AUSTRALIAN MARITIME COLLEGE

FACULTY OF MARITIME
TRANSPORT AND ENGINEERING

SUPPLEMENTARY EXAMINATION

SUBJECT:	**Instrumentation and Process Control**
CODE:	**E07 267**
DATE:	**18 February 2004**
DAY:	**Wednesday**
START TIME:	**0900**
END TIME:	**1215**
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 SUPPLEMENT EXAMINATION.

QUESTION 1

(a) State the open-loop control system and its features. Give an example of the open-loop control system.

[2 Marks]

(b) State the closed-loop control system and its features. Give an example of the closed-loop control system.

[2 Marks]

(c) Explain the term "Steady State Error" (SSE) of a system. State the final value theorem and apply to find the SSE of a second-order system. Use diagrams to illustrate your answer.

[2 Marks]

(d) Explain an ideal measuring system. Explain the necessity for the calibration of a measuring system.

[2 Marks]

QUESTION 2

(a) Define the transfer function (continuous-time and discrete-time) of a dynamic system, its poles and zeros. Use examples to illustrate your answer.

[4 Marks]

(b) What is the static performance of a measuring system? Define the following terms and show examples of them: sensitivity, accuracy and precision, possible and probable errors, reproducibility, repeatability, stability, span, linearity. Use examples (where applicable) to illustrate your anwer.

[4 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.

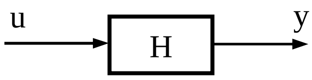

Figure 1

(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 = 1, b = 5, and c = d = 7. Then determine if the close-loop system shown in Figure 2 is stable.

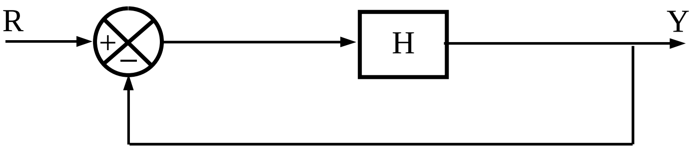

Figure 2

[2 Marks]

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

[2 Marks]

(d) In case of a = 1, b = 5, and c = d = 7 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.

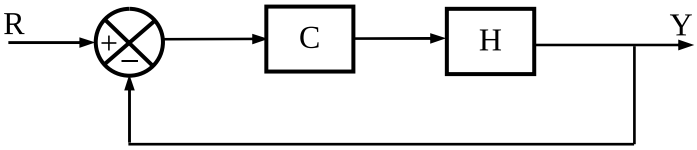

Figure 3

[2 Marks]

QUESTION 4

(a) Explain the block diagram. State and prove the block diagram algebra.

[4 Marks]

(b) Describe the general structure of a control system using the block diagram. Explain the functions of each block.

[4 Marks]

QUESTION 5

(a) Describe a measuring system used in marine and offshore industries and its measuring method.

[4 Marks]

(b) Describe a control system and its basic control principle.

[4 Marks]

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

QUESTION 6

(a) What does PID stand for? Explain the PID control action using appropriate formulae and diagrams.

[4 Marks]

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

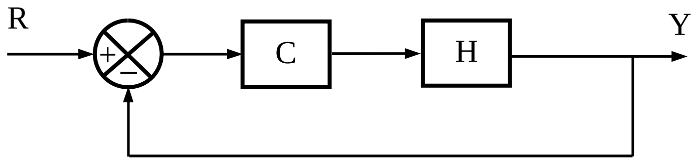

Figure 4

where $H = \frac{K}{Ts + 1}$ (K and T are constant, K = 0.11, T = 7.5 seconds), and $C = K_P + T_D s$ (K_P and T_D are proportional control gain and derivative time constant, $K_P = 2$, $T_D = 4$ 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]