Electromagnetic Induction

Purpose

Using “Borderless Lab 365” platform to study the effects of (1) magnet thickness (magnetic field strength), (2) number of coil turn and (3) rotation speed on the produced electromotive force.

Theory

- Electromagnetic induction is the production of an electromotive force (emf) across a conductor in a changing magnetic field.

- According to **Faraday’s law** $\varepsilon = -\frac{d\varphi}{dt}$ (ε is the induced emf and ϕ is the magnetic flux enclosed by the circuit), the induced emf in any closed circuit is equal to the rate of change of the magnetic flux enclosed by the circuit. Faraday's law of induction makes use of the concept of using magnetic flux through a region of space enclosed by a wire loop.

- Magnetic field is existed between two pieces of magnet. Magnetic field lines are a visual tool used to represent the magnetic fields. It always runs from North to South (as shown in Fig. 1). When a coil (or conducting surface) is inserted into the magnetic field, magnetic flux will be generated. By definition, magnetic flux through a surface is the surface integral of the normal component of the magnetic field over that surface. In this experiment, the configuration of the magnet and coil is shown in Fig. 2.

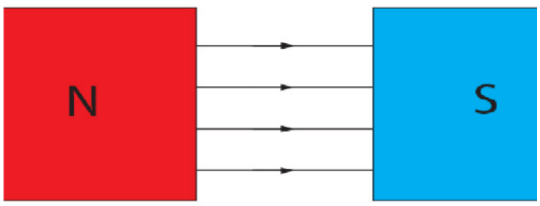

Fig. 1

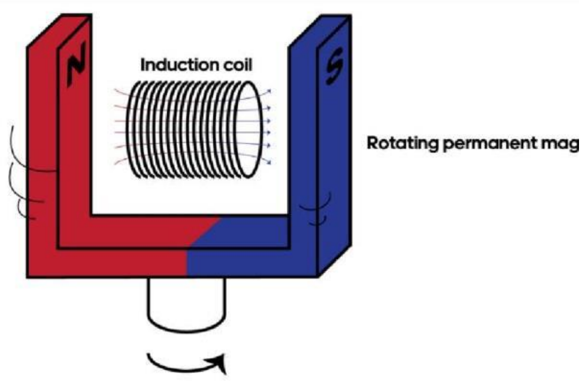

Fig. 2

- The magnitude of the induced emf varies with the cutting angle between the coil and the magnetic field lines. For example, when the coil is parallel to the magnetic field lines (as shown in Fig. 2). The magnetic flux is maximum and the rate of change of the magnetic flux momentarily will be zero. Thus, the induced emf at this position = 0.

- Generating an emf through a variation of the magnetic flux through the surface of a wire loop can be achieved in several ways:
  - A) the magnetic field changes (e.g. an alternating magnetic field, or moving a wire loop towards a bar magnet where the magnetic field is stronger),
  - B) the wire loop is deformed and the surface changes,
  - C) the orientation of the surface changes (e.g. spinning a wire loop into a fixed magnetic field),
  - D) any combination of the above

- In this experiment, the magnitude of the induced emf will be depended on the rotation speed of the magnet, the strength of the magnet and the turns of the coil.

- The magnetic induction can be applied in electric applications, such as generator and electric motor.

Apparatus

- "Borderless Lab 365" Platform
- Magnets with three difference thickness: 2mm/ 3mm/ 5mm
- Coil with different turns: 100/ 200/ 300 (turns)
- Motor that provide Rotation speed with different rpm (rotation per minute): 30-300 (rpm)

Procedure

1. Log in the experiment module "EM induction" on the Borderless Lab 365 platform. https://labxra.edu.hk/remotelab/
2. Choose magnet thickness, coil turns and rotational speed by pressing corresponding button.
3. Press "MEASURE" to record the emf. produced by the coil.
4. Result is shown in the graph, find the peak emf.
5. Download the graph by clicking "Menu" and choose a format (.svg, .png, .csv).

6. Repeat step 2 to 4 under different condition, select 3 different rotation speed and complete the tables.
7. Press "LOGOUT" when you complete the experiment.

Data

Thickness: ______________________ mm

Coil turns: ______________________ turns

Rotational Speed: ______________________ rpm

Sketch the waveform of the emf produced by the coil

Period: ______________________ ms

Max. voltage: ______________________ mV

Rotational Speed ω_1: ______________________ rpm

Rotational Speed ω_2: ______________________ rpm

Rotational Speed ω_3: ______________________ rpm

<u>Thickness of magnet = 2mm</u>

	ω_1(rpm)	ω_2(rpm)	ω_3(rpm)
100 Turns	mV	mV	mV
200 Turns	mV	mV	mV
300 Turns	mV	mV	mV

Thickness of magnet = 3mm

	ω_1(rpm)	ω_2(rpm)	ω_3(rpm)
100 Turns	mV	mV	mV
200 Turns	mV	mV	mV
300 Turns	mV	mV	mV

Thickness of magnet = 5mm

	ω_1(rpm)	ω_2(rpm)	ω_3(rpm)
100 Turns	mV	mV	mV
200 Turns	mV	mV	mV
300 Turns	mV	mV	mV

Discussion

1. Find out how the induced emf is affected if
   a. Rotational magnet is moved with a higher speed,
   b. Stronger magnets are used,
   c. Coil with more number of turns is used.

2. Write down the energy conversion involved in the experiment.

3. If the coil is an incomplete circuit, is there any induced emf or induced current in the coil when the magnet rotating?

4. What are the possible errors of the experiment?

5. Please explain what addition parameter(s) of the experiment is needed to determine the magnitude of the magnetic field.

6. Find the rotational speed from the waveform in one of the cases, is there any error with the theoretical value?