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ACADEMIC COACHING

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PHYSICS

Module 6

ELECTROMAGNETISM

STUDENT BOOKLET

Theory covered:

4. Electromagnetic Induction
   - 4.1. Magnetic Flux
   - 4.2. Faraday's Law
   - 4.3. Lenz's Law
   - 4.4. Eddy Currents
   - 4.5. Electromagnetic braking

YEAR 12

Name:

Class:

Booklet 4: Electromagnetic Induction Summary

Magnetic Flux Formula:

$$\phi = B_{//}A = BAcos\theta$$

Electromagnetic Induction:

Faraday's Law (Magnitude): *A change in magnetic flux will induce an EMF and hence induce a current.*

$$\varepsilon = -n\frac{\Delta\emptyset}{\Delta t} = -n\frac{\Delta(BAcos\theta)}{\Delta t}$$

Lenz's Law (Direction): *The induced EMF will always give rise to current whose magnetic field will oppose the original change in flux.*

Rule to determine the induced current for electromagnetic induction questions is:

1) Original change in flux: Increase/decrease of field lines in which direction?
2) Oppose the change: Flip the change in flux and chase 'increase'
3) Right Hand Grip Rule

Eddy Currents:

- Eddy currents: Induced currents specifically in metal sheets/plates.
- Eddy currents produce heat energy to abide by LOCOE.

Reducing Eddy Currents:

- To reduce eddy currents, slits are cut in metal to introduce electrical discontinuity.

Comparing electromagnetic braking to mechanical braking:

- Advantages: Smooth braking effect which is proportional to $\frac{\Delta\emptyset}{\Delta t}$.
- Disadvantages: Poor braking effect at little to no speed which still requires mechanical braking.

Introduction

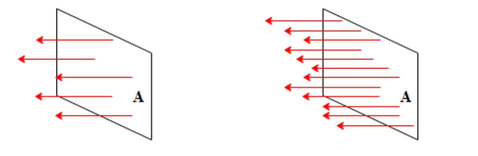
- **Electromagnetic induction** is the concept of how electricity can be induced or created by magnets.
- However, before we understand this, we must familiarise ourselves with some new terminology.

Note: This is the most important topic of module 6!

4.1. Magnetic Flux

Introduction

- **Magnetic Flux**: The total number of magnetic field lines that passes through a specific surface area.
- This concept can be seen below:



- A higher magnetic flux indicates there are more magnetic field lines passing through a specific area and vice versa.

Magnetic Flux Formula

The magnetic flux through a surface is represented by the formula:

Where:

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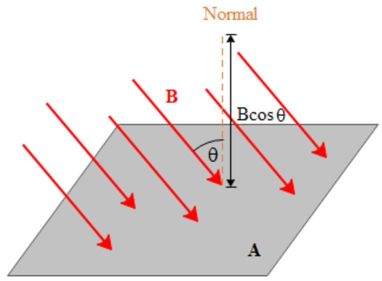
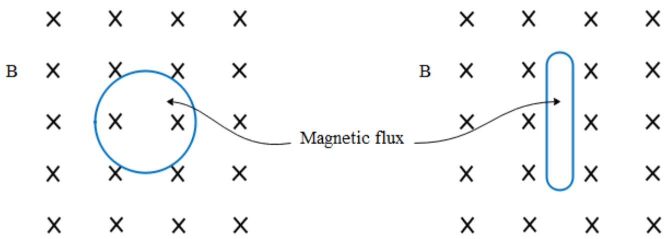


Note: The unit Wb for magnetic flux is known as *Webers*.

Magnetic Flux Density

- Another term to be aware of is magnetic flux density (Do not confuse this with magnetic flux!).
- **Magnetic flux density** is simply another term for magnetic field strength B.
- To understand the difference, consider the diagram below:



- The **magnetic flux density** for both diagrams is constant.
- However, the **magnetic flux** experienced by each area is different.

Example 1

A coil of wire has a cross-sectional area of $0.08\ m^2$. A magnetic field of 0.4T passes through the coil perpendicular to the plane of the coil. What is the total magnetic flux through the coil?

Example 2

The magnetic flux that passes through a loop is $1.25 \times 10^{-5}\ Wb$. Given that the magnetic flux density in the region is $1.25\ mT$, and field lines are directed into the area as shown below, calculate the area of the loop.

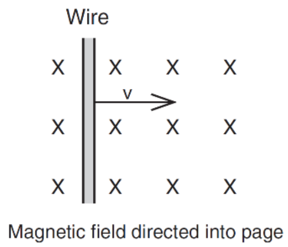
Practice Question 1

A uniform magnetic field its intensity is $30T$ pass an area of coil with 1 turn which makes a 60 angle with the coil. What is the area of the coil if the magnetic flux is 0.15 Wb?

Electromagnetic Induction - Overview

- **Electromagnetic induction** refers to the production of an induced electromotive force (EMF) via a magnetic field.
- This EMF is typically produced due to the relative motion between a conductor and a magnetic field.

- For example, moving a wire inside a magnetic field will induce an EMF.



But what is an EMF?

- EMF can be thought of as a voltage/potential difference.
- Therefore, when there is relative motion between a conductor and magnetic field, a **voltage** is INDUCED within the conductor.
- Due to $V = IR$, this also means a current is induced.
- Recall: A current carrying conductor in a magnetic field will experience a force.
- Hence, the relative motion between a conductor and magnetic field results in a voltage/current being induced which causes a force to act on the conductor.

Note: This is a general overview of electromagnetic induction. To understand this, we must understand Faraday's Law and Lenz's Law.

Key Ideas:

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