Generating Magnetic Field by Electric Current 1

Oersted's Experiment

NaRiKa Corporation

Oersted's Experiment

1. Learning Outcome

While experiments on Electric Current and Magnetic Field are normally done by using dry cell batteries or electric power-supply units, we are going to use the hand-held generator "(Narika) Genecon V3" in this Unit. 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 H. C. Oersted through their hands-on experience.

2. Historical Background

Unlike dynamics, study on Electromagnetism is believed to have remained less-advanced due to its nature of handling with invisible events. Up until W. Gilbert (1544 - 1603, UK) reported his study in 1600, no major study report had been made public for 2200 years ever since Thales of Miletus of ancient Greece recognized the electrostatic phenomenon of attracting dust or feather when rubbing amber with fur in 600 B.C. In 1800, which is 200 years after the Gilbert's report, A.Volta (1745 - 1827, Italy) invented battery (known as the "Voltaic Cell"), which means it took 200 years for the transition from the study on static electricity to dynamic electricity.

W. Gilbert

http://es.wikipedia.org/wiki/

William Gilbert

A. Volta

http://en.wikipedia.org/wiki/

Alessandro_Volta

Voltaic Cell was used by many researchers for its capability of generating large amount of electric current at low voltage. Notable study was made by H. C. Oersted (1777 - 1851, Denmark) when he discovered that compass needle should deflect near a lead carrying current, which was made public as article named "Interaction of Current and Magnetism" in 1820.

It is commonly believed that A. M. Ampere made public his theory of Electricity and Magnetism in the same year, because he was deeply impressed with Oersted's report then, established basis of Electrodynamics. Hence, in this Unit, we will focus on replicating the experiment of H. C. Oersted, who is assumed to be the father of Electrodynamics and Electromagnetism, which is meaningful nowadays even for us.

3. Introduction of Equipment for Experiments

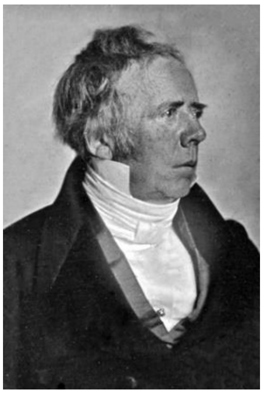
Genecon V3 is a product name of hand-held power generator manufactured by Narika Corporation. Up to 3V DC electricity can be generated just by turning the handle, hence the user realizes how he/she is generating electric

power in person. Since Genecon V3 generates only up to 3V, it highly unlikely damage accessories used for experiment at schools like miniature bulbs, LED lamps, electric musical (melody) boxes, and others. Also, it replaces dry cell batteries used for experiment like lighting miniature bulbs/LEDs, electrically heated wire, or others.

Mechanism of Genecon V3 is quite simple, consisting of the motor inside for generating power, which should leave almost no room for students to misunderstand the relationship/function of internal motor, gears, shafts and handle due to its perfect visibility through the transplant body. For teachers, Genecon V3 significantly helps their explanation to students regarding the fact that motor and generator are identical.

4. Oersted's Experiment

1. Formation of Magnetic Field by Eletric Current ~H. C. Oersted~



http://en.wikipedia.org/wiki/

Hans_Christian_ Ørsted

Only after the discoveries of static electricity related research by W. Gilbert made in 1600, L. Galvani discovery of bioelectric in 1791, and A. Volta's discovery of battery in 1800, further research activities on low voltage and high current electricity took place one after another.

Danish H. C. Oersted (Ørsted) discovered in 1820 that electric current generates magnetic field (interaction of current and magnetism). It is said that, by this discovery, A. M. Ampere was able to reach a stage where he could publish his theory of electricity and magnetism, establishing the modern days theory of electrodynamics.

In this Unit, we will perform the experiment of generation of magnetic field by current experiment done by H. C. Oersted, who contributed greatly to the development of electricity, to understand basic behavior of electric current.

2. Oersted's Experiment

1. Purpose of the experiment:

Purpose of this experiment is, by using dry cell battery, Genecon V3 and magnetic compass, to confirm that generation of magnetic field depends on electric current flowing through cable.

2. What to Prepare:

*Genecon V3: 1 pc (Narika B10-2634)
*Oil-filled Magnetic Compass: 1 pc (Narika B10-3570)
*Miniature Bulb Holder with Leads: 1 pc (Narika P70-0395-01)
*Dry cell battery (AA type): 1 pc (Narika P70-0719-03, 20pcs)
*Battery box with switch: 1 pc
*Cable with clips (red and black): 1 pair (Narika B10-6503)

Genecon V3

3. Experiment 1: Experiment using Dry cell batteries

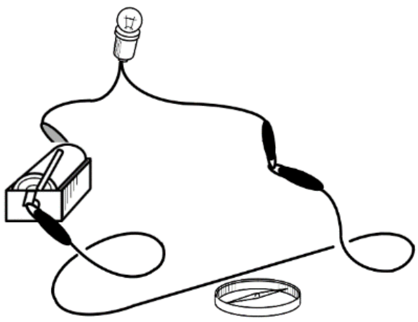
1) Place wooden plate on the table.

2) On the wooden plate, set a battery box with switch and put inside prepared dry cell battery.

3) Create electric circuit by connecting: a miniature bulb holder with cable, a cable with clips and terminals of battery box together like in the drawing on the right. Keep the battery box switched off.

4) Place an oil-filled magnetic compass about 1 cm away from the cable.

Tips: Make sure to set the compass needle and cable in parallel.



5) Switch on the battery box. Check the deflection of the compass needle caused by the electric current and write it down.

6) Change polarity of the battery in step 2, repeat steps 3-5, and check the change in the deflection of the compass needle caused by electric current and write it down too.

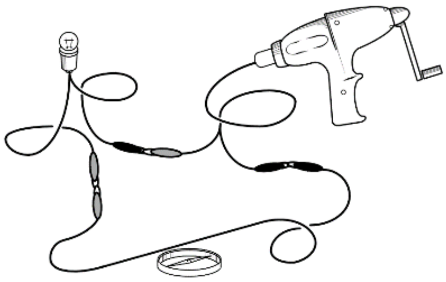
7) Switch off the battery box.

4. Experiment 2: Experiment using Genecon V3

1) Place wooden plate on the table.

2) On the wooden plate, connect a "miniature bulb holder with cable" and "cable with clips" with a Genecon V3.

3) Place an oil-filled magnetic compass about 1 cm away from the cable. Tips: Make sure to set the compass needle and cable in parallel.



4) Turn the handle of Genecon V3. Check the deflection of the compass needle caused by the electric current and write it down.

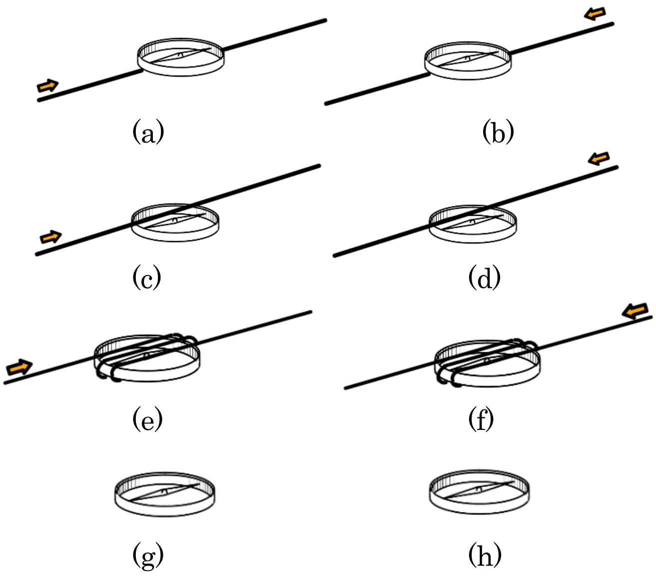
5) Change the direction of turning the handle. Check the change in the deflection of the compass needle caused by electric current and write it down too.

5. Experiment 3: Experiment with different place setting of magnetic compass

1) During experiments 1 and 2, we placed compass about 1 cm away from cable, but now let's change the place where we put compass and conduct experiments.

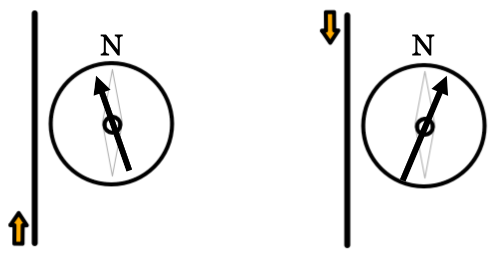
2) Perform experiments 1 or 2 with compass placed in positions as shown on drawings below (a) to (f). For drawings (g) and (h), think about suitable position by yourself and do the experiment.

3) Verify every pattern of deflection of compass needle caused by electric current per experiment condition and write it down.



5. Summary of Oersted Experiment

1. Results of Experiment 1 and Experiment 2



[What you should find out:]
In case the North pole is placed "Up" (further from where the experimenter stands), the direction of the needle deflection differs depending on the direction current flows. In case of (1), North pole is attracted toward the cable,

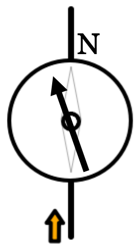
which means the cable assumed the properties of the South pole affected by the influence of current flow.

On the other hand, in case of (2), North pole repulses the cable, which means the cable assumed the properties of the North pole affected by the influence of current flow.

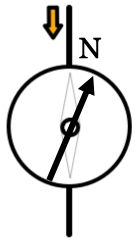
1. Result of Experiment 3

[What you should find out:]
By comparing the result of "Experiment1 or 2" and "Experiment 3", you will realize that three of the patterns (1), (a) and (c) have the same condition in terms of the direction of current flow, while they have different condition in terms of the position of compass. In case of the pattern (a), setting the compass on the cable, the needle of the compass will be deflected to the right.

In case of the pattern (c), setting the compass beneath the cable, the needle will be deflected to the right. In case of the pattern (1), setting the compass on the right side of the cable, the needle will be deflected to the left. From these results, magnetic field that affects the compass seems to be generated around the cable when current is carried.

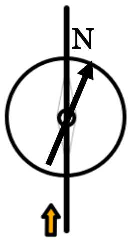


(a)

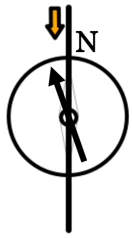


(b)

Likewise, you will realize that three of the patterns (2), (b) and (d) have the same condition in terms of the direction of current flow (opposite to above), while they have different condition in terms of the position of compass. If comparing with above, you will know the direction of magnetic field changes depending on the direction of current carried in the cable.



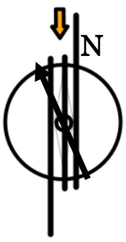
(c)



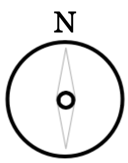
(d)

In case of pattern (e) and (f), the cable is coiled around the compass in solenoidal manner. According to the results, you will know the left side of the solenoid turned South pole in case of (e), while the right side of the solenoid turned South pole in case of (f), which means the direction of current flow determines North/South pole beside solenoid coil.

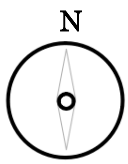
(e)



(f)



(g)



(h)

Advanced interpretation based on "Ampere's law" (Right-hand grip rule) might be effective for students' better understanding, while it is true that figuring out the whole magnetic field generated around the cable is tough for many of the students in the above experiments. It is recommended that you should introduce the "Ampere's law" only when some students have already learned it.

Hence, the learning outcome should be:

1. Magnetic field sufficient to affect compass is generated around the cable by the current flow carried in the cable.
2. If the direction of current flow is switched to the opposite, magnetic field, which is opposite to above, is generated around the cable by the current flow carried in the cable.
3. Degree of needle deflection differs depending on the amount of current carried in the cable.

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