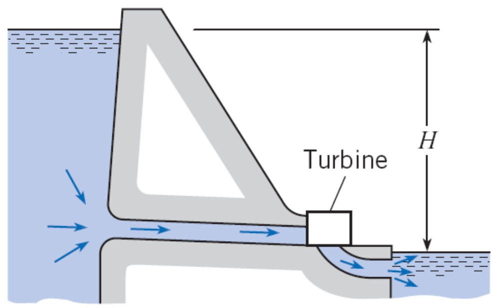
CHEN.3030 Fluid Mechanics

Homework Assignment #7 Spring 2017

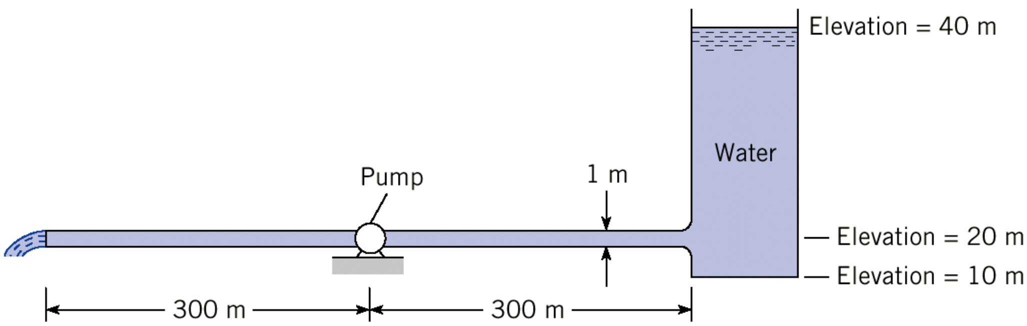
The Energy Equation

1. Consider the small-scale power system shown in the sketch. The discharge of water through the turbine is 1000 ft^3/s and the reservoir elevation is H = 100 ft. What useful power (in hp) is generated if the turbine efficiency is 85% and the total head loss in the pipe is 4 ft?



2. Water flows through the horizontal pipe shown below at a rate of 7.85 m^3/s. The pipe inside diameter is 1 m. The head loss coefficient in the pipe was measured to be about 7.0 based on the velocity head in the pipe.

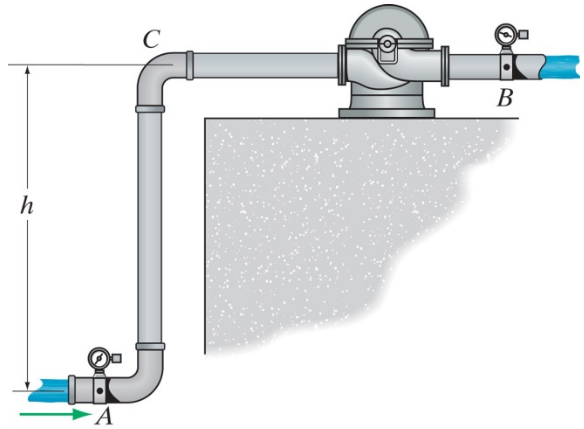
With this information and the configuration data given on the diagram, determine the power (in kW) delivered by the pump to the fluid to achieve the given flow rate.



3. Consider the situation identified in the diagram where water is drawn into the pump as shown. The pipe inside diameter is 4 inches on the suction side of the pump and 3 inches on the discharge side and the remaining data for the problem are given below:

P_A = -6 psi　　　P_B = 20 psi

Q = 4 ft^3/s　　　h = 5 ft



Assuming negligible friction loss in the pipe segment ACB,

a. determine the power output (in hp) of the pump needed to achieve the flow rate indicated, and

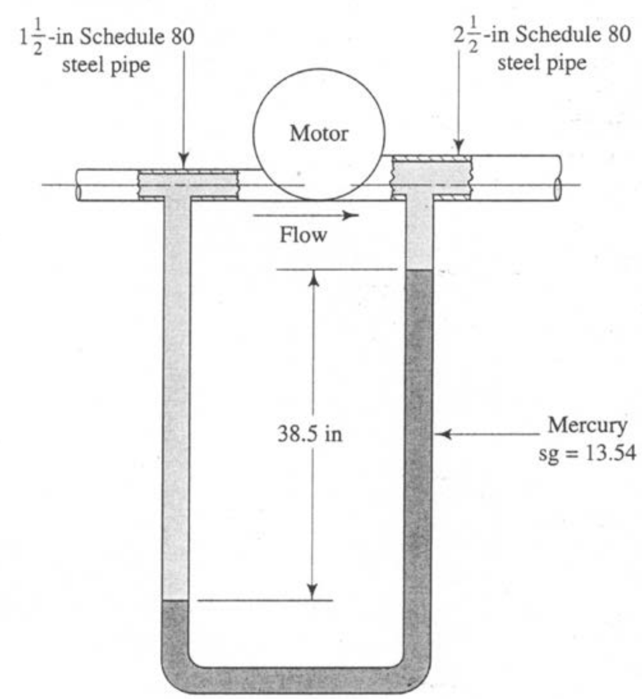
b. carefully draw and label the energy and hydraulic grade lines for the pipe segment ACB (**Note**: here "label" means to indicate the head level (in feet) directly on the EGL and HGL diagrams).

4. The test setup shown in the diagram measures the pressure difference between the inlet and outlet of the fluid motor. The flow rate of the hydraulic fluid (sg = 0.90) is 135 gal/min.

a. Compute the power removed (in hp) from the fluid by the motor.

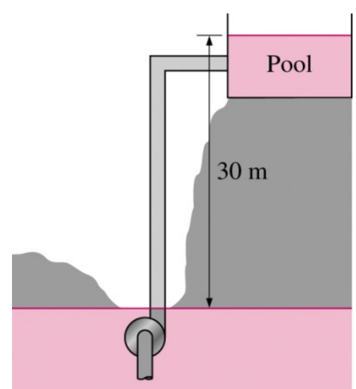
b. If the fluid motor has an efficiency of 78%, how much useful power can be delivered by the motor?

Hint: Look up the standard dimensions for Sch 80 pipe on the web.



5. Underground water is to be pumped by a 70 % efficient 3 kW submerged pump to a pool whose free surface is 30 m above the underground water level. The diameter of the pipe is 7 cm on the intake side and 5 cm on the discharge side.

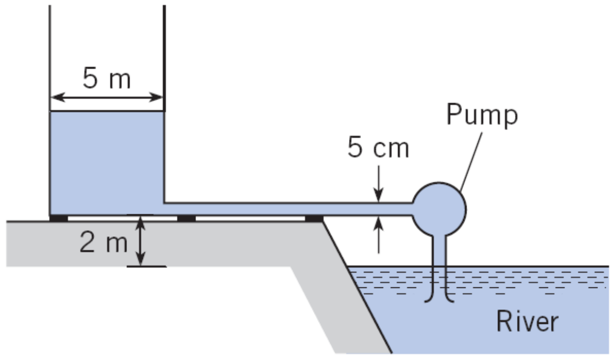
Assuming negligible elevation distance between the pump inlet and outlet, determine the maximum flow rate of water and the ΔP across the pump.



Optional Extra Credit Problem (up to 10 extra points)

A pump is used to fill a cylindrical tank 5 m in diameter from a river as shown in the sketch given below. The water surface in the river is 2 m below the bottom of the tank. The pipe diameter is 5 cm, and the head loss in the pipe is given by $h_L = 10v^2/2g$, where v is the mean fluid velocity in the pipe. The head added to the fluid by the pump varies with the discharge through the pump and is given as $h_A = 20 - 40000Q^2$, where Q is given in m^3/s and h_A is in meters.

Based on this information, how long with it take to fill the tank to a depth of 10 m?



Hint: This problem requires coupling an unsteady mass continuity equation for the rate of change of mass of water in the tank at any time t with a steady state energy balance for the energy per unit weight (i.e. head) for flow from the river to the tank. The coupling occurs because the flow rate from the river is the flow rate into the tank. The mass balance on the tank is unsteady because the amount of water in the CV (i.e. the tank) changes with time. However, at each instant, we can assume steady flow from an energy balance perspective since the energy within a CV defined at time t by the water in the whole flow system with boundaries at the river surface and tank's water surface does not change. The real assumption here is that the energy dynamics are very fast compared to the mass dynamics -- and this is an excellent approximation in flow problems of this nature. This approach is used for most tank filling and draining scenarios of practical interest…