**Chapter 21: Current and Charge**

***Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier***

**Questions to make you think**

A 60 W light bulb is connected to a 120 V outlet. How long in seconds does it take for 1 billion electrons to pass through the light bulb?

**Conductors and Insulators**

**A conductor** is a substance which allows charge to flow through it.

**An insulator** is a substance which does not allow charge to flow through it.

**Electric Current**

An electric current is a flow of charge

(strictly speaking it should be ‘an electric current is a measure of *the rate* of flow of charge’)

The symbol for current is I\*

**The unit of electric current** is the ampere or amp (A).

The definition of the Ampere is covered in chapter 27 – you won’t like it!

The size of an electric current in a conductor is defined as the amount of charge passing a point on that conductor per second.

**I =**

i.e.

From this we can see that the ampere is equivalent to 1 coulomb per second (1 A = 1 C s-1).

**The coulomb is the amount of charge that passes when one Amp flows for one second.**

Rearranging this gives: Charge gone past a point = Current flowing through it × Time

Q = It ( Think ‘QuIt’)

**Conventional Current\***

Conventional Current is current which is represented as going from positive to negative, whereas in reality (for a metal) it is actually the negative electrons which are going from the negative terminal to the positive.

**Measuring Current**

* Current is measured with an ammeter.
* An ammeter must be connected **in series** with that part of the circuit through which the current to be measured is flowing.
* The current is the same at every point in a series circuit\*.
* The sum of the currents flowing into a junction is equal to the sum of the currents leaving the junction\*.

**Leaving Cert Physics Syllabus**

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| --- | --- | --- | --- |
| **Content** | **Depth of Treatment** | **Activities** | **STS** |
| Electric current | Description of electric current as  flow of charge; 1 A = 1 Cs–1 |  |  |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Symbol** | **Unit** | **Symbol of unit** |
| ***Charge*** | Q | *Coulombs* | C |
| ***Current*** | I | *Amps* | A |
| ***Capacitance*** | C | *Farads* | F |
| ***Electric Field Strength*** | E | *Newton per Coulomb* | N/C |

**Extra Credit**

**\*Conventional Current**

We mentioned Benjamin Franklin in the chapter on Static Electricity; he was the dude who labelled electricity as positive and negative, and believed that both types of charge were mobile.

It was also he who promoted the notion that positive charge flowed from the positive end of a battery to the negative end.

Once again he got it arse-ways, but once again scientists in their infinite wisdom decided to keep this erroneous convention, so today in textbooks we represent current as going from positive to negative, whereas in reality (for a metal) it is actually the negative electrons which are going from the negative terminal to the positive.

**\* The symbol for current is I\***

Why is I used to represent current?

Seems that I was used originally to represent Electrical Intensity, but that the term *Current* was later used to signify that something was flowing.

However they couldn’t use C for Curent as it had already been requisitioned to represent Capacitance.

The French use *Intensite* instead of the word *current*.

It seems to me that to define current as being a flow of charge is incorrect; current should be a measure of *the rate of flow* of charge.

The greater the current, the more charge that’s flowing *per second.*

By the way, did you realise that physicists have no idea why the charge on an electron happens to be the same as the charge on a proton?

**\*The current is the same at every point in a series circuit.**

There are a number of different analogies to help students understand current.

The one which I find to be most useful for this concept is as follows; Imagine a small race circuit, the track is completely filled with cars bumper to bumper.

There is now no way that any one part of the circuit can move more quickly than another, so if you can calculate how many cars are passing a given point in one second you know that this is the same for all parts of the circuit – it’s the same for electrons in an electric circuit.

Now if any individual car meets with resistance and has to slow down, so naturally do all the cars behind, but because the circuit is complete, even the cars in front have to slow down to the pace of the slowest car behind them.

**\*The sum of the currents flowing into a junction is equal to the sum of the currents leaving the junction.**

Picture three streams flowing into one lake.

Let’s say coming out of this lake are two other streams.

Now if the size of the lake isn’t getting bigger or smaller then the total amount of water flowing into the lake must equal the total amount of water flowing out.

It’s the same for current.

An analogy to help you understand the flow of the electrons caused by potential difference is to imagine *pushing* a stiff bicycle chain around and around.

Each link is an electron, and they all move at the same speed.

It’s not a bad analogy, but like all analogies it has its limitations; can you see why this one isn’t perfect?

**Exam Questions**

1. [2006][2002 OL][2003 OL][2004 OL][2008 OL][2010]

What is an electric current?

1. [2003 OL][2010 OL]

What is the unit of electric charge?

1. [2009]

Calculate the average current that flows through the victim when the capacitor in a defibrillator containing a charge of 0.16 C discharges in a time of 10 ms.

1. [2008 OL]

Describe an experiment to investigate if a substance is a conductor or an insulator.

**Exam Solutions**

1. An electric current is a flow of charge.
2. The coulomb
3. I = q/t = (0.16)/(10 × 10-3) = 16 A
4. *Apparatus*: circuit to show power source, ammeter/ bulb, leads,

*Procedure*: connect the circuit and place item between contacts

*Observation*: If the bulb lights then the item is a conductor; if the bulb does not light then the item is an insulator.