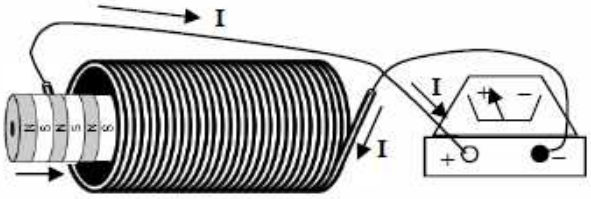
Name: _____

Period: _____

4.3

Magnetic Induction

Magnetic induction is the forcing of electric current by moving wires thru a magnetic field or moving magnets thru wire loops.

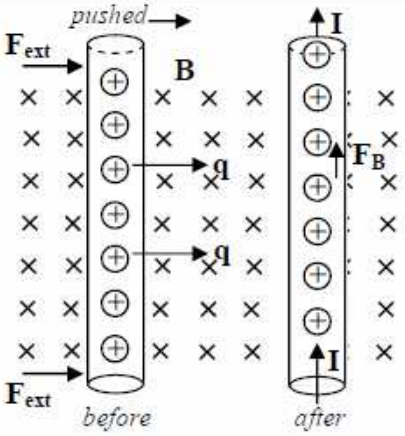


Magnets pushed inside a solenoid induce current.

In this circuit the solenoid is acting like a battery: driving the current with a momentary voltage. The ammeter reads positive because current is going into the positive side. Whichever side the current goes in, that's what the ammeter will read.

Moving Wires and the RHR

Being conductors, wires already have moveable charges inside them. When a wire is moved thru a magnetic field by an external force (i.e., your hand), the direction the wire moves is q for the right hand rule (your thumb). F_B (your palm) is the direction the magnetic field moves the charges inside the wire: the direction of the induced current.



Determining F_B and I

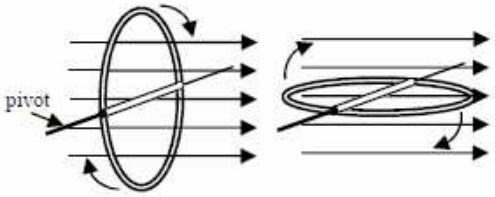
It is easy at this point to become confused as to which is q (your thumb) and F_B (your palm).

q is the moving charges: a proton; the current; a pushed wire.

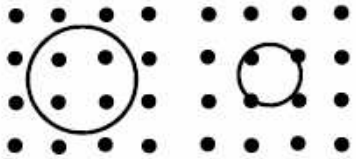
F_B is always what is moved by the magnetic field: turning a proton; moving a wire; inducing a current.

Induced Current in a Loop

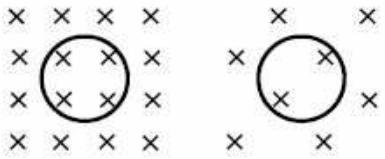
Current is induced in a loop of wire only if the amount of the magnetic field inside the loop changes. The induced current always tries to oppose the change of B.



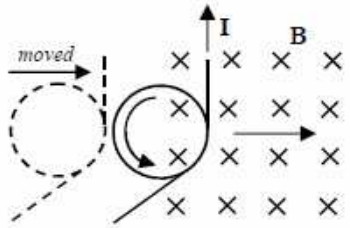
Turn the loop. Notice that the loop break the magnetic field lines only when it's horizontal.



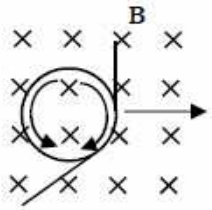
Change the area of the loop. Opening increases B; closing decreases B.



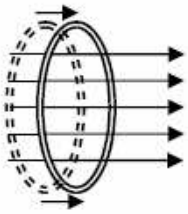
Change the strength of B. Here B is decreasing into the page.



Move the loop of wire into or out of B. The right side of the loop feels a F_B, causing a counterclockwise (CCW) current in the loop. I comes out of the top end of the wire.



When the loop of wire is completely inside the field, B is constant and the F_B on both sides is equal and opposite, canceling out. No current is induced in the wire.

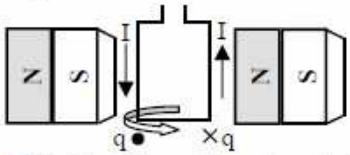


If the loop is moved parallel to B no current is induced because no field lines are broken and there is no change in B inside the loop.

Generators

Generators create electricity from work. Something turns the loop of wire (your hand, the wind, water going thru a dam) near permanent magnets, inducing current in the wire.

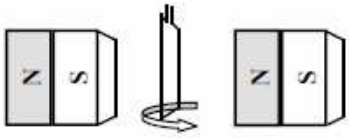
Perpendicular to B = maximum I



The left side of the wire moves out. *The right side of the wire moves in.*

B is to the right (from N to S). On the left side q (the moving wire) is out of the page, so F_B (and I) will be down the left wire. On the right side, q is into the page and F_B is up. The two forces add together to push the current thru the wire.

Parallel to B = no I



When the sides of the loop are moving parallel to the magnetic field, there is no F_B and no induced I.

1. F_B is always the direction the magnetic field (B) moves the charges. For each of the following examples figure out what the magnetic field is moving (F_B) and the charge (q).

   A. A wire is pushed into a magnetic field. A current is induced in the wire.

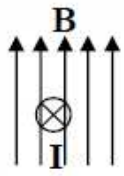
   B. A battery is connected to a wire that is inside a magnetic field. When the battery is on, the wire deflects forward.

   C. A magnet is pushed into a solenoid and an ammeter moves, recording current.

   D. When a proton moves into a magnetic field, the proton moves in a circular path.

2. The X shows current being induced in a wire by the magnetic field.
   A. Which way is the current moving?

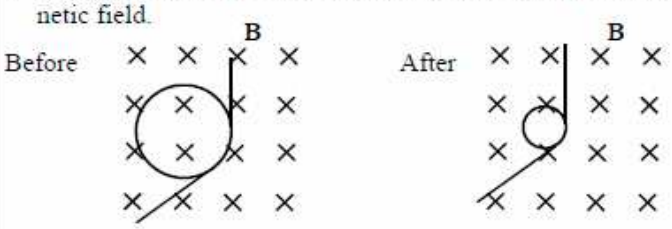
   B. Which direction was the wire pushed?



3. A. What has to happen for current to be induced in a loop of wire?

   B. Give the four ways to do this.

4. The area of a loop of wire is reduced inside a constant magnetic field.

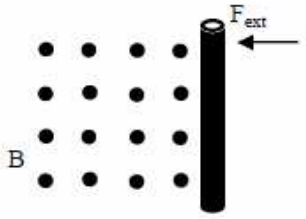


   A. On the left hand side of the loop, what is the direction of the induced current?

   B. On the right hand side of the loop, which is the direction of the induced current?

   C. What would be the direction of the current in the loop if the loop is pulled out of the page?

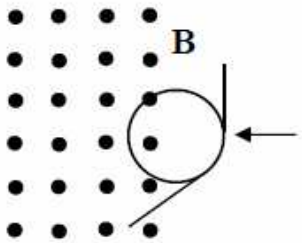
5. The wire is pushed thru a constant magnetic field as shown. What is the direction of the induced current?



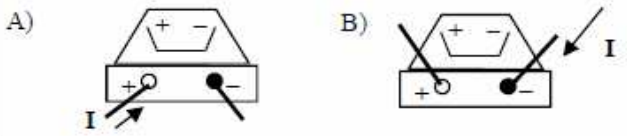
6. A. What is the direction of the current in the left side of the loop as it enters?

   B. Will the induced current in the wire be CW or CCW?

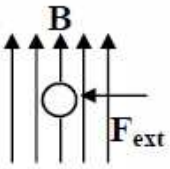
   C. What direction will be the current when the loop is completely inside B?



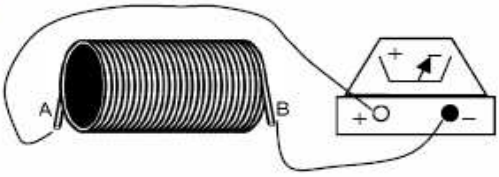
7. In each of the following situations show whether the ammeter reads positive or negative.



8. The wire is pushed to the left by an external force. Which direction will the induced current move: into or out of the page?

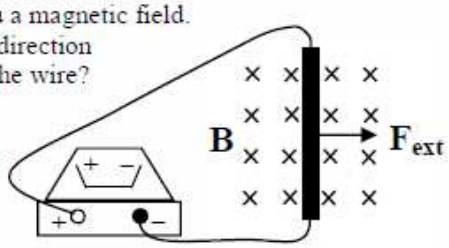


9. Which side of the solenoid is north?



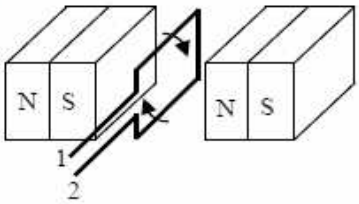
10. A wire is moved thru a magnetic field.
    A. What will be the direction of the current in the wire?

    B. Will the ammeter read + or –?



11. A loop of wire is turned CW between two magnets.
    A. Which direction is B?

    B. In the top position which direction will the induced I be?



    C. The loop is then turned 90° CW, so that the loop is horizontal, which side of the loop will current come out?