

Unit 8 ~ Learning Guide Name: _____

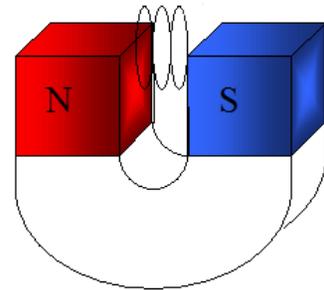
Instructions:

Using a pencil, complete the following notes as you work through the related lessons. Show ALL work as is explained in the lessons. You are required to have this package completed BEFORE you write your unit test. Do your best and ask questions if you don't understand anything!

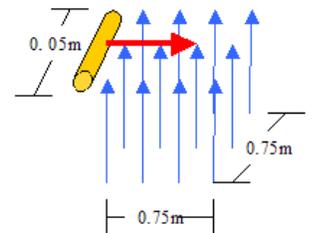
Inducing a Current:

1. What is "electromagnetic induction?"
2. Describe (using sketches as appropriate) "magnetic flux." Make sure you include a general description, equation(s), and units.

3. A circular loop is made from 50 turns of wire and has a radius of 2.0 cm. This, which starts-out sitting between poles on a horseshoe magnet as show below, is quickly pulled away from the magnet. It takes 0.10 seconds to remove the loops from the magnet, which as a magnetic field of 0.18T. What is the average induced EMF in the coils?



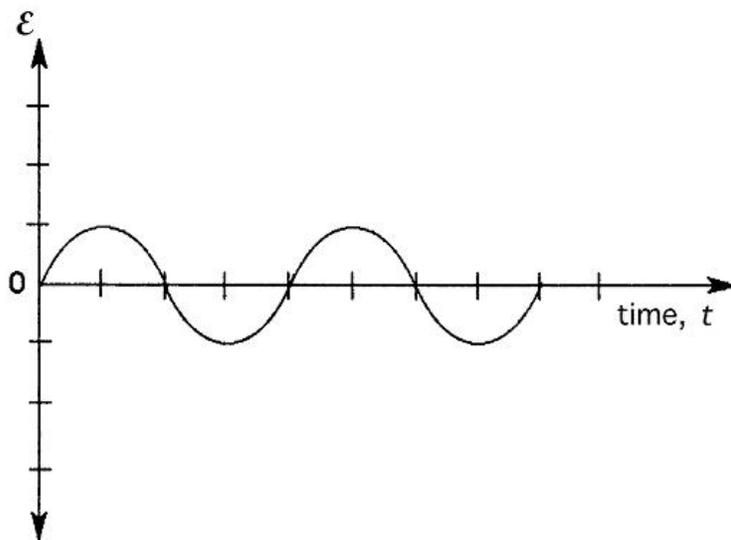
4. A wire of length 0.50m passes over a square magnetic field (0.75m per side) at a speed of 10m/s. The magnetic field is uniform and has a strength of 0.75T, directed upwards. What EMF is induced in the ends of the wire and which way will the current flow?



5. A loop of area 225 cm^2 has 24 turns of wire. It is in a magnetic field of strength $3.6 \times 10^{-2} \text{ T}$. To begin with, its plane (face) is parallel to the magnetic field lines. In a time of 0.15 s it is rotated so that its plane is perpendicular to the magnetic field lines. What is the average emf induced in the loop during the one-quarter rotation?

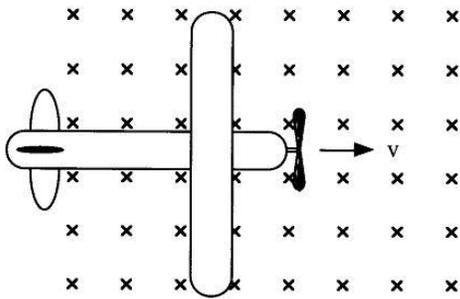
6. By how much must the **magnetic flux** inside a coil of 100 turns change in a time of 1.0 ms to produce an emf of 2.0 V?

7. **The graph below** shows how the emf produced by an AC generator varies with time. Sketch this graph, then show on the same diagram how this graph would change if **both** the number of turns on the generator's rotating armature **and** the frequency of rotation of the armature were doubled.

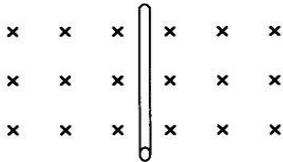


8. If the magnetic flux through a coil of wire with 300 turns changes from $+ 5.0 \text{ Wb}$ to $- 10.0 \text{ Wb}$ in a time of 0.050 s, what emf is induced in the coil?

9. An airplane with a wingspan of 12.0 m travels at right angles through a magnetic field of strength 5.0×10^{-3} T. An emf of 1.5 V is induced between the ends of the wingtips. How fast was the airplane moving?



10. One can induce an emf in the wire XY if one moves the wire in what direction?



11. Determine if the situations below will produce a change in the magnetic flux and if so, give the value of $\Delta\Phi$ and the emf induced. The coil consists of 7 loops, each with area of 0.55 m^2 . The magnetic field strength is 0.60 T. The time for each change is 0.10 s.

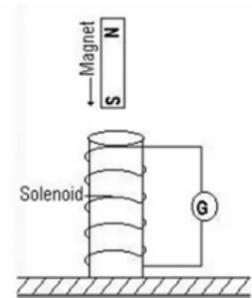
<p>A. Coil is moved to a region of $B=0.60 \text{ T}$ to 0 T</p>	<p>B. Coil is moved and stays in B field</p>
<p>C. Coil is rotated from position shown by 90°</p>	<p>D. Coil is rotated from position shown by 180°</p>

12. A coil has 20 turns each with an area of $1.5 \times 10^{-3} \text{ m}^2$. A magnetic field is perpendicular to the surface at all times. The field increases from 0.5T to 0.6T over a 0.10 second time period. Find
- The initial flux through the coil.
 - The induced emf.
 - The induced emf if the change is reversed and the field is raised back to its original over the same period of time.
13. A flat coil of wire (0.1m by 0.2m) has 50 turns. At $t=0$, the coil is perpendicular to a magnetic field $B = 0.18\text{T}$, (its normal is parallel to the direction of the field). The coil is rotated 30° over a period of 0.1 seconds.
- What is the induced emf?
 - What would the emf be if the coil is now rotated from this position to 90° in 0.1s?
14. A wire is oriented into a loop that has a diameter of 1 cm. This loop is then pulled closed in 0.5 s. If there was a magnetic field directed through the loop of 0.25 T, what emf is induced?

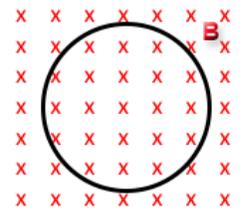
Lenz's Law:

1. Define Lenz's Law in your own words. How is this similar to Newton's Third Law of motion?

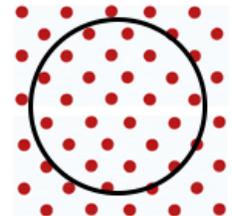
2. Determine the current direction on the galvanometer when a magnet is dropped through a solenoid, as shown.



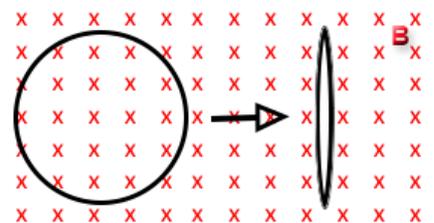
3. Consider the loop of wire in a magnetic field, B. What direction does the current go as the magnetic field is turned off.



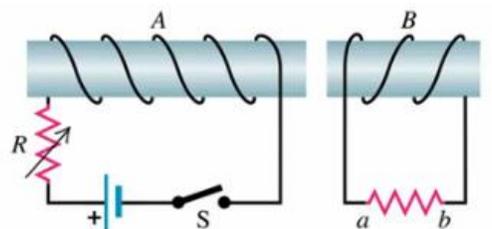
4. Consider the loop of wire in a magnetic field, B. What direction does the current go as the magnetic field is turned-down (weakened).



5. Consider the loop of wire in a magnetic field, B. What direction does the current go as loop is turned by 90°.



6. Once the switch, S, is closed, the current will turn solenoid A into an electromagnet. The resulting electromagnetic field will impact solenoid B, inducing a current. Which would be the positive pole (a or b)?

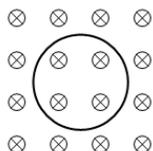


7. For each situation below determine the direction of the induced current in the loop (if there is one).

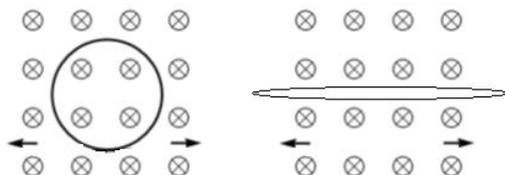
- a. A square loop is **moving at a constant velocity to the right through a uniform magnetic field** that is directed into the page and which extends out of the picture to the left and right. In which direction is the induced current in the loop?



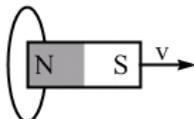
- b. A circular loop is at rest in a magnetic field directed into the page. **The magnetic field is increasing in magnitude.** In which direction is the induced current in the loop?



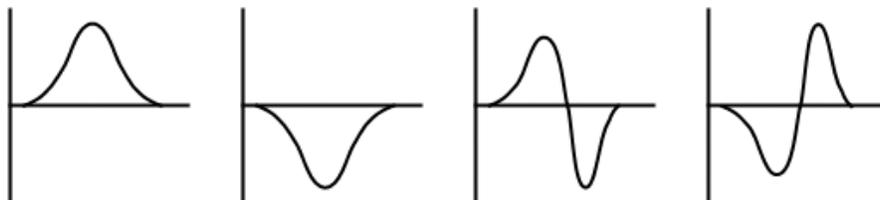
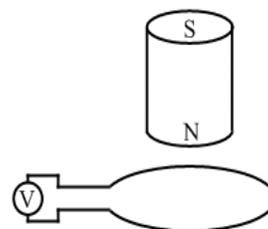
- c. A piece of wire is wrapped into a loop and placed in a uniform magnetic field that is directed into the page. You then pull on the ends of the wire so **the area of the loop is decreasing.** In which direction is the induced current in the loop?



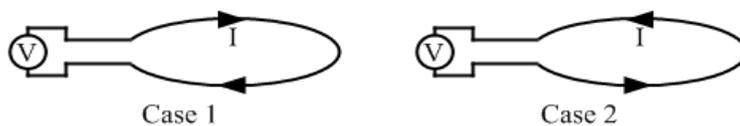
- d. A bar magnet is held near the center of a wire loop. **The magnet is then pulled away from the loop.** The north pole is always closest to the loop. In which direction is the induced current in the loop?



8. In a Faraday's Law experiment, a magnet is dropped from rest, as shown. The magnet accelerates down, passing through the center of a loop of wire connected to a voltmeter. Assume that the magnet is always oriented as shown in the diagram, with the south pole at the top of the magnet and the north pole at the bottom. Use diagrams to answer the following questions.

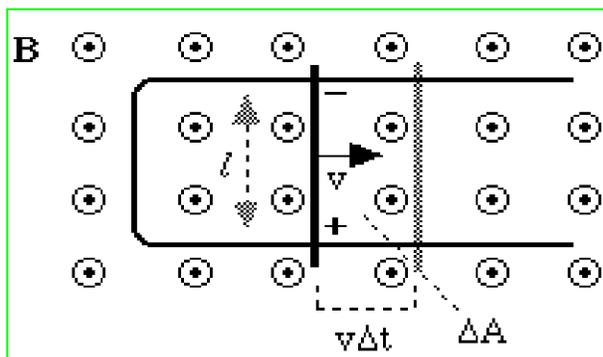


- Let us define positive flux as coming from magnetic field lines that are directed up through the loop. Which graph, above, represents the graph of **magnetic flux** as a function of time for the magnet passing through the loop.
- Which graph would represent induced Emf as a function of time? Label axis on the correct graph. Assume downward through the voltmeter is positive.
- If the magnet is released from rest from a point higher above the loop than it was in part (a), then the height of the peak(s) in the flux vs. time graph would (increase, decrease, stay unchanged). *Circle one.*
- The two pictures below show two possibilities for the current induced in the loop as the magnet falls through the loop.



As the magnet begins to fall through the loop, the current would be show in _____, but just after the magnet exits the loop it will look like _____.

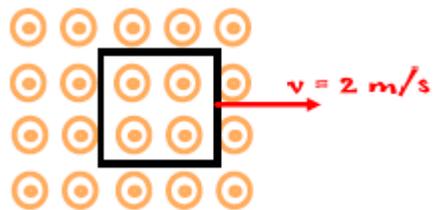
- Where is the center of the magnet when the induced current in the loop reaches its peak (positive) magnitude? Circle one: above the loop, below the loop, or at the center of the loop
 - Which has the bigger magnitude - the positive (maximum) peak or the negative (minimum)? Circle one. Why is this true? _____.
9. Emf can be induced in a moving conductor:
Examine the diagram below. It shows a conductor (a rod) moving across a set of metal rails at a velocity, v .



- Emf is generated by a magnetic flux. In the situation show, the flux occurs because the _____ of the loop is changing.
- Use Lenz's Law to determine the direction of the induced current in this circuit. Draw onto the diagram above.

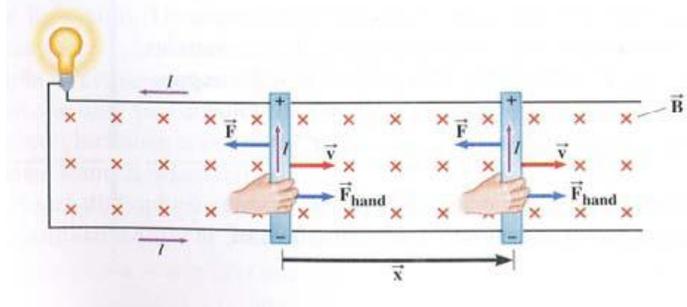
- c. Use the right hand rule to determine the direction of the force acting on the rod as a result of this induced current. Discuss why this answer makes sense according to the laws of physics (it may be easier to discuss why a force in the opposite direction would not make sense)
- d. What formula(s) are appropriate to determine the induced emf in the rod. Describe the variables. Discuss what must be parallel or perpendicular.
- e. An airplane travelling at 278 m/s upward at an angle of 30° to the horizontal is in a region where earth's magnetic field is 5.0×10^{-5} T upward (vertical field from the ground to the sky). What is the potential difference induced between the wing tips that are 80 m apart?

10. A 2cm by 2cm square coil is in a 1.0 T magnetic field as shown below. The coil is pulled out of the field with a constant velocity of 2 m/s.



- a. At what point is an emf induced? Why?
- b. What is the value of the induced emf?
- c. What is the direction of the induced current in the loop?

11. In the diagram below the length of the moving conductor $L=0.25\text{m}$ (you may assume that this is the distance from “rail to rail”). The strength of the magnetic field is 0.25T . If you need 1.5V of induced emf to light the bulb, and the maximum distance the bar can move is 1m , how much time must the bar be moved?



Motors & Generators:

- In industrial plants where there are a number of large motors that need to be started at the beginning of a shift, smart companies are VERY careful to start the motors one-at-a-time. Why is this?
- Why are motors apt to “burn-out” when switched-on if they are jammed (unable to spin quickly)?
- A 12V electric motor is turned on. When the motor is first started, the current is 1.0A . Once running, the current on the motor is 0.24A .
 - What is the resistance of the motor?
 - What is the running voltage for the motor?
 - What is the back-EMF?

4. The armature windings of a dc motor have a resistance of 5.0Ω . The motor is connected to a 120 V line and when the motor reaches full speed against its normal load, the counter emf is 108 V. Calculate:
- The current into the motor when it is just starting up. Be sure to draw the equivalent circuit showing your motor as a resistor, the battery, and the back emf (another battery) if it exists
 - The current when the motor reaches full speed. Be sure to draw the equivalent circuit showing your motor as a resistor, the battery, and the back emf (another battery) if it exists.

Transformers:

- What is the difference in design and purpose for a step-up transformer vs. a step-down transformer?
- If the primary side has four windings, while the secondary has two windings, would this be considered a step-up or a step-down transformer?
- Why do transformers not work with a DC voltage input?
- An ideal transformer has 600 turns on its primary side and 100 turns on its secondary side. The primary voltage is 1000 V AC.
 - Is this transformer considered to be Step-Up or Step-Down?
 - What will the secondary voltage be with this configuration?
 - What is the secondary current if the primary current is 100 A?
 - The primary windings are reconnected to a 1000 V battery (DC) for a long time. What is the secondary voltage?

5. Watch “Non-Idea Transformer – Sample Problem” which looks at a transformer with 110 loops on the primary side and 880 on the secondary.
 - a. If you have 6.7V as input, what is the expected output voltage?

 - b. If you have 4.1A on the primary, what is the expect output current?

 - c. Determine the input and output power for this transformer.

 - d. Determine the efficiency of the transformer.

6. If a transformer is only 75% efficient with a primary voltage of 100V. If it has primary windings of 500 with secondary windings of 250 what will be the secondary current if the input current is 0.010 A and the secondary voltage is measured to be 40 V?

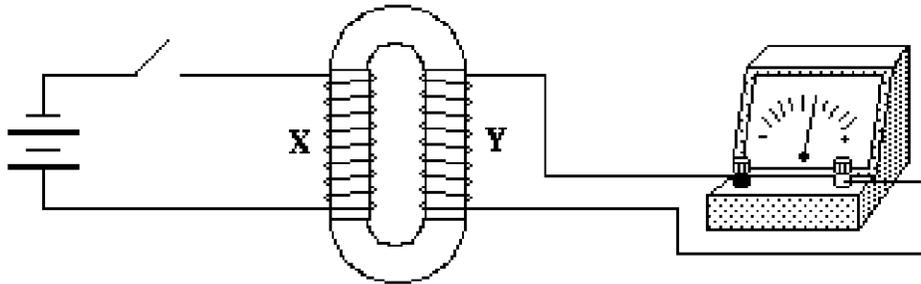
7. A transformer for a transistor radio reduces 120 V ac to 9.0 V ac. The secondary contains 30 turns and the radio draws 400 mA. Calculate
 - a. the number of turns in the primary

 - b. the current in the primary

 - c. the power transformed

8. If a transformer is non-ideal, what can be said about the power in compared to the power out?
Where does the missing power go?

9. Using the diagram below summarize Faraday's experiment. What did he observe



- When the switch is first closed?
- When the switch remains closed?
- When the switch is opened?
- When the switch remains open?

Answers:

Inducing a Current

3) 0.11V 4) 3.75V, out-of-page 5) -0.13V 6) -2.0×10^{-5} Wb 7) amplitude $\times 4$, half period 8) 9.0×10^4 V
9) 25 m/s 10) left or right 11) A) $\Delta\Phi = -0.33$ Wb, $\epsilon = 23.1$ V B) $\Delta\Phi = 0$ Wb, $\epsilon = 0$ V C) $\Delta\Phi = -0.33$ Wb, $\epsilon = 23.1$ V D) $\Delta\Phi = 0$ Wb, $\epsilon = 0$ V 12) a) 7.5×10^{-4} Wb b) -0.03V c) +0.03V 13) a) 0.24V, 1.56V
14) 3.9×10^{-5} V

Lenz's Law

2) up 3) CW 4) CCW 5) CW 6) a 7) none, CCW, CW, CW 8) second, third, unchanged,
case 2, case 1, above, minimum
9) area, CW, left, $E = B\ell v$, 0.96V 10) a) once it first reaches right side, -0.04V, CCW 11) 0.042 s

Motors & Generators

1) peak current 2) extended high current 3) 12Ω , 2.88V, 9.12V 4) 24A, 2.4A

Transformers

1) winding primary/secondary 2) step-down 3) flux 4) step-down, 167VAC, 600A, 0
5) 53.6V, 0.513A, 27.5W, 13.9W, 51% 6) 0.019A 7) 400, 0.03A, 3.6W 8) larger, heat
9) needle deflects, zero, deflects in opposite direction, zero