

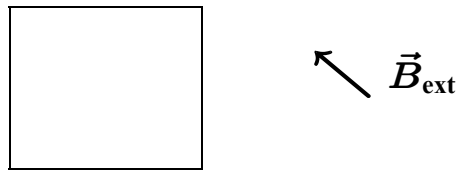
PHYSICS 112 - SUMMER 2005 - EXAM 3

Name: _____ Recitation Section: _____

NO CALCULATORS ALLOWED - BUT, LUCKILY, NO CALCULATORS NEEDED.

SHOW YOUR WORK! Full credit will be given only if you explain how you arrived at your answer. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required, but the grader must be able to follow your reasoning clearly.

1. [5 points] A square circuit is shown below. It is located in a uniform magnetic field directed in the direction shown (in the same plane as the circuit). Assume that there is a clockwise current in the circuit.

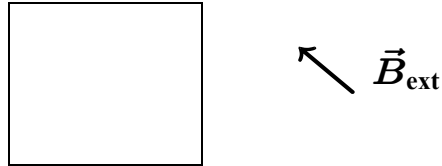


(a) [1 point] Determine the direction of the magnetic field of the current on the inside of the circuit, and mark it on the diagram.

(b) [2 points] Determine the direction of the magnetic force on each side of the circuit. Mark these on the diagram.

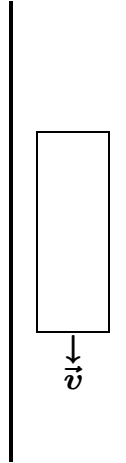
(c) [2 points] Determine if there is a net torque on the circuit, and, if so, describe how the circuit will rotate (for example, "clockwise as viewed from below the bottom of the circuit").

2. [7 points] A square circuit is shown below; it is held so it cannot rotate. Each side has length 0.20 m, and the total resistance of the circuit is 4.0Ω . It is located in a uniform magnetic field of magnitude 0.30 T directed in the direction shown (in the same plane as the circuit). Assume that the direction of the magnetic field changes smoothly over a period of 3.0 seconds through a 90° angle until it is directed up (\odot).



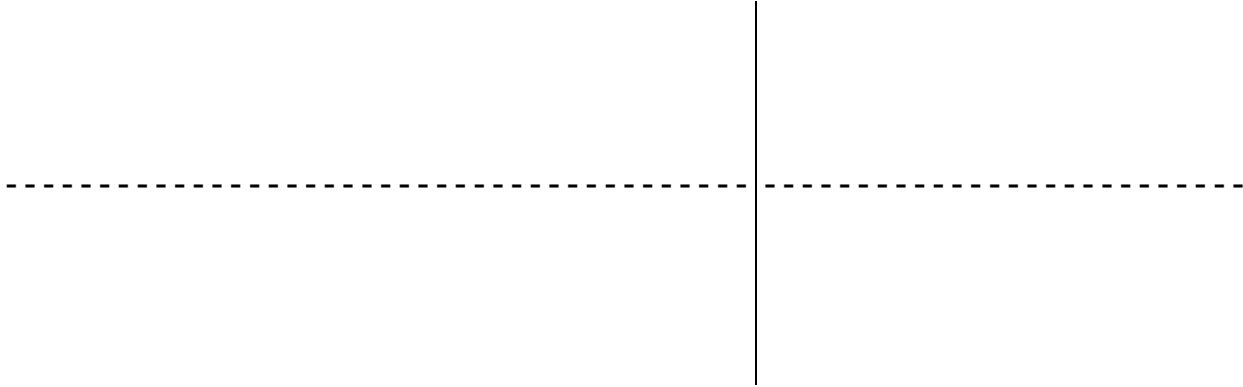
- (a) Determine the initial magnetic flux through the circuit.
- (b) Determine the final magnetic flux through the circuit.
- (c) Determine the direction of the induced current in the circuit. Give a brief explanation.
- (d) Determine the average current during the period the magnetic field is rotating.

3. [8 points] Remember the demonstration of the magnet dropping slowly through a long vertical aluminum tube? Assuming that the magnet is dropping south-pole down, give a careful explanation of why the currents induced below the falling magnet and above the falling magnet both produce upward forces on the magnet. Make reference to (1) the direction of the magnetic field at the location of these currents, (2) whether the field is increasing or decreasing, and (3) the direction of the magnetic field of the currents.



4. [10 points] An object is located on the principal axis of a convergent lens at a distance of 6.0 cm from the vertex of the lens. The magnitude of the focal length of the lens is 18 cm.

(a) [4 points] On the diagram below, approximately to scale, draw three different rays that permit you to locate the image formed by the lens. (The principal axis is shown.)



(b) [3 points] Using your diagram, characterize the image (real or virtual, orientation, size relative to object).

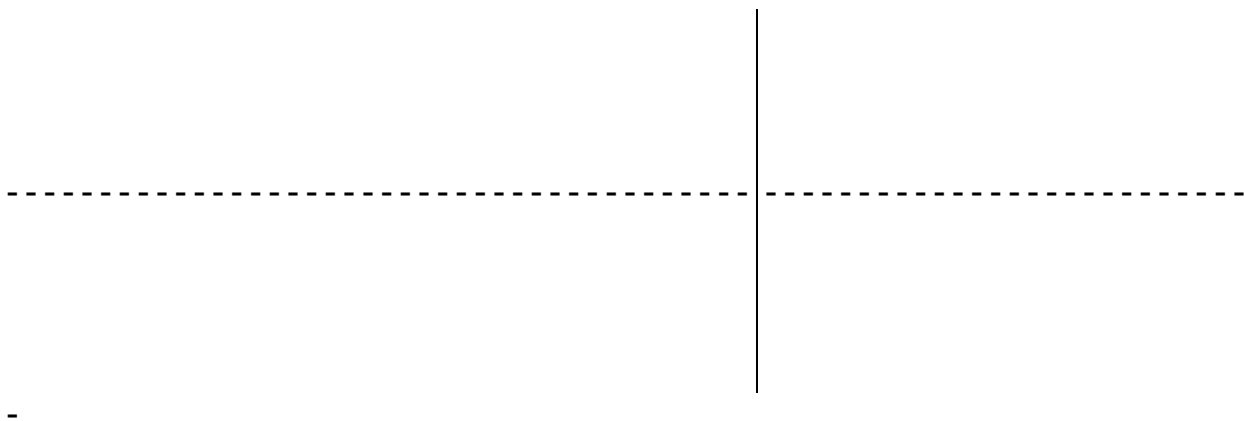
(c) [3 points] Use the lens equation to determine the image distance and magnification (including their correct signs and units!).

5. [10 points] When an object is placed 6.0 cm from a spherical mirror, it is found that the image is a virtual image located 12.0 cm from the mirror.

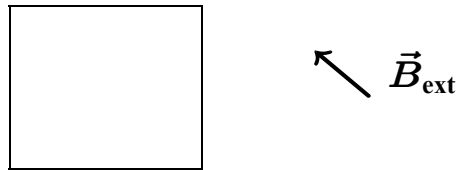
(a) [6 points] Write down the numerical values of the object and image distances and determine the focal length of the mirror; include the correct sign for each of these quantities. What is its radius of curvature of the mirror? Is this a concave mirror or a convex mirror or a plane mirror?

(b) [1 point] What is the magnification m in this case (including the correct sign of m)?

(c) [3 points] Make a sketch of this mirror and its object and image locations, with at least three rays used to location the image properly.



1. [5 points] A square circuit is shown below. It is located in a uniform magnetic field directed in the direction shown (in the same plane as the circuit). Assume that there is a clockwise current in the circuit.



(a) [1 point] Determine the direction of the magnetic field of the current on the inside of the circuit, and mark it on the diagram.

It is \otimes .

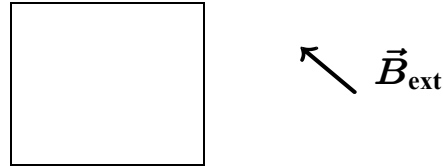
(b) [2 points] Determine the direction of the magnetic force on each side of the circuit. Mark these on the diagram.

\odot on the left and top sides, \otimes on the right and bottom sides.

(c) [2 points] Determine if there is a net torque on the circuit, and, if so, describe how the circuit will rotate (for example, "clockwise as viewed from below the bottom of the circuit").

There is a net torque. The circuit will rotate clockwise as viewed from the bottom left corner.

2. [7 points] A square circuit is shown below; it is held so it cannot rotate. Each side has length 0.20 m, and the total resistance of the circuit is 4.0Ω . It is located in a uniform magnetic field of magnitude 0.30 T directed in the direction shown (in the same plane as the circuit). Assume that the direction of the magnetic field changes smoothly over a period of 3.0 seconds through a 90° angle until it is directed up (\odot).



(a) Determine the initial magnetic flux through the circuit.

Initially the magnetic flux is zero, because there is a 90° angle between the directions of \vec{B}_{ext} and the normal to the plane of the circuit.

(b) Determine the final magnetic flux through the circuit.

$$\Phi = BA \cos \theta = (0.30 \text{ T})(0.20 \text{ m})^2 \cos (0^\circ) = 0.012 \text{ T} \cdot \text{m}^2$$

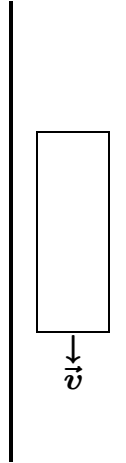
(c) Determine the direction of the induced current in the circuit. Give a brief explanation.

The general direction of the magnetic flux due to the external magnetic field is \odot , and it is increasing in magnitude, so the induced current must be clockwise to oppose this change in magnetic flux.

(d) Determine the average current during the period the magnetic field is rotating.

$$I = (\Delta\Phi/\Delta t)/R = (\Delta\Phi)/R\Delta t = (0.012 \text{ T} \cdot \text{m}^2)/(4.0 \Omega)(3.0 \text{ s}) = 0.001 \text{ A or } 1.0 \text{ mA}$$

3. [8 points] Remember the demonstration of the magnet dropping slowly through a long vertical aluminum tube? Assuming that the magnet is dropping south-pole down, give a careful explanation of why the currents induced below the falling magnet and above the falling magnet both produce upward forces on the magnet. Make reference to (1) the direction of the magnetic field at the location of these currents, (2) whether the field is increasing or decreasing, and (3) the direction of the magnetic field of the currents.

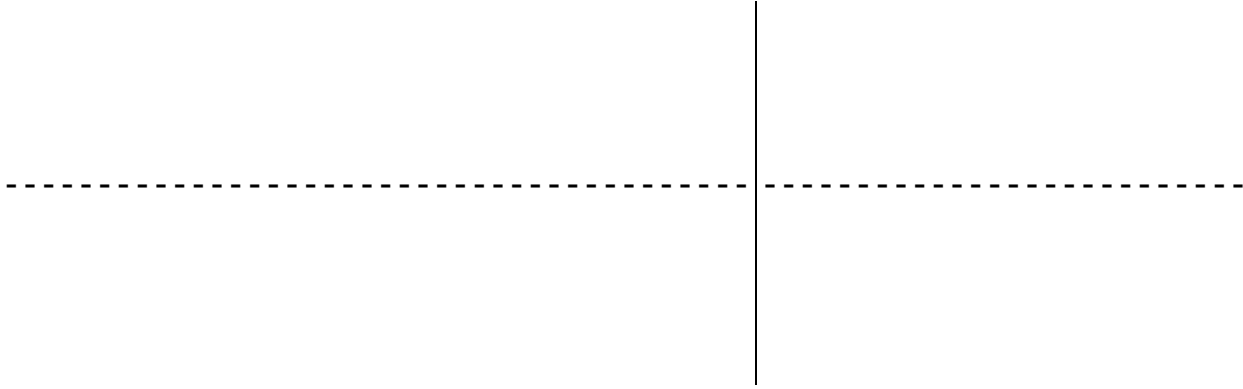


Above the falling magnet the magnet's magnetic field is directed up (\uparrow) from the north pole and is decreasing as the magnet falls, so the induced currents must also produce a magnetic field up, meaning they are also south-pole down. Thus they attract the magnet upward.

Below the falling magnet the magnet's magnetic field is directed up (\uparrow) towards the south pole and is increasing as the magnet falls, so the induced currents must produce an opposing magnetic field down, meaning they are north-pole down. Thus they repel the magnet upward.

4. [10 points] An object is located on the principal axis of a convergent lens at a distance of 6.0 cm from the vertex of the lens. The magnitude of the focal length of the lens is 18 cm.

(a) [4 points] On the diagram below, approximately to scale, draw three different rays that permit you to locate the image formed by the lens. (The principal axis is shown.)



(b) [3 points] Using your diagram, characterize the image (real or virtual, orientation, size relative to object).

(c) [3 points] Use the lens equation to determine the image distance and magnification (including their correct signs and units!).

$f = 18 \text{ cm}$ and $o = 6 \text{ cm}$ are given.

$$1/i = 1/f - 1/o = 1/(18 \text{ cm}) - 1/(6 \text{ cm}) = (1 - 3)/(18 \text{ cm})$$

$$= -2/18 \text{ cm} = -1/9 \text{ cm so } i = -9 \text{ cm}$$

$$m = -i/o = -(-9 \text{ cm})/(6 \text{ cm}) = +1.5$$

This is a virtual image (since i is negative) and it is erect (since m is positive) and 1.5 time larger than the object.

5. [10 points] When an object is placed 6.0 cm from a spherical mirror, it is found that the image is a virtual image located 12.0 cm from the mirror.

(a) [6 points] Write down the numerical values of the object and image distances and determine the focal length of the mirror; include the correct sign for each of these quantities. What is its radius of curvature of the mirror? Is this a concave mirror or a convex mirror or a plane mirror?

We are told that $o = 6.0$ cm and $i = -12.0$ cm (negative because the image is virtual).

Thus $1/f = 1/i + 1/o = 1/(-12.0 \text{ cm}) + 1/(6.0 \text{ cm}) = (-1 + 2)/(12.0 \text{ cm}) = 1/12.0 \text{ cm}$

so $f = 12.0$ cm. Since this is positive, the mirror must be concave. The image was virtual because the object was placed inside the focal point of the mirror.

(b) [1 point] What is the magnification m in this case (including the correct sign of m)?

$$m = -i/o = -(-12.0 \text{ cm})/(6.0 \text{ cm}) = +2.$$

(c) [3 points] Make a sketch of this mirror and its object and image locations, with at least three rays used to location the image properly.

