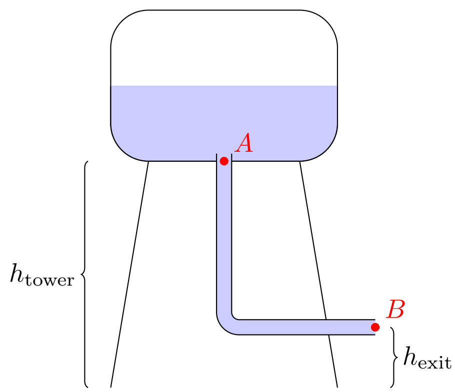
Here is an example of what I imagine an 'ideal' analysis to be.
Try analyzing them yourself first!

Model water tower

Jackson constructs a model of a water tower, connecting the bottom of the reservoir to a pipe that expels the water elsewhere. The water exits at a height (h_{exit}) that is smaller than the height of the tower (h_{tower}). The pressure at the bottom of the reservoir is fixed ($P_{\text{reservoir}}$), and is at least as large as atmospheric pressure. The pressure at the exit is atmospheric. The pipe has a constant area (A), and some resistance (R). Jackson can modify the model by changing the heights, the reservoir pressure, the area, and the resistance.



What are the points of interest?

The only points at which we have information are at the bottom of the water reservoir (A) and at the exit of the pipe (B). So, I expect that these are the points that may be useful to compare.

What energy densities are changing? Between points A and B, the fluid has a change in height, and moves past some resistance. So, the gravitational potential energy goes down, and the thermal energy goes up. The area does not change, and there is no pump, so no need to worry about those. The energy density stored in pressure may change, as it starts at $P_{\text{reservoir}}$ and ends up atmospheric.

What is the relationship between the variables and energy densities mentioned?

Using the energy-density conservation equation to compare points A and B, I find

$$(P_B - P_A) + \rho_{\text{water}} g(h_B - h_A) = -IR.$$

For the pressures and heights, we have some variables to plug in:

$$(P_{\text{atm}} - P_{\text{reservoir}}) + \rho_{\text{water}} g(h_{\text{exit}} - h_{\text{tower}}) = -IR.$$

Furthermore, since the area of the pipe is something that is said might change, it may be useful to remember that $I = Av$.

Why does the scenario given 'work'?

With the equation down, we can interpret the equation a little bit. I would guess that the reservoir has a larger pressure than the atmosphere (after all, it does have some water stacked on

Energy Density Equation	**Continuity Equation**	**Constants**
$\Delta P + \frac{\Delta PE}{\text{vol.}} + \frac{\Delta KE}{\text{vol.}} = \frac{E_{\text{pump}}}{\text{vol.}} - \frac{\Delta E_{\text{th}}}{\text{vol.}}$ $\Delta P + \rho g \Delta h + \frac{1}{2}\rho\Delta(v^2) = E_{\text{pump}}/\text{vol.} - IR$	$I = Av$ $I_{\text{in}} = I_{\text{out}}$	$\rho_{\text{water}} = 1000$ kg/m^3 $g = 10$ m/s^2 $P_{\text{atm}} = 1$ atm $= 10^5$ Pa OR J/m^3 OR kg/(m $\cdot$ s^2)

it). Then, both terms on the LHS are negative, as we would expect given the right hand side certainly being negative.

How do Jackson's modifications affect the result?

Since the heights, the pressures, and the resistance are fixed. The one thing that can respond to changes is the flow rate. If we make the reservoir have a higher pressure, or a larger height, then the left hand side gets more negative. Consequently, such changes will increase the flow rate: more energy became available for the friction to lose.

The area is also said to be possible to change. Since the area does not come up in the energy-density conservation equation, the only thing it would affect is the relationship between speed and flow rate.

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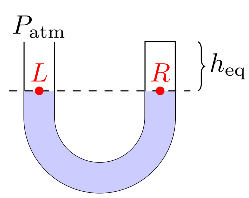
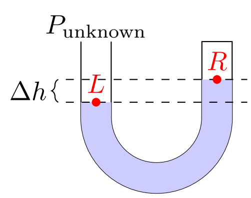
Unusual Barometer

An unusual barometer (i.e. device for measuring pressure) is constructed by having a U-shaped pipe that is open on the left end, and closed on the right end. On the open end, water is exposed to the pressure of the room it is in. On the closed end, some fixed amount of an ideal gas is stored at a constant temperature. Recall that the volume of an ideal gas is inversely proportional to pressure, e.g. doubling the pressure requires the volume to be halved.

The pipe has a constant area, and the amount of water is the same in the following scenarios:

- When the room is at atmospheric pressure, the water levels are equal, with h_{eq} being the height of the air column on the closed side.
- When the room is at some unknown pressure (P_{unknown}), a difference in the height of the water levels (Δh) is observed.





What are the points of interest?

The only points one can really identify here are the points on the surface of the water levels. I will call these L for left and R for right.

What energy densities are changing and what is their relationship?

Since the water for each scenario is static, there are only two things that can change: the pressure and the height. So,

$$(P_R - P_L) + \rho_{\text{water}} g (h_R - h_L) = 0.$$

From the description about giving ideal gases, we know that the pressure on the right P_R gets larger when the air is compressed, i.e. when h_R gets larger.

What can we learn about each scenario using the relationship we found?

In the first scenario, we know that $(h_R - h_L) = 0$ since the water levels are the same, and that $P_L = P_{\text{atm}}$ since the left side is open to the atmosphere. So, the equation is

$$(P_R - P_{\text{atm}}) + \rho g \times 0 = 0 \implies P_R = P_{\text{atm}}$$

so in the first scenario the air on the right side also has atmospheric pressure.

In the second scenario, the air on the right got compressed, so $P_R > P_{\text{atm}}$ and the right side is higher than the left, so $h_R > h_L$. Then,

$$(P_R - P_{\text{unknown}}) + \rho g (h_R - h_L) = 0 \implies P_{\text{unknown}} = P_R + \rho g (h_R - h_L) > P_R > P_{\text{atm}},$$

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so the unknown pressure is bigger than atmospheric, both because the right pressure rose, and because the right water level is higher.

If Δh gets bigger, then the right air gets more squeezed and the height difference gets even larger, so P_{unknown} would have to be even larger.

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