PHYSICS INNOVATION: LAB MANUAL

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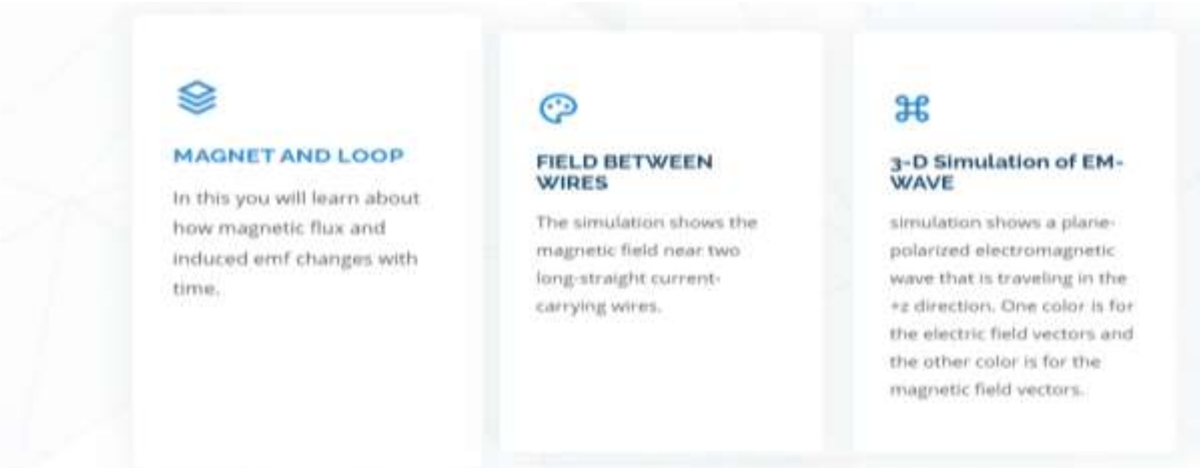
Contents

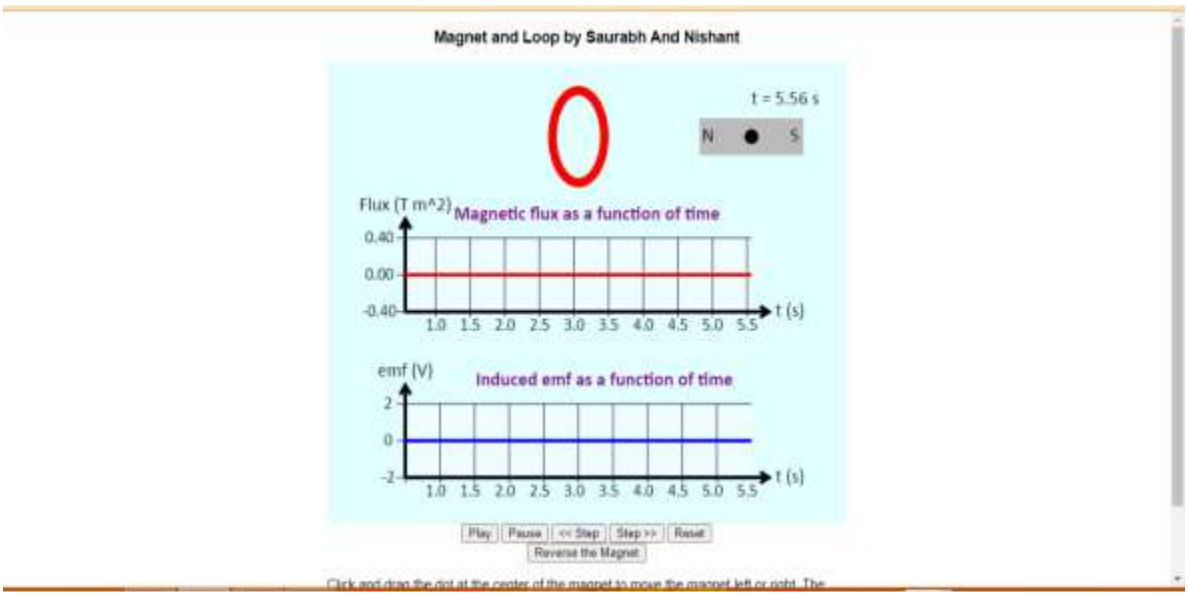
Experiments

At present we provide 3 experiments which are visible on our homepage as clickable links after clicking on each practical you can see the simulation provided by us, along with the practical lab manual.



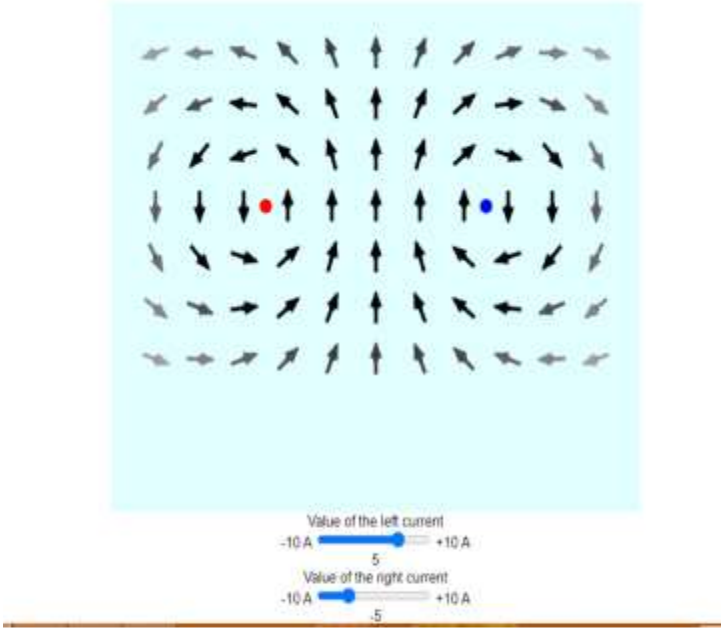
Experiment 1: Magnet and Loop Experiment

In this you will learn about how magnetic flux and induced emf changes with time.



How to Perform: Click and drag the dot at the center of the magnet to move the magnet left or right. The graphs show the magnetic flux through each loop of the coil, as a function of time, as well as the emf induced in the coil as a function of time.

Experiment 2: Magnet Field Experiment



- This shows the magnetic field near two long-straight current-carrying wires. If the wire is drawn in red, the current is directed out of the screen. If the wire is drawn in blue, the current is directed into the screen. The value of currents can be adjusted by using the sliders.

For a current I_1 = ______ Amperes and

radial separation between wires r = ______ m,

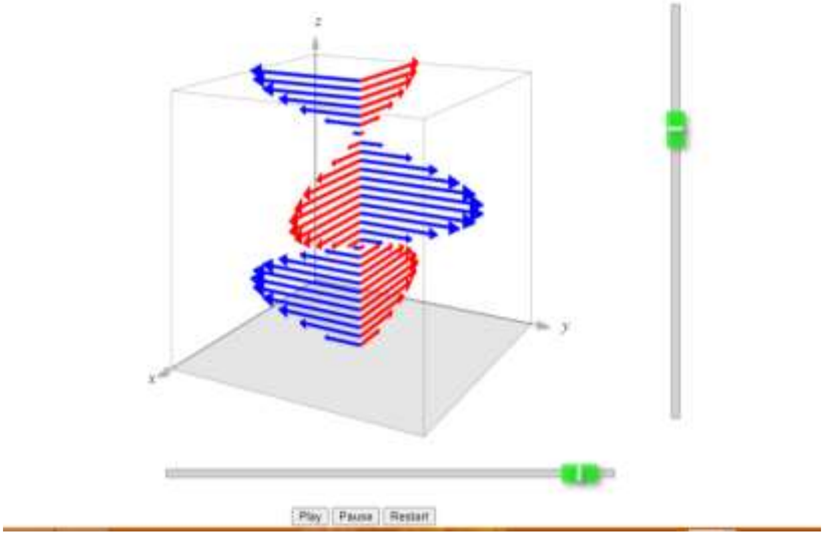
the magnetic field at wire 2 is B = ______ Tesla = ______ Gauss.

If current I_2 = ______ Amperes

then the force per meter is $F/\Delta L$ = ______ Newtons/m

- We can also calculate the value of the magnetic force by providing the value of current.

Experiment 3: Visualization of EM Waves on Screen



- This shows a plane-polarized electromagnetic wave that is traveling in the +z direction. One colour is for the electric field vectors and the other colour is for the magnetic field vectors. The right-hand rule says that if you point the fingers of your right hand in the direction of the electric field vector at a particular location, and then curl your fingers into the direction of the magnetic field vectors, your thumb should point in the direction of the way the wave is traveling. Using this rule, you should be able to determine which colour arrows represent the electric field vectors and which colour arrows represent the magnetic field vectors.

- The 3-D view can be adjusted by sliders.

- This Simulation Will Help Students visualize how EM Waves Travel in 3-D.

Lab manual

We have provided online lab manual for students so that they can easily understand to perform the experiments

Experiment 1

Topic:

To study Faraday's law of Induction.

Things Required:

As this is an Online lab So having an internet supported device will suffice.

Theory :

Faraday's law of electromagnetic induction, also known as Faraday's law, is the basic law of electromagnetism which helps us to predict how a magnetic field would interact with an electric circuit to produce an electromotive force (EMF). This phenomenon is known as electromagnetic induction.

Michael Faraday proposed the laws of electromagnetic induction in the year 1831. Faraday's law or the law of electromagnetic induction is the observation or results of the experiments conducted by Faraday. He performed three main experiments to discover the phenomenon of electromagnetic induction.

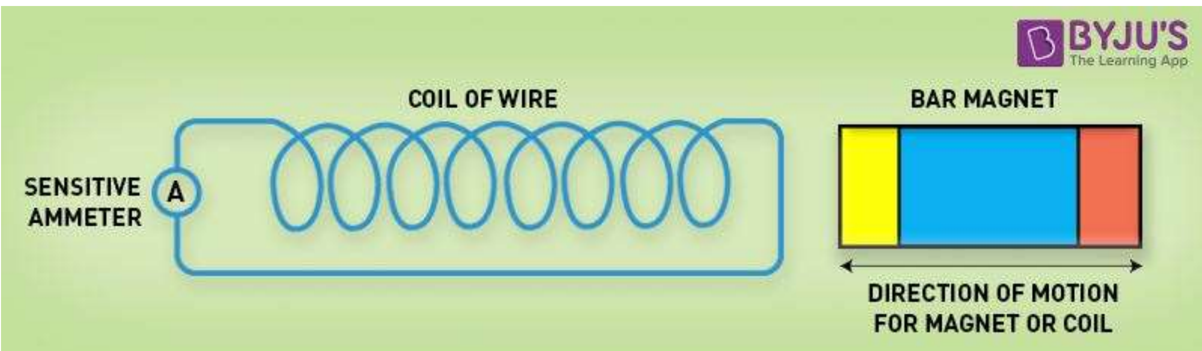
Faraday's Laws of Electromagnetic Induction

Faraday's Laws of Electromagnetic Induction consists of two laws. The first law describes the induction of emf in a conductor and the second law quantifies the emf produced in the conductor. In the next few sections, let us learn these laws in detail.

Faraday's First Law of Electromagnetic Induction

The discovery and understanding of electromagnetic induction are based on a long series of experiments carried out by Faraday and Henry. From the experimental observations, Faraday concluded that an emf is induced in the coil when the magnetic flux across the coil changes with time. Therefore, Faraday's first law of electromagnetic induction states the following:

Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced. If the conductor circuit is closed, a current is induced, which is called induced current.



Mentioned here are a few ways to change the magnetic field intensity in a closed loop:

- By rotating the coil relative to the magnet.
- By moving the coil into or out of the magnetic field.
- By changing the area of a coil placed in the magnetic field.
- By moving a magnet towards or away from the coil.

Faraday’s Second Law of Electromagnetic Induction

Faraday’s second law of electromagnetic induction states that The induced emf in a coil is equal to the rate of change of flux linkage. The flux is the product of the number of turns in the coil and the flux associated with the coil.

The formula of Faraday’s law is given below:

$$\boxed{\varepsilon = -N \frac{\Delta \phi_M}{\Delta t}}$$

Faraday's Law

N = number of loops

$\Delta \phi_M$ = change in magnetic flux

Δt = change in time

ε = induced voltage (also known as emf)

Procedure :

1. Firstly you need to Open E-practical’s website on your pc/mobile.
2. Then Select Magnet and Loop .
3. Click and drag the dot at the center of the magnet to move the magnet left or right. The graphs show the magnetic flux through each loop of the coil, as a function of time, as well as the emf induced in the coil as a function of time.
4. Use the Online simulation to perform the experiment as instructed there and answer the following question after performing them.

Questions :

Q1. What Happens to Magnetic Flux graph as

(i) If the magnet is held stationary near the coil

(ii) If the magnet is held stationary inside the coil

(iii) If The magnet was moving near or inside the coil

Do You Think Any current was being produced if Yes then In which of the following cases and state the reasons behind it ?

Q2. What Happens to Induced EMF graph as

(i) If the magnet is held stationary near the coil

(ii) If the magnet is held stationary inside the coil

(iii) If The magnet was moving near or inside the coil

(iv) What happens when we reverse the direction of the magnet?

Q3. Consider a flat square coil with N = 5 loops. The coil is 20 cm on each side, and has a magnetic field of 0.3 T passing through it. The plane of the coil is perpendicular to the magnetic field: the field points out of the page.
(i) If nothing is changed, what is the induced emf?
(ii) The magnetic field is increased uniformly from 0.3 T to 0.8 T in 1.0 seconds. While the change is taking place, what is the induced emf in the coil
(iii) While the magnetic field is changing, the emf induced in the coil causes a current to flow. Does the current flow clockwise or counter-clockwise around the coil?

Observation :

S.No	Magnetic Field(T)	Area of Loop(m^2)	No. of Turns	Time(s)

Results:
Magnetic Flux and Induced EMF calculated after using the above observations

S.No	Magnetic Flux (Wb)	Induced EMF (V)

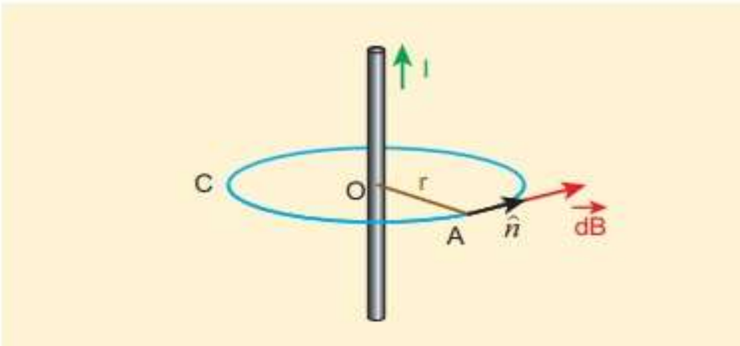
Experiment 2

Topic:
Magnetic force due to 2 Infinite current carrying wire

Things Required:
As this is an Online lab So having an internet supported device will suffice.

Theory :

Consider a straight conductor of infinite length carrying current I and the direction of magnetic field lines is shown in Figure 3.42. Since the wire is geometrically cylindrical in shape and symmetrical about its axis, we construct an Amperian loop in the form of a circular shape at a distance *r* from the centre of the conductor as shown in Figure. From the Ampère's law, we get



$$\oint_C \vec{B}.d\vec{l} = \mu_{\circ} I$$

where $d\vec{l}$ is the line element along the amperian loop (tangent to the circular loop). Hence, the angle between the magnetic field vector and line element is zero. Therefore,

$$\oint B dl = \mu_{\circ} I$$

where I is the current enclosed by the Amperian loop. Due to the symmetry, the magnitude of the magnetic field is uniform over the Amperian loop, we can take B out of the integration.

$$B \oint_C dl = \mu_{\circ} I$$

For a circular loop, the circumference is 2πr, which implies,

$$B\int_0^{2\pi r} dl = \mu_\circ I$$

$$\vec{B}\cdot 2\pi r = \mu_\circ I$$

$$B = \frac{\mu_\circ I}{2\pi r}$$

In vector form, the magnetic field is

$$\vec{B} = \frac{\mu_\circ I}{2\pi r}\hat{n}$$

where n is the unit vector along the tangent to the Amperian loop as shown in Figure. This perfectly agrees with the result obtained from Biot-Savart's law .

Magnetic Force between Two Parallel Current carrying wire

The force between two long straight and parallel conductors separated by a distance r can be found by applying what we have developed in preceding sections. Figure 1 shows the wires, their currents, the fields they create, and the subsequent forces they exert on one another. Let us consider the field produced by wire 1 and the force it exerts on wire 2 (call the force F_2). The field due to I_1 at a distance r is given to be

$$B_1 = \frac{\mu_0 I_1}{2\pi r}$$

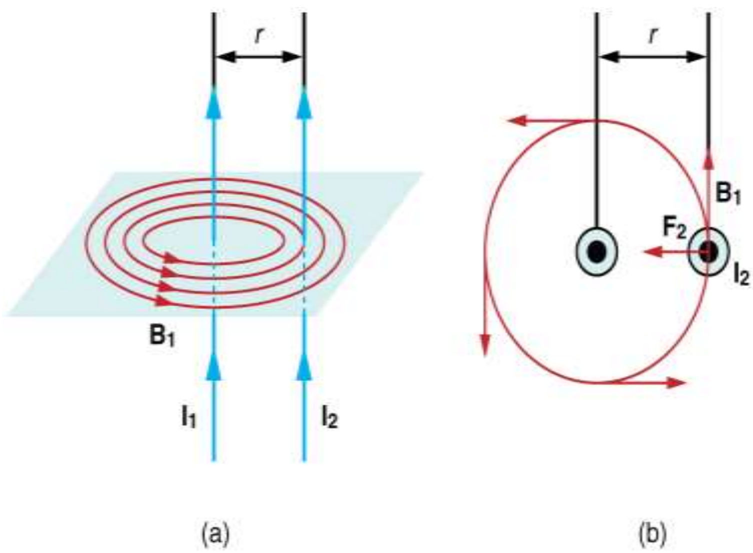


Figure 1. (a) The magnetic field produced by a long straight conductor is perpendicular to a parallel conductor, as indicated by RHR-2. (b) A view from above of the two wires shown in (a), with one magnetic field line shown for each wire. RHR-1 shows that the force between the parallel conductors is attractive when the currents are in the same direction. A similar analysis shows that the force is repulsive between currents in opposite directions.

This field is uniform along wire 2 and to it, and so the force F_2 it exerts on wire 2 is given by

$$F=I.l.B.\sin\theta$$

With

$$\sin\theta=1$$

.

.

$$F_2=I_2lB_1$$

By Newton's third law, the forces on the wires are equal in magnitude, and so we just write F for the magnitude of F2. (Note that F1=−F2.) Since the wires are very long, it is convenient to think in terms of F/l, the force per unit length. Substituting the expression for B1 into the last equation and rearranging terms gives

$$\frac{F}{l}=\frac{\mu_0 I_1 I_2}{2\pi r}.$$

F/l is the force per unit length between two parallel currents I_1 and I_2 separated by a distance *r*. The force is attractive if the currents are in the same direction and repulsive if they are in opposite directions. This force is responsible for the *pinch effect* in electric arcs and plasmas. The force exists whether the currents are in wires or not. In an electric arc, where currents are moving parallel to one another, there is an attraction that squeezes currents into a smaller tube. In large circuit breakers, like those used in neighbourhood power distribution systems, the pinch effect can concentrate an arc between plates of a switch trying to break a large current, burn holes, and even ignite the equipment. Another example of the pinch effect is found in the solar plasma, where jets of ionized material, such as solar flares, are shaped by magnetic forces.

Procedure :

1. Firstly you need to Open E-practical website on your pc/mobile.
2. Then Select Field Between Wires .
3. If the wire is drawn in red, the current is directed out of the screen. If the wire is drawn in blue, the current is directed into the screen. You should be able to click-and-drag the wires to move them around the screen, and use the sliders to change the currents.
4. Use the Online simulation to perform the experiment as instructed there and answer the following question after performing them.

Observation :

S.No	Current in 1st wire(I_1)	Current in 2nd wire(I_2)	Magnetic Field (T)

Results:

Magnetic Field at Wire 2 and Force per meter calculated using above observation :

S.No	Magnetic Field at wire 2 (T)	Force per meter (N)

Questions :

Q1. What Happens when Both wires are carrying the same Current in the same directions ? show the screenshot of the magnetic field simulation at that moment.

Q2. What Happens when Both wires are carrying the same Current in the opposite directions ? show the screenshot of the magnetic field simulation at that moment.

Q3. Calculate the magnetic force when one wire carrying 10A current and other wire carries 25A current in the opposite direction?

Experiment 3

Topic:

To visualise the travelling of EM Waves

Things Required:

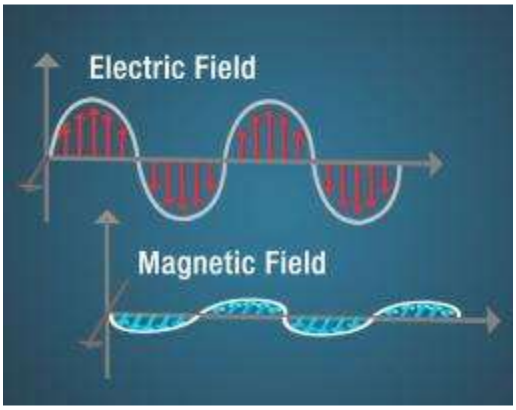
As this is an Online lab So having an internet supported device will suffice.

Theory :

Electromagnetic waves or EM waves are waves that are created as a result of vibrations between an electric field and a magnetic field. In other words, EM waves are composed of oscillating magnetic and electric fields.

Electromagnetic waves are formed when an electric field comes in contact with a magnetic field. They are hence known as ‘electromagnetic’ waves. The electric field and magnetic field of an electromagnetic wave are perpendicular (at right angles) to each other. They are also perpendicular to the direction of the EM wave.

EM waves travel with a constant velocity of 3.00 x 108 ms-1 in vacuum. They are deflected neither by the electric field, nor by the magnetic field. However, they are capable of showing interference or diffraction. An electromagnetic wave can travel through anything - be it air, a solid material or vacuum. It does not need a medium to propagate or travel from one place to another. Mechanical waves (like sound waves or water waves), on the other hand, need a medium to travel. EM waves are 'transverse' waves. This means that they are measured by their amplitude



(height) and wavelength (distance between the highest/lowest points of two consecutive waves).

The highest point of a wave is known as 'crest', whereas the lowest point is known as 'trough'. Electromagnetic waves can be split into a range of frequencies. This is known as the electromagnetic spectrum. Examples of EM waves are radio waves, microwaves, infrared waves, X-rays, gamma rays, etc.

Procedure :

1. Firstly you need to Open E-practical website on your pc/mobile.
2. Just observe and see how in 2-D plane a 3-D EM wave travels.

Observation:

We Observe the travelling of EM Waves, How it travels in the space