Name ___________________

PHYS 2025
Test #3
Fall 2009 (Buckley)

**Conceptual Questions.** Possible points are listed in parentheses to the right of each problem number.

1. (4 points) Consider the figure to the right. The vertical wire conducts a steady current in the direction indicated. State the direction of the current (clockwise, counterclockwise, or no current) induced in both the left loop and the right loop if they are moved as indicated by the \( v \) vectors. Briefly explain why you made each decision.

2. (4 points) Consider the figure to the right. Briefly explain each answer.

   a. In which direction would the current flow through resistor \( R_A \) if Coil A is moved toward Coil B?

   b. In which direction would the current flow through resistor \( R_A \) if resistor \( R_B \) is decreased?
3. (5 points) Consider the figure to the right, but ignore the numerical values on it. Place a check mark next to each action below that would cause the magnetic flux to decrease through the loop.

- Increase the strength of the magnetic field.
- Tip the loop from being parallel to the page to being perpendicular to the page.
- Pull the loop straight up from the page.
- Move the loop to the left without any part of it exiting the magnetic field.
- Move the loop to the left until a part of it has exited the magnetic field.

4. (5 points) Consider again the figure from Problem 3, again ignoring the numerical values on it. Indicate below whether the induced current would be clockwise (CW), counterclockwise (CCW), or there would be no current (0) for each of the situations below.

- Increase the strength of the magnetic field.
- Tip the loop from being parallel to the page to being perpendicular to the page.
- Pull the loop straight up from the page.
- Move the loop to the left without any part of it exiting the magnetic field.
- Move the loop to the left until a part of it has exited the magnetic field.

5. (6 points) Fill in the missing information in the following table. Each row represents a set of results for either a convex or concave mirror.

<table>
<thead>
<tr>
<th>f</th>
<th>d_o</th>
<th>d_i</th>
<th>m</th>
<th>Type of Mirror (Convex or Concave?)</th>
<th>Image Orientation (Upright or Inverted?)</th>
<th>Image Size (Larger or Smaller than object?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0</td>
<td>&gt;0</td>
<td>&lt;0</td>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>-0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Numerical Problems. Show your work on all problems to receive full credit.

6. (9 points) A 10.5-cm diameter horizontal circular loop is in a 1.50-T vertical magnetic field.

   a. Find the induced emf in the loop if it is removed completely from the field in 0.75-s.

   b. If the resistance of the loop is 0.05 Ω, what is the current induced in the loop during the process of part a?

   c. Find the induced emf starting from the initial conditions in the problem statement if the loop is now tilted so it makes an angle of 30° with the vertical in a period of 2.5-s.
7. (3 points) A transformer has 5000 turns on the primary coil and 3000 turns on the secondary coil.

   a. Is this a step-up or a step-down transformer?

   b. If the input voltage is 240-V, what is the expected output voltage?

   c. The input current is 15.0-A. What is the output current?

   d. If the transformer is only 90% efficient, how much power is delivered at the output side?

8. (6 points) A 12.0-cm tall object is placed 25.0-cm from a concave mirror with a focal length of 15.0-cm. Determine the location of the image, its height, whether it is upright or inverted, its magnification, and whether it is real or imaginary.
9. (12 points) Consider the figure to the right. The shape is a nonconducting sphere of radius \( r_0 \) with a centered spherical cavity inside of radius \( r_1 \). The charge \( Q \) is uniformly distributed in the outer shell (between \( r = r_1 \) and \( r = r_0 \)). Let’s use Gauss’s Law to work our way toward finding the electric field as a function of \( r \) for \( r < r_1 \), \( r > r_1 \) and \( r < r_0 \), and \( r > r_0 \).

a. What is the electric field in the case where \( r < r_1 \)?

b. In terms of \( r_0 \) and \( r_1 \) and any necessary constants, what is the volume of the outer shell – remember to exclude the cavity?

c. In terms of \( r_0 \), \( r_1 \), \( r \), and any necessary constants, what fraction of the total volume of the shell is contained a distance of \( r \) from the center where \( r > r_1 \) and \( r < r_0 \)?

d. In terms of \( r_0 \), \( r_1 \), \( r \), \( Q \), and any necessary constants, what fraction of the total charge is contained a distance of \( r \) from the center where \( r > r_1 \) and \( r < r_0 \)?

e. Using Gauss’s Law, find \( E(r) \) for \( r > r_1 \) and \( r < r_0 \)?

f. Using Gauss’s Law, find \( E(r) \) for \( r > r_0 \)?
10. Equations of potential interest:

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{V_S}{V_p} = \frac{N_S}{N_p} \]

\[ \frac{I_S}{I_p} = \frac{N_p}{N_S} \]

\[ \xi = \frac{-\Delta \Phi_B}{t} \]

\[ \Phi_B = B A \cos(\theta) \]

\[ \oint \vec{E} \cdot d\vec{A} = \frac{Q}{\varepsilon_0} \quad \text{(Gauss's Law)} \]

\[ \oint \vec{B} \cdot d\vec{A} = 0 \]

\[ \oint \vec{E} \cdot d\ell = -\frac{d\Phi_B}{dt} \quad \text{(Faraday's Law)} \]

\[ \oint \vec{B} \cdot d\ell = \mu_0 I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} \quad \text{(Ampere's Law with Maxwell's addition)} \]

Volume of sphere = \( \frac{4}{3} \pi r^3 \) \quad Surface area of sphere = \( 4\pi r^2 \)