Name: **Enrolment No:**	

UPES

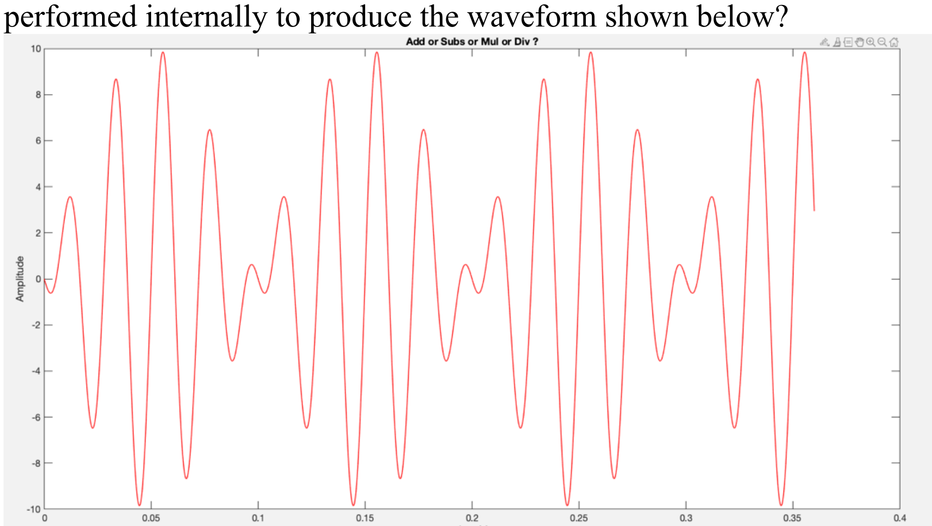
End Semester Examination, May 2025

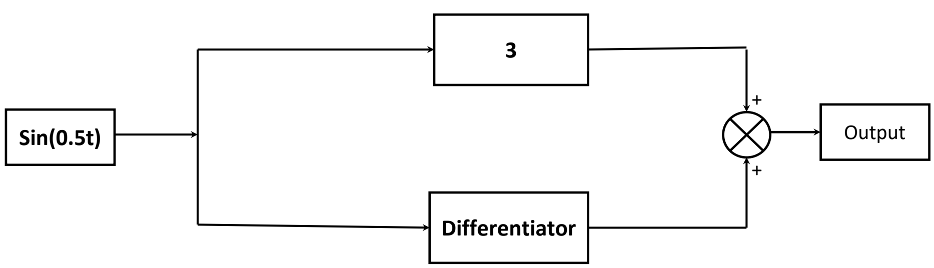
Course: Mechatronics System Design | **Semester: 8**
Program: B.Tech Mechatronics Engineering | **Time : 03 hrs.**
Course Code: MECH4033 | **Max. Marks: 100**

Instructions:
1. Please read each question carefully and then proceed to answer it.
2. Answer all questions.
3. Use figures and diagrams wherever necessary.

SECTION A

(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	You are visiting your department's mechatronics laboratory and notice a waveform on the oscilloscope that resembles the one shown below (Fig. 1). You also see two signal sources generating 5sin(50t) and 5sin(40t), respectively, which are collectively being fed into the oscilloscope. Can you determine and explain which mathematical operation is being performed internally to produce the waveform shown below?  **Fig 1: The signal displayed on the oscilloscope display**	**4**	**CO1**
Q 2	Determine which controller is primarily responsible for minimizing steady-state error in a control system, and justify your reasoning based on their fundamental characteristics.	**4**	**CO1**

Q 3	Draw a simple high-pass filter circuit using a resistor and capacitor. Identify the node where the output signal should be taken.	**4**	**CO1**
Q 4	Based on which parameter is a system categorized as underdamped, overdamped, or critically damped? Also, state the condition for each case.	**4**	**CO2**
Q 5	Plot how the impedance of the resistor, inductor, and capacitor in an RLC circuit changes with frequency when driven by an AC source.	**4**	**CO1**
SECTION B **(4Qx10M= 40 Marks)**			
Q 6	Describe how operational amplifiers can be used as signal conditioning circuits.	**10**	**CO2**
Q 7	Given the open-loop transfer function $G(s)$, construct and interpret the root locus plot of the system. Then, design a PI controller for the open-loop system and compute the steady-state error for both step and ramp input signals $$G(s) = \frac{1}{(S+4)}$$	**10**	**CO3**
Q 8	Derive the output response of the LTI system shown in Fig. 2 for the given sinusoidal input. Discuss the key inferences drawn from the resulting output expression.  **Fig 2: Block diagram representing a LTI system.**	**10**	**CO3**
Q 9	Derive the mathematical form of the transfer function for a simple low-pass filter circuit. Sketch the output response. **Or** a) Discuss five distinct properties of an operational amplifier. b) Briefly discuss the concept of the 'virtual short' in operational amplifiers.	**10**	**CO2**

SECTION-C (2Qx20M=40 Marks)			
Q 10	Consider a vertically suspended spring pendulum. Derive the governing differential equation when an initial displacement is applied at t=0 in the vertical plane. Using Laplace transform, solve the equation and sketch the corresponding output response. **Or** For the control system given below, apply the root locus steps to show the movement of poles and zeros for different values of K and draw the root locus response on the graph sheet provided. $\frac{K\,(S+3)}{S^2+2S+12}$	**20**	**CO4**
Q 11	Sketch Bode plot for a system with complex poles and zeros. Also, explain the steps involved in plotting the gain and phase margin plots.	**20**	**CO4**