Course and Section________ Names ___________________________

Date____________

INDUCED EMF SIMULATION

Introduction

The purpose of this activity is to study how currents can be induced in conductors by the presence of magnetic fields that change with time.
Use the **Answers Page** (the last page) to input all your answers.

According to Faraday's Law of induction a changing magnetic field induces an electric field. For an electrical circuit consisting of N identical turns of wire, the magnitude of the induced emf ΔV is proportional to the number of turns N and to the rate at which the magnetic flux $\Phi(\vec{B})$ is changing:

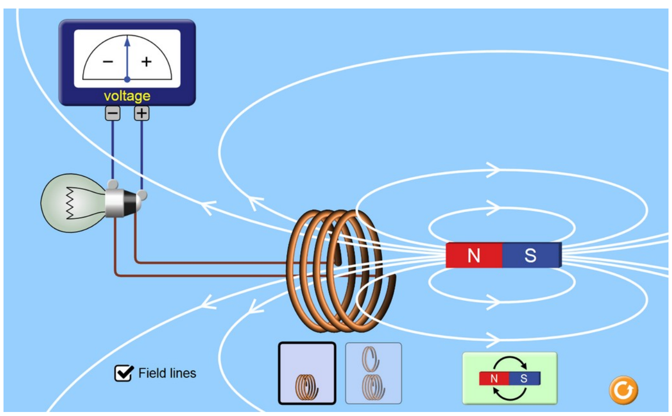
$$\Delta V = -\frac{\Delta}{\Delta t}\Phi(B) \quad \text{(for finite interval)}$$

where the minus sign is referred to as the Lenz Law and indicates that the induced current in the circuit produces an induced magnetic field which opposes the change of the magnetic flux.

Submit your answers using Blackboard.

1 - Magnet in Motion

Open the simulation (https://phet.colorado.edu/en/simulation/faradays-law).



1. What happens to the voltage as the North pole enters into the coil from the right?
2. What happens to the voltage as the South pole exits the coil on the left?

3. What happens to the voltage as the South pole enters into the coil from the right?
4. What happens to the voltage as the North pole exits the coil moving to the right?
5. If the magnet moves at a slower speed than in question 4 how does the voltage change?
6. What happens to the light bulb when the magnet goes up and down outside the coil?
7. What happens to the light bulb when the magnet goes up and down inside the coil? Make sure that the magnet is in the center of the coil and only moves a small distance up and down. Do not touch the coil with the magnet.

Put the magnet inside the coil and spin it several times.
8. What happens to the voltage?
9. What type of current is produced?

2 - Lenz's Law

Open this simulation (https://www.compadre.org/physlets/electromagnetism/prob29_1.cfm)

When t = 0.5 s
10. Which is the direction if any of the current in Loop A?
11. Which is the direction if any of the current in Loop B?
12. Which is the direction if any of the current in Loop C?

When t = 4.5 s
13. Which is the direction if any of the current in Loop A?
14. Which is the direction if any of the current in Loop B?
15. Which is the direction if any of the current in Loop C?

Clicking in the area with the circles the position in the region is given in units of meters. The form that the magnetic field follows is $B(t) = \sin(\omega t)$ where ω = 1 and B is positive when directed into the page. The rate of change of the flux is calculated to be

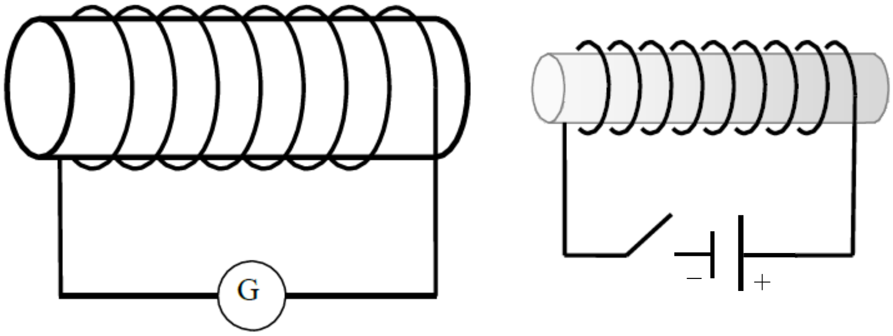
$$\frac{\Delta\Phi}{\Delta t} = -\omega A \cos(\omega t),$$

where A is the area.

Focusing on the left circle at times between $t = 0$ and $t = \pi$:
16. What is area of the circle? (m^2)
17. At what time(s) is the induced emf zero? (s)
18. At what time(s) is the magnitude of the induced emf at its maximum value? (s)
19. What is the magnitude of the induced emf at its maximum value? (V)
20. Suppose the loop has a resistance of R, what is the induced current in the loop?
21. What is the magnitude of the induced current when the induced emf takes its maximum value provided that the loop has a resistance of R = 50Ω? (A)

3 – Mutual Inductance

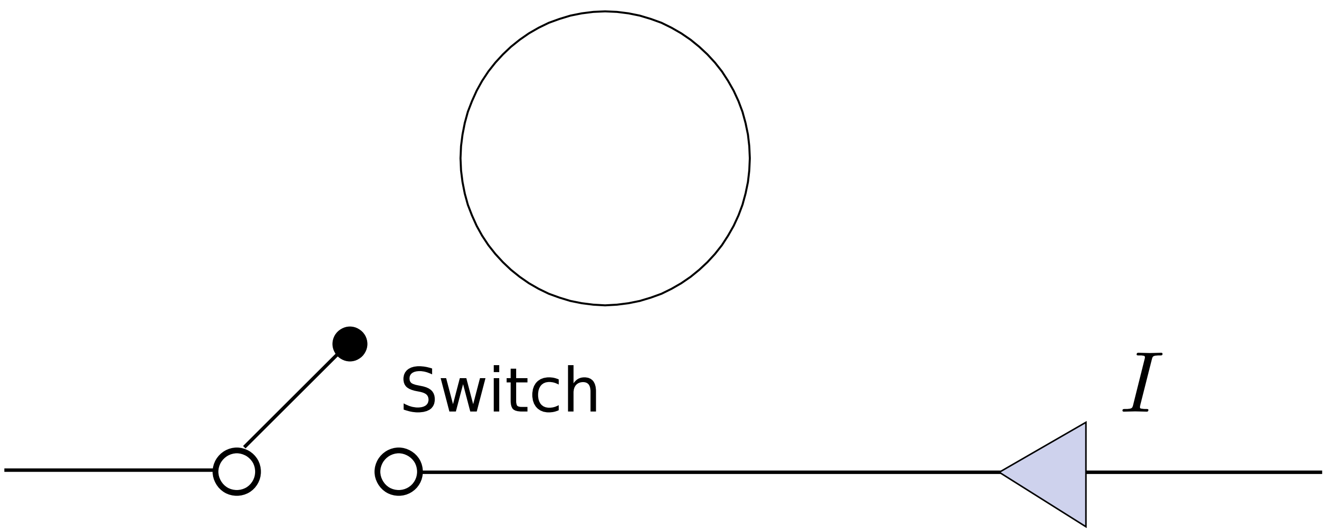
The figure below shows on the left a solenoid connected to a galvanometer (G). On the right another solenoid connected to a battery.



22. Which end of the coil with the battery becomes the North pole if the switch is closed ?
23. Which end of the coil with the galvanometer becomes the North pole if the switch is closed ?
24. What will be the direction of the current through the galvanometer (G) immediately after the switch connecting the battery is closed?

4 - Ampere and Faraday

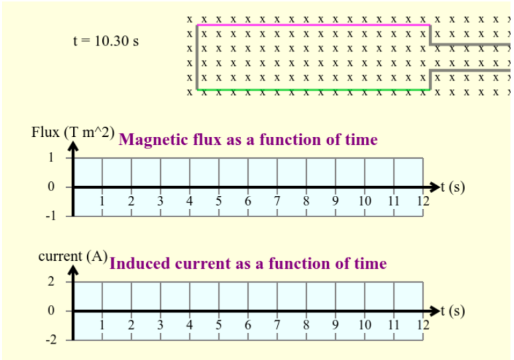
A loop of wire is place above a long straight wire which has a switch. The switch is suddenly closed and a current *I* flows through the wire toward the left.



25. What is the direction of the *B* field (generated by the straight wire) in the center of the loop?
26. What is the direction of the induced *B* field in the center of the wire?
27. What is the direction of the induced current in the loop?
28. What is the direction of induced *B* field on the straight wire?
29. What is the direction of the magnetic force acting on the straight wire?

5 - Electric Generator

Open this simulation. (http://physics.bu.edu/~duffy/HTML5/electric_generator.html)



Click *Show* in order to display the physical quantities.

30. What is the angle between the loop and the *B* field when the flux reaches its maximum values? (deg)

31. What is the angle between the loop and the *B* field when the induced current reaches its maximum values? (deg)

32. What is the value of the current when flux reaches its maximum values? (A)

33. What is the value of the flux when the current reaches its maximum values? (Tm^2)

Compare the rotation period at 4.0 s and 2.0 s.

34. How are the maximum values of the fluxes different?

35. How are the maximum values of the induced current different?