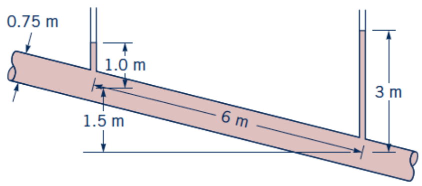
ME 3710
Homework 7
Due Thursday March 19 at 11:59pm – upload to Gradescope
Integral Conservation of Energy and Bernoulli's equation
[9 problems – 27 pts]

Problem 5.98

An incompressible liquid flows steadily along the pipe shown in the figure below. Determine the direction of flow and the head loss over the 6-m length of pipe.

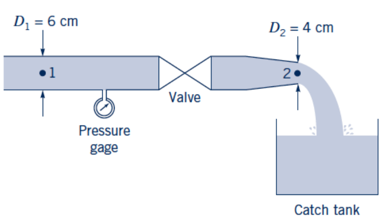


Problem 5.101

The figure below shows a test rig for evaluating the loss coefficient, K, for a valve. Mechanical energy losses in valves are modeled by the equation:

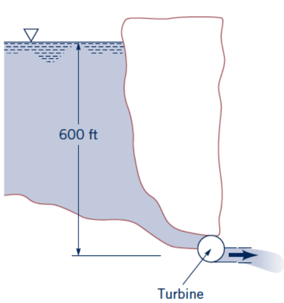
$$gh_L = K\left(\frac{V^2}{2}\right),$$

where gh_L is the mechanical energy loss and V is the flow velocity entering the valve. In a particular test, the pressure gage reads 40 kPa, gage, and the 1.5-m^3 catch tank fills in 2 min 55 s. Calculate the loss coefficient for a water temperature of 20 °C



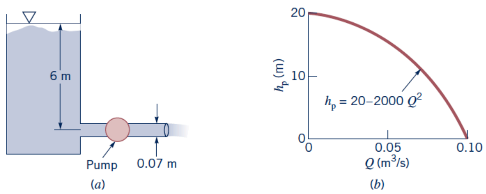
Problem 5.108

The hydroelectric turbine shown in the figure below passes 8 million gal/min across a head of 600 ft. What is the maximum amount of power output possible? Why will the actual amount be less?



Problem 5.110

Water is pumped from the tank shown in the figure (*a*). The head loss is known to be $1.2\frac{V^2}{2g}$, where V is the average velocity in the pipe. According to the pump manufacturer, the relationship between the pump head and the flowrate is as shown in the figure (*b*): $h_p = 20 - 2000Q^2$, where h_p is in meters and Q is in m^3/s. Determine the flowrate, Q.



Problem 5.118

A pump moves water horizontally at a rate of $0.02\,m^3/s$. Upstream of the pump where the pipe diameter is 90 mm, the pressure is 120 kPa. Downstream of the pump where the pipe diameter is 30 mm, the pressure is 400 kPa. If the loss in energy across the pump due to fluid friction effects is $170\,N\cdot m/kg$, determine the hydraulic efficiency of the pump.

Problem 3.2

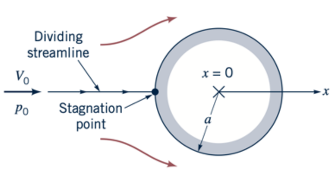
Air flows steadily along a streamline from point (1) to point (2) with negligible viscous effects. The following conditions are measured: At point (1) $z_1 = 2\,m$ and $p_1 = 0\,kPa$; at point (2) $z_2 = 10\,m$, $p_2 = 20\,N/m^2$, and $V_2 = 0$. Determine the velocity at point (1).

Problem 3.8

An incompressible fluid flows steadily past a circular cylinder as shown in the figure below. The fluid velocity along the dividing streamline ($-\infty \le x \le -a$) is found to be

$V = V_0\left(1 - \frac{a^2}{x^2}\right)$, where a is the radius of the cylinder and V_0 is the upstream velocity.

(a) Determine the pressure gradient along this streamline. **(b)** If the upstream pressure is p_0, integrate the pressure gradient to obtain the pressure $p(x)$ for ($-\infty \le x \le -a$). **(c)** Show from the result of part (b) that the pressure at the stagnation point ($x = -a$) is $p_0 + \rho V_0^2/2$, as expected from the Bernoulli's equation.



Problem 3.17

At a given point on a horizontal streamline in flowing air, the static pressure is –2.0 psi (i.e., a vacuum) and the velocity is 150 ft/s. Determine the pressure at a stagnation point on that streamline.

Problem 3.47

At what rate does oil ($SG = 0.85$) flow from the tank shown in the figure below?