Ngā Whetū Resources

Physics Year 13 (Level 8)

Summary Magnetism

A **mass** sets up a **gravity** field → Force on a mass
A **charge** sets up an **Electric** Field → Force on charged particle
A **Magnet** or **Electric Current** set up a **Magnetic** Field → Force on conductor or magnetic materials

Revise last year's chapter on Magnetism

$F = BIL$ Force on conductor carrying current

$F = Bqv$ Force on charge moving with speed *v*

$V = BvL$ Generated Voltage

Right hand rule to determine direction of field line from direction of current or direction of current from direction of field lines.

Magnetic Field

Field lines indicate direction of flow from *North* to *South* pole.
Coil or *Solenoid* increases magnetic field. Inside the coil the magnetic field is *Uniform* (parallel field lines). (Compare with E-field inside capacitior).

Electromagnetic Induction

- A current produces a magnetic field around the conductor.
- In a conductor which moves in a Magnetic Field, a current will be induced.

Magnetic Flux

The amount of *Flux* through a coil relates to Field Strength and Area of coil: $\Phi = BA$;
Φ is Flux (Wb (Weber)), B Magnetic Field Strength (T (Tessla)), A is Area of coil.

Faraday's Law

$V = \dfrac{\Delta\Phi}{\Delta t}$ Induced Voltage relates to *Change of Flux*

The amount of flux produced in a coil is proportional with the current flowing: $\Phi = LI$
where L is the inductance (unit H (Henri)). (Compare this with $Q = CV$ in a capacitor).

So Faraday's law can also be stated as $V = L\dfrac{\Delta I}{\Delta t}$.

Induced Voltage relates to *Change in Current*.

Electric Generator

Flux:	$\Phi = BNA\sin\alpha$	$\Phi_{max} = BNA$ for $\alpha = 90^o$
Voltage:	$V = BNA\omega\cos\alpha$	$V_{max} = BNA\omega$ for $\alpha = 0^o$

Lenz's Law
The induced current in a coil will produce its own magnetic field. This second Magnetic Field will *oppose* the original field (Energy Conservation principle). The direction of the field lines of both fields will be opposite.
With this principle you can determine the direction of the induced current (right hand rule).
Electromagnetic Brakes work according to this principle. The induced current is transformed into heat.

Current growth in an Inductor
When a voltage is set up across an inductor, the inductor will need a short time to create the magnetic field. This growing magnetic field will create a voltage in the opposite direction. The initial current will be slowed down (exponential growth curve). The opposite happens when the power is switched off (exponential decay).

When the power is switched off, the energy of the magnetic field must be released in a very short time. This creates a *spark* across the switch when switching off. (Example: a car's ignition system).

Energy stored in an inductor
$E_{ind} = \frac{1}{2}LI^2$ (compare with $E_{cap} = \frac{1}{2}CV^2$)

Transformer
$\frac{V_{Secondary}}{V_{\text{Primary}}} = \frac{\#\,\text{secondary}\,turns}{\#\,primary\,turns}$, Voltage can be scaled *up* or scaled *down*.
Transformers only work with AC because flux must *change* to create induction.
Total amount of Electric Power remains the same (if no loss): $(VxI)_{primary} = (VxI)_{\text{secondary}}$. Therefore if Voltage is scaled down, current will go up, etc.

Faraday's law for a Transformer
$$V_{primary} = L_{primary}\frac{\Delta I_{primary}}{\Delta t}$$
$V_{\text{secondary}} = M\frac{\Delta I_{primary}}{\Delta t}$, M is *Mutual Inductance* (unit H) of the transformer coils.

Summary of new Units in this Chapter

Quantity	Symbol	Unit name	Unit symbol
Magnetic Field Strength	B	Tessla	T
Flux	Φ	Weber	Wb
Inductance	L	Henry	H