Lab 1 - Ideal Gas

Marie Elster

1. [1 point] What is the pressure of the gas inside the cylinder using the atmospheric pressure P_{atm}, mass of piston and pan M, and cross sectional area of piston A? Show your work.

Given that pressure is the force exerted over a surface area, and adding force (in this case by adding mass) therefore increases pressure, we have that:

$P = P_{atm} + Mg/A$

Where P is the atmospheric pressure, M is mass, g is the gravitational constant, and A is the cross sectional area of the piston. We plug in the respective values and get:

$P = 1.013*10^5\ N/m^2 + (0.477kg*9.81)/(1.307*10^{-4}m^2)$
$P = 137102.3718\ N/m^2 \approx 1.37*10^5\ N/m^2$

2. [3 points] When you add mass to the pan, is the pressure of the gas increasing, decreasing or staying the same? Explain your answer. Hint: look at Eq.(5).

When mass is added to the pan, the pressure increases. This is because pressure is the force exerted over a surface area, and adding weight means more force gets exerted on the gas, causing the pressure to increase.

3. [3 points] Does the volume of the gas increase, decrease, or stay the same when you add mass to the pan? Explain your answer. Hint: Look at Boyle's Law Eq.(2).

The volume of the gas decreases when mass is added to the pan. This is because the volume of the gas is inversely proportional to its pressure, and the pressure increases when weight is added (Boyle's Law).

4. [3 points] Is the height h of the pan higher, lower, or the same as the height when the apparatus was filled with hot water? Explain your answer. Hint: look at Charle's Law Eq.(1).

The height of the pan is lower than when the apparatus was filled with hot water. This is because the volume of a gas is directly proportional to the temperature of the gas, meaning that the gas expands at when the hot water is added, causing the pans height to rise, whereas the height lowers when cold water is added due to contraction.

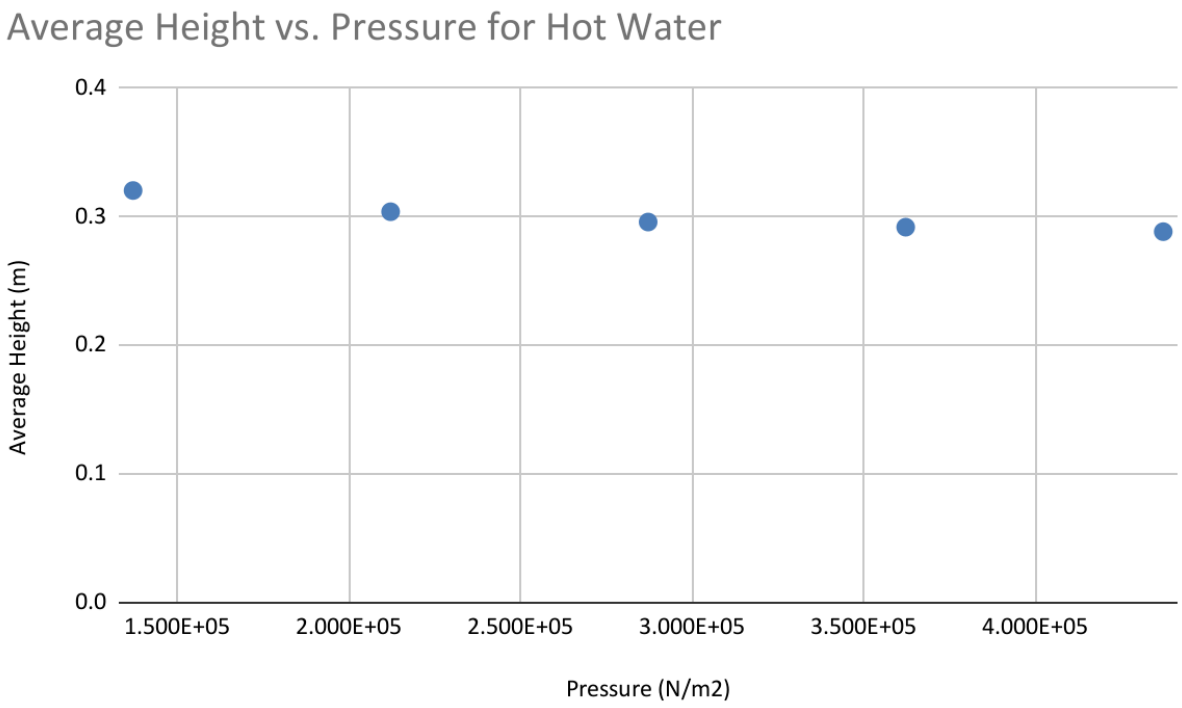
5. [2 points] Calculate the pressure of each additional mass added to the pan.

See spreadsheet

6. [2 points] Calculate the average height of the pan using the height after a *small* push up and *small* push down.

See spreadsheet

7. [3 points] Make a scatter plot of average h vs Pressure:
    a. Click on the header P (N/m2) and drag down the column to select the values of pressure.
    b. Press and hold the Ctrl key and click on the header h_avg (m) and drag down the column to select the values of average height.
    c. Release Ctrl key and open the Insert menu and select Chart.
    d. The Charter Editor will open. In Setup choose Chart Type > Scatter Chart,
    e. Make sure the X-axis indicates P (N/m2).
    f. Make sure the Series indicates h_avg (m). If P (N/m2) is in the Series, remove it.
    g. In Customize > Chart & axis titles add axes titles with units to your graph.
    h. Copy and paste your plot into this document below here:



8. [2 points] Calculate the pressure of each additional mass added to the pan.

See spreadsheet

9. [2 points] Calculate the average height of the pan using the height after a *small* push up and *small* push down.

See spreadsheet

10. [3 points] Make a scatter plot of average h vs Pressure:
    a. Click on the header P (N/m2) and drag down the column to select the values of pressure.

b. Press and hold the Ctrl key and click on the header h_avg (m) and drag down the column to select the values of average height.
c. Release Ctrl key and open the Insert menu and select Chart.
d. The Charter Editor will open. In Setup choose Chart Type > Scatter Chart,
e. Make sure the X-axis indicates P (N/m2).
f. Make sure the Series indicates h_avg (m). If P (N/m2) is in the Series, remove it.
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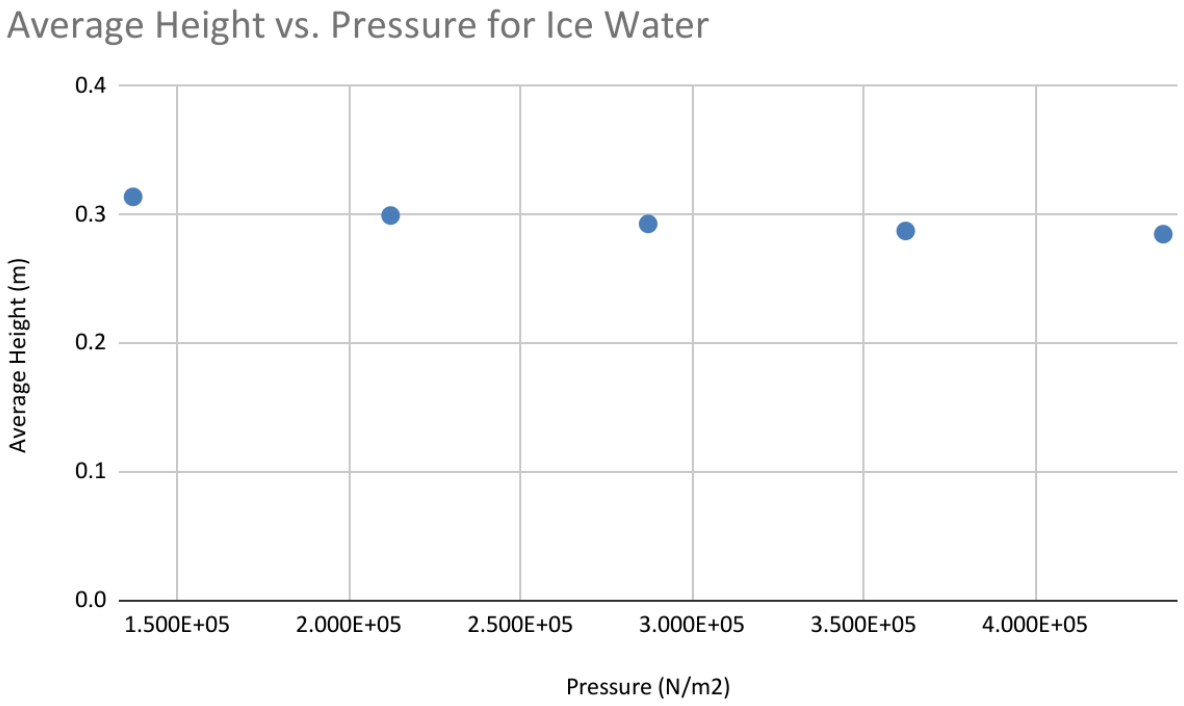


11. [3 points] Look at your two plots of average h vs. Pressure. Describe the *mathematical* relationship of height vs. Pressure. Hint: Look at Boyle's Law Eq.(2)

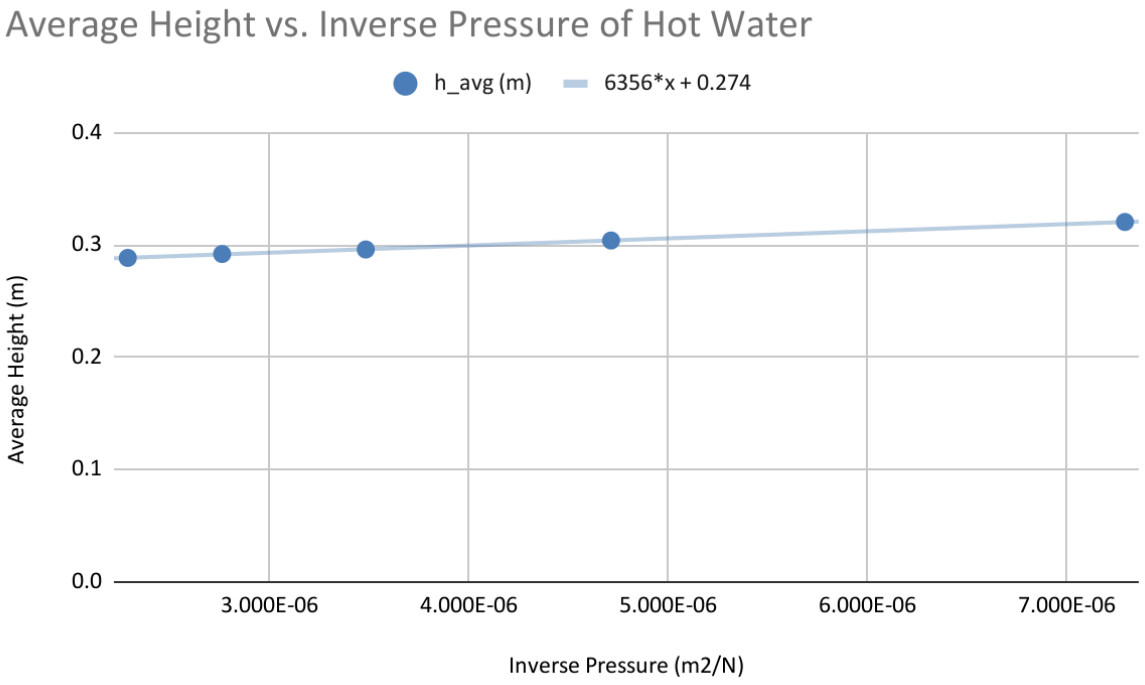
There is a negative linear relationship between the height and the pressure, where the height is inversely proportional to the pressure. This is in accordance with Boyle's Law, which states that if the temperature and number of molecules of the gas is constant, then the pressure of the gas is inversely proportional to the gas's volume.

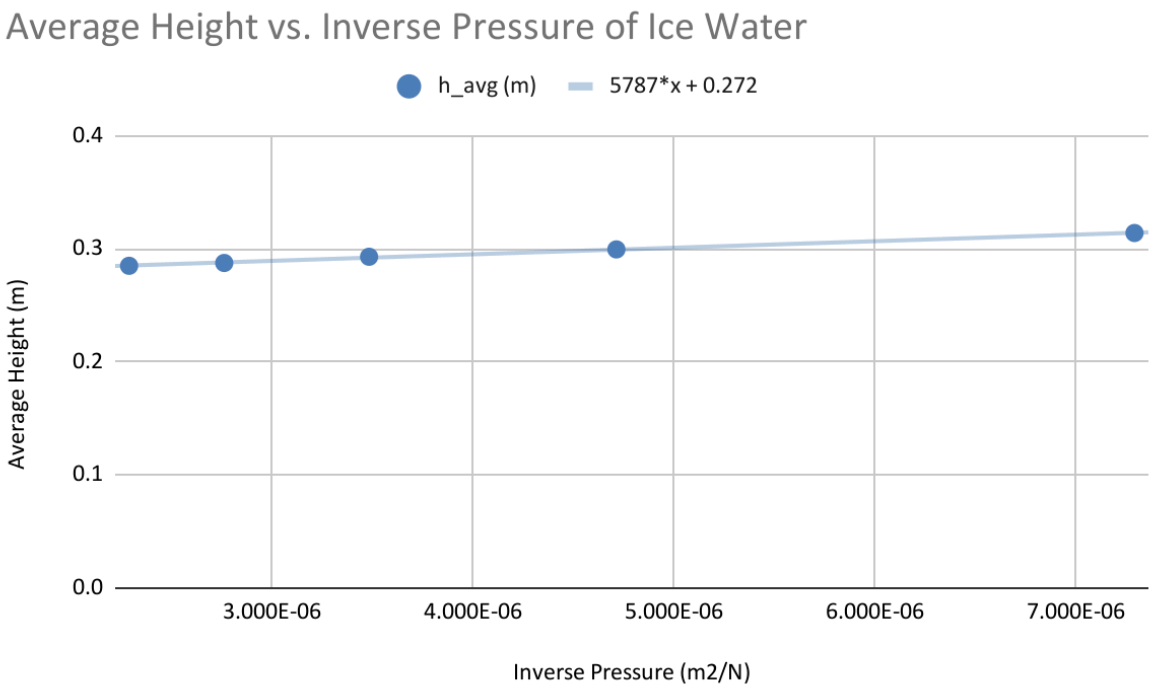
12. [2 points] Calculate inverse pressure for each additional mass added to the pan.

See spreadsheet

13. [6 points total, 3 points for each plot]] Make a scatter plot of average h vs inverse Pressure:
    a. Click on the header 1/P (m2/N) and drag down the column to select the values of pressure.

b. Press and hold the Ctrl key and click on the header h_avg (m) and drag down the column to select the values of average height.
c. Release Ctrl key and open the Insert menu and select Chart.
d. The Charter Editor will open. In Setup choose Chart Type > Scatter Chart,
e. Make sure the X-axis indicates 1/P (m2/N).
f. Make sure the Series indicates h_avg (m). If 1/P (m2/N) is in the Series, remove it.
g. In Customize > Chart & axis titles add axes titles with units to your graph.
h. Copy and paste your plot into this document below here:





14. [3 points] Look at both scatter plots of average h vs. inverse pressure (one for Hot Water, one for Ice Water). Describe the *mathematical* relationship of height vs. inverse pressure. Is this what you expected?

Once again there is a linear relationship between the height and inverse pressure, but this time the function is positive. This is expected since Boyle's Law states that if the temperature and number of molecules of the gas is constant, then the pressure of the gas is inversely proportional to the gas's volume. As such, the height is proportional to the inverse pressure.

15. [1 points] Record the values of the slopes in the tables below:

Hot Water	6356
Ice Water	5787

16. [3 points] Which slope is higher (Hot Water or Cold Water). Is this what you expected? Explain your answer. Hint: look at Charle's Law Eq.(1).

Hot water has a higher slope than cold water. This is expected, due to the fact that the volume is directly proportional to the absolute temperature, which is inversely proportional to the pressure. Therefore the slope will be steeper for hot water, since the temperature is higher.