Ref. No. : Ex/IEBE/T/321/2019

BIEE 3rd Year 2nd Semester Examination, 2019

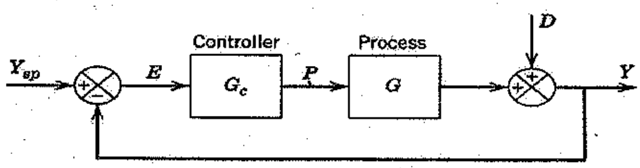
SUBJECT : Process Control – I

Time : Three hours **Full Marks 100**

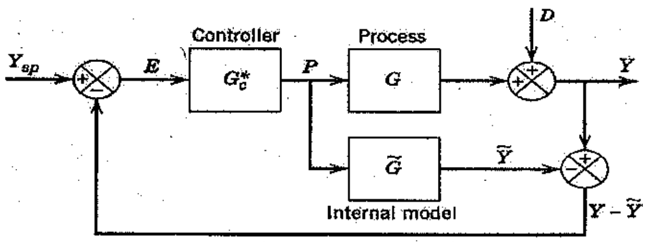
Answer *any* FOUR questions

Q. No.			Marks
1.	a)	Derive the velocity form of the digital PID controller and point out its advantages and disadvantages over the positional form.	5
	b)	Provide a comparative study about the merits and demerits of feedback control and feedforward control systems.	4
	c)	Write down the different forms (Type-A, Type-B, and Type-C) of a parallel PID controller.	2
	d)	In the context of feedback control, what are meant by proportional band, reset time, and derivative time ?	4
	e)	Why an ideal PD controller is physically unrealizable ? How a real PD controller is designed ? What is derivative kick and how it is eliminated ?	6
	f)	What is integral or reset windup and how this problem is resolved ?	4

2. The block diagrams for conventional feedback control and internal model control (IMC) are shown below :



(a) Classical feedback control



(b) Internal model control

			Marks
	a)	Find the relation between G_c and G_c^* so that the two block diagrams become identical. From the block diagram of IMC derive the closed-loop relation among Y, Y_{sp}, and D. Describe the design steps of IMC.	3+3+4
	b)	How PID parameters are tuned by Ziegler and Nichols continuous cycling method ? What are the major disadvantages of this technique ?	5+3
	c)	Describe the relay auto-tuning method for on-line PID tuning. Point out its important advantages compared to the continuous cycling method.	5+2

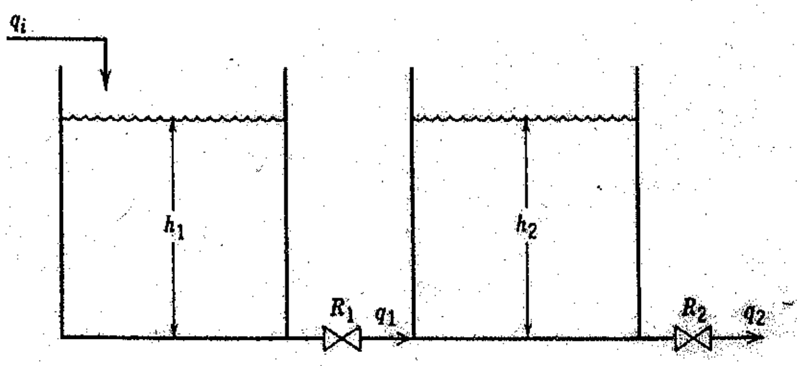
Q. No.		Marks
3.	a) Derive an approximate first-order-plus-time-delay model for the system with transfer function, $G(s) = \dfrac{K(1-0.2s)}{(6s+1)(2s+1)(0.8s+1)}$ using Taylor series expansion.	2
	b) State the Skogestad's 'half-rule' approximation method for higher-order models that contain multiple time constants. Use this method to derive two approximate models:	3+3+3

i) A first-order-plus-time-delay model,

ii) A second-order-plus-time-delay model in the form: $\widetilde{G}(s) = \dfrac{Ke^{-\theta s}}{(\tau_1 s+1)(\tau_2 s+1)}$,

for the system with transfer function, $G(s) = \dfrac{K(1-0.5s)e^{-s}}{(10s+1)(3s+1)(0.4s+1)(0.06s+1)}$.

c) For the two-tank interacting system shown below the transfer function between h_2 and q_i in terms of deviation variables can be expressed as, $\dfrac{H_2'(s)}{Q_i'(s)} = \dfrac{R_2}{\tau^2 s^2 + 2\zeta\tau s + 1}$. Find the expressions for τ and ζ. Assume that the two tanks have different cross-sectional areas A_1 and A_2 and that the valve resistances are fixed at R_1 and R_2. 14



4. Write short notes on (any five) : 5×5=25

a) On-off control

b) Time-delay compensation

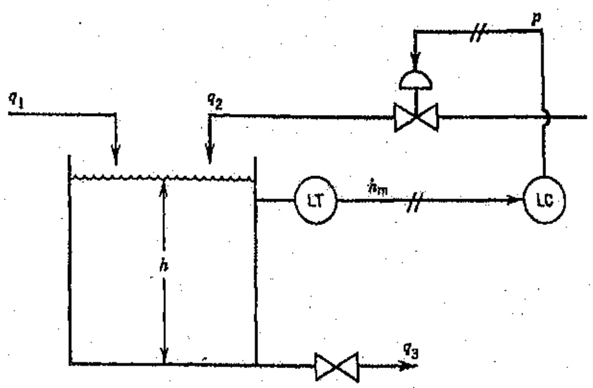
c) Control valve characteristics

d) Controller tuning by step test method

e) Process modeling through process reaction curve

f) Ratio control

Q. No.			Marks
5.	a)	Feedback control makes process performance less sensitive to changes in the process – Justify this statement through robustness analysis in terms of sensitivity function (S) and complementary sensitivity function (T).	5
	b)	Why cascade control is used ? With the help of a practical process, explain the operation of a cascade control system.	2+7
	c)	Consider the liquid-level control system shown below. The liquid level is measured and the level transmitter (LT) output is sent to a feedback controller (LC) that controls liquid level by adjusting volumetric flow rate q_2. A second inlet flow rate q_1 is the disturbance variable. Assume: The liquid density ρ and the cross-sectional area of the tank A are constant. The flow-head relation is linear, $q3 = h/R$. The level transmitter, I/P transducer, and control valve have negligible dynamics.	



Draw the block diagram of the level control system. For a unit step change in disturbance, find the expression of steady-state error or offset under proportional control. 4+7

6.	a)	What is the function of a final control element in a close-loop system ? What is the role of an actuator in a final control element ? Mention various methods of operation of pneumatic actuators.	1+2+2
	b)	What is C_v of a control valve? What is meant by control valve sizing ? What considerations are taken into account while selecting the valve size for a particular process under control ?	1+2+4
	c)	Why spring actuator often requires a positioner ? Providing a neat sketch of such a positioner describe its operation.	1+5
	d)	How the operation of control valves suffers due to *stiction* and *deadband*. What are meant by cavitation and flashing ?	3+4