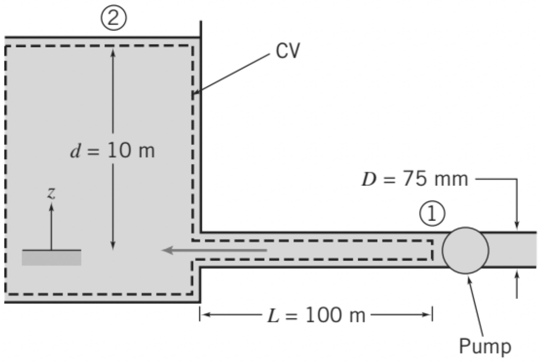
PRACTICE PROBLEM SET 4

(These problems have been sourced from various sources)

1. A 100-m length of smooth horizontal pipe is attached to a large reservoir. A pump is attached to the end of the pipe to pump water into the reservoir at a volume flow rate of 0.01 m3/s. What pressure (gage) must the pump produce at the pipe to generate this flow rate? The inside diameter of the smooth pipe is 75 mm. Consider K (exit loss) =1.0, and α =1.0.



2. Oil, with ρ = 900 kg/m3 and ν (kinematic viscosity) =0.00001 m^2/s, flows at 0.2 m^3/s through 500 m of 200-mm diameter cast iron pipe. Determine (a) the head loss and (b) the pressure drop if the pipe slopes down at 10° in the flow direction. Take ε = 0.26 mm for cast iron pipe.

3. The efficiency η of a fan depends on density ρ, dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rotor and the discharge Q. Express in terms of dimensionless parameters.

   Ans -

$$f_1\left(\eta, \frac{\mu}{D^2\omega\rho}, \frac{Q}{D^2\omega}\right) = 0 \text{ or } \eta = \phi\left[\frac{\mu}{D^2\omega\rho}, \frac{Q}{D^2\omega}\right]$$

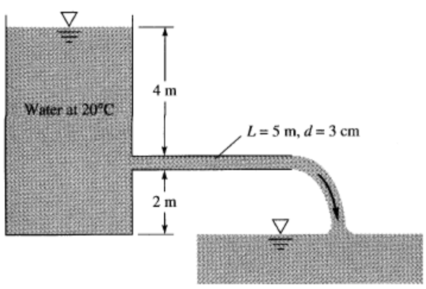
4. Using Buckingham's Pi theorem show that the discharge Q consumed by an oil ring is given by,

$$Q = Nd^3\phi\left[\frac{\mu}{\rho N d^2}, \frac{\sigma}{\rho N^2 d^3}, \frac{w}{\rho N^2 d}\right]$$

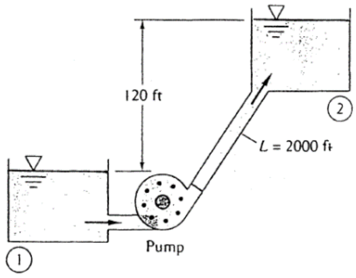
   where D is the internal diameter of the ring, N is the rotating speed, ρ is the density, μ is the viscosity, σ is surface tension and what is the specific weight of the oil.

5. The tank-pipe system is to deliver at least 11 m^3/hr of water at 20 °C to the reservoir. What is the maximum roughness height ϵ allowable for the pipe?

   (For water at 20°C, take ρ = 998 kg/m^3 and μ = 0.001 kg/m s)



6. Water at 20 °C is to be pumped through 2000 ft of pipe from reservoir 1 to 2 at a rate of 3 ft^3/s. If the pipe is cast iron (ϵ/d= 0.0017) of diameter 6 in and the pump is 75 percent efficient, what horsepower pump is needed? (For water at 20°C, take ρ = 998 kg/m^3 and μ = 0.001 kg/m s)



7. Using Buckingham's Pi-theorem, show that the velocity through a circular orifice is given by $V = \sqrt{2gH}\ \phi\left[\frac{D}{H}, \frac{\mu}{\rho V H}\right]$, where H is the head causing flow, D is the diameter of the orifice, μ is the co-efficient of viscosity, ρ is the mass density and g is the acceleration due to gravity.

8. Derive based on dimensional analysis suitable parameters to present the thrust developed by a propeller. Assume that the thrust P depends upon the angular velocity ω, speed of advance V, diameter D, dynamic viscosity μ, mass density ρ, elasticity of the fluid medium which can be denoted by the speed of sound in the medium C.

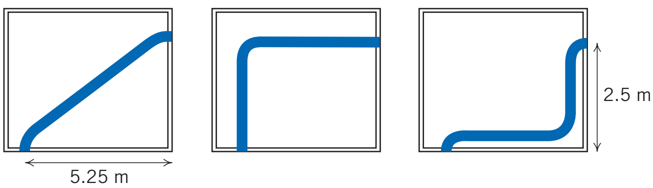
9. The friction torque T of disc of diameter D rotating at a speed of N in a fluid of viscosity μ and density ρ in a turbulent flow is given by.

$$T = D^5 N^2 \rho \phi\left[\frac{\mu}{D^2 N \rho}\right].$$

Prove this with the help of dimensional analysis.

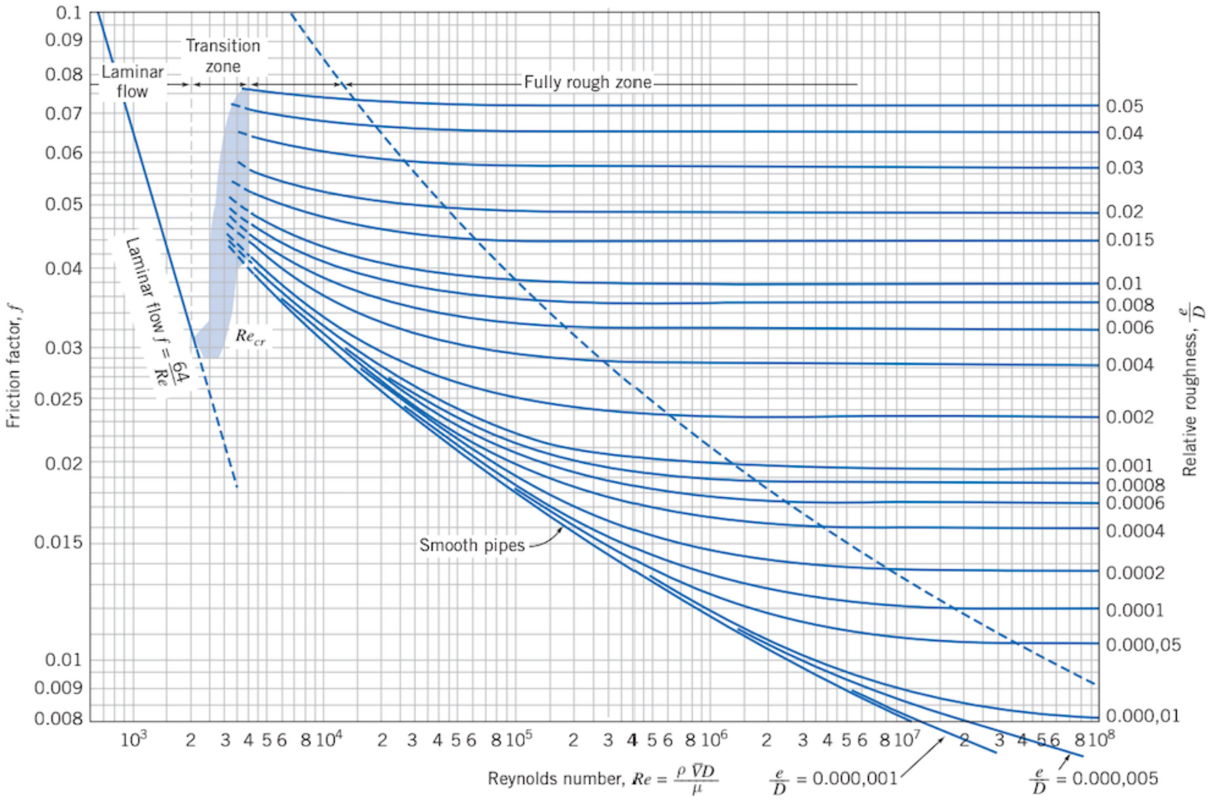
10. A 5-cm-diameter potable water line is to be run through a maintenance room in a commercial building. Three possible layouts for the water line are proposed, as shown. Which is the best option, based on minimizing losses? Assume galvanized iron and a flow rate of 350 L/min.

Hint: To calculate minor losses, use equation $h_{lm} = \sum f \frac{L_e}{D}\frac{V^2}{2}$ (Equation 8.40b, Fox and McDonalds 8th ed.). Take $\frac{L_e}{D} = 13$ for miter bend and 30 for a standard elbow.



(*a*) Two miter bends (*b*) A standard elbow (*c*) Three standard elbows

11. Two reservoirs are connected by three clean cast-iron pipes in series, L_1 = 600m, D_1 = 0.3m, L_2 = 900m, D_2 = 0.4m, L_3 = 1500m, and D_3 = 0.45m. When the discharge is 0.11 m^3/s of water, determine the difference in elevation between the reservoirs.

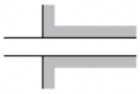
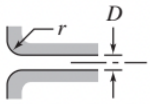


Friction factor for fully developed flow in circular pipes. (Data from Moody , used by permission.)

Roughness for Pipes of Common Engineering Materials

	Roughness, e	
Pipe	Feet	Millimeters
Riveted steel	0.003–0.03	0.9–9
Concrete	0.001–0.01	0.3–3
Wood stave	0.0006–0.003	0.2–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Asphalted cast iron	0.0004	0.12
Commercial steel or wrought iron	0.00015	0.046
Drawn tubing	0.000005	0.0015

Minor Loss Coefficients for Pipe Entrances

Entrance Type		Minor Loss Coefficient, K^{a}
Reentrant		0.78
Square-edged		0.5
Rounded		r/D | 0.02 | 0.06 | ≥ 0.15 K | 0.28 | 0.15 | 0.04