Review problems for Exam 2, 057:020-Fall 2007

Momentum Conservation

6–25 A reducing elbow is used to deflect water flow at a rate of 30 kg/s in a horizontal pipe upward by an angle $\theta = 45°$ from the flow direction while accelerating it. The elbow discharges water into the atmosphere. The cross-sectional area of the elbow is 150 cm^2 at the inlet and 25 cm^2 at the exit. The elevation difference between the centers of the exit and the inlet is 40 cm. The mass of the elbow and the water in it is 50 kg. Determine the anchoring force needed to hold the elbow in place. Take the momentum-flux correction factor to be 1.03.

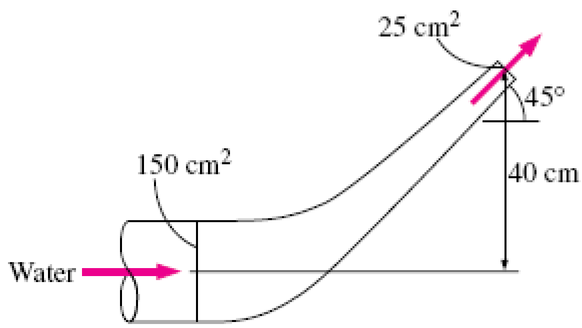
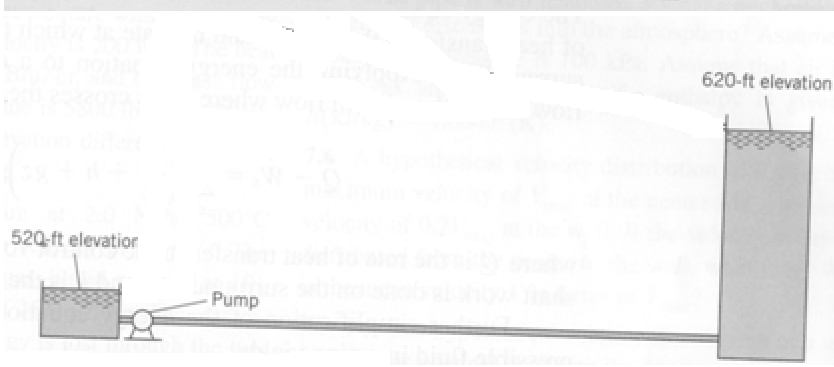


FIGURE P6–25

Energy Equation and HGL/EGL

A pump draws water from a reservoir, where the water-surface elevation is 520 ft, and forces the water through a pipe 5000 ft long and 1 ft in diameter. This pipe then discharges the water into a reservoir with water-surface elevation of 620 ft. The flow rate is 7.85 cfs, and the head loss in the pipe is given by $0.01(L/D)(V^2/2g)$. Determine the head supplied by the pump, h_p, and the power supplied to the flow, and draw the HGL and EGL for the system. Assume that the pipe is horizontal and is 510 ft in elevation.



Differential Analysis of Fluid Flow

9–100 Consider steady, incompressible, laminar flow of a Newtonian fluid in an infinitely long round pipe of diameter D or radius $R = D/2$ inclined at angle α (Fig. P9–100). There is no applied pressure gradient ($\partial P/\partial x = 0$). Instead, the fluid flows down the pipe due to gravity alone. We adopt the coordinate system shown, with x down the axis of the pipe. Derive an expression for the x-component of velocity u as a function of radius r and the other parameters of the problem. Calculate the volume flow rate and average axial velocity through the pipe. *Answers:* $\rho g (\sin \alpha)(R^2 - r^2)/4\mu$, $\rho g (\sin \alpha)\pi R^4/8\mu$, $\rho g (\sin \alpha)R^2/8\mu$

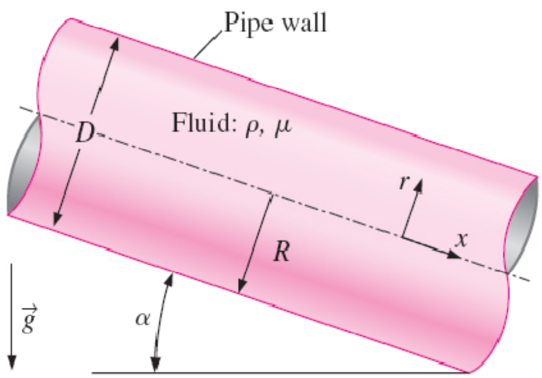


FIGURE P9–100

Dimensional Analysis 1

At low velocities (laminar flow), the volume flow Q through a small-bore tube is a function only of the tube radius R, the fluid viscosity μ, and the pressure drop per unit tube length dp/dx. Using the pi theorem, find an appropriate dimensionless relationship.

Dimensional Analysis 2

7–98 The Stanton number is listed as a named, established nondimensional parameter in Table 7–5. However, careful analysis reveals that it can actually be formed by a combination of the Reynolds number, Nusselt number, and Prandtl number. Find the relationship between these four dimensionless groups, showing all your work. Can you also form the Stanton number by some combination of only *two* other established dimensionless parameters?

TABLE 7–5

Name	Definition
Nusselt number	$\text{Nu} = \frac{Lh}{k}$
Peclet number	$\text{Pe} = \frac{\rho L V c_p}{k} = \frac{LV}{\alpha}$
Prandtl number	$\text{Pr} = \frac{\nu}{\alpha} = \frac{\mu c_p}{k}$
Reynolds number	$\text{Re} = \frac{\rho V L}{\mu} = \frac{VL}{\nu}$
Stanton number	$\text{St} = \frac{h}{\rho c_p V}$