PHY2049 Physics with Calculus II

Section 617503

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Exam 2

July 19, 2019

Name: ______________________________

Instructions:

This exam is composed of **10 multiple choice questions** and **4 free-response problems**. To receive a perfect score (100) on this exam, 3 of the 4 free-response problems must be completed. The fourth free-response problem **may not be answered for extra credit**. Each multiple choice question is worth 2.5 points, for a total of 25 points, and each free-response problem is worth 25 points, for a total of 75 points. This means that your exam will be scored out of 100 total points, which will be presented in the rubric below. **Please do not write in the rubric below; it is for grading purposes only.**

Only scientific calculators are allowed – do not use any graphing or programmable calculators.

For multiple choice questions, no work must be shown to justify your answer and no partial credit will be given for any work. However, for the free response questions, **work must be shown to justify your answers.** The clearer the logic and presentation of your work, the easier it will be for the instructor to follow your logic and assign partial credit accordingly.

The exam begins on the next page. **The formula sheet is attached to the end of the exam.**

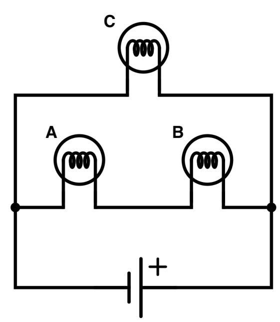
Exam Grade:

Multiple Choice	
Problem 1	
Problem 2	
Problem 3	
Problem 4	
Total	

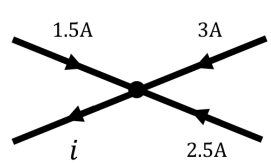
MULTIPLE CHOICE QUESTIONS

1. Capacitance is a quantity that should depend upon:
   (a) The charge stored on the capacitor
   (b) The voltage across the capacitor
   (c) The geometry of the capacitor
   (d) All of the above

2. A parallel plate capacitor is formed by placing two plates of area A a distance d apart. If these plates are connected to a battery of voltage V, a charge Q is produced on the plates. **While remaining connected to the battery**, the plate distance is doubled to $2d$. What would the new charge on the capacitor be?
   (a) $Q/4$
   (b) $Q/2$
   (c) Q
   (d) $2Q$



3. In the above figure, each lightbulb has the same resistance. Which lightbulb will glow the brightest?
   (a) A
   (b) B
   (c) C
   (d) They would glow equally bright in each arrangement



4. What is the value of i in the above figure?
   (a) 1A
   (b) 2A
   (c) 4A
   (d) 7A

5. Which arrangement of four equal resistors would have the greatest resistance?

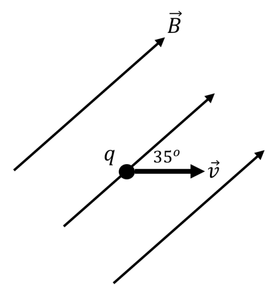
   (a) All in series
   (b) All in parallel
   (c) A mixture of series and parallel
   (d) Can't be answered without an arrangement specified

6. A wire running East-West carries a current to the east while the Earth's magnetic field points to the North. In what direction does the wire feel a magnetic force?

   (a) West
   (b) North
   (c) Up
   (d) Down

7. A 5C charge moving with a speed of 15 m/s upward enters a 2T magnetic field into the page, causing it to undergo circular motion. After one-quarter of a revolution, how much work is done on the charge?

   (a) 0J
   (b) 50J
   (c) 100J
   (d) 150J



8. A charge $q = -9$ nC moves with a speed of $v = 10,000$ m/s in the presence of a magnetic field $B = 0.05$T, as shown in the figure above. What is the force, both magnitude and direction, on the charge?

   (a) 2.6 μN, into the page
   (b) 2.6 μN, out of the page
   (c) 4.5 μN, into the page
   (d) 4.5 μN, out of the page

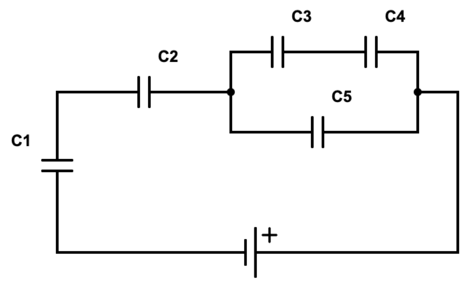
9. Two parallel wires, with currents in the same direction, will exter a force on one another that is:

   (a) Always attractive
   (b) Always repulsive
   (c) Sometimes attractive and sometimes repulsive
   (d) There isn't enough information to answer the question

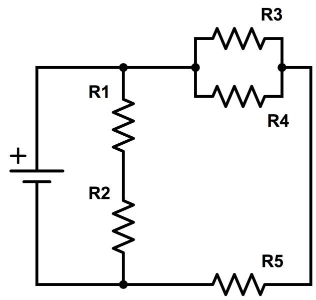
10. A wire, with a current pointing out of the page, produces a magnetic field pointing:

   (a) Counter-clockwise around the wire
   (b) Clockwise around the wire
   (c) Radially-outward from the wire
   (d) Radially-inward towards the wire

FREE-RESPONSE PROBLEMS



1. In the above circuit, the battery's voltage is 10V, $C_1 = 2\text{F}$, $C_2 = 5\text{F}$, $C_3 = 3\text{F}$, $C_4 = 1\text{F}$, and $C_5 = 2\text{F}$.
   (a) What is the equivalent capacitance of the entire circuit?
   (b) What charge is stored on C_1?
   (c) What is the voltage across C_3?
   (d) How much energy is stored by C_5?



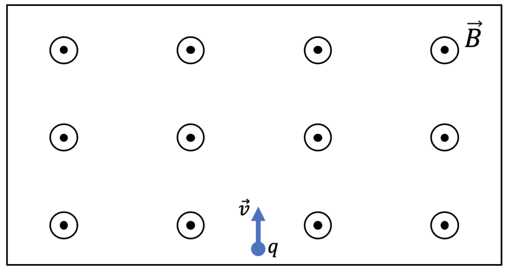
2. For the circuit above, $R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 1\Omega$, $R_4 = 3\Omega$, $R_5 = 2\Omega$, and the voltage of the battery is 10V.

(a) What is the equivalent resistance of the circuit?

(b) How much current produced by the battery?

(c) What current flows through R_3?

(d) What is the voltage across R_5?

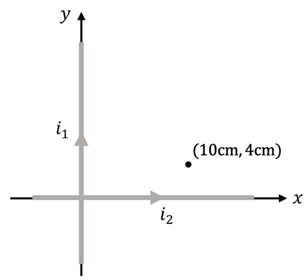


3. A mass spectrometer has a magnetic field pointing out of the page at 0.4T. A 10μC charge enters the mass spectrometer, moving upward at a 20,000 m/s, as shown in the figure.

(a) Along what path does the charge move when it enters the mass spectrometer?

(b) If the charge is detected 10cm from where it entered the mass spectrometer, what is the charge's mass?

(c) If an unknown charge were to enter the mass spectrometer at the same speed, and was found 15cm from where it entered, what is its charge per unit mass?



4. As shown the figure above, two very long wires carry perpendicular currents, with $i_1 = 1000\text{A}$ and $i_2 = 500\text{A}$.

(a) Determine the magnetic field, both magnitude and direction, of wire 1 at the point identified in the figure.

(b) Determine the magnetic field, both magnitude and direction, of wire 2 at the point identified in the figure.

(c) What is the total magnetic field, both magnitude and direction, at the point identified in the figure?

FORMULA SHEET

- Vectors:

$$\vec{A}\cdot\vec{B} = AB\cos\theta = A_xB_x + A_yB_y + A_zB_z$$
$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$

- Physics I Formulae:

$$\sum\vec{F} = m\vec{a}$$
$$W = \vec{F}\cdot\Delta\vec{x}$$
$$W_{tot} = \Delta K$$
$$W_{cons} = -\Delta U$$
$$K = \frac{1}{2}mv^2$$
$$K_i + U_i = K_f + U_f$$

- Electric Forces and Fields:

$$e = 1.6\times10^{-19}\ \mathrm{C}$$
$$\left.\begin{array}{l} k = 8.99\times10^{9}\ \dfrac{\mathrm{Nm}^2}{\mathrm{C}^2} \\ \epsilon_0 = 8.85\times10^{-12}\ \dfrac{\mathrm{F}}{\mathrm{m}} \end{array}\right\}\ k = \frac{1}{4\pi\epsilon_0}$$
$$Q = (N_p - N_e)e$$
$$F = k\frac{q_1q_2}{r^2}$$
$$\vec{F} = q\vec{E}$$
$$E = k\frac{q}{r^2}\ \text{(point charge)}$$
$$E = \frac{\lambda}{2\pi\epsilon_0}\ \text{(infinite line of charge)}$$
$$E = \frac{\sigma}{2\epsilon_0}\ \text{(infinite sheet of charge)}$$

- Gauss' Law:

$$\Phi_E = \vec{E}\cdot\vec{A} \quad \text{or} \quad \Phi_E = \int\vec{E}\cdot d\vec{A}$$
$$\Phi_{tot} = \frac{q_{enc}}{\epsilon_0}$$
$$\lambda = \frac{Q}{L} \quad \text{or} \quad \sigma = \frac{Q}{A} \quad \text{or} \quad \rho = \frac{Q}{V} \quad \text{(charge densities)}$$

- Electric Potential Energy and Electric Potential:

$$U = k\frac{q_1 q_2}{r}$$

$$\phi = k\frac{q}{r}$$

$$U = q\phi \quad \text{and} \quad \Delta U = q\Delta\phi$$

$$\vec{E} = -\vec{\nabla}\phi \quad \text{with} \quad \vec{\nabla} = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

- Resistors:

$$R = \rho\frac{L}{A}$$

$$V = iR$$

$$E = \frac{V}{L}$$

$$P = Vi$$

$$R_{\text{eq}} = R_1 + R_2 + R_3 + ... \text{ (series)}$$

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... \text{ (parallel)}$$

- Capacitors:

$$Q = CV$$

$$\left.\begin{aligned} C &= \epsilon_0\frac{A}{d} \\ E &= \frac{\sigma}{\epsilon_0} \end{aligned}\right\} \text{Parallel plate capacitors}$$

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... \text{ (series)}$$

$$C_{\text{eq}} = C_1 + C_2 + C_3 + ... \text{ (parallel)}$$

- Circuits:

$$\Delta\phi_{\text{loop}} = 0$$

$$\sum i_{\text{in}} = \sum i_{\text{out}} \text{ (Kirchhoff's Junction Rule)}$$

- Magnetism:

$$\mu_0 = 4\pi \times 10^{-7}\ \frac{\text{Tm}}{\text{A}}$$

$$B = \frac{\mu_0 i}{2\pi r} \text{ (long wire)}$$

$$\vec{F}_B = q\vec{v} \times \vec{B} \text{ (point charge)}$$

$$\vec{F}_B = i\vec{l} \times \vec{B} \text{ (wire)}$$