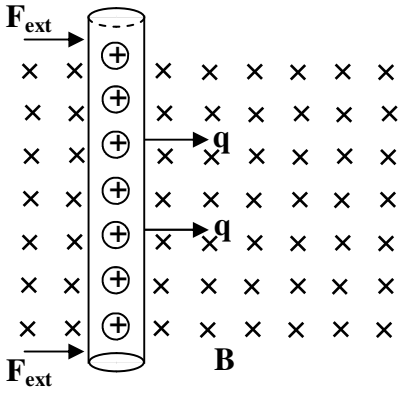
PreAP Magnetism 5

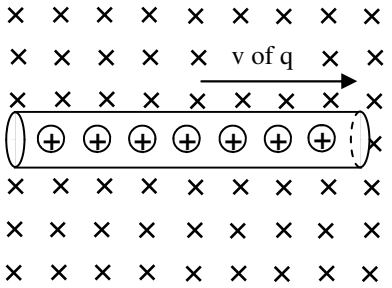
1. A wire has moveable charges in it because it is a conductor. When we move a wire with an external force (like your hand), the charges IN THE WIRE all move the same way, as shown at the right.



   A. What is the direction of the magnetic field?
   B. What is the direction of the moving charges?
   C. * By the RHR (right hand rule), what is the direction of the magnetic force (F_B) on the charges in the wire?
   D. * Forces in wires cause voltages, which cause electric currents as long as the force is along the wire. What is the direction of the current produced in the wire by the magnetic force?

*And this upward current (propelled by the magnetic force) is called an **induced current**.*

2. The wire is then turned so that it is horizontal. The wire is still moved to the right by an external force (like your hand). All of the charges in the conducting wire also move to the right.

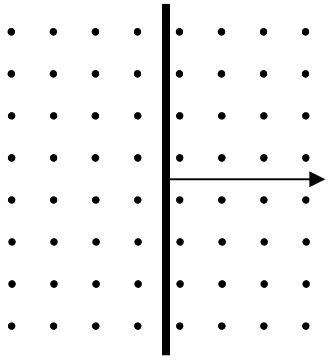


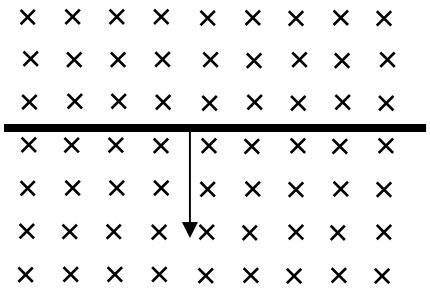
   A. * Since the wire is horizontal, which way can current flow: vertically or horizontally? (*Hint: think of a water pipe*.)
   B. The direction of the magnetic field and q are still the same, so the direction of the magnetic force is still the same, too: up (toward the top of the page). So any induced current would need to be up (vertical), which is not possible with a horizontal wire.

So, in this case, the F_B (magnetic force) cannot produce current. All it can do is force the charges to the top side of the wire, where they will hit the insulation and stop. Actually, it creates a small force on the wire that tries to push it upward, but this force is very small.

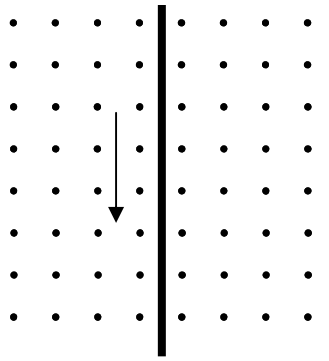
Now, let's practice what we just learned.

3. A wire is moving to the right through a magnetic field, as shown at the right.
   A. What is the direction of F_B in the wire?
   B. * What is the direction of the induced current (if possible)?





4. A wire is moving down the page in a magnetic field, as shown at the left.
   A. What is the direction of F_B in the wire?
   B. * What is the direction of the induced current (if possible)?



5. A wire is moving down the page in a magnetic field, as shown at the right.
   A. What is the direction of F_B in the wire?
   B. * What is the direction of the induced current (if possible)?

1C: up (B [fingers] points into page; v [thumb] is right; F_B [palm] is up).
1D: up, same direction as F_B. 2A: only horizontally.
3B: down (fingers out of page; thumb to right; palm is down) 4B: right (fingers into page; thumb down; palm is to the right)
5B: No current. Force is to left, (fingers out; thumb down; palm is left) but only vertical current is possible in a vertical wire.

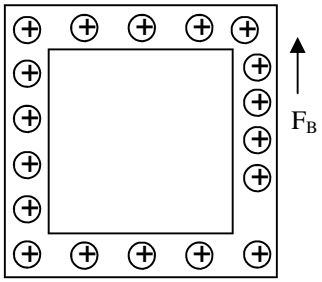
6. But what about wire loops? Loops of wire have charges in them ALL THE WAY AROUND. We will use a square loop. Imagine there is a force in the right side of the loop.

   A. Do the +'s attract or repel each other?

   B. Since two objects can't be in the same space, what happens to the +'s around the loop when the +'s on the right side move?

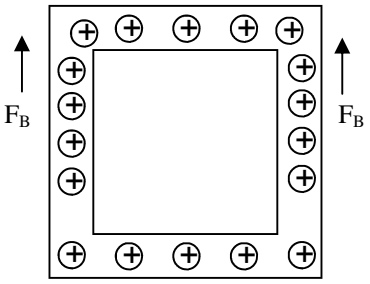
   C. * So, if there is an upward magnetic force in the right side of the loop, what would be the direction of current in the loop: clockwise (CW) or counterclockwise (CCW)?

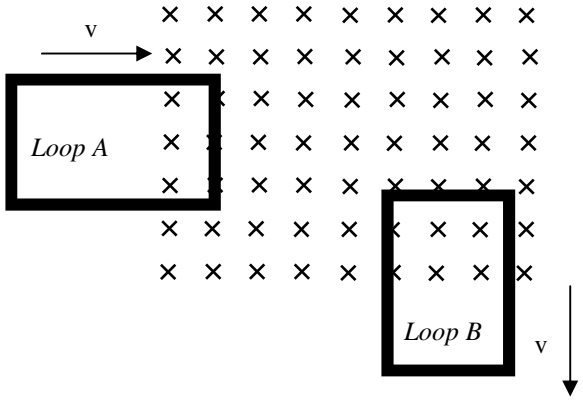
   D. * And if there was an upward F_B in the left side of the loop the current would flow:



7. What if BOTH the left AND right sides of the loop have magnetic forces in them? The left side pushes up and the right side pushes up. * So what is the direction of the current in the wire loop?

   And remember that if there are upward magnetic forces in the upper and lower parts of the loop they only move the charges to the sides of the wire and don't create current at all.





8. Two wire loops moves into and out of a magnetic field.

   A. * Which sides or side of Loop A creates current?

   B. * What is the direction of the current in the Loop A: CW or CCW?

   C. * What is the direction of the current in Loop B: CW or CCW?

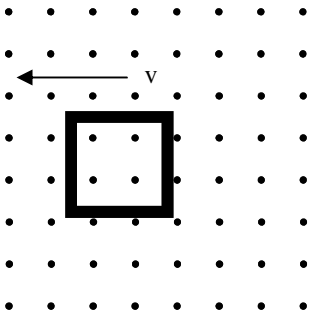
9. A square wire loop moves to the left in a magnetic field.

   A. * What is the direction of the magnetic force (F_B) in the left side of the loop?

   B. * What is the direction of the F_B in the right side of the loop?

   C. * What is the direction of the current in the loop?

   D. What is the direction of the current in the loop when it starts to LEAVE the magnetic field?



6C: CCW ↶ *6D: CW 7: no current since the two sides cancel each other out.*
8A: only the right side. (top + bottom only push against the sides of the wire).
8B: CCW (up on the right pushes all the +'s CCW around).
8C: CW (only force that matters is in the upper part where FB is to the right, pushing the charges around CW).
9A: up (fingers out of page; thumb to left; palm faces up page).
9B: same: up. 9C: no current. The two upward forces on the left and right sides cancel each other (see Q7).