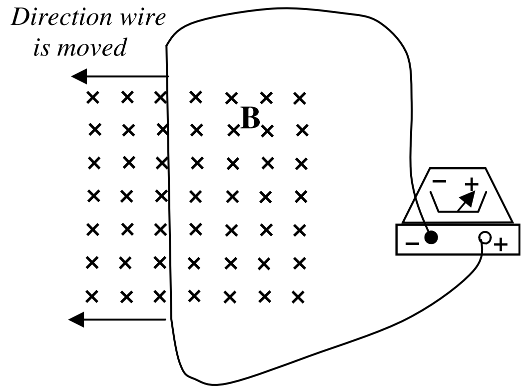
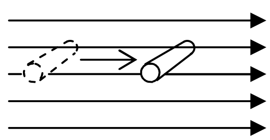
PreAP Magnetism 6



Background information: A galvanometer (which reads μA) tells you which side the + current flows into. If + current flows into the + side, it reads +, etc. If + current flows into the − side, it reads −.

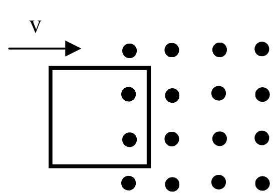
1. Let's learn what part of the right-hand rule is a moving wire. The diagram at the right shows a wire being moved to the left by an external force (like a person).
   A. * What is the direction of the external magnetic field?
   B. * Since the galvanometer reads positive, draw the current all the way around the wire so that it flows into the positive side of the galvanometer.
   C. * It is the magnetic force in the moving wire that causes this induced current to flow. What is the direction of the magnetic force in the moving wire?
   D. * The direction of the magnetic force (which is the same as the current) is what part of the RHR?
   E. * So, the moving wire must be what part of the RHR?

The moving wire is your thumb, because this is the direction the + charges (the protons in the wire) are moving. Your fingers are still the external magnetic field and your palm is the magnetic force in the wire which causes the induced current.



Also, 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. The wire 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)

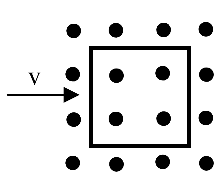


2. A square loop is moving to the right. It enters into a magnetic field that is pointing out of the page.
   A. * The left side of the loop is not yet into the field, so what is the direction of the magnetic force in the left side of the loop?
   B. * The right side of the loop has just entered the 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 $B_{induced}$.

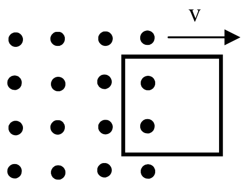
   Notice that the direction of $B_{induced}$ is opposite of the original magnetic field. This is "Lenz's Law": "The induced magnetic opposes a change of magnetism." As the loop enters the magnetic field the amount of magnetic field is increasing into the loop. (Right now there are 2 field lines going thru 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: CW or CCW?

   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.



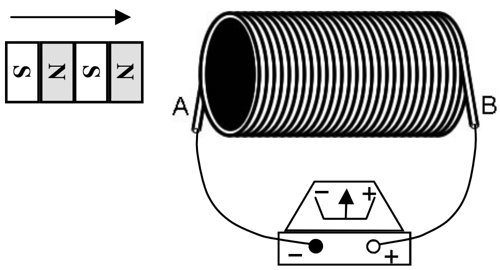
Finally, the loop is moving out of the field on the right side.

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: CW or CCW?

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.



3. 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?

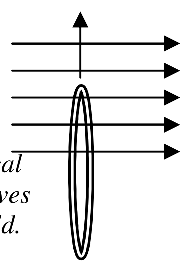
   B. * Since a north pole is moving into the solenoid, which way would the $B_{induced}$ have to point to oppose the incoming magnet?

   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?

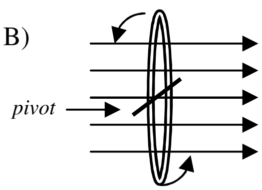
4. Now you know that there has to be a change of B inside the loop for current to be induced. For each of the following instances, decide if there will be an induced current in the wire loop.

A)



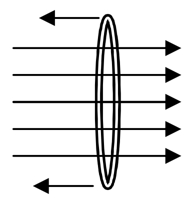
A vertical loop moves into field.

B)



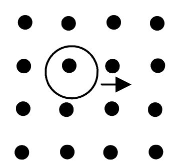
Spin the loop around a diameter.

C)



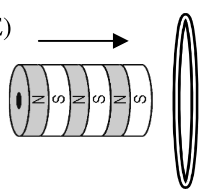
Move the loop parallel to the field.

D)



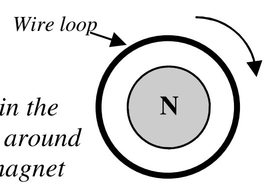
While the loop is completely inside the field.

E)



Move magnets into the loop.

F)



Spin the loop around a magnet

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

1A) into page 1B) Should be CCW around the loop. 1C) toward bottom of the page 1D) palm 1E) thumb: the moving charges in the wire.

Q2A) thumb (q) Q2B) down (toward bottom of page)
2A) None (not in field yet) 2B) down (bottom of page) 2C) CW 2D) into page
2E) down 2F) no induced current (they cancel) 2G) CCW 2H) out of page
3B) N out of the left side of the solenoid 3C) CCW