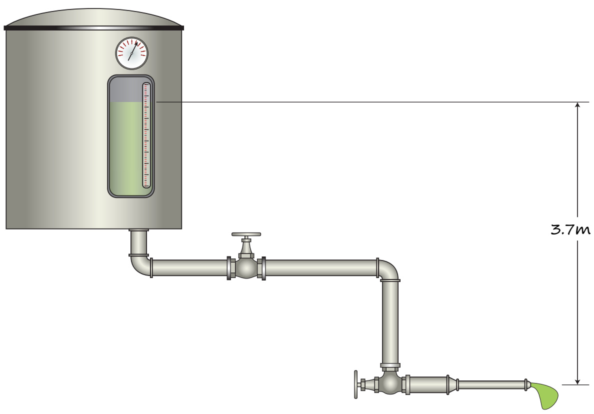
Module 4: The General Energy Equation (CIVL 318)

GEE:	$\frac{p_A}{\gamma} + z_A + \frac{v_A^2}{2g} + h_A - h_R - h_L = \frac{p_B}{\gamma} + z_B + \frac{v_B^2}{2g}$
Power added by a pump:	$P_A = h_A \gamma Q$
Power removed by a turbine:	$P_R = h_R \gamma Q$
Efficiency of a pump:	$e_M = \frac{\text{power delivered to fluid}}{\text{power input to pump}} = \frac{P_A}{P_I}$
Efficiency of a turbine:	$e_M = \frac{\text{power output from turbine}}{\text{power removed from fluid}} = \frac{P_O}{P_R}$

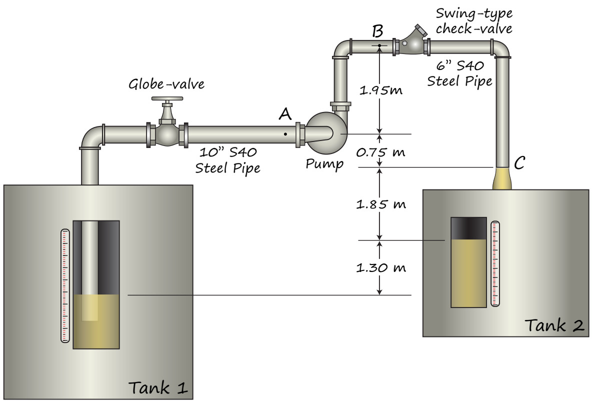
Example 1:



Liquid with a specific gravity of 0.9 flows from a tank, pressurized to 57 kPa, through the pipe system shown, before entering the atmosphere through a nozzle with diameter 125 mm.

If the volume flow rate is $Q = 89\,\text{L/s}$, determine h_L, the head loss due to friction and fittings.

Example 2:

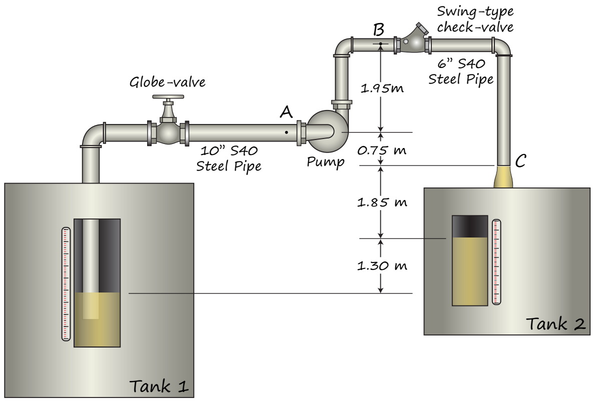


Liquid with a specific gravity of 0.87 is pumped from Tank 1; the liquid exits the pipe at C before dropping into Tank 2 at 180 L/s.

Determine the head added by the pump and the pressure at A.

(Assume that friction losses are not significant.)

Exercise 1:

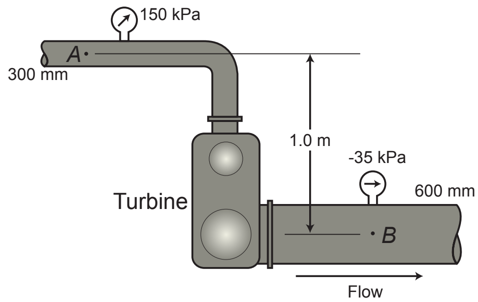


Liquid with a specific gravity of 0.87 is pumped from Tank 1; the liquid exits the pipe at C before dropping into Tank 2 at 180 L/s. (Neglect any head losses due to friction and valves.)

Determine the pressure at B:

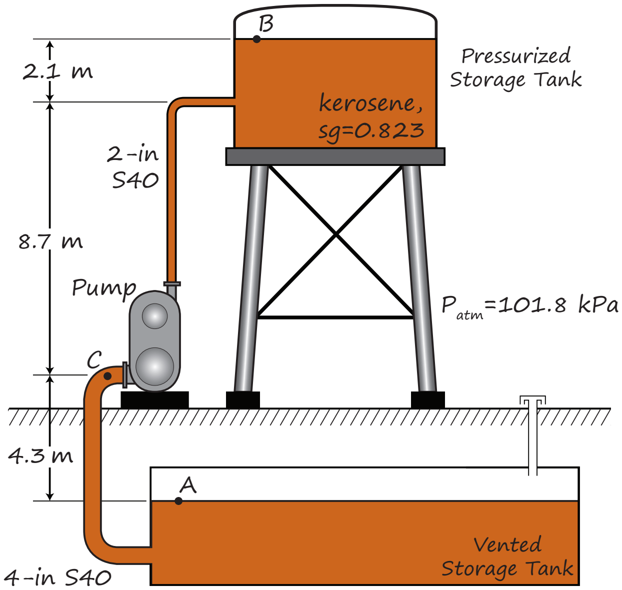
(1) First, by applying the GEE between the surface of Tank 1 and B;
(2) Second, by applying the GEE between A and B;
(3) Finally, by applying the GEE between B and C.

Example 3:



Water flows from A to B at the rate of 120 L/s
Determine the head removed by the turbine.

Example 4:



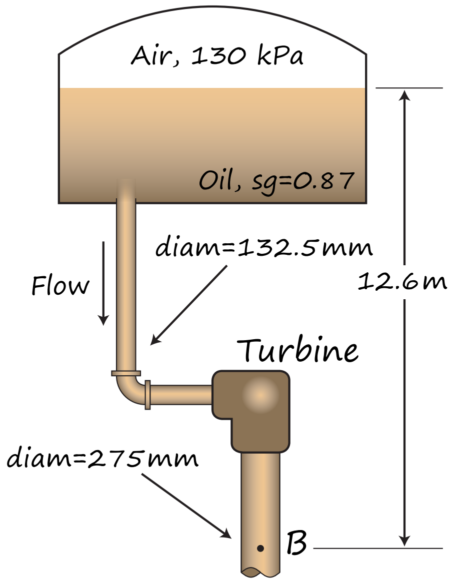
A pump produces a flow of 1024 L/min of kerosene with a specific gravity of 0.823 from vented underground storage to an elevated tank pressurized to 512 kPa. Energy loss between the underground storage and the pump is 0.95 m and energy loss between the pump and the elevated tank is 4.9 m.

(a) Determine the power added to the fluid by the pump.

(b) If the pump has an efficiency of 73%, determine the (electrical) power drawn by the pump.

(c) Determine the gauge and the absolute pressure at the pump inlet.

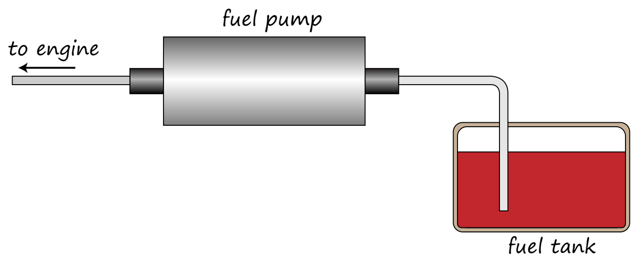
Exercise 2:



Oil, with sg $= 0.87$, flows from a tank pressurized at 130 kPa at a rate of 72 L/s and powers a fluid motor as shown. Energy losses due to friction and fittings between the tank and B are estimated to be 1.81 m.

If the pressure at B is found to be -56 kPa and the motor has an efficiency of 78%, determine the power output from the motor.

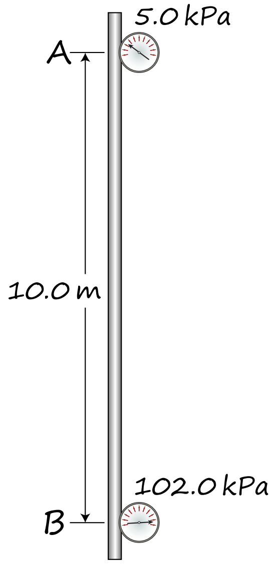
Example 5:



A car fuel pump pumps 1 L of gasoline every 45 s when is has a suction pressure of 155 mm of mercury vacuum and a discharge pressure of 32 kPa. Both the suction and the discharge lines have the same diameter.

If the pump efficiency is 68%, determine the power drawn from the engine.

Example 6:

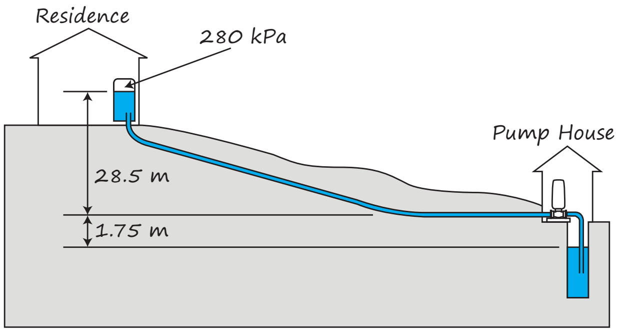


Water flows at a steady rate in a vertical pipe. Two pressure gauges are set 10 m apart, as shown. There are no pumps or turbines and the pipe is of constant diameter.

Determine which of the following is true:

(a) flow is upward
(b) flow is downward
(c) there is no flow

Exercise 3:



A rural house relies upon a shallow well for its water supply. The pump at the well is required to supply $210\,\mathrm{L/min}$ of water. The water tank at the house maintains a pressure of $280\,\mathrm{kPa}$. Friction losses in the pipe amount to $4.35\,\mathrm{m}$.

If the pump is 72% efficient, determine the power delivered to the pump by the electrical supply and the power added to the water by the pump.