Safety Warning

We have tried to make the following experiment as safe as possible. This includes the use of a safety mains lamp socket, which has a built in switching system that only allows it to be switched on when a lamp is inserted. We have also included two switches, which must be pressed simultaneously to route the mains current through the low voltage lamp. Furthermore the switches are sited at opposite ends of the case, requiring two hands to operate them. However, it must be appreciated that you are working with potentially lethal voltages and currents and therefore extra care should be taken.

Factors affecting a Lamp's Brightness

Set up a simple circuit with the 12V, 5W lamp in series with a multimeter set to 2A a.c. and connect this to a low voltage power supply set to 12V a.c. (The power supply should be capable of delivering at least 0.5A.). Connect a multimeter set to 20V a.c. to read the exact voltage applied to the lamp.

Observe the brightness of the lamp and record the current and voltage readings.

Always disconnect the unit from the mains before making <u>any</u> adjustments.
Using the "Lamp Brightness Comparison" unit, insert a 100W mains lamp into the socket and move the black switch to on. Insert the12V 5W lamp into the SBC socket.
Using a multimeter, select the 2 amp a.c. range and connect to the yellow sockets using the multimeter probes. *The use of a meter is essential to the correct operation of the experiment.*
Caution. Remember the meter probes are "live". Do not touch.

Plug the unit into a suitable mains socket. The mains lamp should illuminate.

Once again observe the brightness of this lamp and record the current. It may be assumed that the mains voltage is 230V. The electricity supplier carefully controls this.

The mains lamp is connected directly to the mains and should operate normally.

It is useful, at this stage, to compare the two current readings. The current through the 100W mains lamp is about 0.4A and through the 12V lamp about 0.4A. They are each carrying approximately the same current, so how come the mains lamp is brighter?

Predict what would happen if we wired the 100W lamp and the 12V, 5W lamp in series and connected them to the 230V supply. Would anything happen? Would one or both of the lamps blow or explode?

Depressing the two black buttons on the sides of the unit, simultaneously, will connect the two lamps in series. It may be noted that the mains lamp is fractionally dimmer than it was, and that the current has reduced slightly.

At this point it is worth considering the resistance of the lamp filaments.
As **Resistance = Voltage/Current,** the resistance of each filament may be calculated from the measurements taken.
The idea of a potential divider may then be introduced. i.e. resistances in series share out the voltage in proportion to their relative size.
Using a rough calculation (which may be a little out because of the characteristics of various lamps*), the resistance of the 100W lamp is 529 ohms and that of the 5W lamp is 28.8 ohms.
(**Resistance = Voltage^2/Power**)

*** NB.** We purchased a number of 100W lamps to try out the system. They were all labelled 240V, despite the fact that the mains voltage has been 230V for the past 10 years. Using 240V as a baseline gives the resistance of a 100W lamp as 576Ω and the current through it as 0.399A. This agrees exactly with our measurements taken. We have put the calculations for using a 240V lamp in **bold** type below. It seems that the manufacturers have decided that it is not worth redesigning their products for the new harmonised voltage. In practice this means that a 100W, 240V lamp running on 230V only gives out 92W. (But at least it should last longer!)

The voltage will be shared as follows:

Genuine 230V lamp	***240V lamp***
$\frac{529 \times 230V}{(529 + 28.8)}$ across the 100W lamp	$\mathbf{\frac{576 \times 230V}{(576 + 28.8)}}$
$\frac{28.8 \times 230V}{(529 + 28.8)}$ across the 5W lamp	$\mathbf{\frac{28.8 \times 230V}{(576 + 28.8)}}$

Note that adding the two expressions together gives 230V.

The total current flow will be:

$$\frac{230}{(529 + 28.8)} \text{ A} \qquad \mathbf{\frac{230}{(576 + 28.8)} \text{ A}}$$

Using a multimeter to read the resistance of the lamp shows that the resistance is lower than calculated previously. Why should this be? What effect would this have on the current flow?

Why do mains lamps most often "blow" when they are first switched on rather than when they have been on for some time?

We are now into the realms of temperature dependence. If the students want to persue this they can use the 5W lamp and increment the voltage, take voltage and current readings and plot a graph of voltage against current. This graph may be compared with those of a fixed carbon resistor and a silicon diode.

Replacement 12V, 5W lamps are available from us at the address below.

Electrosound, 30, Goulds Farm, Shalford Road, Rayne, Essex CM77 6TY
www.electrosound.co.uk