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INDIAN INSTITUTE OF TECHNOLOGY–KHARAGPUR

Mid-Autumn Semester 2015-16 (closed book)

Course No.: CH 31011 **Max. Time:** 2 hrs

Course Title: Instrumentation and Process Control **Total Marks:** 30

Answer all questions

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1. (a) Two liquid streams with flow rates F_1 and F_2, and temperatures T_1 and T_2 flow through two separate pipes which converge at a mixing junction (see Figure 1). We want to maintain constant the flow rate F_3 and the temperature T_3 of the liquid stream resulting from the mixing of the first two streams.

   (i) Identify the control objectives, disturbances, and controlled and manipulated variables

   (ii) Develop the feedback control configurations **[(2+2)+(1+1.5)+(3+4)=13.5]**

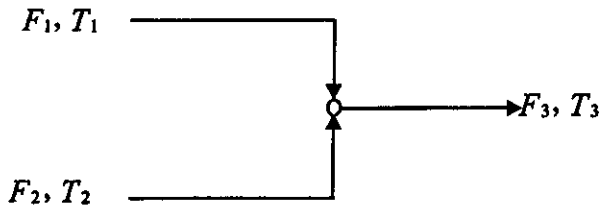

Figure 1.

(b) (i) Define dead time with an example system.

(ii) Does the approximation of dead time create any problem in process response? How?

(c) (i) Making suitable assumptions, develop the modeling equations for a feed tray of the distillation column that receives a partially vaporized feed stream.

(ii) Discuss the computation of all unknown variables associated with the model.

2. (a) Consider the storage tank of Figure 2. Suppose that we want to control the liquid level in the tank at the height of 5 ft, by manipulating the effluent flow rate F_2, according to the following *proportional control* law: **[(1+2+2+1)+3=9]**

$$F_2 = 10(5-h)+1$$

   (i) Develop the transfer function between h and F_1.

   (ii) Determine the time constant and static gain of the tank, under control.

   (iii) Predict the dynamic response of the liquid level to a step change in F_1 by 1 ft^3/min.

   (iv) Find the value of the response in percent of its final value when the time elapsed (t) is equal to 0.3 min.

(b) Discuss the interaction of a multicapacity process having two liquid tanks connected in series.

PTO

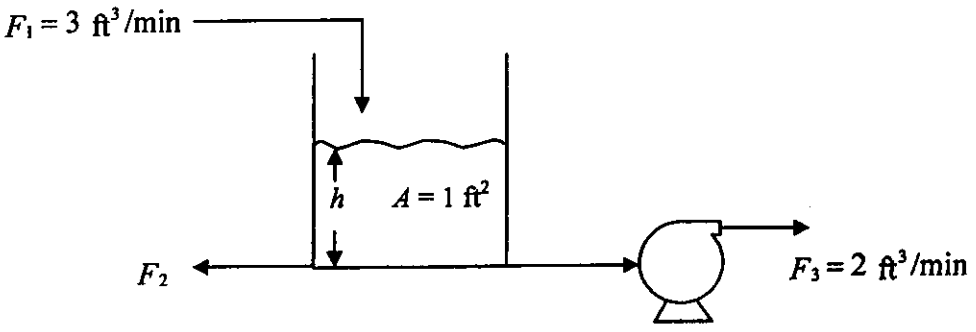

Figure 2. Pump

3. (a) Derive an expression for mercury-in-glass thermometer that relates the displacement of mercury to the change in temperature of thermometer bulb. Use this equation to comment on the possible design of such mercury-in-glass thermometer with small value of time constant. Clearly state all your assumptions. **[1.5+0.5 = 2]**

(b) Explain, with a suitable diagram, the construction and working principle of a flapper-nozzle system. Derive an expression that relates the output pressure of the flapper-nozzle system to the distance between flapper and nozzle. **[1.5+1 = 2.5]**

(c) Give two examples of each of the following types of instruments: (i) active instruments, (ii) passive instruments. **[1+1=2]**

(d) Explain, with a suitable example, the "method of opposing inputs" for correction of interfering inputs. **[1]**

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