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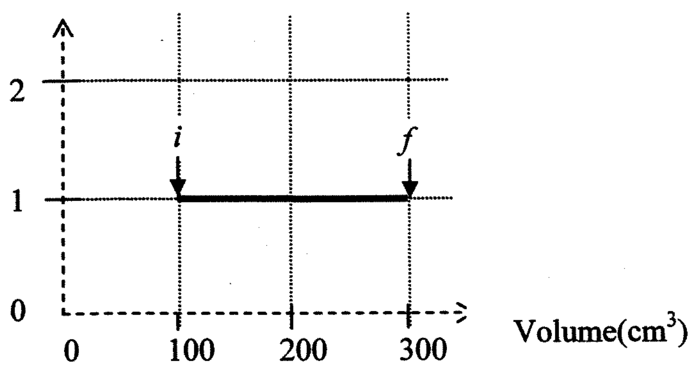
19) An ideal gas containing 0.01moles undergoes a process that is shown by the graph below. R= 8.3 J/(mol.K). (1 atm $=1.01\times10^5$ Pa, 1 cm^3 $=1\times10^{-6}$ m^3.) The number of moles remains the same throughout.

a) Determine the initial and final values of the pressure, volume and temperature of the gas. (That's 6 quantities)
b) Describe what is happening to the gas *macroscopically*. (This means talking about the physical quantities: temperature pressure and volume.)
c) Represent the process using P-T and V-T graphs.
d) Explain what happens to the gas *microscopically* (talk about what happens to the molecules of the gas) as the gas changes from the initial to the final state.



(a)

$P_i = 1\,\text{atm} = 1.01\times10^5\ \text{Pa}$; $P_f = 1\,\text{atm} = 1.01\times10^5\ \text{Pa}$

$V_i = 100\,\text{cm}^3 = 1\times10^{-4}\,\text{m}^3$; $V_f = 300\,\text{cm}^3 = 3\times10^{-4}\,\text{m}^3$

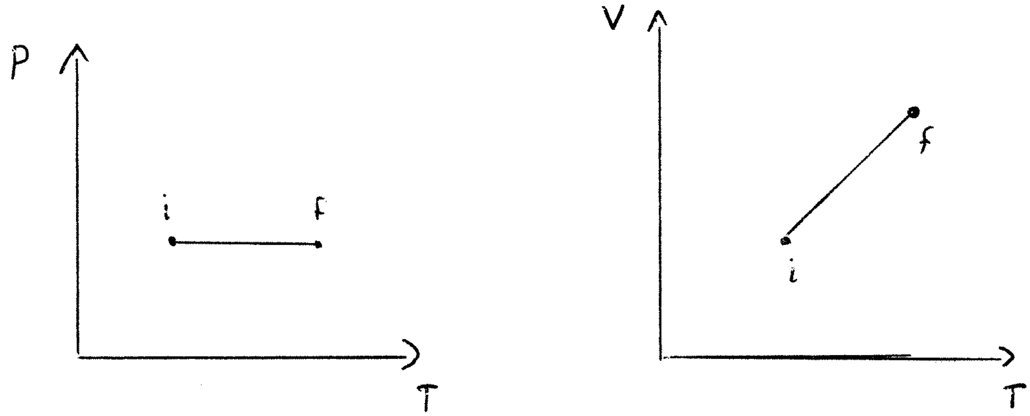
$T_i = \dfrac{P_i V_i}{nR} = \dfrac{(1.01\times10^5)(1\times10^{-4})}{(0.01)(8.3)} = \boxed{122K}$; $T_f = \dfrac{P_f V_f}{nR} = \dfrac{(1.01\times10^5)(3\times10^{-4})}{(0.01)(8.3)} = \boxed{365\,K}$

T_f can also be arrived at by scaling

$\dfrac{T_f}{V_f} = \dfrac{T_i}{V_i} \Rightarrow T_f = \left(\dfrac{V_f}{V_i}\right)T_i = 3\,T_i$

(b) Temperature increases, volume increases, pressure remains constant.

(c)



(d) Microscopically, an increase in temperature means that the kinetic energy of the gas molecules has increased. In turn, this means that the molecules are moving faster, hitting the walls of their container harder & more frequently. This forces the walls of the container to expand outwards to maintain a constant pressure.

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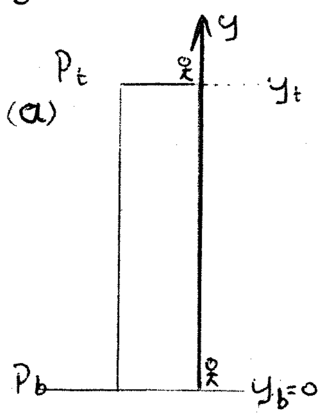
20) Niels Bohr decides to measure height of a building by measuring the pressure at the top of the building and at the bottom of the building with a barometer (a pressure gauge that measures absolute pressure). He measures the *difference in pressure* between the top and the bottom of the building to be 400 Pa. (I.e., $P_{\text{bottom}} - P_{\text{top}} = 400$ Pa.) Then he drops the barometer from the top of the building and (with a stopwatch) times how long it takes for it to fall and smash on the ground below. The time he measures is 2.5 seconds.

a) Use the barometer readings to estimate the height of the building. Also list the assumptions you made to make this estimate. (The density of air is 1.23 kg/m^3 at a temperature of 15°C and pressure of 1.01×10^5 Pa, if you need it.)

b) Use the time of the fall of the barometer to estimate the height of the building. Also list the assumptions you made to make this estimate.

c) If the smallest unit that the barometer reads is 100 Pa, estimate the uncertainty in the height estimate in part a). Also estimate the uncertainty in the height estimate for part b). You might want to estimate a *reasonable* reaction time uncertainty for the time measurement to do this. Based on your calculations, which method do you think will give the better result? Why?



$$P_b = P_t + \rho_{air}\, g\, \Delta y$$

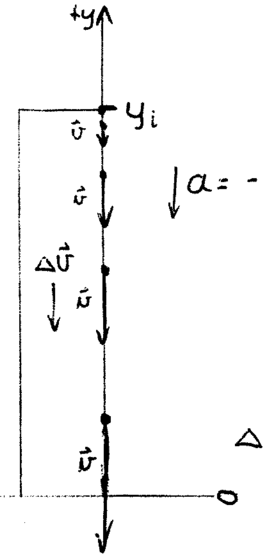
$$\Rightarrow P_b - P_t = \rho_{air}\, g\, (y_t - y_b)$$

$$\Rightarrow y_t = \frac{P_b - P_t}{\rho_{air}\, g} = \frac{400\ \text{Pa}}{(1.23)(10)} = \boxed{32.5\,\text{m}}$$

Assumed: Either air is incompressible fluid, or constant ρ_{air} from bottom to top. (These amount to the same thing)

You might also mention: , constant temperature (15°C), & still air (no velocity.)

(b)



$a = -10\,m/s^2$

$y_i = ?$

$v_i = 0$

$\Delta t = 2.5s$

use $y_f = y_i + v_i t + \frac{1}{2}at^2$

$\Rightarrow 0 = y_i + 0 - \frac{1}{2}(10)(2.5)^2$

$\Rightarrow \boxed{y_i = 31.25m}$

Or $v_f = v_i + at = 0 + -10(2.5)$

$= -25m/s$ . . .

then $\Delta y = v_{avg}\Delta t = \left(\frac{-25m/s}{2}\right)(2.5s)$

$= -31.25m$

$\Rightarrow y_i = 31.25m$

assumed: • Ignored air resistance • assumed g constant • Ignored any other external interactions, assumed inertial reference frame etc...

(C) Barometer uncertainty: $\Delta P\% = \frac{100\,Pa/2}{400Pa} = 12.5\%$ (I'll accept $\frac{100Pa}{400Pa} = 25\%$)

height uncertainty $= 32.5m \pm 12.5\%$

$= (32.5 \pm 4)m$

Time uncertainty: $\Delta t\% = \frac{0.2s}{2.5s} = 8\%$

height uncertainty $= 31.25 \pm 8\% = (31.25 \pm 2.5)m$

This estimate is based on a reasonable reaction time of 0.2s. Note that I did <u>not</u> use the minimum reading of the stopwatch (maybe 0.01s) since it is smaller than the reaction time.

One should argue that the height estimate with the smaller uncertainty is more reliable. If the two uncertainties are roughly equal then there is no preference for either measurement

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21) You decide to figure out the density of salt water in the Dead Sea. You estimate that 20% of your body volume is sticking out of the water when you float in the Dead Sea. What is the density of the water of the Dead Sea? (Hint: you might need to estimate your density.)

FBD. floating in Dead Sea

If system is in equilibrium, then:

$$F_{w \text{ on me}} = F_{E \text{ on m}}$$

$$\Rightarrow \rho_w g V_{displaced} = m_{me} g$$

given that $V_{displaced}$ is $0.8 V_{me}$;

$$\Rightarrow \rho_w g \, 0.8 V_{me} = \rho_{me} V_{me} g$$

$$\Rightarrow \rho_w = \rho_{me} / 0.8$$

It is therefore crucial to make a good estimate of ρ_{me}.

in regular water a human can barely float. It seems reasonable to estimate $\rho_{me} = 1000 \text{ kg/m}^3$

then $\rho_w = 1000/0.8 = \boxed{1250 \text{ kg/m}^3}$

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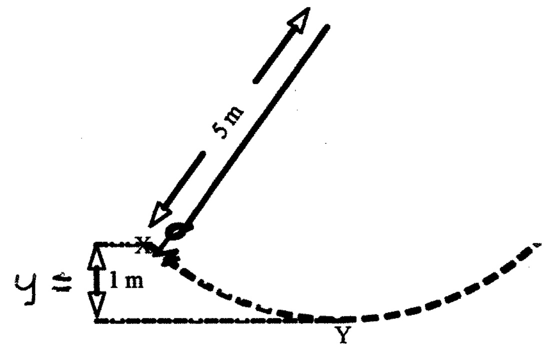
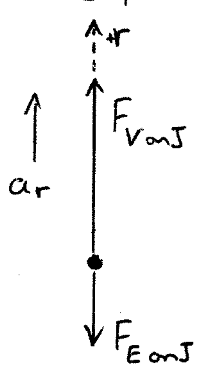
22) Jane (50 kg) swings down, holding a 5 m long vine. She starts from rest at point X. What is the force exerted by the vine on Jane at the bottom of her swing (point Y). (Point X is 1 m above point Y.) (Remember to show all your work.)



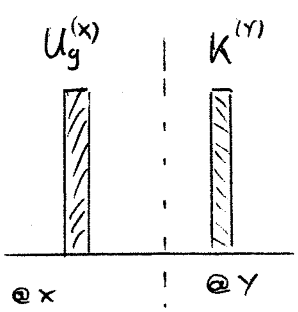
FBD @ pnt Y:



$$a_r = \frac{v^2}{r} = \frac{F_{VonJ} - F_{EonJ}}{m_j}$$

$$\Longrightarrow \quad F_{VonJ} = \frac{m_J v^2}{r} + m_J g$$

It is necessary to figure out the speed v @ pnt Y in order to solve the problem. The best way to do this is with energy conservation:



$$\longrightarrow \quad m_J g y = \frac{1}{2} m_J v^2$$

$$\Longrightarrow \quad v^2 = 2gy$$

$$\therefore \quad F_{VonJ} = \frac{2 m_J g y}{r} + m_J g$$

$$= \frac{2(50)(10)(1)}{5} + (50)(10) = \boxed{700\text{ N}}$$

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23) Your friend is writing a lab report and asks you to read the report and help him find mistakes or omissions. In the space below please make a list of things that you think your friend should revise or add to improve his/her report.

I. Testing experiment: energy conservation

You have a Styrofoam cup, half-filled with hot water, some ice at 0°C, a weighing scale, a thermometer, and paper towels.

Your goal is to test whether the energy conservation principle can be used to predict accurately the amount of ice (in grams) that you should add to the cup of hot water for the ice and water to reach a final temperature that is half the initial temperature of the hot water.

Lab Report:

Prediction: The amount of energy gained by the ice will equal the amount of energy lost by the hot water when the ice-water system reaches the uniform temperature given as ½ the initial temperature.

Mathematical procedure:

Mass of hot water m_{water}=107.2;

Temperature of hot water $T_{initial}$=70°C;

Temperature of ice T_{ice}=0°C;

C_w=4186;

Heat of fusion of ice $L_{ice}=3.35\times10^5$;

Final temperature of water should be $T_{initial}/2$=35°C;

m_{ice} – mass of ice (term to be solved for).

$$m_{ice} = \frac{C_{water}\, T_{initial}/2}{L_{ice} + C_{water}\, T_{initial}/2}\, m_{water}$$

Calculated prediction: $m_{ice} = [107.2\times4186\times35] / [3.35\times10^5+4186\times35] = 32.6$g

Experiment result: 32g of ice added to hot water at temperature 70°C and water cooled to 33.4°C

Judgment: The predicted temperature was 35°C, the experimental value was 33.4°C. Experiment outcome did not match our prediction possibly because of human error. However we can make a conclusion that conservation of energy is applicable to this situation.

1. Prediction is restatement of hypothesis. Prediction should be m_{ice} = 32.6g (Predicted outcome of experiment based on energy conservation)

2. No description of experiment, diagrams etc etc.... Need to describe what was done & how it was done.

3. Note missing units all over the place!

4. Need to make a list of assumptions & how they affect the results (eg: assume no energy lost to the surroundings. If energy were lost the measured final temp would be less than 35°C;

5. No estimate of uncertainties or list of sources of uncertainties.

6. (a) Judgement has no justification since no uncertainties were calculated. The statement that the desired temp of 35°C & the actual measured temp of 33.4°C are different may not be true when uncertainties are included. It is quite possible that these two values are the same when uncertainties are taken into account.

(b) If the two values are different, how can you justify that energy conservation is applicable to this situation? A good judgement here needs to include a discussion of energy lost by heating from the system. If this loss is taken into account, it is possible to argue that energy conservation is still applicable. As it stands you have to conclude that energy conservation is *not* applicable to this situation.

7. Need to explain the discrepancy between the two values better.