Name:____________________

Physics 222
Test 3

General Physics II
11/15/2019

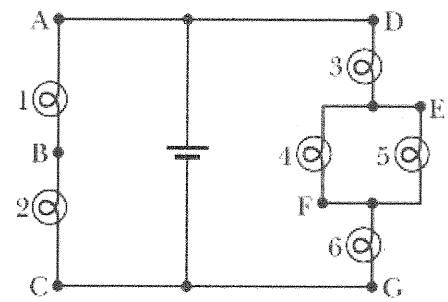
Directions: Write your name on each page of the test. Show your work as completely as possible. Partial credit will be given if your reasoning makes sense, even if the final numerical value is incorrect. Answers without explanation or work shown may receive no credit. If a problem is best answered with words, use complete sentences. Pay attention to the point values of the problems and manage your time wisely. Do not spend too much time on any individual problem.

The Honor Code requires that examinations and selected assignments contain the following pledge statement to which students are expected to sign:

> On my honor, I pledge that I have upheld the Honor Code, and that the work I have done on this assignment has been honest, and that the work of others in this class has, to the best of my knowledge, been honest as well.

Signature:______________________________ Date:________________

1. (10 points) Examine the figure below.



(a) Rank the bulbs according to brightness. Justify your answers with an explanation.
(b) What happens to the brightness of the remaining bulbs if bulb 4 is unscrewed?
(c) What happens to the brightness of the remaining bulbs (bulb 4 is still gone) if a wire is used to connect points A and F?

Power = brightness. $P = IV = I^2R = \frac{V^2}{R}$ find $R \to R_{left} = 2R$

$R_{right} \Rightarrow \frac{1}{R_{45}} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \to R_{45} = \frac{R}{2} \Rightarrow R_{right} = \frac{5R}{2}$

V across right + left the same. $I_{left} = \frac{V}{2R}$

$I_{right} = \frac{2V}{5R}$

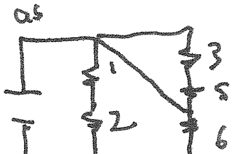
So $\begin{cases} P_1 = P_2 = I_{left}V = \left(\frac{V}{2R}\right)V = \frac{V^2}{2R} \\ P_3 = P_6 = \left(\frac{2V}{5R}\right)V = \frac{2V^2}{5R} \\ P_4 = P_5 = \left(\frac{I_{right}}{2}\right)V = \frac{2V^2}{10R} \end{cases}$

$P_1 = P_2 > P_3 = P_6 > P_4 = P_5$ ←

(b) total R↑, so total I↓. Current through 5 ~~goes~~ up. Now 5 is as bright as 3+6 Bulb 4 gone.

$P_1 = P_2 > P_3 = P_5 = P_6 > P_4 = 0$

(c) Write as



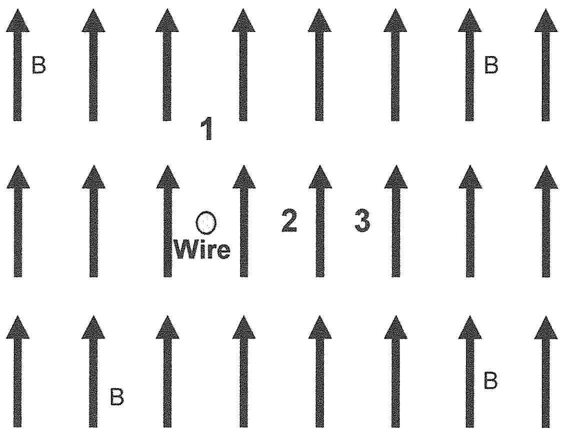
Now 3+5 go out and 1 and 2 are in parallel with 6.

$I_{12} = \frac{I_6}{2}$ since 2R vs. R. $P_1 = P_2 = \left(\frac{I_6}{2}\right)V < P_6 = I_6 R$ → P_6 brightest.

Name:____________________

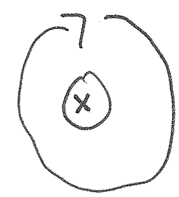
2. (10 points) A uniform magnetic field points upward, in the plane of the paper, as shown by the arrows in the figure below. A wire is perpendicular to the paper. When the wire carries a current, the net magnetic field at point 2 is zero. The distance from the wire to point 2 is 1 cm.

(a) What is the direction of the current in the wire – into or out of the paper? Explain.
(b) Point 1 is the same distance from the wire as point 2. Use a vector diagram to determine the net magnetic field at point 1.
(c) Point 3 is twice as far from the wire as point 2. Use a vector diagram to determine the net magnetic field at point 3.
(d) If the net magnetic field at point 3 is 1.0 x 10^{-4} T, how much current is flowing in the wire?

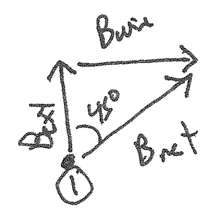


(a) $B = 0$ @ 2 implies B_{wire} @ 2 should be down. RHR says I into the page.

(b) at 1 →

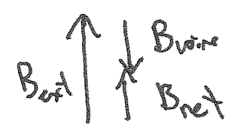


so



(c) $B_{wire} = \frac{\mu_0 I}{2\pi r}$ 3 is 2x as far from wire as 2.

so $B_{wire}(3) = \frac{1}{2} B_{wire}(2)$



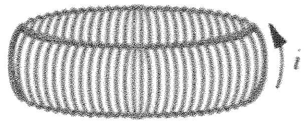
(d) $B(@2) = 0 = B_{ext} - \frac{\mu_0 I}{2\pi a}$ $a = 1\,cm$ $\Rightarrow \vec{B}_{ext} = \frac{\mu_0 I}{2\pi a}$, down

$$B(@3) = \frac{\mu_0 I}{2\pi a}\,(up) - \frac{\mu_0 I}{2\pi (2a)}\,(up) = \frac{\mu_0 I}{2\pi a}\left(1 - \frac{1}{2}\right) = \frac{\mu_0 I}{4\pi a}$$

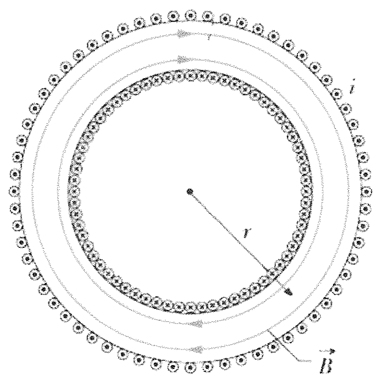
$$\Rightarrow I = \frac{4\pi a B_3}{\mu_0} = \frac{4\pi\,(0.01\,m)(1\times10^{-4}\,T)}{4\pi \times 10^{-7}\ Tm/A} = \underline{10\ A}$$

Name:____________________

3. (10 points) One of Maxwell's equations is Ampere's Law.
   a. State Ampere's Law and describe, in words, what Ampere's Law says in one or two sentences.
   b. The figure below shows a toroid, which may be described as a solenoid bent into the shape of a hollow doughnut. (a) shows an outside view, while (b) shows the horizontal cross section of the toroid. This toroid has a radius r and carries a current i. Using Ampere's Law, find the magnetic field within the toroid, *i.e.* at radius r.



(a)

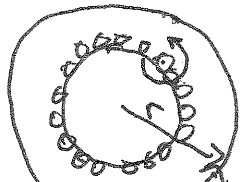


(b)

(a) $\int B \cdot dl = \mu_0 I$

The line integral of the B-field around any closed loop is equal to μ_0 times the current enclosed by the loop.

(b) Draw Amperian loop around center, in direction of B from RHR

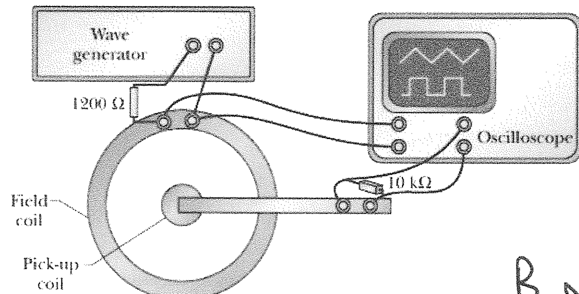


$\int B \cdot dl = B(2\pi r) = \mu_0 N I$ → N loops of wire

$$B = \frac{\mu_0 N I}{2\pi r}$$

Name:____________________

4. (10 points) Consider the experimental setup shown below. Both coils have many turns of conducting wire. For each of the plots below, sketch what you would predict for current in the coil based upon the measured current in the other coil. Since the sizes of the currents are not specified, you cannot obtain specific values, but the relative size and shape of the predictions will be noted.

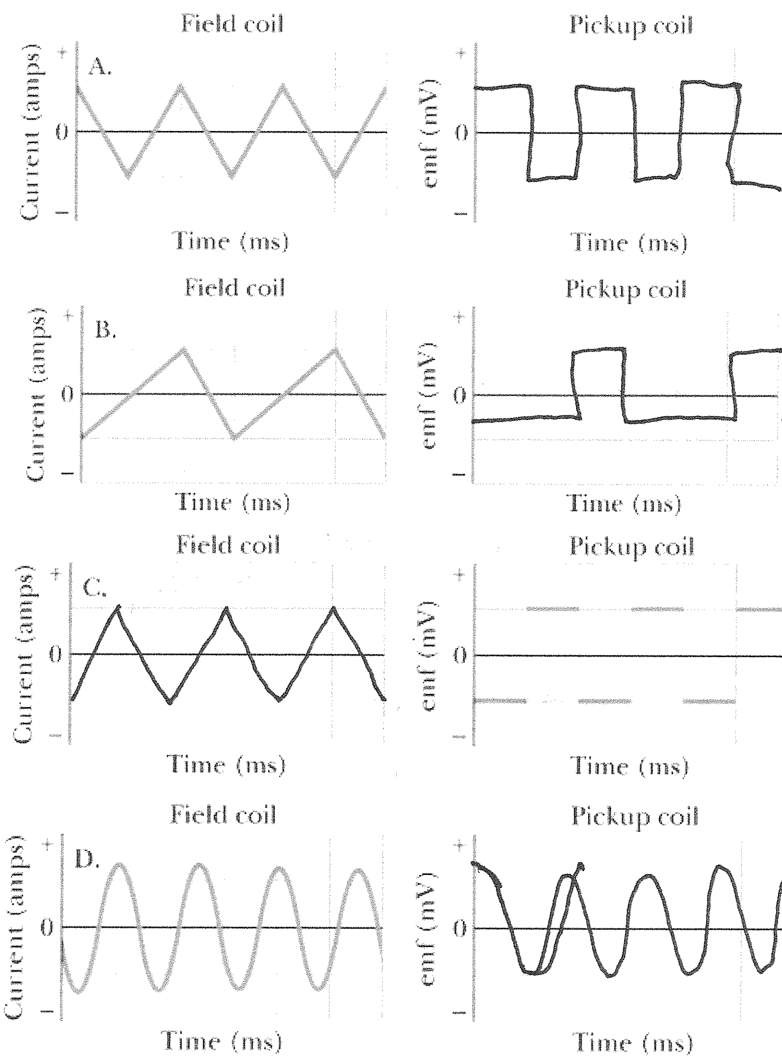


Faraday

$\oint E \cdot dl = -\frac{d}{dt}\int B \cdot dA$

B proportional to I

so $\frac{dBA}{dt} = A\frac{dB}{dt}$ proportional to $\frac{dI}{dt}$



→ 1/2 of + amplitude since slope is half as much

EMF = $-\frac{d}{dt}\int B \cdot dA$

$\frac{d}{dt}(-\sin \omega t) = -\omega \cos(\omega t)$

so EMF $\propto +\omega \cos(\omega t)$

amplitude $\propto \omega$