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University of Maryland
Department of Physics

Physics 122 Dr. David Noyes: Exam 2 Make up /25 + /30+ /45

Instructions: Do not open this examination until the proctor tells you to begin. Read these instructions while waiting.

1. When the proctor tells you to begin, **write your name and section number at the top of every page.**

2. Do your work for each problem on the page for that problem. I will pass around paper so you can do your scratch work on it before starting to write out your answer on the exam. **If part of your answer is on the back, be sure to check the box on the bottom of the page so the grader knows to look on the back!**

3. Partial credit will be granted for correct steps shown, even if the final answer is wrong. So be sure to show your work.

4. Write clearly and logically so I can understand what you are doing and can give you as much partial credit as you deserve. I cannot give credit for what you are thinking — only for what you show on your paper.

5. If on a multi-step problem you can't do a particular part, don't give up. Go on to the next part anyway. If necessary, define a name for the quantity you couldn't find and express your answer in terms of it.

6. You are not permitted to have any outside information during this exam. This includes any written information and any relevant information programmed into a calculator. If you are caught using such information, you will be prosecuted and may receive a grade of XF for this course.

7. If there is a formula or constant that is not given, but you think is needed, ask me and if reasonable, I will put it on the board. However I will not tell you which equation is needed for a given problem. Also note that some of the formulas that are given only apply in certain situations, so be sure to take that into account.

8. Take a deep breath, relax, and good luck!

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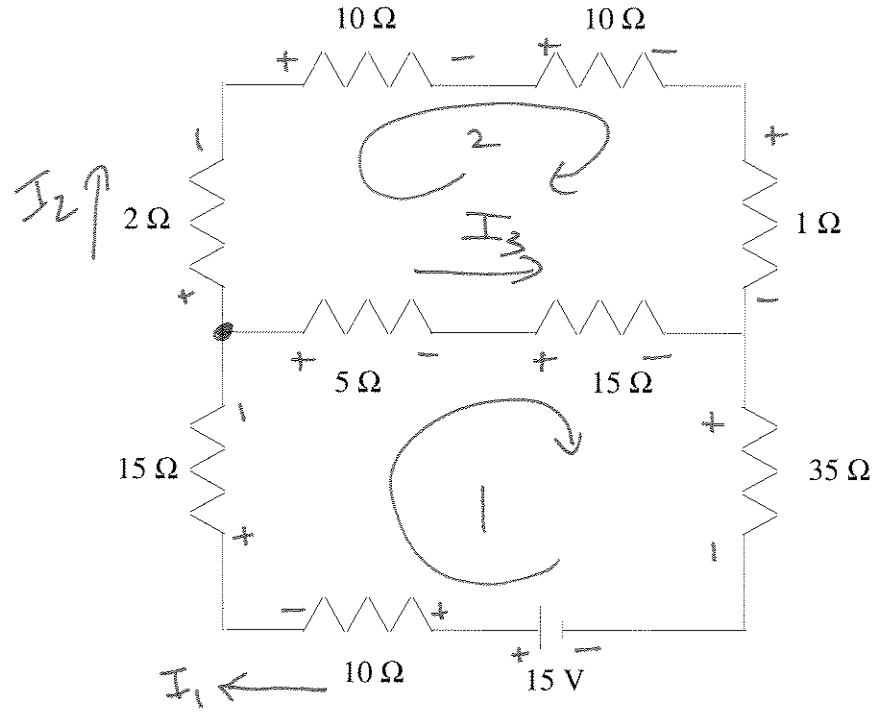
DC Circuits (25 points) **/20 +** **/5** **=** **/25**

1) **(20 points)** For the circuit shown below:



$I_1 = 0.212\,A$
$I_2 = 0.099\,A$
$I_3 = 0.113\,A$

a. **(10 points)** Use Kirchhoff's rules to find the current through through each resistor.

$I_1 = I_2 + I_3$

① $15 - 10I_1 - 15I_1 - 5I_3 - 15I_3 - 35I_1 = 0$

$15 - 60I_1 - 20I_3 = 0$

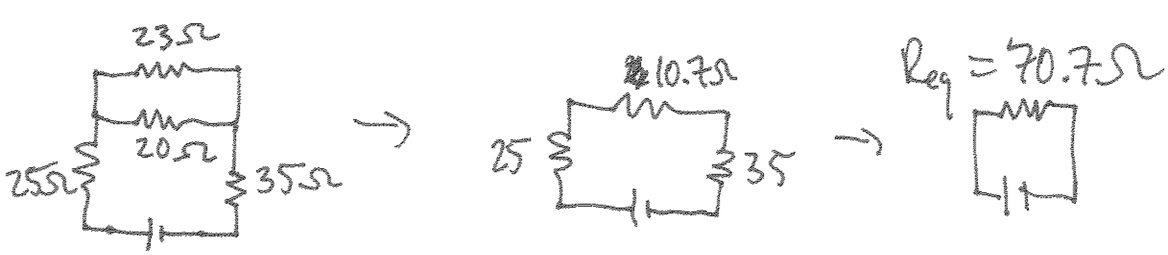
② $-2I_2 - 10I_2 - 10I_2 - 1I_2 + 15I_3 + 5I_3 = 0$

$20I_3 - 23I_2 = 0$

b. **(4 points)** Calculate the power dissipated by the 1 Ω resistor.

$P = I_2^2\, 1\Omega = (0.099A)^2 * 1\Omega = 0.0098W$

c. **(6 points)** Find the equivalent resistance of the circuit.



$I_3 = \frac{23}{20} I_2 = 1.15 I_2$

$I_1 = I_2 + 1.15I_2 = 2.15I_2$

$15 - 60(2.15I_2) - 20(1.15I_2) = 0$

$I_2 = \frac{15}{152} = 0.099A$

$I_1 = 2.15 * 0.099\,A = 0.212\,A$

$I_3 = 1.15 * 0.099\,A = 0.113\,A$

$I_1 = I_2 + I_3$ ✓

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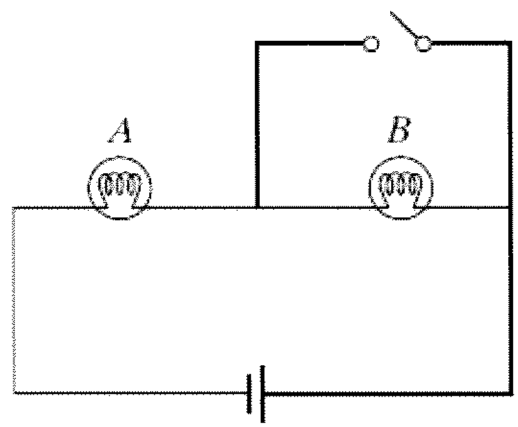
2) **(5 points)** The circuit below consists of two identical light bulbs burning with equal brightness and a single 12 V battery.



When the switch is closed, the brightness of bulb A:

a. Increases.

b. Decreases.

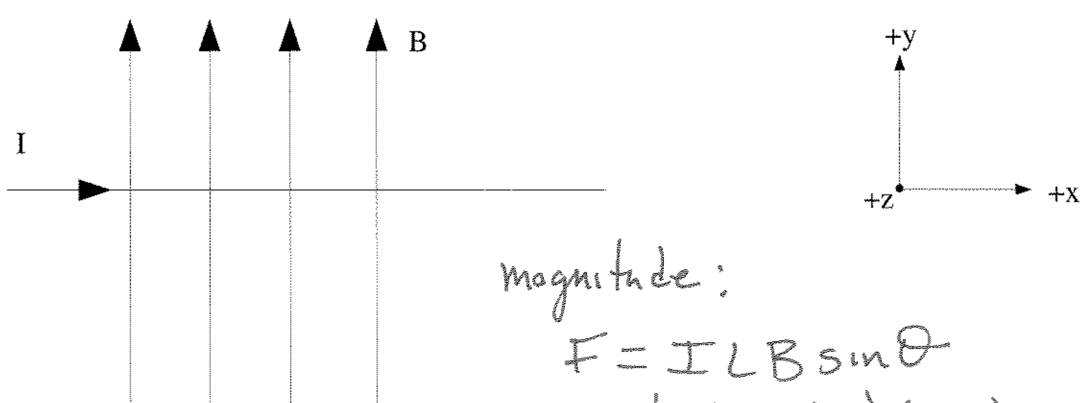
c. Remains the same.

current follows path of least resistance.

Magnetism (30 points) **/10 +** **/20 =** **/30**

3) **(10 points)**

a.) **(5 points)** A wire of length L = 10 cm, carrying a current of 1 A in the +x direction is placed in a magnetic field B = 10 T which is in the +y direction. Find the magnitude and direction of the magnetic force on the wire. Note: directions refer to the coordinate system at the right.



magnitude:

$F = ILB\sin\theta$

$= (1A)(0.1m)(10T)\sin 90$

$= 1N$

direction: +z

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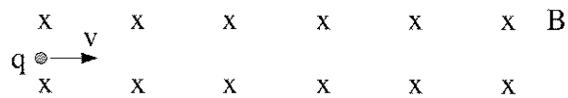
b.) **(5 points)** A charged particle with charge q = 10 nC and velocity v = 10 m/s in the +x direction enters a region of uniform constant magnetic field B = 1T, which is in the -z direction. Give the magnitude and direction of the magnetic force on the particle.

direction: +y ↑



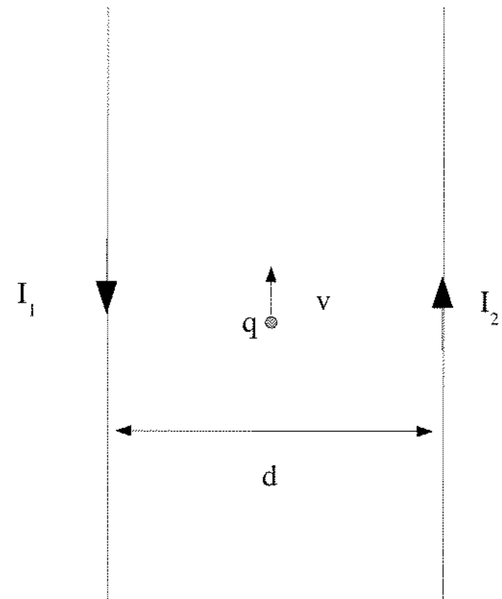
mag.

$F = qvB\sin\theta$

$= (10\times10^{-9}C)(1T)(10 m/s) \sin 90$

$= 10^{-7} N$

4.) **(20 points)** A particle with charge q and velocity v moves between two long current-carrying wires with currents I_1 and I_2 are as shown below. For this problem you need the magnetic field due to a long current-carrying wire: $B = \mu_0 I/2\pi r$, where $\mu_0 = 4\pi \times 10^{-7}$ T m/A. At the instant shown, q is midway between the two wires.



For the following questions, take I_1 = 1A, I_2 = 2A, d = 10 mm, q = 10nC, and v =1000 m/s.

a) **(3 points)** Let the magnetic field due to I_1 be B_1 and the magnetic field due to I_2 be B_2. Give the magnitude and direction of B_1 and B_2 at the point where the charged particle is located.

$B_1 = \frac{\mu_0 I_1}{2\pi (d/2)} = \frac{(4\pi\times10^{-7} Tm/A)(1A)}{2\pi(5\times10^{-3}m)} = 4\times10^{-5} T$ +z direction

$B_2 = \frac{\mu_0 I_2}{2\pi (d/2)} = \frac{4\pi\times10^{-7} Tm/A}{2\pi(5\times10^{-3}m)}(2A) = 8\times10^{-5} T$ +z direction

b.) **(2 points)** Give the magnitude and direction of the net magnetic field at the point where the charged particle is located.

$B_{net} = B_1 + B_2 = 12\times10^{-5} T$ +z direction

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c.) **(6 points)** Give the magnitude and direction of the net magnetic force on the particle at the instant shown.

$F_{net} = qvB_{net}\sin\theta$

$= (10 * 10^{-9} C)(10^3 m/s)(12 \times 10^{-5} T)\sin 90$

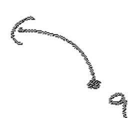
$= 12 \times 10^{-10} N$ +x direction

d.) **(3 points)** Sketch the initial trajectory of the particle.

e.) **(3 points)** Sketch the initial trajectory of the particle if I_2 is reversed and now points in the same direction as I_1.

Now B_2 is in −z direction. Since $B_2 > B_1$

B_{net} is in −z direction → F_{net} is in −x directio[n]

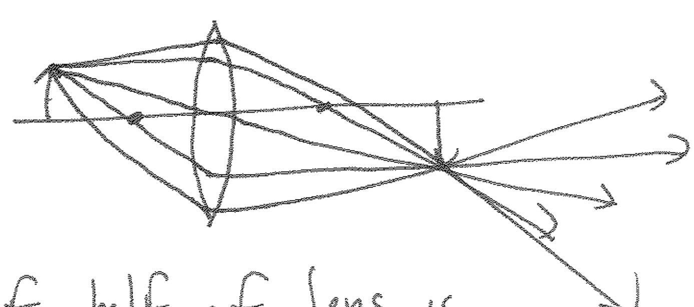


Reflection and Refraction + Mirrors and Lenses (50 points)

/5 + /5 + /20 + /15 = /45

5.) **(5 points)** A lens is used to image an object onto a screen. If the right half of the lens is covered,

a. The left half of the image disappears.
b. The right half of the image disappears.
c. The entire image disappears.
d. The image becomes blurred.
e. The image becomes fainter.
f. We need more information to decide.



If half of lens is blocked image is still formed, but with fewer rays → fainter

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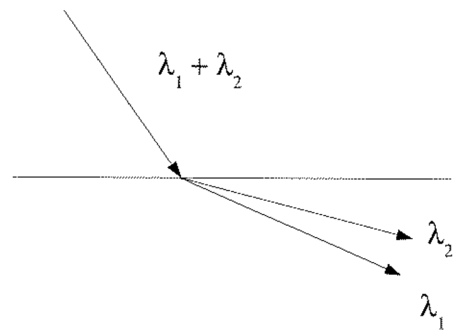
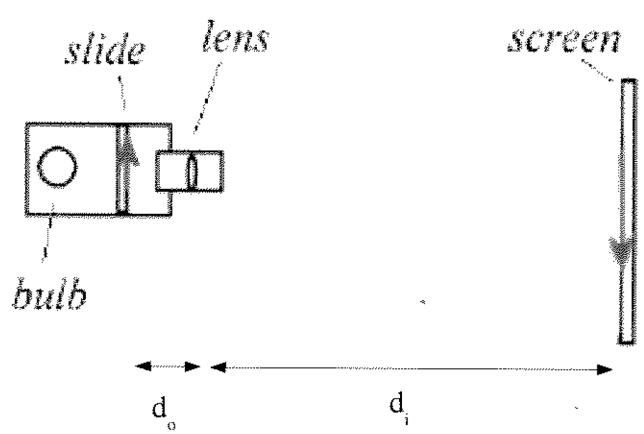
6.) **(5 points)** Light consisting of two wavelengths λ_1 and λ_2 passes from glass to air. The light undergoes dispersion due to the fact that the index of refraction depends on the wavelength of the light. Given the drawing on the right, which of the following is true:



a. $n(\lambda_1) > n(\lambda_2)$
b. $n(\lambda_2) > n(\lambda_1)$
c. $n(\lambda_1) = n(\lambda_2)$
d. none of the above.

7.) **(20 points)** I have an old slide projector that is pretty broken up. It has only a single lens (fancy projectors have multiple lenses) and the ratchet that moves the lens back and forth jams so it can only move to distances between 50 mm and 100 mm from the slide. The power cord is also frayed and needs to be replaced. I can pretty easily fix the power cord, but not the ratchet that moves the lens. The lens says it has a focal length of 45 mm. I want to calculate to see if the image will be big enough to make it worth my while to fix the power cord.



a) **(10 points)** Where should I put the screen and lens adjustment in order to have the image in focus and have it be as large as possible?

$M = -\frac{d_i}{d_o}$ to make M big, we want $d_i \to$ big, $d_o \to$ small $\to d_o = 50\text{mm}$

$\frac{1}{d_i} + \frac{1}{50} = \frac{1}{45} \to$ $d_i = 450\text{mm}$, $d_o = 50\text{mm}$

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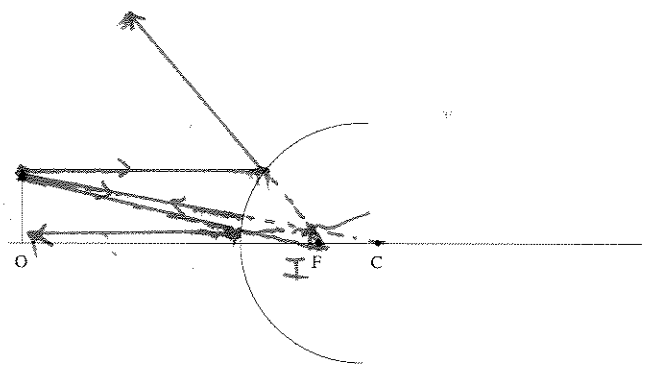
b) **(10 points)** If my slide is 35 mm across, how big will the image be when you set the system up as you calculated in part (a)?

$$M = -\frac{d_i}{d_o} = -\frac{450}{50} = -9 = \frac{h_i}{h_o} = \frac{h_i}{35mm}$$

$$h_i = -9 * 35mm = -315 \text{ mm}$$

8.) **(15 points)** An object is placed in front of a convex mirror as shown below. The radius of curvature of the mirror is 20 cm.



a.) **(6 points)** The object is placed 30 cm in front of the mirror. Draw 3 rays above to locate the image.

b.) **(3 points)** Is the image real or virtual?

c.) **(6 points)** Given that the object distance is 30 cm, use the mirror equation to find the image distance.

$R = -20cm \quad d_o = 30cm$

$$\frac{2}{R} = \frac{1}{d_o} + \frac{1}{d_i} \qquad \frac{2}{-20} = \frac{1}{30} + \frac{1}{d_i}$$

$$d_i = -7.5cm$$

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Extra Credit (5 points)

How many times does a person's heart beat in a lifetime? Be sure to state all assumptions.

assume:

60 beats/min

70 yrs/lifetime

$$\text{min/yr} = 60\,\frac{\text{min}}{\text{hr}} * 24\,\frac{\text{hr}}{\text{day}} * 365\,\frac{\text{day}}{\text{yr}}$$

$$= 525600 \text{ min/yr}$$

$$60\,\frac{\text{beats}}{\text{min}} * 525600\,\frac{\text{min}}{\text{yr}} * \frac{70\text{ yr}}{\text{life}}$$

$$\approx 2.2 \times 10^{9}\,\frac{\text{beats}}{\text{lifetime}}$$