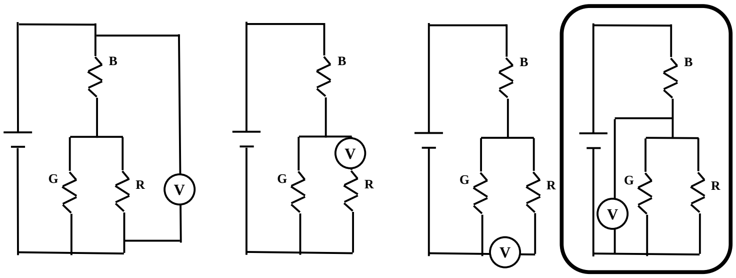
PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 13: Circuits

1. Which diagram below shows a correct placement of a voltmeter to measure the voltage across the Red resistor? (R = Red, B = Blue, G = Green) Circle the correct diagram.



Hook up voltmeter in parallel with circuit element.

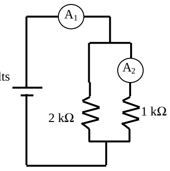
Suppose the resistances are such that $R_G = 2R_R = 3R_B$, and the current through the Green resistor is 0.14A. Determine the current through the Red resistor. Show all your work or explain reasoning.

Ohm's Law: $I = \frac{\Delta V}{R} \Rightarrow \left\{ \begin{matrix} \Delta V_G = I_G R_B \\ \Delta V_R = I_R R_R \end{matrix} \right\}$.

Loop Rule: $\Delta V_G + \Delta V_R = 0 \Rightarrow |\Delta V_G| = |\Delta V_R|$;

$$I_G R_G = I_R R_R \Rightarrow I_R = \frac{R_G}{R_R} I_G = \frac{2R_R}{R_R}(0.14\ \text{A}) = \boxed{0.28\ \text{A}}$$

2. The diagram at right shows a circuit composed of a battery and two resistors with values as given in the diagram. Two ammeters A_1 and A_2 are also placed in the circuit to measure currents.



Determine the current measured by ammeter A_1. $\boxed{\textbf{0.0135 A}}$

Determine the current measured by ammeter A_2. $\boxed{\textbf{0.009 A}}$

Loop Rule:

(1) Loop with battery and 2 kΩ resistor

$$+9V - I_{(1)}(2k\Omega) = 0 \Rightarrow I_{(1)} = \frac{9V}{2k\Omega} = 0.0045A$$

(2) Loop with battery and 1 kΩ resistor

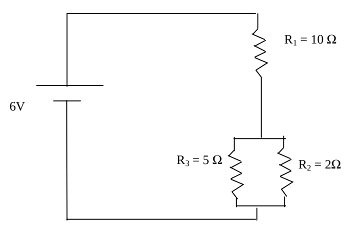
$$+9V - I_{(2)}(1k\Omega) = 0 \Rightarrow I_{(2)} = \frac{9V}{1k\Omega} = 0.009A$$

Junction Rule: Current into junction = current out.

Current in = $I_{(1)} + I_{(1)} = 0.0045A + 0.009A = 0.0135A$

3. Consider the following circuit:

a) Determine the potential difference across R_1 if the current through R_1 is equal to 0.525 A.



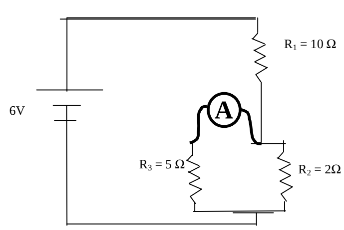
$\Delta V = IR = (0.525A)(10\Omega)$
$= \boxed{5.25V}$

b) Determine the current through R_3.

Loop Rule: Loop with battery , 10Ω resistor and 5Ω resistor.

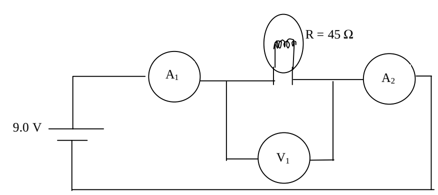
$$+6V - I_1R_1 - I_3R_3 = 0 \Rightarrow I_3 = \frac{6V - I_1R_1}{R_3} = \frac{6V - 5.25V}{5\Omega}$$
$= \boxed{0.15A}$

c) How would you place an ammeter in the circuit to measure the current through R_3? Show this by sketching the circuit including the ammeter.



Hook up ammeter in series with circuit element

4. Consider the following circuit, which contains a light bulb and a battery that supplies a constant potential difference. Several ammeters and voltmeters are wired into the circuit as shown.



a) Determine the reading on voltmeter V_1.

Loop Rule: Loop with battery and light bulb.
$+9.0V + \Delta V_{bulb} = 0 \Rightarrow |\Delta V_{bulb}| = 9.0V$. **Voltmeter in parallel across bulb, so measures voltage drop across bulb:** $\boxed{V_1 = 9.0V}$

b) Determine the reading on ammeter A_1.

Ohm's Law: $I_{bulb} = \frac{\Delta V_{bulb}}{R_{bulb}} = \frac{9V}{45\Omega} = 0.2A$. **Ammeter 1 is in series with bulb; elements in series all have the same current, so ammeter 1 measures current in bulb:** $A_1 = \boxed{0.2A}$.

c) Determine the reading on ammeter A_2.

Ammeter 2 is also in series with bulb so ammeter 2 measures same current in bulb: $A_2 = \boxed{0.2A}$.

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 14: Charged Particles in Fields

1. In the e/m for electrons lab, you observed a circular path of electrons as they passed through a glass gas-filled tube in a magnetic field. What would happen to the radius of this path if you made the following independent changes?

a) Increasing the accelerating voltage would make the radius

increase decrease stay the same

Increasing accelerating voltage increases speed; increasing speed decreases radius.

b) Increasing the Helmholtz current (i.e., the current in the large outer coils) would make the radius

increase decrease stay the same

Increasing Helmholt current increases magnetic field; increasing magnetic field decreases radius.

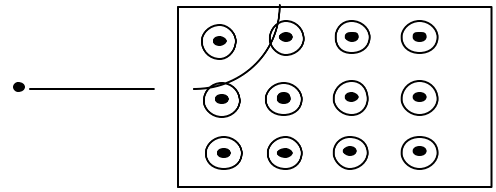
c) Magically doubling the electron mass would make the radius

increase decrease stay the same

Increasing mass increases radius.

See 4b) for relations between speed, field, mass, radius.

2. An electron is shot through a region of magnetic field out of the page, as shown in the picture.



a) On the diagram above, draw the path of the electron as it enters the region of magnetic field.

Use right hand rule. Remember negative charge on electron.

b) Circle your answer to each of the following statements.

(i) If the magnetic field is doubled the radius of curvature for the electron will increase: True False

See 4b) for relationship.

(ii) A neutron will curve upward: True False

No charge on neutron, so no magnetic force.

(iii) An electron and proton have a different radius of curvature: True False

See 4b) for relationship. Assume that the electron and proton have same speed.

3. In an experiment to measure e/m for an electron, the following five values are obtained:

	e/m (C/kg)
	1.7488×10^{11}
	1.7507×10^{11}
	1.7533×10^{11}
	1.7473×10^{11}
	1.7519×10^{11}
Average =	1.7504×10^{11}
Std dev =	2.1410×10^{8}

a) In your conclusion, how would you write your value of e/m including the uncertainty?

Report: mean $\pm$ standard deviation of the mean.

Std dev. of mean = $\frac{s}{\sqrt{N}} = \frac{2.141\times 10^{8}}{\sqrt{5}}$

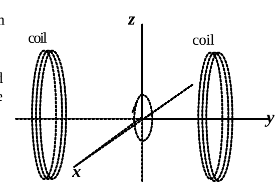
$= 9.575\times 10^{7}$ **C/kg** $= 0.0001\times 10^{11}$ **C/kg (round uncertainty to one or two significant figures).**

Answer (average value in this case) should be rounded to match uncertainty:
$(1.7504 \pm 0.0001)\times 10^{11}$ **C/kg.**

b) Is this data consistent with the actual value of 1.7588×10^{11} C/kg? Explain why or why not.

NO! 1.7588×10^{11} **C/kg is far outside the "range"** $(1.7504 \pm 0.0001)\times 10^{11}$ **C/kg.**

4. Consider the illustrated path of electrons traveling in the region between two current-carrying coils of wire.



a) Indicate the direction of the magnetic field produced by the current in the coils at the origin of the coordinate system in the above diagram. (Circle one)

+x *-x* *+y* *-y* *+z* *-z*

Use right hand rule. Remember negative charge on electron.

b) Starting with Newton's second law, derive an equation for the radius of the electron's path R in terms of the magnetic field strength B, the velocity of the electrons v, the mass of the electrons m, and the charge of the electrons q.

$\sum \vec{F} = m\vec{a}$**; assume only force is magnetic, and motion is circular, so** $\vec{F} = q\vec{v}\times\vec{B} \Rightarrow |\vec{F}| = qvB\sin\theta$;

$\theta = 90^{o} \rightarrow \sin 90^{o} = 1$; $ma = ma_c = m\frac{v^2}{r}$**. Put together and get** $qvB = m\frac{v^2}{r} \Rightarrow r = \frac{mv}{qB} \Rightarrow R = \frac{mv}{qB}$**.**

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 15: Motors and Generators

1. A wire hooked up to a battery is placed into a magnetic field as shown in the figures below.

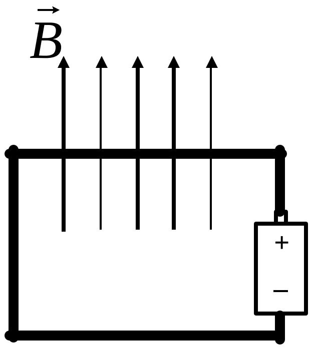


Figure A

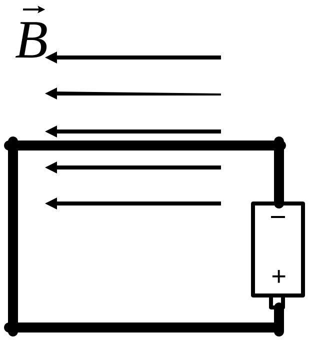


Figure B

a) For Figure A, which of the following is correct for the direction of the magnetic force exerted on the wire in magnetic field? Circle one.

Up	**Left**	**Into Page**	**No Force**
Down	**Right**	**Out of Page**	**Can't be determined**

b) For Figure B, which of the following is correct for the direction of the magnetic force exerted on the wire in magnetic field? Circle one.

Up	**Left**	**Into Page**	**No Force**
Down	**Right**	**Out of Page**	**Can't be determined**

2. In preparing the coil for the simple motor, you were careful to sand only half the axles. Your friend accidentally sanded the axles all the way around and got some different results than you when the circuit was connected. What kinds of motion might you expect to see with your friend's coil?

Oscillatory motion, coil moving back and forth about some equilibrium. Maybe "stuck" in preferred orientation.

3. A conducting disk lying flat in the plane of this page can rotate about its axis. A uniform magnetic field points into the plane of the page. A battery connected to the disk by wires allows current to flow either from the center of the disk out to the edge or from the edge of the disk in towards the center. When current flows through the disk, it rotates clockwise.

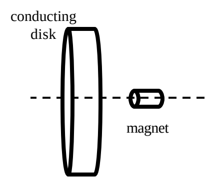
a) Is the current flowing from the center of the disk to the edge of the disk or from the edge of the disk to the center? Briefly explain.

Edge of disk to center. Use RHR with current pointing from edge to center and field pointing into page and get clockwise force.

b) What are two changes you could make that would cause the disk to rotate counter-clockwise?

Reverse direction of current OR reverse direction of magnetic field.

4. A conducting disk and a cylindrical bar magnet have their axes aligned as shown in the figure. For each of the following cases, what is true about the potential difference generated in the conducting disk?



a) The conducting disk is rotated about its axis while the magnet is held fixed:

Potential difference generated in disk **No potential difference generated in disk**

Not enough information to tell

b) The magnet is rotated about its axis while the conducting disk is held fixed:

Potential difference generated in disk **No potential difference generated in disk**

Not enough information to tell

c) Both the conducting disk and the magnet are rotated about their mutual axis at the same rate:

Potential difference generated in disk **No potential difference generated in disk**

Not enough information to tell

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 16: Interference of Light

1. Your lab partner yanks a hair out of your head and shines a laser across it. You notice that it makes a line of bright and dark spots on a distant background screen, and the width of the bright spots is 5 mm. After the bleeding stops, you decide to return the favor, yank a hair out of your partner's head, and repeat the experiment exactly. You notice, however, that the width of the bright spots is only 2.5 mm when using your lab partner's hair.

a) Who has thicker hair, you or your lab partner?

Thicker obstruction is like widest single slit, so narrowest pattern. Lab partner's hair has narrower pattern, so lab partner has thicker hair.

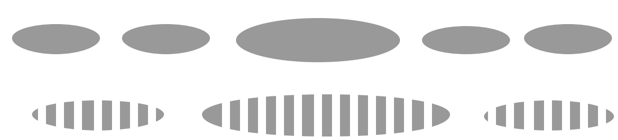
b) How many times thicker is the thicker strand of hair? Circle the best answer:

(i) 2.0 (ii) 2.5 (iii) 4.0 (iv) 8.0

Width of central bright spot is inversely proportional to width of slit, so inversely proportional to thickness of hair. Since width of spot decreases by 2x, then thickness of hair increased by 2x

2. The figure below shows the pattern on a screen when laser light is illuminates a single slit with width 0.02 mm. In the space below, draw the pattern that you would expect if light illuminates a **double** slit arrangement, where each slit has a width of 0.01 mm and the spacing between the centers of the the slits is 0.100 mm.

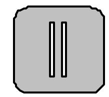
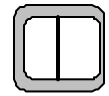
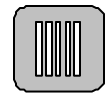
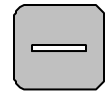
Pattern with single slit with width 0.02 mm



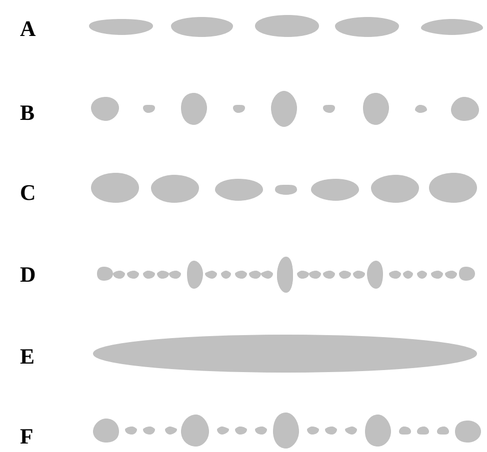
DECREASE slit width by 2x, so patterns get WIDER by 2x.

ADD slit, so get interference pattern of bright "stripes" within central maximum.

3. You illuminate several different slides with laser light and noted the resulting intensity patterns produced on a distant screen. For each of the following slides, identify the best corresponding intensity pattern from the list of patterns **A** through **F** given below. Also be sure to circle the appropriate *orientation* of the pattern

		Pattern Choice	Orientation	
a) double slit		A B C D E F	horizontal	vertical
b) a single hair		A B C D E F	horizontal	vertical
c) a 5-slit arrangement		A B C D E F	horizontal	vertical
d) a single slit		A B C D E F	horizontal	vertical

Pattern Choices (Note: grey indicates a bright spot)

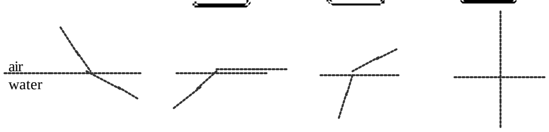


PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 17: Refraction of Light

1. This question involves propagation of light across an interface.

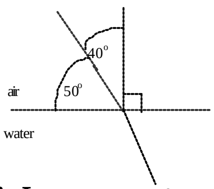
a) Circle all of the following diagrams which correctly illustrate the approximate path light could take in traveling between two points on the opposite (or same) side of an air-water interface:

A. $\boxed{\textbf{B.}}$ $\boxed{\textbf{C.}}$ $\boxed{\textbf{D.}}$



b) Use Snell's Law to calculate the correct angle of the refracted ray for light traveling through air which is incident onto water as shown below. Use these values of the indices of refraction: $n_{air} = 1.00$; $n_{water} = 1.33$.

For full credit, show your work including a sketch indicating the refracted ray and the angle of refraction.



Angle of refracted ray = $\boxed{28.8^o}$

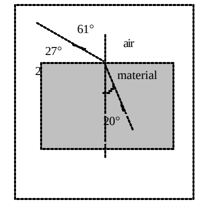
Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$**; measure all angles with respect to normal to interface. So**

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \Rightarrow n_a \sin\theta_a = n_w \sin\theta_w$$

$$\sin\theta_w = \frac{n_a}{n_w}\sin\theta_a = \frac{1}{1.33}\sin 40^o$$

$$\theta_w = \sin^{-1}\left[\frac{1}{1.33}\sin 40^o\right] = 28.8^o$$

2. The figure to the right shows a beam of light passing from air into some material. Calculate the index of refraction of the material. The index of refraction of air is 1.

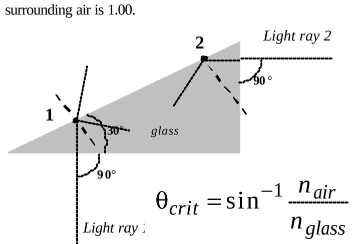


Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$**; measure all angles with respect to normal to interface. So**

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\Rightarrow n_2 = \frac{\sin\theta_1}{\sin\theta_2} n_1 = \frac{\sin 61^o}{\sin 20^o}(1) = 2.56$$

3. Consider the glass prism shown in the diagram below as viewed from above as it sits on a laboratory table. The refractive index of glass is 1.50 and the refractive index of the surrounding air is 1.00.



$$\theta_{inc} = \theta_{reflect}$$

$$\theta_{1,reflect} = 30^o$$

$$\theta_{2,reflect} = 60^o$$

$$\theta_{crit} = \sin^{-1}\frac{n_{air}}{n_{glass}} = 41.8^o$$

$\rightarrow$ **no refracted ray for ray 2**

$$\theta_{1,refract} = \sin^{-1}\left[\frac{n_{air}}{n_{glass}}\sin\theta_{1,inc}\right]$$

$$\rightarrow \sin^{-1}\left[\frac{1.5}{1}\sin 30^o\right] = 36.4^o$$

4. Consider light traveling from water into glass, as shown below. The refractive index of water is 1.34.

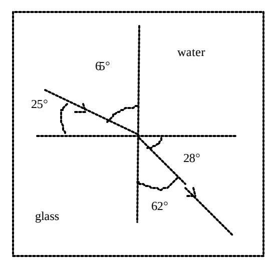
a) Calculate the refractive index of the glass to two decimal places.

b) Under which of the following cases is total internal reflection possible? Circle the appropriate case.

i) Light travelling from water to glass.

ii) Light travelling from glass to water.

iii) Light travelling from water to glass and from glass to water.



a) Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$**; measure all angles with respect to normal to interface. So**

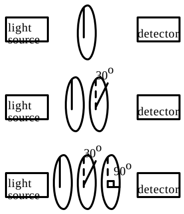
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\Rightarrow n_2 = \frac{\sin\theta_1}{\sin\theta_2} n_1 = \frac{\sin 65^o}{\sin 62^o}(1.34) = (1.03)(1.34) = 1.38$$

b) Can only have total internal reflection when going from low speeds to high speeds (high index of refraction to low index of refraction). Glass has higher index of refraction that water. Also can see from picture that ray bends more away from normal in water than in glass.

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 18: Polarization of Light

1. Assume we have ideal polarizers; that is, the polarizers transmit 100% of the incident light that is correctly polarized. Consider the arrangement of polarizers shown below. If the voltage of the photodiode detector in situation A is 2.00V, determine the correct voltage reading for situations B and C below.



A = 2.00 V

B = 1.5V

C = 0.375 V

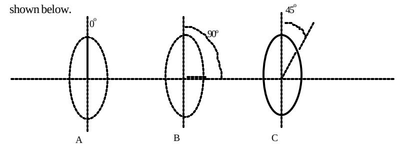
Use $I = I_0 \cos^2(\theta_2 - \theta_1)$ **with** $I_0 = 2.00$ **V.**

B: $I_{12} = I_0 \cos^2(\theta_2 - \theta_1) = 2 \times \cos^2(30^o - 0) = 2 \times \frac{3}{4}$ **= 1.5V**

$$I_{12} I_{23} = I_0 \cos^2(\theta_2 - \theta_1)\cos^2(\theta_3 - \theta_2)$$

C: $= 2\cos^2(30^o - 0)\cos^2(90^o - 30^o) = 2\left(\frac{3}{4}\right)\left(\frac{1}{4}\right)$ **= 0.375 V**

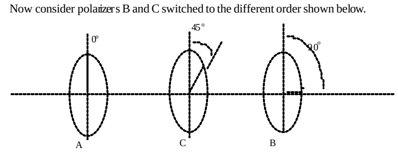
2. Three ideal polarizers are shown in the diagrams below. The transmission axis of polarizer A is at an angle of 0° with respect to the vertical; polarizer B at an angle of 90° with respect to the vertical; and polarizer C at an angle of 45° with respect to the vertical. They are arranged in the order shown below.



a) The intensity of the light which makes it through polarizer A is I_0. What is the intensity of any light that it makes it through the last polarizer, polarizer C (in terms of I_0)?

$$I_{12} I_{23} = I_0 \cos^2(\theta_2 - \theta_1)\cos^2(\theta_3 - \theta_2)$$
$$= I_0 \cos^2(90^o - 0)\cos^2(45^o - 90^o) = I_0(0)(0.5) = 0$$

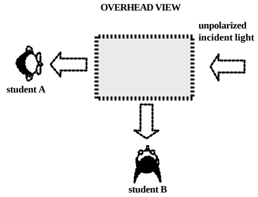
Now consider polarizers B and C switched to the different order shown below.



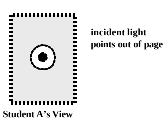
b) The intensity of the light which makes it through polarizer A is I_0. What is the intensity of any light that it makes it through the last polarizer, polarizer B (in terms of I_0)?

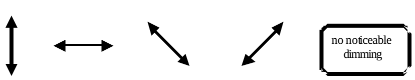
$$I_{12} I_{23} = I_0 \cos^2(\theta_2 - \theta_1)\cos^2(\theta_3 - \theta_2)$$
$$= I_0 \cos^2(45^o - 0)\cos^2(90^o - 45^o) = I_0\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{I_0}{4}$$

3. Unpolarized light passes through a tank filled with a water/creamer mixture, and is observed by two students. Student A, who is looking at the tank along the direction of the incident light, observes light coming directly towards him. Student B, who is looking at the tank from the side (with respect to the incident light,) observes light coming directly towards her.

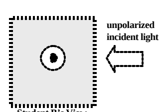


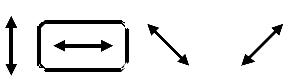
a) Student A looks at the light coming towards him through a polarizing filter. What orientation of the ***transmission axis*** of the polarizer would result in the most noticeable **dimming** of this light? (Circle one.)





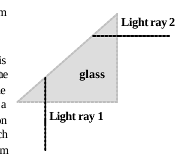
b) Student B looks at the light coming towards her through a polarizing filter. What orientation of the ***transmission axis*** of the polarizer would result in the most noticeable **dimming** of this light? (Circle one.)





4. Consider the glass prism shown in the diagram as viewed from above as it sits on a laboratory table.

Suppose the electric field vector associated with light ray 1 is polarized in a direction perpendicular to the page (i.e., the electric field vector oscillates in and out of the page) and the electric field vector associated with light ray 2 is polarized in a direction parallel to the page and perpendicular to the direction of light ray 2. Viewing the prism as shown in the figure, which light ray will appear brighter due to the scattering of light from the molecules in the glass? Explain your answer.



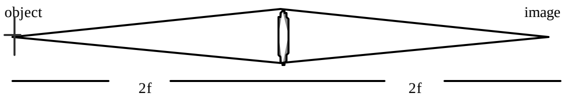
Ray 1 **Ray 2** **Both Rays Equally Bright**

Maximum (re-) radiation in direction perpendicular to charge acceleration. So for ray 2, electric field causes charge to move in plane of page, up and down, so looking from above, get most scattered light.

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 19: Lenses and Imaging

1. Using the lens equation, determine if the following ray diagrams are possible. Word descriptions are included for clarity. Circle either **TRUE** or **FALSE**

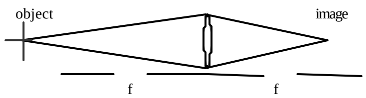
a) An object located at twice the focal length in front of a lens will have a sharply-focused image at the same distance beyond the lens: **TRUE** **FALSE**



Use Lens Equation: $\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{2f}+\frac{1}{2f}=\frac{2}{2f}=\frac{1}{f}$;

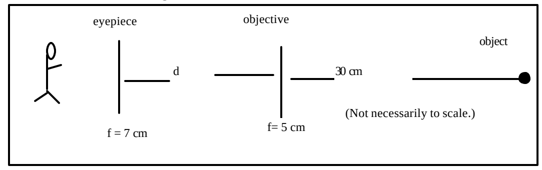
Checks out, so TRUE

b) An object located at a distance greater than the focal length in front of a lens will have a sharply-focused image at a distance less than the focal length beyond the lens:
TRUE **FALSE**



IMPOSSIBLE to form image closer than focal length. Focal length is closest distance image will form; image forms at focal length when object is very (infinitely) far away.

2. The figure below shows a crude telescope similar to the one you made in lab. The focal length of each lens is indicted in the diagram.



a) How many centimeters to the left of the objective is the image formed by the objective?

Use Lens Equation: $\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}\Rightarrow\frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$

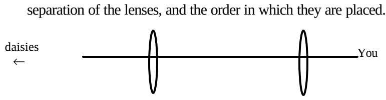
$\frac{1}{d_i}=\frac{1}{5}-\frac{1}{30}=\frac{6}{30}-\frac{1}{30}=\frac{5}{30}\Rightarrow d_i=\frac{30}{5}=6$ **cm.**

b) What should be the distance ***d*** for best focussing of the object (i.e., the rays come out of the eyepiece approximately parallel or collimated)?

For collimation, want Image from Objective to be at Focal Length of Eyepiece. Since image forms 6 cm from objective, we want the eyepiece to be 6 cm + 7 cm = 13 cm away from the objective.

Note this isn't the best arrangement for a telescope; you'd want the smaller focal length to be your eyepiece for max. magnification.

3. You decide to make a telescope to view the daisies in a distant field. You have two converging lenses at your disposal, one of focal length 20 cm, and one of 70 cm. Explain how you should position the lenses so as to optimize the performance of your telescope. Discuss the relative separation of the lenses, and the order in which they are placed.



Looking at a far away object results in the image from the objective forming at the focal length of the objective lens. For collimation, want the image from the objective to be at the focal length of the eyepiece. So when looking at very distant ("infinitely far") objects, want the eyepiece and objective to be separated by SUM of focal lengths: 20 cm + 70 cm = 90 cm.

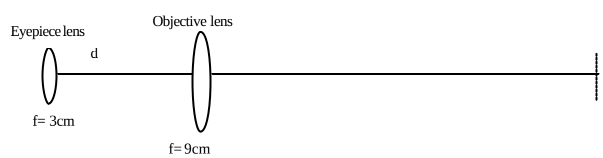
For magnification, want eyepiece to have the smaller focal length, so eyepiece, which is closest to you, should be the 20 cm focal length lens.

Your friend is using a small telescope to watch a football practice from his fraternity room. A small bird lands in the apple tree next to his window. He tries to identify the bird, but it appears blurry. How must he adjust his telescope to see the bird clearly?

- **A.** Move entire telescope closer to the bird.
- **B.** Decrease the separation of the eyepiece and objective lenses.
- **C.** Increase the separation of the eyepiece and objective lenses.
- **D.** Clean the eyepiece lens of his telescope.
- **E.** Smear peanut butter on the objective lens.

Moving object closer to objective increases image distance, so want to increase the distance between eyepiece and objective.

4. Given the telescope configuration given below.

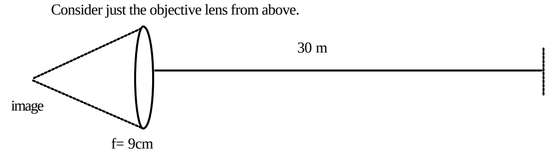


a) Consider the object to be very far away from the objective lens. How far apart should the eyepiece and the objective lens be placed for a clearly focused image?

d= **12 cm**

See question 3; 3 cm + 9 cm = 12 cm

Consider just the objective lens from above.



b) If the object is now moved from 30 m to 10 m away, the image distance will:

Increase Decrease Stay the same

Use Lens Equation: $\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}\Rightarrow\frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$

$\frac{1}{d_i}=\frac{d_o-f}{d_o f}\Rightarrow d_i=\frac{d_o f}{d_o-f}=\frac{(30)(9)}{30-9}=12.86$ **m;**

$d_i=\frac{d_o f}{d_o-f}=\frac{(10)(9)}{10-9}=90$ **m → Increase.**

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 20: Wave-Particle Duality

1. In the wave-particle duality lab, what was the evidence you found that

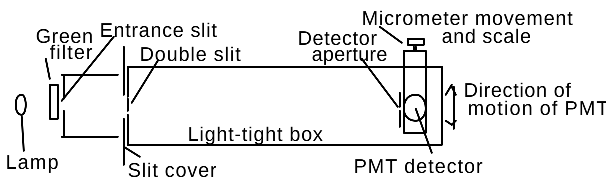
a) light can be thought of as a wave?

Detected pattern of maxima and minima in photon count, just like classical wave intensity to pattern.

b) light can be thought of as a bunch of particles?

Counted individual photons. Saw negative spikes on oscilloscope from photons striking PMT. PMT works by photoelectric effect, which uses photon interpretation.

2. In the wave-particle duality experiment, you investigated the intensity pattern produced by photons passing through two slits and detected by a PMT detector as in the figure below.



For each of the following statements, circle if they are true (T) or false (F).

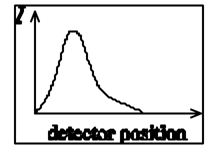
a) An interference type result was obtained with both slits open because a photon going through one slit interferes with a photon going through the other slit. T F

b) At any given detector position, the number of particles detected with both slits open is approximately the sum of the number detected with just slit #1 open and the number detected with just slit #2 open. T F

c) The light seems to behave like particles at the slits and like waves at the detector. T F

d) The observed interference pattern supports the argument that light behaves like a particle. T F

3. To test wave-particle duality of photons, light is first sent through a double-slit apparatus with the **right slit closed.** The following intensity plot results:



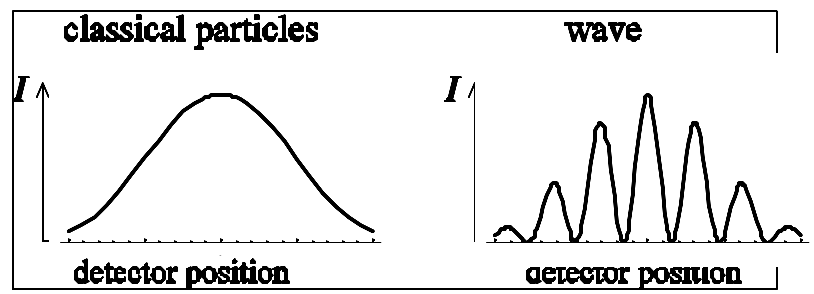
a) On the basis of this data, what can you conclude? (Choose one.)

i) Light behaves like particles, with no interference;

ii) Light behaves like a wave, with interference;

iii) Not enough information to choose between i) and ii).

b) You now send the light through **both** slits. In the space provided below, sketch what the intensity would look like if light were made up of **classical** particles, and then what the intensity would look like if light behaved as a **classical** wave.



c) Indicate the plot that best matches what you observed.

WAVE

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 21: Counting Statistics

1. Chris measured the number of gamma rays emitted in one second from a radioactive cobalt source and found that the average count rate was 1092 counts/sec. Cobalt has a very long half life. Shawn is about to repeat this same experiment. Predict the count rate that Shawn should measure and place your answer in the boxes below.

count rate: $\boxed{1092}$ ± $\boxed{33}$ counts/sec

Long half life → so radioactive decays here are random, independent events occurring in a fixed time interval → Poisson distribution, so standard deviation = $\sqrt{a}$**, where** a **is the average number of counts in the counting interval; here** $a = 1092$ **counts/sec →** $\sqrt{1092} \approx 33$

2. A detector measures gamma rays produced each second from a radioactive sample which has a very long half-life, i.e., 30 years. With 100 measurements, the average count rate per second is found to be 243. What is the expected value (with uncertainty) for the 101st measurement?

Again, use Poisson distribution:

$$\left.\begin{array}{l} a = 253 \\ \pm\sqrt{a} \approx 15.6 \end{array}\right. \Rightarrow a \pm \sqrt{a} \Rightarrow 253 \pm 16 \text{count/sec.}$$

3. In the geologically active region known as "Shaker Valley," seismologists have been carefully monitoring the frequency of earthquake tremors for the past sixty-two years, and recorded an average of eleven tremors each year. In 1997, the region experienced nine tremors, while in 1998, seismologists a total of eight was recorded. In 1999, fourteen tremors were monitored. It was also the first year in which a multi-national oil company began drilling in the area. Can you legitimately conclude that the increased seismic activity in 1999 was due to the oil drilling? Explain your reasoning.

Poisson distribution: $a \pm \sqrt{a} \Rightarrow 11 \pm 3$ tremors / year. In 1999, measured 14 tremors / year. But 11+3 = 14, so this is within one standard deviation of the average; can't conclude that there was unexpected amounts of seismic activity in 1999.

4. An astronomer is searching for evidence of bright supernova explosions in a distant galaxy. To make the measurement, she connects a photomultiplier tube (PMT) to the focus of a telescope and measures the PMT counts at a sampling frequency of one measurement every second. She observes the galaxy M51 for ten minutes and measures an average count rate of 1012 counts/second and a maximum count rate of 1024 counts/second.

The astronomer would like to know whether the maximum count rate constitutes a significant brightening of the galaxy above its average brightness. Consider the counts collected by the photomultiplier tube to be random events. **← Poisson distribution.**

a) What is the expected uncertainty in the average count rate?

$\sqrt{a} = \sqrt{1012} \approx 32$ **counts/second;**

std. dev. of mean = $\dfrac{s}{\sqrt{N}} = \dfrac{\sqrt{a}}{\sqrt{600}} = 1.3 \approx 1$ **count/sec**

b) Can she claim a detection of significant brightness increase? Give the reason for your answer in a single sentence.

$a \pm \sqrt{a} = 1012 \pm 32$ **counts/second →** $1012 + 32 = 1044$ **counts/second. So 1024 is within one standard deviation of average number of counts; she can't claim significant brightness increase.**

5. Two different lab groups measure the number of gamma-rays detected from the same long-lived radioactive source as in the "Counting Statistics" lab. Each group measures the total number of counts in a five minute interval using the same equipment. One group measures 4865 counts and the other group measures 4797 counts.

Are the two measurements statistically consistent with one another? Explain.

$4865 \pm \sqrt{4865}$ **count/second →** 4865 ± 70 **cts/sec.**

$4865 - 70 = 4795$**, so 4797 count/sec within one standard deviation of 4865 count/sec. The two measurements are statistically consistent.**

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 22: Radioactivity

1. You are monitoring a radioactive material that has been dumped in the forest behind your house. On May 12, 1990, you detected an average of 2.0×10^7 gamma particles each second when standing a distance 5 m from the material. On May 12, 1998, you measure the radioactivity again and detect an average of 2.5×10^6 gamma particles each second when standing 5 m from the material.

What is the half-life of the radioactive material? Express your answer in years.

$R(t) = R_0 e^{-Bt} = R_0 e^{-\frac{\ell n 2}{T}t}$ **; measure time in years and rate in particles/second. Take ratio:**

$$\frac{R(8)}{R(0)} = \frac{R_0 e^{-\frac{\ell n2}{T}8}}{R_0 e^{-\frac{\ell n2}{T}0}} = \frac{2.5\times10^6}{2.0\times10^7} \Rightarrow e^{-\frac{8\ell n2}{T}} = \frac{1}{8}.$$

Take natural log of both sides:

$$-\frac{8\ell n2}{T} = \ell n\left(\frac{1}{8}\right) = -\ell n8 = -\ell n2^3 = -3\ell n2 \Rightarrow T = \frac{8\ell n2}{3\ell n2}$$

$T = \frac{8}{3}$ **years.**

2. You are given a radioactive sample which decays to the ground state via the emission of gamma rays. You collect the following data using a scintillation detector and counter-timer. Note that you have already subtracted the background radiation from all of your data.

time (sec)	detection rate (counts/sec)
0	2,392
10	1374
20	789
30	453
40	260
50	150
60	86

t = 0→ 2392
t = T→ 2392/2=1196
t = 2T→ 1196/2=598
t = 3T→ 598/2=299
t = 4T→ 299/2=150
4T = 50 s → T = 12.5 s

The half-life of this substance is __**12.5 s**__

3. The rate of gamma-ray emission from a radioactive source is measured at two different times, as summarized in the table below. From this data, estimate the half-life of the radioactive source. (Show all work for full credit.)

Time(sec)	Counting Rate
5	16,000
17	4,000

Start time at t = 0 with count rate 16,000. Then at t = 12 sec, count rate = 4,000.

t = 0 → 16,000
t = T → 8,000
t = 2T → 4,000 2T = 12 sec; T = 6 sec.

4. A radioactive sample in the lab was measured to have an initial count rate of 10,000 counts/sec at the beginning of the lab. The sample has a known half-life of 12 minutes.

a) Estimate the count rate of the sample after 24 minutes. Circle the best answer.

1000 counts/sec 1250 counts/sec 2403 counts/sec 2500 counts/sec 2635 counts/sec

24 minutes = 2T, so count rate drops by

$$\frac{1}{2}\times\frac{1}{2} = \frac{1}{4} \Rightarrow \frac{10{,}000}{4} = 2{,}500$$

b) Estimate the count rate of the sample after 30 minutes. Circle the best answer.

1250 counts/sec 1705 counts/sec 1768 counts/sec 1875 counts/sec 2000 counts/sec

$$R(t) = R_0 e^{-\frac{\ell n2}{T}t} = 10{,}000 e^{-\frac{\ell n2}{12}30} = 1768$$

5. The following data was taken from a radioactive sample whose half-life is known to be quite long. The gamma-ray count rate has already had background subtracted.

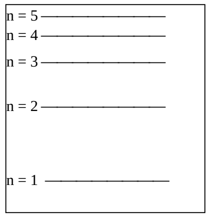
Date	Gamma-ray count rate (counts / sec)
April 15, 1980	*16,000*
April 15, 1992	*4,000*

Based on this sparse data, determine an estimate (in years) for the half-life of this radioactive sample. Clearly explain your method of solution.

T = 6 years; same method as #3 above.

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 23: Emission Spectra

1. In the emission spectrum lab, you observed a red, green and violet emission line from Hydrogen. Match up the observed line with the appropriate atomic transition. (See figure to the right for the energy levels of Hydrogen.)



a) Red line (circle one)

5 to 2   4 to 2 $\boxed{\text{3 to 2}}$ 2 to 5   2 to 4   2 to 3

b) Green line (circle one)

5 to 2 $\boxed{\text{4 to 2}}$ 3 to 2   2 to 5   2 to 4   2 to 3

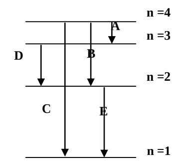
c) Violet line (circle one)

$\boxed{\text{5 to 2}}$ 4 to 2   3 to 2   2 to 5   2 to 4   2 to 3

d) Briefly explain why you chose the answers that you did.

Emission, so must have transition from high energy level to low energy level. Red line is longest wavelength, smallest energy, so "smallest" transition. Violet is shortest wavelength, largest energy, so "largest" transition.

2. The wavelengths of the photons emitted by hydrogen can be determined experimentally using a spectrometer. The energy level diagram at right shows some of the transitions in hydrogen which give rise to photons.



Determine the wavelength of the photon emitted by the hydrogen atom when the transition corresponding to letter *B* occurs.

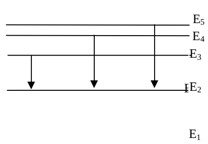
Transition B is from n = 4 to n = 2. Use $E_n = -\dfrac{13.6}{n^2}$ **eV to get** $E_4 = -\dfrac{13.6}{4^2} = -0.85$ **eV and**

$E_2 = -\dfrac{13.6}{2^2} = -3.4$ **eV. So change in energy is** $\Delta E = E_f - E_i = E_2 - E_4 = -3.4 - (-0.85) = -2.55$ **eV; atom loses energy, which goes into a photon, so** $E_{photon} = \dfrac{hc}{\lambda} = |\Delta E| \Rightarrow \lambda = \dfrac{hc}{|\Delta E|} =$

(1240 eV nm)/(2.55 eV) = 486 nm.

3. In the emission spectrum lab, we observed a red (656.3 nm), green (486.1 nm), and violet (434.0 nm) line from the spectrum of hydrogen.

On the energy diagram at right, indicate the corresponding transition in the blank boxes provided. Use the notation R,G,V for red, green, and violet respectively.



R   **G**   **V**

See question 1)

4. In the experiment "**Emission Spectra and Atomic Transitions**" a spectrometer was used to determine the wavelengths for three spectral lines in hydrogen (red, green, and violet). Data for this experiment is provided in the table below. The grating used in the experiment had a spacing d = 1.65 x10^{-6}m. Complete the table below by filling in the missing information. For the uncertainty calculation assume no uncertainty in the grating spacing (i.e. $\Delta d = 0$) and that the uncertainty in the measured angle is $\Delta\theta = \pm 0.05°$.

color	Diffraction angle $\theta_{average}$ (°)	Wavelength λ (nm)	Uncertainty $\Delta\lambda$ (nm)
	15.3	**435**	$\underline{+}1$
green	17.2	**488**	[redacted]
	23.4	**655**	

Use: $m\lambda = d\sin\theta$**, with** $m = 1$ **for first order diffraction as measured in lab.**

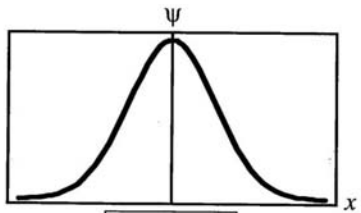
→ $\lambda = d\sin\theta = 1.65\times10^{-6}\sin\theta$**, in meters (since grating spacing given in m). So calculate wavelengths using this relation.**

Uncertainty:
$\Delta\lambda = \lambda(\theta+\Delta\theta) - \lambda(\theta)$ → **"worst" value for wavelength minus "best" value for wavelength.**

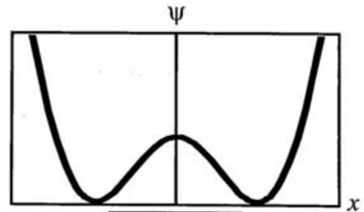
$$\begin{aligned}\Delta\lambda &= d\sin(\theta+\Delta\theta) - d\sin\theta \\ &= 1.65\times10^{-6}\left[\sin(15.3^o + 0.05^o) - \sin 15.3^o\right] \\ &= 1.4\times10^{-9}\,\textbf{m.}\end{aligned}$$

PHYSICS 212 CHECK-OUT QUESTIONS
Laboratory 24: Numerical Determination of Energy Levels

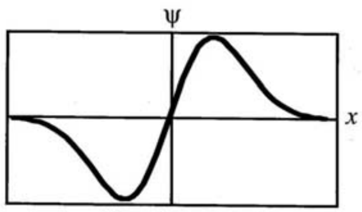
1. In the lab "Numerical Determination of Energy Levels," you determined the wavefunction as a function of distance for specific values of energy using the Schrödinger equation and stepping equations. The figures below are examples of the wavefunction as a function of distance generated from these equations.



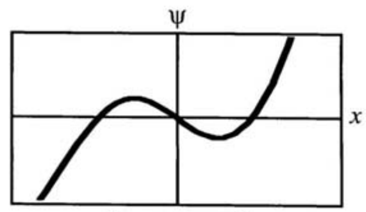
D



A, C



B



A, C

For each of the figures, write the letter of ***any*** appropriate statement(s) in the box below each figure.

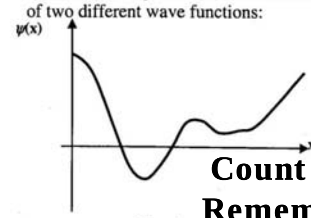
A The energy chosen for this solution of the Schrödinger equation produces a wavefunction which is not acceptable.

B This wavefunction corresponds to the first excited state.

C This wavefunction is not allowed because it cannot satisfy the condition $\int_{-\infty}^{+\infty} |\psi|^2 dx = 1$.

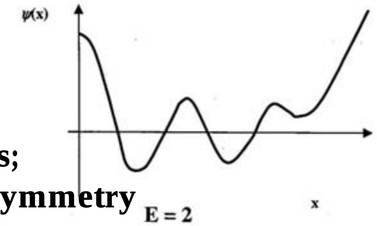
D This wavefunction corresponds to the lowest allowed energy.

2. Consider the simple harmonic oscillator potential $U = x^2$. A numerical integration of Schrödinger's equation with two indicated values of the energy E gives the following graphs of two different wave functions:



E = 1

Count nodes;
Remember symmetry

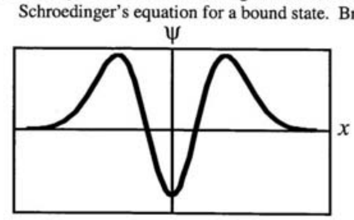


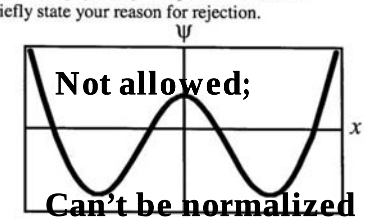
E = 2

Of the following statements, circle the one that is TRUE.

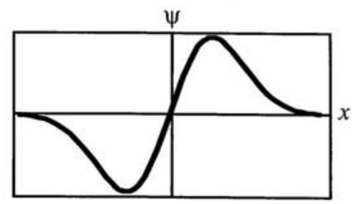
- There are no allowed energy levels in the range $1 \le E \le 2$.
- There is exactly 1 allowed energy level in the range $1 \le E \le 2$.
- There are exactly 2 allowed energy levels in the range $1 \le E \le 2$.
- There are more than 2 allowed energy levels in the range $1 \le E \le 2$.
- It is impossible to tell how many allowed energy levels there are in the range $1 \le E \le 2$ from the given information.

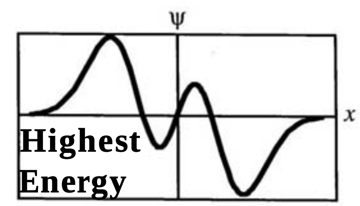
3. Identify which of the following wavefunctions is not a physically acceptable solution to Schroedinger's equation for a bound state. Briefly state your reason for rejection.





Not allowed;
Can't be normalized





Highest
Energy
→most nodes

Of the physically acceptable wavefunctions, identify the one which has the highest energy.