

PHY2049 Physics with Calculus II

Section 589357

Prof. Douglas H. Laurence

Exam 2 (Chapters 27 – 31)

July 16, 2018

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** be answered for extra credit, giving a total possible score of 125/100 on the exam. 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.

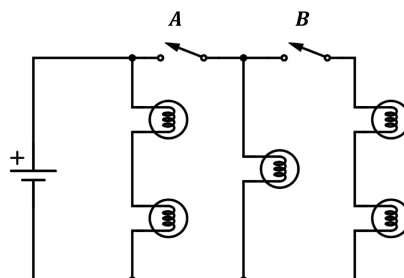
For multiple choice questions, no work must be shown to justify your answer and no partial credit will be given for any work. However, for the free response questions, **work must be shown to justify your answers**. The clearer the logic and presentation of your work, the easier it will be for the instructor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

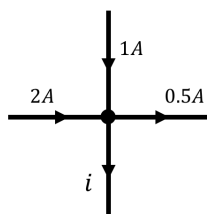
Exam Grade:

Multiple Choice	
Problem 1	
Problem 2	
Problem 3	
Problem 4	
Total	

MULTIPLE CHOICE QUESTIONS

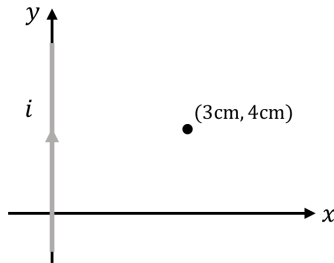


- Above, A and B are switches: If a switch is closed, current can run through the wire, but if a switch is open, current cannot. In which configuration will the total power emitted by all lightbulbs be greatest?
 - Both A and B open
 - A open but B closed
 - Both A and B closed
 - All configurations will emit the same total power
- Consider a cylindrical resistor of radius r , a length L , and a resistance R . If you doubled the radius and doubled the length, what would the new resistance be?
 - $R/8$
 - $R/4$
 - $R/2$
 - $2R$

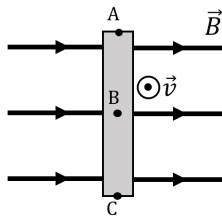


- What is the unknown current i in the figure above?
 - $0.5A$
 - $1.5A$
 - $2.5A$
 - $3.5A$
- An electron moves to the right in a magnetic field into the page. What direction is the magnetic force on this electron?
 - Up
 - Into the page
 - Down
 - Out of the page

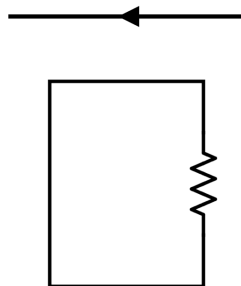
5. A proton, $q = +e$ and $m = 1.67 \times 10^{-27}$ kg, moves to the right with $v = 1500$ m/s in a magnetic field $B = 0.01$ T out of the page. The proton moves in a:
- (a) Clockwise circle, of radius $R = 1.6$ mm
 - (b) Counterclockwise circle, of radius $R = 1.6$ mm
 - (c) Clockwise circle, of radius $R = 638.7$ m
 - (d) Counterclockwise circle, of radius $R = 638.7$ m



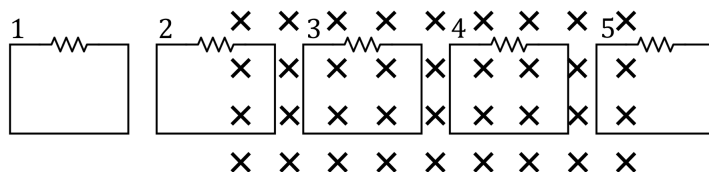
6. A very long wire, as shown in the figure above, produces a magnetic field at the point indicated. If $i = 500$ A, what is the magnitude and direction of this magnetic field?
- (a) 0.0025T into the page
 - (b) 0.0025T out of the page
 - (c) 0.0033T into the page
 - (d) 0.0033T out of the page
7. Two parallel wires carrying currents in opposite directions will produce a force on each other that is:
- (a) Attractive
 - (b) Repulsive
 - (c) Neither attractive nor repulsive
 - (d) No force will be produced in this situation



8. A conductor moves out of the page in a horizontal magnetic field, as shown above. Which point on the conductor is at the lowest potential?
- (a) A
 - (b) B
 - (c) C
 - (d) All are at equal potential

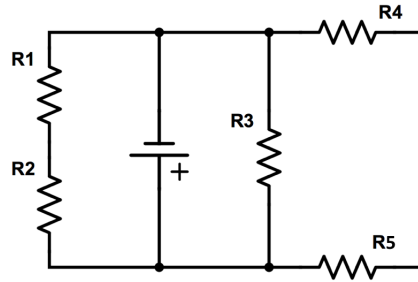


9. In the above figure, the wire carries a current that is decreasing. In what direction through the resistor will the induced current move?
- (a) Up
 - (b) Down
 - (c) Out of the page
 - (d) Into the page

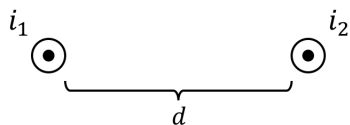


10. A loop moves to the right, passing through a region of uniform magnetic field into the page, as shown above. During which motions will there be an induced current in the loop?
- (a) 1-to-2 and 2-to-3
 - (b) 1-to-2, 2-to-3, and 3-to-4
 - (c) 1-to-2 and 4-to-5
 - (d) 1-to-2, 2-to-3, and 4-to-5

FREE-RESPONSE PROBLEMS

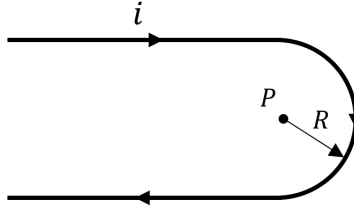


1. In the circuit above, $R_1 = 1\Omega$, $R_2 = 3\Omega$, $R_3 = 2\Omega$, $R_4 = 1\Omega$, $R_5 = 2\Omega$, and the battery is 5V.
 - (a) What is the equivalent resistance of this circuit?
 - (b) What is the current through R_3 ?
 - (c) How much power is produced by R_4 ?
 - (d) What is the voltage across R_1 ?



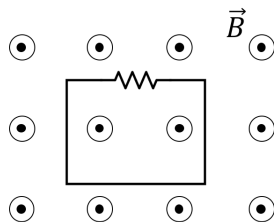
2. As shown above, a very long wire carrying a current $i_1 = 2000\text{A}$ out of the page is placed a distance $d = 7\text{cm}$ away from a second very long wire, carrying a current $i_2 = 2500\text{A}$ out of the page.

- (a) What is the magnitude of the force per unit length between each wire? Is it attractive or repulsive?
- (b) What is the magnetic field produced at the center of these two wires? Give both magnitude and direction.
- (c) What would the force on a 1m wire, carrying a current $i_3 = 1000\text{A}$ into the page, be if it were placed halfway between the two wires in the above figure? Give both magnitude and direction.



3. In the above figure, we want to break the wire up into three segments: 1) the long wire on top, carrying the current to the right; 2) the half-loop, carrying the current clockwise; and 3) the long wire on bottom, carrying the current to the right. In this problem, the current is $i = 200\text{A}$ and the radius of the loop is $R = 17\text{cm}$.

- (a) What will the magnitude of the magnetic field be due to segments 1 and 3 at point P ? *Hint: Don't forget that the point P is at the end of the wire, not somewhere in the middle.*
- (b) What will the magnitude of the magnetic field be due to segment 2 at point P ?
- (c) What is the direction of the magnetic field produced by each segment?
- (d) Using the answers to parts (a), (b), and (c), what is the net magnetic field at point P ? This is the magnetic field due to the entire, U-shaped wire.



4. As shown above, a loop is placed in a magnetic field pointing out of the page. The loop has dimensions $10\text{cm} \times 15\text{cm}$.

- (a) When the magnetic field is $B = 1.5\text{T}$, what is the magnetic flux through the loop?
- (b) If this magnetic field decreased at 0.2 T/s , what would the induced EMF on the loop be?
- (c) If the resistor shown in the loop was 8Ω , what would the induced current in the loop be?
- (d) In what direction through the resistor would the induced current flow?

FORMULA SHEET

- Vectors:

$$\vec{A} \cdot \vec{B} = AB \cos \theta = A_x B_x + A_y B_y + A_z B_z$$

$$|\vec{A} \times \vec{B}| = AB \sin \theta$$

- Physics I Formulae:

$$\sum \vec{F} = m\vec{a}$$

$$W = \vec{F} \cdot \Delta \vec{x} \quad \text{or} \quad W = \int \vec{F} \cdot d\vec{x}$$

$$W_{tot} = \Delta K$$

$$W_{cons} = -\Delta U$$

$$K = \frac{1}{2}mv^2$$

$$K_i + U_i = K_f + U_f$$

$$\vec{F} = -\vec{\nabla}U \quad \text{where} \quad \vec{\nabla}f = \frac{\partial f}{\partial x}\hat{i} + \frac{\partial f}{\partial y}\hat{j} + \frac{\partial f}{\partial z}\hat{k}$$

$$a_c = \frac{v^2}{r}$$

- Electric Forces and Fields:

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\left. \begin{aligned} k &= 8.99 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \\ \epsilon_0 &= 8.85 \times 10^{-12} \frac{\text{F}}{\text{m}} \end{aligned} \right\} k = \frac{1}{4\pi\epsilon_0}$$

$$Q = Ne$$

$$F = k \frac{q_1 q_2}{r^2}$$

$$\vec{F} = q\vec{E}$$

$$E = k \frac{q}{r^2}$$

$$\text{or} \quad E = \int k \frac{dq}{r^2} \quad \text{with} \quad dq = \text{density} * \text{space element}$$

$$\text{where} \quad \lambda = \frac{Q}{L} \quad \text{or} \quad \sigma = \frac{Q}{A} \quad \text{or} \quad \rho = \frac{Q}{V} \quad (\text{densities})$$

$$\Phi_E = \vec{E} \cdot \vec{A} \quad \text{or} \quad \Phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\Phi_{tot} = \frac{q_{enc}}{\epsilon_0}$$

- Electric Potential Energy and Electric Potential:

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

$$\phi = k \frac{q}{r} \quad \text{or} \quad \phi = \int k \frac{dq}{r}$$

$$dq = \text{density} * \text{space element}$$

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

$$\vec{\nabla} f = \frac{\partial f}{\partial x} \hat{i} + \frac{\partial f}{\partial y} \hat{j} + \frac{\partial f}{\partial z} \hat{k}$$

$$\vec{F} = -\vec{\nabla} U$$

$$\vec{E} = -\vec{\nabla} \phi$$

$$U = - \int \vec{F} \cdot d\vec{x} \quad \text{or} \quad \Delta U = - \int_S \vec{F} \cdot d\vec{x}$$

$$\phi = - \int \vec{E} \cdot d\vec{x} \quad \text{or} \quad \Delta \phi = - \int_S \vec{E} \cdot d\vec{x}$$

$$V = \Delta \phi$$

- Capacitance and Dielectrics:

$$Q = CV$$

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

- Direct Current Circuits

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

$$V_R = iR$$

$$P = Vi = i^2 R = \frac{V^2}{R}$$

$$\sum_{\text{loop}} V = 0 \quad (\text{Kirchhoff's Loop Rule})$$

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

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

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

- Magnetism

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

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \vec{r}}{r^3} \quad (\text{Biot-Savart law, point charge})$$

$$\vec{B} = \frac{\mu_0}{4\pi} \int \frac{id\vec{l} \times \vec{r}}{r^3} \quad (\text{Biot-Savart law, current})$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 i_{\text{enc}} \quad (\text{Ampere's law})$$

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

$$B = \frac{\mu_0 i}{2R} \quad (\text{center of a loop})$$

$$B = \mu_0 \frac{N}{L} i = \mu_0 n i \quad (\text{center of a solenoid})$$

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

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

- Electromagnetic Induction

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$$

$$\mathcal{E}_{\text{ind}} = -\frac{d\Phi_B}{dt}$$