Activity 4.4 – Mr. Immel

Pre-test Assignment – Magnetic Forces and Fields

Due Date: ____________________

Show all work for problems involving calculations.

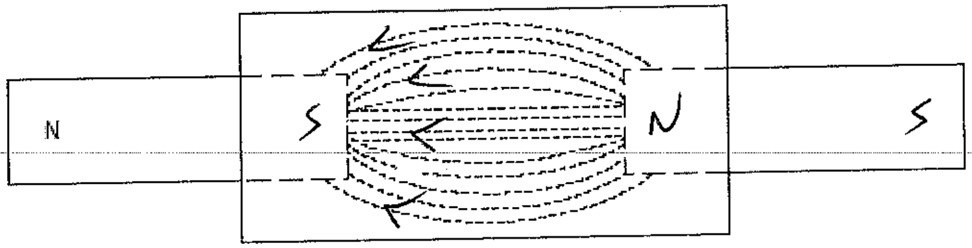
1. New technologies often have expected and unexpected benefits to society. The discovery of lodestone 2000 years ago is such an example.

a. Describe the immediate uses of lodestone to society 2000 years ago.

navigation is more reliable - doesn't rely solely on sun and stars.

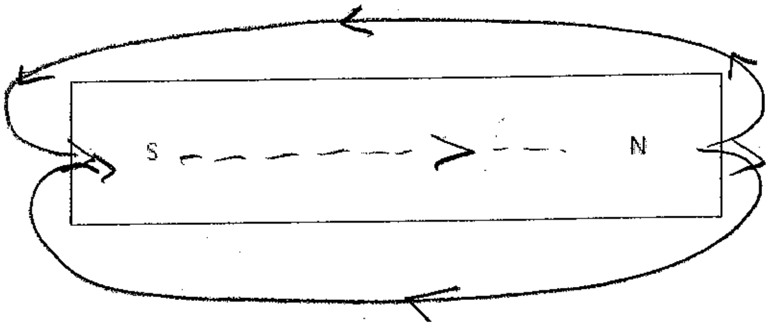
b. Describe some of the potential spin-off benefits that may have been an indirect result of the use of lodestone. more exploration, better maps, expansion of trade routes.

2. A piece of white paper is placed over the ends of two bar magnets that are adjacent to each other. Iron filings are then sprinkled onto the paper. The iron filings create the pattern shown in the diagram.



Indicate whether [✓ an attractive] or repulsive force exists between the magnets and label the poles on the bar magnets.

3. On the following diagram of a bar magnet, sketch several magnetic field lines and arrows to indicate the direction of the magnetic field inside and outside the magnet.

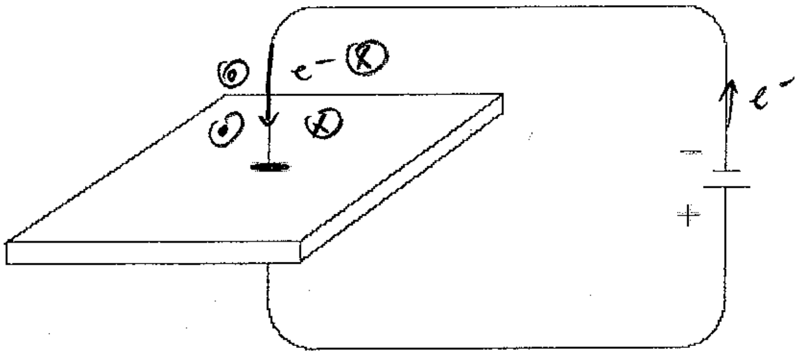


N → S

4. Identify the sources of electric fields, magnetic fields, and gravitational fields.

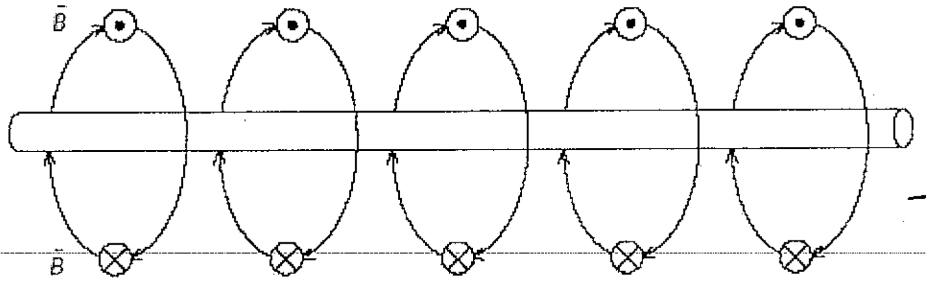
	source
electric fields –	electric charges
magnetic fields –	moving charges
gravity fields –	masses

5. Sketch the magnetic field created on the piece of paper by the current-carrying wire that passes through it. Which hand rule is used?



1st left hand rule

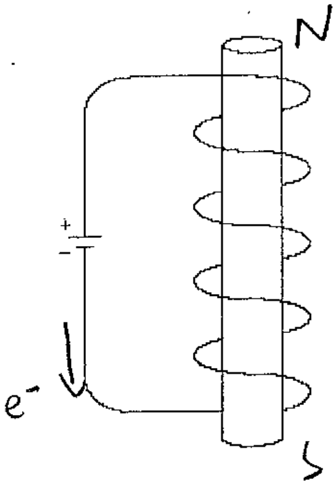
6. The magnetic field around a horizontal current-carrying wire is illustrated in the following diagram. What is the direction of conventional current flow through the wire? Explain how you would determine this.



→ conventional I

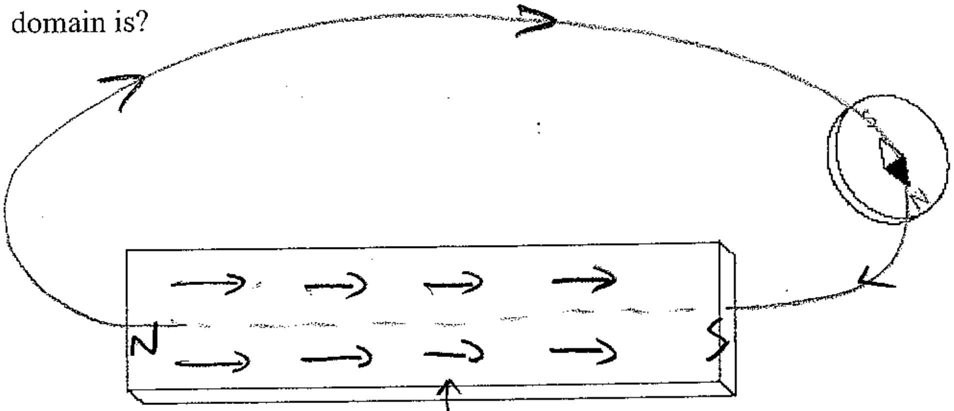
1st right hand rule

7. Determine which end of the electromagnet is the north pole and which end is the south pole. Explain how you would determine this.



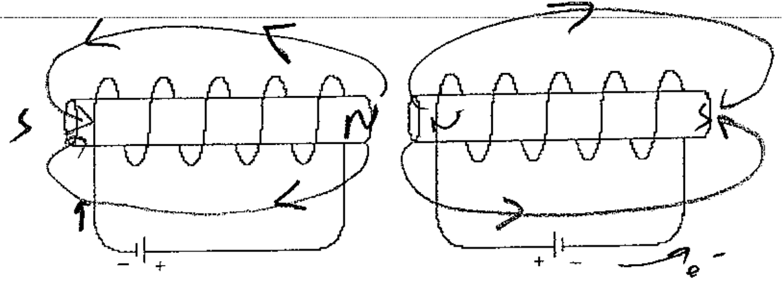
2nd hand rule

8. The following diagram shows a compass placed near the end of a bar magnet. Use arrows to sketch the alignment of the domains within the bar magnet. Describe what a domain is?



domains - magnetically aligned ferromagnetic group of atoms.

9. The following diagram shows two electromagnets placed close together.

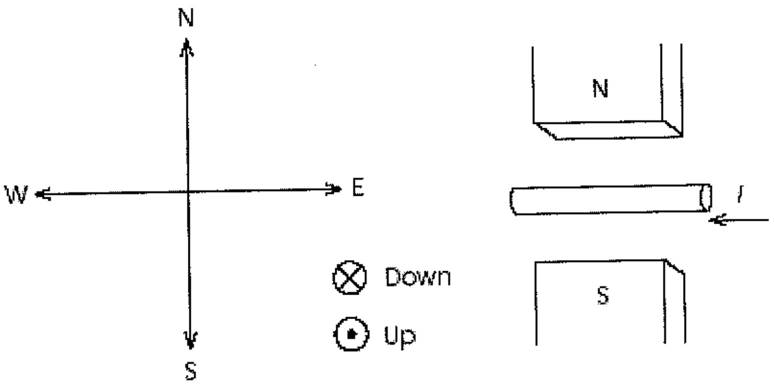


Sketch the pattern of magnetic field lines around each electromagnet and in the region between them. Explain your answer.

10 Briefly describe the discoveries about electricity and magnetism made by Oersted and Ampere.

- moving charges create magnetic fields
- a magnetic force is exerted on a current-carrying wire when placed in a magnetic field.

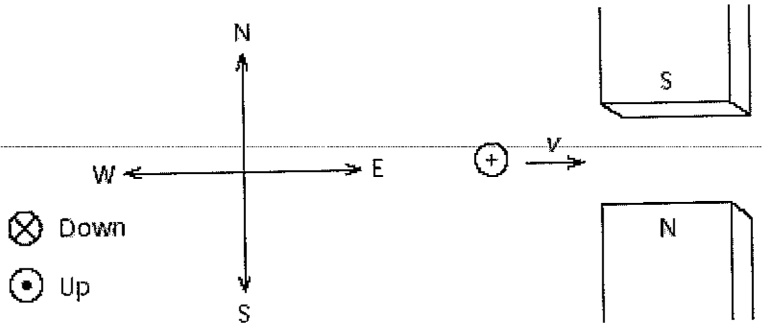
11 Use the appropriate hand rule to label the direction of the force exerted on the wire carrying a conventional current in the following diagram. Explain your answer.



Fm is out of page
⊙

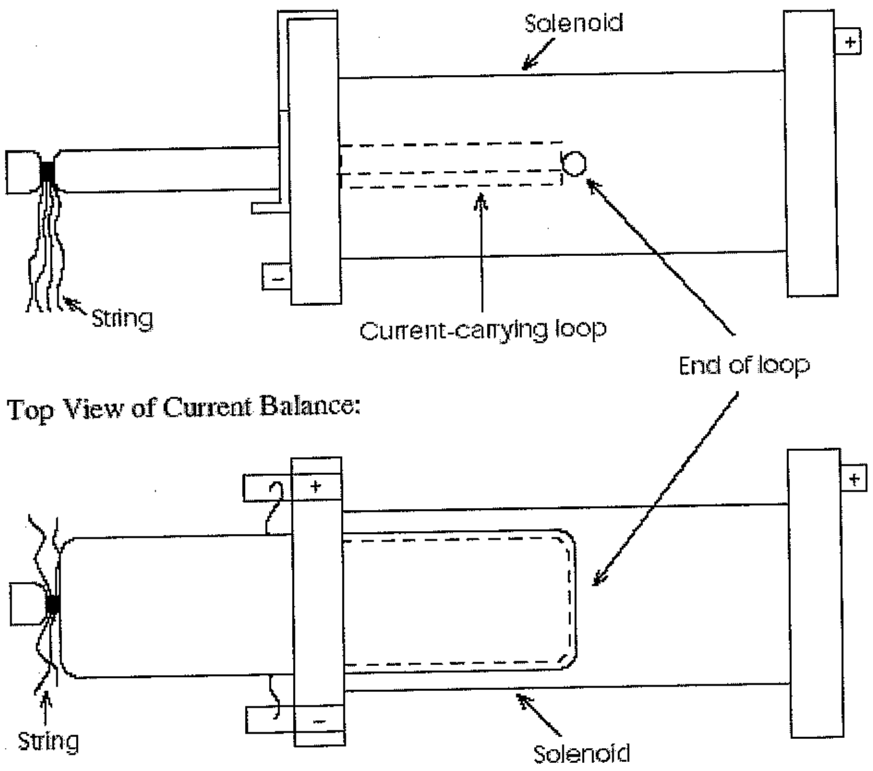
↑
3rd hand rule
↓

12. Apply the appropriate hand rule to determine the direction in which a proton will deflect when passing through the magnetic field in the following diagram. Explain your answer.



Fm is out of page

13. The following information describes a current-balance investigation. The current in the solenoid that generates the magnetic field was held constant and the length of wire in the end of the loop in the field was 0.050 m long.



Side View of Current Balance:

Top View of Current Balance:

a. Calculate the magnetic force on the end of the loop to balance the gravitational force on the string. Record the values in the data chart. Show the calculation for the first value and the last value.

Current in Solenoid (A)	Current in Loop (A)	Mass of String ($\times 10^{-4}$ kg)	Force on End of Loop ($\times 10^{-3}$ N)	Magnetic Field ($\times 10^{-3}$ T)
3.5	8.9	3.4	3.3	7.5
3.5	7.1	2.7	2.6	7.5
3.5	5.3	2.0	2.0	7.4
3.5	3.5	1.3	1.3	7.3
3.5	1.6	0.6	0.59	7.4

(1st value)

use $F_g = F_m$

$mg = F_m$

$3.4\times10^{-4}\times 9.81 = F_m$

$3.3\times10^{-3}\,N = F_m$

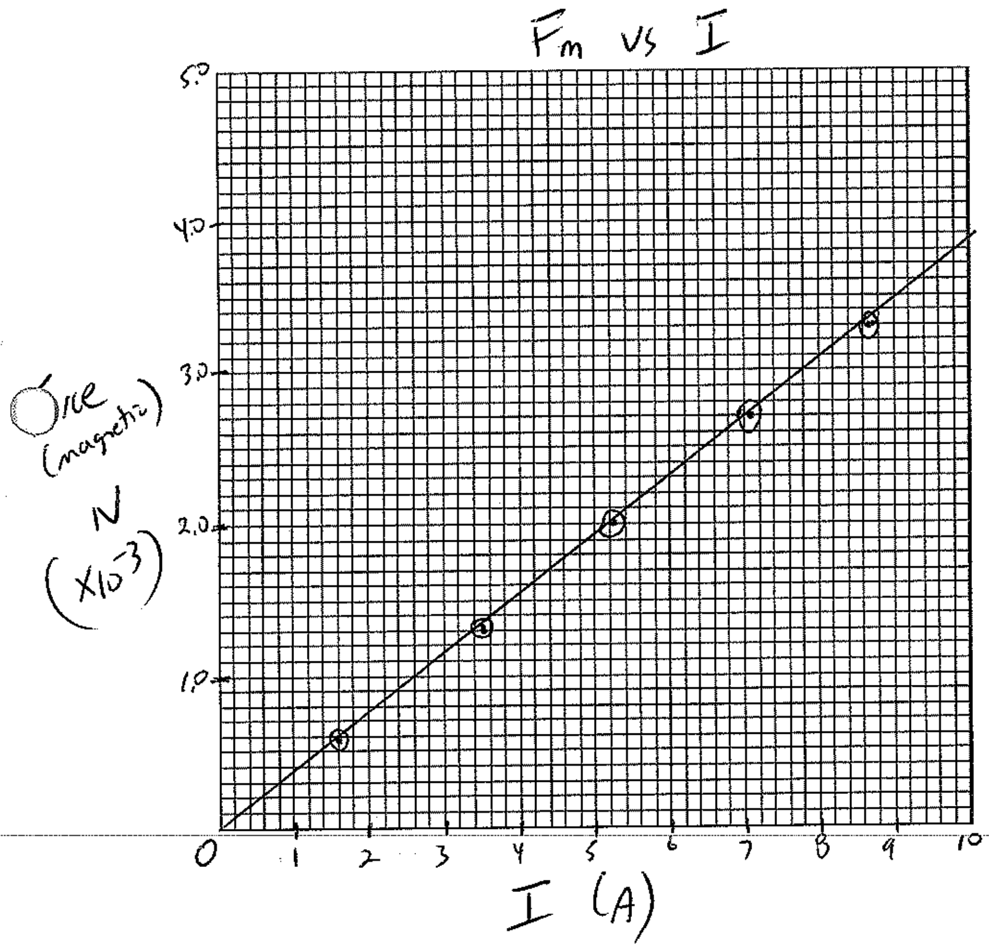
use $F_m = F_g$

$B_\perp I l = F_g$

$B_\perp = \frac{F_g}{I l} = \frac{3.3\times10^{-3}\,N}{8.9A \times 0.050m} = B_\perp$

b. Calculate the magnetic field of the solenoid for each trial. Show all five calculations in the space that follows and record your values on the previous data chart.

c. Plot a graph with force on the end of the loop versus current through the loop.



d. State the relationship between force on the loop and the current in the loop when the magnetic field in the solenoid is constant.

$F_m \propto I$

$F_m = BIl$

slope $\boxed{\frac{F_m}{I}} = Bl$

$\frac{\text{slope}}{l} = B_\perp$

$\frac{3.71\times10^{-4}}{0.05} = B_\perp$

$B_\perp = \boxed{7.4\times10^{-3}\,T}$

e. Calculate the slope of the graph and use this value to calculate the strength of the magnetic field in the solenoid. Support your answer.

$$\text{slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{(3.3\times10^{-3} - 0.59\times10^{-3})\,N}{(8.9 - 1.6)\,A} = 3.71..\times10^{-4}\,\frac{N}{A}\left(\frac{F_m}{I}\right)$$

f. If there was a larger current passing through the solenoid, explain how the string masses given in the data chart would differ from those initially provided.

more current means stronger $B_\perp$, A greater force would be needed to balance the stronger F_m (more string needed)

14. List the three factors which affect the magnitude of the magnetic force on a charged particle travelling through a magnetic field.

$F_m =$ q - charge magnitude
v - speed of charge
$B_\perp$ - strength of external mag. field.

15. Calculate the magnetic force on a 250-m length of blasting wire carrying a current of 32.0 A to an explosive when it is at right angles to Earth's magnetic field of 4.8 × 10^{-5} T.

$$F_m = B_\perp I l$$
$$= 4.8\times10^{-5}\,T \times 32.0 \times 250\,m$$
$$= 0.31\,N$$

16. An electron enters a magnetic field travelling at 2.40 × 10^{6} m/s and is deflected by a force of 2.76 × 10^{-15} N. If an alpha particle with a charge of +3.20× 10^{-19} C and a mass of 6.65 × 10^{-27} kg travels the same velocity as the electron into the magnetic field, what force will be exerted on the alpha particle?

First find $B_\perp$

$$F_m = qvB_\perp$$
$$2.76\times10^{-15}\,N = (1.60\times10^{-19})(2.4\times10^{6})B_\perp$$
$$0.007187\,T = B_\perp$$

Now find F_m on alpha

$$F_m = qvB_\perp$$
$$= (3.2\times10^{-19})(2.4\times10^{6})(0.007187)$$
$$= 5.52\times10^{-15}\,N$$

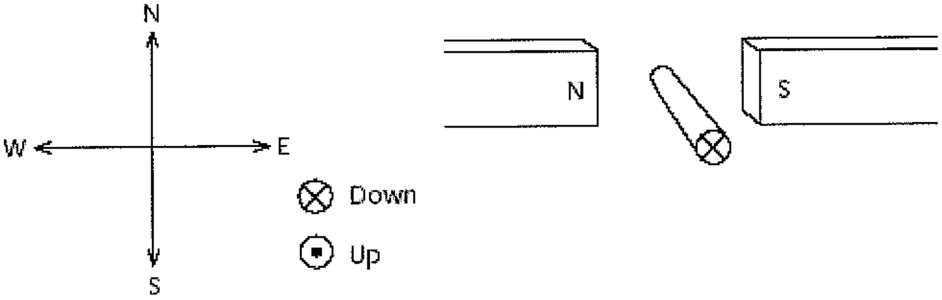
or

$F_m \propto q$

$2 \propto 2$

$2\times2.76\times10^{-15} = 5.52\times10^{-15}\,N$

17. Consider the following diagram to answer this question. A current-carrying wire that is 45.0 cm long is carrying a conventional current of 1.2 A, directed into the page, within a magnetic field of 7.2×10^{-3} T. Determine the magnitude and direction of the force acting on the current-carrying wire.



$\vec{F}_m = B_\perp I l$

$= (7.2\times10^{-3})(1.2)(0.45)$

$= 3.9\times10^{-3}$ N [South]

18. A charge of 3.6 C flows through a conductor in 3.0 min. The conductor, which is positioned perpendicular to a magnetic field of 9.0×10^{-2} T, experiences a force of 7.2×10^{-3} N. Calculate the length of wire placed in the magnetic field.

$F_m = B_\perp I l$

$\frac{7.2\times10^{-3}}{9.0\times10^{-2}\times\left(\frac{3.6}{180}\right)} = l$

4.0 m = l

19. A force of 9.2×10^{-14} N acts on an unknown particle that travels at 2.40×10^{6} m/s into a magnetic field of 4.8×10^{-2} T. How many elementary charges does the particle carry? (An elementary charge is equivalent to a charge on an electron or proton.)

$F_m = q\vec{v}B_\perp$

$9.2\times10^{-14} = q(2.40\times10^{6})(4.8\times10^{-2})$

$\frac{7.99\times10^{-19}\,C = q}{1.6\times10^{-19}\,C/e^-}$

5 q

20 ~~19~~. An alpha particle with a charge of 3.20 × 10^{-19} C and a mass of 6.65 × 10^{-27} kg is travelling at 5.0 × 10^{6} m/s. When it enters a magnetic field of 6.4 × 10^{-2} T , a magnetic force provides the centripetal force for the alpha particle. The centripetal force causes the alpha particle to travel in a circular path. Calculate the radius of the circular path.

$$\vec{F}_m = \vec{F}_c$$

$$q\cancel{v}B_\perp = \frac{mv^{\cancel{2}}}{R}$$

$$R = \frac{mv}{qB} = \frac{(6.65\times10^{-27})(5\times10^{6})}{(3.2\times10^{-19})(6.4\times10^{-2})}$$

$$\boxed{1.6\,m}$$

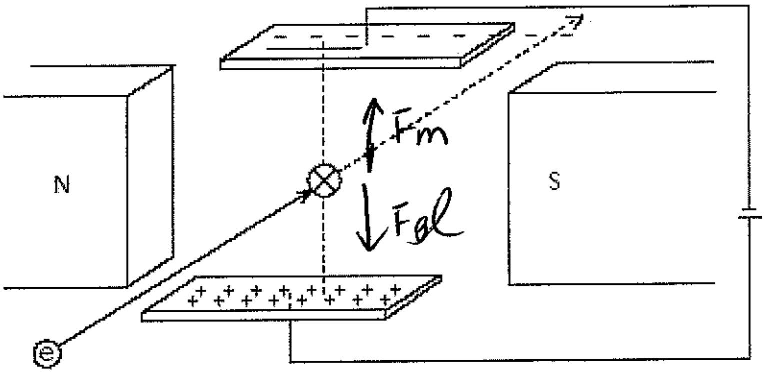
20. Consider the following diagram to answer the question.

An electron moves into the plane of the page.

$V = 2000$ V between charged plates

$d = 0.080$ m between charged plates

$B_\perp = 0.0028$ T



The electron enters the electric field, which is perpendicular to the magnetic field, and passes through both fields undeflected.

a. Draw vectors on the diagram to indicate the direction of $\vec{F}_m$ and $\vec{F}_e$ on the electron. Explain your answer.

Fel - down toward + plate (unlike charges attract)

Fm - up toward - plate (3rd left hand rule)

b. Calculate the speed of the electron moving into the electric and magnetic fields.

$$F_m = F_{el}$$

$$\cancel{q}vB_\perp = \cancel{q}|E|$$

$$v = \frac{|E|}{B_\perp} = \frac{\frac{V}{d}}{B} = \frac{\frac{2000}{0.080}}{0.0028} = \boxed{8.9\times10^{6}\,\frac{m}{s}}$$

Name: ______________________ **Class:** __________________ **Date:** _________ **ID: A**

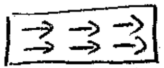
Magnetism/Electromagnetism Practice Show work for mathematical questions

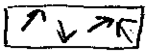
---

Multiple Choice
Identify the choice that best completes the statement or answers the question.

C 1. The definition that is **not** used for defining the directions of gravitational, electric or magnetic fields, is:
- a. direction of the force on a small test mass ⟶ used to define grav. field direction
- b. direction of the force on the N-pole of a small compass → used to define magnetic field direction
- [✓ c.] direction of geographic north
- d. direction of the force on a positive test charge → used to define electric field direction.

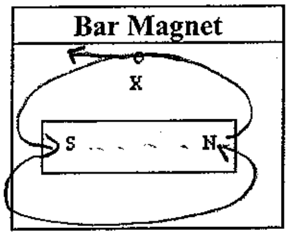
B 2. A magnetic domain can best be described as a region
- a. surrounding a current-carrying wire
- [✓ b.] within a ferromagnetic material in which the magnetic fields of most atoms are aligned
- c. within a ferromagnetic material in which the magnetic fields of all the electron motions are random
- d. in the space, surrounding a magnet, which can exert a magnetic force on a ferromagnetic material


magnetic


non-magnetic

C 3. Navigational compasses are not used in the far north because Earth's magnetic field lines:
- a. do not exist in the far north
- b. point out into space in the far north
- [✓ c.] point down to the Earth in the far north
- d. run parallel to the Earth's surface in the far north

____ 4.



mag. field N → S

The direction of the magnetic field, at point X, is toward the:
- a. bottom of the page
- b. right of the page
- [✓ c.] left of the page
- d. top of the page

____ 5. The diagram that best illustrates the magnetic field near a wire that carries an electron current into the plane of the paper is:

a. 

b. 

c. 

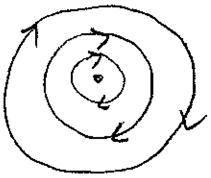
[✓ d.] 

The $\vec{B}$ created by a single moving charge can be visualized as "ripples" moving out from the charge in the space behind the moving charge. The $\vec{B}$ dissipates as the charge moves forward.

1st left hand rule

D 6. A wire carrying a large and constant current passes through the center of and perpendicular to a piece of cardboard. If iron filings are sprinkled on the cardboard, they arrange along magnetic lines of force that:

a. are random
b. are similar to those of a bar magnet
c. extend straight outwards from the wire
[✓ d.] form concentric circles surrounding the wire



B 7. The **correct** statement, concerning electricity and magnetism, is:

a. electricity and magnetism are separate and unrelated
[✓ b.] magnetism can produce electricity and electricity can produce magnetism
c. electricity can produce magnetism, but magnetism cannot produce electricity
d. magnetism can produce electricity, but electricity cannot produce magnetism

(moto effect) electricity $\xrightarrow{\text{creates}}$ magnetism (Oersted, Faraday)

(generator effect) magnetism $\xrightarrow[\text{creates}]{}$ electricty (Faraday)

B 8.

Magnetic Field Units	
I.	$\frac{Ns}{Cm}$ ✓
II.	$\frac{N}{\frac{C}{s}m}$ ✓
III.	$\frac{J}{C}$ →
IV.	T ✓

$V = \frac{\Delta E}{q} = \frac{J}{C} \Rightarrow$ measure Voltage

The **correct** unit combinations for a magnetic field are:

a. I, II, and III
[✓ b.] I, II, and IV
c. I, III, and IV
d. II, III, and IV

main unit Tesla (T)

$F_m = B_\perp I l$ or $F_m = q v B_\perp$

$B_\perp = \frac{F_m}{I l}$

$= \frac{N}{A\cdot m}$

$= \frac{N}{\frac{C}{s}\cdot m}$

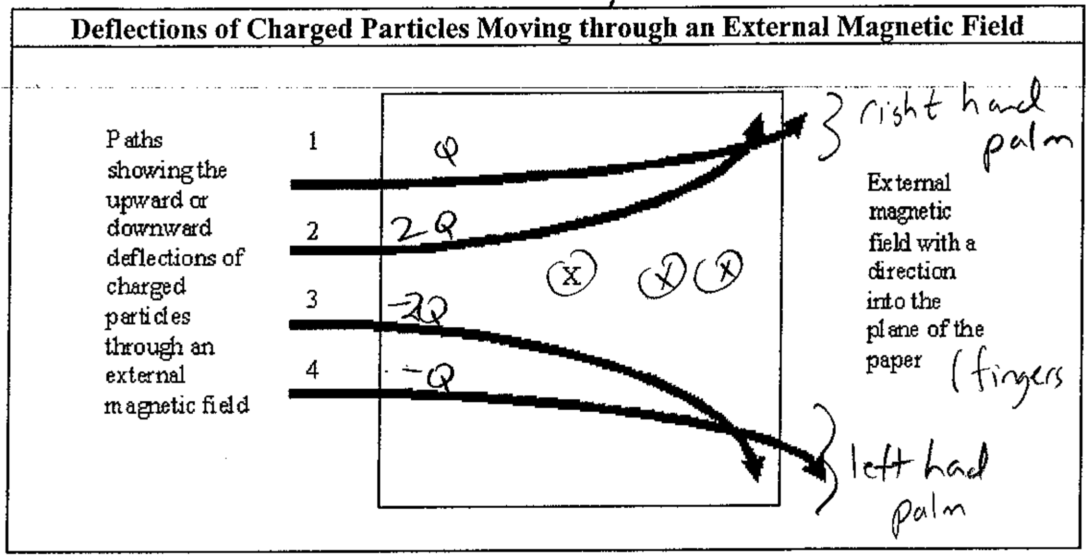
$B_\perp = \frac{F_m}{v \cdot q}$

$= \frac{N}{\frac{m}{s}\cdot C}$

$= \frac{N\cdot s}{C\cdot m}$

Name: ____________________ **ID: A**

3rd magnetic hand rule.



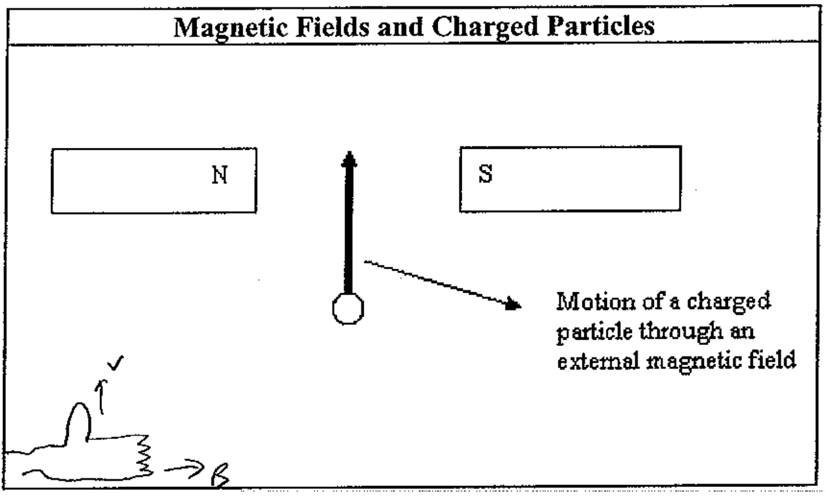
D 9. Refer to the above diagram. If the masses of all the charged particles are equal, then the charges of particles 1 and 2, respectively, could be:

a. -Q, +Q
b. +Q, +Q
c. +2Q, +Q
[✓ d.] +Q, +2Q

$F_m = qvB$

$F_m \propto q$ (more q more F_m)

B 10.



3rd hand rule

assume "–"

If the initial motion of the charged particle is upwards towards the top of the page, the charged particle, as it enters the external magnetic field of the magnets, will deflect:

a. into the page
[✓ b.] out of the page
c. toward the N-pole
d. toward the S-pole

C 11. Van Allen radiation belts, surrounding Earth, deflect fast moving charged particles from space by:

a. an energy field
b. an electric field
[✓ c.] a magnetic field
d. a gravitational field

Northern and Southern lights

(see quick review 4.3)

$F_m = qvB$

$= (2)(2)(1) = 4\times$ original F_m

D 12. If the speed and the charge of a particle moving across a magnetic field are each doubled, the deflecting force will be:

a. halved
b. doubled
c. quartered
[✓ d.] quadrupled

An alpha particle, entering a uniform external magnetic field, begins to move in a circular path.

B 13. Based on the above information, if the speed of the alpha particle were doubled, the radius of curvature would be:

a. $\frac{1}{2}r$
[✓ b.] $2r$
c. $\frac{1}{4}r$
d. $4r$

$F_m = F_c$

$qvB_\perp = \frac{mv^2}{R}$

$qBR = m\vec{v}$

$R \propto \vec{v}$

$\underset{\text{responding}}{(2)} \propto (2) \leftarrow$ manipulated

C 14. Based on the above information, if the alpha particle were replaced by an electron, then the radius of curvature of the electron would be:

a. a little smaller because the electron has a larger charge
b. a little larger because the electron has a smaller charge
[✓ c.] much smaller because the electron has a much smaller mass
d. much larger because the electron has a much smaller mass

$qB_\perp = \frac{mv}{R}$

$R \propto m$ a smaller mass deflects in smaller radius

An electron is shot at 3.20 × 10^5 m/s at right angles into a uniform magnetic field with a strength of 2.00 × 10^{-5} T.

C 15. Based on the above information, the magnitude of the magnetic deflecting force on the electron is:

a. 3.20 N
b. 6.40 N
[✓ c.] 1.02 × 10^{-18} N
d. 2.04 × 10^{-18} N

$F_m = qvB_\perp$

$= (1.6\times10^{-19})(3.20\times10^{5})(2.0\times10^{-5})$

$= 1.02\times10^{-18}$ N

B 16. Based on the above information, the radius of the path of the electron is:

a. 0.0110 m
b. 0.0911 m
c. 9.11 m
d. 11.0 m

B 17. A 12 cm long wire, placed perpendicular in an external magnetic field of 0.10 T, has a current of 10 A flowing through it. The magnetic force on the wire is:

a. 0.012 N
[✓ b.] 0.12 N
c. 1.2 N
d. 12 N

16) $F_m = F_c$

$qvB = \frac{mv^2}{R}$

$R = \frac{mv}{qB}$

$= \frac{(9.11\times10^{-31})(3.2\times10^{5})}{(1.60\times10^{-19})(2.0\times10^{-5})}$

$= 0.0911$ m

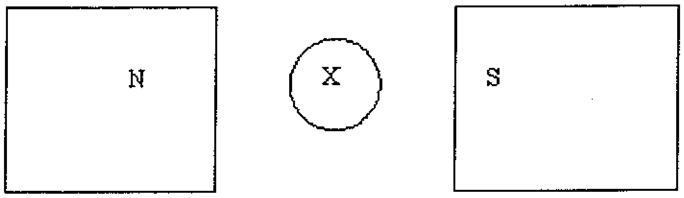
17) $F_m = B_\perp I l$

$= (.10\text{T})(10\text{A})(.12)$

$= 0.12$ N

C 18. 3rd

The X represents a wire, lying between two external magnets and carrying an electron current into the page.



thumb = into the page
fingers N → S
palm - top of page

The wire will deflect towards the:

a. S-pole
b. N-pole
[✓ c.] top of the page
d. bottom of the page

D 19. The governing physical principle determining the generation of an induced voltage in a coil of wire is:

a. 2 current-carrying wires exert forces on one another
b. a current through a coil of wire creates a magnetic force
c. the magnetic field strength varies as the inverse square law
[✓ d.] a current is induced in a wire moving through a magnetic field

discovered by Faraday called electromagnetic induction or the generator effect.

	Operation of a Motor or a Generator
1.	A current is supplied to a loop of wire within an external magnetic field.
2.	A loop of wire is rotated within an external magnetic field.
3.	A magnetic force is created that causes rotation of the loop of wire.
4.	A current is induced in the loop of wire.

____ 20. Refer to the above list of operations. The statements that apply to the operation of a simple electric motor are:

a. 1 and 2
b. 2 and 3
c. 3 and 4
[✓ d.] 1 and 3

electrical energy → mechanical energy MOTOR EFFECT

____ 21. Refer to the above list of operations. The statements that apply to the operation of a simple electric generator are:

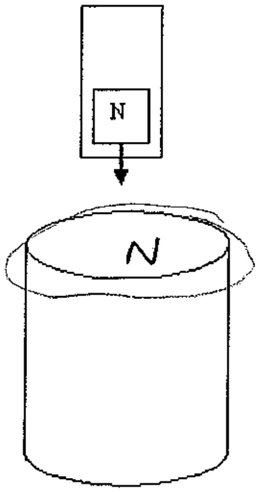
a. 1 and 2
b. 2 and 3
c. 3 and 4
[✓ d.] 2 and 4

mechanical energy → electrical energy GENERATOR EFFECT

Name: ____________________ **ID: A**

Magnet Dropping Through a Hollow Metal Cylinder

~~A magnet is dropped through a hollow metal cylinder.~~



Lenz law

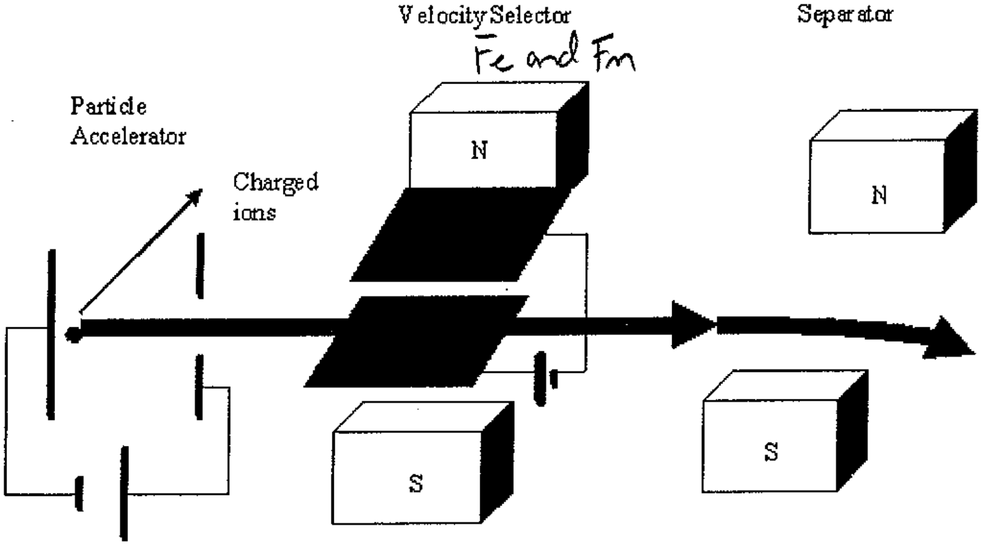
a current is induced in the cylinder which creates a $\vec{B}$ OPPOSING that of the falling magnet.

A 22. Refer to the above diagram. As the magnet approaches the top of the metal cylinder, which of the following statements is true?

[✓ a.] A north pole is created at the top of the cylinder to oppose the motion of the magnet
b. A south pole is created at the top of the cylinder to attract the motion of the magnet
c. A north pole is created at the top of the cylinder to attract the motion of the magnet
d. A south pole is created at the top of the cylinder to oppose the motion of the magnet

Mass Spectrometer

A simple mass spectrometer consists of a particle accelerator, an ion velocity selector and a separator, as shown below.



Fm causes Fc (circular motion)

balanced forces

A 23. Refer to the above diagram. If the beam of charged ions passes undeflected through the ion velocity selector, then the derived equation that could be used to determine the speed of the undeflected ions is:

[✓ a.] $v = \frac{\vec{E}}{\vec{B}}$

b. $v = \sqrt{\frac{2E_k}{m}}$

c. $v = \frac{Q\vec{B}r}{m}$

d. $v = \frac{m\vec{g}}{Q\vec{B}}$

$\uparrow F_{el}$

$\downarrow F_m$

$F_{el} = F_m$

$\cancel{q}|E| = \cancel{q}\vec{v}\vec{B}$

$\frac{|\vec{E}|}{|\vec{B}|} = \vec{v}$

C 24. Refer to the above diagram. As the beam of charged ions enters the separation chamber, the derived equation that could be used to determine the orbital speed of the charged ions is:

a. $v = \frac{\vec{E}}{\vec{B}}$

b. $v = \sqrt{\frac{2E_k}{m}}$

[✓ c.] $v = \frac{Q\vec{B}r}{m}$

d. $v = \frac{m\vec{g}}{Q\vec{B}}$

$F_m = F_c$

$q\cancel{v}B_{\perp} = \frac{mv^{\cancel{2}}}{R}$

$\frac{qBR}{m} = \vec{v}$

I will explain how the properties of electric and magnetic fields are applied in numerous devices.