Family name: KHO **First name:** LUCY

Problem # 1

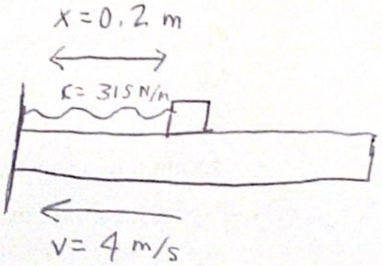
A 2.00 kg frictionless block is attached to a spring and undergoing simple harmonic oscillation. The force constant of the spring is 315 N/m. When the block displacement is $x = +0.200$ m, it is moving in the negative x - direction with a speed of 4.00 m/s. Find

a./ the amplitude of the motion,

b./ the block's maximum acceleration, and

c./ the maximum force the spring exerts on the block.

a. I will use equations of horizontal SHM.



$$\omega = \sqrt{\frac{315}{2}} = \sqrt{157.5} = 12.5 \text{ rad/s}$$

$$A^2 = x_0^2 + (v_0/\omega)^2 = (0.2)^2 + (4^2/12.5^2)$$

$$\sqrt{A^2} = \sqrt{0.1415}$$

$$A = 0.376 \text{ m}$$

The amplitude of motion is 0.376 m.

b. $F = ma \rightarrow a = \frac{F}{m}$

$\downarrow$

$$F_{netx} = -Kx = ma$$

~~$-(315)(0.2) = (2)(a)$~~

~~$a = -31.5 \text{ m/s}^2$~~

$a = \frac{-K\textcircled{x}}{m} \rightarrow$ should correspond to A, amplitude of motion

$$a = \frac{(315)(0.376)}{2} = 59.2 \text{ m/s}^2$$

The max acceleration is 59.2 m/s²

c. $F = ma = (2)(59.2) = 118 N$

The max force is 118 N.

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$P = \frac{1}{5}$

Problem # 2

A light beam coming from an underwater spotlight exits the water at an angle of 56°. At what angle of incidence did it hit the air-water interface from below the surface?
(the refraction index of water is 1.33)

A

I will use Snell's law, taking in to account the different indices of refraction

$n_1 \sin\theta_1 = n_2 \sin 56$

$= \sin 56$

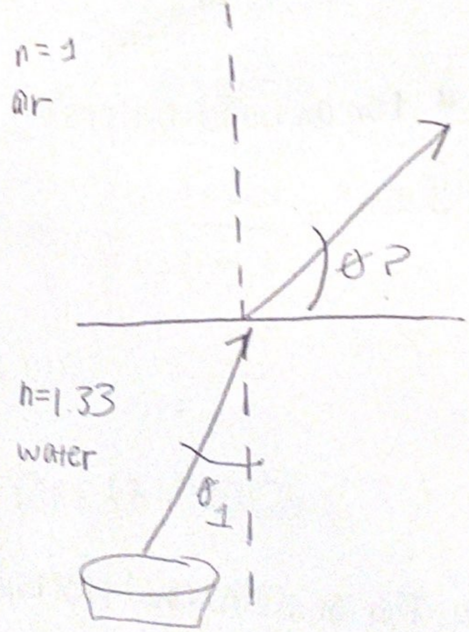
$1.33 \sin\theta_1 = \sin(56^\circ)$

$\sin^{-1}$

$\cancel{\sin}\theta_1 = \left(\frac{\sin(56)}{1.33}\right)^{\sin^{-1}}$

$\theta_1 = \cancel{38}\ 38.6^\circ \approx 39^\circ$

It hit the interface at 39°.



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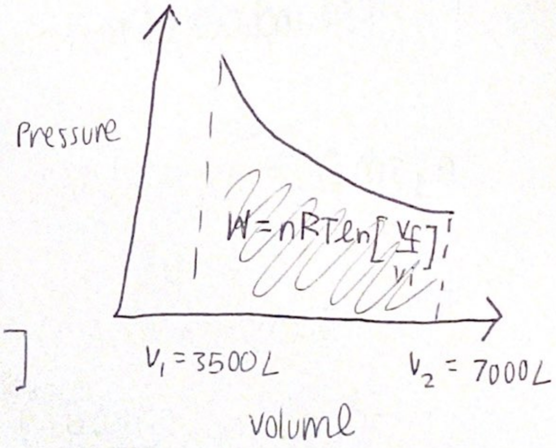
Problem # 3

Suppose 2.60 mol of an ideal gas of volume $V_1 = 3.50\ \text{m}^3$ at $T_1 = 290$ K is allowed to expand isothermally to $V_2 = 7.00\ \text{m}^3$ ($T_2 = 290$ K). Determine

a.) the work done by the gas.
b.) The heat added to the gas, and
c.) The change in the internal energy of the gas.

I will use equations related to isothermal processes



a. For an isothermal process, $W = \overset{mol}{n}R\overset{K}{T}\ln\left[\frac{\overset{L}{V_f}}{V_i}\right]$

$3.5\text{m}^3 \times \frac{1000\ \text{L}}{1\ \text{m}^3} \equiv 3500\ \text{L}$

$7.00\ \text{m}^3 \times \frac{1000\ \text{L}}{1\ \text{m}^3} = 7000\ \text{L}$

$W = (2.6)(8.314)(290)\ln\left(\overset{2}{\cancel{\frac{7000}{3500}}}\right) = 4.3 \times 10^3\ \text{J}$

4.3×10^3 J of work are done.

b. For an isothermal process,

$\Delta U = 0 \rightarrow Q - W = 0$

$Q = W$

$Q = 4.3 \times 10^3\ \text{J}$

4.3×10^3 J of heat are a added

c. For an isothermal process, $\Delta E = 0$.

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Problem # 4

A nature photographer wishes to photograph a $\overset{h}{40}$ m tall tree from a distance of $\overset{s}{65}$ meter. What focal-length lens should be used if the image is to fill the $\underset{h'}{\overline{24 \text{ mm}}}$ height of the sensor?

I will use the thin-lens equation and magnification ratio.

Known vs. unknown variables

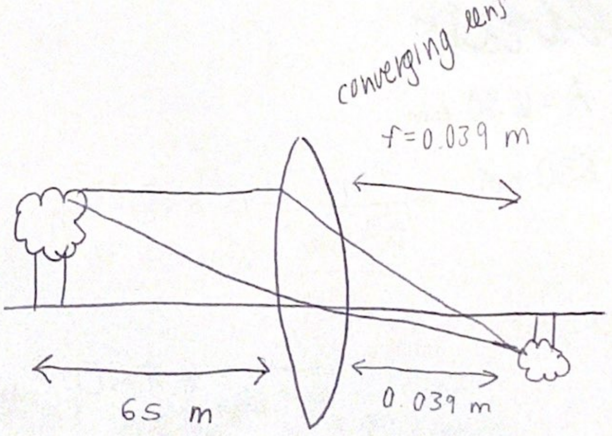
[illegible] $h = 40 m$

$h' = 0.024\ m$

$s = 65\ m$

$s' = ?$

$f = ?$



~~$M = \frac{0.024}{4}$ $\frac{40}{-0.024}$ -1666.66~~ $\rightarrow |m| = \frac{h'}{h} = \frac{s'}{s}$

~~$-1666.66 = \frac{65}{s'}$~~

~~$s' = -0.039\ m$~~

~~$\frac{1}{65} + \frac{1}{-0.039} = \frac{1}{f}$~~

~~$\frac{1}{f} = -25.63$~~

~~$f = -0.039$~~

[illegible] $= \frac{h'}{h} = \frac{s'}{s} = \frac{0.024\ \cancel{m}}{40\ \cancel{m}}$

$6 \times 10^{-4} = \frac{s'}{65}$

$s' = 0.039\ m$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = \frac{1}{65} + \frac{1}{0.039} = \frac{1}{f}$

$f = 0.039\ m$

* The focal length lens should be 0.039 m or 39 mm.

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Problem # 5

Parallel beam of light from a He-Ne laser, with wavelength of 630-nm, falls on two very narrow slits 0.068 mm apart. How far apart are the fringes in the center of the pattern on a screen 3.8 m away?

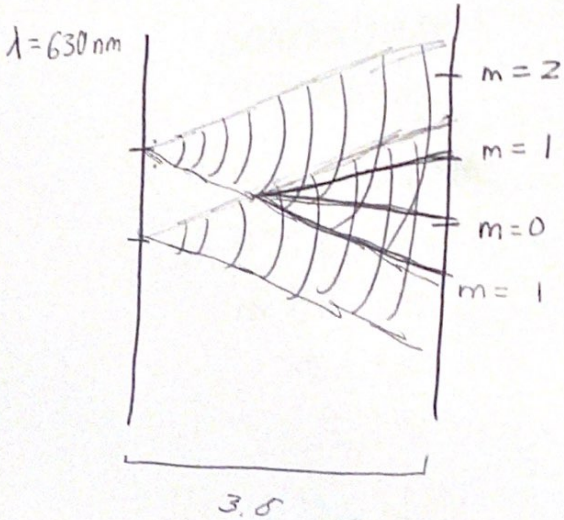
I will compare the positions of the bright fringes with $y_m = \frac{m \lambda L}{d}$ for the m and m+1 bright fringe.

~~y_m [illegible]~~

$\lambda = 630$ nm

$630 \cancel{nm} \times \frac{1 m}{10^9 \cancel{nm}} = 6.3 \times 10^{-7}$ m

$d = 0.068$ mm $\times \frac{1 m}{10^3 mm} = 6.8 \times 10^{-5}$ m



$$y_{m=1} = \frac{(1)(63 \times 10^{-7})(3.8)}{(6.8 \times 10^{-5})} = 0.035 m$$

$$y_{m=2} = \frac{(2)(6.3 \times 10^{-7})(3.8)}{(6.8 \times 10^{-5})} = 0.070 m$$

$\Delta y_m = y_{m=2} - y_{m=1} = 0.07 - 0.035 = 0.035$ m.

*They are 0.035 m apart.

e the thin lens

$+ \frac{1}{s'}$

$+ \frac{1}{(}$

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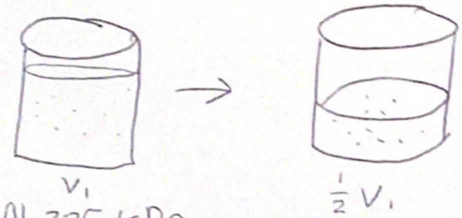
Problem # 6

If 14.00 mole of Helium gas is at 10.0°C and at pressure of 0.350 atm, calculate

a./ the volume of the Helium gas under these conditions, and

b./ the temperature if the gas is compressed to precisely half of the volume at a pressure of 1 atm.

I will consider the conditions of an ideal gas with $pV = nRT$.



a. $p = 0.35 \text{ atm} \times \frac{101.325 \text{ KPa}}{1 \text{ atm}} = 35.46 \text{ KPa}$

$35.46 \text{ KPa} \times \frac{1000 \text{ Pa}}{1 \text{ KPa}} = 35460 \text{ Pa}$
$= 3.5 \times 10^4 \text{ Pa}$

$T = 283.15 \text{ K}$

$V = \frac{nRT}{P} = \frac{(14.00)(8.31)(283.15)}{35.46 \times 10^3} =$ [illegible] $= 0.928 \text{ m}^3$

~~$929 \text{ m}^3 \times \frac{1000 L}{1 \text{ m}^3} = 9.29 \times 10^5 L$~~

$0.928 \text{ m}^3 \times \frac{1000 L}{1 \text{ m}^3} = 928.9 L$

The volume is [illegible] is 0.929 m^3 or $928.9 L$.

b. ~~$W = P\Delta V = NK\Delta T$~~
~~(101.325)(~~

~~$V_f = V_1 \left(\frac{P_1}{P_f}\right)\left(\frac{T_f}{T_1}\right) = \left(\frac{929}{2}\right) = (929)(1)\left(\frac{T_f}{283.15}\right) \quad \frac{1}{2} = \frac{T_f}{283.15}$~~

~~T_f~~ $= \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \rightarrow \frac{(0.35)(0.928)}{283.15} = \frac{(1)(\frac{0.928}{2})}{T_2} \rightarrow 0.001147 = \frac{0.464}{T_2}$

$T_2 =$ [illegible] K
405K

*The temperature is [illegible] K
405

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Problem # 7

You take a pendulum whose period at the Earth is 1 s to a planet whose gravitational strength is 16 times that of the Earth. What is the period time of the pendulum on this planet?

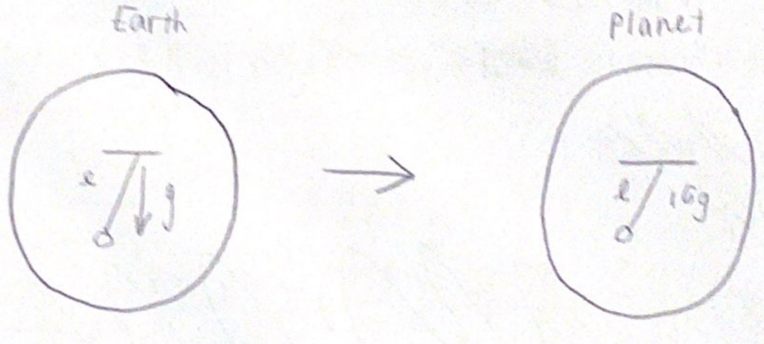
I will compare the periods of oscillation when changing the g-value.

$$T_E = 1 = 2\pi\sqrt{\frac{l}{g}}$$

$$T_p = 2\pi\sqrt{\frac{l}{16g}} = T_p = 2\pi\sqrt{\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)\frac{l}{g}} = \frac{1}{4}\overset{\nearrow 1}{\boxed{2\pi\sqrt{\frac{l}{g}}}}$$

$$= \frac{1}{4} = 0.25 \text{ s.}$$

* The period is 0.25 secs.



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Problem # 8

373.15

~~373.15~~

If 0.45 kg of water at 100°C is changed by a reversible process to steam at 100°C, determine the change in the entropy of

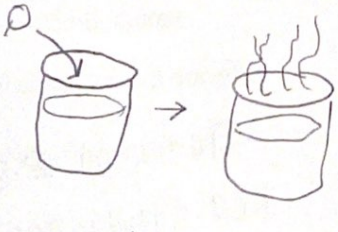
a.) the water,

b.) the surroundings,

c.) the universe as a whole

d.) How would your answers differ if the process were irreversible?

(Note: quantitate answers are expected)



I will consider enthropy changes for reversible and irreversible processes

a. ~~$0.45 kg \times \frac{1000 g}{1 kg} \times \frac{1 mol}{18 g}$~~

Heat of Vaporization (water) $= \frac{40 KJ}{mol}$

$\Delta S = \frac{\Delta Q}{T}$

$\frac{40.6 KJ}{mol} \times \frac{1 mol}{18 g} \times \frac{1000 g}{1 Kg} = 2255 KJ/Kg$

$Q = \frac{2255.55 KJ}{Kg} \times 0.45 Kg \times \frac{1000 J}{1 KJ} = 1.015 \times 10^6 J$

$\Delta S = \frac{(1.015 \times 10^6) J}{373.15 K} = 2720 J/K$

ΔS of the water is 2720 J/K

b. $\Delta S = \frac{-\Delta Q}{T} = -2720 J/K$

The change in entropy of the surroundings is -2720 J/K

c. In a reversible process, total entropy is 0. $\Delta S_{total} = 0$.

d. I would expect the total entropy > 0 if the process were occuring irreversibly. So, $\Delta S_{total} = \Delta S_{water} + \Delta S_{surr} > 0$, causing an increase in energy of the system and environment.

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Question #1

The second law of thermodynamics can be worded in different ways, such as

a.) heat can flow spontaneously from a hot object to a cold object, or

b.) the total entropy of any system plus that of the environment increases as a result of natural processes.

Why are these statements equivalent? What are the consequences? Explain, give examples, etc.

- The two above statements are equivalent when the heat Flow is analyzed for case A. Here, heat transfers from warm to cold, so we can say $\Delta S_{hot} = \frac{-Q}{T_1}$, because some amount of heat is being lost. For the cold object, the $\Delta S_{cold} = \frac{Q}{T_2}$ because of the input of heat. The temp. associated with the hot object is higher than that of the low object, so $\Delta S_{cold} > |\Delta S_{hot}|$. We can calculate $\Delta S_{system} = S_f - S_i = \frac{-Q}{T_1} + \frac{Q}{T_2}$, which produces a positive value since $T_1 > T_2$ and $Q/T_2 > -Q/T_1$. Thereby, total entropy of the system is increasing because of this natural, spontaneous process. This allows us to predict what heat flow processes will take place spontaneously when analyzing change in entropy.

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Question #2

It is important to measure time - over the history many different type of clocks has been constructed and used to do just that. These clocks (pendulum, wrist watch, electronic, quartz, digital watch, etc.) appear to be very different.
Can you describe what do you see common and similar in all of them?

- Clocks measure how many oscillations of an object take place in a period of time, knowing the period of oscillation/ frequency for that object.
- For instance, with a grandfather clock, it is often designed so one swing of the pendulum takes 1 s in either direction, and this physical displacement can be used to mark time. Each 1/2 of a period measures one second (i.e. T=2).