Name: ______________________

Class: ______________________

Due Date: ______________________

D.4 Induction

Additional HL Understandings

- Magnetic flux Φ as given by $\Phi = BA\cos\theta$.
- A time-changing magnetic flux induces an emf ε as given by Faraday's law of induction $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$.
- A uniform magnetic field induces an emf in a straight conductor moving perpendicularly to it as given by $\varepsilon = Bvl$.
- The direction of induced emf is determined by Lenz's law and is a consequence of energy conservation.
- A uniform magnetic field induces a sinusoidal varying emf in a coil rotating within it.
- The effect on induced emf caused by changing the frequency of rotation.

Additional HL Equations

$\Phi = BA\cos\theta$

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

$\varepsilon = BvL$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. C: Define *induction* and *induce*.

2. C: What are the units of *electromotive force* ε?

3. C: True or false: *Electromotive force* ε is a force.

4. C: Define *flux*. Draw a picture.

5. C: *Magnetic flux* is defined as $\Phi = BA\cos\theta$. Define and give the units of each variable. Draw an image showing *magnetic flux* and label theta θ in the image. Also draw an image of magnetic flux when $\theta = 0°$ and when $\theta = 90°$.

6. E: Consider a single loop of wire which is 25.0 cm by 25.0 cm. Passing through this loop is a magnetic field which has a magnitude of 0.220 T.

    a. Assuming that the magnetic field is parallel to the normal of the loop, what will be the total magnetic flux passing through the loop?

    b. Assuming that the magnetic field meets the normal to the loop at an angle of 35.0°, what will be the total magnetic flux passing through the loop?

    c. Assuming that the magnetic field is perpendicular to the normal to the loop, what will be the total magnetic flux passing through the loop?

7. C: Use words to define and describe *Faraday's Law* $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$. Draw a picture if you have to.

8. E: Consider a single loop of wire which encloses an area of 50.0 cm^2. A magnetic field, which is parallel to the normal of this loop, initially has an intensity of 0.220 T. Over a time period of 0.200 s the magnetic field strength drops to zero.

   a. What will be the resulting emf in the loop?

   b. What will be the emf in this circuit if the loop consists of 1,000 turns rather than a single turn?

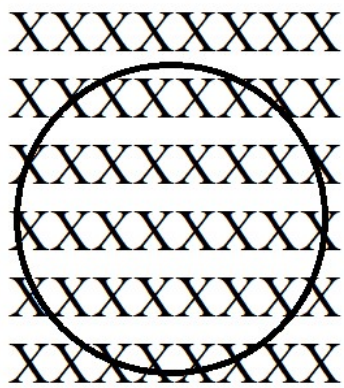
9. E: Consider a coil of wire which has 1,200 turns, encloses an area of 18.0 cm^2, and contains a magnetic field of 3.50 T oriented parallel to the normal to the loop. What will be the induced emf in this coil if the magnetic field drops to zero in 0.0167 s?

10. C: The negative sign in *Faraday's Law* is known as *Lenz's Law*. What does it mean?

11. C: Use *Lenz's law* and the right hand rule to determine the direction of the induced current on the metal conducting wire.

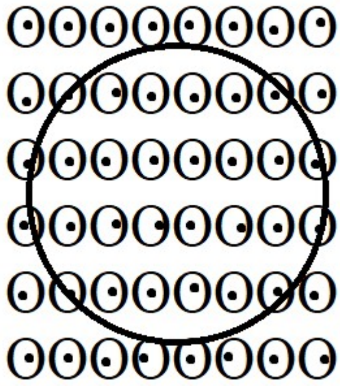
    a. There is a magnetic field which points into the page. The magnitude of the magnetic field is

        i. decreasing
        ii. constant
        iii. increasing

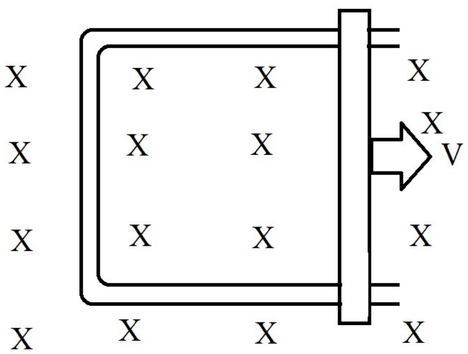
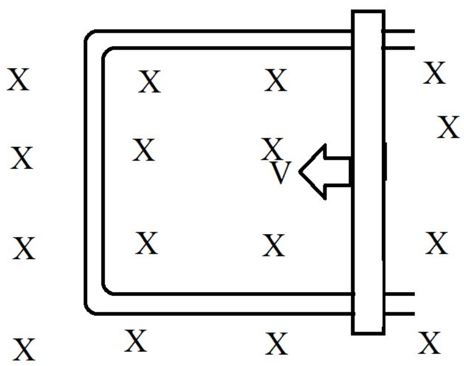


b. There is a magnetic field which points out the page. The magnitude of the magnetic field is

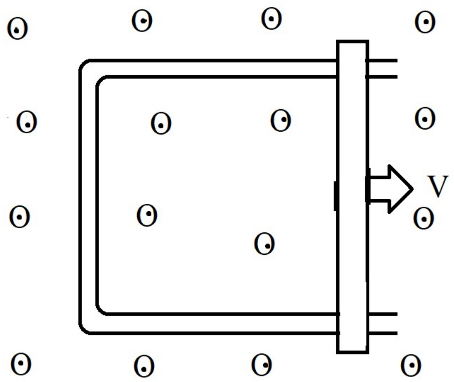
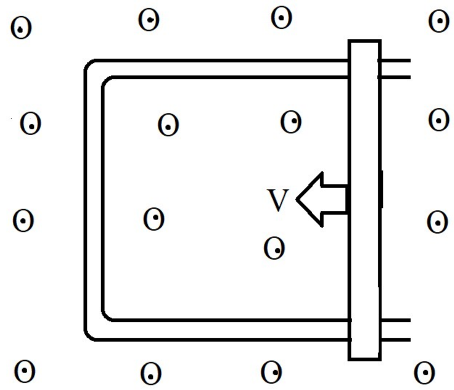
i. decreasing
ii. constant
iii. increasing



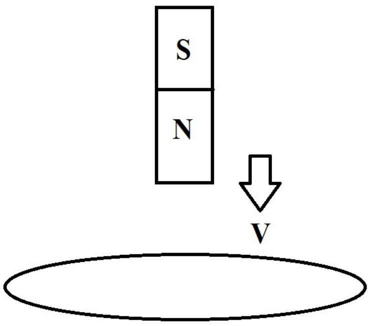
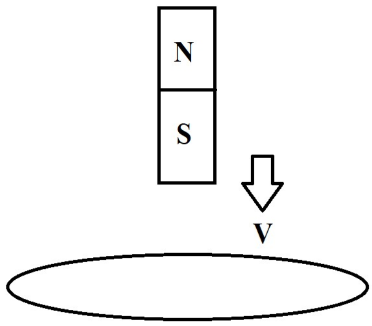
c. There is a constant magnetic field into the page. Which direction is the induced current?

i. The area of the loop is increasing.	ii. The area of the loop is decreasing.
	

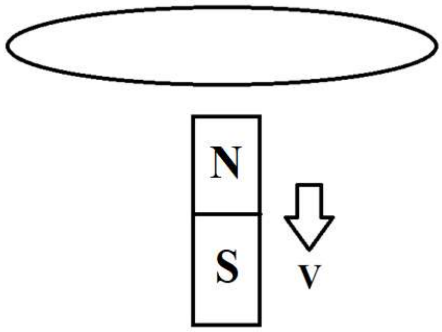
d. There is a constant magnetic field out of the page.

i. The area of the loop is increasing.	ii. The area of the loop is decreasing.
	

e. A magnet is falling down and entering a loop. Which direction is the induced current if we are looking downwards?

i. The north pole is facing downwards.	ii. The south pole is facing downwards.
	

f. A magnet is falling down and leaving a loop. Which direction is the induced current if we are looking downwards?

<table>
<tr>
<td>i. The north pole is facing upwards.

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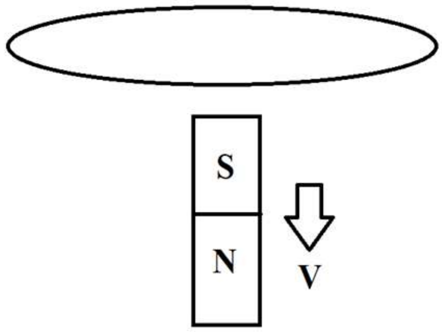
<td>ii. The south pole is facing upwards.

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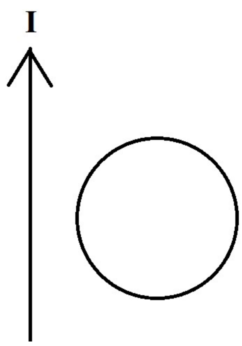
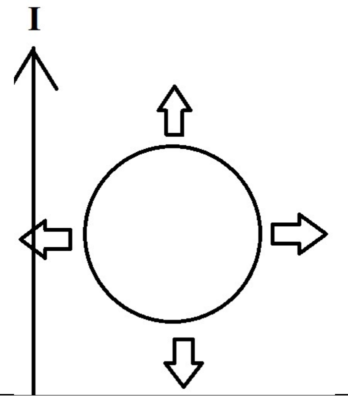
g. There is a current carrying straight wire. There is a circular wire next to it. The current in the straight wire is

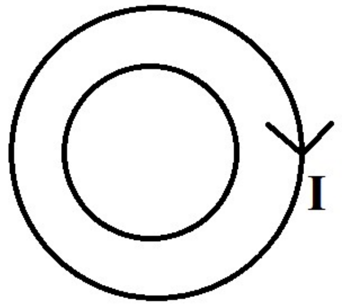
i. decreasing
ii. constant
iii. increasing



h. There is a current carrying straight wire. There is a circular wire next to it. The circular wire

i. moves up parallel to the wire ii. moves down parallel to the wire iii. moves to the left perpendicular to the wire iv. moves to the right perpendicular to the wire	

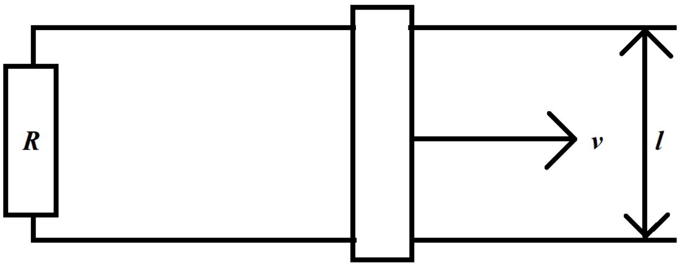
i. A small loop of wire is inside a larger loop of wire. The larger loop of wire has a constant current clockwise. What is the direction of the induced current of the smaller loop if the current of the larger loop is

i. decreasing ii. constant iii. increasing	

12.C: What happens to a magnet if it falls down a hollow metal cylinder? Why?
https://www.youtube.com/watch?v=N7tIi71-AjA

13.C: Describe the equation $\varepsilon = BvL$.

14.E: Two parallel rails are connected together at one end by a resistance of 20.0 Ω. Across these two rails, which are 45.0 cm apart, there lies a conducting metal bar. The magnetic field is uniform, has a strength of 2.20 T, and is directed into the page. A force is applied to the metal bar so as to push the bar to the right with a velocity of 8.40 m/s.



a. What will be the resulting emf in this circuit?

b. What will be the direction of the resulting conventional current flowing through this circuit?

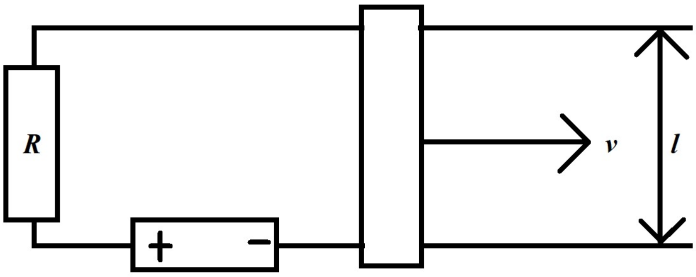
c. What will be the magnitude of the resulting current?

d. At what rate is electrical energy being generated?

e. How much force is being applied to this bar?

f. At what rate is mechanical energy being consumed?

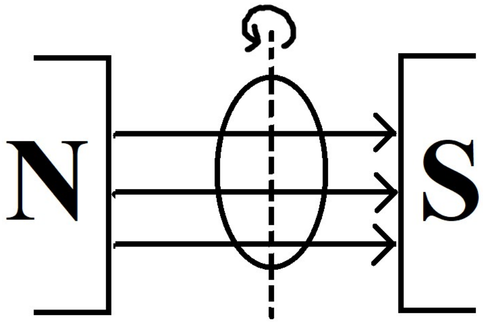
15.E: A battery, which has an emf of 6.00 V, is inserted into a circuit. The magnetic field has an intensity of 2.20 T and is directed into the paper. The resistance has a value of 20.0 Ω and the two parallel horizontal rails are separated by a distance of 45.0 cm. A current of 0.200 A is measured to be flowing through the circuit.



a. What will be the resulting velocity of the bar?

b. How much force is being applied to the bar by the magnetic field as it moves through the field?

16.C: Draw an *emf vs. time* graph of a conducting loop rotating in the presence of an external magnetic field with a frequency of f and $2f$.



17.C: Define *self-induction*.