Non-Programmable Calculator
Formula Sheet (*)

(*) The formula sheet with any annotation is illegal.

This examination paper consists of **6** pages.

BACHELOR OF ENGINEERING (OCEAN ENGINEERING)

BACHELOR OF ENGINEERING (MARINE & OFFSHORE SYSTEMS)

INSTRUMENTATION AND PROCESS CONTROL

E07 267

SEMESTER 2, 2003

INSTRUCTIONS TO CANDIDATES:

TIME ALLOWED: 3 HOURS

THERE ARE SIX (6) QUESTIONS

ANSWER ALL QUESTIONS

YOU MAY ANSWER THE EASY QUESTIONS FIRST. YOU SHOULD READ THE QUESTIONS VERY CAREFULLY BEFORE ANSWERING IN ORDER TO AVOID DIGRESSION OF THE SUBJECTS OF THE QUESTIONS. ONLY THE CORRECT ANSWERS ARE MARKED. THERE ARE NO PENALTIES ON THE INCORRECT ANSWERS.

THE MARK FOR EACH QUESTION IS INDICATED BELOW EACH QUESTION

THERE ARE A TOTAL OF 48 MARKS AVAILABLE IN THIS EXAMINATION

PASS LEVEL: YOU ARE REQUIRED TO ACHIEVE OVER 40% OF THE POSSIBLE MARKS FOR THIS EXAMINATION BEFORE YOU CAN BE CONSIDERED FOR A GRADE OF PASS OR BETTER.

QUESTION 1

(a) State the needs for instrumentation. Why is instrumentation important in a control system?

[2 Marks]

(b) Describe the general block diagram of a measuring system and state functions of each block. Use an example of a measuring system in maritime industry.

[2 Marks]

(c) Classify measuring systems. Which measuring system is preferred nowadays and why?

[2 Marks]

(d) Use an example of a measuring method and describe the corresponding instrument and its principle in the maritime industry.

[2 Marks]

QUESTION 2

(a) State the general structure of a control system (using block diagram). Explain the function of each block.

[2 Marks]

(b) Describe the comparison element of a control system and its operational principle.

[2 Marks]

(c) Describe a sensor or transducer used in the maritime industry.

[2 Marks]

(d) Describe a final control element.

[2 Marks]

QUESTION 3

The following differential equation represents a dynamic system

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

where a, b, c and d are constants, y and u are output and input as shown in Figure 1.

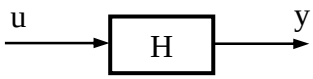

Figure 1

(a) Write the state space representation for the system.

[2 Marks]

(b) Find the transfer function (H, with zero initial conditions) of the system. Find poles and zeros of the transfer function in case of a = 2, b = 4, and c = d = 13. Then determine if the close-loop system shown in Figure 2 is stable.

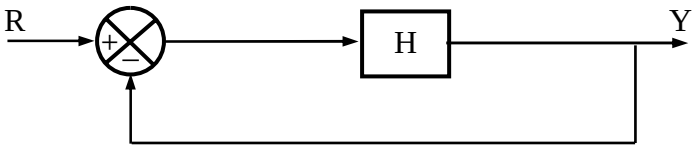

Figure 2

[2 Marks]

(c) Find the steady state error if a unit ramp input signal is applied.

[2 Marks]

(d) In case of a = 2, b = 4, and c = d = 13 and a proportional control ($C = K_P$) is designed for the above system as shown in Figure 3, determine the value of K_P for which the closed-loop system is stable.

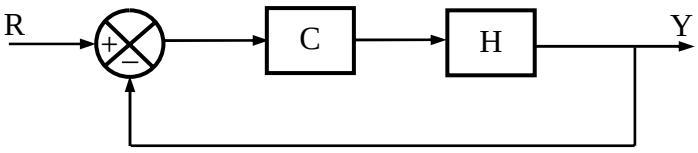

Figure 3

[2 Marks]

QUESTION 4

(a) What is the static performance of a measuring system? Define the following terms and show examples of them: accuracy and precision, reproducibility, repeatability, stability, span, linearity.

[4 Marks]

(b) What is the dynamic performance of a measuring system? Given a first order measuring system as follows:

$$\tau\frac{dy}{dt} + y = Ku$$

where τ and K are constants, y and u are output and input, respectively, describe the output response, then find the steady state error when:

(i) a unit step test signal is applied (unit step response);
(ii) a unit ramp test signal is applied (unit ramp response).

[4 Marks]

QUESTION 5

(a) Describe a control system used in marine and offshore industries;

[4 Marks]

(b) State its basic control principle.

[4 Marks]

Hints: Formulas and block diagrams can be used to illustrate your answer.

QUESTION 6

(a) Describe the PID control system (P, I, D, PI, PD and PID control actions).

[4 Marks]

(b) Given the following block diagram in Figure 4,

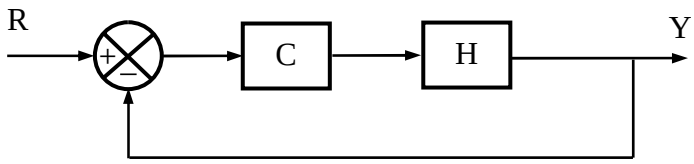

Figure 4

where $G = \frac{K}{Ts+1}$ (K and T are constant, K = 0.11, T = 7.5 seconds), and $C = K_P + \frac{1}{T_I s}$ (K_P and T_I are proportional control gain and integral time constant, K_P = 4, T_I = 100 seconds):

(i) Find the closed loop transfer function and open loop transfer function. Find poles and zeros (if any) of the closed-loop transfer function.
(ii) Determine if the closed-loop system is stable.

[4 Marks]