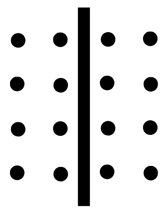
A-Day Due Wed., May 20
B-Day: Due Thurs., May 21

2009 PreAP Magnetism 5

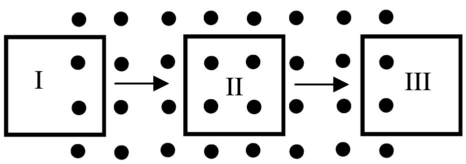
I think some of this homework will be lecture with questions interspersed.

Remember that there are two ways to decide if there will be an induced current in a wire.

Method 1: Does the wire break the magnetic field lines. Problem with this method is sometimes the answer is yes, but there still is no induced current. For example, from our last homework:

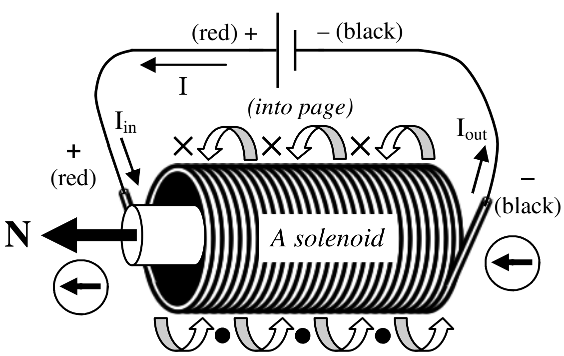


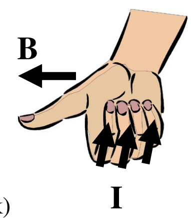
1. A wire is in a magnetic field, as shown. In which of the following cases is there an induced voltage (causing a current) produced in the wire?
   A. The wire is moved up (toward the top of the page).
   B. The wire is moved to the right.
   C. The wire is pulled out of the page.
2. If the wire is moved to the right, what is the direction of the induced emf (voltage) in the wire?



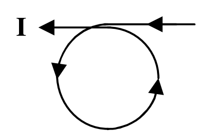
3. Now a square wire loop is moved thru a magnetic field.
   A. What is the direction of the induced potential difference (emf) in the horizontal sides of the wire?
   B. What is the direction of the induced potential difference in the vertical sides of the wire (draw them)?
   C. What is the direction of the induced current in position I?
   D. What is the direction of the induced emf in position II?
   E. What is the direction of the induced emf in position III?

Method 2 of deciding if there is an induced current (emf, voltage, potential difference): Is the strength of the magnetic field changing in the loop? In the above example, this method would make it obvious that position II has no change of B, even though it is breaking the field lines. Now, let's see if I can help you understand Lenz's Law. Before I do so, I need to make sure that you figured out that $I_{induced}$ in the vertical wire segments is down, which means that the current flows CW in position I and CCW in position III.

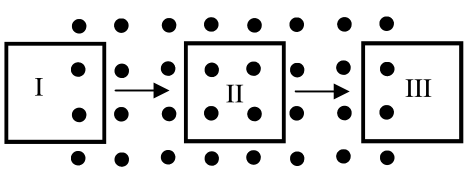




Also remember that if the current flows in a circle, you can use your right hand to determine the direction of the north pole of the loop. Imagine looking at the solenoid from the left side. You would see that current is flowing CCW in the loops, as seen below.



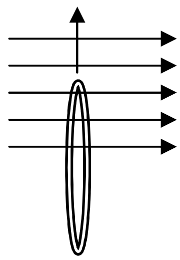
With your fingers wrapped CCW, you will find that the loop's North pole is out of the page.



4. You now know the direction that the induced current is flowing in the wire loop at each position. Since any current produced a magnetic field, the loops that have an induced current will also have an induced north pole. Determine the direction of N for each position.

Let me complete the picture now. In position I, the induced current is CW, which means its induced North pole is into the page, which is opposite the increasing external magnetic field. In other words: the North pole of the external field (the dots) is increasing into the loop (out of the page), so the induced magnetic in the loop points the opposite way (into the page). Which your thumb pointing into the page, you will see that your fingers are pointing CW around the loop, as we found with the RHR.

Lenz's Law states: The induced magnetic field will always try to oppose any changing magnetic field.

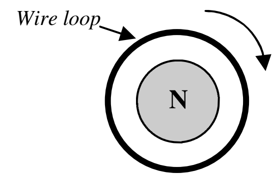


Move the loop in B

Use Lenz's Law to do the following examples.

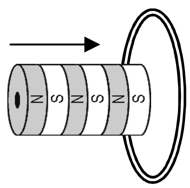
5. A wire loop moves into the magnetic field. The magnetic field is increasing in the loop toward the right.
   A. This means, by Lenz's Law, that the induced magnetic field will be toward what direction?

   B. This means that, if you are looking from the left side, the current in the wire will be flowing which direction?



Spin the loop around a magnet

6. A wire loop is spun around a magnet.
   A. Is there any change of magnetic field in the loop?
   B. Is there any induced emf in the loop?



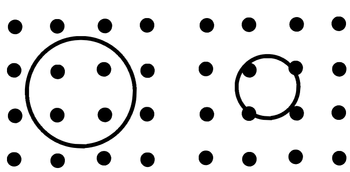
Move a magnet into the loop

This example can be done by both RHR or Lenz's Law.

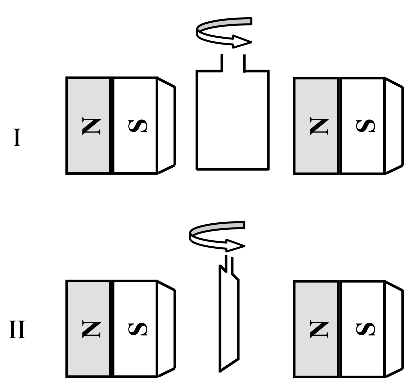
7. A stack of magnets is moved into a wire loop as shown.
   A. To oppose a south pole moving in, the loop will have to do what?

   B. So, looking from the left side, which direction will the induced current flow in the wire loop: CW or CCW?

   C. (Now using RHR.) You remember that magnetic fields point from N to S. At the end of the magnetic stack the magnetic field lines point **into** the S pole. So, your fingers will point into the magnet's south pole. Let's work from the top of the wire loop. Point your fingers toward the south pole (down). Since the magnet is moving to the right, the wire is moving to the left (relative to the magnet), so point your thumb to the left. Which way is the magnetic force (your palm) pointing at the top of the loop? So, will the current flow CW or CCW in the loop (if you are facing it from the left)?



8. A wire loop's area is decreased in a magnetic field.
   A. Is the strength of B increasing or decreasing?
   B. Determine the direction of the induced potential difference in the loop.



9. A wire loop is rotated between two magnets.
   A. Which direction does B point?
   B. In which position (I or II) is the induced emf the greatest?
   C. In which position is the induced current the least?
   D. As the loop completes one revolution, explain the changes in the emf's magnitude.

Use the "Faraday's Law" notes to answer the following:

10. A coil has 100 turns, each with an area of 0.35 m^2 and are perpendicular to the magnetic field.
    A. How much emf is created if the magnetic field increases by 1.2 T in 0.4 seconds?

    B. If the induced emf is hooked up to a circuit, how much current flows thru a 330Ω resistor?

11. From the book p.821 Q10. A flexible wire loop (so, only 1 turn) has a radius of 0.12m and is perpendicular to a uniform magnetic field of strength 0.15T. The loop is closed so that it has an area of only $3\times10^{-3}m^2$ in 0.20 seconds. Find the emf in the loop. Use Sig. Figs.