Generating Electric Current by Magnetic Field 2

Experiment with Electromagnetic Induction 2

~ Michael Faraday ~

NaRiKa Corporation

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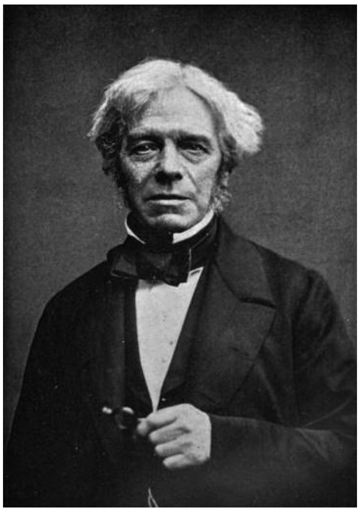
1. Learning Outcome

We can exemplify how magnetic field is generated by electric current through the experiments of Oersted, Ampere's Right-hand grip rule, and electromagnet as we did in the previous Units. In this Unit, we are going to examine, when electric current is carried through a coil, how magnetic field is generated and affect another adjacent coil. Insert an iron bar (core) into two coils that are not connected to each other. Then, connect a hand-held generator “Genecon V3” to one of the coils, and connect a Galvanometer to the other coil. By turning the handle of the Genecon V3 to pass an electric current through a coil, we will check how the Galvanometer connected to the other coil would be affected.

In case of using dry cell batteries or electric power-supply units, students can merely turn on a circuit and observe the electrical phenomena. However, they cannot only observe the experiment in operation, but also control it as they wish by using the hand-held generator Genecon V3, which helps students’ better understanding of experiments objectives through hands-on experience involving them.
Learning outcome of this Unit is for students to better understand the phenomena of experiment of M. Faraday through their hands-on experience.

2. Historical Background

Michael Faraday (1791 - 1867) was an English scientist who contributed to the fields of electromagnetism and electrochemistry. His main discoveries include electromagnetic induction, diamagnetism and electrolysis. It was by his research about magnetic field around a conductor carrying direct current, that Faraday established the basis for the concept of the electromagnetic field in physics.



Michael Faraday
http://en.wikipedia.org/wiki/
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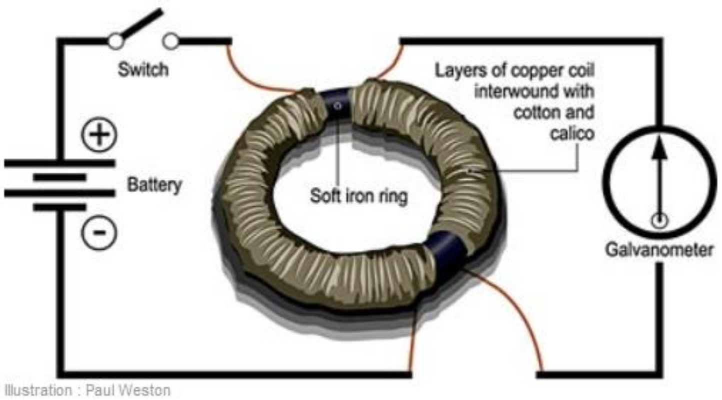
When Oersted discovered that electricity produces magnetism, Faraday wondered if magnetism could produce electricity. In 1831 he showed that it can. In Faraday's first experimental demonstration of electromagnetic induction, he wrapped two wires around opposite sides of an iron ring. He plugged one wire into a galvanometer and watched it as he connected the other wire to a battery. When the battery was connected, the needle of the galvanometer leaped into action, registering current in one coil. However, the effect quickly faded, and the needle soon detected no current, even though the battery was still connected.

Finally, years later, he found that if the battery is switched off and on repeatedly, the effect can be iterated over and over again. When the battery is connected, electrons flow along the copper wire of one coil round the windings around the ring. The effect of this is to induce magnetism in the ring. A magnetic field of excited electrons is created, producing an electrical current in the other coil, which is inside the magnetic field. This is one of Faraday's great discoveries: **Reciprocal (Mutual) Induction**: production of current in a coil only when changes of current occur (no change occurs during current carrying).

His major accomplishments:

- Electromagnetic induction
- Faraday effect
- Faraday constant
- Faraday's law of electrolysis
- Electric line of force
- Faraday gauge
- Faraday cup

Nowadays **Reciprocal (Mutual) Induction's** Definition: It is the phenomenon in which a change of current in one coil causes an induced emf (electromagnetic field) in another coil placed near to the first coil. The coil in which current is changed is called primary coil and the coil in which emf is induced is called secondary coil. Consider two coils placed near each other. When current is passed through the primary coil, magnetic flux is produced. This magnetic flux is also linked with the secondary coil. If the current is changed by varying the resistance in the primary circuit, the magnetic flux also changes. As this changing flux is linked with the secondary coil, it induces an emf in it. This phenomenon of inducing emf in a coil by changing current in another coil is known as mutual inductance.



3. Introduction of Equipment for Experiments

Galvanometer GM-6000:

Galvanometer is equipment used to detect current with sensitivity of approx. 2.5 μA and full scale indicating ±50 μA. Being equipped with amplifier (approx. 1000x), this is a special extremely sensitive Galvanometer which can detect very small amount of electric current.

For instance, it is able to detect small amount of electric current generated by the electromagnetic induction that happens when a magnet is brought near a straight wire. Also, it is still able to detect very small amount of electric current generated by the electromagnetic induction that happens when a long wire interacts with the "magnetic field lines of the earth" instead of a magnet.

- ●Voltage sensitivity: approx. 1.6 x 10^{-4} V/mm
- ●Current sensitivity: approx. 2.5 x 10^{-6} A/mm, Full scale indicating ±50 μA (center zero)
- ●Amplification degree: Differential amplification, Amplification factor 60dB

Galvanometer GM-6000

(Narika A05-7120)

4. Faraday's Experiment with Electromagnetic Induction ~ Michael Faraday ~

Years after A. M. Ampere discovered the Ampere' law (right-hand rule) in 1820, by which basic theory of electricity and magnetism was proposed, William Sturgeon and Joseph Henry discovered and invented electromagnet in 1828.

Michael Faraday has, derived from the Oersted discovery of fact that electric current makes magnetic field, started to think that magnetic field can make electricity. He had been conducting research related to magnetic field created around electrical conductor when direct electric current was flowing.

Faraday created two coils by wrapping nichrome wires on an iron ring. When he supplied electric current to one of the coils, he found that the current flow instantaneously in the other coil, as well (in 1831).

Faraday's Apparatus (Narika)

5. Experiment with Electromagnetic Induction 2

1. Purpose of the Experiment:

To confirm Faraday's experiment with electromagnetic induction by using coils, magnet and Galvanometer.

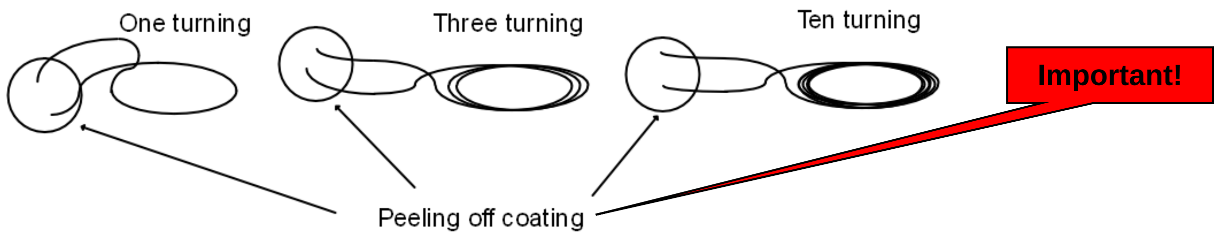
2. What to prepare:

*Galvanometer GM-6000: 1 pc (Narika A05-7120)
*Alnico Bar Magnet: 1 pc (Narika B10-3090-01)
*Enamel Cable: Adequate dose (Narika P70-2251-04)
*Cable with clips (red and black):1 pc (Narika B10-6503)

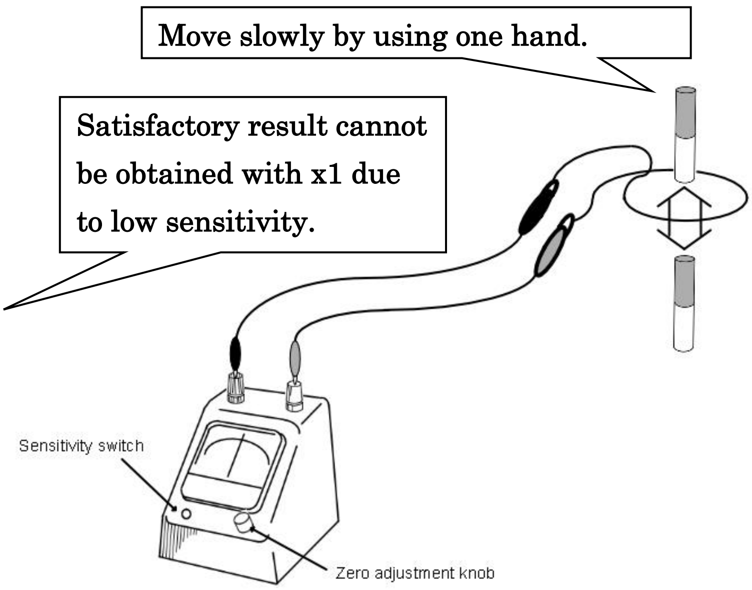
Galvanometer GM-6000
(Narika A05-7120)

3. Experiment 1: ~Electromagnetic Induction caused by taking in/out magnet ~

1) Make 3 coils (solenoids) by using of enamel wire, 1 turning, 3 turnings and 10 turnings.
2) Rub off with sandpaper enamel coating on the pointed ends of each coil until you will see metallic copper.



3) Connect two cables with clips to metallic copper part of coil cables by pinching them (as shown on drawing on the right).
4) Connect the other edge of the two cables with clips to terminals on Galvanometer GM-6000 in accordance with the colors on the terminals (red to red and black to black).
5) <u>Change the sensitivity switch on Galvanometer GM-6000 to 1000x position.</u>
6) Hold coil with 1 turning in one hand and insert Alnico bar magnet in and out of the center of the coil.
7) Record in the table below the

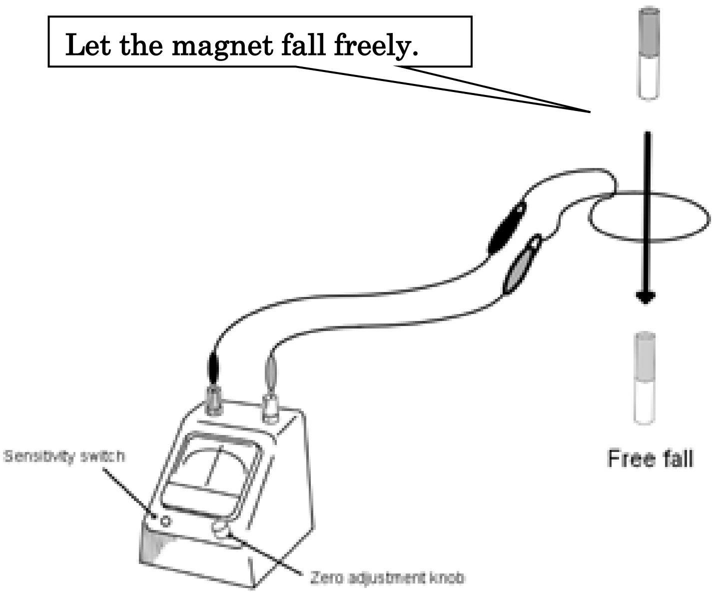


maximum and instantaneous value shown by the needle on Galvanometer GM-6000 during the course of action.

8) Change the coil with one turning for another and repeat steps 6 and 7 to fill in the blanks of the table below.

4. Experiment 2: Electromagnetic induction by falling magnet

1) Use coils created in experiment 1.
2) Follow the steps 2 to 5 from experiment 1.
3) Hold coil with one turning in one hand and drop through the center of the coil Alnico bar magnet, at the same time swiftly move the hand beneath the coil to catch it.
4) Record in the table below the maximum and instantaneous value shown by the needle on Galvanometer GM-6000 at that time.
5) Change the coil with one turning for another and repeat steps 3 and 4 to fill in the blanks of the table below.



6. Summary of the Experiments

In the table below record the value of the needle on Galvanometer GM-6000 for each case (there is no name of the unit in the value of the needle).

Record table：Results of experiments

Experiment	Value of the needle on Galvanometer GM-6000		
	1 turning coil	3 turnings coil	10 turnings coil
Experiment 1	**Three scales (divisions)**	**5~7 scales (divisions)**	**10~15 scales (divisions)**
Experiment 2	**4 scales (divisions)**	**6~10 scales (divisions)**	**15~20 scales (divisions)**

<u>1. Depending on the number of turnings of coil, how much did the needle of Galvanometer deflected</u>?

Largely (more) deflected = **<u>10 turnings</u>** ＞ **<u>3 turnings</u>** ＞ **<u>1 turning</u>** = Slightly (less) deflected

2. Compare the amplitude of deflected needle of the Galvanometer between Experiment 1 and 2. Write down to the underline space > < accordingly.

Experiment 1 < Experiment 2

3. From the results of experiment 1 and 2, explain below the electromagnetic induction.

According to the results of experiment, acceptable explanations would be as follows:

1) According to the result of Experiment 1 and 2, we can tell that the needle deflection of Galvanometer occurs when a magnet is brought near the wire, while the needle deflection of Galvanometer to the other direction occurs when a magnet is brought away from the wire.

2) According to above 1), we can tell the needle deflection of Galvanometer occurs when the pole (S/N) of a magnet is brought near/away from the wire determines the direction of the needle deflection of Galvanometer.

3) According to comparison of the results of Experiment 1 and 2, we can tell that if a magnet goes through wire faster, needle of Galvanometer deflects more (indicating larger divisions), since the needle of Experiment 2 deflected more than that of Experiment 1.

According to comparison of the results of Experiment 1 and 2, we can tell that if a magnet goes through wire of more turnings, then needle of Galvanometer deflects more (indicating larger divisions). This means a coil with more wire turnings seems to generate more (larger) needle deflection of Galvanometer.

CAUTION!!!

Height of point where you release the magnet matters when you make the Experiment 2 (A magnet free fall). Hence, if significant difference is not shown, it means the height is too low.

Be sure to place cushion at the magnet landing site as the fallen magnet might be damaged, if it was dropped from sufficiently high point, on the ground or even damage table.