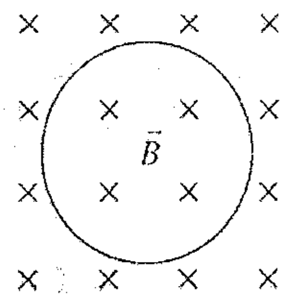
Name: KEY Student Number:

Physics Tutorial
Magnetic Induction

Question 1



Does the loop of wire have a clockwise current, a counterclockwise current, or no current under the following circumstances? Explain.

a. The magnetic field points into the page and its strength is increasing.

CCW - The system wants to make an upward flux through the loop (out of the page) to oppose the change.

b. The magnetic field points into the page and its strength is constant.

ZERO - The current only appear when there is a change in magnetic flux.

c. The magnetic field points into the page and its strength is decreasing.

CW - The system wants to make a field in to the page to make the field as strong as it was before.

note: the induced field will not be strong enough to make the field as strong as it was before.

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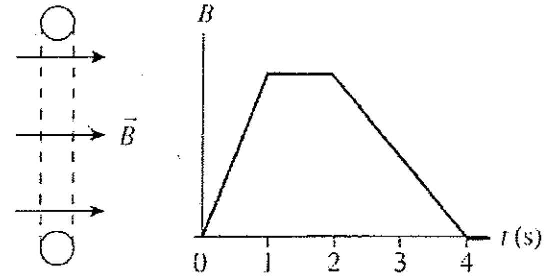
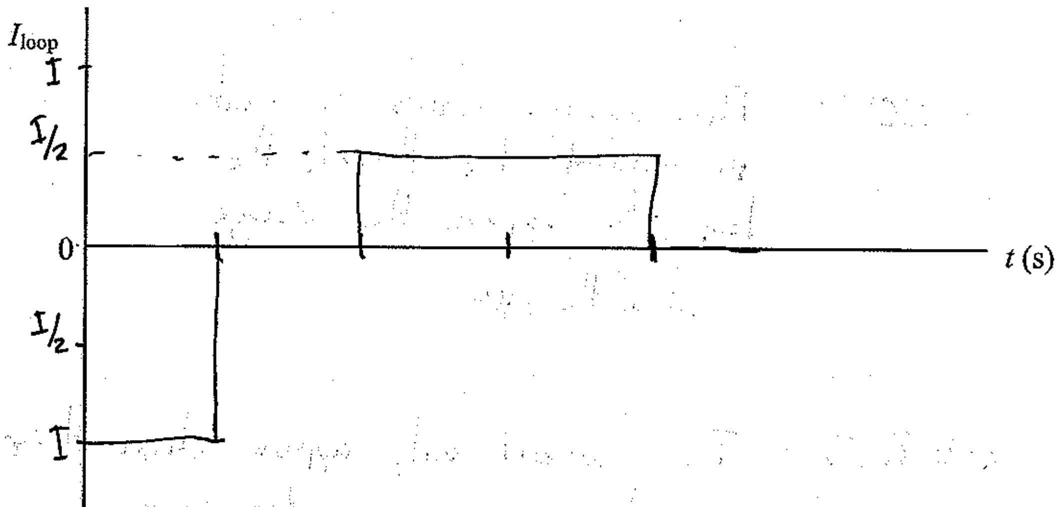
Question 2

A loop of wire is perpendicular to a magnetic field. The magnetic field strength as a function of time is given by the top graph. Draw a graph of the current in the loop as a function of time.

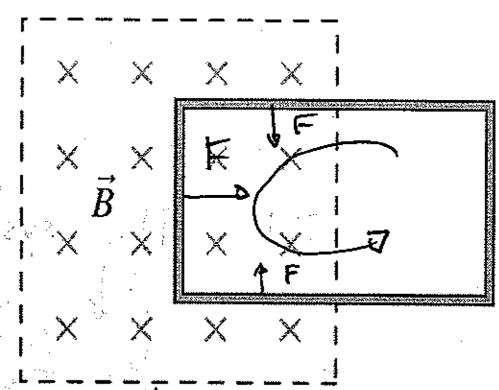


Let a positive current represent a current that comes out of the top and enters the bottom. There are no numbers for the vertical axis, but your at graph should have the correct shape and proportions.



Question 3

A conducting loop is halfway into a magnetic field. Suppose the magnetic field begins to increase rapidly in strength. What happens to the loop?



The increasing field makes a ccw current in the loop.

The current inside the magnetic field experiences a force. The top and bottom forces cancel. The force of the left side of the loop makes the loop shoot out to the right.

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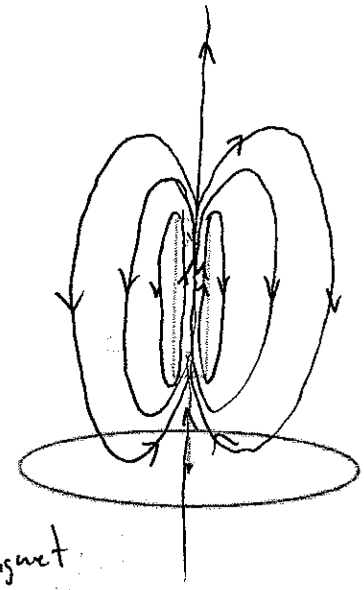
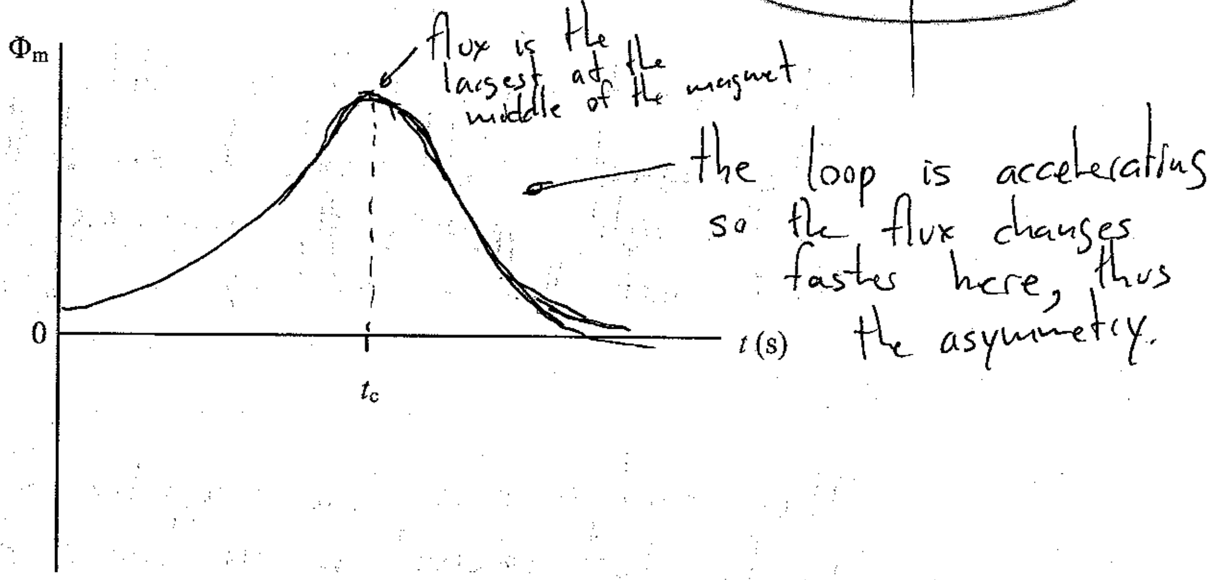
Question 4

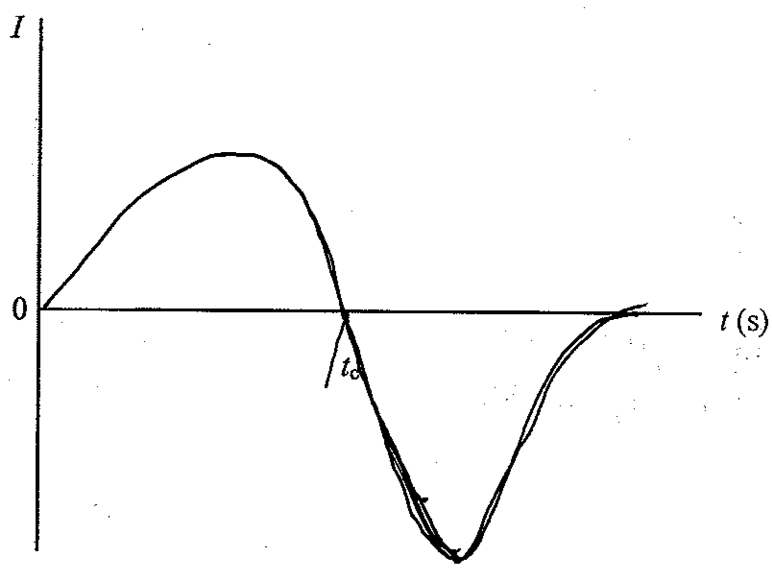


A bar magnet is dropped, south pole down, through the center of a loop of wire. The center of the magnet passes the plane of the loop at t_c,

a. Sketch a graph of the magnetic flux through the loop as a function of time.



b. Sketch a graph of the current in the loop as a function of time. Let a clockwise current be a positive number and a counterclockwise current be a negative number



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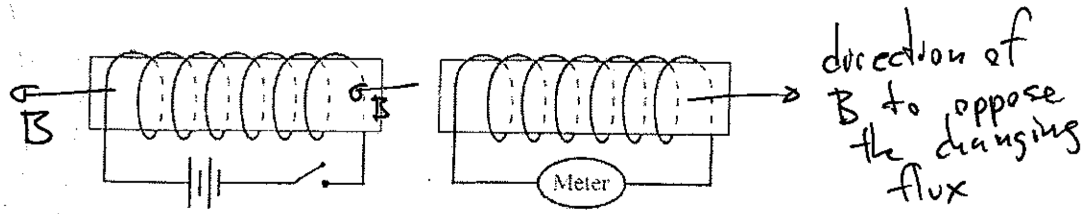
Question 5



a. Just after the switch on the left coil is closed, does current flow right to left or left to right through the current meter of the right coil? Or is the current zero? Explain.

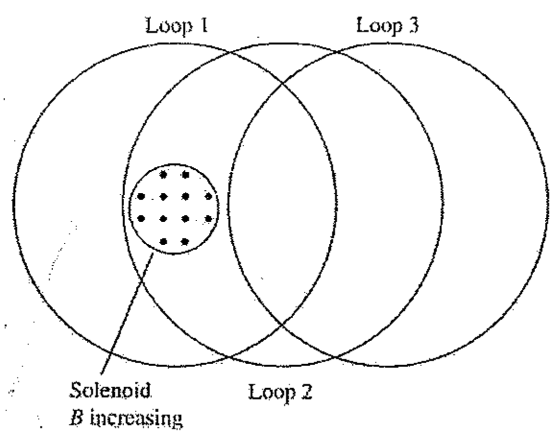
The current flows left to right. The magnetic field inside to solenoid then points to the right, opposing the increasing B pointing to the left that is created by left solenoid.

b. Long after the switch on the left coil is closed, does current flow right to left or left to right through the current meter of the right coil? Or is the current zero? Explain.

The current is zero. The magnetic field in the left solenoid is no longer changing, so there's no change in flux to oppose.

Question 6

A solenoid is perpendicular to the page, and its field strength is increasing. Three circular wire loops of equal radii are shown. Rank in order, from largest to smallest, the size of the induced emf in the three rings.



Order: $1 = 2 > 3$

Explanation:

$\Phi = A \cdot B$ is equal for 1 and 2. For 3, $B = 0$, so $\Phi = 0$.

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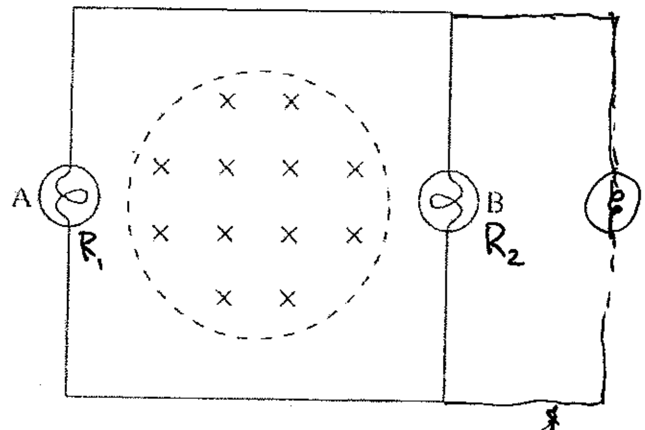
$$I = \frac{\varepsilon}{R_1 + R_2}$$

Question 7

A conducting loop around a magnetic field contains two light bulbs, A and B. The wires connecting the bulbs are ideal, with no resistance. The magnetic field is increasing rapidly.



a. Do the bulbs glow? Why or why not?

The change in flux creates an emf in the wire that makes a current.

The bulbs glow.

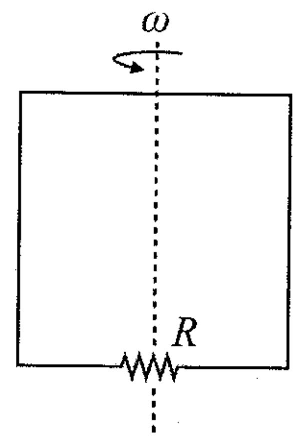
b. If they glow, which bulb is brighter? Or are they equally bright? Explain.

The bulbs have equal resistance, so the glow the same brightness.

The bulbs still glow the same brightness if we move this bulb further away from the flux.

Question 8

Wind and water turbines use induction to generate electricity. One way to do this is to have the spinning blades rotate a wire loop sitting inside a constant magnetic field.



B is uniform into page

Imagine the loop in the picture is a square with sides of length ℓ that is rotating at a constant angular velocity ω. The wire has a total resistance of R.

Find an expression for the current generated in the loop. You'll find it helpful to start by determining how the magnetic flux through the loop changes as a function of time. This can be used to find the emf, and thus the current.

$$\Phi = A \cdot B = AB\cos\theta = AB\cos(\omega t)$$

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

$$I = \frac{\varepsilon}{R} = -\frac{\omega AB}{R}\sin(\omega t)$$

The windmill generates AC current!

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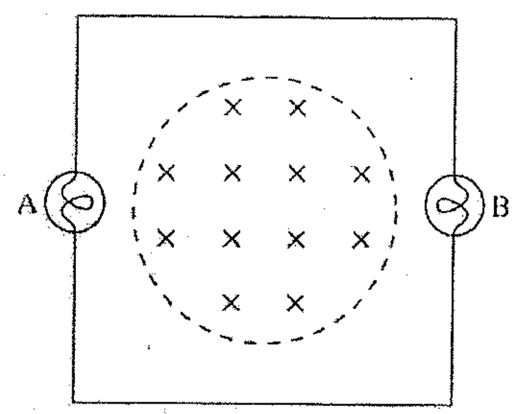
Question 9 (Extra)

The situation is similar Question 7, but now A and B have different resistances, R_A and R_B.

The magnetic field is increasing rapidly.



a. What is the current through each light bulb? Is it the same or different?

Same. (I)

b. What is the voltage dropped across each light bulb?

$V_A = IR_A \quad V_B = IR_B$

c. Do your results agree with Kirchhoff's loop law? Explain. If not, explain how you could modify the loop law.

The loop law says that $\Delta V_{loop} = 0 \Rightarrow -V_A - V_B = 0$! Which isn't true. In fact,

$-V_A - V_B = -\frac{d\Phi}{dt}$ as given by Faraday's Law.