**(3 hour)** **[Total marks: 80]**

**N.B.:**

1) **Question-1 is compulsory. Answer any three questions from remaining**
2) **Assume data if necessary and specify the assumptions clearly**
3) **Draw neat sketches wherever required**
4) **Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other**

Q.1. a) Discuss classification of variables in process control [05]

Q.1 b) An ordinary mercury in glass thermometer follows first order transfer function with time constant of 10 sec. Initially it is at steady state temperature of 0°C. If at time t=0, it is immersed in a constant temperature bath of a 100°C, calculate the time required for the thermometer to read 95°C. [05]

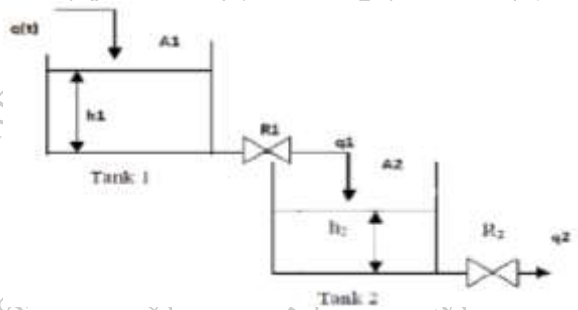
Q.1 c) A process of unknown transfer function is subjected to a unit impulse input. The output of the process is measured accurately and is found to be represented by the function $Y(t) = t\,e^{-t}$. Determine the unit step response of this process. [05]

Q.1.d) Discuss the significance of damping coefficient in second order system [05]

Q.2.a) A liquid surge tank has the following transfer function of $\frac{H(s)}{Q(s)} = \frac{10}{50s+1}$ [10]

The system is operating at the steady state with qis=0.4m$^3$/s, and hs=4m when the inlet flow rate fluctuates as a sine wave with an amplitude of 0.1m$^3$/s and a cyclic frequency of 0.002 cycles/s. What is the maximum and minimum value of the level after 10 min?

Q.2.b) Derive the transfer function $H_2(s)/Q(s)$ for the two liquid level system connected in series in non-interacting mode. Assume that resistances $R_1$ and $R_2$ are linear. [10]




Q.3.a) Develop the dynamic model for the stirred tank heating process, assuming constant hold up and perfect mixing. Classify all the variables and carry out degree of freedom analysis. [10]

Q.3.b) Derive the transfer function of a mercury thermometer [Y(s)/X(s)] located in a flowing fluid for which temperature x varies with. Y denotes thermometer reading. Make suitable assumptions and use regular notations. . [10]

Q.4.a) For the unity feedback control system, $G(s) = \frac{100}{s(s+0.5)(s+10)}$ Draw the bode plot. Determine GM, PM, $\omega$gc, $\omega$pc,. Comment on stability. [15]

Q.4.b) Write short note on phase margin and gain margin [05]

Q.5.a) What is the significance of controller gain? A pneumatic proportional controller is used in the process to control the cold stream outlet temperature within the range of 60 to 120C. The controller gain is adjusted so that the output pressure goes from 3 psig (valve fully closed) to 15 psig (valve fully open) as the measured temperature goes from 60 to 63C with the set point held constant. Find the controller gain Kc [10]

Q.5.b) A second order process having transfer function $G_p = \frac{1}{s^2+2s+2}$ is controlled using PI controller with $\tau_I = 1$. Find the characteristic equation for this system assuming unity feedback. Also find the range of Kc for which system is stable [10]

Q.6.a) Explain in details ultrasonic flow measurement [10]

Q.6.b) Explain performance characteristics of instruments [10]

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