Group Work for 20ABCD Name ___________________________

I. Map problems. ***F = Il**x**B*** **Directions:** **N**orth **E**ast **S**outh **W**est **U**p **D**own.
Find the direction of the missing vector: **F:** Force, **Il:** Current, **B**: Magnetic field.

F:	**Il:**	**B:**	**F:**	**Il:**	**B:**	**F:**	**Il:**	**B:**
?	D	E (S)	W	?	N (U)	S	E	? (U)
?	S	W (D)	D	?	W (S)	N	U	? (E)
?	U	S (E)	E	?	N (D)	S	U	? (W)
?	N	W (U)	D	?	E (N)	U	S	? (E)

II. Forces on a Wire *F = IlBsin(Θ)- NESW*
1. A current of 16.2 A flows West along a wire in a magnetic field of 0.0113 T that is 35.0^o west of North. What force acts on the wire if it is 12.0 m long? (Magnitude and direction) (1.80 N, vert downward)

2. A current of 24.1 A flows East along a wire in a magnetic field of 0.0241 T that is 20.0^o east of North. What force acts on the wire if it is 18.5 m long? (Magnitude and direction) (10.1 N, vert upward)

3. A current of 62.4 A flows South along a wire in a magnetic field of 0.0615 T that is 15.0^o east of North. What force acts on the wire if it is 116 m long? (Magnitude and direction) (115.2 N, vert upward)

III. Forces on a Wire *F = IlBsin(Θ)- NESW* perpendicular
4. A 32.7 cm long wire experiences a force of 4.12 N to the West in a vertically upward 0.0452 T magnetic field. What is the current, and in what direction does it flow? (Assume it is perpendicular) (279 A South)

5. A 1.59 Amp current flows East in a wire that is 34.2 cm long. What is the magnetic field (Assume it is perpendicular) if the wire experiences a Northerly force of 3.74 N? (Magnitude and direction) (6.88 T vert downward)

6. A 3.80 Amp current flows South in a wire that is 21.1 cm long. What is the magnetic field (Assume it is perpendicular) if the wire experiences a vertically upward force of 4.78 N? (Magnitude and direction) (5.96 T East)

IV. Particles *F = qvBsin(Θ) (remember – negative charges are the opposite)*
7. A proton travels at 3.20×10^3 m/s vertically upward, and experiences a force of 9.50×10^{-15} N to the South. What is the magnitude and direction of the magnetic field exerting this force? (18.5 T West)

8. A moving electron travels through a 5.60 T easterly magnetic field, and experiences a force of 2.50×10^{-12} N vertically upward. What is the magnitude and direction of the electron's velocity? (2.79×10^6 m/s North)

9. An electron travels at 6.50×10^4 m/s to the South through a vertically upward 0.315 T magnetic field. What is the magnitude and direction of the force acting on the electron? (3.28×10^{-15} N East)

V. Crossed Fields Direction only. **N**orth **E**ast **S**outh **W**est **U**p **D**own. **B**: Magnetic field, **E:** Electric field, **v:** velocity. Determine what direction the missing vector should be so that a moving charged particle can go straight. Assume all angles are perpendicular.

B:	**E:**	**v:**	**B:**	**E:**	**v:**	**B:**	**E:**	**v:**
N	?	E (D)	?	E	N (D)	S	E	? (D)
U	?	N (W)	?	D	W (S)	U	W	? (N)
W	?	D (S)	?	S	W (U)	D	N	? (W)
S	?	W (D)	?	E	U (N)	S	U	? (E)

VII. Simple Crossed Fields problems. *$F = qvB\sin(\Theta)$ and $F = Eq$*

10. A proton traveling East at 5.90×10^{4} m/s through a northerly magnetic field of 0.290 T experiences what magnetic force in what direction? (2.74×10^{-15} N, vert upward) What electric field in what direction would keep it going straight? (1.71×10^{4} N/C, vert downward)

11. A proton goes straight East at 7.18×10^{3} m/s through a vertically downward electric field of 4.50×10^{5} N/C What must be the direction and magnitude of the magnetic field in this region? (62.7 T, North) If the proton were to speed up which way would it deflect? (up) If the proton were to slow down which way would it deflect? (down) If the magnetic field decreased? (down) increased? (up) If the electric field increased? (down) decreased? (up) If the mass of the particle increased, decreased? (no effect either way)

12. An electron travels in a straight line through a southerly electric field of 3.80×10^{5} N/C, and a magnetic field of 0.287 T that is vertically downwards. What must be the direction and magnitude of the electron's velocity? (1.32×10^{6} m/s, East) If the electron were to speed up which way would it deflect? (South) If the magnetic field decreased? (North) If the electric field increased? (North)

VIII. Circular Motion and Crossed Fields *$F = qvB\sin(\Theta)$ and $F = mv^2/r$ and $F = Eq$*

Directions: up the page, right, down the page, left, into the page, out of the page

13. a. A proton traveling at 3.71×10^{6} m/s in the plane of this page travels clockwise in a circle with a radius of 4.90 cm. What is the **magnitude and direction** of the **magnetic** field that effects this? (0.791 T out of the page)

b. What **<u>electric field</u>** in what **<u>direction</u>** would make the proton go straight to the left on the page (🡐) in the previous problem? (2.93×10^{6} N/C, down the page)

14. a. An electron in a 0.0312 mT magnetic field into this page is going in a 2.65 mm radius circle. What is the electron's **velocity**, and which direction does it circle, **ACW or CW**? (1.45×10^{4} m/s, CW)

b. What **<u>electric field</u>** in what **<u>direction</u>** would make the electron go straight up the page in the previous problem? (0.454 N/C, right)

15. a. A mystery particle with a mass of 6.69×10^{-27} kg traveling 3.62×10^{6} m/s in a 0.982 T magnetic field into this page revolves anti-clockwise with a radius 7.70 cm. What is the **charge** of the particle, and is it **positive, or negative**? (3.20×10^{-19} C, positive)

b. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight down the page in the previous problem? (3.55×10^{6} N/C, left)

IB Physics

FA 20.2 - Forces on Wires and Particles

N
W E
S

Name___________________________

Favorite Composer/Songwriter____

Show your work, circle your answers, and use sig figs to receive full credit.

1. 18.2 A of current flow east along a wire in a magnetic field of 0.0150 T that is 17.0^{o} east of North. What force acts on the wire if it is 113 m long? (Magnitude and direction)

2. A 4.2 Amp current flows North in a wire that is 12.1 cm long. What is the magnetic field (Assume it is perpendicular) if the wire experiences a vertically upward force of 12.15 N? (Magnitude <u>and</u> direction)

3. An electron travels at 3.5 x 10^{4} m/s to the North, and experiences a force of 2.1 x 10^{-14} N vertically downward. What is the magnitude and direction of the magnetic field exerting this force?

4. A proton is going 1.71 x 10^{5} m/s in the plane of the page in a 2.30 T magnetic field out of this page. What is the radius of its path? Which direction does it circle, ACW or CW?

5. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight up the page in the previous problem?

Practice for 20.2 (Optional)

1\. a. 26.1 A of current flow north along a wire in a magnetic field of 0.0154 T that is 62.0° east of South. What force acts on the wire if it is 132 m long? (Magnitude and direction) (46.8 N vert down)
b. A 1.48 Amp current flows South in a wire that is 17.2 cm long. What is the magnetic field (Assume it is perpendicular) if the wire experiences a vertically upward force of 3.17 N? (Magnitude <u>and</u> direction) (12.5 T east)
c. A moving electron travels through a 2.43 T upward magnetic field, and experiences a force of 7.2×10^{-12} N to the east. What is the magnitude and direction of the particle's velocity? (1.8×10^{7} m/s south)
d. A mystery particle with a mass of 6.69×10^{-27} kg traveling 2.96×10^{6} m/s in a 1.21 T magnetic field out of this page revolves clockwise with a radius 5.11×10^{-2} m. What is the **charge** of the particle, and is it **positive, or negative**? (3.20×10^{-19} C, positive)
e. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight down the page in the previous problem? (3.58×10^{6} N/C right)

2\. a. 21.4 A of current flow west along a wire in a magnetic field of 0.0305 T that is 78.0° north of east. What force acts on the wire if it is 215 m long? (Magnitude and direction) (137 N vert down)
b. A current of 31.8 A flowing in a wire experiences a force to the North of 1.61 N in a region where there is a magnetic field of 0.597 T vertically upward. What is the length of the wire perpendicular to the magnetic field, and in what direction does the current flow? (0.0848 m, west)
c. A proton travels at 2.17×10^{3} m/s vertically upward, and experiences a force of 8.1×10^{-16} N to the east. What is the magnitude and direction of the magnetic field exerting this force? (2.33 T south)
d. An electron is going 2.47×10^{6} m/s in the plane of the page in a 0.128 T magnetic field out of this page. What is the **radius** of its path? Which **direction** does it circle, **ACW or CW**? (1.10×10^{-4} m, ACW)
e. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight to the right on the page(**➔**) in the previous problem? (3.16×10^{5} N/C up the page)

3\. a. 11.8 A of current flow east along a wire in a magnetic field of 0.0451 T that is 32.0° east of North. What force acts on the wire if it is 126 m long? (Magnitude and direction) (56.9 N vert up)
b. A vertical wire 35.7 cm long experiences a 0.821 N force to the East in a 0.0783 T Northerly magnetic field. What is the current flowing in the wire, and which way does it flow? (Assume it is perpendicular) (29.4 A vert down)
c. A moving electron travels through a 0.78 T westerly magnetic field, and experiences a force of 2.5×10^{-14} N vertically upward. What is the magnitude and direction of the particle's velocity? (2.0×10^{5} m/s south)
d. A proton traveling at 4.81×10^{6} m/s in the plane of this page travels anti-clockwise in a circle with a radius of 2.87 mm (2.87×10^{-3} m). What is the **magnitude and direction** of the **magnetic** field that effects this? (17.5 T into the page)
e. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight to the left on the page (**🡐**) in the previous problem? (8.42×10^{7} N/C up the page)

4\. a. 13.1 A of current flow south along a wire in a magnetic field of 0.0241 T that is 56.0° north of West. What force acts on the wire if it is 501 m long? (Magnitude and direction) (88.4 N vert down)
b. A 45.7 cm long wire experiences a force of 3.12 N to the North in a vertically upward 0.0382 T magnetic field. What is the current, and in what direction does it flow? (Assume it is perpendicular) (179 A West)
c. A proton travels at 5.2×10^{3} m/s to the North through a vertically downward 0.45 T magnetic field. What is the magnitude and direction of the force acting on the particle? (3.7×10^{-16} N West)
d. An electron in a 0.00287 T magnetic field out of this page goes in a circle with a radius of 0.0781 m. What is the electron's **velocity**, and which direction does it circle, **ACW or CW**? (3.94×10^{7} m/s, ACW)
e. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight up the page in the previous problem? (1.13×10^{5} N/C left)

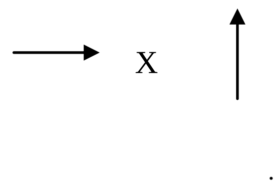
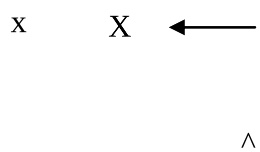
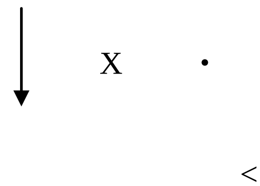
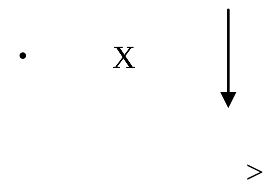
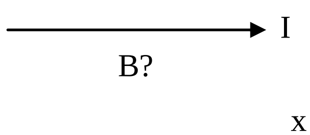
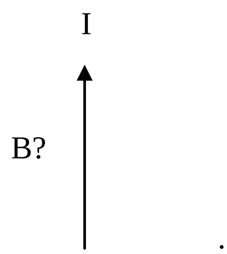
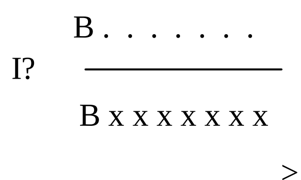
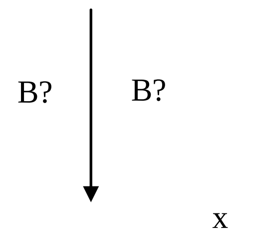
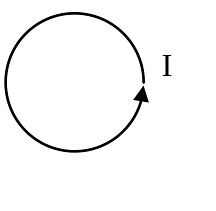
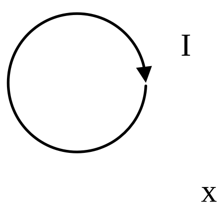
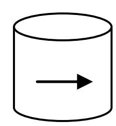
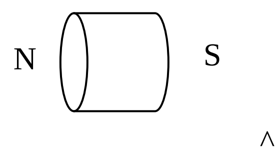
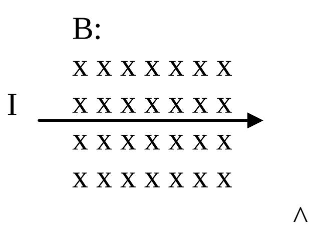
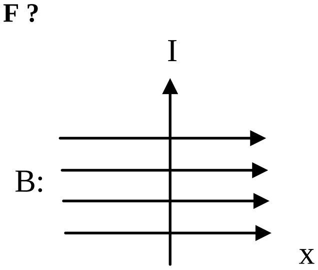
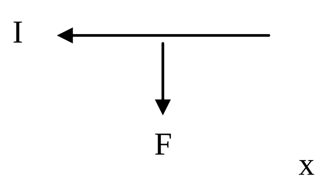
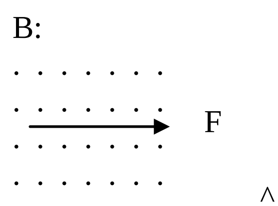
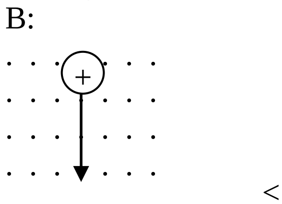
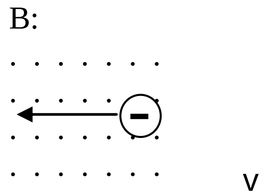
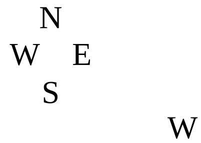
5\. a. 15.2 A of current flow north along a wire in a magnetic field of 0.0127 T that is 23.0° south of East. What force acts on the wire if it is 157 m long? (Magnitude and direction) (vert down 27.9 N)
b. A 3.2 Amp current flows West in a wire that is 32.1 cm long. What is the magnetic field (Assume it is perpendicular) if the wire experiences a vertically downward force of 4.17 N? (Magnitude <u>and</u> direction) (4.1 T North)
c. An electron travels at 7.8×10^{5} m/s to the South, and experiences a force of 4.3×10^{-14} N to the East. What is the magnitude and direction of the magnetic field exerting this force? (0.34 T vert up)
d. A proton in is going 3.71×10^{5} m/s in the plane of the page. A magnetic field is making it travel in clockwise circles with a radius of 2.37 m. What is the **magnitude** and **direction** of the **magnetic field**? (0.00163T out of page)
e. What **<u>electric field</u>** in what **<u>direction</u>** would make the particle go straight down the page in the previous problem? (607 N/C right)

IB Physics
FA 20.1 - Right Hand Rules

Name_________________________(We will do this on Canvas)

Favorite Oxymoron____

Label the direction of the quantity listed in the location indicated. (˙ = out of the page, x = into the page)

1				
2				
3	**Which way does the north pole point?** 	**Which way does the north pole point?** 	**Which way does the north pole point?**  **(Current flow L to R on Front of coil)** ^	**Which way does the current flow on the front side of this coil** 
4	**F ?** 	**F ?** 	**B ? (That causes the force)** 	**I ?** 
5	**Which way is the force on the moving particle?** 	**Which way is the force on the moving particle?** 	**Which way must a proton move to experience a vertically downward force in a northerly magnetic field?** 	**An electron moving east experiences a force to the north. B is what way?** 

IB Physics
FA 20.3 - Ampere's law

Name________________________

Favorite Orchestra_____________________________________

Show your work, circle your answers, and use sig figs to receive full credit.

1. What is the magnetic field 3.50 cm to the right of a long straight in the plane of the page wire carrying 120. A? (6.86×10^{-4} T into the page)

2. There is a magnetic field of 8.20×10^{-5} T into the page 12.0 cm to the right of a long straight wire that runs up and down the page. What is the current flowing in the wire, and does it flow up or down the page? (49.2 A up the page)

3. Two straight wires are parallel for 3.40 m at a distance from each other of 15.0 cm. The leftmost has a current of 12.0 A flowing <u>up</u> the page, and the rightmost, a current of 18.0 A flowing <u>down</u> the page. What is the force on the <u>leftmost</u> wire? <u>On the back of this sheet write the complete definition of the Ampere</u> (9.79×10^{-4} N to the left)

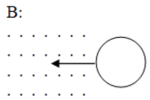
4. A narrow solenoid is 14.0 cm long and has 112 windings. What is the magnetic field inside if it carries 2.30 A of current? (0.00231 T)

5. One of my solenoids is 2.70 cm long, and has 50.0 windings. What current must flow in the wires if we want to create a magnetic field of 1.00 Tesla? (solenoids with iron cores would require much less current) (430. A)

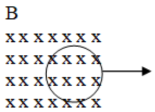
Group Work for 21ABCEF Name ___________________________

II. Simple solenoids moved relative to B field.

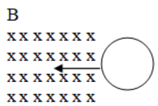
1. The 16.0 cm **diameter** loop below has 42 windings is pushed into the 8.70 T magnetic field in 0.0140 s. What is the average EMF, and what direction does the current flow? (525 V, CW)



2. The 15.0 cm **radius** loop below has 12 windings is pulled from the 7.20 T magnetic field generating an average EMF of 67.0 V. What time did this take, and which direction did the current flow? (91.2 ms, CW)

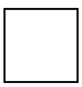


3. The loop below is put into the 6.30 T magnetic field in 0.0120 s generating an average EMF of 93.0 V. What is the **diameter** of the 56 winding loop and which direction does the current flow? (6.35 cm, ACW)

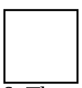


III. Magnet Approaches/Recedes

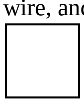
4. The recession of the South pole of a magnet from above the page changes the magnetic field from 9.50 T out of the page, to 3.20 T out of the page in 0.0130 s inside this 0.510 m x 0.510 m square. What is the induced EMF, and what current flows in what direction (CW or ACW) if the loop has a resistance of 2.70 Ω? (126 V, 46.7 A, ACW)



5. The motion of the North pole of a magnet from above the page changes the magnetic field by 2.70 T inside this 0.820 m x 0.820 m square. A current of 2.10 A flows CW in the loop with a resistance of 0.260 Ω, so what is the induced EMF, how much time did the magnet take to move, and did it approach or recede? (546 mV, 3.33 s, The magnet receded)

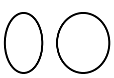


6. The approach of the South pole of a magnet from above the page changes the magnetic field from 0.105 T out of the page, to 3.60 T out of the page in 0.0150 s inside this 0.480 m x 0.480 m square. The current in the wire is 12.5 A. What is the induced EMF, what is the resistance of the wire, and what direction did the current flow? (53.7 V, 4.29 Ω, CW)

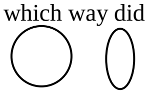


IV. Loop rotation $\Delta\Phi_B = (BA\cos\theta_1 - BA\cos\theta_2) = BA(\cos\theta_1 - \cos\theta_2)$

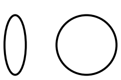
7. A single loop of wire with a **diameter** of 0.210 m starts at an angle of 54.0^o with the page, and is rotated to an angle of 23.0^o with the page. If there is a 12.0 T magnetic field into the page, and the rotation takes 0.0150 s, what is the average EMF generated? Which way does it flow? (9.22 V, ACW)



8. A single loop of wire with a **radius** of 0.650 m is in the plane of this page, and is rotated so that the loop forms a 65.0^o angle with the page. If there is a 6.50 T magnetic field into the page, and this generates an average EMF of 18.0 V, in what time did the loop undergo the rotation, and which way did the current flow? (CW or ACW) (0.277 s, CW)



9. A single loop of wire with a **diameter** of 0.780 m starts at an angle of 78.0^o with the page, and is rotated to the plane of the page. If there is a voltage of 32.0 V making current go clockwise, and the rotation takes 0.0160 s, what is the magnetic field (assume it is perpendicular to the page), and which way is it, into or out of the page? (1.35 T, out of the page)



V. Moving Conductors

10. A 25.6 cm long horizontal wire in the plane of the page is traveling down the page at 12.5 m/s through a 2.50 T magnetic field into the page. What is the EMF from one end to the other? Which end is positive, the right or the left? (8.00 V, right is positive)

11. A vertical wire 13.5 m long in the plane of the page traveling to the right through a 1.10 T magnetic field out of the page. What is its velocity if there exists a potential of 64.0 V from one end to the other? Which end is positive, the top or the bottom? (4.31 m/s, bottom is positive)

12. A vertical wire in the plane of the page is 15.0 m long, and is traveling to the left at 22.0 m/s through a magnetic field perpendicular to the page. There exists a potential of 1.35 V between one end and the other. The bottom is positive. What is the magnitude of the magnetic field, and is it into or out of the page? (4.09 mT, into the page)

VII. Transformers

13. A transformer has 5200. primary windings, and 208 secondary windings. What is the voltage in the secondary if there is a voltage of 125 V (AC) in the primary? What is the secondary current if the primary is 12.0 mA? (5.00 V, 300 mA)

14. A transformer has 412. primary windings, and 6700. secondary windings. What is the voltage in the primary if there is a voltage of 112 V (AC) in the secondary? What is the primary current if the secondary is 140. mA? (6.89 V, 2.28 A)

15. You want to step 120. VAC down to 9.60 VAC with a transformer. What should be the number of primary windings if you have 120. secondary windings? What is the secondary current if the primary is 220. mA? (1,500 windings, 2.75 A)

VIII. Transmission of Power

16. If you transmit 1300. W of power at 700. VAC, how much power is lost if the lines have a resistance of 7.20 Ω? (24.8 W)

17. If you wanted to transmit 1700. W of power over 3.20 Ω power lines, what voltage would you need to use to waste only 6.50 W? (1193 V)

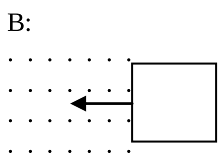
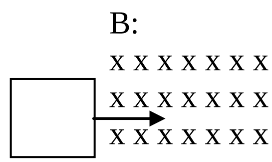
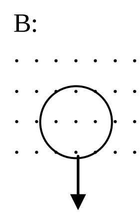
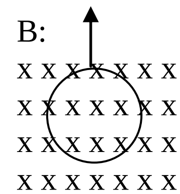
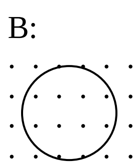
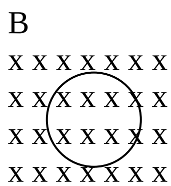
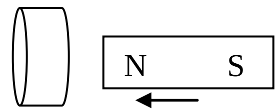
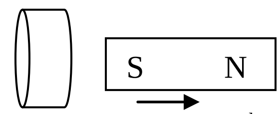
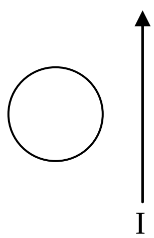
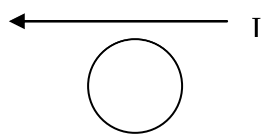
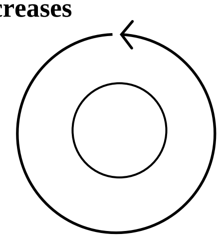
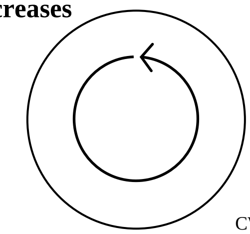
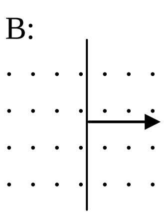
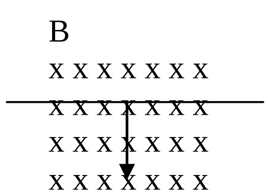
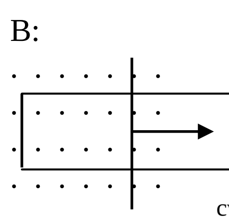
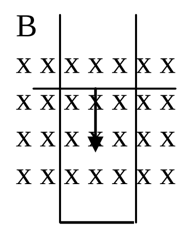
18. You transmit 19,000. W of power at 15,800 VAC and waste only 3.40 W. What is the resistance of your transmission lines? (2.35 Ω)

IB Physics
FA 21.1 - Lenz's Law

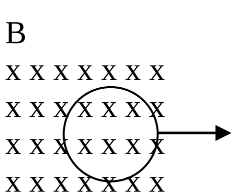
Name________________________

Favorite Slogan____

Find the direction of the induced current (CW or ACW) "." = out of the page, "x" = into the page)

1	 CW	 ACW	 ACW	 CW
2	**B increases**  CW	**B decreases**  CW	**The magnet moves as shown. Which way does the current flow on the front of the coil?**  down	**The magnet moves as shown. Which way does the current flow on the front of the coil?**  down
3	**Current increases**  CW	**Current decreases**  ACW	**Current in outer loop increases**  CW	**Current in inner loop increases**  CW
4	**Which end of the wire is +?**  bottom	**Which end of the wire is +?**  right	**CW or ACW?**  cw	**CW or ACW**  cw

5. The 12.0 cm diameter loop below has 58 windings, and is pulled from the 3.10 T magnetic field in 0.0150 s. What is the average EMF, and what direction does the current flow? (136 V, CW)



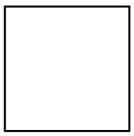
IB Physics
FA 21.2 - Electrical Induction

Name_________________________

Favorite Band____

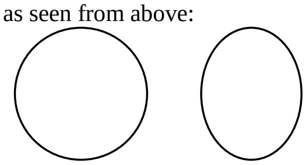
Show your work, circle your answers, and use sig figs to receive full credit.

1. The motion of a North pole of a magnet above the page makes the magnetic field change by 1.15 T inside this 0.650 x 0.650 square wire loop. If the loop has a resistance of 1.30 Ω, and a current of 560. mA flowed ACW while the magnet was moving, what time did it take the magnet to move, and did the magnet approach or recede?



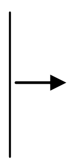
2. A loop of wire with a radius of 0.78 m is in the plane of this page, and is rotated so that the loop forms a 23.0^{o} angle with the page. If there is a 3.72 T magnetic field into the page, and the rotation takes 0.0150 s, what is the average EMF generated? Which way does it flow?

as seen from above:



before after

3. The wire below is 2.28 m long (really!) and is traveling through a 6.71 T magnetic field out of the page. What is its speed if there exists a potential of 41.6 V from one end to the other? Label the positive end of the wire with a "+".



4. A transformer has 350. primary windings, and 1600. secondary windings. What is the voltage in the primary if there is a voltage of 512 V (AC) in the secondary? If the transformer has 3.40 A in the primary, what is the current in the secondary? (Assume it is 100% efficient)

5. If you transmit 1200. W of power at 800. VAC, how much power is lost if the lines have a resistance of 3.20 Ω? How much would be lost if you transmitted the same power at 10,000. VAC?

Practice for 21.2 - Faraday's Law (Optional)

1. a. The approach of the South pole of a magnet from above the page changes the magnetic field from 0.125 T out of the page, to 1.60 T out of the page in 0.0260 s inside this 0.450x0.450 m square. What <u>current</u> flows in <u>what direction</u> (CW or ACW) if the loop has a resistance of 0.850 Ω? (EMF = 11.5 V, I = 13.5 A, CW)
b. A loop of wire with a radius of 0.430 m starts at an angle of 75.0^{o} with the page, and is rotated to the plane of the page. If there is a 6.95 T magnetic field into the page, and the rotation takes 0.00500 s, what is the average EMF generated? Which way does it flow? (598 V, ACW)
c. A vertical wire in the plane of the page traveling to the right is moving at 1.05 m/s through a 7.24 T magnetic field out of the page. What is its length if there exists a potential of 4.72 V from one end to the other? Which end is positive, the top or the bottom? (0.621 m, bottom)
d. A transformer has 3800. primary windings, and 550. secondary windings. What is the voltage in the primary if there is a voltage of 72.6 V (AC) in the secondary? What is the secondary current if the primary is 120. mA? (502 V, 829 mA or 0.829 A)
e. If you transmit 1500. W of power at 800. VAC, how much power is lost if the lines have a resistance of 4.10 Ω? (14.4 W)

2. a. The motion of the North pole of a magnet from above the page changes the magnetic field in 0.0340 s inside this 0.630x0.630 m square. A current of 3.40 A flows CW in the loop with a resistance of 0.530 Ω, so how large was the change in magnetic field, and did the magnet approach the page, or recede? (0.154 T, magnet receded)
b. A loop of wire with a radius of 0.900 m is in the plane of this page, and is rotated so that the loop forms a 42.0^{o} angle with the page. If there is a 5.73 T magnetic field into the page, and this generates an EMF of 16.7 V, in what time did the loop undergo the rotation, and which way did the current flow? (CW or ACW) (0.224 s, CW)
c. A vertical wire in the plane of the page is 2.86 m long, and is traveling to the left at 16.0 m/s through a magnetic field perpendicular to the page. There exists a potential of 19.2 V between one end and the other. The top is positive. What is the magnitude of the magnetic field, and is it into or out of the page? (0.420 T out of page)
d. You want to step 120. VAC down to 24.0 VAC with a transformer. What should be the number of primary windings if you have 1300. secondary windings? What is the secondary current if the primary is 180. mA? (6500 windings, 900. mA or 0.900 A)
e. If you wanted to transmit 1400. W of power over 4.20 Ω power lines, what voltage would you need to use to waste only 1.70 W? ($2.20\text{x}10^{3}$ V)

3. a. The motion of the North pole of a magnet from above the page changes the magnetic field by 4.20 T in 0.0210 s inside this square. A current of 8.60 A flows ACW in the loop with a resistance of 0.930 Ω, so what is the area of the loop in m^2, and did the magnet approach or recede? (0.0400 m^2, or 20 cm on a side, magnet approached)
b. A loop of wire is in the plane of this page, and is rotated so that the loop forms a 78.0^{o} angle with the page. If there is a 4.92 T magnetic field into the page, and the rotation takes 0.0180 s, and there is an EMF of 56.2 V generated, what is the radius of the loop, and what is the direction of the current flow, CW or ACW? (0.287 m, CW)
c. A horizontal wire in the plane of the page wire is 6.05 m long and is traveling down the page through a 2.64 T magnetic field out of the page. What is its speed if there exists a potential of 21.7 V from one end to the other? Which end is positive, the right, or left? (1.36 m/s, left side)
d. A transformer has 340. primary windings, and 8900. secondary windings. What is the voltage in the primary if there is a voltage of 343 V (AC) in the secondary? What is the primary current if the secondary is 130. mA? (13.1 V, 3.40 A or 3403 mA)
e. You transmit 18,000. W of power at 12,300 VAC and waste only 2.30 W. What is the resistance of your transmission lines? (1.07 Ω)

4. a. The motion of the South pole of a magnet from above the page changes the magnetic field by 5.20 T inside this 0.420x0.420 square. A current of 5.10 A flows CW in the loop with a resistance of 0.530 Ω, so how much time did the magnet take to move, and did it approach or recede? (0.339 s, magnet approached)
b. A loop of wire with a radius of 0.320 m starts at an angle of 60.0^{o} with the page, and is rotated to the plane of the page. If there is a voltage of 23.1 V making current go clockwise, and the rotation takes 0.0520 s, what is the magnetic field (assume it is perpendicular to the page), and which way is it, into or out of the page? (7.47 T, out of the page)
c. A horizontal wire in the plane of the page is traveling up the page at 5.29 m/s through a 3.03 T magnetic field into the page. What is its length if there exists a potential of 9.00 V from one end to the other? Which end is positive, the right or the left? (0.561 m. left side)
d. You want to step 120. VAC down to 5.00 VAC with a transformer. What should be the number of secondary windings if you have 5600. primary windings? What is the primary current if the secondary is 170. mA? (233 windings, 3403 mA or 3.40 A)
e. You are wasting 1.10 W of power, when you transmit at 13,400 VAC on 1.60 Ω transmission lines. What is your transmitted power? (11,100 W)

5. a. The recession of the North pole of a magnet from above the page changes the magnetic field from 7.30 T into the page, to 1.60 T into the page in 0.0160 s inside this 0.530x0.530 m square. What <u>current</u> flows in <u>what direction</u> (CW or ACW) if the loop has a resistance of 0.150 Ω? (667 A, CW)
b. A loop of wire with a radius of 0.310 m starts at an angle of 57.0^{o} with the page, and is rotated to the plane of the page. If there is a 2.74 T magnetic field into the page, and the rotation takes 0.0540 s, what is the average EMF generated? Which way does it flow? (6.98 V, ACW)
c. A vertical wire in the plane of the page is 6.19 m long, and is traveling to the left at 67.1 m/s through a magnetic field perpendicular to the page. There exists a potential of 12.7 V between one end and the other. The top is positive. What is the magnitude of the magnetic field, and is it into or out of the page? (0.0306 T, out of the page)
d. A transformer has 170. primary windings, and 4500. secondary windings. What is the voltage in the primary if there is a voltage of 645 V (AC) in the secondary? What is the primary current if the secondary is 190. mA? (24.4 V, 5029 mA or 5.03 A)
e. If you transmit 1800. W of power at 10,200. VAC, how much power is lost if the lines have a resistance of 2.10 Ω? (0.0654 W)

Specific Heat of Water

We are going to use an electric pot to calculate the specific heat of water. We will calculate the electrical power it is consuming, time how long it is on to get the energy delivered, measure the mass of the water, and its temperature rise and voila!

Here's what to do:

1. Carefully measure 1.5 liters of water into the pot. **Write down the mass and the uncertainty of the mass.** The uncertainty of the mass will be twice half the smallest division on the graduated cylinder. Don't turn it on yet, but place it on the base, and put the thermometer in and let it come to equilibrium. **Measure the initial temperature, and estimate the uncertainty of the temperature.**
2. Put the multimeter on 200 VAC, and CAREFULLY plug the leads into the same strip as the pot. Don't read the voltage yet, wait until the pot is on.
3. Get the stopwatch ready, and turn on the pot for 4 minutes, (**Write down the time you use and its uncertainty**) and then turn it off. While it is on write down the voltage. **The voltage will vary, so come up with what you think is an average, and an uncertainty.**
4. Watch the thermometer, and read the highest value it reaches. **Write the temperature down and its uncertainty**.
5. Take out the thermometer, pour out the water, take the pot off its base, turn it over, and with the multimeter on 200 ohms, **measure the resistance of the leads and its uncertainty**, (Touch the leads together firmly), and the **resistance of the heating element and its uncertainty.** (Turn switch to "on", and find the resistance between the outer two plugs on the bottom. Don't forget to turn the switch off when you are done.)
6. Make a nice **data table with units and uncertainties.**

How to calculate:

1. Find the change in temperature and the uncertainty of the change by subtracting initial from final temperature. Remember, the uncertainty of a difference is the sum of the uncertainties.
2. Find the resistance of the heating element and its uncertainty by subtracting the resistance of the leads from the resistance you measured between the two prongs on the pot.
3. Calculate the power delivered to the element from the voltage and the resistance.
4. Calculate the energy delivered to the water by multiplying time by power.
5. Use $Q = mc\Delta T$ to find C
6. Use $\frac{\Delta C}{C} = 2\frac{\Delta V}{V} + \frac{\Delta R}{R} + \frac{\Delta m}{m} + \frac{\Delta T}{T} + \frac{\Delta t}{t}$ to find the uncertainty of the specific heat.
7. Express the specific heat as a best guess +/- an uncertainty.

How to conclude:

1. Citing data from your experiment, and what the accepted value is for the specific heat of water, (Look it up. it actually depends on the temperature....) **make a logical argument as to whether the accepted value does or does not fall within your uncertainty.**
2. Heat almost certainly was lost to the surroundings. Would that make your value for C too high or too low. **Explain why**
3. List at least three main sources of error in the experiment. (I can think of about ten...)
4. For your three sources, explain how we might mitigate them.

Magnaprobe Lab

0. Pick up a magnaprobe from the paper from one of the outlines. These are actually very expensive little things, so be very gentle with them. Try to avoid sticking them to anything. The red end is the north pole end, and so it is like the tip of an arrow; whichever way the red end points, so points the magnetic field.

A. The Fixed Magnets.

1. Move the probe around the rectangular fixed magnet and let the magnaprobe trace out the magnetic field. Which end of this magnet is the North pole end?
2. The rock looking thing is a piece of lodestone – magnetic ore from the earth. Map out its magnetic field. Where is its north pole?
3. Carefully figure out on the hard drive magnets taped to the counter where the N and S poles are. Inside the hard drive they would face each other.
4. Check out the see-through computer hard drive.

B. The mysterious Levitation Spinny Magnet.

Solve the mystery that is the levitation spinny magnet using your magnaprobe. Where are magnets hidden in the base, and spinny part? What is their polarity?

C. Electric motors

Check out the electric motors. Where are the poles on the fixed magnets? Look at the motor for the hard drive. Find the poles on the rotor (The thing that spins attached to the platters)

D. The hand crank generator.

Turn this generator gently – it is very expensive to replace. Try turning the generator with nothing attached, and then connect it to the bulb. Notice how the resistance changes. Now try connecting the clips together in a dead short. Notice how it is really hard. The idea here is that the work you are doing turning the crank turns into electrical power. The more current that flows, the more work you must do. Try the hand crank flashlight. Squeezing the handle makes a generator spin inside the body of the flashlight. How does the light stay lit when you are not actually squeezing the handle?

E. A current carrying straight wire.

Turn the power supply on, and check to see that about 4 A of current is flowing. Find the large square made of many windings. Pick the vertical side nearest you and treat it as a long straight wire. Use the wire right hand rule to predict which way the magnetic field wraps around the wire. (Thumb – I, fingers wrap as B) Now use the magnaprobe to confirm this.

F. Flat solenoid.

Now treat the large square with many windings as a flat magnet. Use the right hand rule for solenoids to determine where the north pole is on this magnet. (fingers wrap as I, thumb is the N pole) Use the magnaprobe to check this. Figure out which way the field is in the area inside the coil in general.

G. The long long solenoid.

Turn the power supply on and check to see that a current of about 4 A is flowing. The current is coming out of the red terminal of the power supply, and going into the black terminal. Use your right hand rule for solenoids to determine the north pole for this solenoid. (fingers wrap as I, thumb is the N pole) Generally check out the direction of the magnetic field around and inside the solenoid.

Put your magnaprobe back on the paper where you found it.

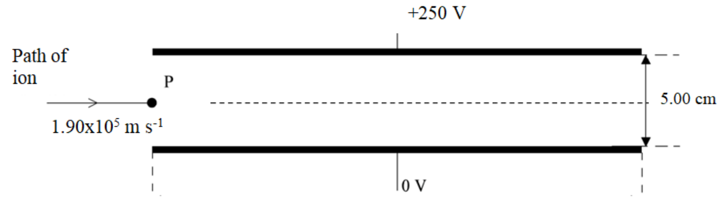
H. BusyTown

By reaching under the box, find the little magnets stuck the underside of the street. Use this to drive your little car around the streets of BusyTown. Remember to stop at the intersections – they are all four way stops, and also stay on the right side of the road – because this isn't Britain, is it?? See if you can find your way to the gas station, the antique shop, and the shoe store. But seriously, you can steer the car, so how must the poles of the magnets be laid out above and below the cardboard?

IB Magnetism Mock Test (Do this on your own paper)

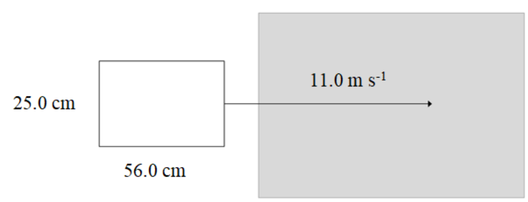
1. An electron goes in clockwise in a 0.00115 m radius circle in the plane of this page. It has a velocity of $1.60\text{x}10^6$ m s^{-1}.
a. Draw the velocity, magnetic force, and acceleration vectors. Calculate the magnetic field, state the direction. (7.91 mT, into page)
b. Show that the magnetic field is given by $B = \frac{mv}{er}$ where m is the electron mass, v the velocity, e the elementary, r the radius
c. Show that the period T of its motion is given by $T = \frac{2\pi m}{eB}$ where etc.
d. What is the relationship between the velocity of the electron and its radius r of curvature? How does mass affect r? How does B affect r? (Increasing v increases r, increasing m increases r, increasing B decreases r)

2. A negatively charged ion traveling at $1.90\text{x}10^5$ m/s is moving with a purely horizontal velocity between two parallel plates separated by 5.00 cm. The top plate is at a positive potential of 250. V, and the bottom plate is at 0 V.



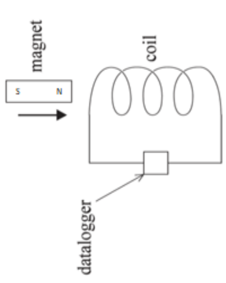
a. Calculate the electric field between the plates. Indicate the direction of the electric force. (5000 V/m down, upwards)
b. The plates are now placed in a magnetic field so that the ion goes straight. Calculate the magnitude and direction of the field. (26.3 mT into page)
c. Determine how <u>increasing</u> the following would deflect the ion (up, down, not deflected) : Ion velocity, ion mass, ion charge, magnetic field, potential across the plates. (v:down, m:not, q:not, B:down, V:up)

3. A rectangular wire loop with a resistance of 0.215 Ω starts outside a magnetic field perpendicular to this page and is pulled at a constant velocity of 11.0 m/s until it is entirely inside the magnetic field.



a. Explain why there is an induced EMF in the coil. Explain when the EMF begins to be induced, and exactly when it ends. If the EMF makes the current in the loop go anti-clockwise as it enters the field, is the magnetic field <u>out of</u> or <u>into</u> the page? (B is into page)
b. As the loop enters the magnetic field, there is a force opposing its motion. Explain the origin of this force.
c. The induced EMF in the loop is 6.20 V. Calculate the current that flows and the magnetic field strength. Calculate the force opposing the motion of the loop. Show that the magnetic field is given by $B = \frac{\sqrt{\frac{RF}{v}}}{l}$ R is the resistance of the loop, F the force, v the velocity, and l the length of the side entering the magnetic field. (28.8 A, 2.25 T, 16.3 N)

4. A datalogger is attached to a coil so that it registers a <u>positive</u> emf value when the current is flowing <u>up</u> the <u>front</u> of the coil. A magnet with the North pole facing to the right can move through the coil.



a. Explain why the motion of the magnet induces an EMF in the coil.
b. Draw a graph of how the potential changes with time as the magnet passes through at a constant speed from left to right. (positive then negative emf spike, equal in size)
c. Draw a graph of how the potential changes with time as the magnet passes through at a steadily increasing speed from left to right. (small positive, then big negative emf spike)
d. Draw a graph of how the potential changes with time as the magnet passes through at a steadily decreasing speed from left to right. (big positive, then small negative spike)
e. The coil has 500. windings and a diameter of 3.50 cm. In one instance the magnetic field goes from 0 to 312 mT to the right in 0.520 s. What is the rate change in flux in the coil? What is the induced EMF in the coil? ($5.77\text{x}10^{-4}$ Webers/s, 289 mV)

5. An ideal step-up transformer steps 650. V up to a higher voltage There are 312 primary windings, and 62,400 windings on the secondary. There are 2.15 A of current in the secondary.
a. What is the voltage on the secondary? (130 kV)
b. What is the power passing through the transformer? (279.5 kW)
c. What is the current in the primary ? (430. A)
Some transmission lines have a resistance of 4.00 Ω.
d. How much power is lost if you transmit 10,000 Watts of power at 650. V? at 330. kV? (947 W, 3.67 mW)
e. Why do we laminate the cores of transformers?
f. Why do we transmit power at high voltages over long distances?