CHEN.3030 Fluid Mechanics

V. Bernoulli Equation and General Energy Equation + Applications…

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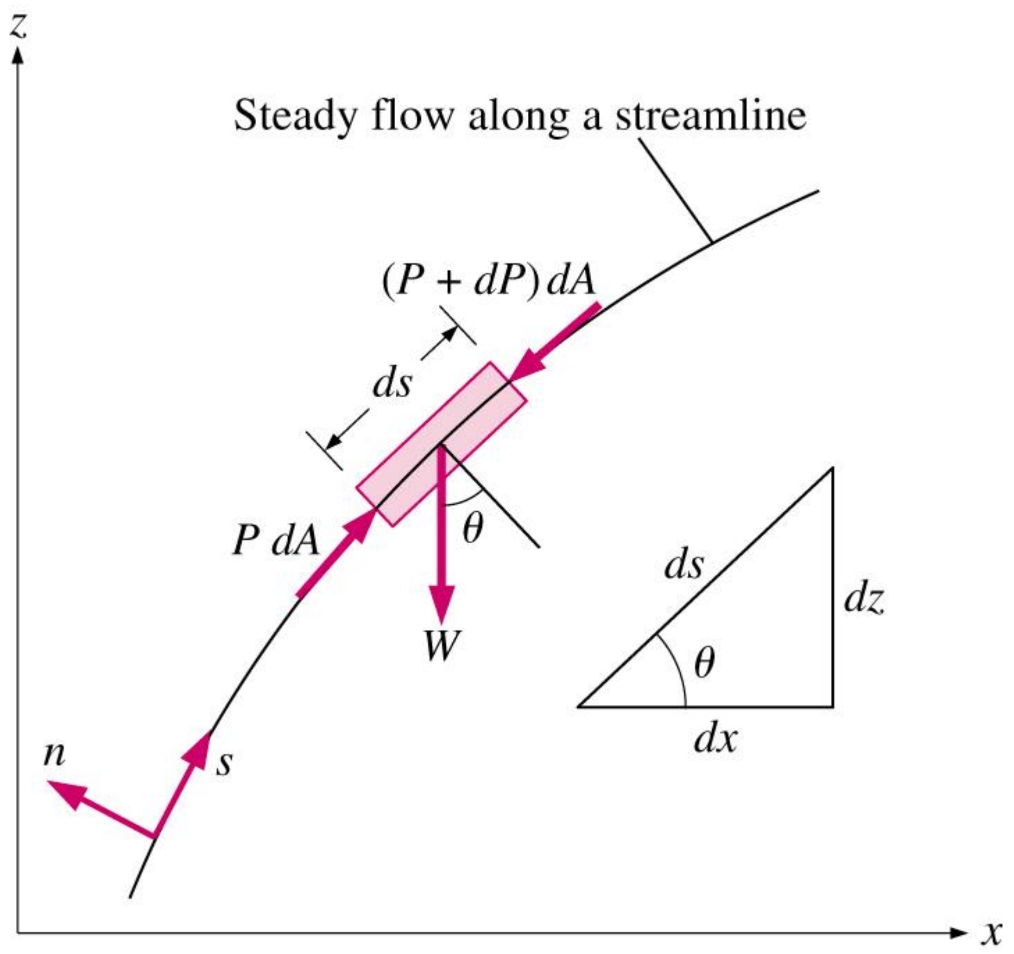
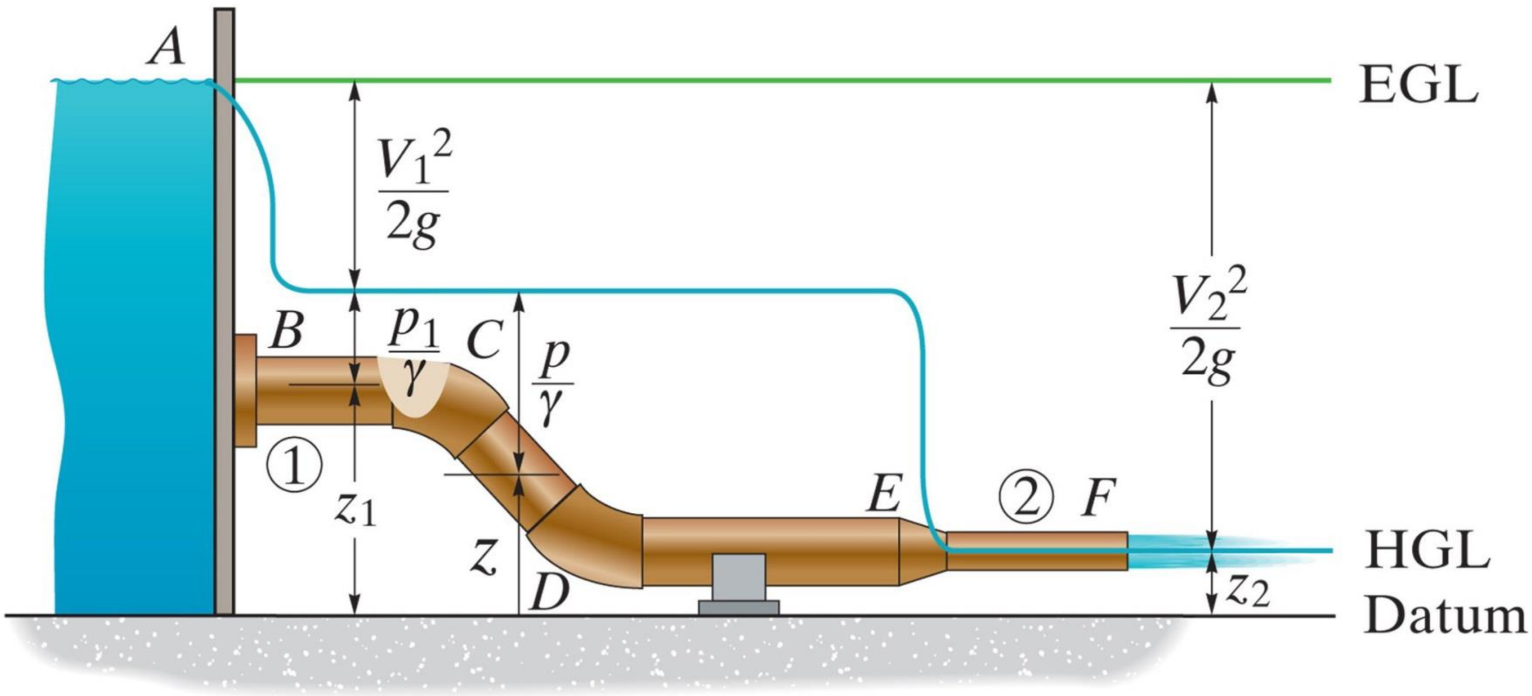
See Chapter 5 (sections 1–5) in your text by Hibbeler

Flow Along a Streamline



Energy and Hydraulic Grade Lines



$$\text{EGL} \Rightarrow \frac{P}{\gamma} + \frac{v^2}{2g} + z = \text{total head}$$

$$\text{HGL} \Rightarrow \frac{P}{\gamma} + z = \text{hydraulic head}$$

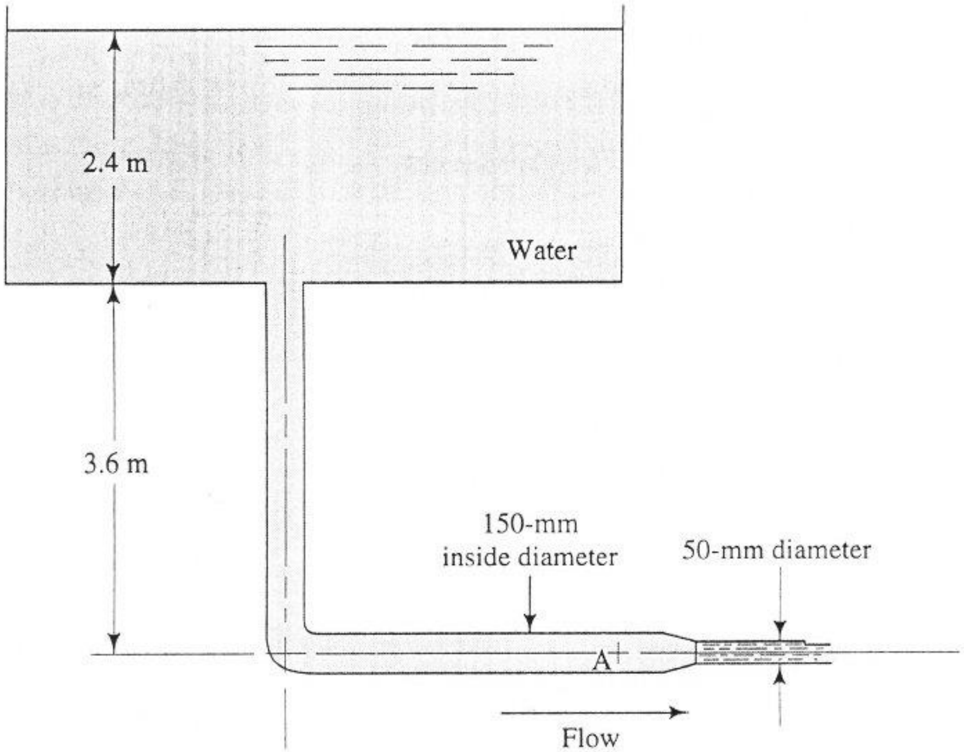
Ex #1: Bernoulli Equation

For the system shown, compute the following quantities:

a. **Volume flow rate from the nozzle.**

b. **Pressure at Point A.**

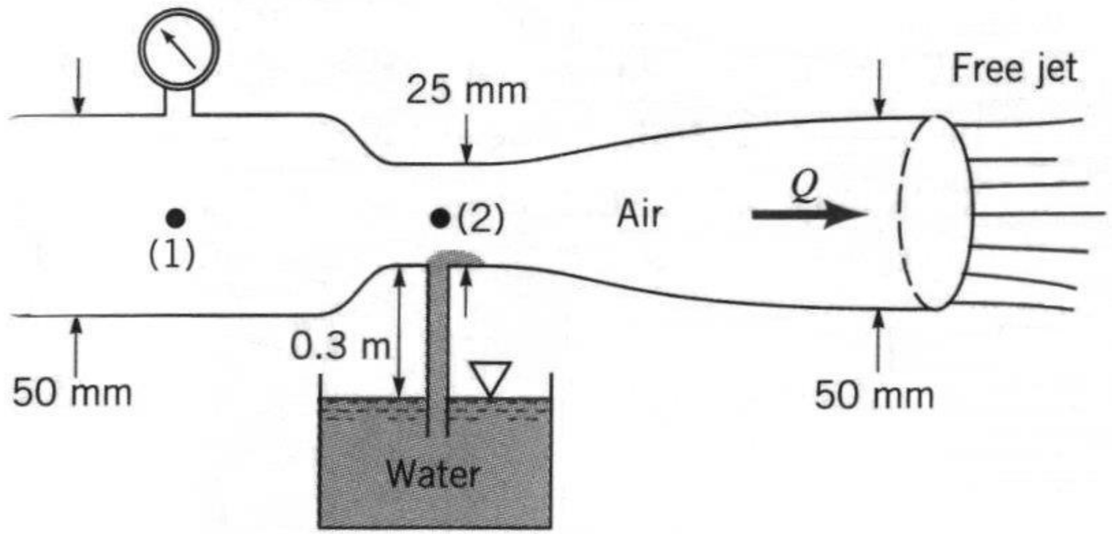
c. **Also sketch the energy and hydraulic grade lines (i.e. EGL and HGL).**



Ex #2: Bernoulli Equation

Air flows through the device shown. If the flow rate is large enough, the pressure within the narrow section will be low enough to draw the water up the tube and into the air flow stream, as shown.

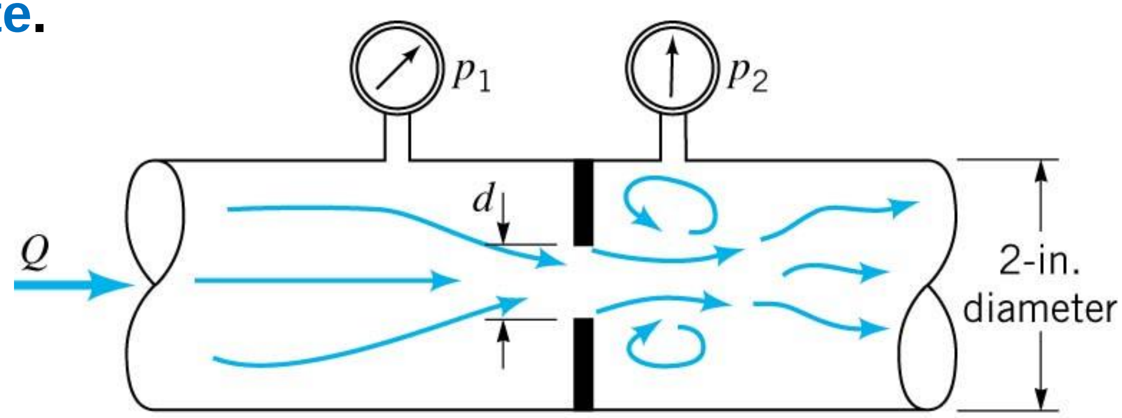
Neglecting compressibility and viscous effects, determine the flow rate, Q, and the pressure needed at Section 1 to draw the water just into Section 2.



Ex #3: Bernoulli Equation

What diameter orifice hole, d, is needed if, under ideal conditions, the flow rate through the orifice meter is 30 gpm of sea water (sg = 1.026)?

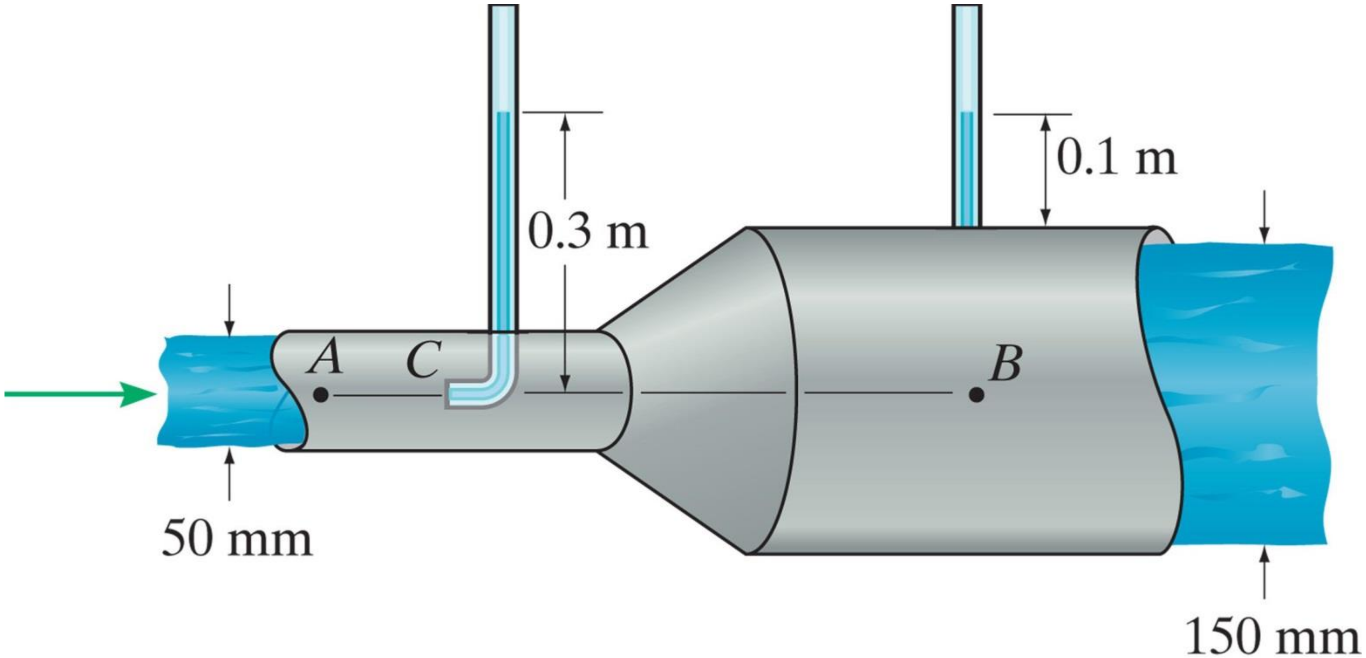
For the given flow rate, the measured pressure difference is $P_1 - P_2 = 2.37$ psi and the contraction coefficient is c = 0.63, where the contraction coefficient is the ratio of the minimum flow area at the vena contractor (Point 2) to the area at the orifice plate.



contraction coeff: $C = A_{min}/A_{open}$

Ex #4: Bernoulli Equation

For the situation shown in the diagram, determine the volumetric flow rate of the water and the pressure in the pipe at Point A if the height of the water column in the Pitot tube is 0.3 m and the height in the piezometer water is 0.1 m.

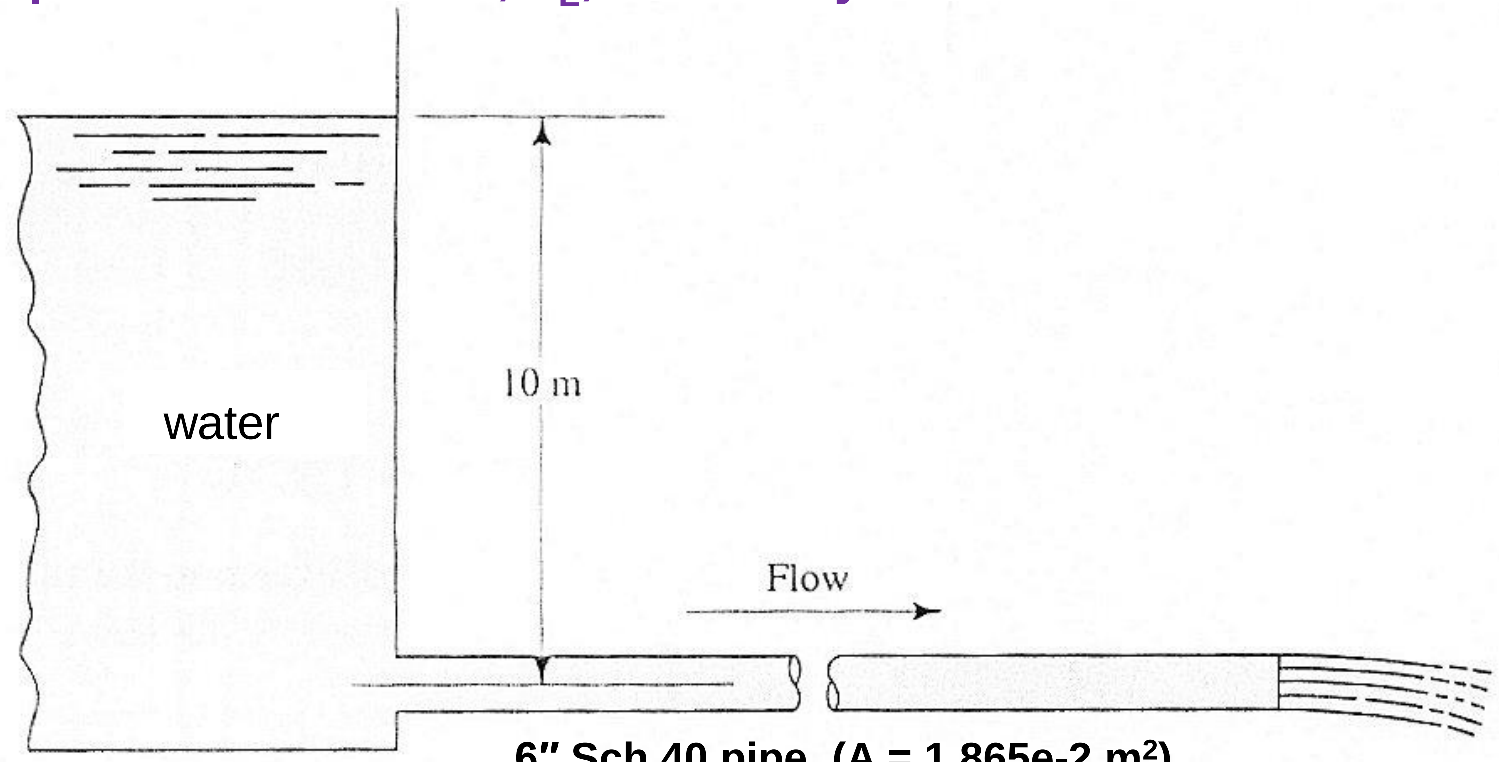


water

Ex #1: Energy Equation

For the system shown, the measured water flow rate is $Q = 0.085\ m^3/s$.

Compute the head loss, h_L, for this system.



6″ Sch 40 pipe (A = 1.865e-2 m^2)

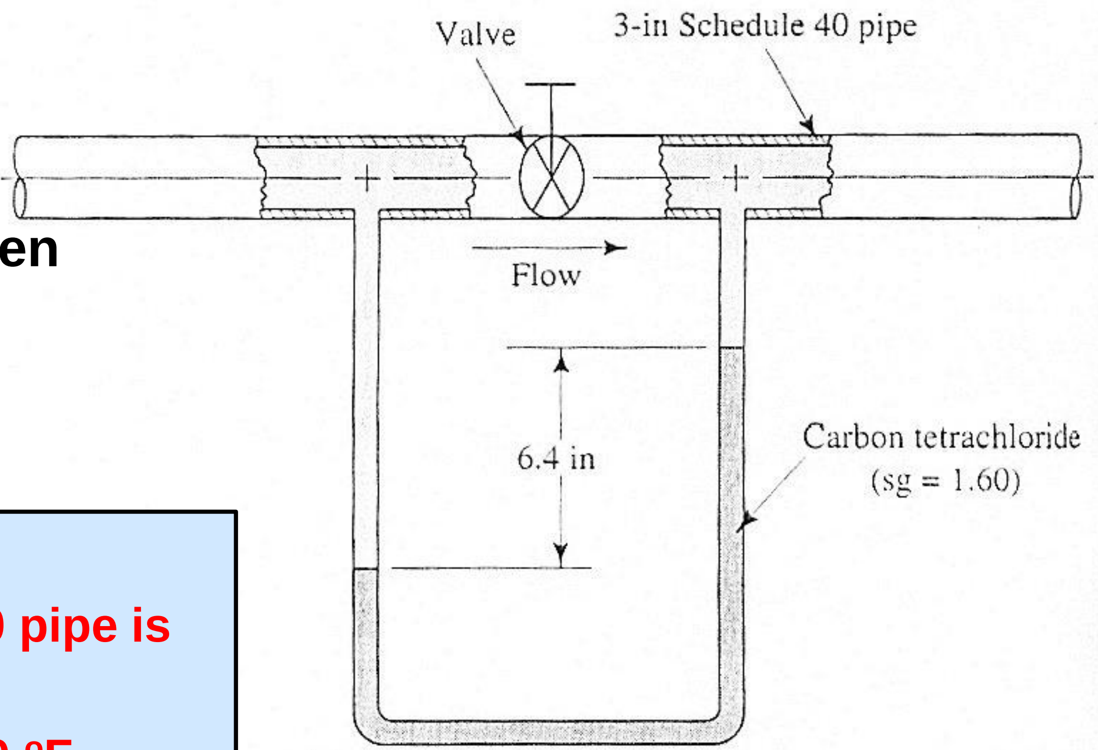
Ex #2: Energy Equation

A test setup to find the energy loss coefficient of a valve is shown in the diagram.

Compute h_L if the measured $Q = 0.10$ ft³/s of water for a given valve position.

For this position, also compute the resistance coefficient, K, if h_L is given as

$$h_L = K\frac{v^2}{2g}$$



Notes

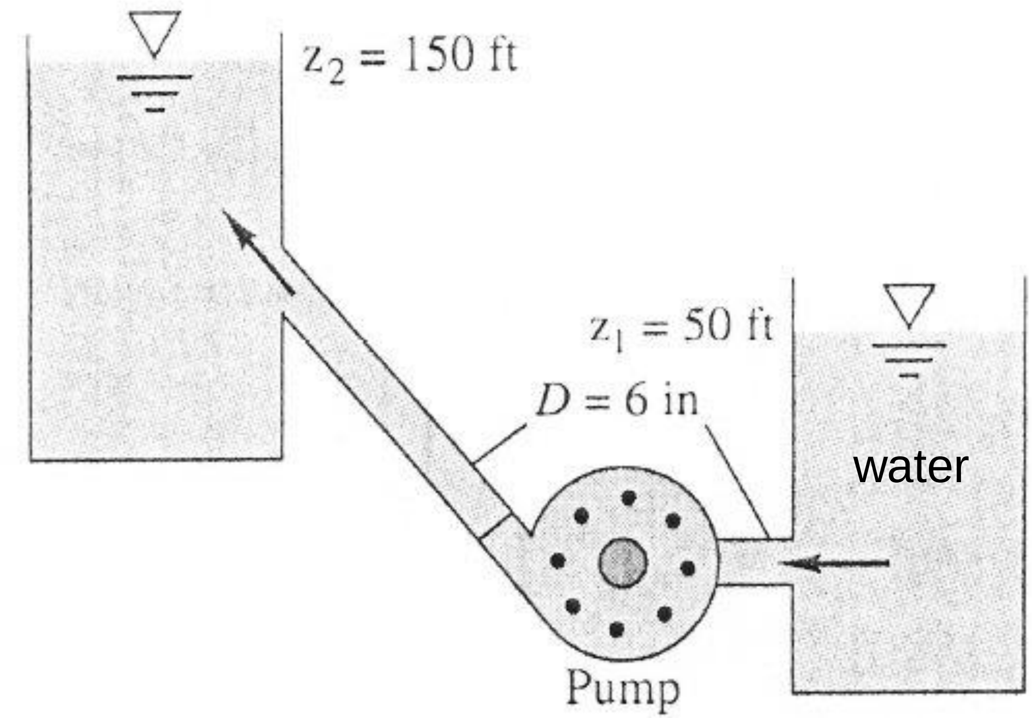
The flow area for 3″ Sch 40 pipe is 0.05132 ft^2.

Working fluid is water at 40 °F.

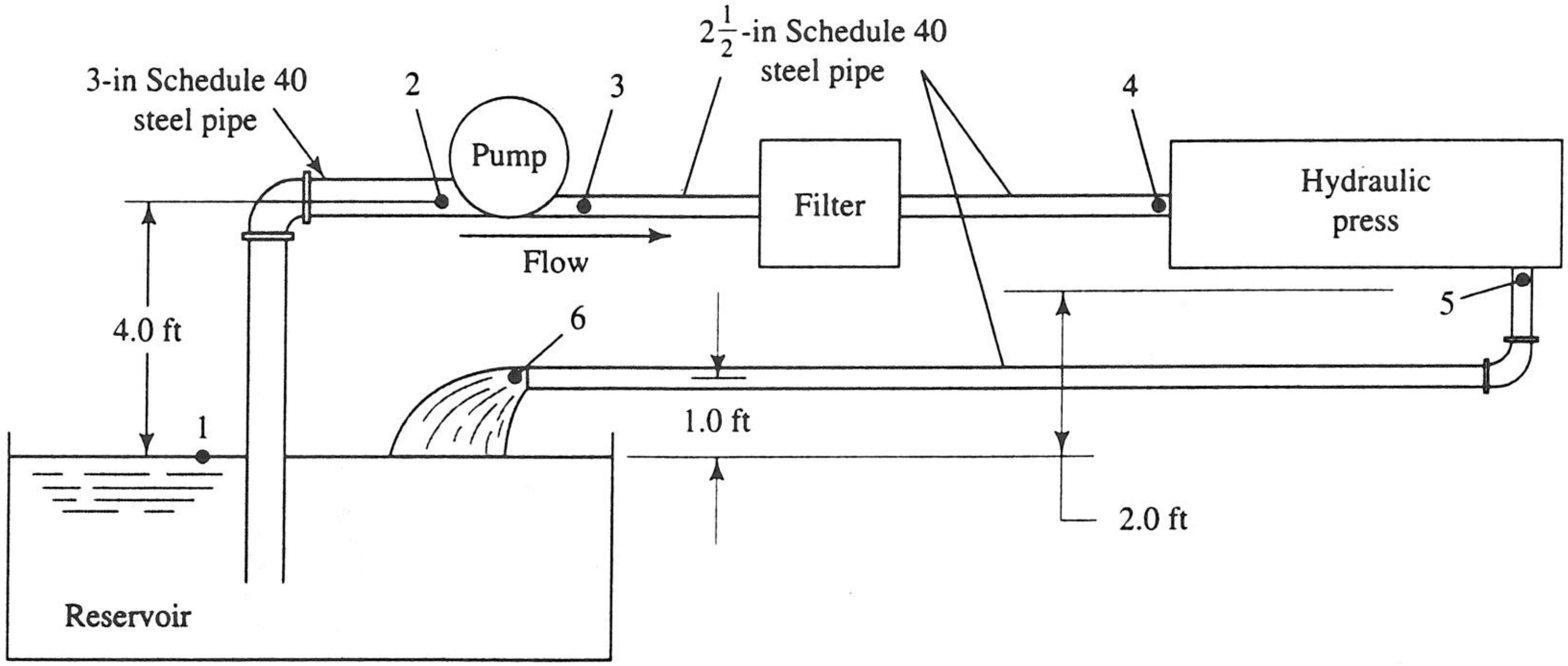
Ex #3: Energy Equation

Water is pumped at 1500 gpm from the lower to the upper reservoir. The pipe friction is given by $h_L = 27\ v^2/2g$.

If the pump is 75% efficient, what horsepower motor is needed for this system?



Ex #4: Energy Equation



The **working fluid is oil** (sg = 0.93) and the **volume flow rate is 175 gal/min**.

The **input power to the pump is 28.4 hp** and the **pump efficiency is 80%**.

The **flow area for a 3-inch Sch 40 pipe is $A_{3''} = 0.0513\ ft^2$** and, **for a 2.5-inch pipe $A_{2.5''} = 0.0333\ ft^2$**.

The **energy losses** (with units of ft-lbf/lbf of fluid) were measured to be:

Points 1 to 2: 2.80 ft **Points 3 to 4: 28.5 ft** **Points 5 to 6: 3.50 ft**

Compute the power removed from the fluid by the hydraulic press.