

**LOCATION: SWANSEA**

**LLEOLIAD: ABERTAWE**

**LEVEL 4**

**LEFEL 4**

**EXAMINATION PERIOD**  
**MAY 2025**

**CYFNOD ARHOLIADAU**  
**MAI 2025**

## **HND ELECTRICAL AND ELECTRONIC ENGINEERING**

**MODULE CODE: GOEE4002**

**Dynamics Control and Instrumentation**

**TIME: 2 HOURS**

**ANSWER ALL FIVE QUESTIONS**

*Equipment or materials required – Calculators and a formulae booklet are allowed.*

*Adnoddau neu ddefnyddiau sydd eu hangen -*

### **Question One (20 marks)**

A control system is being designed to regulate the temperature in a room. The system uses a heating element as the actuator, a temperature sensor as the feedback, and a controller that adjusts the heating element based on the sensor input.

- a. If the heating system in the room is designed as an open-loop system where the heating element is turned on for a fixed period, regardless of the room temperature.

i. Using a simple block diagram, illustrate the open-loop system.

[4 marks]

- ii. If the system experiences an external disturbance, such as a cold breeze entering the room, how will the open-loop system respond?

[1 mark]

- b. In contrast, a closed-loop system adjusts the heating element based on the actual room temperature, using feedback from the temperature sensor. Using a simple block diagram, illustrate the feedback control loop for this closed-loop system, showing the components of the system.

[5 marks]

- c. The closed-loop system is designed with a proportional controller with gain,  $K_p$ , and the sensor has unity feedback. The heating element has a transfer function given by:

$$G(s) = \frac{1}{s + 2}$$

If the desired temperature is changed by a step input of  $T_{set} = 30^\circ\text{C}$ , answer the following:

- i. Derive the closed-loop transfer function.

[4 marks]

- ii. Determine steady state temperature response  $T_{ss}$ , if the desired temperature is changed by a step input of  $T_{set} = 30^\circ\text{C}$ .

[6 marks]

### Question Two (20 marks)

A block of mass  $m=5\text{kg}$  is placed on a rough horizontal surface. The coefficient of friction between the block and the surface is  $\mu=0.3$ . A force  $F = 20\text{N}$  is applied horizontally to the block.

- a. Using Newton's second law, calculate the acceleration of the block. Assume that the applied force is greater than the force of friction and that frictional force is kinetic.

[4 marks]

- b. The block is subjected to a PID controller that adjusts the applied force  $F$  to maintain the block's speed at a constant value of  $2\text{m/s}$ . The transfer function of the system, representing the relationship between the force and velocity is given by:

$$G(s) = \frac{1}{ms + b}$$

- i. If  $b = 0.5\text{Ns/m}$  is the damping coefficient, use the transfer function to derive the steady state applied force to maintain the block's velocity at  $2\text{m/s}$  in the presence of friction.

[4 marks]

- i. Calculate  $G(0)$  and explain its significance in determining the steady state-applied force.

[4 marks]

- c. Assume that the block is connected by a string to another block of mass,  $m_2 = 8\text{kg}$ , which hangs vertically off the edge of the surface. The string passes over a pulley. The system is controlled by a feedback loop that adjusts the tension in the string to keep the blocks moving at a constant acceleration of  $2\text{m/s}^2$ . Write down the equations of motion for both blocks and derive the required tension  $T$  using Newton's second law.

[4 marks]

- d. Consider that the position of Block 1 (the one on the surface) is measured using a position sensor which provides a voltage output that is proportional to the position of the block, with a scaling factor of  $0.01\text{V/m}$ . If the block moves at a constant velocity of  $2\text{m/s}$ , calculate the voltage output of the sensor after 5 seconds.

[4 marks]

**Question Three (20 marks)**

A unity feedback system has the following open loop transfer function:

$$G(s) = \frac{(s + 3)}{(s + 4)(s^2 + 3s + 6)}$$

- a. Draw the poles and zeros diagram.

[8 marks]

- b. Evaluate the value of  $G(s)$  at the point  $s = -2 + j$ .

[12 marks]

**Question Four (20 marks)**

For the given system block diagram:

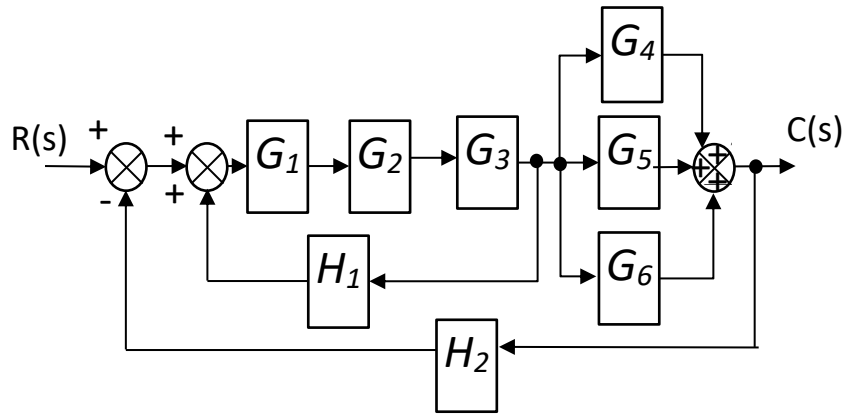


Figure 1

Determine the transfer function  $\left(\frac{Y(s)}{R(s)}\right)$  of the system using block diagram reduction method and draw all the reduction steps.

**Question Five (20 marks)**

An RLC circuit has resistance,  $R = 150\Omega$  inductance,  $L = 2H$ , and capacitance,  $C = 25\mu F$ .

The current in the circuit is given by;

$$\frac{d^2i}{dt^2} + \frac{R}{L} \frac{di}{dt} + \frac{1}{LC} i = \frac{V}{CL}$$

- a. What is the natural frequency of the circuit?

[4 marks]

- b. Determine whether the system overdamped, critically damped or underdamped?

[4 marks]

- c. What is the damped frequency of oscillation of the circuit?

[4 marks]

- d. Calculate the time constant  $\tau$  for the circuit.

[4marks]

- e. If the applied voltage is

$$V(t) = V_0$$

Where  $V_0 = 10V$  is constant, find the steady- state current,  $i_{ss}$  of the circuit?

[4 marks]

**Good luck**

**End of the exam**