E.13 Electrical Safety

The damaging effect of an electrical shock in the human body is the result of current passing through the body.

Recall from Ohm's Law: $I = \frac{V}{R}$

Thus the current through the body depends on the applied voltage and the electrical resistance of the body. The resistance of a human body ranges from about 100 Ω, if the person is soaked with salt water, to about 50,000 Ω if the person's skin is very dry.

The following table describes the effects of different amounts of current, for a half second duration, on the human body.

CURRENT mA	**EFFECT**
1	Able to be felt
3	Easily felt
10	painful
20	Muscles paralysed – cannot let go
50	Severe shock
90	Breathing upset
150	Breathing very difficult
200	Death likely
500	Serious burning, breathing stops, death inevitable

The amount of electrical energy also depends on the duration of the shock. The table below shows the likely effect of a 50mA shock for different time periods.

Time Seconds	**Effect on the Body**
less than 0.2	noticeable but usually not dangerous
0.2–4 significant shock	possibly dangerous
more than 4 severe shock	possible death

Example:
If an active wire in a household supply is touched while a person is standing on the ground then a potential difference of 240 V exists between the person's hand and the ground. If the person's feet and the ground are wet there is a very low electrical resistance bond between the person and the ground which can easily produce fatal currents in the human body.

1. Assume the resistance of your body is 100,000 ohms. Determine the current passing through your body if you touched the terminals of a 12 volt car battery and describe the sensation that you would feel.

   Use V = I R to find I

2. After emerging wet from a swimming pool, your skin being very wet, reduces your resistance to 1,000 ohms. Determine the current passing through your body if you now touched the terminal of a 12 volt car battery and describe the sensation that probably would be felt.

Use V = I R to find I

3. If, while wet, body resistance is 1,000 ohms, you touched a live wire of a 240 V appliance and you were standing on a concrete patio, determine the current that would pass through your body and the probable effect it would have on your body.

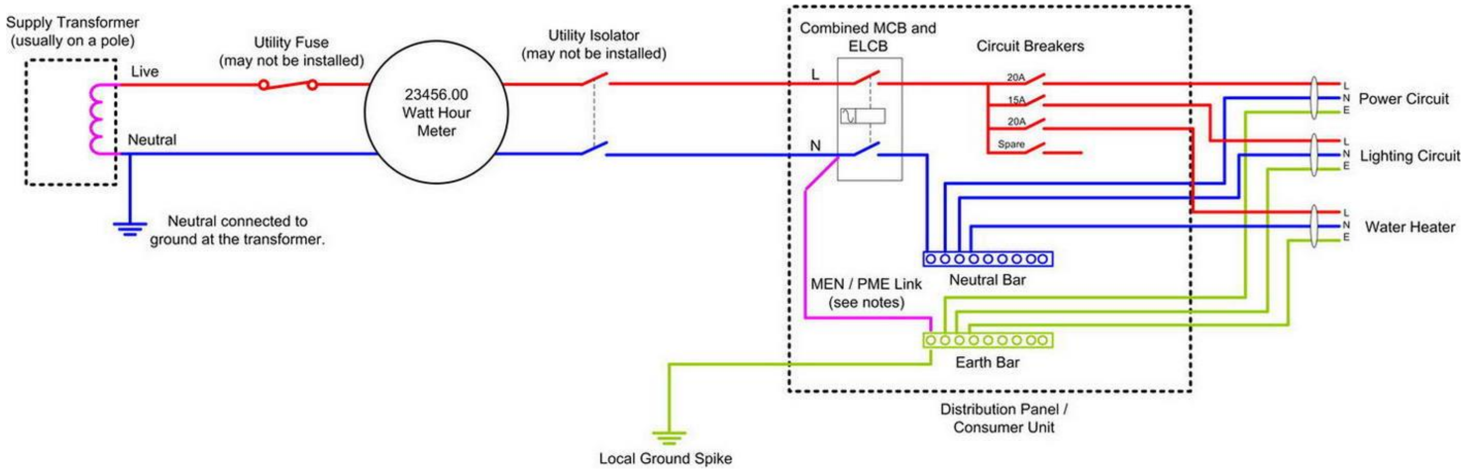
Use V = I R to find I

Electric shock overheats the tissues in the body and disrupts normal nerve functions. Thus such a shock can upset the nerve centre that controls breathing.

E.13.1 Fuses & Circuit Breakers

If circuits suddenly carry more current than that for which they are designed then the distribution wires may become hot enough to ignite the surrounding substances. Recall that the heating effect is proportional to the square of the current. ($E = V I t = I^2Rt$).

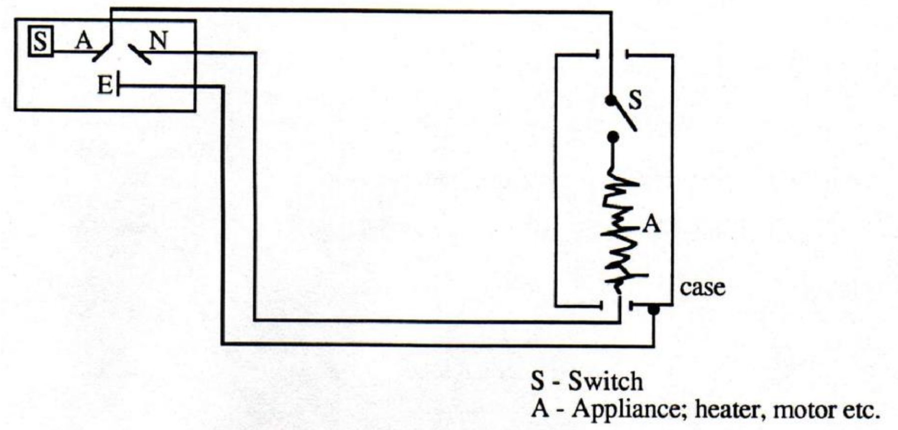
To avoid the danger of fire each circuit should have a safety device that will 'open' the circuit if excess current develops. This safety device is usually either a fuse (low melting point wire) or a circuit breaker (usually incorporating a bimetallic strip that bends away from a contact when it is heated).



E.13.2 Earth Wire and Double Insulation

Shocks can occur when the surface of an electrical appliance is at a different potential from the surfaces of other nearby devices. If a person touches surfaces at different potentials electrical current will pass through the person's body, often with fatal consequences. To overcome this problem an 'earth' wire, that is connected directly to the ground, is connected to the metal body of the appliance. If a wire breaks free or the insulation on the wire becomes frayed and an active wire touches the metal body of the appliance, then the current is 'short circuited' to the earth which would also mean the excess current flow would overheat and rupture the fuse or 'trip' the circuit breaker in the circuit

Below is a diagram of our 'earthed' appliance.



Switches are placed on the active side of the circuit. A switch on the neutral side would work but could be dangerous, e.g. a light switch in the neutral wire could mean that somebody changing a globe could touch a 'live' active contact even though the switch is turned off.

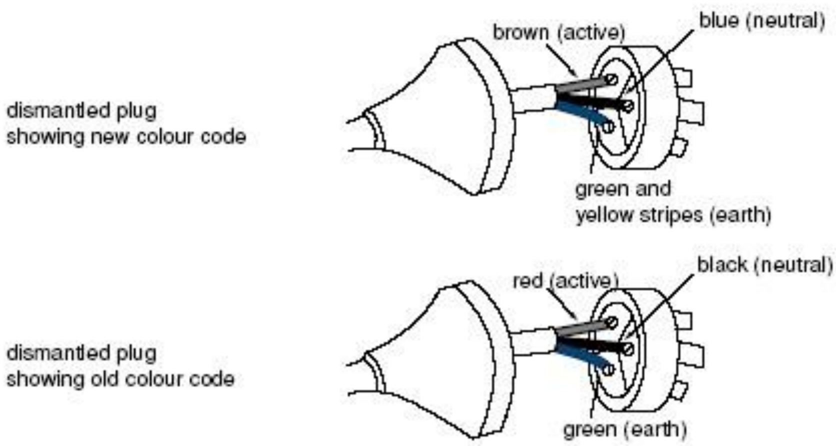


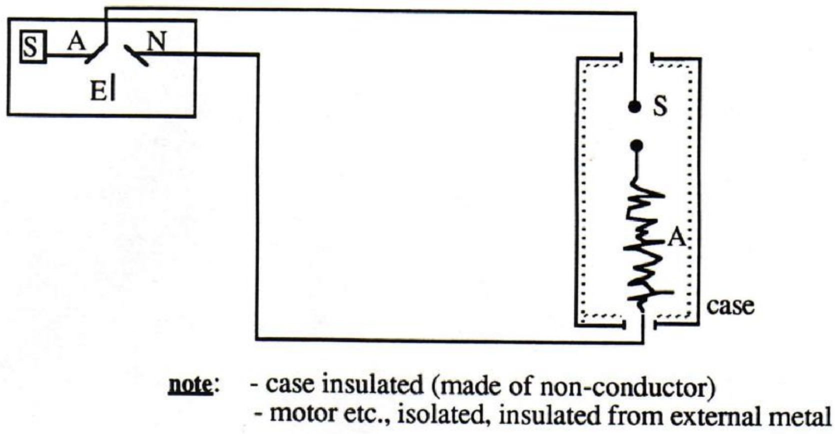
Figure 9.24 This diagram shows correctly wired plugs using both the new and old colour codes. The new code is an international standard which should be used all around the world.

Often appliances do not have an earth 'pin' and such appliances are termed 'double insulated' appliances. In all such appliances the outer case is insulated (made from a non-conductor). Protection from frayed, ruptured or shorting wires is at two levels:

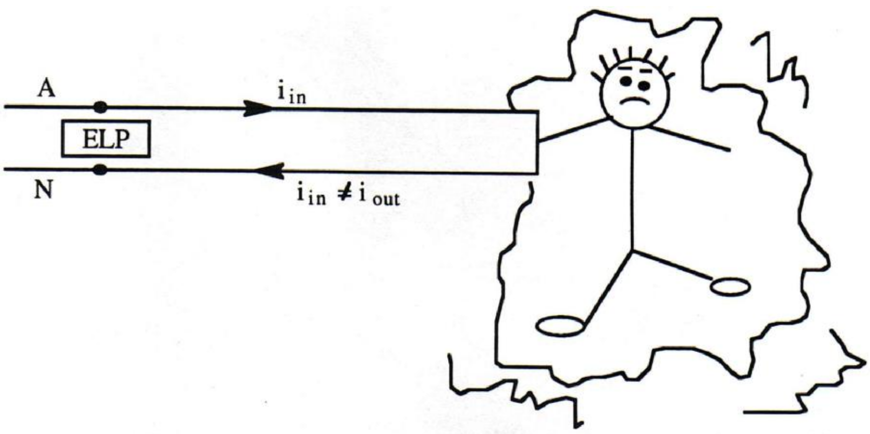
(a) **<u>Functional Insulation</u>**
This is the insulation around the live wires.

(b) **<u>Protective Insulation</u>**
This is insulation in the form of a plastic (non-conducting) case.

It is highly unlikely that both forms of insulation would fail simultaneously without the device being totally inoperative.



E.13.3 Earth Leakage Protection (Safety Switch) (Residual Current Device)



Earth leakage protection device continuously monitors the currents in Active and Neutral wires. These two currents will at all times be the same unless some of the current has leaked to earth. The device will switch off the power in a matter of milliseconds in order to prevent electrocution. ELP devices are mandatory in Victoria in all new buildings.

Problem Set #7: Text Section 4.3 Page 153 Questions 1, 2, 5 – 10

Test Revision: Text Page 117 – 118 All Questions
Text Page 154 – 156 All Questions