*Ref. No.* Ex/IEBT/T/221/2018

**B.Tech. IEE 2nd Year 2nd Semester Examination – 2018**

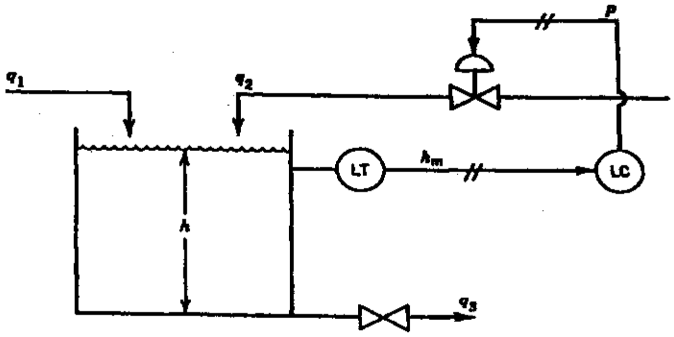
**SUBJECT : Process Control – I**

**Time : Three hours** **Full Marks 100**

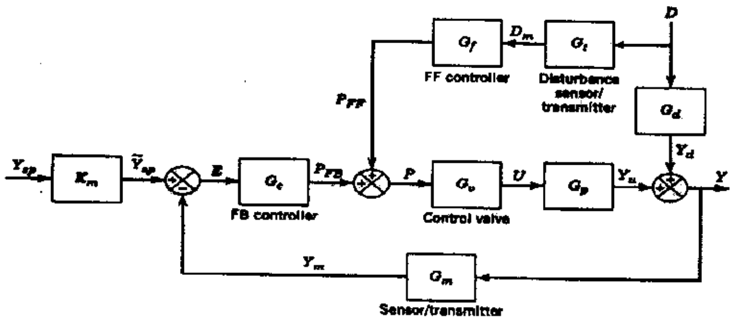
Answer *any* FOUR questions

| Qn. | | Marks |
|---|---|---|
| 1. | a) State the Skogestad's "*Half Rule*" for approximating higher-order transfer function models with lower-order models. Give an example of this rule to have a SOPDT model from a fourth-order dead-time model. | 2+3 |
| | b) Provide a comparative study about the merits and demerits of feedback control and feedforward control systems. | 5 |
| | c) Derive the dynamic model of a stirred-tank heating process with constant holdup. | 6 |
| | d) How set-point filtering and set-point weighting are implemented in PID controllers to improve servo responses ? | 4 |
| | e) Derive the velocity form of digital PID controller and point out its advantages. | 5 |
| 2. | 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) Why spring actuator often requires a positioner ? Providing a neat sketch of such a positioner describe its operation. | 1+4 |
| | c) What are meant by *air-to-close* and *air-to-open* valves. What is meant by control valve sizing ? State the procedure for selection of control valve size. | 4+2+4 |
| | d) What are meant by cavitation and flashing ? How the operation of control valves suffers due to *deadband.* | 3+2 |
| 3. | a) Describe the Direct Synthesis (DS) method to derive PID controllers. Point out some limitations of this method. | 8+2 |
| | b) How PID parameters are tuned by Ziegler-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. Mention its important advantages compared to the continuous cycling method. | 5+2 |
| 4 | Write short notes on (any *five*) :<br>a) On-off control<br>b) Controller tuning by step test method<br>c) Ratio control<br>d) Control valve characteristics<br>e) Process modeling through process reaction curve<br>f) Internal model control | 5×5 |

| Qn. | | Marks |
|---|---|---|
| 5. | a) What are meant by proportional band, reset time, derivative time ? Briefly state how these parameters influence the performances of closed-loop systems. What is integral windup and how this problem is resolved ? | 6+3+3 |
| | b) A liquid-level control system is 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. (Here, (i) the liquid density $\rho$ and the cross-sectional area of the tank $A$ are constant, (ii) the flow-head relation is linear, $q3 = h/R$, and (iii) 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. Show that for the same disturbance there will be no offset under PI control. | 3+5+5 |
| 6. | a) Define *sensitivity function* ($S$) and *complementary sensitivity function* ($T$) of a close-loop feedback control system. Feedback control makes process performance less sensitive to changes in the process – Justify this statement by robustness analysis in terms of sensitivity functions S and T. | 2+6 |
| | b) Illustrate the cascade control system of an exothermic chemical reactor. | 7 |
| | c) The block diagram of a feedforward-feedback control system is given below: | |




| | | |
|---|---|---|
| | Design the ideal feedforward controller $G_f$ considering the controlled variable remains exactly at the set-point despite arbitrary changes in the disturbance variable $D$. Justify that $G_f$ has no effect on the stability of the feedback control system. Find the $G_f$ when $G_t = K_t$, $G_v = K_v$, $G_d = K_d/(\tau_d s + 1)$, and $G_p = K_p e^{-\theta s}/(\tau_{p1} s + 1)$. State whether the derived controller is physically realizable or not. | 4+2+2+2 |