Energy and Power

Power

From mechanics, we know that **power** is a measure of how quickly something can transfer energy. Power is linked to energy by the equation:

$$\boxed{Power = \frac{Energy}{time}}$$

Power is measured in Watts, W
Energy is measured in Joules, J
Time is measured in seconds, s

We can derive a new equations for energy transferred and power in electrical circuits:

Energy

$V = \frac{E}{Q}$ can be rearranged into $E = VQ$ and we know that $Q = It$ so combining these equations we get a new one to calculate the energy in an electric circuit:

$E = VQ$ <---------------------- $Q = It$ so $\boxed{E = VIt}$

Power

If we look at the top equation, to work out power we divide energy by time:

$\frac{E}{t} = \frac{VIt}{t}$ which cancels out to become $\boxed{P = VI}$

If we substitute $V = IR$ into the last equation we get another equation for power:

$P = IV$ <---------------------- $V = IR$ so $\boxed{P = I^2 R}$ This is the power dissipation due to heating.

We can also rearrange $V = IR$ into $I = \frac{V}{R}$ and substitute this into $P = VI$ to get our last equation for power:

$P = VI$ <---------------------- $I = \frac{V}{R}$ so $\boxed{P = \frac{V^2}{R}}$

Fuses

The heating effect of electric current is used in fuses to protect the appliance. Electrical devices connected to the Mains supply by a three-pin plug have a fuse as part of their circuit. This is a thin piece of wire that melts if the current through it exceeds its maximum tolerance. The common fuses used are 3A, 5A and 13A. A 100W light bulb connected to the UK Mains would have a 240V potential difference across it. Using $P = IV$ we can see that the current would be 0.42A so a 2A fuse would be the best to use.

Applications

The starter motor of a motor car needs to transfer a lot of energy very quickly, meaning it needs a high power. Millions of Joules are required in seconds; since the voltage of the battery is unchanging, we need current in the region of 160A, which is a huge current.

The power lines that are held by pylons, to transfer electricity from power stations to our homes, are very thick wires and carry electricity that has a very high voltage. Increasing the voltage lowers the current so if we look at the equation $\boxed{P = I^2 R}$ we can see that this reduces the current and so the heating effect to the surroundings is reduced.