Practice Quiz 1A/B **DL**_____ **Name** (last)____________________ (first)________________ | | | (1)

first 3 letters last name

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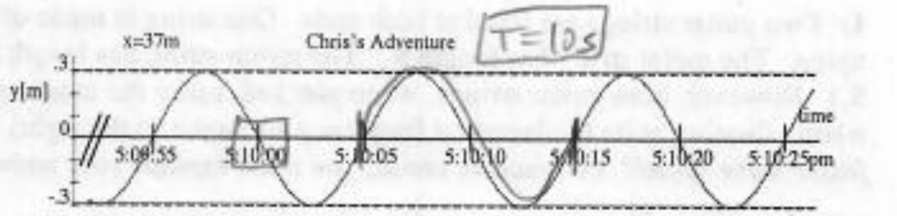
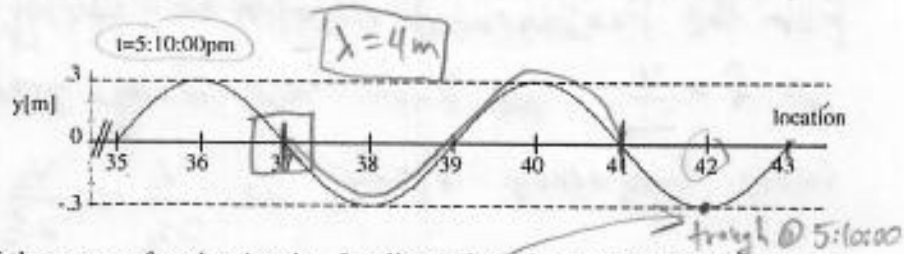
A large storm hit Davis and caused severe harmonic waves in Putah Creek (It could happen!). Two ducks (they mate for life!) were in the water during the storm. The duck known as Chris was located 37m from the bridge. The first graph on the right shows the oscillations that Chris endured around dinner time. Meanwhile, Chris's mate, Pat, was located 42m from the bridge.



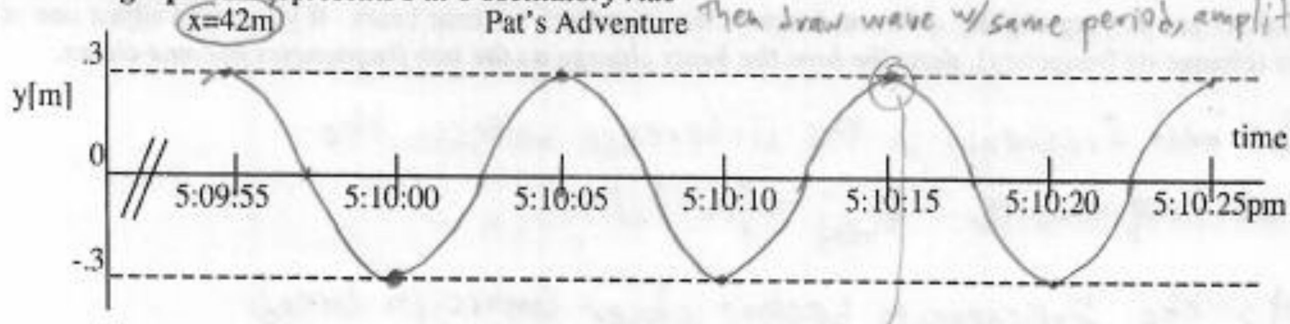


During this time, Leslie was taking pictures of the waves for the Aggie. Leslie took a picture at 5:10:00 PM and again at 5:10:15PM. The second graph on the right represents the wave shape in Leslie's first photo.

→ so look for more info about x=42

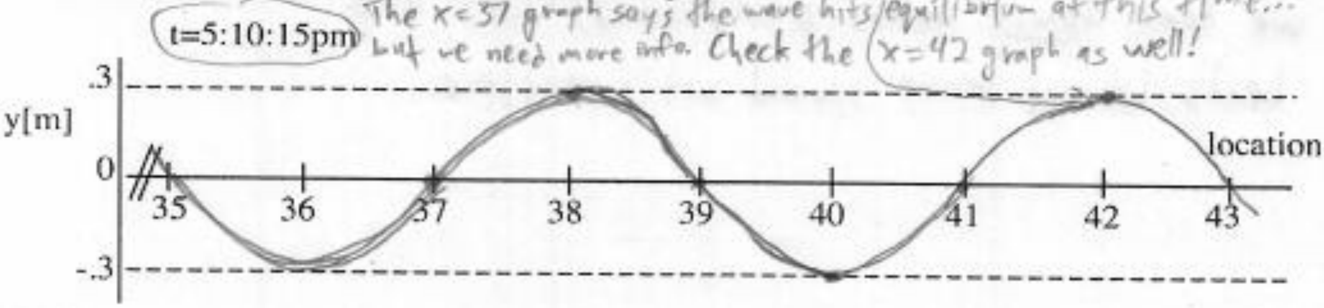
1) Draw a **graph** that represents ***Pat's oscillatory ride***

Then draw wave w/ same period, amplitude, etc.



2) Draw another **graph** to represent ***Leslie's second photo.***

The x=37 graph says the wave hits equilibrium at this time... but we need more info. Check the x=42 graph as well!



3) Write the wave ***equation*** for this phenomenon. Assume that the initial phase (φ) is 0. ***Indicate*** the following values (**A, y_o, λ, & T**) on the ***top two graphs.***

$$y = .3\text{m} \cdot \sin\left(\frac{2\pi}{10\text{s}} \cdot t + \frac{2\pi}{4\text{m}} \cdot x\right)$$

we know the wave is moving to the left by comparing x=37 on the first x vs. y graph to t=5:10:00 on the first t vs. y graph.

②

Quiz 4A **TA**__________ **Name** (last)____________________ (first)____________ |__|__|__|
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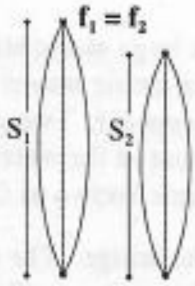
1) Two guitar strings are fixed at both ends. One string is made of metal; the other is made of nylon. The metal string has length $\mathbf{S_1}$. The nylon string has length $\mathbf{S_2}$ (which is shorter than S_1). However, both guitar strings, when plucked, make the exact same note (same frequency when vibrating at its fundamental frequency as shown to the right). ***Which string has the faster wave speed?*** (To receive credit, you must ***explain*** your answer.)



For the fundamental vibration on a string, $\lambda = 2L$, so $f = \frac{v}{2L}$. We know these strings produce the same frequency: $f_1 = f_2$, so $\frac{v_1}{2S_1} = \frac{v_2}{2S_2}$, so $v_1 = \frac{S_1}{S_2} \cdot v_2$.

We know that $S_1 > S_2$, so $\frac{S_1}{S_2} > 1$, so $v_1 > v_2$.

2) Two speakers are playing slightly different frequencies; therefore, we hear beats. If you could adjust one of the speakers (change its frequency), ***describe how the beats change as the two frequencies become closer.***

The beat frequency is the difference between the two frequencies, $f_{beat} = |f_1 - f_2|$.

As the frequencies become closer (more in tune), we hear <u>fewer</u> beats per second; i.e., the beats become more "spread out" in time.

$$y(x,t) = A\sin\left(\frac{2\pi t}{T} \pm \frac{2\pi x}{\lambda} + \varphi\right) + y_o;\ \lambda = \frac{v_{wave}}{f};\ T = \frac{1}{f};\ \lambda = d\sin\theta;\ f_{beat} = |f_1 - f_2|;\ f_{carrier} = \frac{f_1 + f_2}{2}$$

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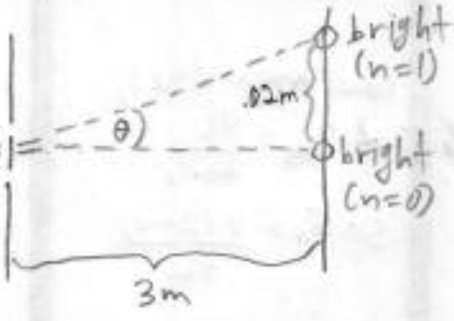
2. a) A red laser ($\lambda = 700.0$ nm) shines on a piece of black plastic with two narrow slits in it. The light then passes through the two slits and strikes a wall 3.0 m away. If the bright spots that appear on the wall are separated by 2.0 cm, how far apart are the slits in the plastic?



Bright spots should appear when $n \cdot \lambda = d \cdot \sin\theta$.

For $n=1$, $\theta = \tan^{-1}\left(\frac{.02m}{3m}\right) \approx .382°$,

so $d = \frac{n \cdot \lambda}{\sin\theta} = \frac{1 \cdot 700nm}{\sin(.382°)} \approx 105\,000\,nm$

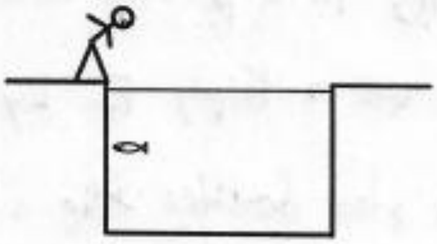
$d \approx .105mm$

$d \approx 1.05 \times 10^{-4} m$

Note: we can get an easy and very close approximation by assuming that $\sin\theta \approx \tan\theta$ (this works when θ is small),

so $d \approx \frac{n \cdot \lambda}{\tan\theta} = \frac{1 \cdot 700nm}{\left(\frac{.02}{3}\right)} = \frac{3 \cdot 700}{.02} nm = 105\,000 nm$

b.) A fish is swimming 2.0 m below the surface of a pond. You look straight down through the water (with an index of refraction $n = 1.33$) and see the fish. At what depth does the fish appear to be swimming? Explain.



Don't worry about this one; it relies on a fact about index of refraction that isn't used in Physics 7C.

If you're curious: the ratio of indeces of refraction (in this case, n_{air} vs. n_{water}) also equals the ratio of actual depth vs. perceived depth.

4)

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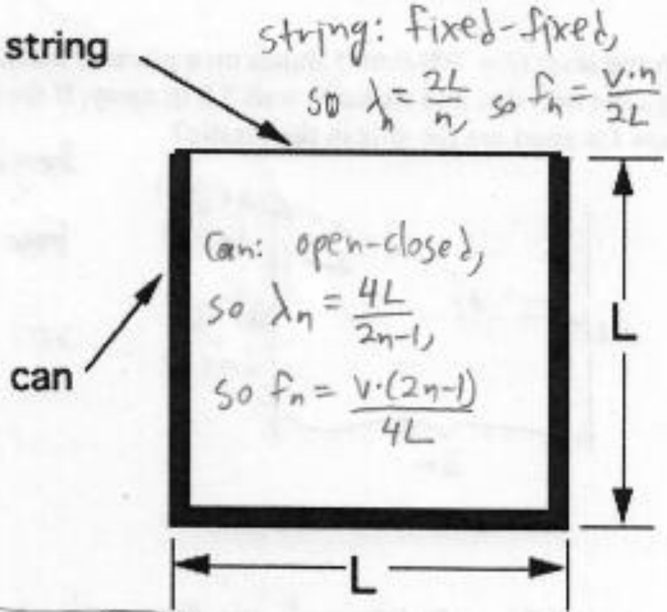
2. The Physics 7C Whole Earth Festival Recycled Musical Instrument is shown at the right. The instrument is made from an old coffee can and a piece of used string. The can is a open-closed pipe of length L, and diameter L. The string is stretched across the top. To tune the instrument the tension in the string is adjusted so that the frequency of the third harmonic ($f_3 = 3f_{fundamental}$) of the string is equal to the fundamental frequency of the pipe.



string: fixed-fixed, so $\lambda_n = \frac{2L}{n}$, so $f_n = \frac{v \cdot n}{2L}$

Can: open-closed, so $\lambda_n = \frac{4L}{2n-1}$, so $f_n = \frac{v \cdot (2n-1)}{4L}$

a) When the instrument is in tune, what is the relationship between the speed of the waves in the string, and the speed of sound in air?

$f_{1_{can}} = f_{3_{string}} \rightarrow \frac{V_{air} \cdot 1}{4L} = \frac{V_{str} \cdot 3}{2L} \rightarrow \boxed{V_{str} = \frac{V_{air}}{6}}$

b) If you increase the tension of the string by a factor of **4**, what will the instrument sound like ? **WHY**?

Waves in a string have speed $v = \sqrt{\frac{F_T}{\sigma}}$.
If we multiply F_T by 4, then v is multiplied by 2.
This also doubles the frequency produced $\left(\frac{V_{str} \cdot 3}{2L}\right)$;
if we double the other side of the equation, though, then it is no longer $\frac{V_{air} \cdot (odd)}{4L}$, so the note produced by the tighter string will <u>not</u> resonate properly in the can.

Quiz 5C Student ID: ______________ **Name:** ________________ , ________________ |____|

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ANSWERS WITHOUT WORK WILL RECEIVE NO CREDIT. MARK YOUR ANSWERS CLEARLY.

Useful Information:

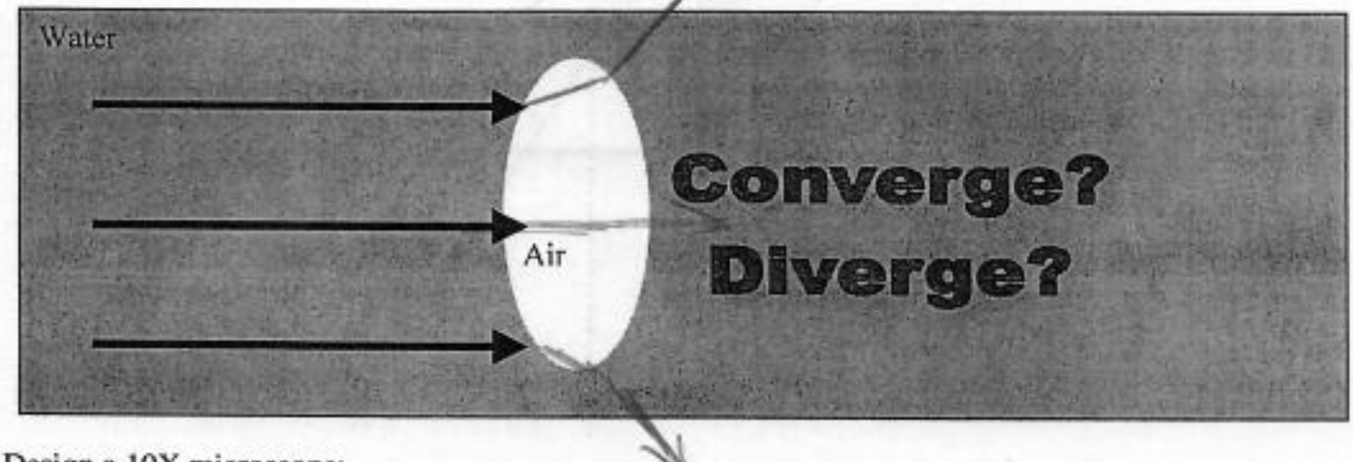
$\frac{1}{f}=\frac{1}{o}+\frac{1}{i}$, $m=-\frac{i}{o}$, $n_1\sin\theta_1=n_2\sin\theta_2$, $n=\frac{c}{v}$, $m=-\frac{h_i}{h_o}$

Suppose we mold a hollow piece of plastic into the shape of a double convex lens. We fill it with air and make it watertight. We now place this lens in water, and shine a beam of light on it. Does the lens converge or diverge the beam of light? Explain your reasoning. Take:

$n_{plastic}=n_{water}=1.33$

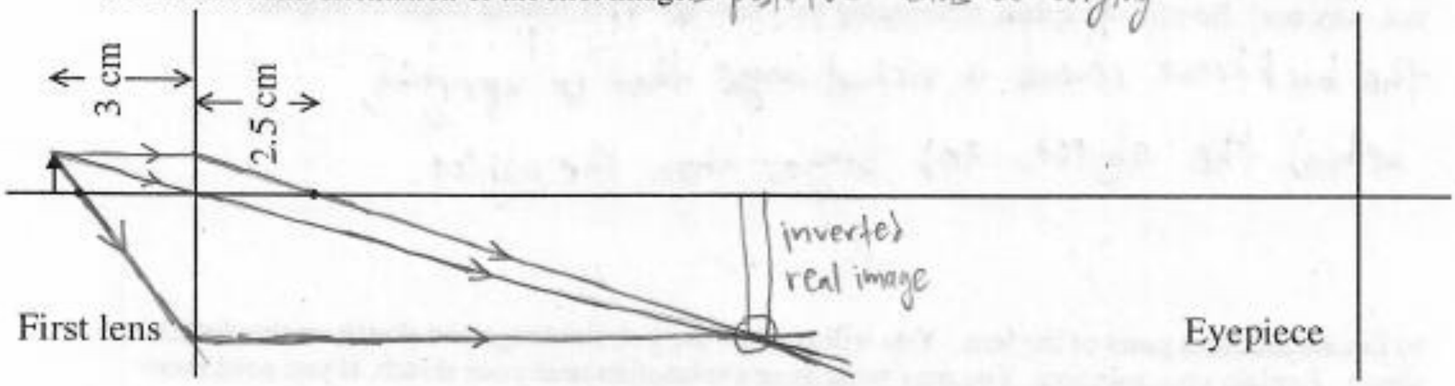
$n_{air}=1.00$

It diverges! Swapping the materials reverses the results.



1. Design a 10X microscope:

   A. The first lens has a focal length of +2.5 cm. The object is 3 cm from the lens. Use ray tracing to show the location and orientation of the first image. > positive means converging



   B. The second lens (eyepiece) will create a virtual image that is twice as large as the first image. This lens is located at 10 cm from the first image. Determine its *focal length* (is it *convergent or divergent*?). **Also** determine the *location of the final image*. **Show your work.**
   (Note: You do not need the results of part A to answer this question.)

o=10cm → so M=+2

$M=-\frac{i}{o}$, so $+2=\frac{-i}{10\text{cm}}$, so $i=-20\text{cm}$. $\frac{1}{o}+\frac{1}{i}=\frac{1}{f}$

$\frac{1}{10}+\frac{1}{-20}=\frac{1}{20}$, so $f=+20\text{ cm}$ (convergent)

(6)

Quiz 5 (A) Student ID: ________ **Name:** ____________, ______________ [ ]

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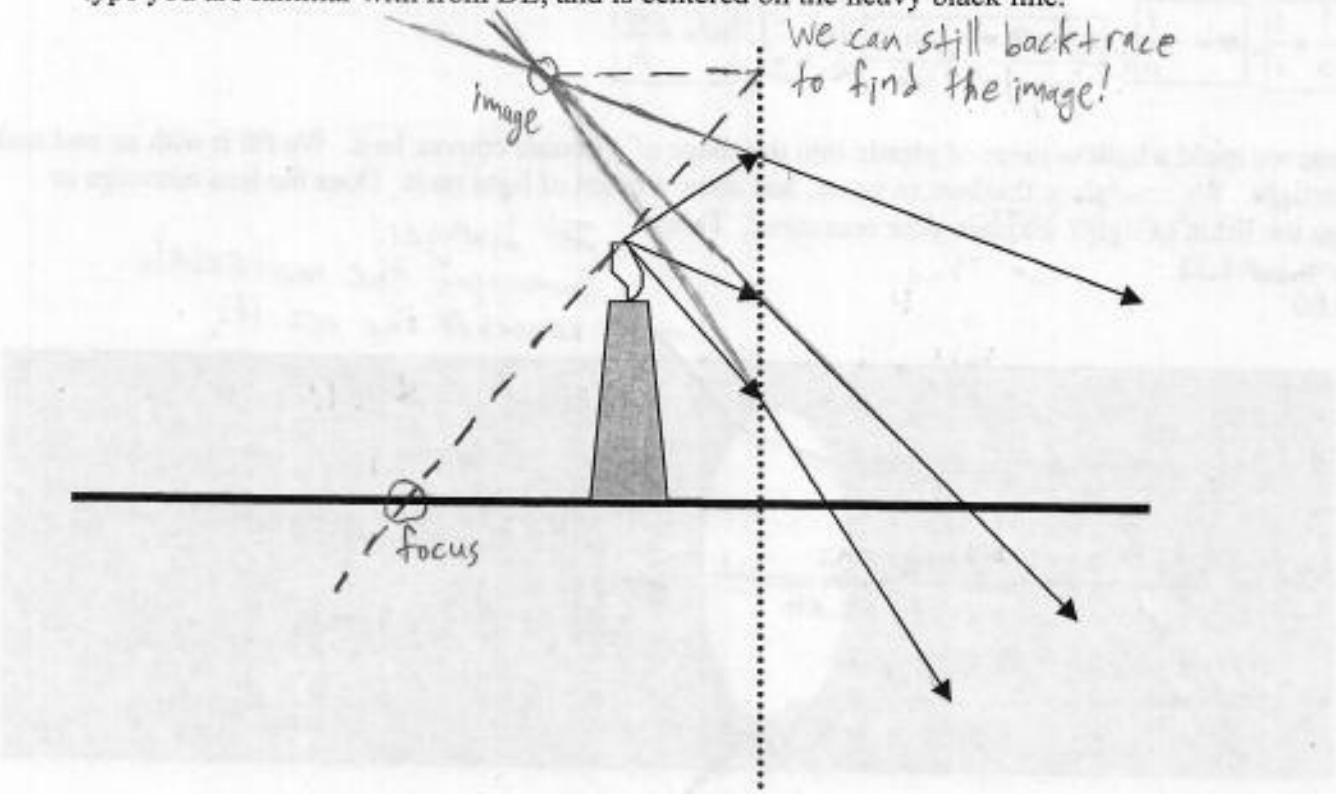
1) A candle stands in front of a lens. The candle flame emits light in all directions. Three light rays are shown—note that these are **not** the principal rays you often drew in DL. The lens is a type you are familiar with from DL, and is centered on the heavy black line.



a) You stand somewhere far to the right and look through the lens. Describe what you see. Do you see an image? If so, what type (real image or virtual image? Upright or inverted? Bigger or smaller?) If not, why not? Be sure to explain, referencing the drawing—a ray tracing might be helpful.

The backtrace reveals a virtual image that is upright, behind the object, and bigger than the object.

b) Locate the focal point of the lens. You will need to use a straightedge and sketch on the picture above. Explain your solution. You may write your explanation near your sketch, if you need more space.

We know that a ray through the object and the focal point will bend to become horizontal when it hits the lens, so we can reverse this process too: draw a horizontal from the image; where it hits the lens, backtrace through the object until it hits the central axis at the focus (see dashed line).

Practice Quiz 6 **DL #**_____ **Name** (last)____________________ (first)____________________ |___|___|___|
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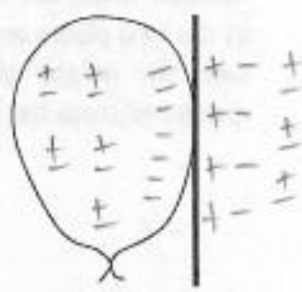
1. You can rub a balloon against your shirt, where it picks up extra electrons, and then hold the balloon against the wall and it will stick to the wall. Explain why the balloon sticks to wall (Remember the wall is not metal and therefore does not have "free electrons"). Include a balanced force diagram that includes the electrical force and gravitational force (assume the electrical force is twice the magnitude of the gravitational force). Draw all of the forces to scale.



The extra electrons in the balloon repel the nearby electrons in the wall (which can move a little bit, even though the wall is not a conductor). Those extra electrons in the balloon are now nearest to protons in the wall, so they attract each other. Friction between the surfaces also prevents the balloon from sliding downwards

2. A negatively charged cart moves along a frictionless track from point A to point B. The care has enough speed to make it all the way to point B. There is a non-constant electric field along the track. The field values change at each meter of the track and are known (<– Toward A or –> Toward B). This info is given below. At which meter marker is the cart moving the fastest? Explain.

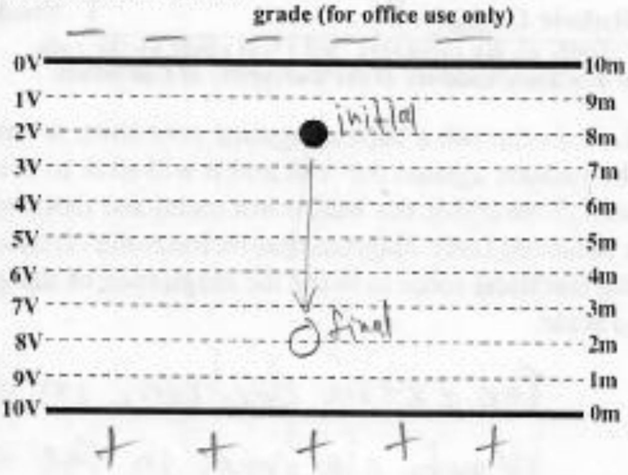
1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m	distance [m]
150 →	50 →	0	50 ←	100 ←	200 ←	100 ←	50 ←	0	100 →	E field [V/m]

$\vec{E}$ always points towards lower voltage, so $x=3$m is very low V and $x=9$m is very high V.
However, $PE = q\cdot V$, and q is negative, so we reverse:
$x=3$m is very high PE and $x=9$m is very low PE.
By conservation of energy, KE is highest when PE is lowest, so the cart has fastest speed at $\boxed{x=9\text{m}}$

$F_{grav} = GMm/r^2 = mg$; $F = -dPE/dr = -\Delta PE/\Delta r$;

$F_{elec} = kQq/r^2 = qE$; $E = -dV/dr = -\Delta V/\Delta r$; $\Delta PE = q\Delta V$; $PE = -pE\cos\theta$

5. Two parallel plates (solid lines) and the equipotentials (dashed lines) are shown in the figure. The potential value of the two plates and each equipotential is shown on the left side; the height of each plate and each equipotential, as measured from the ground, is shown on the right.



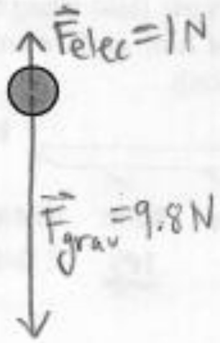
a) Identify the positive plate and the negative plate, with a brief explanation.

Voltage is higher near positive source charge and lower near negative source charge, so the botom plate is positive.

b) An object of mass m = 1 kg and charge q = +1 C is placed on the 2 V equipotential, and released from rest. Draw a force diagram, showing all the forces acting on the object, when it is on the 2 V equipotential. You should show both the magnitude, as well as the direction, of each force.

$$\|\vec{E}\| = \left|\frac{\Delta V}{\Delta x}\right| = \frac{1\text{ V}}{1\text{ m}} = 1\frac{\text{N}}{\text{C}}$$

and points towards lower V (up).



$$\vec{F}_{elec} = q \cdot \vec{E} = +1\text{C} \cdot 1\frac{\text{N}}{\text{C}} = 1\text{ N}$$
(up) (up)

$$\vec{F}_{grav} = m \cdot g = 1\text{kg} \cdot 9.8\frac{\text{m}}{\text{s}^2} = 9.8\text{N}$$
(down) (down) (down)

c) What is the speed of this object as it crosses the 8 V equipotential line? The initial speed of the object, when it is on the 2 V equipotential, is 0 m/s.

Conservation of energy: $\Delta E_{tot} = 0$

$$\Delta KE + \Delta PE_g + \Delta PE_{elec} = 0$$

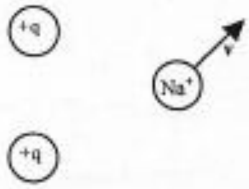
$$\frac{1}{2} m \Delta(v^2) + mg\Delta h + q \cdot \Delta V = 0$$

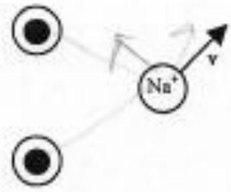
$$\frac{1}{2}\text{kg} \cdot (v_f^2 - 0) + 1\text{kg} \cdot 9.8\text{N} \cdot (2\text{m} - 8\text{m}) + 1\text{C} \cdot (8\text{V} - 2\text{V}) = 0$$

$$\frac{1}{2}\text{kg} \cdot v_f^2 - 58.8\text{J} + 6\text{J} = 0 \rightarrow \boxed{v_f = 10.28\frac{\text{m}}{\text{s}}}$$

(or $10.39\frac{m}{s}$ if you use $g \approx 10\frac{m}{s^2}$)

1) A sodium ion (12 protons, 12 neutrons, 11 electrons, Na^+) travels in the direction shown. In case i, on the left, the ion is in the presence of two unknown plus charges. In case ii, on the right, the ion is in the presence of two neutral, current-carrying wires (current coming out of the page, as shown).

i) 

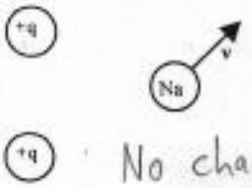
ii) 

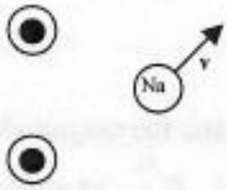
a) Determine the direction of the net force on the sodium ion for each case above. Show your work so it is clear how you arrive at your final force vector. Also be certain it is clear which of your vectors is the net force, if you draw more than one vector.

i) At the ion's location, $\vec{E}$ = ↗ + ↘ = ⟶.
The ion is positive, so $\vec{F}_e$ also points to the right.

ii) At the ion's location, $\vec{B}$ = ↖ + ↗ = ↑.
Using R.H.R. #2, we find that $\vec{F}_m$ points out of the page.

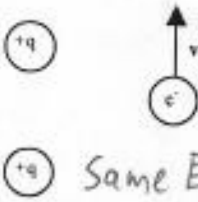
b) Suppose we replace the sodium ion with a sodium atom (12 protons, 12 neutrons, 12 electrons, Na). Which of the net force arrows would change? Why? Draw new net force vectors for the sodium atom on both images below.

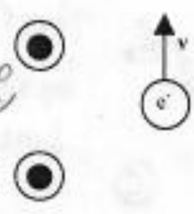




Both forces vanish.
No charge on test object means no electric or magnetic forces!

c) Suppose we replace the sodium ion with a free electron. Further, suppose this electron travels directly upwards. Draw new net force vectors for the electron on both images below. Explain how you arrived at your answer.





Same $\vec{E}$ as before, but the test charge is negative, so $\vec{F}_e$ is reversed and the electron is pulled to the left.

Same $\vec{B}$ as before, but the new $\vec{v}$ is parallel to $\vec{B}$, so there is no $\vec{F}_m$!

↓ θ=0

$E=kq/r^2$ $E=-\Delta V/\Delta r$ $PE=qV$ or $-pE\cos\theta$ $F=qE$ $F=-\Delta(PE)/\Delta r$

$B_{wire}=\mu_0 I/2\pi r$ (RHR1) $PE=-mB\cos\theta$ $F=qvB\sin\theta$ (RHR2) $q=1.6\times10^{-19}$c

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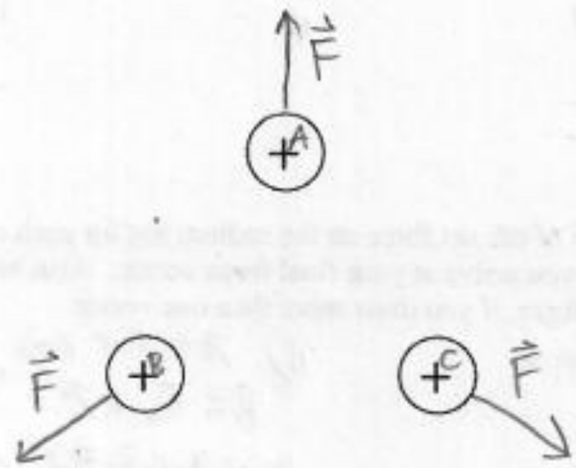
4. (electric/magnetic forces) In the diagram below we find three positive charges, each with magnitude 2 C. They are arranged in an equilateral triangle 0.2 m on a side.

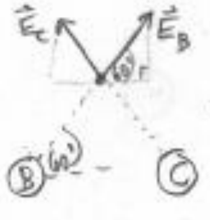


a) Indicate on each charge the direction of the net force on that charge.

b) Calculate the magnitude of the force on each charge.

Because of symmetry, the forces are all equal in magnitude, so we only need to calculate one of them. The top will be easiest.

$\vec{F} = q \cdot \vec{E}$, so let's find the E-field at location A (caused by charges B & C).



Their x-components will cancel out, so all we have to do is find one y-component and double it. Thanks again, symmetry!

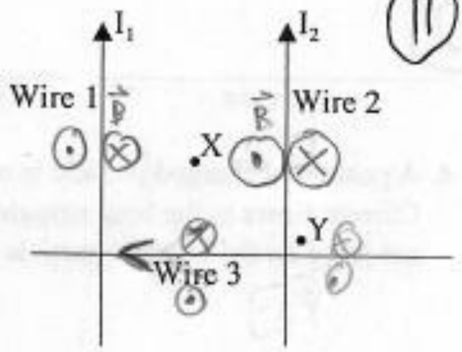
$$\|\vec{E}_B\| = \frac{k \cdot Q}{r^2}$$

$$E_{By} = \frac{kQ}{r^2} \cdot \sin 60°, \quad \text{so} \quad \|\vec{E}\| = 2 \cdot \frac{kQ}{r^2} \cdot \sin 60°.$$

Multiply by Q (they're identical) to find $\|\vec{F}\|$: $\frac{2 \cdot k \cdot Q^2}{r^2} \cdot \sin 60°$

$$\text{so } \|\vec{F}\| = \frac{2 \cdot 9 \times 10^9 \frac{N \cdot m^2}{C^2} \cdot (2C)^2}{(0.2m)^2} \cdot \sin 60° \approx \boxed{1.6 \times 10^{12} N}$$

2. There are three wires carrying current. The direction of the currents for wires 1 & 2 are as shown in the drawing to the right. The current in wire 1, I_1, is smaller than the current in wire 2 ($I_1 < I_2$). At ***Point X***, the magnetic field is zero ($B = 0$). Note: Point X is ***equidistant*** to all three wires.



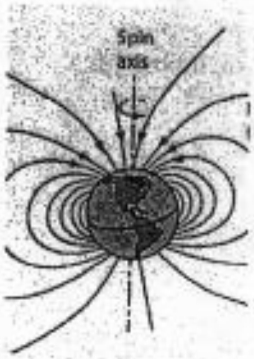
a. Determine the **direction** of the current in wire 3 (I_3). **Explain**

Considering just wires 1 & 2, the net $\vec{B}$-field would be outwards (because I_2 is stronger), so I_3 needs to create an inwards $\vec{B}$ to counter this. A current to the left will do the trick.

b. Determine the **direction** the **magnetic field** at point **Y**. **Explain**

All three wires produce inward $\vec{B}$-field at point Y.

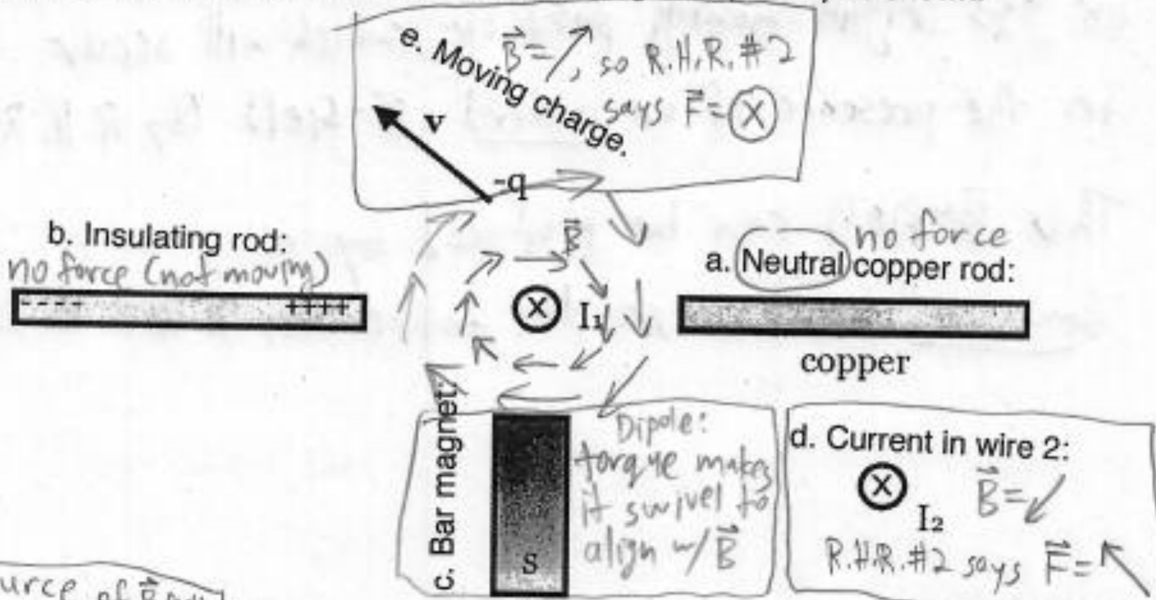
3. Cosmic rays (atomic nuclei stripped bare of their electorns) would continuously bombard Earth's surface if most of them were not deflected by Earth's magnetic field. Given that Earth is, to an excellent approximation, a magnetic dipole, the intensity of cosmic rays bombarding Earth's surface is greatest at which spot? Explain your answer using the magnetic field and force model.



a) North pole
b) Halfway between equator and north pole
c) Equator
d) South pole
e) even everywhere

Near the poles, the cosmic rays are coming in along the $\vec{B}$-field lines, so they experience no force. (They then continue towards Earth, hit the atmosphere, and cause the epic lightshow known as "aurora.")

4. A charged rod, a moving charge, a neutral copper rod, a current in wire 2, and a bar magnet are arranged around a current carrying wire (wire 1) as shown.



source of $\vec{B}$ field
Wire 1 is fixed in place. The rest are free to move or turn. Consider the interaction between wire one and each of the objects placed near it (you may ignore the effects of the objects on eachother). For each, will it stay where it is, mover toward away from the wire, move in some other direction, or rotate clockwise or counter clockwise? Justify your choice.

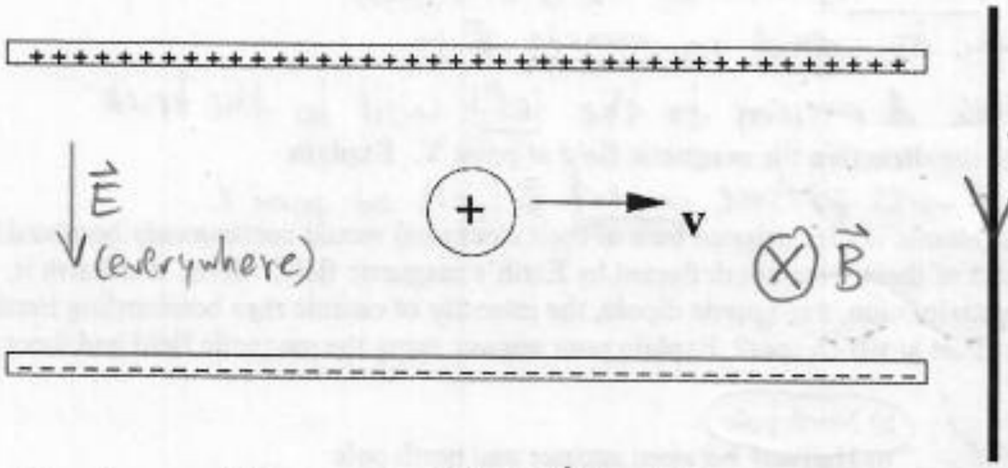
(12)

Last name | First name | DL Sec | First three initials of last name

Type to enter 5

grade (for office use only)

4. A positively charged particle is moving between the plates of a parallel plate capacitor as shown in the figure. Current flows in the long straight wire at the right. What should the direction of the current in the wire be if the net force on the charged particle is zero? Explain your answer clearly.



$\vec{E}$ points down (from positive plate to negative plate), and the test particle is positive, so it feels a downwards electrical force ($\vec{F} = q \cdot \vec{E}$).

That means we need an upwards magnetic force on this right-moving particle, which will occur in the presence of an inward $\vec{B}$-field (by R.H.R. #2).

This $\vec{B}$-field can be produced by a downward current in the wire (by R.H.R. #1).

(13)

Last name | First name | DL Sec | First three initials of last name

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8. A laser shines on cold helium gas. (Since the helium is cold, you can assume that electrons are in the lowest allowed energy state.) The energy levels of helium are shown below, and the frequency of the laser is 2.4×10^{15} Hz. Explain what happens to the laser light, and why.

The energy of one photon of light is $E_{phot} = h \cdot f = (4.14 \times 10^{-15}\ eV{\cdot}s) \cdot (2.4 \times 10^{15}\ Hz)$

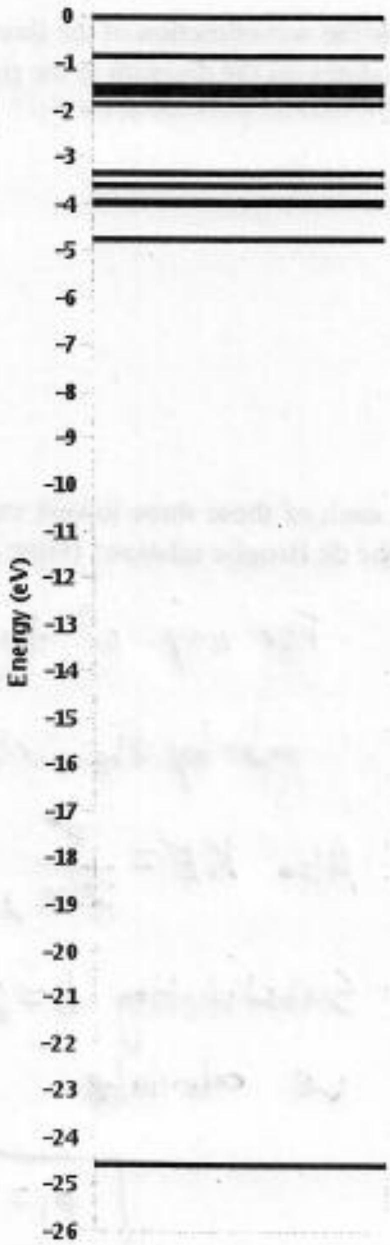
$E_{phot} \approx 9.9\ eV$

The He electrons are in their lowest state of $E \approx -24.6\ eV$; adding an extra 9.9 eV won't bring them up to the next allowed state of $E \approx -4.9\ eV$.

Thus the He atoms cannot absorb these photons, and the light will simply pass right through.

This also means that He is translucent to this color.

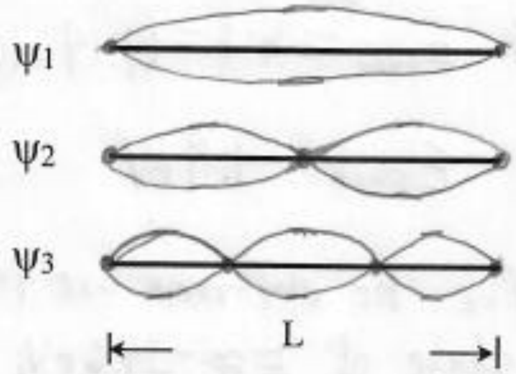
Energy Levels of Helium



(14)

8. An electron confined to move in a one-dimensional region of length L=2 nm behaves like a standing wave on a string. That is, its wavefunction is analogous to the displacement of a vibrating string, with a fundamental wavelength of 2L, the first excited state with a wavelength L, and the second excited state with a wavelength of 2L/3, etc

a) Draw the wavefunction of the three lowest states on the diagram at the right.



b) For each of these three lowest states, determine the momentum, and then the kinetic energy, of the electron, using the de Broglie relation. (Hint: do it *algebraically* first!)

For any of these, $\lambda_n = \frac{2L}{n}$

and by the deBroglie equation, $p = \frac{h}{\lambda}$, so $p_n = \frac{h \cdot n}{2L}$

Also $KE = \frac{p^2}{2m}$, so $KE_n = \frac{h^2 n^2}{8L^2 m}$

Substituting $h = 6.63 \times 10^{-34}$ J·s, $L = 2 \times 10^{-9}$ m, and $m_{elec} = 9 \times 10^{-31}$ kg, we calculate

$p_1 = 1.66 \times 10^{-25} \frac{kg \cdot m}{s}$	$KE_1 = 1.52 \times 10^{-20}$ J
$p_2 = 3.32 \times 10^{-25} \frac{kg \cdot m}{s}$	$KE_2 = 6.11 \times 10^{-20}$ J
$p_3 = 4.97 \times 10^{-25} \frac{kg \cdot m}{s}$	$KE_3 = 1.37 \times 10^{-19}$ J