IIT ROPAR
SEMESTER I 2021-22
NUMERICAL SIMULATION LAB (CH230)
Assignment 4 Max Marks: 50

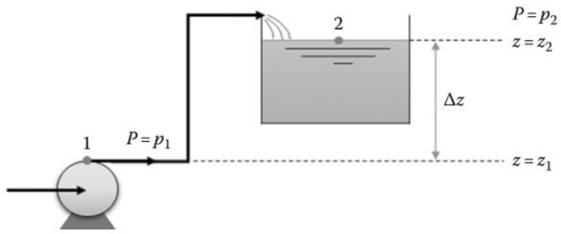
Note: Marks will be awarded for well written codes. Ensure that the files submitted are complete in all respects and only needed to be executed to get the required answers.

1. Figure below shows a pipeline that delivers water at constant temperature from point 1 to point 2. At point 1 the pressure and elevation is p_1 = 100 psig and z_1 = 0 ft, and point 2 pressure is atmospheric and elevation is 300 ft. The density (lb/ft^3) and viscosity (lb/ft.s) of water can be estimated by the following equations

$$\rho = 62.122 + 0.0122T - 1.24 \times 10^{-4} T^2 + 2.65 \times 10^{-7} T^3 - 2.24 \times 10^{-10} T^4$$

$$\ln \mu = -11.0318 + \frac{1057.51}{T + 214.624}$$

Where T is in °F.



The fluid flow for an incompressible fluid in the pipe is given by the Bernoulli equation as follows

$$-\frac{1}{2}v^2 + g\Delta z + \frac{g_c \Delta P}{\rho} + 2f\frac{Lv^2}{D} = 0$$

Where v = velocity (ft/s); g =acceleration due to gravity (ft/s^2); g_c = conversion factor (ft lb/s^2 lb_f); f = Friction factor; L = effective length of pipe (ft); D = pipe diameter (ft); ΔP =pressure drop across pipe (lb_f/ft^2). The values of g and g_c can be assumed to be 32.2.

The friction factor is related to the Reynolds number ($N_{Re} = Dv\rho/\mu$) and is given by the following corelations

For N_{Re} <2100; $$f = \frac{16}{N_{Re}}$$

For N_{Re} >2100; $$f = \frac{1}{16}\left[\log\left\{\frac{\epsilon/D}{3.7} - \frac{5.02}{N_{Re}}\log\left(\frac{\epsilon/D}{3.7} + \frac{14.5}{N_{Re}}\right)\right\}\right]^{-2}$$

a) Determine the velocity (ft/s) and volumetric flow rate (gal/min) at T=60 °F, for a pipeline with an effective length L =50 ft and diameter of 8 inches with surface roughness (ε) of 0.0015 ft.
b) Estimate the flow velocities v in ft/sec and flow rates q in gal/min at T = 60°F for pipelines with effective lengths of L = 500, 1,000, 1,500, …, 10,000 ft and having diameters of 4, 5, 6, and 8 in. Prepare plots of velocity v versus D and L, and flow rate q versus D and L. (25M)

2. A liquid feed stream of an ideal 4-component mixture is flashed in a flash drum at 50 °C. The composition of the feed stream is given below with the Antoine equation constants. The flash drum operates under high pressure, between 15 and 25 atm. Estimate the percent of the total feed at 50°C that is evaporated, α (=*V*/*F*), and the corresponding mole fractions in the liquid and vapor streams for *P* = 16, 18, 20, and 24 atm. Determine the dew point and bubble point temperatures. (25M)

		Antoine Equation Constants		
Component	**Mole Fraction (z_j)**	***A***	***B***	***C***
Ethylene	0.10	6.64380	395.74	266.681
Ethane	0.25	6.82915	663.72	256.681
Propane	0.50	6.80338	804.00	247.040
n-Butane	0.15	6.80776	935.77	238.789

Where pressure is in mm Hg and temperature is in °C.

Hint: Bubble point temperature is the temperature at which the first bubble (of vapor) forms i.e α = 0. Dew point temperature is the temperature at which the first liquid droplet forms i.e α = 1. The following conditions are satisfied at dew point and bubble points

At dew point,

$$f(T) = \sum_{j=1}^{N} \frac{z_j}{K_j} - 1 = 0$$

At bubble point,

$$f(T) = \sum_{j=1}^{N} z_j K_j - 1 = 0$$

Where z is the feed composition and $K_i = y_i/x_i$