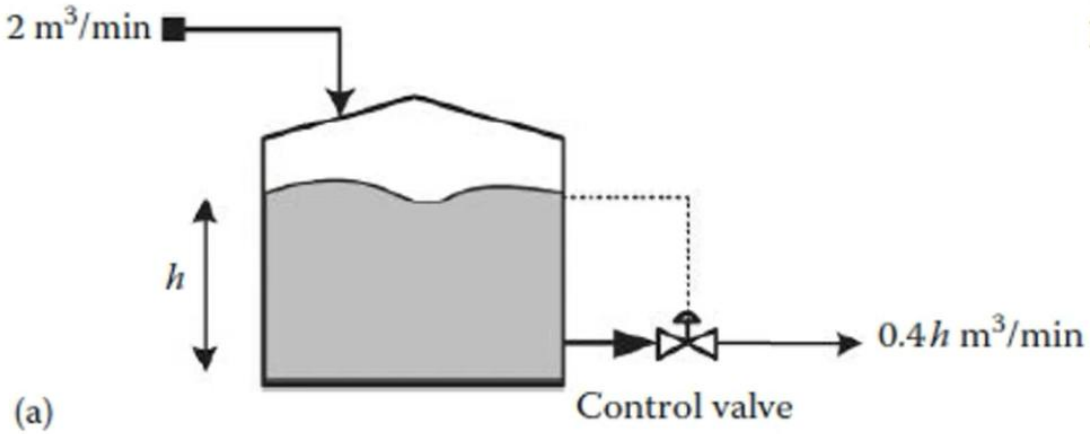
A series of tank

ChE 3230



(a)

Unsteady-state mass balance:
Neither generation nor consumption occurs in the process:

$$\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out}$$

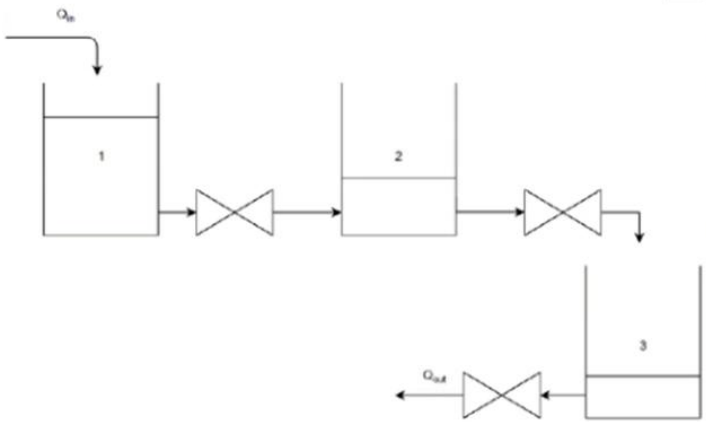
$$m = \rho V = \rho(Ah), \quad A = \pi D^2/4$$

$$\dot{m} = \rho \times \dot{V}$$

$$\frac{d(\rho Ah)}{dt} = \rho\dot{V}_{in} - \rho\dot{V}_{out}$$

$$A\frac{dh}{dt} = \dot{V}_{in} - \dot{V}_{out}$$

1



All tanks have the following characteristics.

Height = 5 m, Diameter = 10 m and Valve coefficient = 5 $m^{2.5}$/min.

Outlet flowrates are proportional to the square root of the heights of the tanks.

Flow rate = valve coeffiecnt*(height)$^{0.5}$

Initially all the tanks are empty. **The input flowrate is 4 m^3/min at first and is then increased to 6 m^3/min after 500 min.** Which of the tanks will overflow (if any)? In case of multiple tanks overflowing, which one will overflow first? What is the corresponding time?

2

$$\frac{dh_1}{dt} = \frac{Q_{in} - Q_1}{A}, \qquad Q_1 = 5 \times h_1^{0.5} - 5 \times h_2^{0.5}$$

3

$$\frac{dh_2}{dt} = \frac{Q_1 - Q_2}{A}, \qquad Q_2 = 5 \times h_2^{0.5}$$

4

$$\frac{dh_3}{dt} = \frac{Q_2 - Q_3}{A}, \qquad Q_3 = 5 \times h_3^{0.5}$$