

## All About Electricity

A practical tour of  
Unit 1 study 2  
&  
Unit 4 study1

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You've read the book

Now see the actual apparatus

## Electricity: What is it?

### Electrostatics

The ancient Greeks discovered that rubbing amber (fossilised tree resin) produced some strange results

**Amber** : The Greek name for amber was  $\eta\lambda\epsilon\kappa\tau\rho\nu$  (electron). It is discussed by Theophrastus, possibly the first ever mention of the material in the 4th century BC.

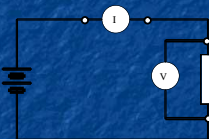
## Electrostatics

- We understand today that these properties are due to the movement of elementary particles (the electron).
- Spooky Action at a distance
- Conductors and insulators
- Tribo-electric series

### It takes work to separate electrons from atoms

- Once the separation of charge has been accomplished the system has the **potential** to do work
- We saw this potential to do work when the amber was able to pick up the pieces of styrofoam
- A battery separates charge chemically and has the same potential to do work (but better)
- A battery is able to move charge around a circuit= current

## Ohms Law



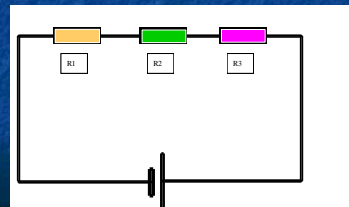
$$V = RI$$

- Linear relation between applied voltage and current
- Notice Voltmeter is applied across measuring point
- Ammeter must be inserted into a break in the circuit
- **NB: The Voltage and Current must relate to the same circuit element**

## Series Circuit

$$R = R_1 + R_2 + R_3$$

- Traffic Model
- Number of cars per sec is the current



## Ohms law

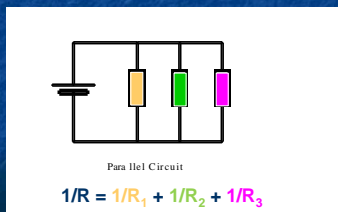
- Series circuit
- Current indicated by strength of glow
- Demo globes in series

## The simplest series circuit

- 10 Volt supply and 10 ohm resistor
- Ohms law tells us the current is 1 A
- 3 resistors all 10 ohm
- Power =  $VI = I^2R$
- Demo two resistors

## Parallel circuits

- Traffic Model again



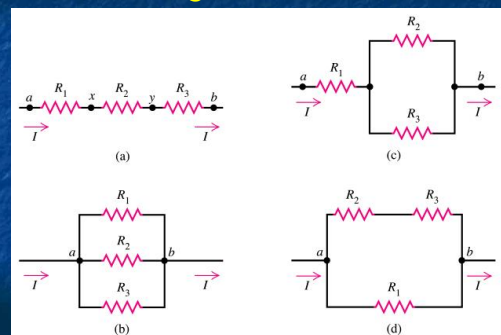
## Parallel circuits

- NB: Independent circuits
- The current in each arm of a circuit can be calculated independently of other arms
- The current in each arm contributes to the total current flowing in the circuit

## Parallel circuits

- Demo board
- Voltage across each parallel arm equal
- Compare with a series circuit

## Solving DC circuits



## Series and Parallel circuits

Janelle now adds a third resistor,  $R_3 = 20\ \Omega$ , as shown in Figure 2.

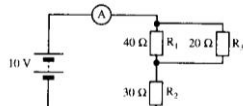


Figure 2

Question 3

What is the current through the ammeter A now?

## Magnetic Field

- Needle stroked with a loadstone becomes a magnet
- Spooky Action at a distance again

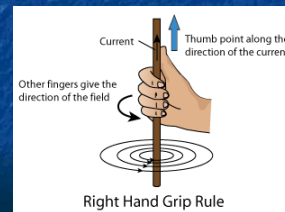


## But where did the magnetic field come from?

- Oersted's experiment 1820
- First demonstration of relationship between electricity and magnetism
- Demo Ohd
- RH Grip rule

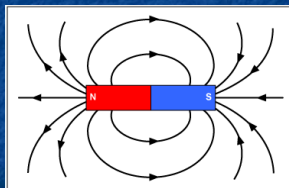
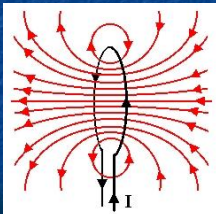
## The Magnetic Field

- Demo lattice model etc
- Magnetic field around a wire
- Magnetic field around a solenoid



## The Magnetic Field

Useful to remember that a current carrying loop is equivalent to a bar magnet



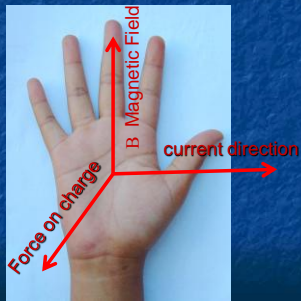
## Force on a constant current in a magnetic field

Due to force on electrons





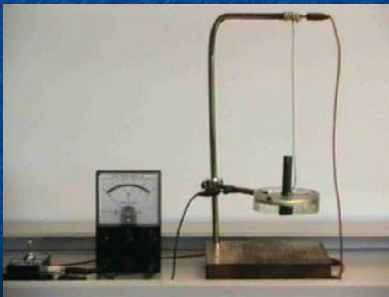
## Right hand slap rule



## Force on current in B field



## Faraday's Motor The worlds first



## Barlows wheel



## Fields and Flux

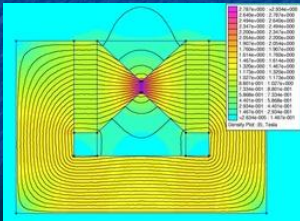
- The concept of a field (Faraday)
- Faraday had a geometric view of the world
- Magnets did something to space
- Currents (electrons) interacted with this modified space
- This overcome the problem of spooky action at a distance

## Magnetic Field

What is the difference between B and flux

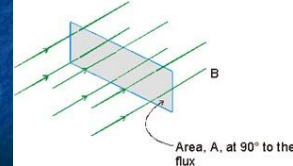
- 1 Tesla=1 Weber/square meter
- Think of the number of B lines in a unit area
- $\text{Flux}(\phi) = B \times \text{Area}$
- $= \text{Weber}$

- Magnet and Tapered Pole pieces
- Same magnet concentrates magnetic field into a smaller area

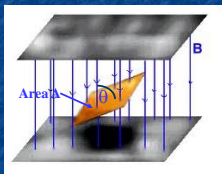


## Magnetic Field strength

- Flux  $\phi = B \times A$
- $A$  = area of coil perpendicular to Magnetic field



## Perpendicular area



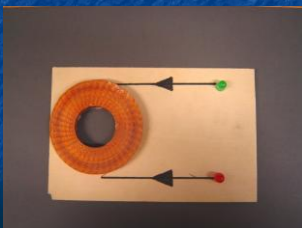
Perpendicular area =  $A \sin \theta$

## Faraday's law of induction

- ✓ Faraday reasoned that since a current could produce a magnetic field, a magnetic field should be able to produce a current. (Symmetry)
- ✓ The induced emf (voltage) occurs whenever there is a change in magnetic flux
- ✓  $\epsilon = d\phi/dt$  (where  $\phi = BA$ ) ..... Faradays law
- ✓  $\epsilon$  = change in ( $\phi$ ) per time interval  $dt$
- ✓ Faradays law above gives the magnitude of  $\epsilon$
- ✓ Lenz's Law  $\rightarrow \epsilon = -d\phi/dt$  gives the direction
- ✓ demo

## Lenz's Law

- The direction of the induced e.m.f. is that of a current whose magnetic action would neutralize or oppose the flux change.
- Coil and Magnet



## Jumping rings



## Lenz's Law

- Ring pendulum



## Eddy Currents

- A conductor in a varying magnetic field has an e.m.f. induced in it even when not in the form of a coil.
- Magnet and Aluminium pipe
- Magnets Jaycar
- Aluminium thick walled

Lenz  $\rightarrow \frac{d\phi}{dt} = -\epsilon_{ind}$



## Lenz's law

- Pipe demo
- Consider the aluminium pipe as made up of a series of single turn coils.

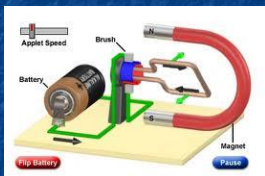
Lenz  $\rightarrow \frac{d\phi}{dt} = -\epsilon_{ind}$



## Motors and generators

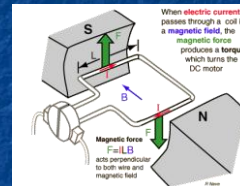
- You supply power to a motor to produce motion
- You supply motion to a generator to produce electricity

## Motors and generators



- [DC motor link](#)

## Motors and generators

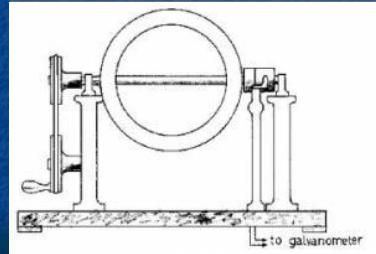


- [link to dc motor 2](#)

## DC Generator

- [link to dc generator](#)

## AC Generator



## Summary

Circuits series-parallel

- ❑ Remember-V and I relate to a circuit component
- ❑ Parallel circuits are independent
- ❑ Non linear- Use characteristics
- ❑ Current B field RHG
- ❑ Faradays law
  - RH Slap Rule
  - $\text{Flux} = B \times A_{\text{perp}}$
- ❑ Lenz's law

## Resources

The Web

- <http://lecturedemo.ph.unimelb.edu.au>
- <http://www.magnet.fsu.edu/education/tutorials/java/demotor/index.html>
- <http://www.animations.physics.unsw.edu.au/>
- <http://www.falstad.com/mathphysics.html>
- <http://www.launc.tased.edu.au/online/sciences/physics/Lenz%27s.html>
- <http://www.launc.tased.edu.au/online/sciences/physics/tutes1.html>
- <http://hyperphysics.phy-astr.gsu.edu/hbase/emcon.html#emcon>
- <http://www.ph.unimelb.edu.au/museum>