Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: B. Tech CE+RP **Semester: VI**
Subject: Process Dynamics Instrumentation and Control
Time: 03 hrs. **Max. Marks: 100**
Instructions: Assume the appropriate value of missing data if any.

SECTION A (4×5=20 M)
All the questions are compulsory

S. No.		Marks	CO
Q 1	Write the expression for proportional (P), proportional plus integral (PI), proportional plus derivative (PD) and proportional plus integral plus derivative (PID) control actions and explain the terms used therein.	5	CO2
Q 2	Discuss the concept of simple performance criteria and time integral performance criteria of controller setting.	5	CO4
Q 3	Obtain the transfer function of a purely capacitive process.	5	CO1
Q 4	Describe the working of an optical pyrometer with the help of neat sketch.	5	CO6

SECTION B (4 × 10 = 40 M)
Answer all the questions. Q 7 has an internal choice

Q 5	A system with unity gain is having complex conjugate poles **-0.1 + j (2/15) and -0.1 – j (2/15)**. This system is perturbed with a unit step input. Find the overshoot, decay ratio and time period of oscillation.	10	CO1
Q 6	Draw a root locus diagram for the open loop transfer function (use graph sheets to draw the root locus) $G(s)=\frac{3K}{(s+1)(2s+1)(s+3)}$. Determine the value of K for threshold instability.	10	CO3
Q 7	A PI controller with integral time constant of 0.1 min is to be designed to control a process with transfer function, $G_P(s)=\frac{10}{s^2+2s+100}$. Assume the transfer functions of the measuring element and the final control element are both unity. Find the gain of the controller that will constitute the critical condition for stability of the PI feedback control system. OR For a closed loop system consider the following transfer functions: process $G_p(s)$, controller $G_c(s)$, measuring element $G_m(s)$, and final control element $G_f(s)$	10	CO5

	$G_p(s) = \frac{2}{7s+1}$, $G_c(s) = 1$, $G_m(s) = G_f(s) = 1$ Find the offset in the closed loop response due to unit step change in the set point.		
Q 8	Describe the working of a pneumatic operated air fail to close and air fail to open control valve with the help of neat sketch. Discuss the flow characteristics of linear opening, quick opening and equal percentage control valve.	**10**	**CO6**
SECTION-C (2×20= 40 M) **Answer all the questions**			
Q 9	A closed loop feedback control system consists of a second order process $G_p(s) = \frac{K_p}{(\tau_1 s+1)(\tau_2 s+1)}$ and a proportional control $G_c(s) = K_c$. In the absence of controller (**$K_c = 0$**), the roots of the characteristics equation of the closed loop are **-2** and **-1** and roots are **$-1.5 \pm j\,0.5$** when **$K_c = 4$**. (a) Determine K_p, τ_1 and τ_2 (b) Determine limits on K_c so that the response of the system to a step input is non - oscillatory.	**20**	**CO2**
Q 10	Consider the following second order plus dead time process. $$G_P = \frac{3e^{-2s}}{s^2 + 0.2s + 1}.$$ Transfer function of all other elements in the control loop is unity. Draw a Bode plot for the frequency range $0.01 \le \omega \le 10$ qualitatively (make a table for AR and ϕ Vs ω and draw the Bode plot qualitatively on the plane paper) Design a PID controller using Ziegler-Nichols tuning technique. [Hint: In order to calculate the cross over frequency, use hit and trial method. The cross ov over frequency is one of the following three, 0.8734, 0.9178, 0.9635 and you may use hit hit and trial method for the same]	**20**	**CO4**

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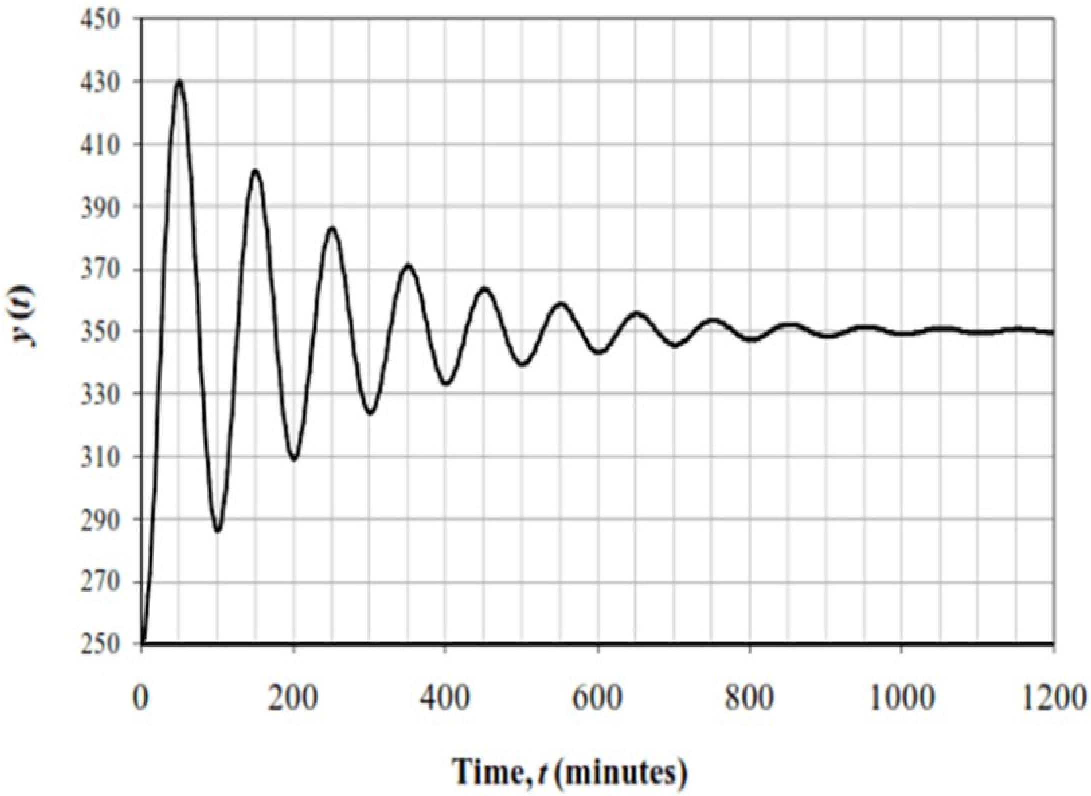
S. No.		Marks	CO
	SECTION A (4×5=20 M) **All the questions are compulsory**		
Q 1	Draw the block diagram of a control system illustrating ratio control.	**5**	**CO2**
Q 2	Derive analytical expression for the amplitude ratio and phase shift of the ultimate frequency response of sinusoidal input for two first order systems in series.	**5**	**CO3**
Q 3	Derive the transfer function for a purely dead time	**5**	**CO1**
Q 4	Describe the working of a radiation pyrometer with the help of neat sketch.	**5**	**CO6**
	SECTION B (4× 10 = 40 M) **Answer all the questions. Q 7 has an internal choice**		
Q 5	Draw the root locus diagram for the open loop transfer function (use graph sheets to draw the root locus) $G(s) = \dfrac{K}{(s+1)(s+2)(s+3)}$ Find the value of K for which the closed loop response is stable.	**10**	**CO3**
Q 6	The open loop transfer function of a process is $\dfrac{1}{4(3s+1)^4}$, where the time constant is in minutes. Determine the cross over frequency and ultimate gain. Also find the Zeigler Nichols tuning parameter for a PI control.	**10**	**CO4**
Q 7	Prove that the two first order processes (non - interacting) in series is equivalent to a second order process which is always over- damped in nature. OR The following second order process is controlled by a proportional controller of gain	**10**	**CO1**

	1.6 $G(s) = \frac{5}{(s+1)(2s+1)}$ For a unit step input in its set point, find the offset, overshoot, decay ratio, period of oscillation, natural period of oscillation, damping coeffcient.		
Q 8	An ideal PD controller had the transfer function $P = K_c(1+\tau_D s)\varepsilon$. An actual PD controller had the transfer function $P = K_c \frac{(1+\tau_D s)}{1+(\tau_D/\beta)s}\varepsilon$. Where β is a large constant in an industrial controller. If a unit step change in error is introduced into an industrial PD controller having the second transfer function, show that $P(t) = K_c(1 + Ae^{-\beta t/\tau_D})$. Where A is a function of β , which you are to determine.	**10**	**CO2**
	SECTION-C (2×20= 40 M) **Answer all the questions**		
Q 9	For a unit step input, the response of a second order system is given as, $y(t) = K_P\left(1 - \frac{1}{\sqrt{1-\xi^2}}e^{-\xi t/\tau}\sin(\frac{\sqrt{1-\xi^2}}{\tau}t + \phi)\right)$. Where, K_p is the steady state gain, ζ is the damping coefficient, τ is the natural period of oscillation and ϕ is the phase lag. For a unit step input, the response of the system from an initial steady state condition at t = 0 is shown in the figure below. Find the decay ratio, rise time, period of oscillation and the overall transfer function of the process in terms of process gain K_p.	**20**	**CO5**

			
Q 10	Design the P, PI and PID controller using Ziegler-Nichols tuning technique for a first order followed by a pipe of dead time of 2 (time units) with the transfer function $G_P = \left[\frac{2}{0.5s+1}\right]\left[e^{-2s}\right]$ and the transfer function of measuring element $H = \left[\frac{1}{2s+1}\right]$ and final control element is 1. Get amplitude ratio and phase angle for the process. Show the bode plot on plane paper qualitatively. Find the crossover frequency and gain margin.	**20**	**CO4**