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VCE Physics Unit 4

Area Of Study 1, Electric Power, Study Notes 1

Magnets

Magnets are objects that have an attractive force towards some metals. Iron, Nickel and Cobalt are the main elementary metals attracted by magnets.

Magnets are “dipoles”. This means that all magnets have two ends (“poles”) that cannot be separated. One pole is called “North”, and the other “South”. Break a magnet into small pieces, and every piece will still have a North and a South pole. For every North pole in the universe, there’s a South pole to which it’s attached.

Magnets attract or repel other magnets:
- **opposite poles** of magnets **attract** each other, and
- **like poles** of magnets **repel** each other.

The Earth has poles because it acts like a giant magnet. Compasses indicate direction because they themselves are magnets too. The North pole of the magnet in a compass points towards the South pole of the Earth’s magnetism because they are attracted.

Induced Magnetism

Iron objects in the close vicinity of magnets become magnetised. This means they are magnets as well while in the close vicinity of a “permanent” magnet.

Induced magnetism occurs because the “dipoles” that make up an iron object become aligned. When all the dipoles are aligned, the whole object becomes dipolar, and hence magnetic.

“Soft” iron objects are only temporarily magnetised. Their magnetism only exists while in the close vicinity of a another magnet. The dipoles that make up the object return to their original orientation when removed from another magnet.

“Hard” iron objects become permanently magnetised. Their magnetism remains after they are no longer in the close vicinity of another magnet. The dipoles that make up the object stay aligned when removed from another magnet.

Magnetic Fields

A magnetic field is the area around a magnet within which the magnetic effects are observable.

Magnetic **field lines** diagrammatically represent magnetic fields as arrows. The arrows point in the direction of the force that would be experienced by a North magnetic pole at any particular point in space. So, because North poles are repelled by other North poles, and attracted to South poles, magnetic field lines always point **from North to South**.

Magnetic Flux Density

This is a vector quantity being the magnitude (strength) and direction of a magnetic field. The magnitude of magnetic **flux density** is proportional to the number of field lines per unit of area. The direction is represented as described above (under the heading “Magnetic Fields”).

As the field lines per unit area is dense near a magnet, and sparse far away, it should make sense that flux density, and hence magnetic field strength, is **high near** a magnet and **low far away**.

$\vec{B}$ represents flux density, and is measured in Tesla, T.

Magnetic Flux

This is the flux density acting across a unit of area, or the area affected by or experiencing a quantity of flux density. Magnetic flux is hence the product of flux density and the amount of area across which it is considered.

The difference between **flux density** and **flux**:
- **flux density** considers the entire field strength (at some point in space around a magnet), and
- **flux** considers the **flux density** across a **specific amount of area**.

So:

$$\phi_B = BA\cos\theta$$

Where: ϕ_B = magnetic flux, in Weber, Wb
$\vec{B}$ = magnetic flux density (magnetic field strength), in T
A = area (across which $\vec{B}$ is considered), in m^2
θ = angle between the direction of the magnetic field and the normal to the area, in degrees

ϕ_B represents flux, and is measured in Weber, Wb:
- $1\text{Wb} = 1\text{Tm}^2$ or $1\text{T} = 1\text{Wbm}^{-2}$

When the direction of the magnetic field is perpendicular to the area it affects, θ = zero, and $\cos\theta = 1$, so the above formula can be simplified to:

$$\phi_B = BA$$