# PH170 LAB 6

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**ID: 202151160**

- ## **Aim:-**

1. Predict the direction of the magnetic field for different locationsaround a bar magnet and an electromagnet.
2. Compare and contrast bar magnets and electromagnets.
3. Identify the characteristics of electromagnets that are variable andwhat effects each variable has on the magnetic field's strength and direction.
4. Relate magnetic field strength to distance quantitatively andqualitatively.
5. Identify equipment and conditions that produce induction.
6. Compare and contrast how both a light bulb and voltmeter can beused to show characteristics of the induced current.
7. Predict how the current will change when the conditions are varied.

- ## Theory:-

**Lenz's law** states that the current induced in a circuit due to a change in a magnetic field is directed to oppose the change in flux and to exert a mechanical force which opposes the motion. This means that the direction of the back EMF of an induced field opposes the changing current that is itscause.

Faraday's law states that there is EMF (electromotive force, defined as electromagnetic work done on a unit charge when it has traveled one round of a conductive loop) on the conductive loop when the magneticflux through the surface enclosed by the loop varies in time.

**Faraday's law** is one of Maxwell's equations. Faraday's law states thatthe absolute value or magnitude of the circulation of the electric field **E**around a closed loop is equal to the **rate of change** of the magnetic fluxthrough the area enclosed by the loop. The equation below expresses Faraday's law in mathematical form.

$\Delta\Phi_B/\Delta t$ (through a fixed area) = $-\Sigma_{\text{around loop}}$ $\mathbf{E}\cdot\Delta\mathbf{r}$ (at a fixed time)

The minus sign in this equation tells us about the direction of thecirculation. (See below.)

When the magnetic flux through the area enclosed by the loop changes,$\Sigma_{\text{around loop}}$ $\mathbf{E}\cdot\Delta\mathbf{r}$ is not zero, the electric field **E** circulates.

$\mathbf{E}\cdot\Delta\mathbf{r}$ is the work done per unit charge by the electric field in moving thecharge a distance $\Delta\mathbf{r}$.

If the loop is an actual wire loop, then there is actual work done by theinduced field on free charges.

$\Sigma_{\text{around loop}}$ $\mathbf{E}\cdot\Delta\mathbf{r}$ is the work per unit charge by the field in moving the charge once around the loop.

This is an **induced emf**, and it is measured in Volts.

The induced emf causes a current to flow without a potential differencedue to separated charges.

$\Delta\Phi_B/\Delta t$ (through a fixed area) = induced emf

The induced electric field is **NOT** a conservative field. When you move a charge against the induced field once around the loop, you have to do work. But your work is **NOT** stored as potential energy. You cannot let

the electric field do work to recover the energy you expended in moving the charge. The induced electric field disappears as soon as the magnetic flux is no longer changing. The work you do on a charge againstthe induced field is not locally stored. The energy may be transported away in the form of an electromagnetic wave. Electromagnetic waves carry energy through free space.

A bar magnet is a rectangular piece of an object, made up of iron, steel or any other ferromagnetic substance or ferromagnetic composite, that shows permanent magnetic properties. It has two poles, a north and a south pole
such that when suspended freely, the magnet aligns itself so that the northern
pole points towards the magnetic north pole of the earth.

Electromagnets are made out of a coil of wire (wire curled in series). This ismore effective in producing a magnetic field than just a wire running straight.This effect can be strengthened by winding a wire tightly around a powerful core, made of magnetic material, such as iron. The picture above shows a coilwound around an iron nail. On its own, the iron nail is not magnetic.

## Differences between Electromagnets and Bar Magnet:-

- Most bar magnets are blocks of ferromagnetic materials while electromagnets are coils of wire which sometimes are surrounded by aferromagnetic core. Electromagnets behave like bar magnets when anelectric current is passed through them.
- Bar magnets generate their own magnetic field while electromagnets depend on the external sources of electric current for the generation ofmagnetic field.
- Bar magnets have a constant magnetic pull as they are

permanent magnets while electromagnets do not have a constant magnetic pull asthey are controlled by external sources of electric current.

- The magnetic force of the bar magnet is constant and is dependent onthe material it is made from while the magnetic force of an electromagnet can be varied by varying the amount of electricity flowingthrough the coil.

## Difference between Permanent Magnet and Electromagnet

| Permanent (Bar) Magnet | Electromagnet |
|---|---|
| They are permanently magnetized. | These are temporarily magnetized. |
| These are usually made of hard materials. | They are usually made of soft materials. |
| The strength of the magnetic field line is constant i.e. it cannot be varied. | The strength of the magnetic field lines can be varied according to our need. |
| The poles of a Permanent magnet cannot be changed. | The poles of an electromagnet can be altered. |
| Example of a permanent magnet is a Bar Magnet | Example of a temporary magnet is solenoid wounded across a nail and connected to a battery. |

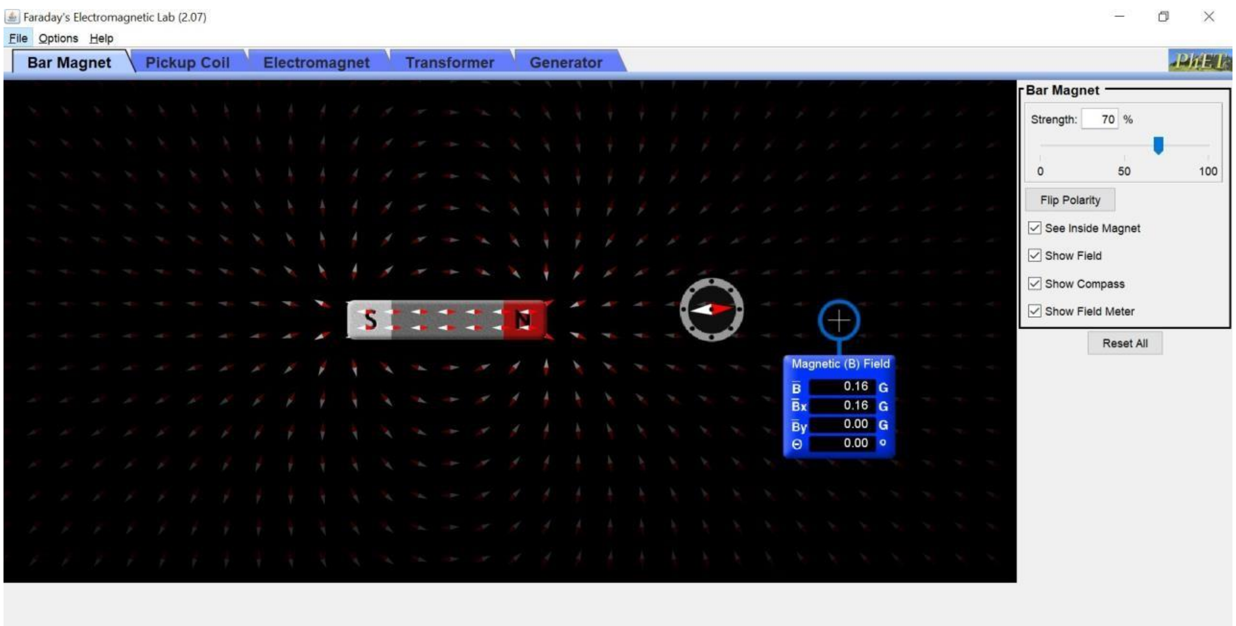
A **magnetic field** is a vector field that describes the magnetic influence on moving electric charges, electric currents, and magneticmaterials

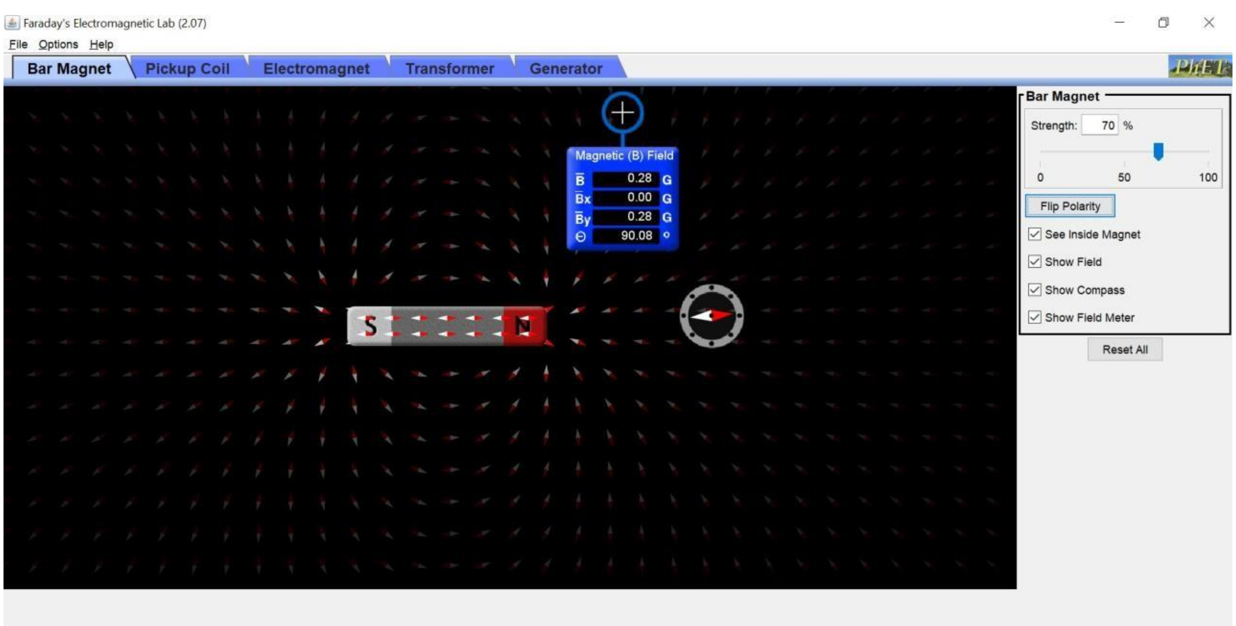
**Magnetic field strength**, also called **magnetic intensity** or **magnetic field intensity**, is the part of the magnetic field in a material that arises from an external current and is not intrinsic to the material itself.

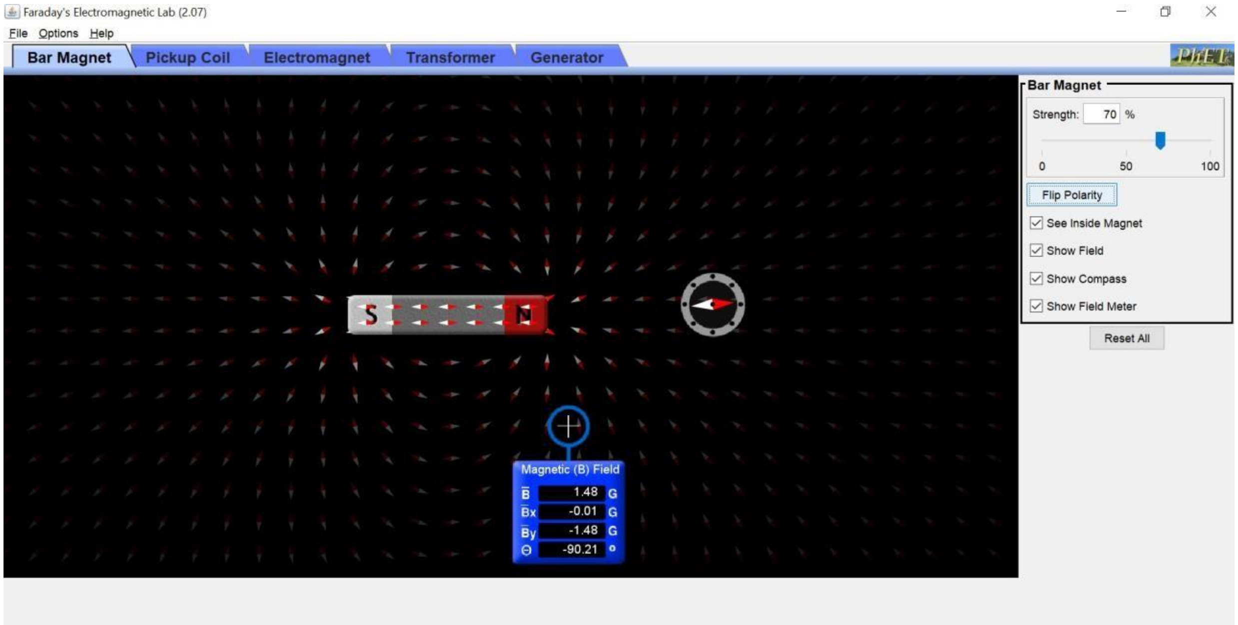
The equation for magnetic force is similar to Coulomb's Law (if you are familiar with it). But the key point is that the force is **inversely proportionalto the distance squared** (i.e. it obeys an inverse square law with distance).

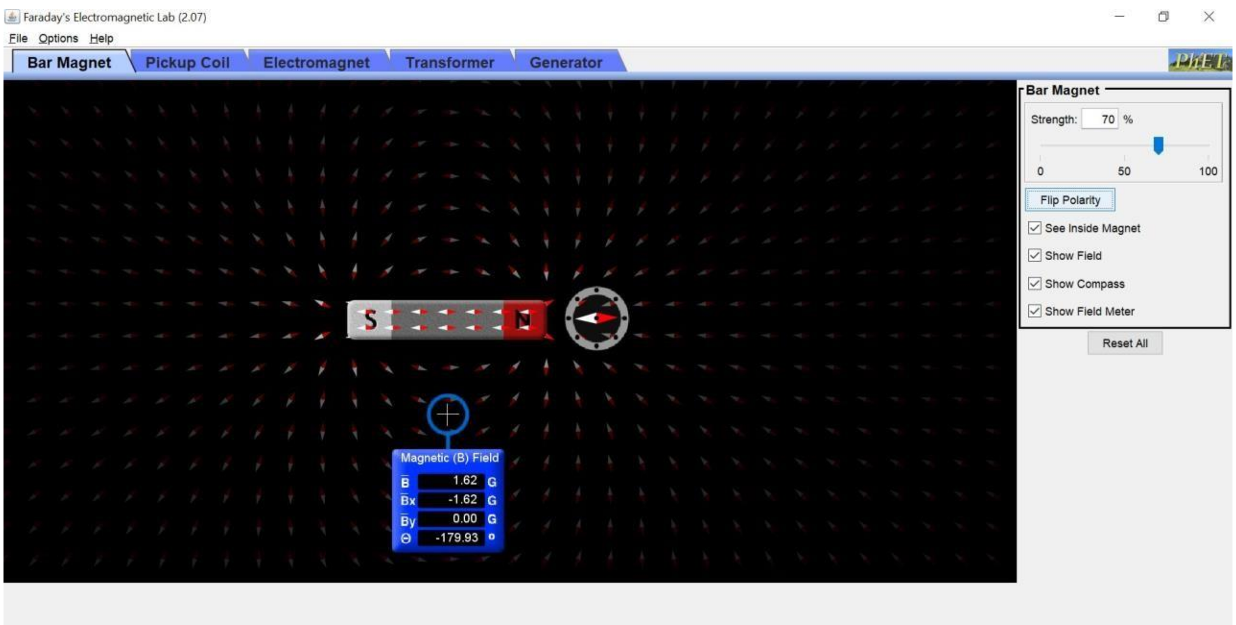
- ## Simulation (Observations):-

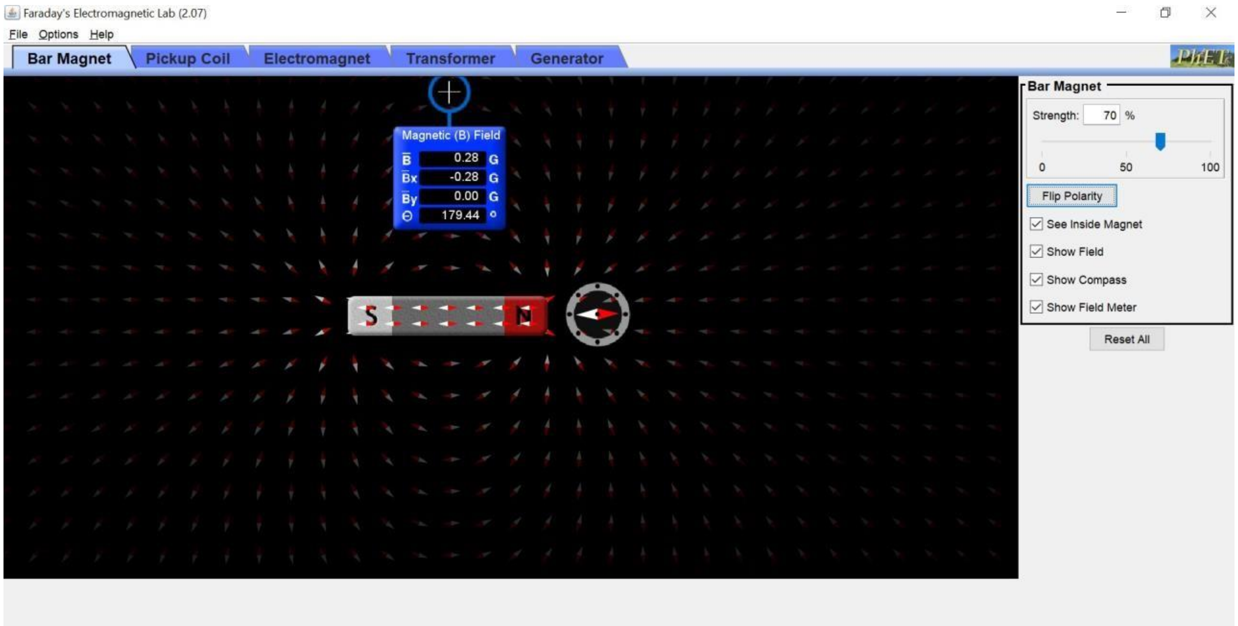
### Aim:-



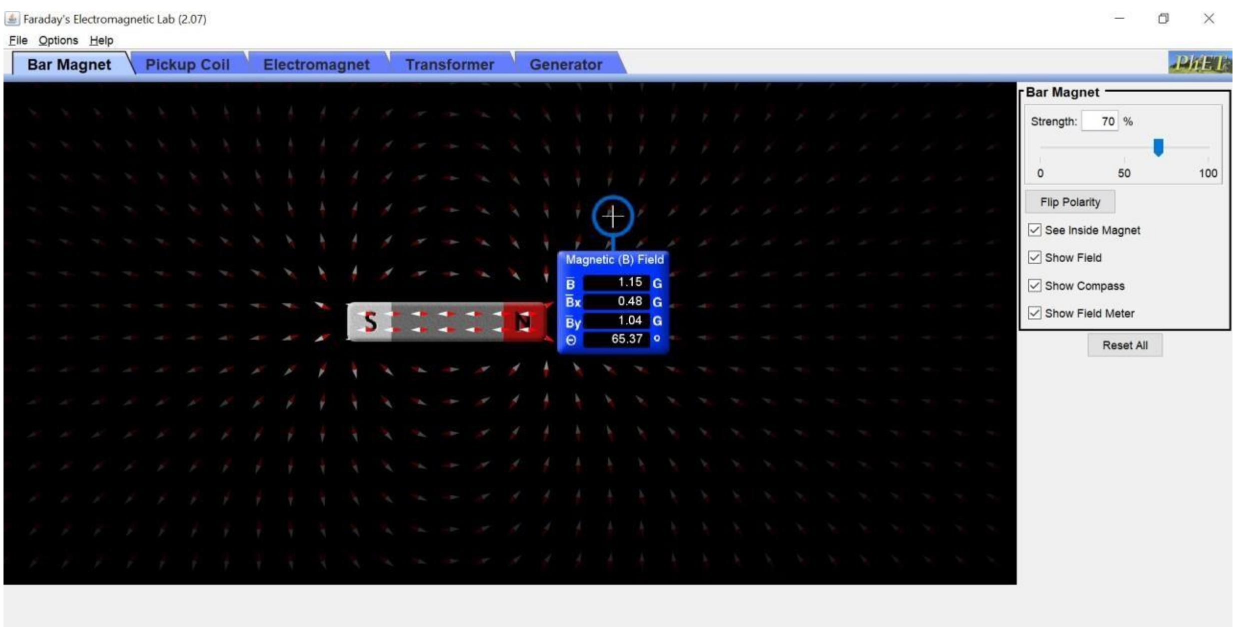




Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
S
N
Magnetic (B) Field
B 1.48 G
Bx -0.01 G
By -1.48 G
Θ -90.21 °
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All

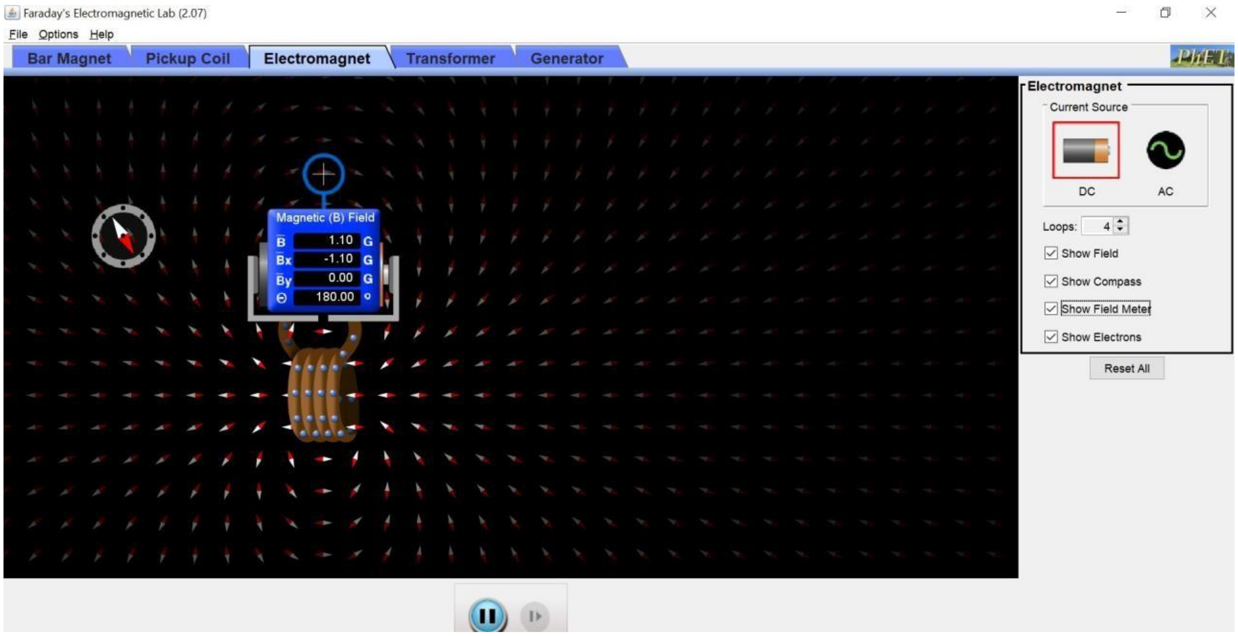

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
S
N
Magnetic (B) Field
B 1.62 G
Bx -1.62 G
By 0.00 G
Θ -179.93 °
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All

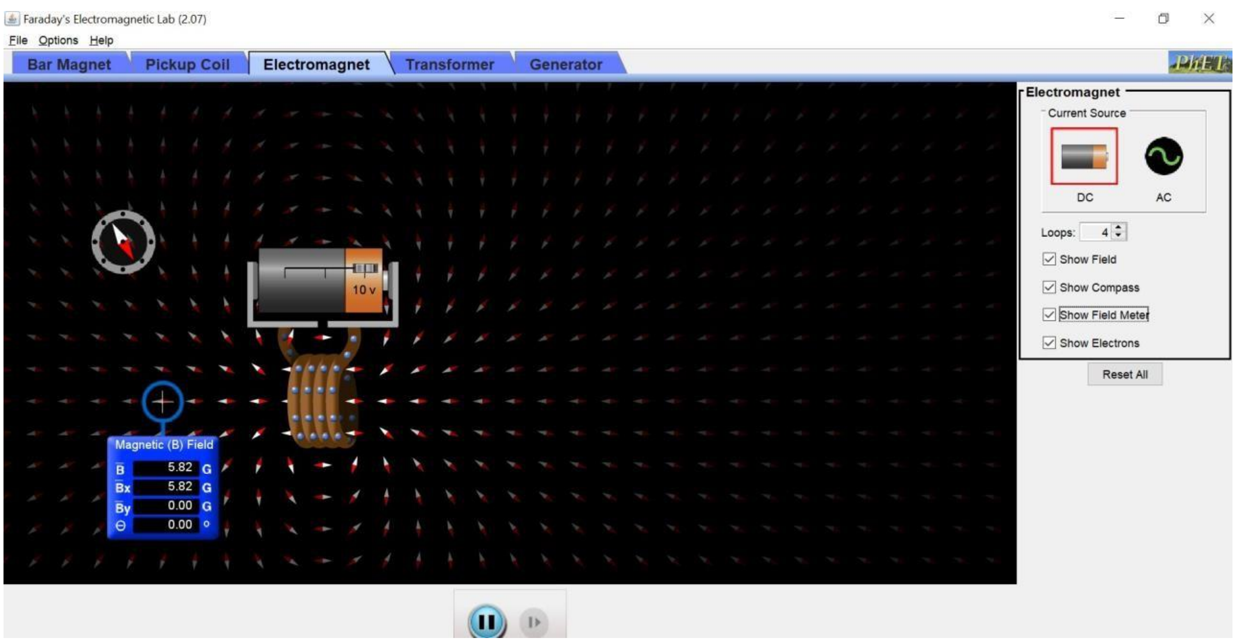


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Magnetic (B) Field
B 0.28 G
Bx -0.28 G
By 0.00 G
Θ 179.44 °
S
N
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All

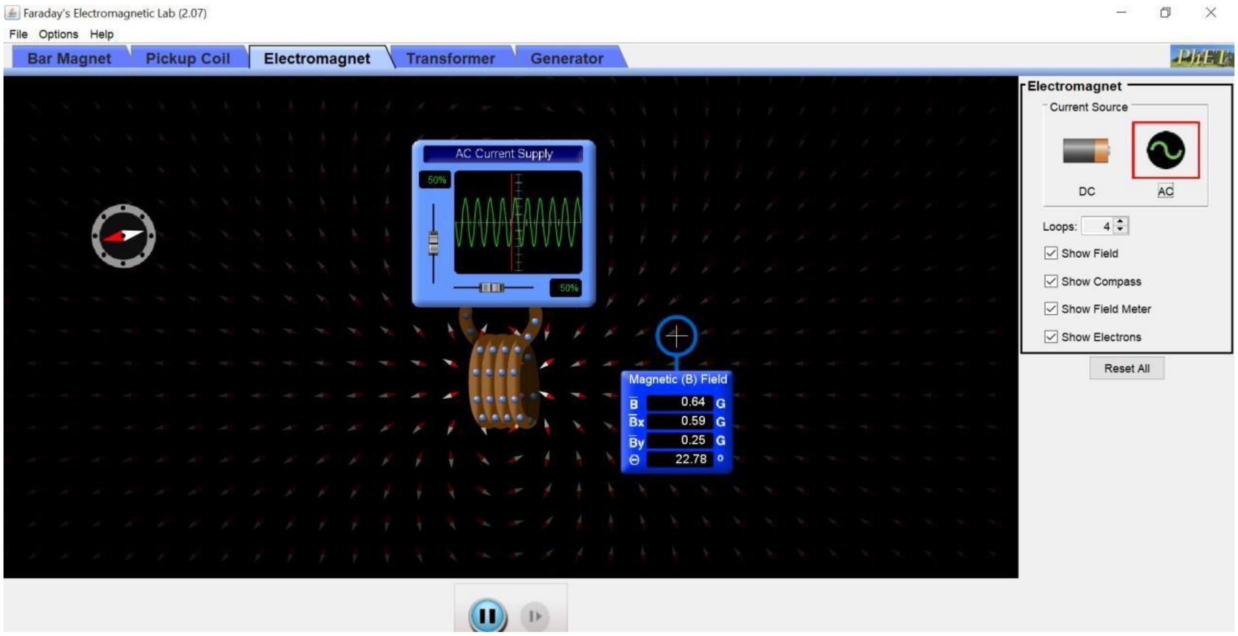



Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Magnetic (B) Field
B 1.15 G
Bx 0.48 G
By 1.04 G
Θ 65.37 °
S
N
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Magnetic (B) Field
B 1.10 G
Bx -1.10 G
By 0.00 G
Θ 180.00 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
10 v
Magnetic (B) Field
B 5.82 G
Bx 5.82 G
By 0.00 G
Θ 0.00 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

# Aim 2:-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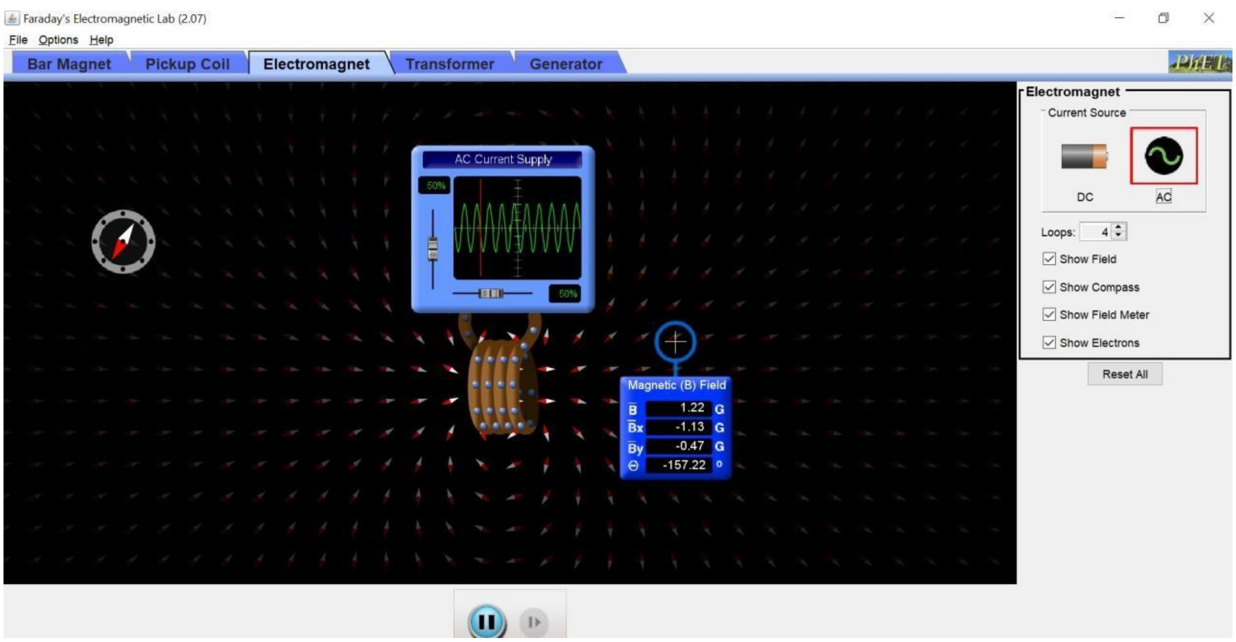
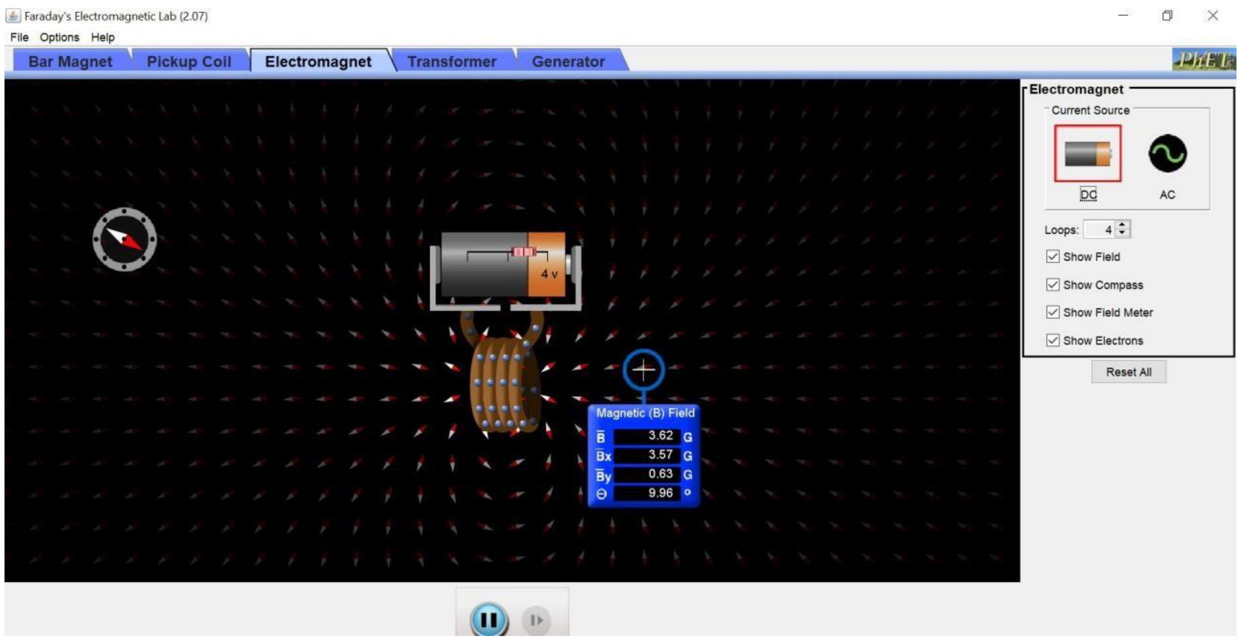
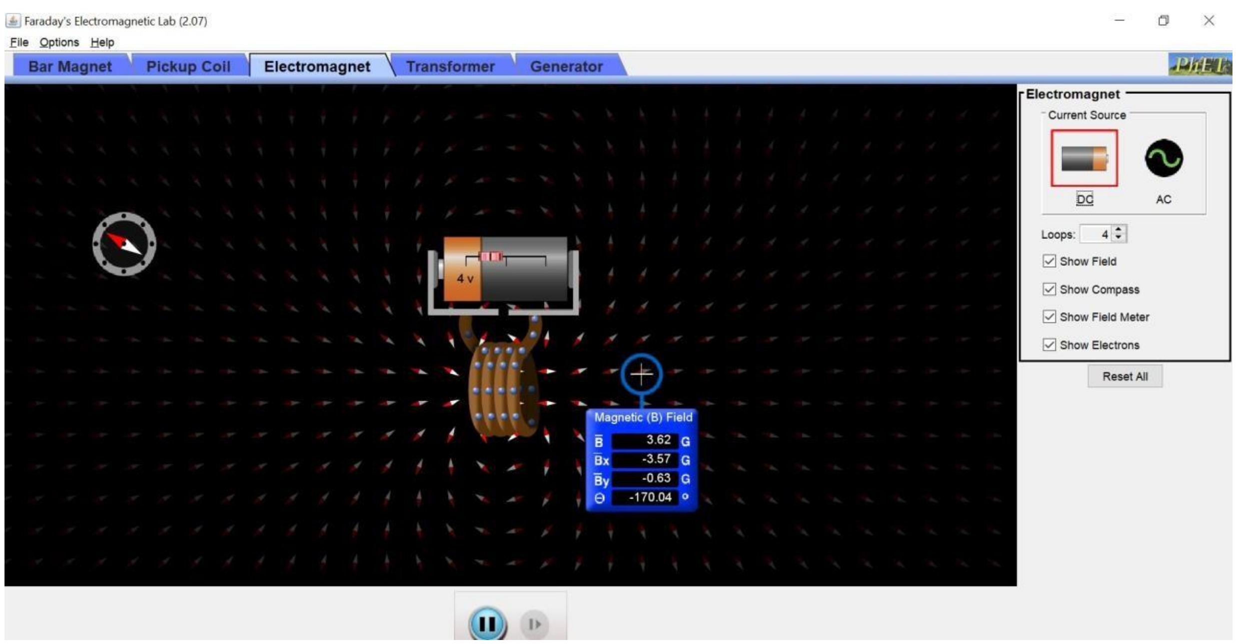
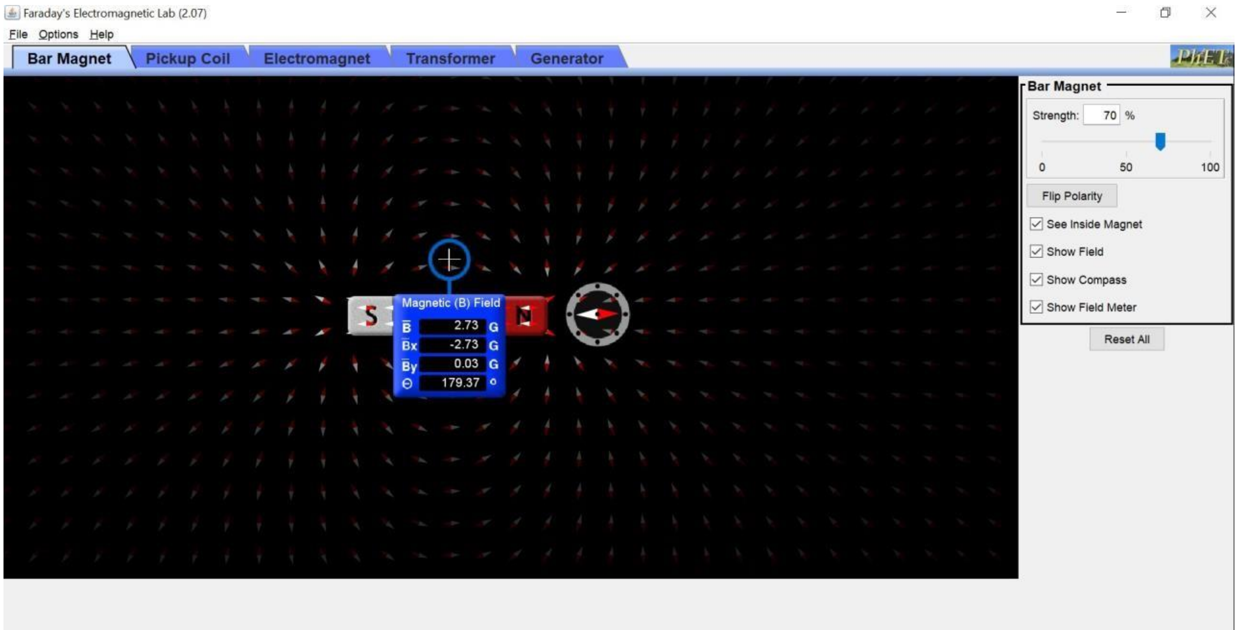
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Magnetic (B) Field
B 0.64 G
Bx 0.59 G
By 0.25 G
Θ 22.78 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

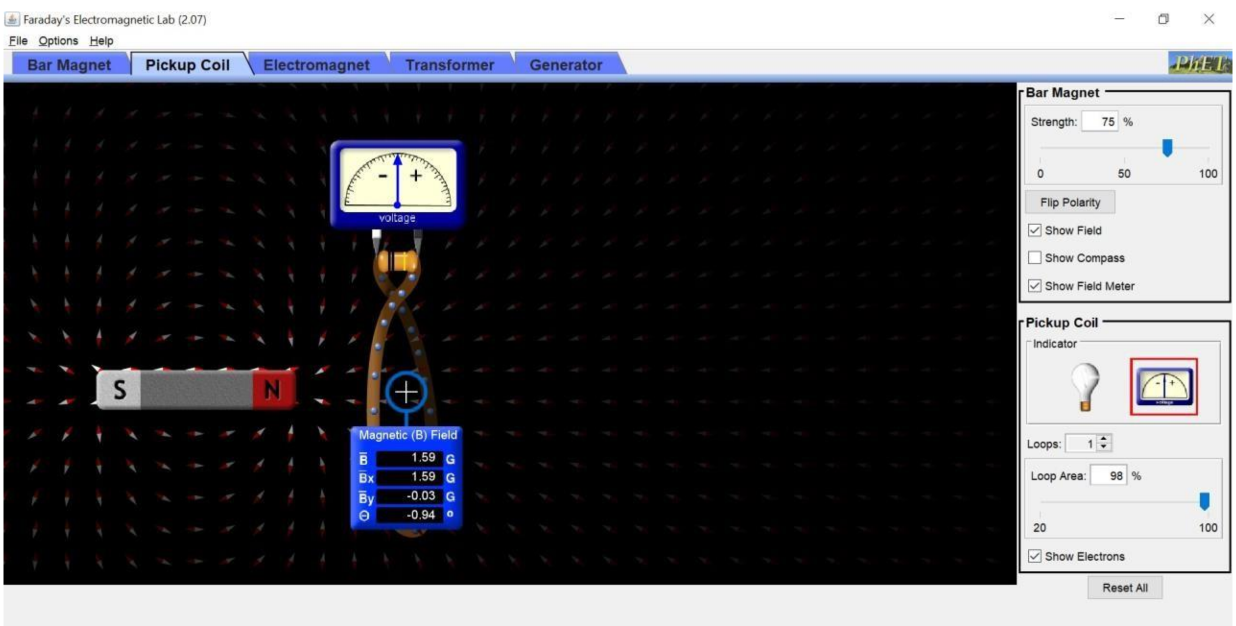

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Magnetic (B) Field
B 1.22 G
Bx -1.13 G
By -0.47 G
Θ -157.22 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

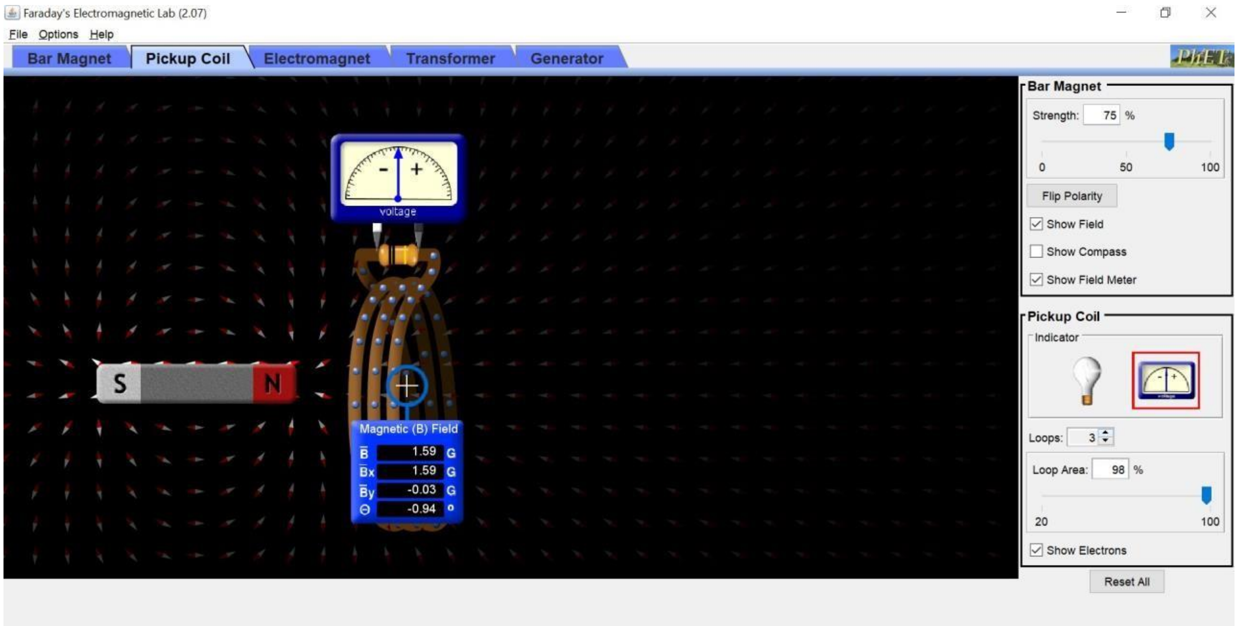

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All
4 v
Magnetic (B) Field
B 3.62 G
Bx 3.57 G
By 0.63 G
θ 9.96 °

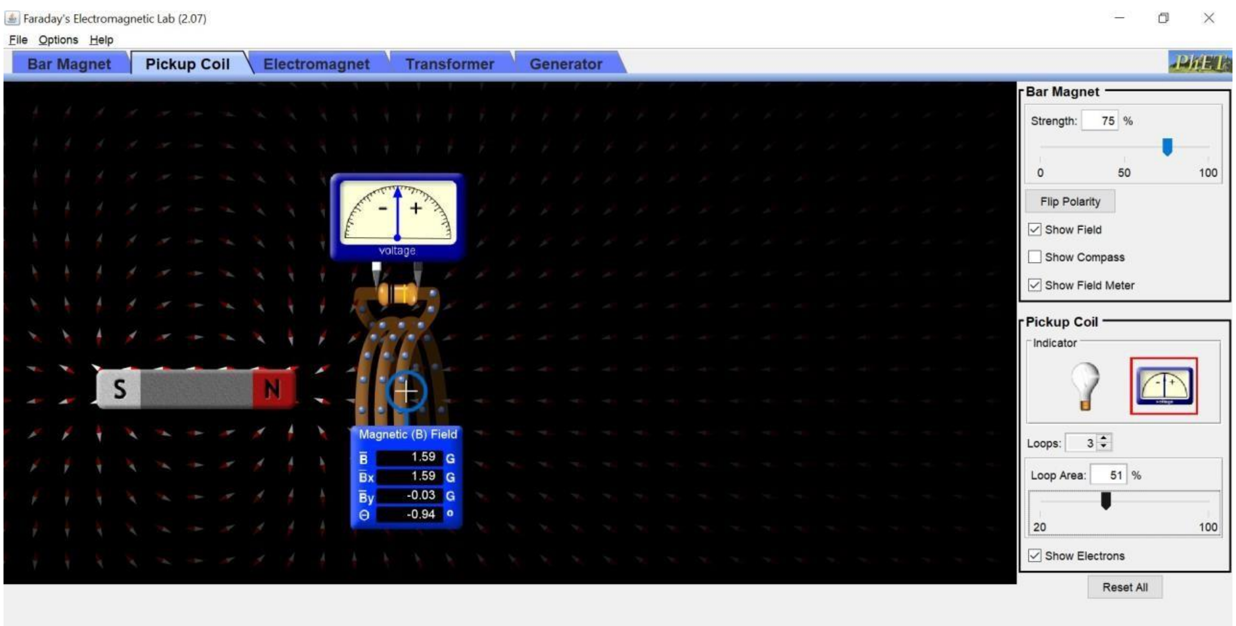

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All
4 v
Magnetic (B) Field
B 3.62 G
Bx -3.57 G
By -0.63 G
θ -170.04 °

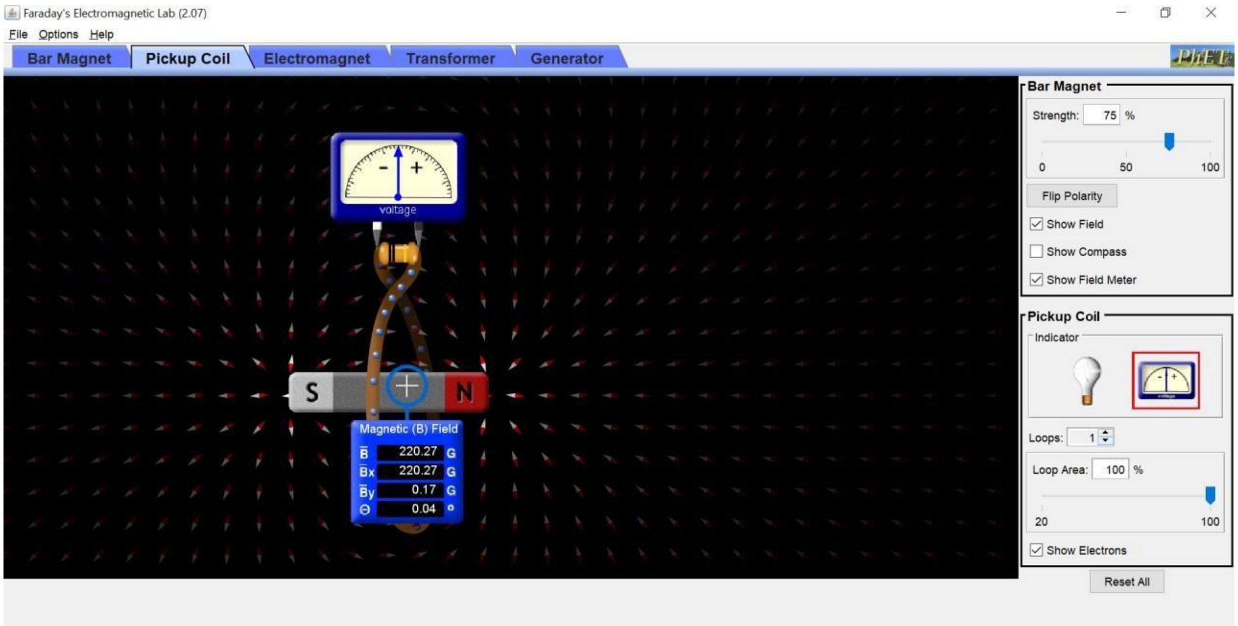

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Magnetic (B) Field
B 2.73 G
Bx -2.73 G
By 0.03 G
Θ 179.37 °
S
N
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All

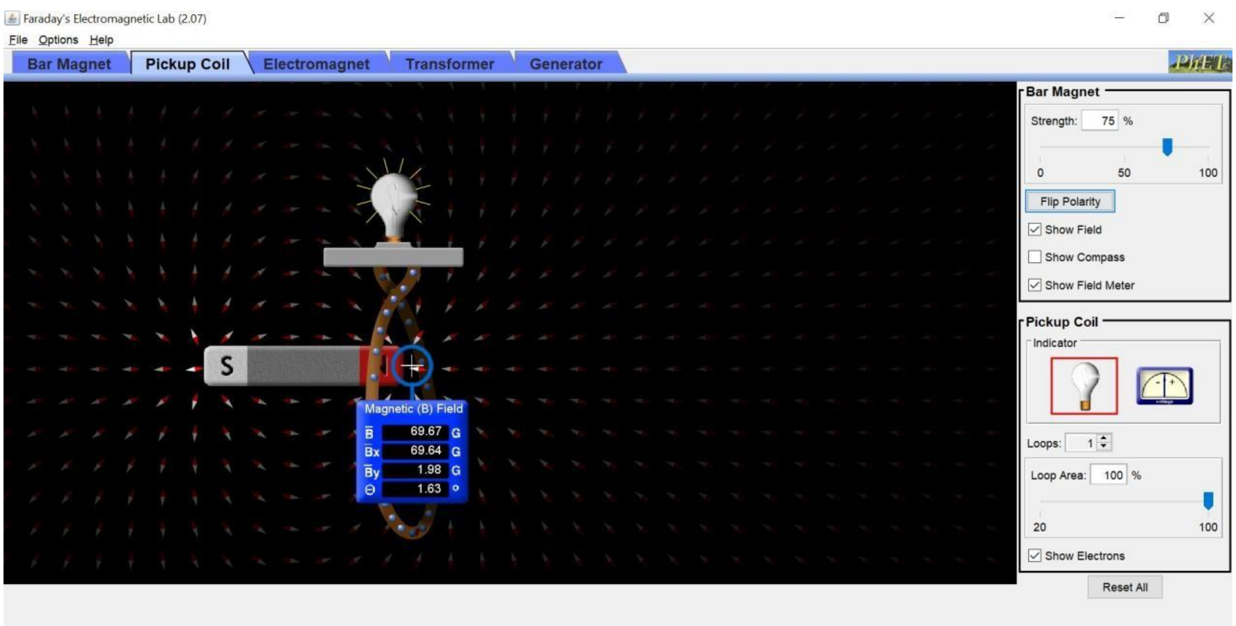
# Aim 3:-


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
voltage
S
N
Magnetic (B) Field
B 1.59 G
Bx 1.59 G
By -0.03 G
Θ -0.94 °
Bar Magnet
Strength: 75 %
0 50 100
Flip Polarity
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 1
Loop Area: 98 %
20 100
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
voltage
S
N
Magnetic (B) Field
B 1.59 G
Bx 1.59 G
By -0.03 G
Θ -0.94 °
Bar Magnet
Strength: 75 %
0 50 100
Flip Polarity
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 3
Loop Area: 98 %
20 100
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
voltage
S
N
Magnetic (B) Field
B 1.59 G
Bx 1.59 G
By -0.03 G
Θ -0.94 °
Bar Magnet
Strength: 75 %
0 50 100
Flip Polarity
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 3
Loop Area: 51 %
20 100
Show Electrons
Reset All

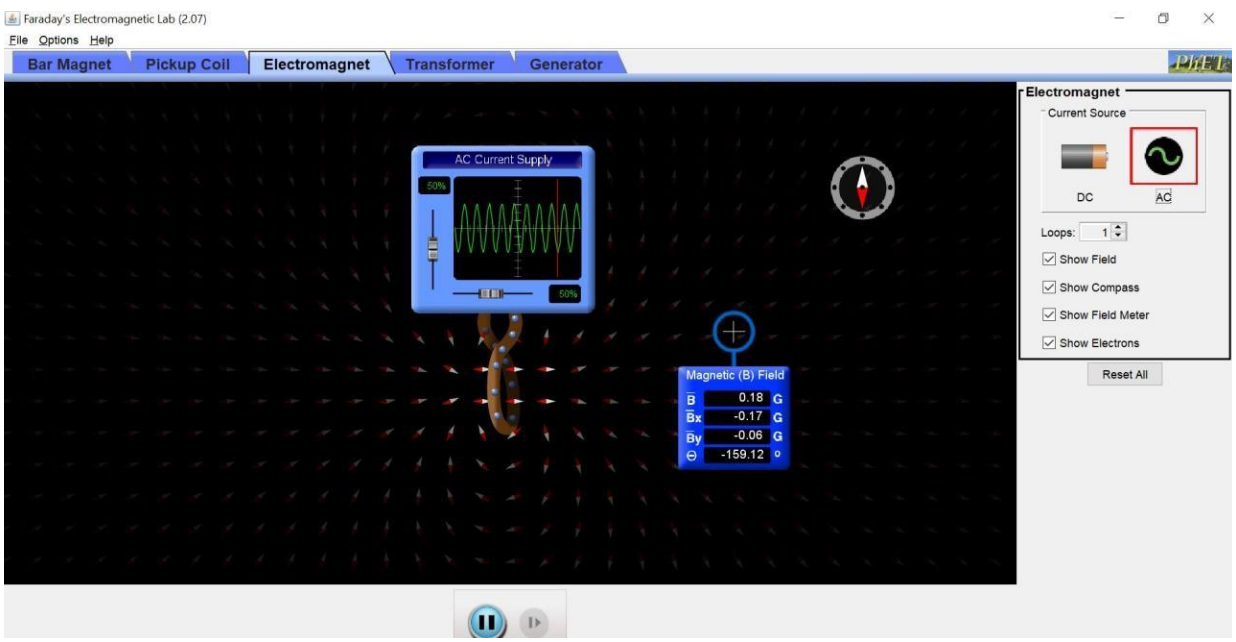

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
voltage
S
N
Magnetic (B) Field
B 220.27 G
Bx 220.27 G
By 0.17 G
Θ 0.04 °
Bar Magnet
Strength: 75 %
0 50 100
Flip Polarity
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 1
Loop Area: 100 %
20 100
Show Electrons
Reset All

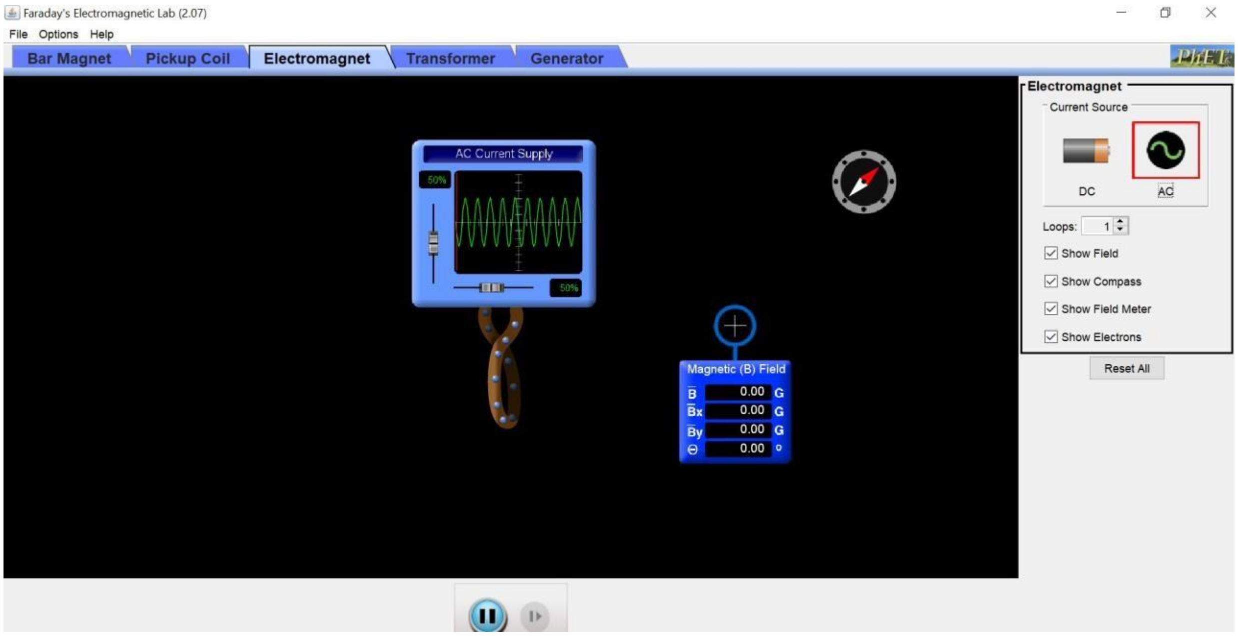

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
S
Magnetic (B) Field
B 69.67 G
Bx 69.64 G
By 1.98 G
Θ 1.63 °
Bar Magnet
Strength: 75 %
0 50 100
Flip Polarity
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 1
Loop Area: 100 %
20 100
Show Electrons
Reset All

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
10 v
Magnetic (B) Field
B 0.77 G
Bx 0.70 G
By 0.34 G
Θ 26.19 °
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

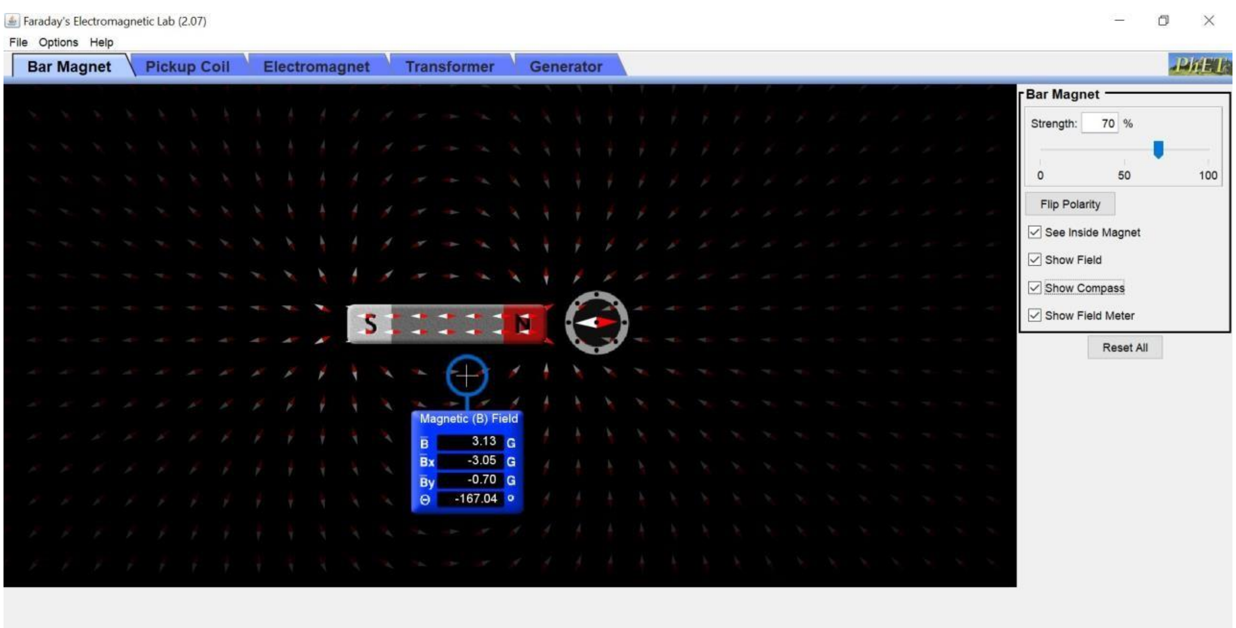

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
10 v
Magnetic (B) Field
B 3.10 G
Bx 2.78 G
By 1.37 G
Θ 26.19 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

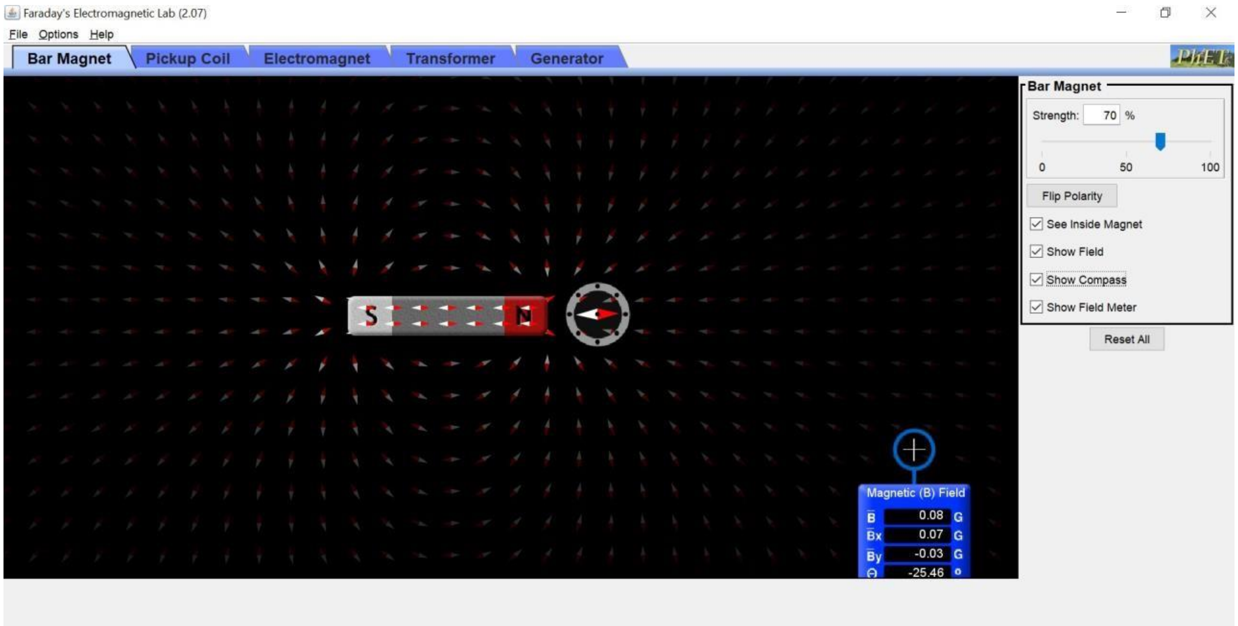

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All
10 v
Magnetic (B) Field
B 0.77 G
Bx -0.70 G
By -0.34 G
Θ -153.81 °


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All
Magnetic (B) Field
B 0.18 G
Bx -0.17 G
By -0.06 G
Θ -159.12 °

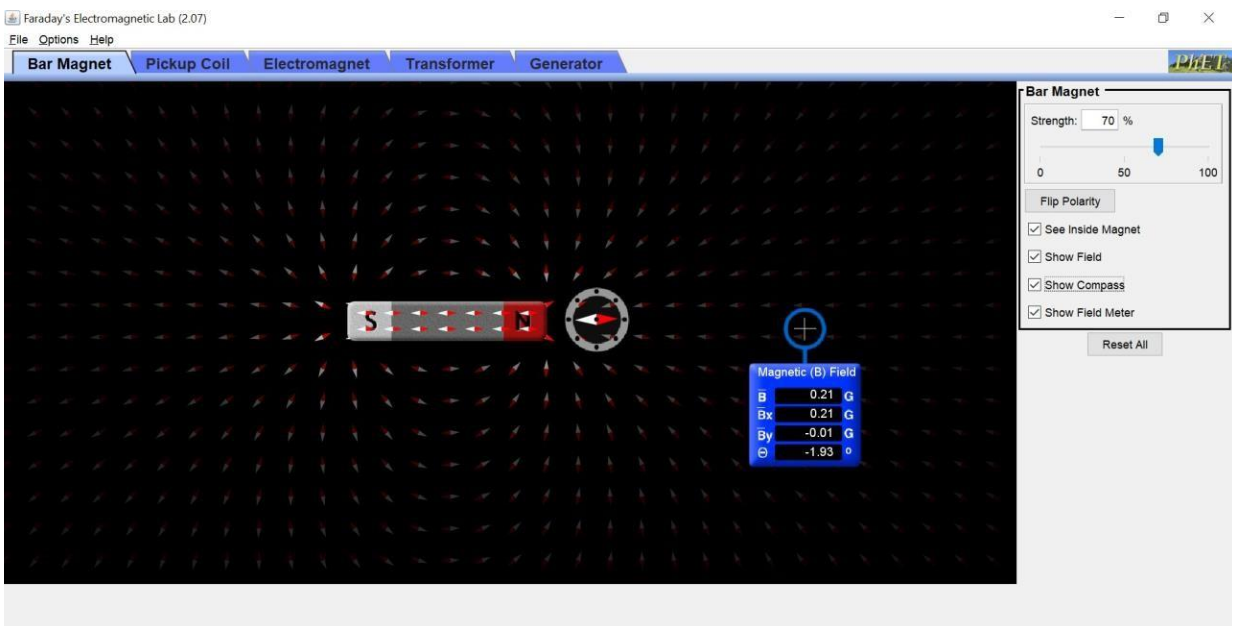

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Magnetic (B) Field
B 0.00 G
Bx 0.00 G
By 0.00 G
θ 0.00 °
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

## Aim 4:-


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
S
N
Magnetic (B) Field
B 3.13 G
Bx -3.05 G
By -0.70 G
θ -167.04 °
Bar Magnet
Strength: 70 %
0
50
100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All



Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All
S
N
Magnetic (B) Field
B 0.08 G
Bx 0.07 G
By -0.03 G
Θ -25.46 °

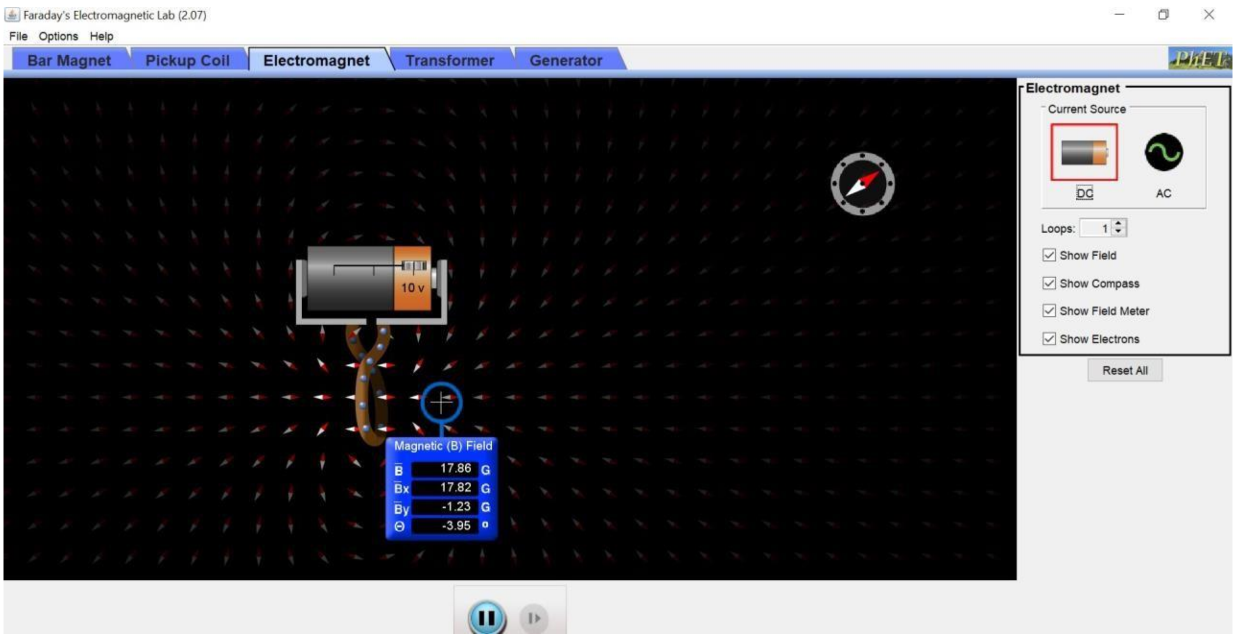
Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
Bar Magnet
Strength: 70 %
0 50 100
Flip Polarity
See Inside Magnet
Show Field
Show Compass
Show Field Meter
Reset All
S
N
Magnetic (B) Field
B 0.21 G
Bx 0.21 G
By -0.01 G
Θ -1.93 °

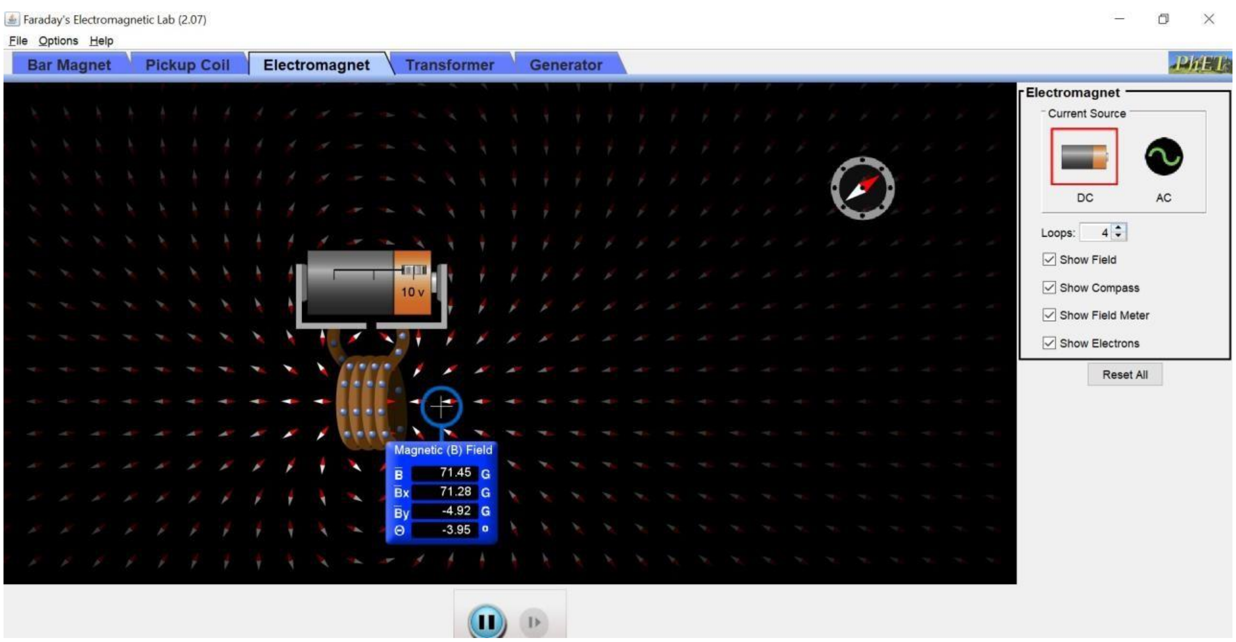


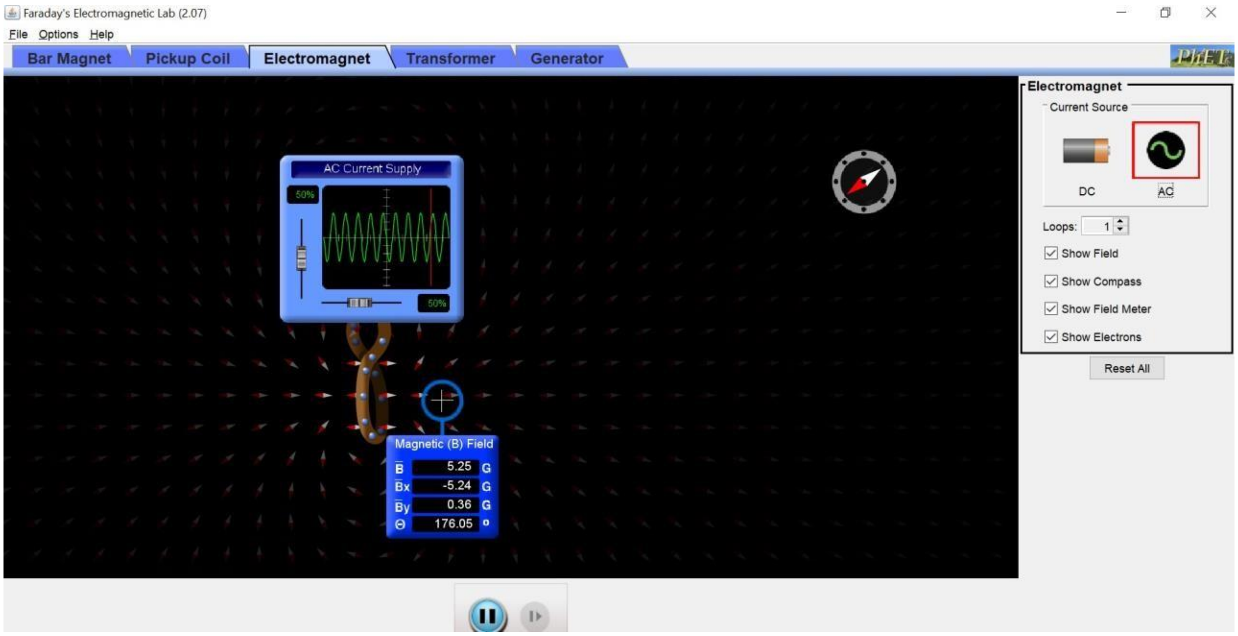
As the distance is increasing, the magnetic field is decreasing sharply with rate of $1/r^2$ (Inverse Square law)

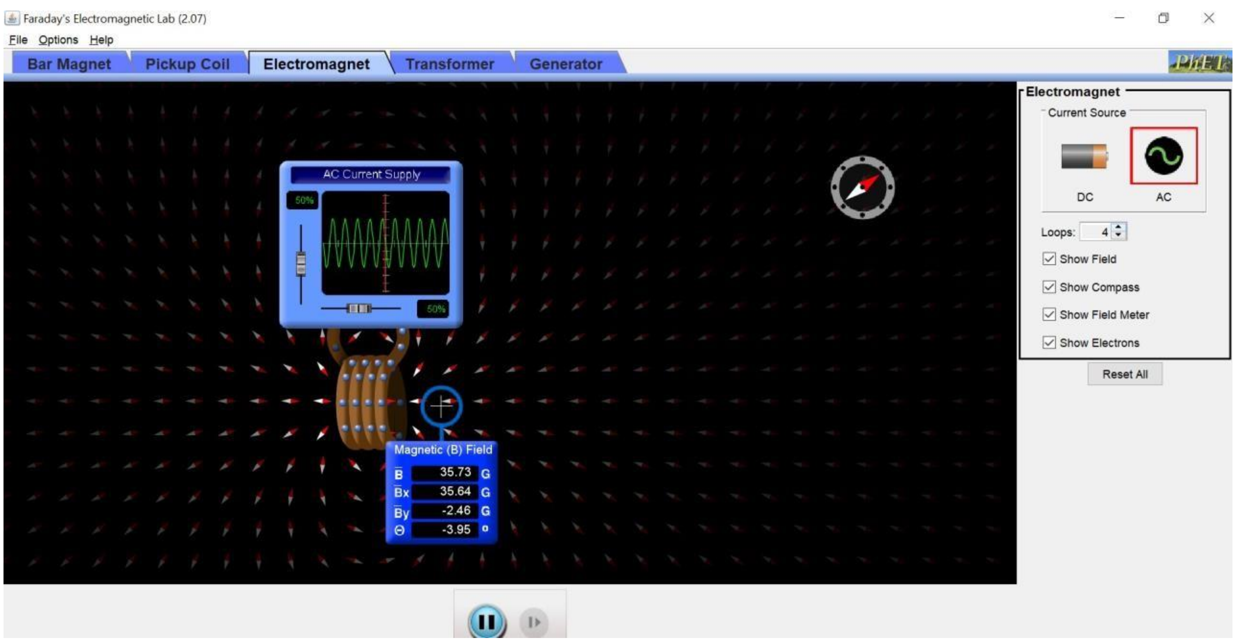
At very large distances, the magnetic field strength willtend to zero.

## Aim 5:-

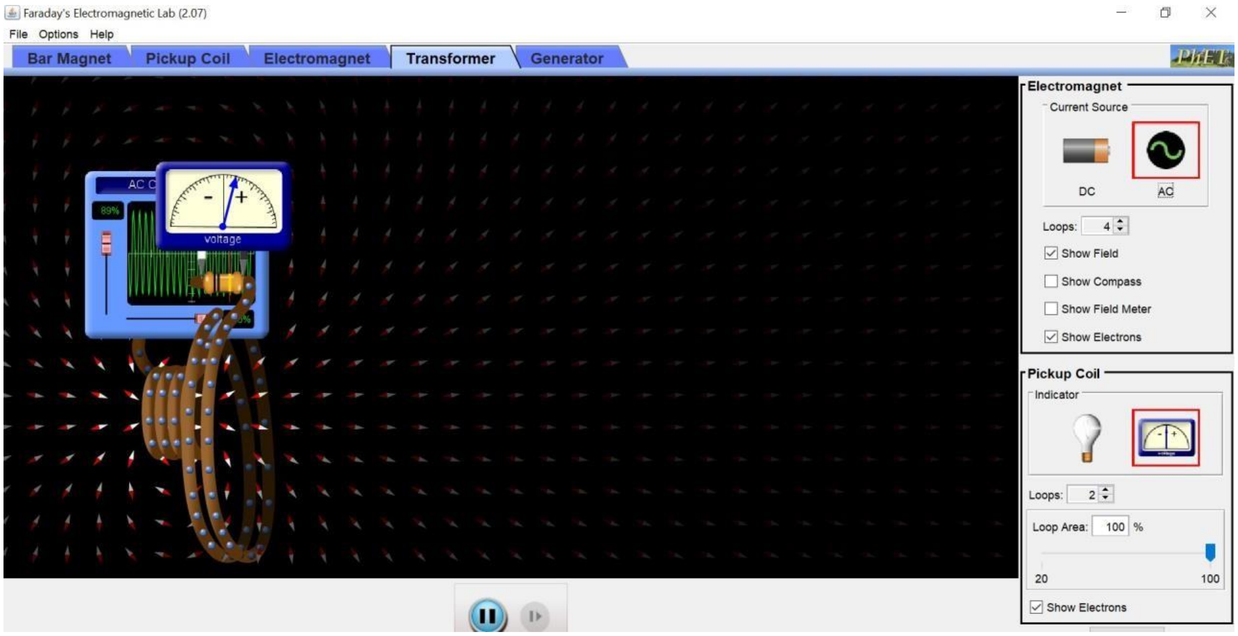

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
10 v
Magnetic (B) Field
B 17.86 G
Bx 17.82 G
By -1.23 G
Θ -3.95 °
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
10 v
Magnetic (B) Field
B 71.45 G
Bx 71.28 G
By -4.92 G
Θ -3.95 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

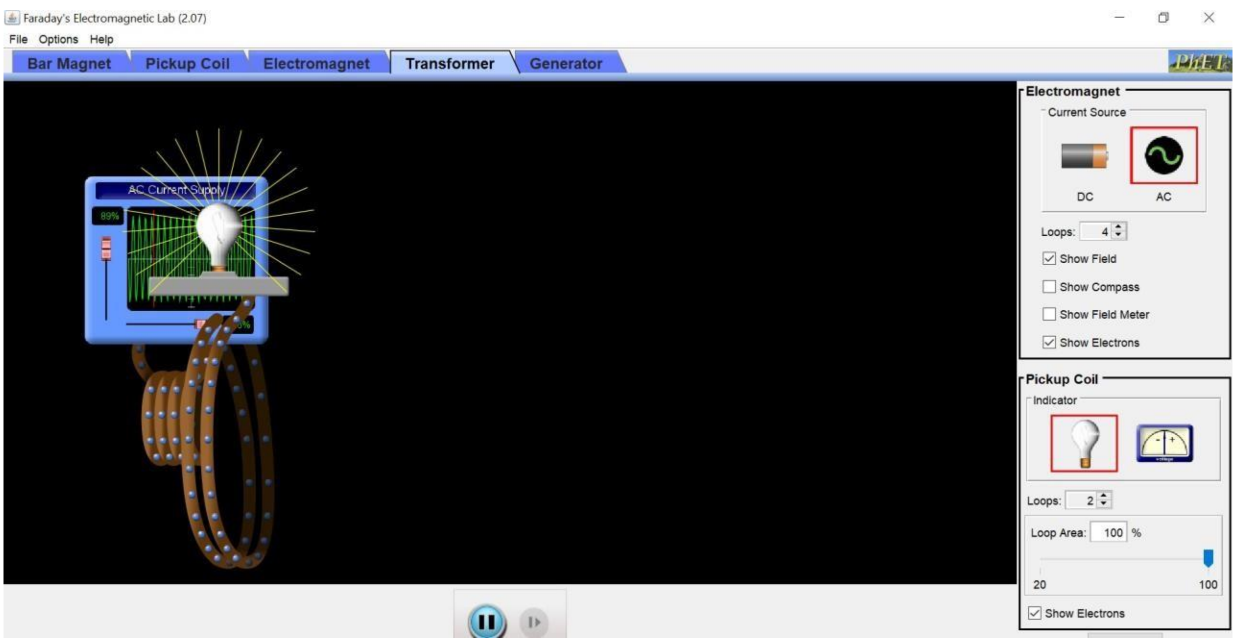

Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Magnetic (B) Field
B 5.25 G
Bx -5.24 G
By 0.36 G
Θ 176.05 °
Electromagnet
Current Source
DC
AC
Loops: 1
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
50%
50%
Magnetic (B) Field
B 35.73 G
Bx 35.64 G
By -2.46 G
Θ -3.95 °
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Reset All

# Aim 6:-

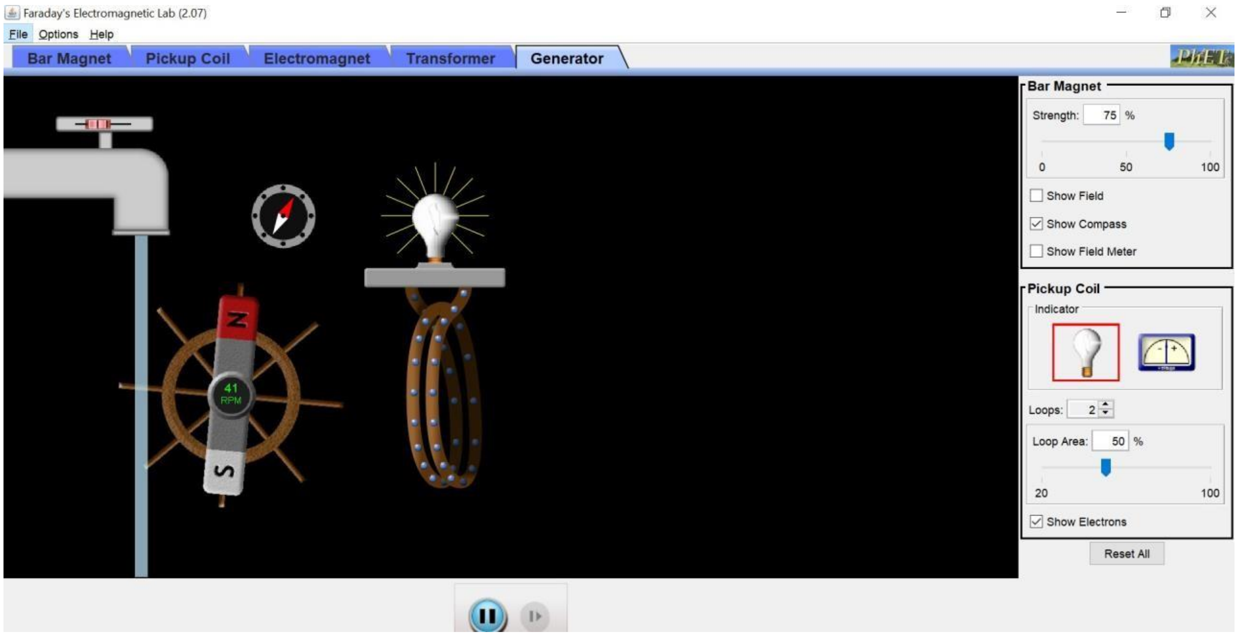


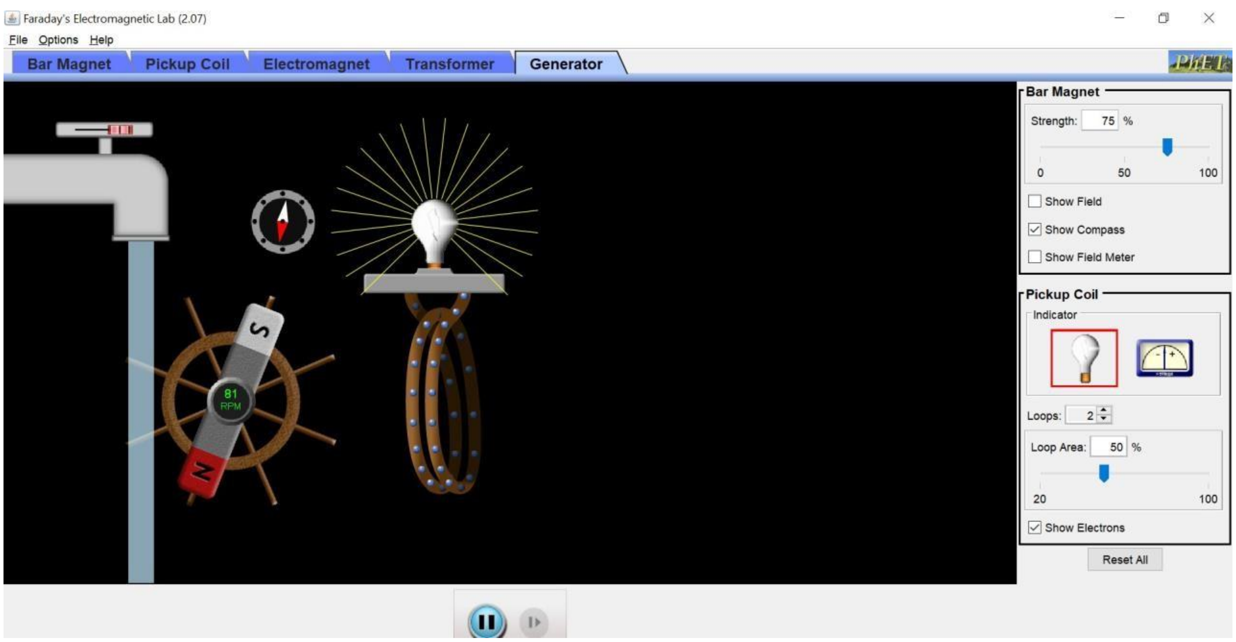
Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
voltage
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Pickup Coil
Indicator
Loops: 2
Loop Area: 100 %
20
100
Show Electrons

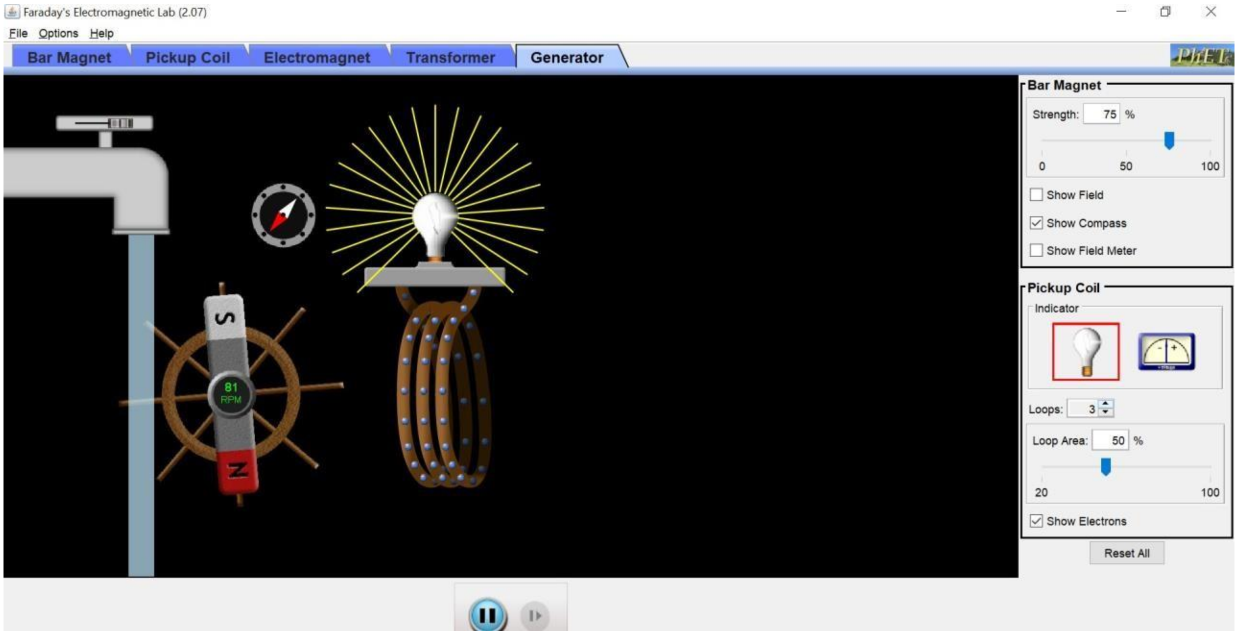



Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
AC Current Supply
Electromagnet
Current Source
DC
AC
Loops: 4
Show Field
Show Compass
Show Field Meter
Show Electrons
Pickup Coil
Indicator
Loops: 2
Loop Area: 100 %
20
100
Show Electrons


## Aim7:-


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
41
RPM
Bar Magnet
Strength: 75 %
0 50 100
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 2
Loop Area: 50 %
20 100
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
81
RPM
Bar Magnet
Strength: 75 %
0 50 100
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 2
Loop Area: 50 %
20 100
Show Electrons
Reset All


Faraday's Electromagnetic Lab (2.07)
File Options Help
Bar Magnet
Pickup Coil
Electromagnet
Transformer
Generator
81
RPM
S
N
Bar Magnet
Strength: 75 %
0
50
100
Show Field
Show Compass
Show Field Meter
Pickup Coil
Indicator
Loops: 3
Loop Area: 50 %
20
100
Show Electrons
Reset All

- ## Result Analysis:-

1. The lines of magnetic field from a bar magnet form closed lines.

2. The magnetic field is strongest inside the magnetic material.

3. The strongest external magnetic fields are near the poles.

4. A magnetic north pole will attract the south pole of another magnet, and repel a north pole.

5. The direction of the magnetic field is tangent to the magnetic field line at any point in space. The strength of the magnetic field is visualized by the closeness of the lines to each other. It is proportional to the number of linesper unit area perpendicular to the lines. A commonly used phrase is "magnetic flux density". Magnetic field lines never cross. The magnetic fieldat any point is unique. Magnetic field lines are continuous, forming closed loops without beginning or end.

6. Bar magnet is a permanent magnet whereas an electromagnet is a temporary magnet.

7. On Increasing the Number of loops, the Magnetic field Strength will also increase.

8. As the distance is increasing, the magnetic field is decreasing sharply with rate of $1/r^2$ (Inverse Square law)

9. At very large distances, the magnetic field strength will tend to zero.

10.1 The metal core for a different metal will make the electromagnet stronger or weaker.

11. The greater the current in the coil, the stronger the magnetic field will grow. Conversely, lowering the battery voltage decreases the current, weakening the field.

12. Different types of metal wire will also affect the field strength, because every metal has a different inherent resistance to current.

13. By increasing loop Area, induced current will also increase because the more Magnetic field lines is Passing through it.

14. Electromagnetic induction can be produced by a moving magnet, using Simple Generators.

15. A light bulb lights up to show when current is flowing, and a voltmetershows the voltage drop across the light bulb.

16. The strength of the current will vary in proportion to the change ofmagnetic flux.

17. If the applied magnetic field is increasing, the current in the wire will flow in such a way that the magnetic field that it generates around the wire will decrease the applied magnetic field.

18. The value of induced current will be changed by changing the strength of the magnetic field, moving the conductor in and out of the field, alter the distance between a magnet and the conductor, or change the area of a loop located in a stable magnetic field.

19. On Increasing Magnetic Field Strength and decreasing distance between them, Ammeter carrying loops go closer to electromagnets and increasing the area of loop, these all things result in increasing Induced Current.

20. On Decreasing Magnetic Field Strength and Increasing distance between them, Ammeter carrying loops going far away from electromagnets and decreasing the area of loop, these all things result in decreasing Induced Current.