Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

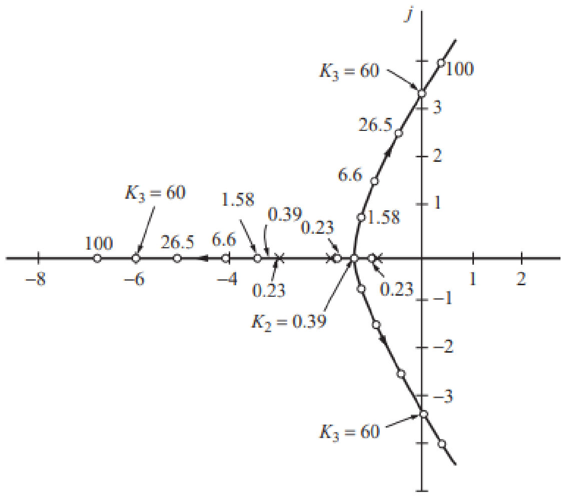
End Semester Examination, December 2024

Programme Name : B. Tech Mechatronics **Semester : V**
Course Name : Process Control **Time : 03 hrs**
Course Code : MECH3040P **Max. Marks: 100**
Nos. of page(s) : 03

Instructions: Assume suitable values of variables/parameters, if not given in the problem.

SECTION A
(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	(a) Define the term transfer function and its importance in process control. (b) Discuss the effect of poles and zeros on the final response of a system.	**4**	**CO1**
Q 2	Comment on direct acting and reverse acting controllers.	**4**	**CO1**
Q 3	Explain the concepts of marginal and asymptotic stability in a dynamic system. Comment on the system's response when its poles are located on the imaginary axis.	**4**	**CO1**
Q 4	Describe the key characteristics of the response of a second-order system for overdamped, underdamped, and critically damped conditions.	**4**	**CO2**
Q 5	Discuss the limitations of Laplace domain analysis.	**4**	**CO2**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	(a) Analyze the Routh-Hurwitz criterion and evaluate its role in determining the stability of a linear system. (b) Describe the key components of a Bode plot and assess how they are used to analyze the frequency response of a system. (c) Interpret the Nyquist stability criterion and apply it to analyze the stability of control systems.	**10**	**CO3**
Q 7	Elucidate on the properties and limitations of P, PI and PID controllers in the context of a close loop feedback control system.	**10**	**CO2**

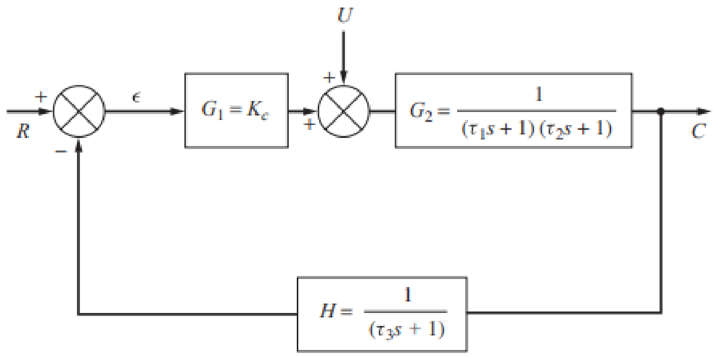
Q 8	Define root locus diagram. Explain the root locus diagram of the characteristic equation: $(s+1)(s+2)(s+3) + 6K_c = 0$, where K_c controller's gain, shown below. 	**10**	**CO3**
Q 9	A second-order process is described by the differential equation: $$\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 9y(t) = 9u(t)$$ (a) Write the transfer function $G(s)$ relating the output $y(t)$ to the input $u(t)$. (b) For a step input of magnitude 2, determine the steady-state response of the system. **OR** In a chemical process, the concentration of a reactant follows first-order dynamics, governed by the equation: $$\frac{dC_A(t)}{dt} + \frac{1}{\tau}C_A(t) = \frac{1}{\tau}C_{Ain}$$ (a) Derive the time response $C_A(t)$ for a step change in the inlet concentration C_{Ain}. (b) Explain how changing the time constant τ affects the speed of response in the system.	**10**	**CO2**

SECTION-C

(2Qx20M=40 Marks)

Q 10 (20 Marks, CO4)

Consider the close loop feedback control system as shown below. Write regulatory, $U(s)$ and servo, R(s) transfer functions for this close loop feedback control system.



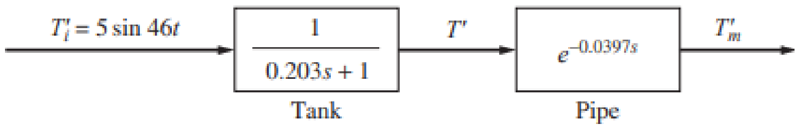
(a) Using $\tau_1 = 1$, $\tau_2 = ½$, $\tau_3 = 1/3$, determine the values of K_c for which the control system is stable.

(b) For the value of K_c for which the system is on the threshold of instability, determine the roots of the characteristic equation.

(c) Determine the stability of the system for which a PI controller is used. Use $\tau_1 = 1$, $\tau_2 = ½$, $\tau_3 = 1/3$, $K_c = 5$ and $\tau_I = 0.25$.

Q 11 (20 Marks, CO4)

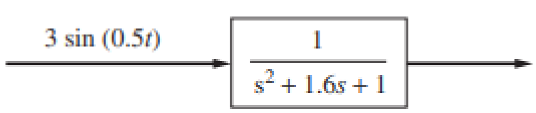
(a) Determine the form of the response for process shown below,



(b) Draw the Bode and Nyquist plots for the plant transfer function of the Tank shown above.

OR

(a) Consider a second-order transfer function, with τ = 1 and ζ = 0.8, being disturbed with a sine wave input of 3 sin (0.5t) (refer figure below). Determine the form of the response after the transients have decayed and steady-state oscillations are established.



(b) Draw the Bode and Nyquist plots for first order system with time delay of the form:$(K_p/(\tau s + 1)) * e^{\tau_d s}$