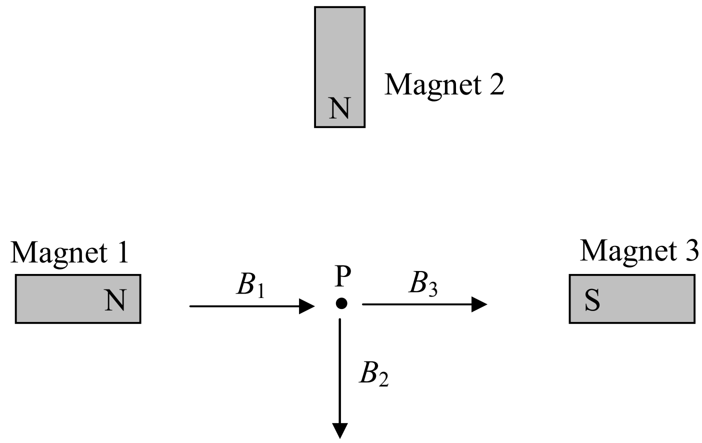
UNIT 2 REVIEW #2: ELECTROMAGNETISM ***SOLUTIONS***

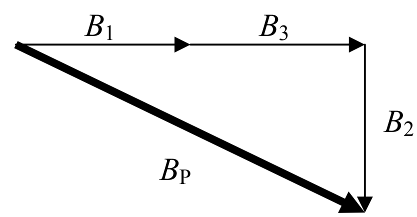
1. Place a North test particle at location P.
   The North magnets will repel it (like poles), while the South magnet will attract it (opposite poles).



The net magnetic field is given by

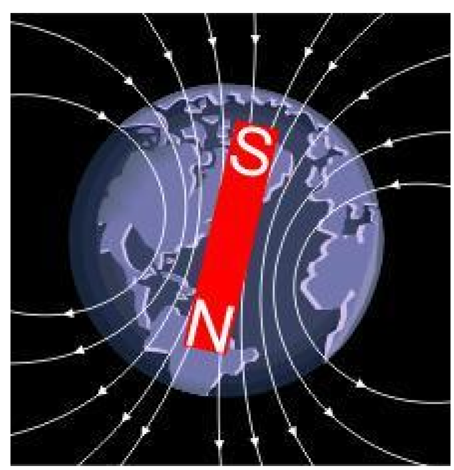
$$\vec{B} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

The vectors can be added in any order.
So, add the horizontal vectors first, and then add the vertical vector.

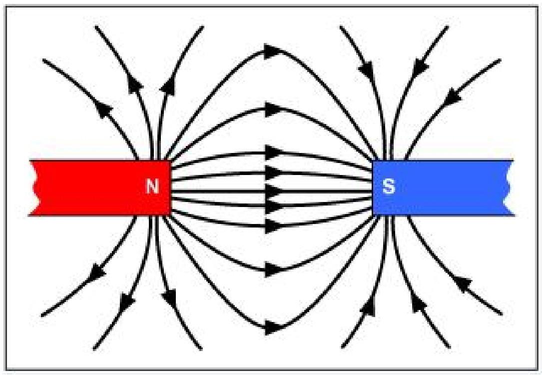


2. For a bar magnet, the magnetic field goes from North to South (outside the magnet).

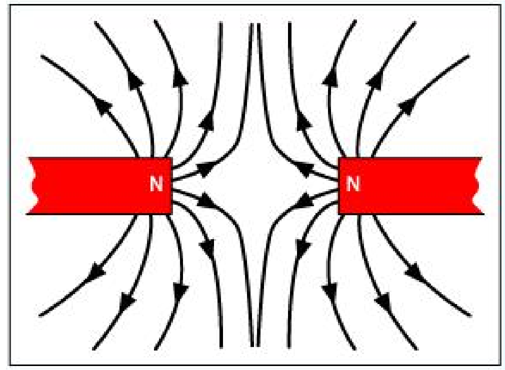
   Also, the magnetic South pole is approximately in the same location as geographic North.



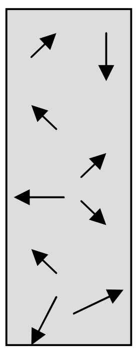
3. a)



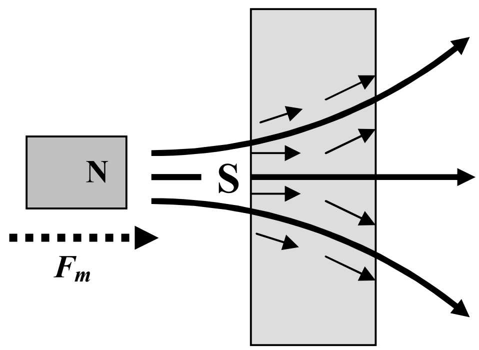
b)



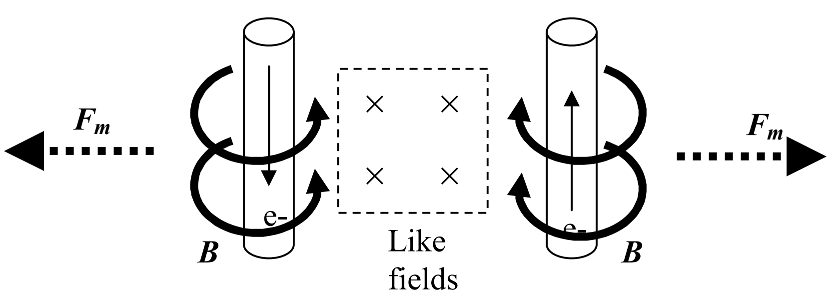
4. The refrigerator door must be made of ferromagnetic material, which is composed of magnetic domains. At first, the fridge door is unmagnetized, which means the domains have random directions (with a net magnetic field of zero). When the magnet is brought near to the fridge, it creates a magnetic field directed away from the North pole.
The domains align in the same direction as the external magnetic field. This induces the opposite pole in the closest side of the fridge door, which attracts the magnet.



unmagnetized door



5. a) Use **left hand rule #1**: Thumb = Direction of the electron flow
Curled fingers = Direction of magnetic field



b) Since the two wires create like magnetic fields in the space between them, they will repel each other.

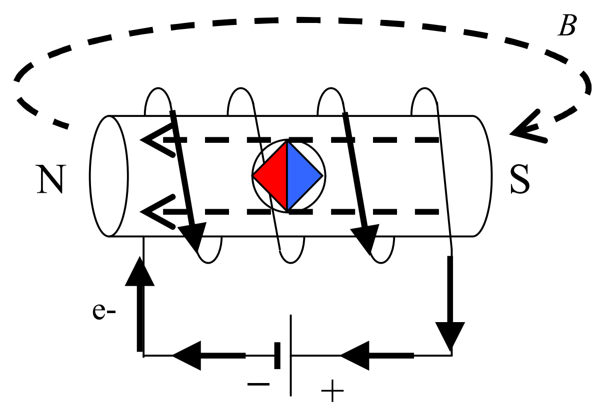
6. Electron flow is from the negative terminal to the positive terminal.
   i.e. It gets attracted to the positive terminal.)

   Use **left hand rule #2** (for solenoids):

   Curled fingers = direction of the electron flow around the solenoid
   Thumb = points towards the North, and it is the direction of the magnetic field inside of the solenoid

   The compass points in the same direction as the external magnetic field.

   Thus, it points towards the left.

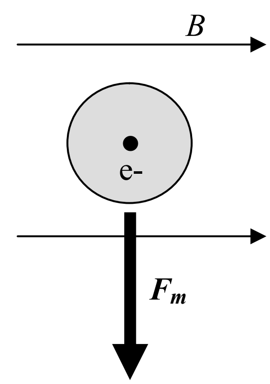


7. Direction:

   Use **left hand rule #3**:

   Thumb = Direction of electron flow
   Straight fingers = Direction of the external magnetic field
   Palm = Direction of the magnetic force

   Thus, the magnetic force is directed South.



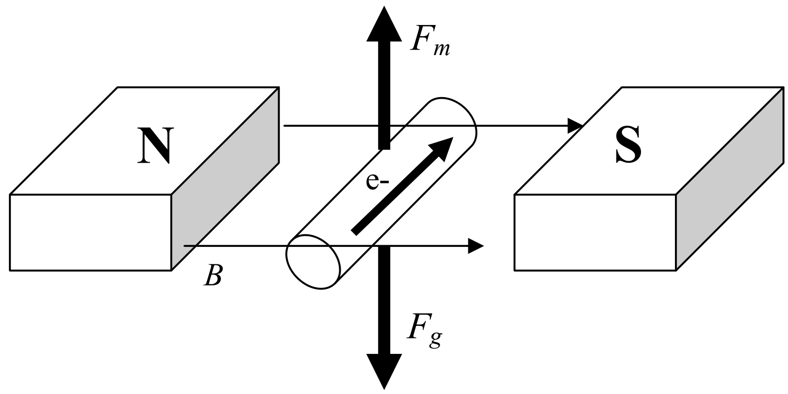
Magnitude:

$$I = \frac{q}{t} = \frac{44.0\ C}{8.62\ s} = 5.1044\text{ A}$$

$$F_m = L\,I\,B_\perp = (0.115\text{ m})\,(5.1044\text{ A})\,(0.270\text{ T})$$

$$= 0.158\text{ N}$$

8. Direction of current:



The external magnetic field goes from the North pole to the South pole (so, to the right). The magnetic force must go upward, since it is equal but opposite with the force of gravity.

Use **left hand rule #3**:

Thumb = Direction of electron flow
Straight fingers = Direction of the external magnetic field
Palm = Direction of the magnetic force

Magnitude of current:

If the wire is suspended, the forces must be balanced (i.e. equal but opposite).

$$F_m = F_g \qquad L I B_\perp = m g \qquad I = \frac{m g}{L B_\perp}$$

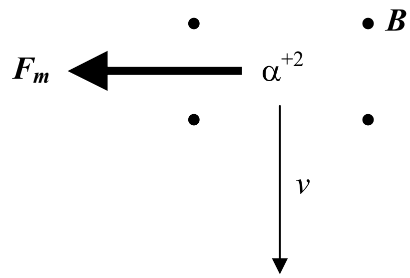
$$I = \frac{(0.00810\ kg)(9.81\ N/kg)}{(0.070\ m)(0.450\ T)} = 2.5\text{ A}$$

9. Direction:

Use **right hand rule #3 (positive charge)**:

Thumb = Direction of velocity
Straight fingers = Direction of the external magnetic field
Palm = Direction of the magnetic force

Thus, the magnetic field is directed out of the page.



Magnitude:

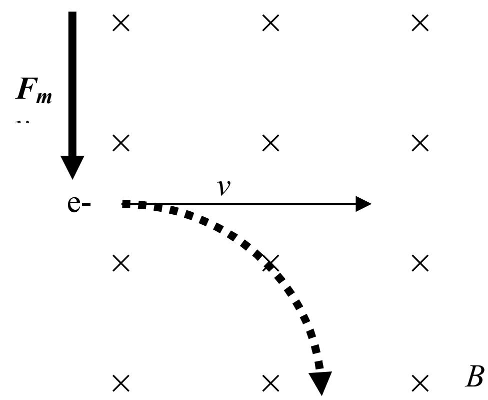
$$F_m = q\,v\,B_\perp \qquad B_\perp = \frac{F_m}{q\,v} = \frac{3.19\times10^{-11}\,N}{2(1.60\times10^{-19}\,C)(7.20\times10^{5}\,m/s)} = 138\ \text{T}$$

10. a) Consider the electron when it first enters into the magnetic field.

Use **left hand rule #3**:

Thumb = Direction of electron's velocity
Straight fingers = Direction of the external magnetic field
Palm = Direction of the magnetic force

Since the force acts towards the bottom of the page, it will be deflected clockwise.



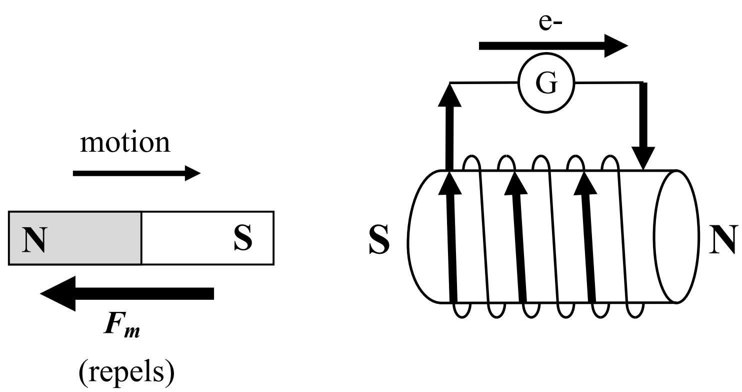
b) **Uniform circular motion** (unbalanced forces)

$$F_{net} = m\,a \qquad F_m = m\,a_c \qquad q\,v\,B_\perp = \frac{mv^2}{r}$$

$$q\,B_\perp = \frac{mv}{r} \qquad q\,B\,r = mv \qquad r = \frac{m\,v}{q\,B}$$

$$r = \frac{(9.11\times10^{-31}\,kg)(1.40\times10^{7}\,m/s)}{(1.60\times10^{-19}\,C)(0.0386\,T)} = 2.07\times10^{-3}\ \text{m} = 2.07\ \text{mm}$$

11.



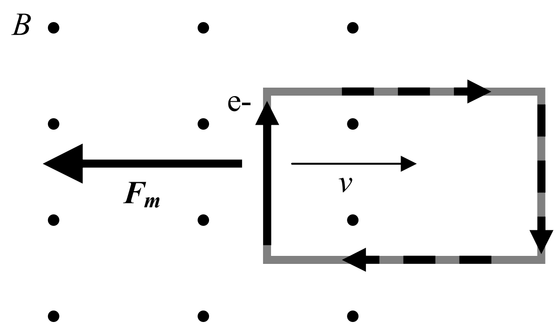
According to Lenz's law, the induced current will create a magnetic field that will fight the motion. Thus, it exerts a force to the left on the magnet
Since this is a repulsive force, the magnet must have induced a like pole (i.e. South) in the nearest part of the solenoid.

Use **left hand rule #2** (for solenoids):

Curled fingers = direction of the electron flow around the solenoid
Thumb = points towards the North pole

Thus, the electron flow goes to the right through the galvanometer.

12.



We focus our attention on the left side of the loop, since this is the part that is perpendicular to the field and it is "sweeping" through the field, thus inducing current.

According to Lenz's law, the induced magnetic force will resist the motion, so it will act to the left on the wire.

Use **left hand rule #3**:

Thumb = Direction of electron flow (upward through wire)
Straight fingers = Direction of the external magnetic field (out of the page)
Palm = Direction of the magnetic force (to the left)

Thus, the electrons flow clockwise around the wire.