CONFIDENTIAL

UNIVERSITI KUALA LUMPUR
Malaysian Institute of Marine Engineering Technology

FINAL EXAMINATION
OCTOBER 2025 SEMESTER SESSION

SUBJECT CODE	:	**LEB31502**
SUBJECT TITLE	:	**FUNDAMENTAL INSTRUMENTATION AND CONTROL SYSTEM**
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	**BACHELOR OF ENGINEERING TECHNOLOGY (OFFSHORE) WITH HONOURS**
TIME / DURATION	:	**2.00 PM - 5.00 PM (3 HOURS)**
DATE	:	**28 JANUARY 2026**

INSTRUCTIONS TO CANDIDATES

1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **TWO (2)** Sections; Section A and Section B.
4. Answer **ALL** question in Section A. For Section B, and **THREE (3)** questions **ONLY**.
5. Answer **ALL** questions in English language **ONLY**.
6. Formula is appended for your reference.

THERE ARE 8 PAGES OF QUESTIONS, EXCLUDING THIS COVER PAGE

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

(a) Control systems play a crucial role in modern engineering by enabling accurate regulation of processes and system behavior. One of the most important concepts in control engineering is the use of feedback control systems.

i. Name two (2) applications of feedback control systems?

(4 marks)

ii. State two (2) reasons for using feedback control systems and one (1) reason for not using feedback control systems.

(6 marks)

(b) For each of the following transfer functions, write the corresponding differential equations:

i. $$\frac{X(s)}{F(s)} = \frac{7}{s^2+5s+10}$$

(5 marks)

ii. $$\frac{X(s)}{F(s)} = \frac{15}{(s+10)(s+11)}$$

(5 marks)

Question 2

(a) In any measurement system, understanding the fundamental characteristics and limitations of instruments is crucial for ensuring reliable and repeatable results. Among the key concepts are precision and accuracy, which describe how consistent and correct a measurement is. Additionally, various types of measurement errors can affect the quality of data obtained from instruments.

i. Define the terms precision and accuracy in the context of measurement systems.

(2 marks)

ii. Elaborate any two (2) major types of measurement error and provide a brief elaboration for each.

(4 marks)

(b) A group of eight maintenance technicians tested a newly installed temperature sensor by measuring the temperature of a controlled heat source that was set at a constant value. Table 1 shows the temperature readings (in °C) recorded by each technician.

i. Calculate the mean temperature recorded by the sensor.

(2 marks)

ii. Determine the precision of all the temperature measurements.

(4 marks)

iii. Identify the most accurate and least accurate readings.

(2 marks)

iv. Compute the deviation for each reading and determine the average deviation and standard deviation.

(6 marks)

Table 1: Temperature Readings (in °C)

Reading No.	V_{in} (V)	Output Displacement (Degrees)
1	75	75.1
2	75	75.0
3	75	75.2
4	75	74.8
5	75	74.7
6	75	75.0
7	75	75.3
8	75	74.9

SECTION B (Total: 60 marks)

INSTRUCTION: Answer THREE (3) questions only.
Please use the answer booklet provided.

Question 3

(a) Find the transfer function, $G(s) = V_0(s)/V_i(s)$ for the network shown in Figure 1. ~~below:~~

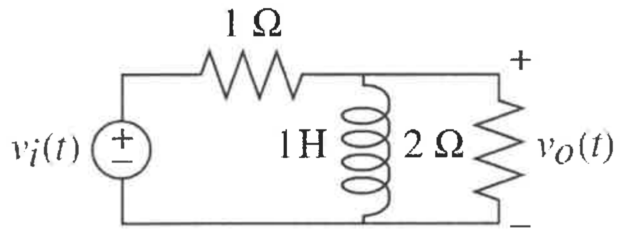


Figure 1

(7 marks)

(b) Find the state-space representation in phase-variable for the transfer function below:

$$\frac{C(s)}{R(s)} = \frac{30}{(9s^3 + 6s^2 + s + 30)}$$

(7 marks)

(c) Using the Laplace transform pairs from the formula, derive the Laplace transform for the following time functions:

i. $e^{-at} \sin \omega t \, u(t)$

ii. $e^{-at} \cos \omega t \, u(t)$

(6 marks)

Question 4

(a) Given the following transfer function for a Second-Order System:

$$\frac{C(s)}{R(s)} = \frac{16}{s^2 + 3s + 16}$$

Compute the following dynamic response characteristics:

i. Natural frequency ω_n

(1 mark)

ii. Damping ratio ζ

(1 mark)

iii. Rise time T_r

(2 marks)

iv. Peak time T_p

(1 mark)

v. Percent overshoot (%OS)

(2 marks)

vi. Settling time T_s.

(1 mark)

(b) Referring to the block diagram shown in Figure 2, Simplify the block diagram then obtain the close-loop transfer function $C(s)/R(s)$.

(12 marks)

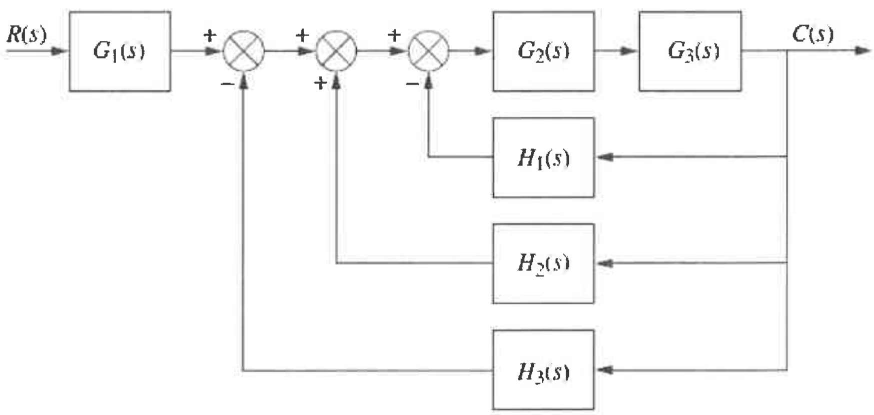


Figure 2

Question 5

(a) In the analysis of linear time-invariant (LTI) systems, understanding the behavior of the system's response is crucial for determining its performance and reliability. The stability of an LTI system is often assessed by examining both the natural response and the total response.

i. Identify the part of the output response responsible for determining system stability.

(1 mark)

ii. Explain the required pole locations for a stable system.

(2 marks)

iii. Interpret the information provided by the Routh-Hurwitz criterion.

(3 marks)

(b) Using the Routh table, tell how many poles of the following function are in the right half-plane, in the left half plane, and on the $j\omega$-axis.

$$T(s) = \frac{s+8}{s^5 - 4s^4 + 3s^3 - 3s^2 + 3s - 2}$$

(14 marks)

Question 6

(a) By using Partial-Fraction Expansion, determine the inverse transform of function

$$V(s) = \frac{5}{s^2 + 8s + 15}$$

(7 marks)

(b) Figure 3 shows four arms of an unbalanced Wheatstone bridge with the following parameters: R3=60Ω, R4=6Ω, R2=3Ω, R1=12Ω. A galvanometer with internal resistance of 20Ω and sensitivity of 8mm/μA is connected between BD. A battery of 12Vdc is connected between AC. Calculate the:

i. voltage drops across the arms; V_{BC} and V_{DC}.

(4 marks)

ii. voltage difference between the nodes B and D.

(3 marks)

iii. current through the galvanometer.

(3 marks)

iv. value of resistance to be put on the arm R1 so that the bridge is balanced (null condition exist).

(3 marks)

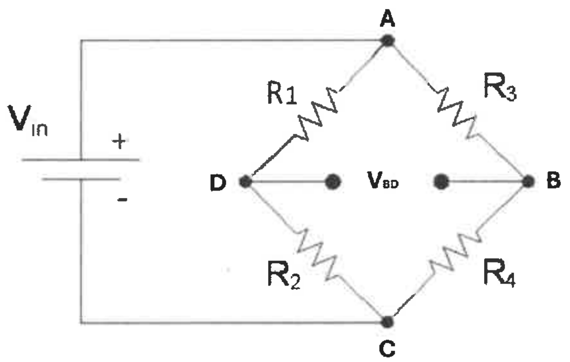


Figure 3

END OF EXAMINATION PAPER

FORMULA

Partial fraction

$$\frac{1}{s(s+A)} = \frac{a_0}{s+A} + \frac{a_1}{s}$$

$$\frac{1}{s(s+A)(s^2+B)} = \frac{a_0}{s+A} + \frac{a_1}{s} + \frac{a_2 s + a_3}{s^2+B}$$

Standard Deviation

$$s = \sqrt{\frac{1}{n-1}\sum(x_i - \bar{x})^2}$$

Inverse Laplace transform

$$\mathscr{L}[f(t)] = F(s) \quad = \int_{0-}^{\infty} f(t)e^{-st}dt$$

$$\mathscr{L}[kf(t)] \quad = kF(s)$$

$$\mathscr{L}[f_1(t) + f_2(t)] = F_1(s) + F_2(s)$$

$$\mathscr{L}[e^{-at}f(t)] \quad = F(s+a)$$

$$\mathscr{L}[f(t-T)] \quad = e^{-sT}F(s)$$

$$\mathscr{L}[f(at)] \quad = \frac{1}{a}F\left(\frac{s}{a}\right)$$

$$\mathscr{L}\left[\frac{df}{dt}\right] \quad = sF(s) - f(0-)$$

Laplace transform

$$L\left\{\frac{dy(t)}{dt}\right\} = sY(s) - y(0)$$

$$L\left\{\frac{d^2y(t)}{dt^2}\right\} = s^2Y(s) - sy(0) - \frac{dy(0)}{dt}$$

$$L\{y'\} = sY(s) - y(0)$$

$$L\{y''\} = s^2Y(s) - sy(0) - \frac{dy(0)}{dt}$$

Laplace transform table

$$\delta(t) = 1$$

$$u(t) = \frac{1}{s}$$

$$tu(t) = \frac{1}{s^2}$$

$$t^n u(t) = \frac{n!}{s^{n+1}}$$

$$t^{-at}u(t) = \frac{1}{s+a}$$

$$\sin \omega t u(t) = \frac{\omega}{s^2 + \omega^2}$$

$$\cos \omega t u(t) = \frac{s}{s^2 + \omega^2}$$

2nd order systems

Peak time, $T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

Settling time, $T_s = \frac{4}{\zeta\omega_n}$

overshoot percentage $\%OS = e^{-(\zeta\pi/\sqrt{1-\zeta^2})}x100$

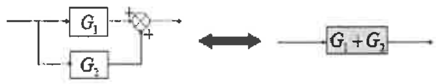
$$G(s) = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2}$$

Damping ratio	Normalized rise time
0.1	1.104
0.2	1.203
0.3	1.321
0.4	1.463
0.5	1.638
0.6	1.854
0.7	2.126
0.8	2.467
0.9	2.883

Reduction techniques

Combining blocks in cascade

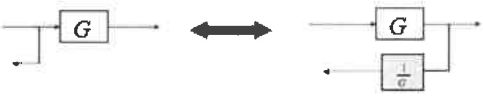
Combining blocks in parallel (feed-forward)



Eliminating a feedback loop (a)

Eliminating a feedback loop (b)

Moving a pickoff point behind a block



Moving a pickoff point ahead of a block

Moving a summing point ahead of a block

Moving a summing point behind a block