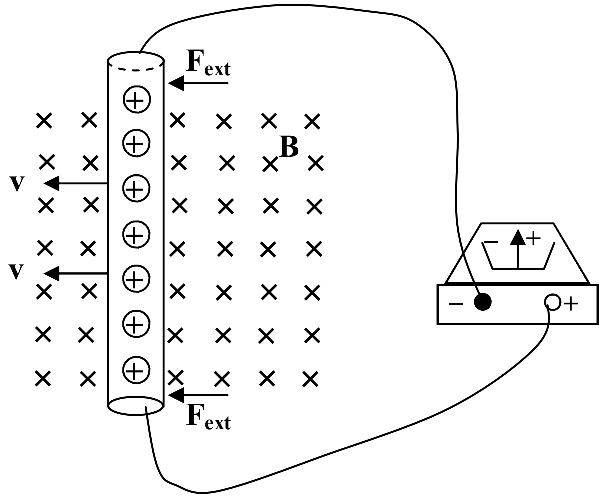
2011 PreAP Magnetism 4

1. From the notes, define electromagnetic induction.



2. A wire is moved while inside a magnetic field, as shown. The wire is NOT being moved by the magnetic force, but by an external force (*like a person*). When the wire moves, a bunch of positive charges (+q's) are moving to the left.
   A. * What part of the RHR is the moving wire?

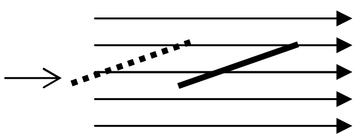
   B. * Which direction will the magnetic force inside the wire be?

   This magnetic force pushes the charges in the wire.

   C. Which direction will the induced current flow inside the wire?

   D. If the wire is connected to a galvanometer as shown, will the galvanometer read positive or negative (*see top of notes*)?

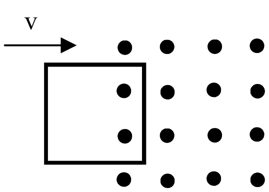
   So, you should now know how to use the RHR to find the induced current in a wire.



In the above example you will notice that the wire is "breaking" the magnetic field lines. Image the field lines as laser beams or infrared sensor beams going into the page. The wire is crossing them, setting off a burglar alarm.

In the example at the left the magnetic field lines are pointing to the right and the wire is moving to the right. It is NOT breaking the magnetic field lines: it is passing between them. So no current is induced in this wire. OR, by the RHR, the wire (q, thumb) and B (fingers) are in the same direction, so no force (palm)

3. A square loop is moving to the right. It enters into a magnetic field that is pointing out of the page.



A. * The left side of the loop is not yet into the field, so what is the direction of the magnetic force in the left side of the loop?

B. * The right side of the loop has just entered the field. What is the direction of the magnetic force in the right side of the loop?

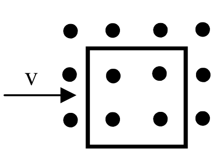
Like charges repel each other, so if the charges in the right side of the loop move down, they will push all of the charges around the loop.

C. * Will the induced current in the square loop be clockwise (CW) or counterclockwise (CCW)?

D. * This induced current ($I_{induced}$) causes it own magnetic field, called the induced magnetic field ($B_{induced}$). (*Remember that circular current creates straight magnetic fields*.) Use the circular right hand rule to figure out the direction of $B_{induced}$.

Notice that the direction of $B_{induced}$ is opposite of the original magnetic field. This is "Lenz's Law": "The induced magnetic opposes a change of magnetism." As the loop enters the magnetic field the amount of magnetic field is increasing into the loop. (Right now there are 2 field lines going thru the loop. Soon 4 lines will be in the loop, then 6 lines. The magnetic field is increasing in the loop out of the page.) So, $B_{induced}$ opposes that change by pointing into the page.

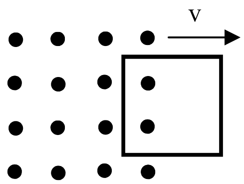
Now let's consider when the loop is entirely in the magnetic field.



E. * Just as before, in part B above, what is the direction of the magnetic force (and $I_{induced}$) in the two vertical sections of the loop?

F. * One of these forces pushes the current CW and the other CCW. So what is the direction of $I_{induced}$ in the loop?

So, since the loop is entirely inside the field, there is no change of B in the loop, so there is no $I_{induced}$ and no $B_{induced}$ in the loop.



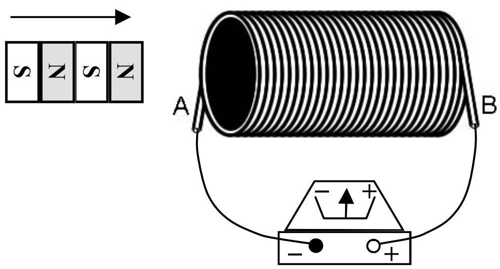
Finally, the loop is moving out of the field on the right side.

G. * What is the direction of $I_{induced}$ in the loop?

H. * What is the direction of $B_{induced}$ caused by $I_{induced}$ in the loop?

As the loop leaves the field, the amount of B pointing out of the page is decreasing, so $B_{induced}$ restrengthen the magnetic field, pointing out of the page to oppose the change.

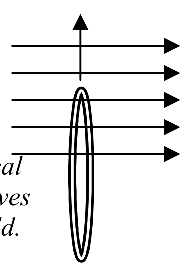
So, once again, $I_{induced}$ creates a $B_{induced}$ that OPPOSES a change of magnetic field. This is Lenz's Law. Let's show this a different way.



4. The north pole of a stack of magnets is moved into a solenoid.
   A. When is there an induced current: when the magnets are moving into, moving out, or just sitting in the solenoid?
   B. * Since a north pole is moving into the solenoid, which way would the $B_{induced}$ have to point to oppose the incoming magnet?
   C. * Looking from the left, is the induced current be moving clockwise or counterclockwise in the loops?
   D. Will the induced current cause the galvanometer to read positive or negative?

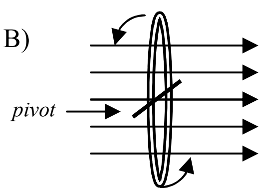
5. Now you know that there has to be a change of B inside the loop for current to be induced. For each of the following instances, decide if there will be an induced current in the wire loop.

A)



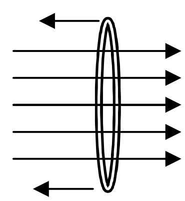
A vertical loop moves into field.

B)



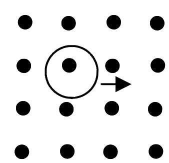
Spin the loop around a diameter.

C)



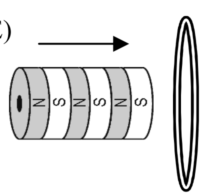
Move the loop parallel to the field.

D)



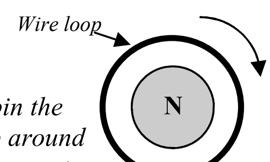
While the loop is completely inside the field.

E)



Move magnets into the loop.

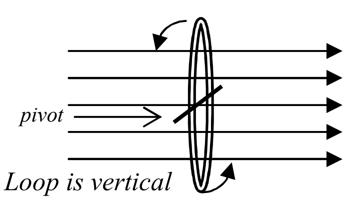
F)



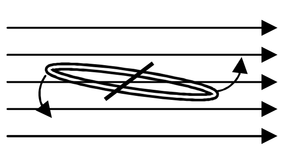
Spin the loop around a magnet

You should have chosen A, B, and E, only.

Let's talk more about breaking magnetic field lines (previous page, just before Q3). Also, look at the generator discussion at the bottom of the "Induction" notes.



Loop is vertical

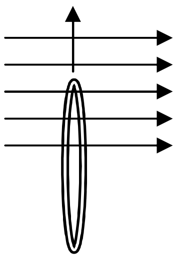


Loop is horizontal

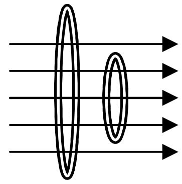
6. A loop is rotated counter-clockwise (CCW) about a diameter in a magnetic field.
   A. * When the loop is vertical, is it breaking any magnetic field lines?
   B. So is there any $I_{induced}$ when the loop is vertical?

      Or, by the right-hand rule, the top of the vertical loop is moving parallel to B, so there can't be a RHR force (q and B can't be parallel).
   C. When the loop is horizontal, is it breaking any magnetic field lines?
   D. Is there any $I_{induced}$ when the loop is horizontal?
   E. Using either Lenz's Law or the RHR, determine the direction of $I_{induced}$ in the horizontal loop, as viewed from above.

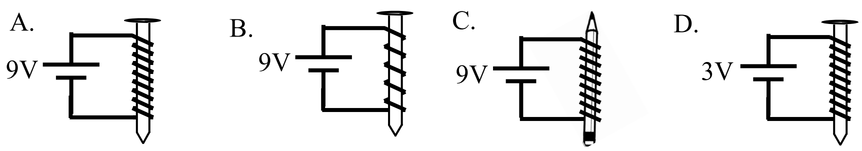
Use Lenz's Law or the RHR to figure out the direction of I induced in these next two examples.



7. A. As the loop moves into the magnetic field, is B increasing or decreasing in the loop?
So $I_{induced}$ must oppose the change by making a north to the left.
B. As seen from the left, which direction must $I_{induced}$ be flowing in the loop?



8. A. As the loop shrinks, does B (the magnetic field) inside the loop increase or decrease?
B. So the $I_{induced}$ opposes the change, making a magnetic field point left or right?
C. As seen from the left, give the direction of the induced current in the loop.

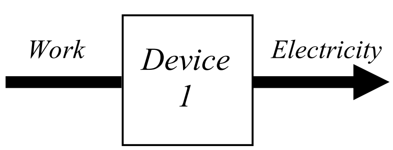


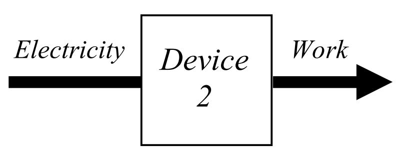
9. Which of the four electromagnets will be the strongest? (*You should be able to figure this out.)*

A generator generates" electricity by wires being turned thru magnetic fields (or vice versa). Generators take mechanical energy from wind, moving steam (as in power plants), or a belt in your car and turn it into electrical energy. If hooked up in reverse (electricity in) a generator becomes a motor, which takes electrical energy and turns it into motion. A generator can be a motor. A motor can be a generator. Both contain magnets and wires.

10. Motor, Generator, or Both?

A. ____ Creates electricity.
B. ____ Has loops of wire in it.
C. ____ Creates motion.
D. ____ Is turned by a force.
E. ____ Device 1 (below).
F. _____ Can make electricity.
G. _____ Used in a hydroelectric dam.
H. _____ Opens the windows in a car.
I. _____ Turns when electricity is applied .
J. _____ Device 2 (below).





Q2A) thumb (q) Q2B) down (toward bottom of page)
3A) No current (not in field) 3B) down (bottom of page) 3C) CW 3D) into page
3E) down 3F) no induced current (they cancel) 3G) CCW 3H) out of page
4B) N out of the left side of the solenoid 4C) CCW
6A) No