PHYS 212 *Laboratory* Exam **Name** __________________
May 6, 2004 **Score** __________

Show all work for full credit!

$s = \sqrt{<x^2> - <x>^2}$

standard deviation of the mean $= \frac{s}{\sqrt{N}}$ Poisson distribution standard deviation $= \sqrt{a}$

$I = \frac{1}{R}\Delta V$ $n = \frac{c}{v}$ $n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$R(t) = R_o e^{-Bt} = R_o e^{\frac{-\ell n2}{T}t}$ $K_{\max} = E_{photon} - W = hf - W$ $P_2 = \cos^2(\theta_2 - \theta_1)$

$m\lambda = d\sin\theta$ $E_n = \frac{-13.6}{n^2}\text{eV}$ $E_{photon} = E_{upper} - E_{lower} = E_1\left[\frac{1}{n_{upper}^2} - \frac{1}{n_{lower}^2}\right]$

$\psi''(x) = -(E - U_o x^2)\psi(x)$ $\psi(x+\Delta x) = \psi(x) + \Delta x\ \psi'(x)$ $\psi'(x+\Delta x) = \psi'(x) + \Delta x\ \psi''(x)$

1. (5 pts) Verizon is examining the capability of their network to handle phone calls. A representative states that the network can handle 1,000,000 calls in a 10 minute interval. During regular working days, the peak 10 minute interval averages 985,000 calls. Over the last month, two work days had peak call rates during a ten minute interval as 988,000 and 987,000. Is the network large enough or does it need to be upgraded to handle more traffic (circle a choice below)? Justify your answer quantitatively. use Poisson distribution

$S = \sqrt{a} = \sqrt{985{,}000} = 992$

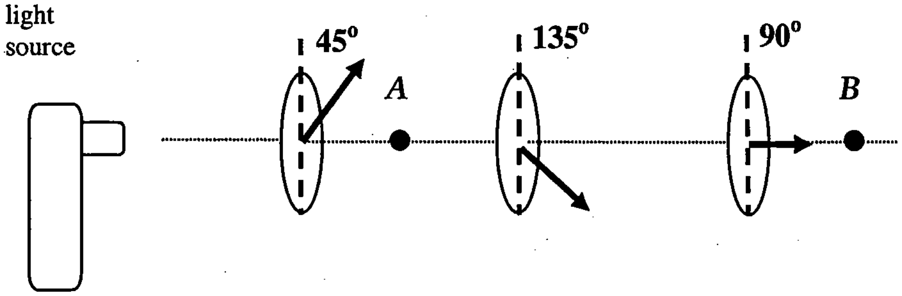
# of calls = 985,000 ± 992

max calls in 10 minutes = 1,000,000 >> 985,000 + 992

can handle traffic as is.

UPGRADE [✓ **DON'T UPGRADE**]

2. (6 pts) Examine the following configuration of ideal identical polarizers. The transmission axis for each polarizer is initially vertical. Each polarizer is then rotated by an angle as shown in the figure.



a) Determine the final intensity of the beam as measured at the point *B* given that the intensity at the point *A* is I_o.

135° ⊥ 45°; no light from point A makes it through second filter, so none makes it to point B

$\boxed{0}$

b) The middle polarizer is now rotated to an angle of 55° relative to vertical. Find the new intensity at the point *B* given that the intensity at the point *A* is I_o.

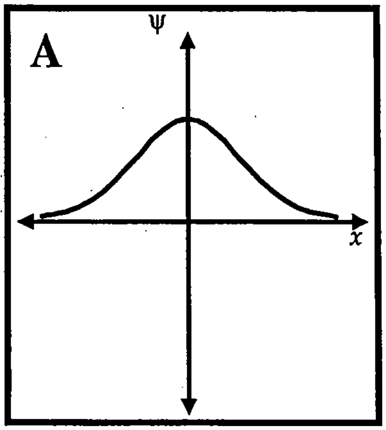
use $\cos^2(\theta_2-\theta_1)\cos^2(\theta_3-\theta_2)$

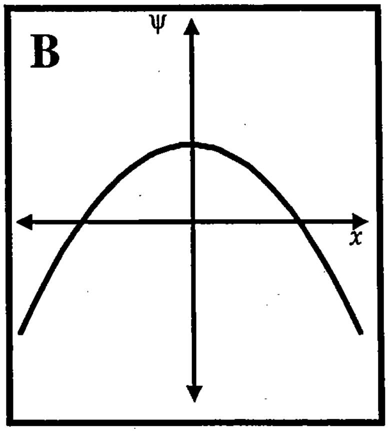
$= \cos^2(55°-45°)\cos^2(90°-55°)$

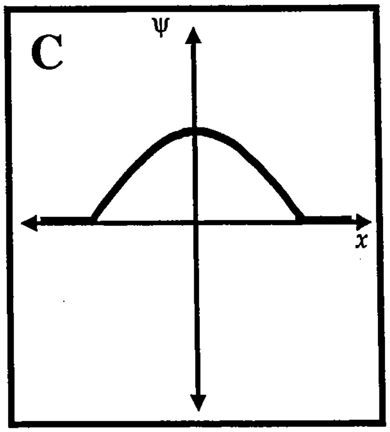
$= 0.65$

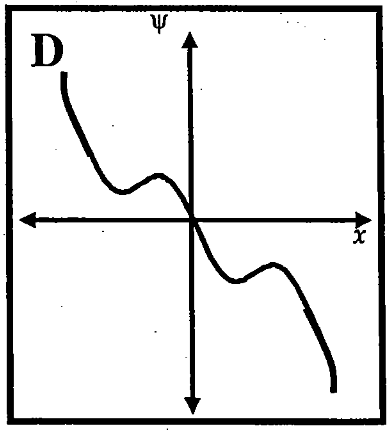
$\Rightarrow \boxed{0.65\, I_o}$

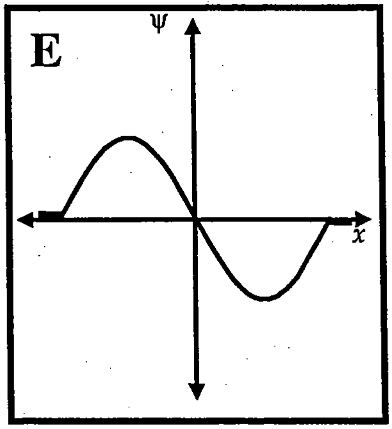
3. (6 pts) In the lab "Numerical Determination of Energy Level," you determined the shapes of physically acceptable wavefunctions for bound states. You are given the following proposed wavefunctions.

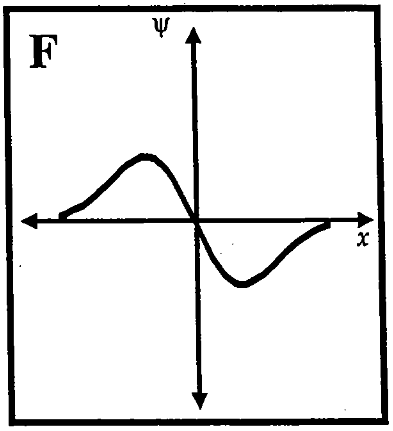












a) Identify and write down the letters for **any** wavefunctions which are physically **unacceptable:** B, D   not normalizable

b) Identify and write down the letter for the ground state of the harmonic oscillator potential as used in the lab: A

c) Identify and write down the letter for the first excited state of the harmonic oscillator potential as used in the lab: F

4. (5 pts) In the "Interference of Light" lab, you shined a red laser through various sets of single-, double-, and multiple slits. You then observed the patterns of red light on a white board.

a) For a single slit of width 0.08 mm, one group found the central red spot on the screen to be 4.2 cm wide. When the slit width was changed to 0.04 mm, how wide was the central red spot on the screen? (circle one)

0.04 mm **1.05 cm** **2.1 cm** **4.2 cm** [✓ **8.4 cm**] **16.8 cm**

b) The laser light passed through a slide with multiple-slits being illuminated; the center of the pattern on the screen looked like this, where the dark spots on the diagram represent bright red spots on the screen.

How many slits were being illuminated to make this pattern? (circle one)

2 **3** [✓ **4**] **5** **6** **can't be determined**

5. (6 pts) In the Emission Spectra lab, you calibrated your spectrometer by observing the green line of mercury vapor ($\lambda = 546.1$ nm) to calculate d. Suppose your partner used the green line in the 2^{nd} order spectrum to get the angle $\theta = 19.1°$, but you calculated d under the assumption that the observed line was in the 1^{st} order spectrum.

Using this incorrect calibration, you found the red line of hydrogen to have a wavelength of $\lambda = 326 \pm 2$ nm. Your lab instructor noticed the error and asked you to recalculate the wavelength of the red hydrogen line.

Determine the corrected, recalculated value (including uncertainty) for the red line of hydrogen, using the same data.

↓ mercury

Mercury: Wrong $d = \frac{\lambda(1)}{\sin\theta}$ right $d = \frac{\lambda(2)}{\sin\theta} = 2(\text{wrong } d)$

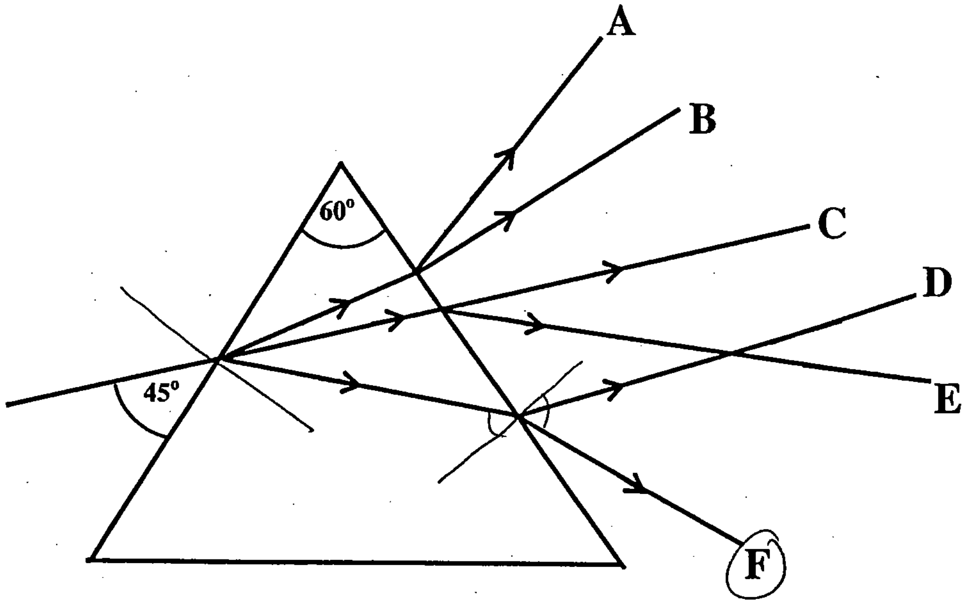
Hydrogen Wrong $\lambda = \frac{m_H\, d\text{wrong}}{\sin\theta_H}$

Right $\lambda = \frac{m_H}{\sin\theta_H} d\text{ right} = 2\left(\frac{m_H}{\sin\theta_H} d\text{wrong}\right)$

$2(\text{wrong } \lambda) = \boxed{652 \pm 4 \text{ nm}}$

7

6. (5 pts) Consider light traveling from air into a prism made of glass, whose index of refraction is 1.38, as illustrated. Which of the following best represents the path that the light ray takes (circle a letter)? **Briefly explain** your choice below.



when passing from a material of lower n to higher n the ray is bent towards the normal ⇒ E or F.

~~sot~~ converse from higher n → lower n ⇒ F

7. (4 pts) The rate of production of alpha particles from a radioactive sample is measured to be 27,000 counts/second at an initial instant. At another instant 20 minutes later it is found to be 9,000 counts/second. What is the count rate 40 minutes after the <u>initial</u> measurement?

$$R(t) = R_0 e^{-t\ln 2/T} \qquad R_0 = 27,000$$

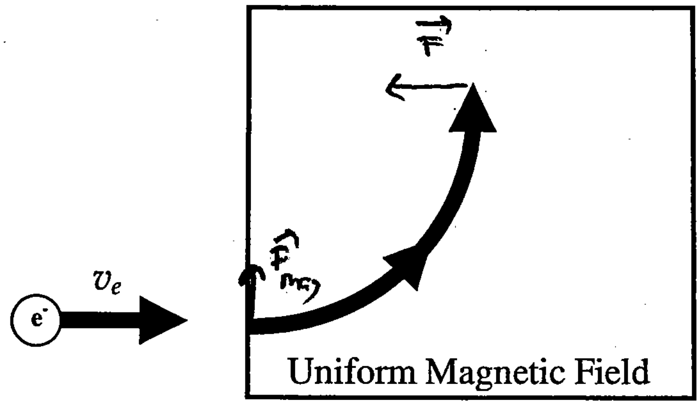
$$R(20) = R_0 e^{-20\ln 2/T} = 9,000 \Rightarrow e^{-20\ln 2/T} = \frac{1}{3}$$

$$R(40) = R_0 e^{-40\ln 2/T}$$

$$= R_0 \left[e^{-20\ln 2/T}\right]^2 = 27,000 \left(\frac{1}{3}\right)^2$$

$$= 3,000$$

8. (5 pts) An electron is traveling at speed v_e, to the right. The electron then enters a region of uniform magnetic field. A portion of the trajectory of the electron in this uniform magnetic field is shown.



$\vec{F}_{mag} = q\vec{v} \times \vec{B}$

- use Right Hand Rule
- electron has negative charge

a) What is the direction of the magnetic field? (circle one)

← → ↑ ↓ ⊗ into page [✓ ⊙ out of page]

b) The magnetic field is doubled. What happens to the radius of curvature of the electron's trajectory? (circle one)

increases by more than 2x

increases by 2x

remains the same

[✓ **decreases by 2x**]

decreases by more than 2x

can't be determined

$|\vec{F}_{mag}| = qvB\sin\theta = qvB \quad (\vec{v} \perp \vec{B})$

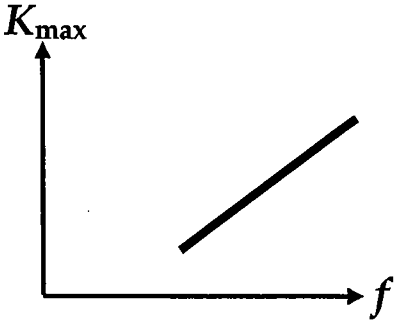
$F = ma = m\frac{v^2}{R}$ (circular motion)

$qvB = \frac{mv^2}{R} \Rightarrow R = \frac{mv}{qB} \Rightarrow B \to 2B$

$R \to \frac{R}{2}$

9. (pts) In a photoelectric effect experiment, you shine light of different frequencies on a metal plate, and determined the maximum kinetic energy of electrons ejected from the metal surface. You obtain the following results:

f (Hz)	4.84×10^{14}	6.0×10^{14}	7.5×10^{14}
K_{max} (eV)	1	1.48	2.1



When you plot maximum kinetic energy vs. frequency, you obtain a straight line as sketched on the right:

a) At what value of frequency does this straight line intersect the x-axis?

use $K_{max} = hf - W$

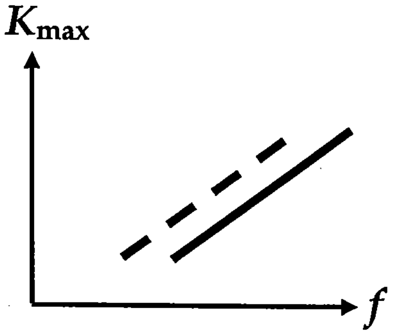
slope = Planck's constant = $\frac{rise}{run} = \frac{\Delta K_{max}}{\Delta f}$

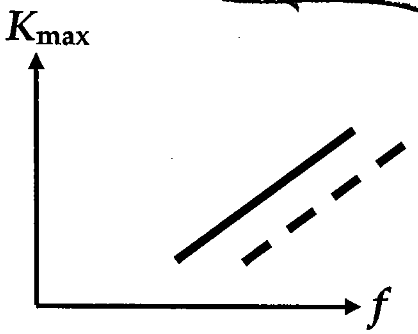
intersects axis at $K_{max} = 0$,

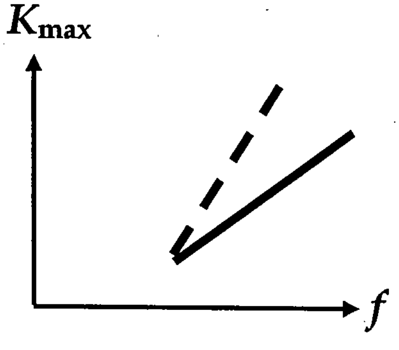
$$h = \frac{K - 0}{f - f_{th}} \Rightarrow f_{th} = f - \frac{K}{h} = \boxed{2.42 \times 10^{14} \text{ Hz}}$$

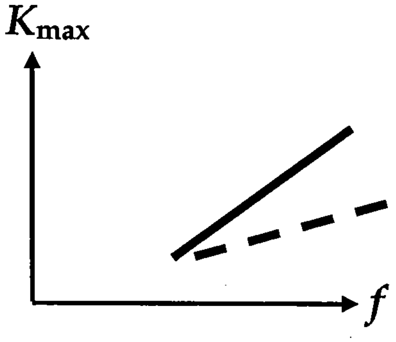
b) You repeat this experiment, this time using a metal with a higher binding energy (work function.) Which of the following best indicates the graph you would obtain when you plot maximum kinetic energy vs. frequency? The solid line is the previous data set, and the dashed line is the new data. (Circle one)

same slope; higher f_{th}

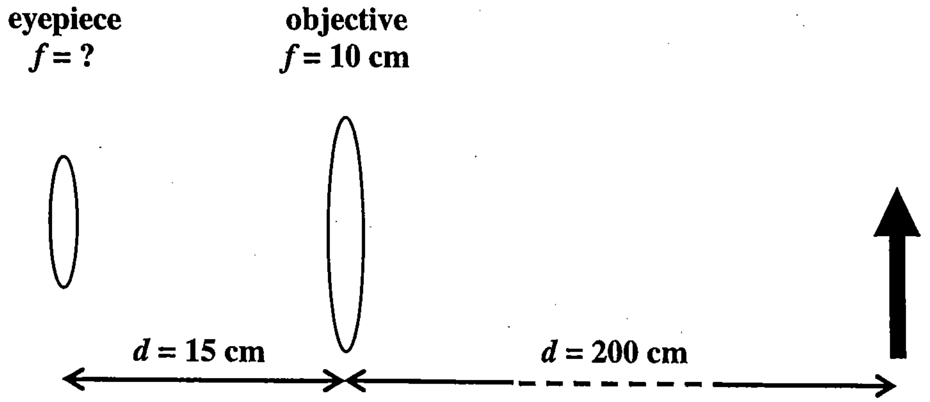








10. (6 pts) The diagram below shows lenses arranged as a telescope, so that when looking through the eyepiece, the arrow is in focus.



a) Determine the focal length of the eyepiece. Show all work.

step 1 find image distance $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \Rightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = 10 \cdot 53$ cm

To see an image through the eyepeice, the image formed by the objective must be at a distance from the eyepiede, equal to the focal length of the eyepiece.

Therefore $f_{eye} = 15$ cm $- 10{\cdot}53$ cm $= 4 \cdot 47$ cm

b) This telescope was then used to view a very distant object. The eyepiece was:

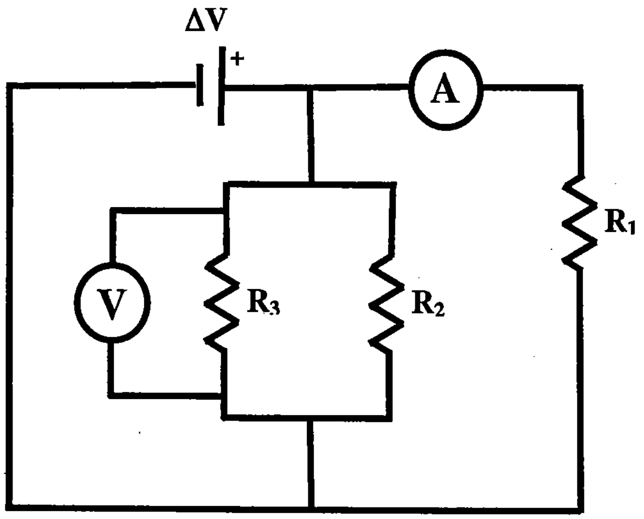
(i) left at the same distance from the objective.

[✓ (ii)] moved closer to the objective.

(iii) moved further away from the objective.

(iv) There is insufficient information to determine how the eyepiece was moved.

11. (6 pts)Given the following circuit diagram:



$\Delta V = 12$ V

$R_1 = 10\ \Omega$

$R_2 = 3\ \Omega$

$R_3 = 3\ \Omega$

a) Use a Kirchoff Rule and Ohm's Law to determine the current through R_3. Show all work.

Loop Rule: $\Delta V_{battery} + \Delta V_{R_3} = 0 \Rightarrow |\Delta V_{R_3}| = |\Delta V_{batt}|$

$= 12\ V$

Ohm's Law: $\Delta V_{R_3} = I_3 R_3$

$$I_3 = \frac{\Delta V_{R_3}}{R_3} = \frac{12\ V}{3\ \Omega} = \boxed{4\ A}$$

b) What is the reading on the voltmeter?

3 V 4 V 6 V [✓ 12 V]

(see above)