UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: May 2026

Module Number: MN7206 **Module Name: Automated Systems**

[Three Hours]
[Answer all five questions]

Provide neat sketches and state any reasonable assumptions made. Make sure to use standard notations and SI units where appropriate. Follow standard notations.

Q1 a) Given the following differential equation, solve for $y(t)$ if all initial conditions are zero. Use the Laplace transform.

$$\frac{d^2y}{dt^2} + 12\frac{dy}{dt} + 32y = 32ut$$

[2.5 Marks]

b) Find the transfer function represented by

$$\frac{dc(t)}{dt} + 2c(t) = r(t)$$

[2.5 marks]

c) Find the transfer function, $X_2(s)/F(s)$, for the system of Figure 1.1.

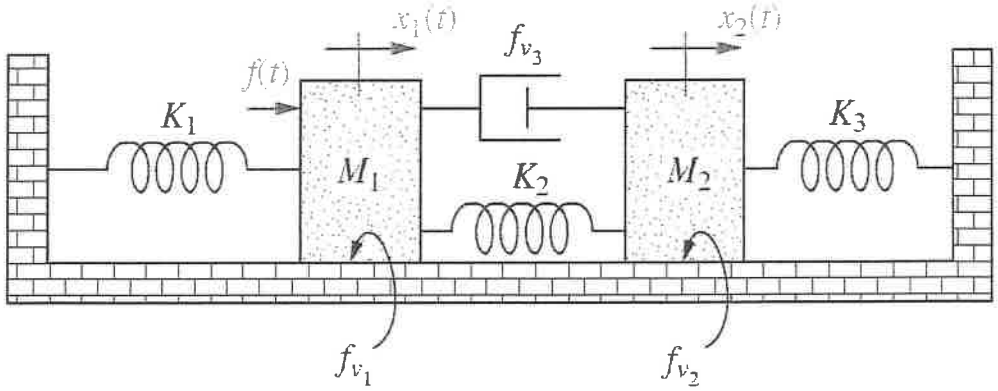


Figure 1.1

[2.5 Marks]

d) Find the state equations for the translational mechanical system shown in Figure:1.1.

[2.5 marks]

e) How does an open-loop system work? Please expand on its advantages and drawbacks.

[2.5 Marks]

f) With a suitable example, explain the principle of operation of a closed loop system.

[2.5 Marks]

g) Explain the behavior and stability of a second-order dynamic system's step response based on the location of its poles in the complex s-plane. The general form of the second-order transfer function is given by:

$$G_s = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n + {\omega_n}^2}$$

[5.0 Marks]
[Total marks 20]

Q2

a) i. With a suitable diagram, explain the role of sensor and transmitter.
ii. What are the differences between a transducer and a transmitter?
iii. What is the significance of the $4 - 20$ mA of sensor signal.

[5.0 Marks]

b) With suitable examples and diagrams, highlight the differences between switches and transducers.

[2.5 marks]

c) List the three basic types of pressure measuring devices and explain their working principles.

[2.5 marks]

d) For a real-time ship hull structural health monitoring (SHM) system, select the appropriate sensor technology and briefly explain its operation.

[5.0 marks]
[Total marks 15]

Q3 a) A medium size diesel engine requires proper lubrication pressure before starting. Design an electrical control system using two push buttons (START and STOP) to initiate and stop the starting system. Programmable controllers are not allowed; only relays and timers may be used.

The required operating sequence is as follows:

1. When the **START push button** is pressed, the **lubrication pump (LP)** should start.
2. After **20 seconds**, the lubrication pump should stop.
3. Then, the engine should start by activating the **starter motor (SM)**.
4. At the same time, the **diesel fuel supply valve (DFV)** should open.
5. After **5 seconds**, the starter motor should stop.
6. When the **STOP push button** is pressed, the diesel fuel supply valve should close.

[5.0 Marks]

b) Write a ladder diagram for an XOR gate.

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

Figure 3.1 XOR gate

[2.5 marks]

c) Write a ladder logic diagram for the sequential control of three motors. Motor 1 starts when the START push button is pressed. After a delay of 10 seconds, Motor 2 starts. After another 10-second delay, Motor 3 starts. Pressing the STOP push button should stop all motors.

[7.5 Marks]
[Total marks 15]

Q4 a) Condition-Based Maintenance (CBM) is considered superior to Reactive and Preventive maintenance for critical assets like a ship's Main Engine.

i. Differentiate between **Preventive** and **Condition-Based** maintenance in terms of cost and equipment reliability.

[5.0 Marks]

ii. Propose a CBM system architecture for a marine engine. Your answer must include:

- At least three parameters to monitor.
- The specific sensor types required for those parameters.
- A brief description of how 'Trend Analysis' is used to prevent engine failure.

[5.0 Marks]
[Total marks 10]

Q5 Designing a Dynamic Positioning (DP) System for a semi-submersible drilling platform is a high-stakes engineering task. Unlike a standard ship, a semi-submersible must maintain a precise "station" over a wellhead in deep water, often for months at a time, despite wind, waves, and currents.

a) Propose a redundant sensor suite. For each of the following categories, specify the **sensor type** and explain why that specific technology is chosen for a deepwater semi-submersible:

i. **Position Reference (Provide 2 different types):** Ensure at least one is independent of satellite signals.
ii. **Environmental/Motion Reference:** Identify how the system measures wind and the platform's vertical movement.
iii. **Heading Reference:** Specify the quantity and type.

[5.0 Marks]

b) Explain the control techniques of your DP Controller.

[2.5 Marks]

c) Draw a **Schematic Diagram** of the proposed DP system.

[2.5 Marks]
[Total marks 10]

Appendix: Laplace transform tables

Item no.	$f(t)$	$F(s)$
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

Item no.	Theorem	Name
1.	$\mathcal{L}[f(t)] = F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$	Definition
2.	$\mathcal{L}[kf(t)] = kF(s)$	Linearity theorem
3.	$\mathcal{L}[f_1(t)+f_2(t)] = F_1(s)+F_2(s)$	Linearity theorem
4.	$\mathcal{L}[e^{-at}f(t)] = F(s+a)$	Frequency shift theorem
5.	$\mathcal{L}[f(t-T)] = e^{-sT}F(s)$	Time shift theorem
6.	$\mathcal{L}[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$	Scaling theorem
7.	$\mathcal{L}\left[\frac{df}{dt}\right] = sF(s)-f(0-)$	Differentiation theorem
8.	$\mathcal{L}\left[\frac{d^2f}{dt^2}\right] = s^2F(s)-sf(0-)-f'(0-)$	Differentiation theorem
9.	$\mathcal{L}\left[\frac{d^nf}{dt^n}\right] = s^nF(s)-\sum_{k=1}^{n} s^{n-k}f^{k-1}(0-)$	Differentiation theorem
10.	$\mathcal{L}\left[\int_{0-}^{t} f(\tau)d\tau\right] = \frac{F(s)}{s}$	Integration theorem
11.	$f(\infty) = \lim_{s\to 0} sF(s)$	Final value theorem[1]
12.	$f(0+) = \lim_{s\to \infty} sF(s)$	Initial value theorem[2]