MODULE 06

MAGNETIC FIELD INDUCTION AND DC ELECTRIC MOTOR

1. EXPERIMENT AIM

1.1 Determine the distribution of magnetic field values between two magnetic poles,
1.2 Determine the effect of changes in the input voltage on the angular speed of rotation produced by the electric motor,
1.3 Determine the efficiency of the electric motor.

2. EXPERIMENT APARATUS

2.1 Electric Motor (1 set)
2.2 DC Power Supply (1 piece)
2.3 Ruler (1 piece)
2.4 Computer with Logger Pro App (1 set)
2.5 Amperemeter (1 piece)
2.6 Labquest mini (1 piece)
2.7 Photogate (1 piece)
2.8 Gaussmeter (1 piece)
2.9 Banana-Clamp Cable (2 pieces)
2.10 Banana-Banana Cable (1 piece)
2.11 Coil (1 piece)

3. TEORI DASAR

An electric motor is a device that can convert electrical energy into mechanical energy. One of the electric motors used is a DC electric motor which requires a direct voltage supply to the field coil to be converted into mechanical energy. The mechanical energy produced is in the form of rotational motion of the coil wire. The DC motor schematic is shown in Figure 6.1 below.

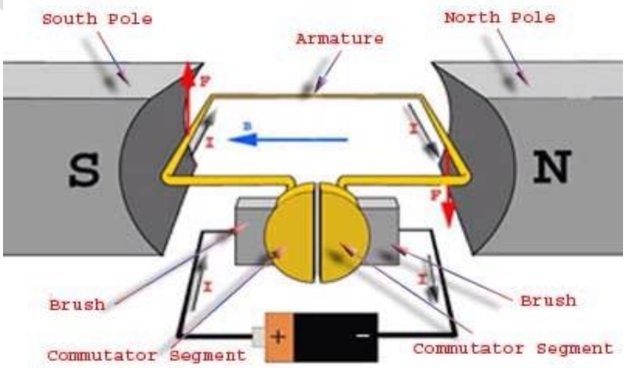

Figure 6.1. Simple DC Motor Basic Schematic.

In the schematic above, the motor rotor is schematized with an armature that forms a rectangle. The motor stator is composed of two magnets with different poles facing each other, where the direction of the magnetic field is from the north pole to the south pole. The DC voltage source is illustrated with the battery image in the DC motor schematic above. Each pole of the battery is connected to a carbon brush (brush), so that a DC electric current is created with the current direction from the positive to the negative pole as in the picture above

In a DC motor, a wire in a magnetic field when an electric current flows through it will cause a force whose direction is perpendicular to the direction of the electric current flow and the direction of the magnetic field. Mathematically it can be written as follows:

$$\vec{F} = i\vec{L}\ x\ \vec{B} \tag{6.1}$$

Theoretically, the magnitude of the magnetic torque generated on the wire due to electric current and magnetic fields is as follows:

$$\vec{\tau} = \vec{r}\ x\ \vec{F} \tag{6.2}$$

The direction of the force and the working principle of a DC motor will be explained more easily by the illustration in Figure 6.2 below:

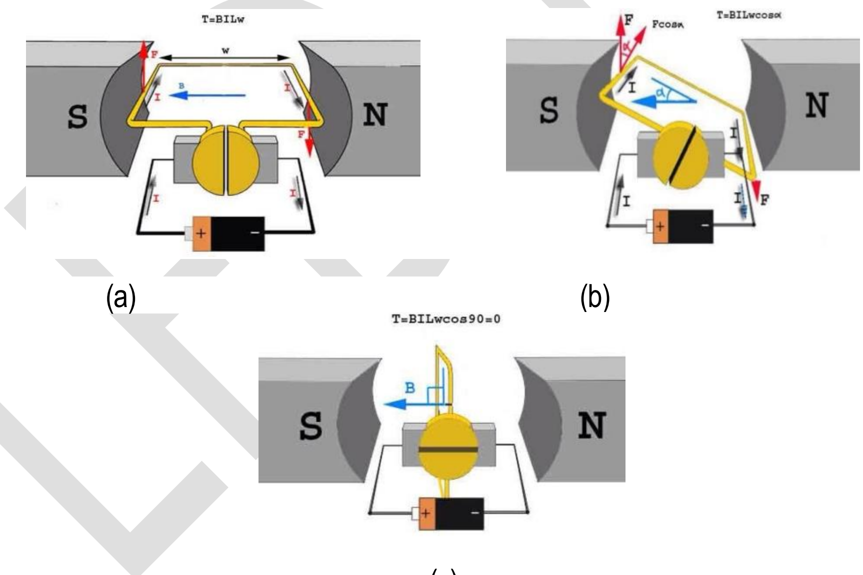

Figure 6.2. (a) when the conducting wire is parallel to the direction of the magnetic field
(b) when the conducting wire with the direction of the magnetic field makes an angle
(c) when the conducting wire is perpendicular to the direction of the magnetic field.

If there are more than one coil in the rotor, in general the magnetic torque for a coil consisting of N turns of wire is:

$$\tau = NBiA \tag{6.3}$$

On the other hand, the torque on the loop is related to the angular acceleration and the moment of inertia of the loop as:

$$\tau = I\alpha \tag{6.4}$$

where I is the moment of inertia of the loop and is the angular acceleration of the coil with respect to the change in the angular velocity of the coil with time. For the assumption of as the average angular acceleration of the coil, then:

$$\alpha = \frac{wt - wo}{t} \tag{6.5}$$

where wo = 0 if the coil is initially at rest.

The efficiency of an electric motor can be calculated from the ratio between the mechanical output power produced and the electrical input power:

$$\eta = \frac{Pout}{Pin}\ x\ 100\% \tag{6.6}$$

Where $P_{out} = \tau\omega$, $P_{in} = VI_{in}$ and I_{in} are the input current values, each in SI units (J/s). It is important to note, that the value of the input current (I_{in}) is not the same as the value of the current flowing in the circuit (coil) when the electric motor is running (I) due to the emergence of the phenomenon of magnetic induction.

4. EXERCISE

4.1 Explain how the magnetic field lines of force differ in the area between the two magnetic poles when the two magnetic poles are the same and different types!

4.2 Explain the right-hand rule to determine the direction of the force due to electric current in a magnetic field!

4.3 Briefly explain the difference in the magnitude of the torque value when the conducting wire is parallel to the magnetic field and when the conducting wire is perpendicular to the magnetic field!

5. PROCEDURE

5.1. The Magnetic Field around the Two Poles is different from the Disc Magnet

1. Arrange the disc magnets with the two opposite poles separated by a distance of about 10 cm,
2. Record the value of the magnetic field between the two poles of the disc magnet using a Gaussmeter for several positions or observation distances, each at the center and side of the disc magnet. Record the observations in Table 6.1.

Table 6.1. Magnetic field.

Position (x,y)	B (mT)
(0, 0)	
(0, 2)	
(0, -2)	
(2, 0)	
(-2, 0)	

Where the coordinates (x , y) follow the Cartesian coordinates as follows:

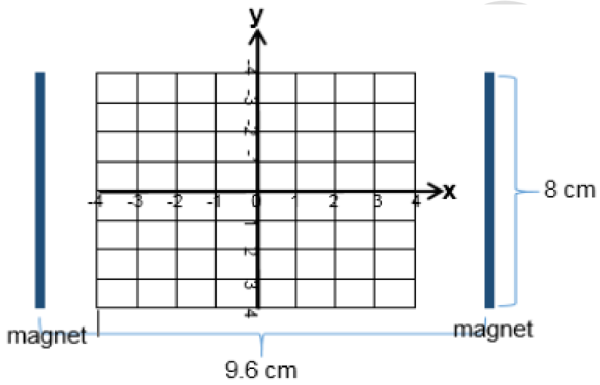

Figure 6.3. Illustration of the coordinates of the magnetic field measurement position.

5.2. Magnetic Torque (Electric Motor)

1. Take a loop or coil of wire. Measure the dimensions of length and width, number of turns and mass. Record the data in Table 6.2.

Table 6.2. Coil wire dimensions.

Parameter	Value	Unit
N		coil
P		cm
L		cm
Mass		gram

2. Attach the coil to the electric motor set.
3. Apply force to check the coil rotation (make sure the coil can rotate without resistance).
4. Connect the power supply, ammeter and electric motor set so that it becomes a series circuit.
5. Install the photogate, make sure the photogate can detect the coil rotation.
6. Turn on the power supply.
7. Retrieve the electric motor rotation data using the Logger Pro application and set the total data retrieval time to 20 seconds.

8. Measure the value of the current using the Ammeter during rotation. Record in Table 6.3.
9. Repeat the experiment for variations in the amount of current and the type of coil (square and circle).

Table 6.3. Magnetic torque.

V (volt)	I (A)	n	f (hz)	ω (rad/s)	τ (N)	P_{in} (watt)	P_{out} (watt)	η (%)

6. ANALYSIS

6.1 Explain why the magnetic field B is not constant between the two poles?

6.2 Explain why the input current (Iin) is not the same as the current flowing in the circuit (coil) when the electric motor is running (I)?

6.3 Explain how the effect of efficiency (η) on the input current (Iin)?

6.4 Why is the alternating rotation of the coil observed?

7. REFERENCES

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