

Unit 4: Electricity (Part 2)

Learning Outcomes

Students should be able to:

1. Explain what is meant by power and state its units
2. Discuss the importance of reducing electrical energy wastage
3. State some electrical hazards and precautionary measures to ensure the safe use of electricity in the home

Electrical Power

Definition:

Power is the energy converted per second.

S.I. unit for power : watt (W)

1 kW = 1000 W

1 MW = 1 000 000 W

Electrical Power

$$\text{Power} = \frac{\text{Energy used}}{\text{time}}$$

$$P = E/t$$

where

P = power (unit : watt, W)

E = energy (unit: joule, J)

t = time (unit: second, s)

$$1 \text{ W} = 1 \text{ J/s}$$

Energy used = Power x time

$$E = Pt$$

Electrical Power

- $100 \text{ W} = 100 \text{ J/s}$
- A **100 W** lamp converts 100 J of electrical energy into heat and light energy in 1s.
- Which lamp is brighter? :
40 W or 100 W??

Electrical Power

An electric iron is labelled

'240 V, 1 kW.'

This means that the iron when connected to a voltage supply of 240 V, will use up electrical energy of 1000 J in 1s.

Electrical Power

Typical power ratings of some common appliances

Appliance	Power
Electric iron	950 W
LCD TV	125 W
Fluorescent lamp	32–40 W
Electric kettle	2 kW
Air conditioner	1–2 kW

Example

An electric kettle of 2200 W is used for 1 min.
How much electrical energy is used?

Solution

$$E = Pt$$

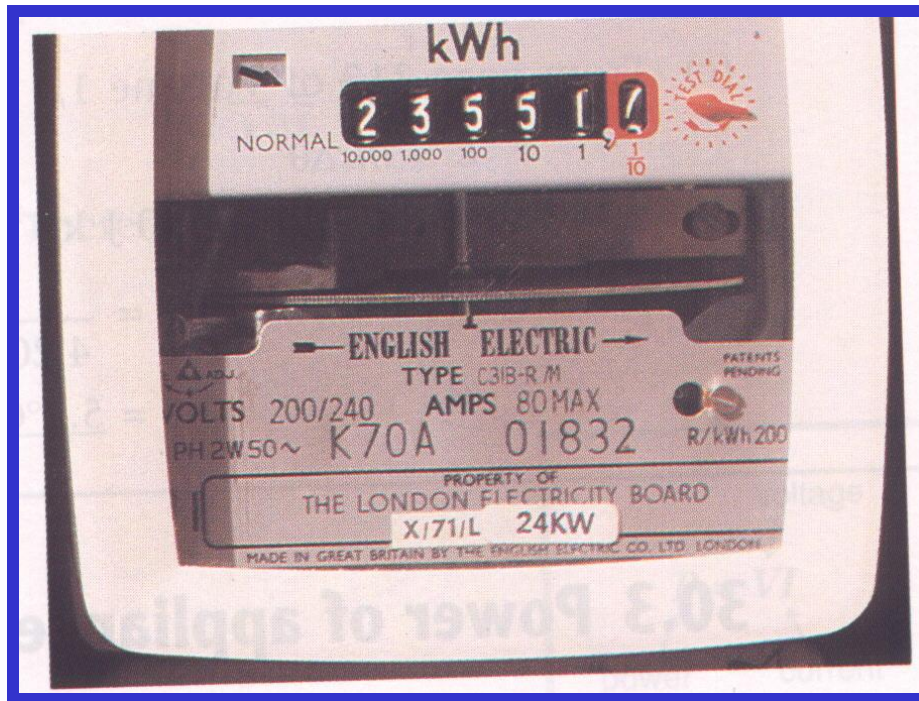
$$= 2200 \times 1 \times 60$$

$$= 132000 \text{ J}$$

$$= \underline{1.32 \times 10^5 \text{ J}}$$

Commercial Unit of Electricity

- In Singapore, every home has an electricity meter to measure the amount of **electrical energy** has been used.



An electricity meter

kilowatt hour (kWh)

- **Electrical energy is sold in units of kilowatt hour (kWh) (or one unit of electricity).**
- **One kWh is the energy used by a 1 kW electric appliance in an hour.**
- **1 unit of electricity = 1 kWh**

$$\text{Energy consumed} = \text{Power} \times \text{Time}$$
$$E \text{ (kWh)} = P \text{ (kW)} \times t \text{ (h)}$$

Example

If SP Services charges 18 cents for each kWh of electrical energy used, calculate the total cost of using a 3 kW electrical kettle for 20 minutes and a 100 W filament bulb for 5 hours.

Solution:

Electrical energy used by electric kettle,

$$E_1 = P \times t = 3 \text{ kW} \times (20/60)\text{h} = 1 \text{ kWh}$$

Electrical energy used by bulb,

$$E_2 = (100/1000)\text{kW} \times 5 \text{ h} = 0.5 \text{ kWh}$$

$$\text{Total energy used } E = E_1 + E_2 = 1 + 0.5 = 1.5 \text{ kWh}$$

$$\text{Hence the total cost} = 1.5 \times 18 = 27 \text{ cents} = \$0.27$$

Practice

- How much would you have to pay SP Services if you used two 40 W lamps and a 120 W television for 5 hour a day for the month of April? (Assume the cost of 1 kWh of energy to be 16 cents).

- **Solution**

Total energy used $E = P t$

$$= \left[\frac{(2 \times 40) + 120}{1000} \right] (5 \times 30) = 30 \text{ kWh}$$

$$\text{Cost needed} = \$ 0.16 \times 30 = \underline{\underline{\$ 4.80}}$$

Account No : 5904512801
Type : Domestic
Deposit : \$150.00

This is your tax invoice in respect of
31 HOUGANG AVE 7 #12-07 SINGAPORE 538800

SUMMARY OF CHARGES for 15 Aug 2007 to 14 Sep 2007	<i>Amount (\$)</i>
Balance B/F from Previous Bill	201.00
Payment on 30-08-2007 - Thank You	201.00
Outstanding Balance	0.00
Total Current Charges due on 01 Oct 2007	183.38
Total Charges will be deducted from your account with DBS Bank Ltd on 01 Oct 2007	\$183.38

SP Services Ltd
Orchard P.O. Box 341
Singapore 912312
Co. Registration No.: 199504470N
GST Reg No. M2-8920920-4
General Enquiries: 1800 2222333
Credit Arrangement: 6723 3502
6304 8229
www.spservices.com.sg

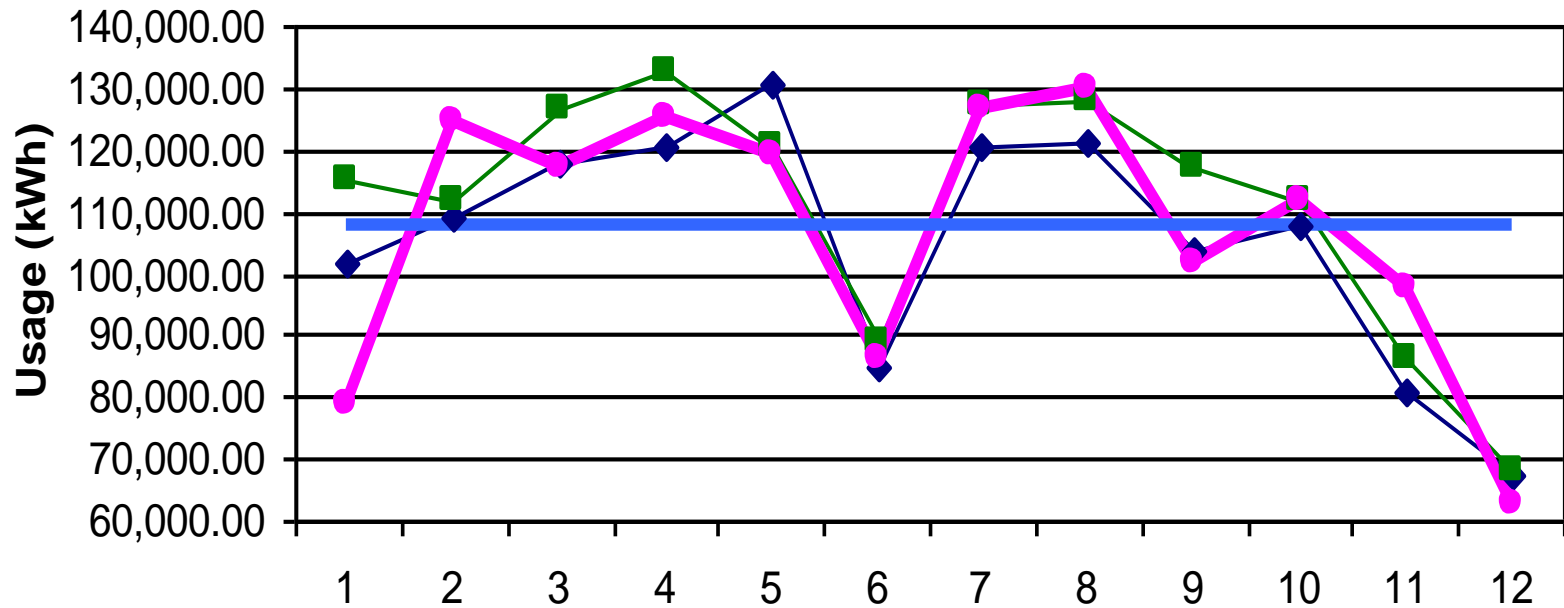
Payment received on or after 15.09.2007 may not be included in this bill.

CURRENT MONTH CHARGES	<i>Usage</i>	<i>Rate (\$)</i>	<i>Amount (\$)</i>	<i>Total (\$)</i>
Electricity Services				
Reading estimated on 14-09-2007 : 40782				
Electricity	676 kWh	0.2052	138.72	138.72
Gas Services by City Gas Pte Ltd				
Reading estimated on 14-09-2007 : 2321				
Gas	19 kWh	0.1755	3.33	3.33
Water Services by Public Utilities Board				
Reading estimated on 14-09-2007 : 835.5				
Water	8.5 Cu M	1.17	9.95	
Waterborne Fee	8.5 Cu M	0.30	2.55	
Sanitary Appliance Fee	5 Fittings	3.00	15.00	27.50
Water Conservation Tax				
		\$9.95	30%	2.98
Goods & Services Tax				
	\$154.98	7%	10.85	10.85
Total Charges for this month				\$183.38

Please make full payment by the due date to avoid \$0.50 Pink Notice fee and 1% Late Payment Charge.

Electrical Consumption In School

Electricity Usage(2004,2005 vs 2006)



- ◆ 2004 Monthly Usage (kWh)
- 2005 Monthly Usage (kWh)
- 2006 Monthly Usage
- Average usage 107502.12 kWh

Monthly

School Usage only - Less Canteen**Electricity**

Electricity Usage	2004 Monthly Usage (kWh)	2005 Monthly Usage (kWh)	2006 Monthly Usage (kWh)
Jan	101,420.00	115,157.50	78,919.217
Feb	109,350.00	111,862.50	124,383.358
Mar	117,555.00	126,290.00	117,467.075
Apr	120,326.88	132,885.50	125,323.772
May	130,826.52	120,342.50	118,881.646
Jun	84,655.176	88,754.100	86,050.518
Jul	120,323.37	127,033.60	126,626.940
Aug	120,840.94	127,679.70	129,654.238
Sep	103,613.93	116,953.30	101,831.875
Oct	107,879.30	111,810.70	111,560.247
Nov	81,026.21	86,381.60	97,934.340
Dec	67,251.46	67,786.00	62,797.538
Monthly average	105,422.40	111,078.08	106,785.90

Reducing Energy Wastage

- Effects of climate change such as warming temperatures and rising sea levels are due to the emission of greenhouse gases such as carbon dioxide.
- In Singapore, carbon dioxide is largely released when fossil fuels such as oil and gas are burnt to meet our energy needs.
- Our energy demand is expected to grow in the future due to an expanding economy and a growing population.
- Much of this growing energy demand could be avoided if we use energy more efficiently instead of increasing energy production.
- **Energy Efficiency is therefore an important strategy to reduce our GHG emissions.**

Five Simple Steps to Save 10% of Your Home Electricity Use

- The air-conditioner uses the bulk of the electricity in a home. A fan uses less than 1/10th the electricity used by an air-conditioner!
- The lower the temperature setting, the more energy used by your air-conditioner. If you use an air-conditioner, set the temperature at 25°C or higher. For every degree raised, save about \$15 a year.
- Switch off home appliances at the power socket. Standby power can account for up to 10% of your home electricity use.



Five Simple Steps to Save 10% of Your Home Electricity Use

- Choose energy efficient light bulbs (e.g. compact fluorescent lamps). Using a compact fluorescent lamp (7W) instead of an incandescent bulb (40W) can save about about \$15 per bulb per year*.
- Choose an energy-efficient appliance (e.g. air-conditioner. refrigerator) by checking the energy labels. A 4-tick air-conditioner saves you about \$270 in electricity bills a year compared to a 1-tick model, and a 4-tick refrigerator saves you about \$80 a year over a 1-tick model*.

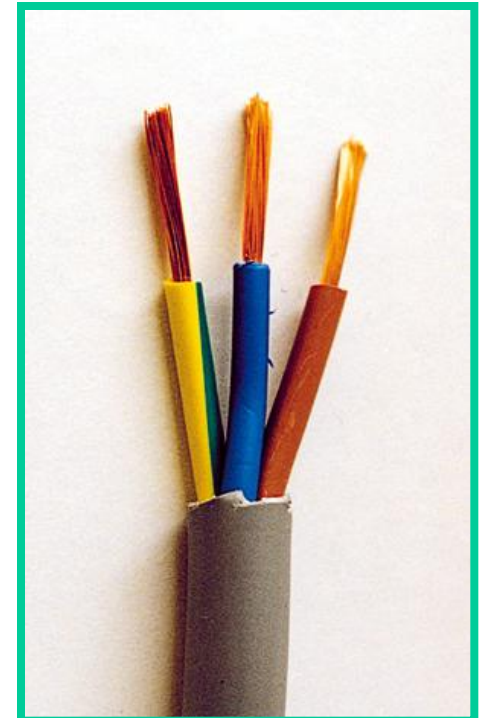
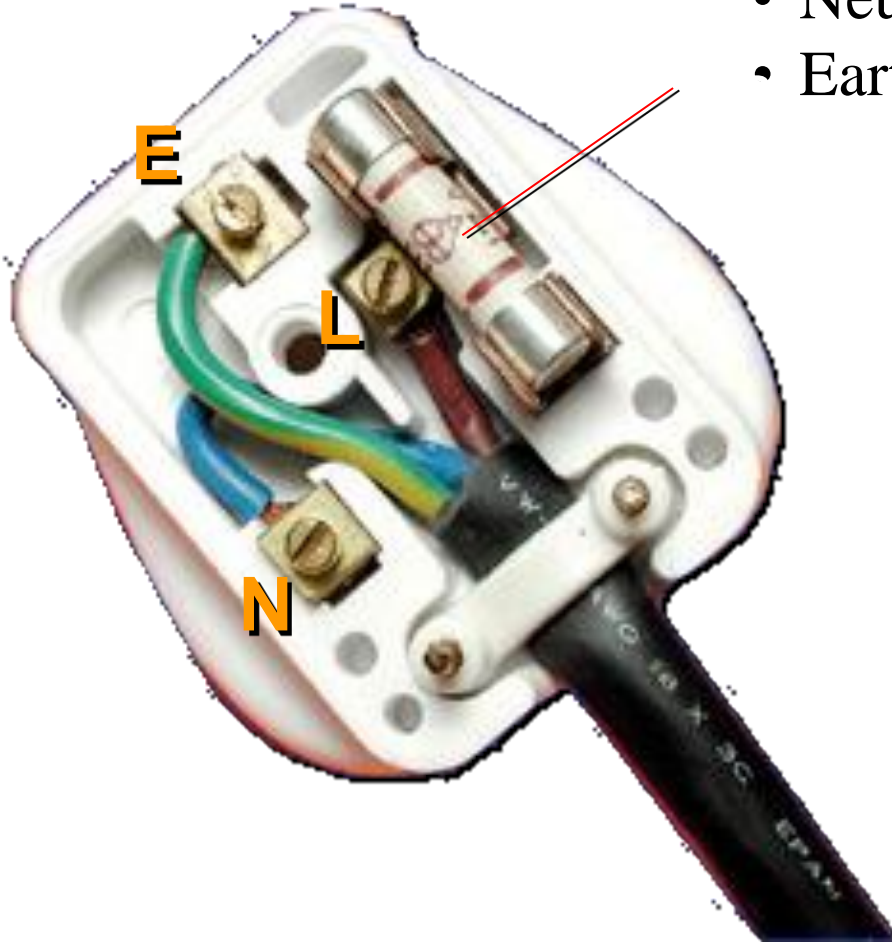


<http://www.e2singapore.gov.sg/energy-saving-tips.html>

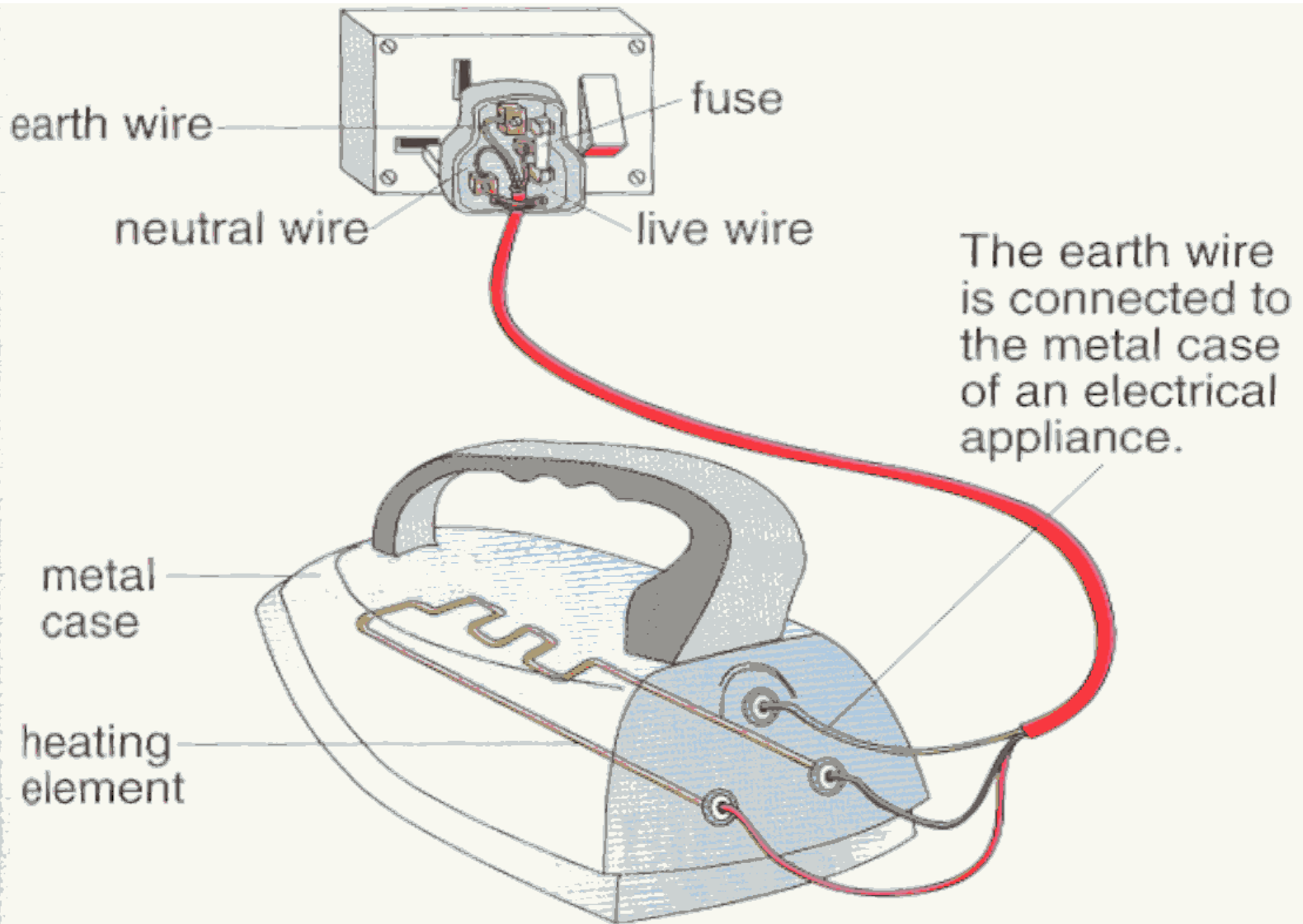
Safe use of electricity in the home

wiring a 3-pin plug

- Three wires are required in a three-pin plug:
 - Live wire (brown)
 - Neutral wire (blue)
 - Earth wire (yellow-green strips)

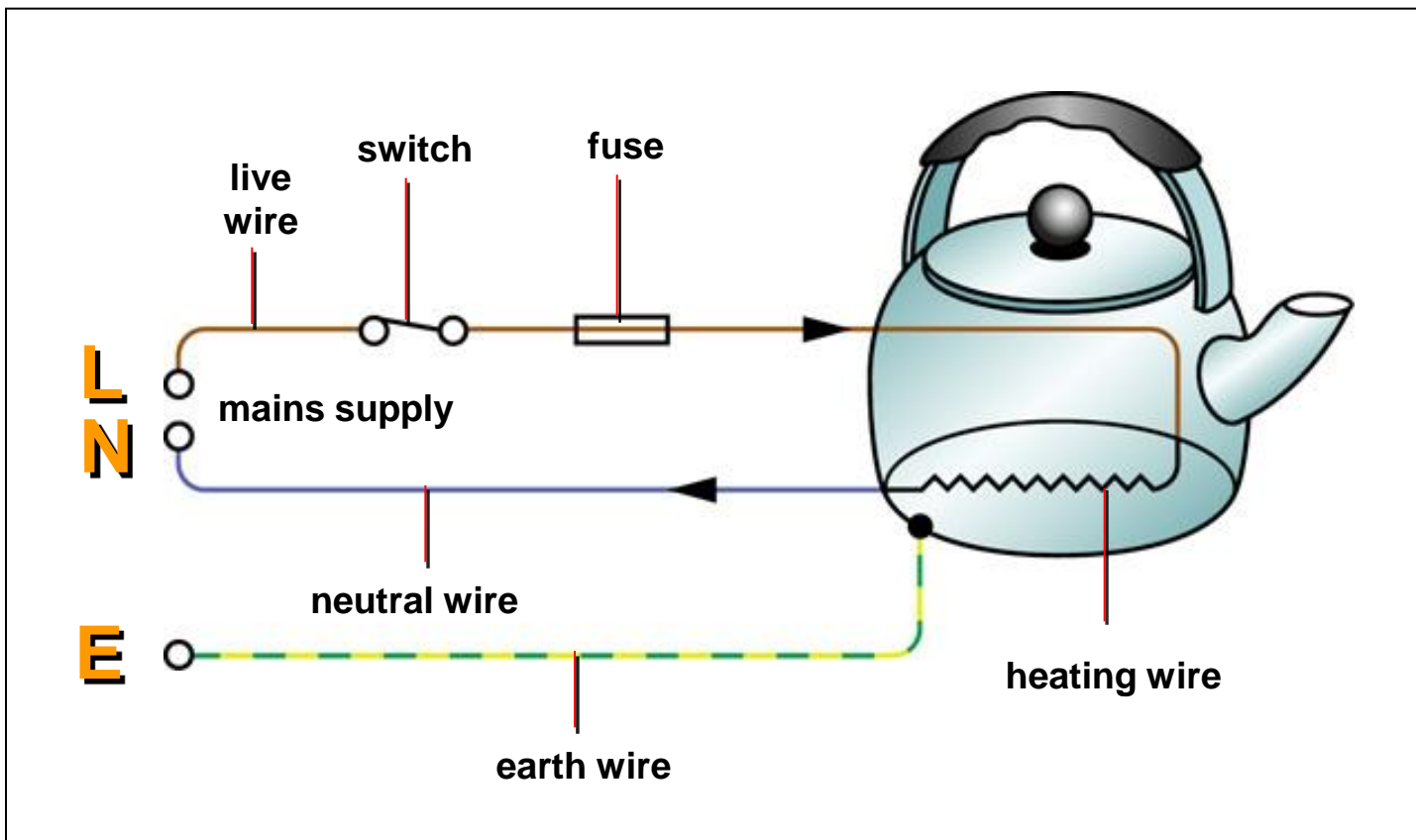


The Earth Wire in an Iron



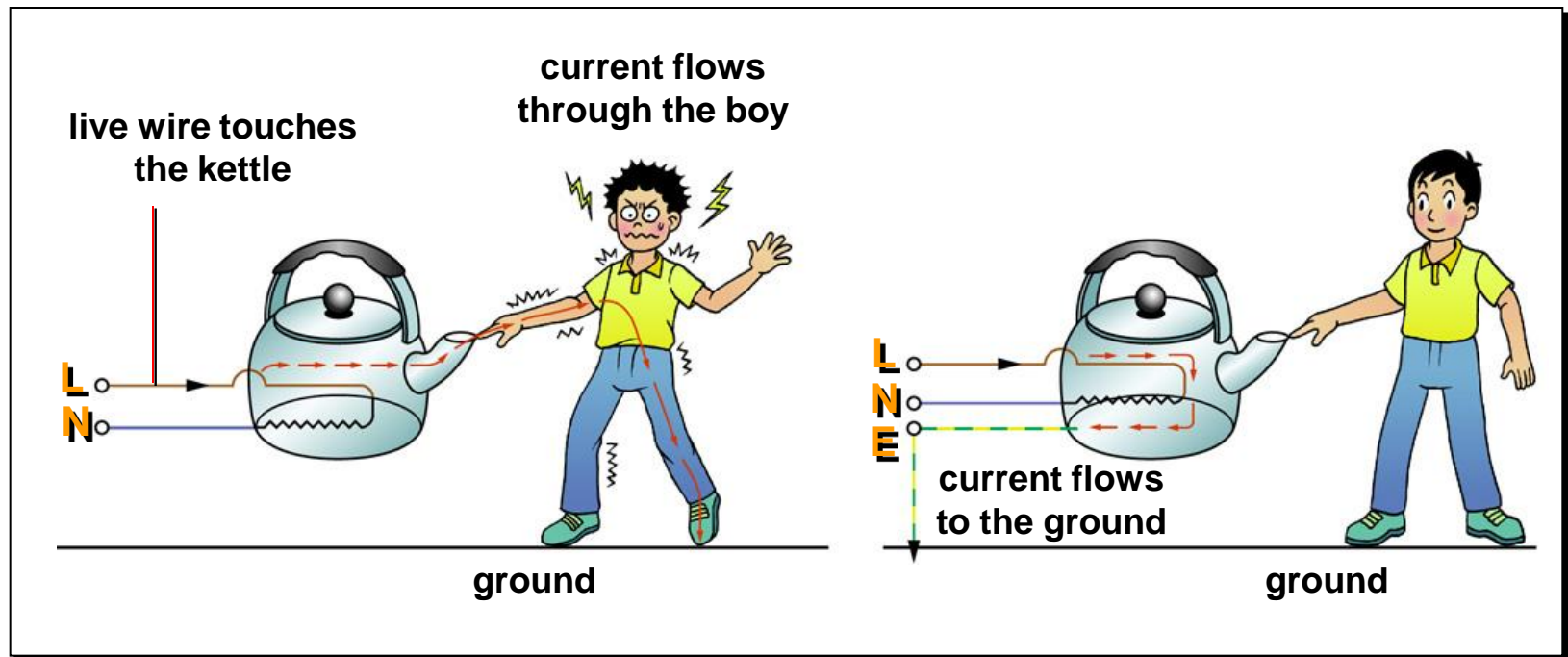
Safe use of electricity in the home

Electricity flows through the live and neutral wires but not the earth wire.



Safe use of electricity in the home

The earth socket is connected to the ground to prevent a person from getting an electric shock when touching the appliance.



danger of not earthing the appliance

when appliance is earthed, it is safe to touch

Safe use of electricity in the home

Earthing

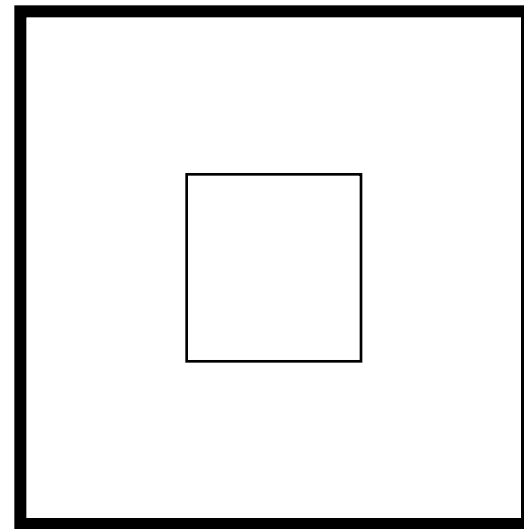
- **Earthing prevents user from getting an electric shock when he touches a faulty appliance which has accidentally become 'LIVE'!**
- **It is a good conductor which has a very low resistance in comparison to human body, i.e current will take the earth wire and by-pass human body to the Earth in the case where an appliance becomes 'LIVE' .**

safe use of electricity in the home

double insulation

Some electrical appliances (e.g. hair dryers, electric shavers and television sets) connected to power circuits are not earthed by having only a 2-pin plug (live and neutral wires).

- double insulation is used
- live electrical components are carefully shielded and isolated from the user
- accessible metal parts cannot become live unless two independent layers of insulation fail

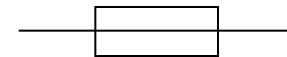


symbol for double insulation

safe use of electricity in the home

Fuse

- Fuse is a safety device used to protect equipment and wiring from excessive current flow.
- When a current larger than the fuse rating flows, the fuse wire becomes hot and melts (blown).
- It is always installed on the **live** wire.
- Fuse ratings:
1A, 2A, 5A, 10A, 13A



fuse symbol

safe use of electricity in the home

Circuit Breakers

main switch

– turns on and off the electricity supply to the whole house

earth leakage circuit breaker – an electromagnetic switch that breaks (trips) the circuit when there is a current leakage of 30mA or more through the earth wire

miniature circuit breaker – an electromagnetic switch that breaks (trips) the circuit when there is too much current

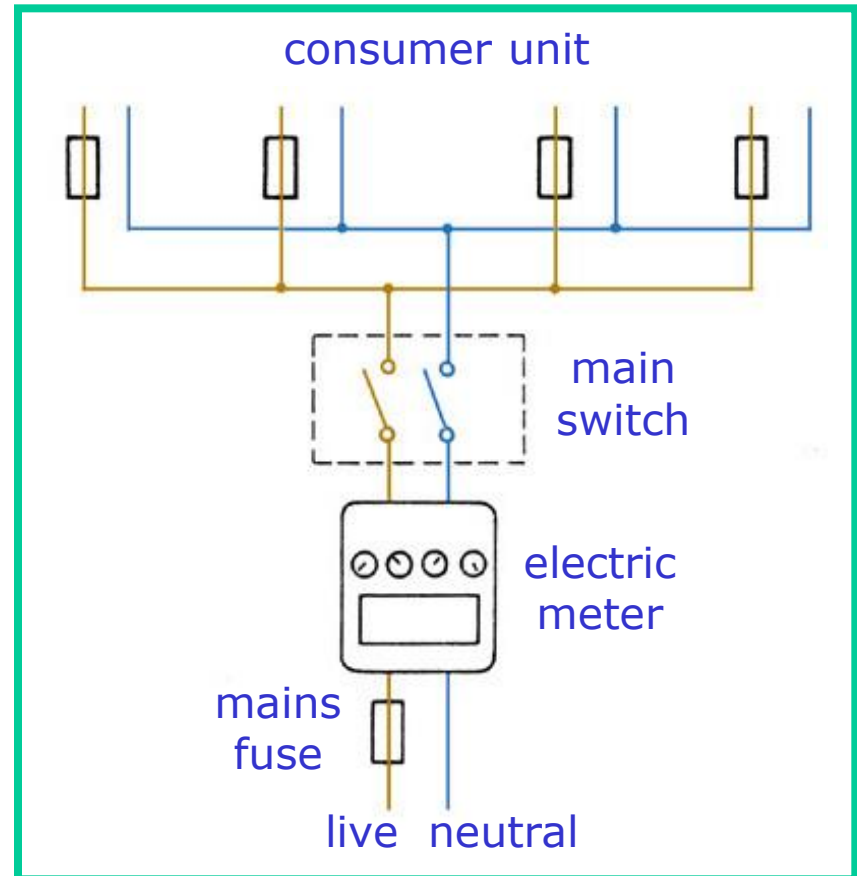


safe use of electricity in the home

Electricity is supplied to the house through the mains cable which consists of a live wire and a neutral wire

- the mains cable is connected to a mains fuse, an electricity meter and consumer unit
- a live wire allows current to flow through; has a certain potential
- a neutral wire is at zero potential

circuit showing how electricity is supplied to the home



Dangers/Hazards of Electricity

Two major dangers when using electricity

- risk of an electric shock
- risk of fire

Dangers are caused by

- the use of electrical wires with damaged insulation
- the overheating of cables
- touching wet electrical appliances

Dangers/Hazards of Electricity

Damaged insulation

- Damaged insulation exposes the live wire carrying the current.
- When the live wire is touched, it will cause an electric shock.

Safety precaution :
Regular checks and replacement of damaged cables.



Dangers/Hazards of Electricity

Electric fires may be due to :

- Short circuit
- Overloading

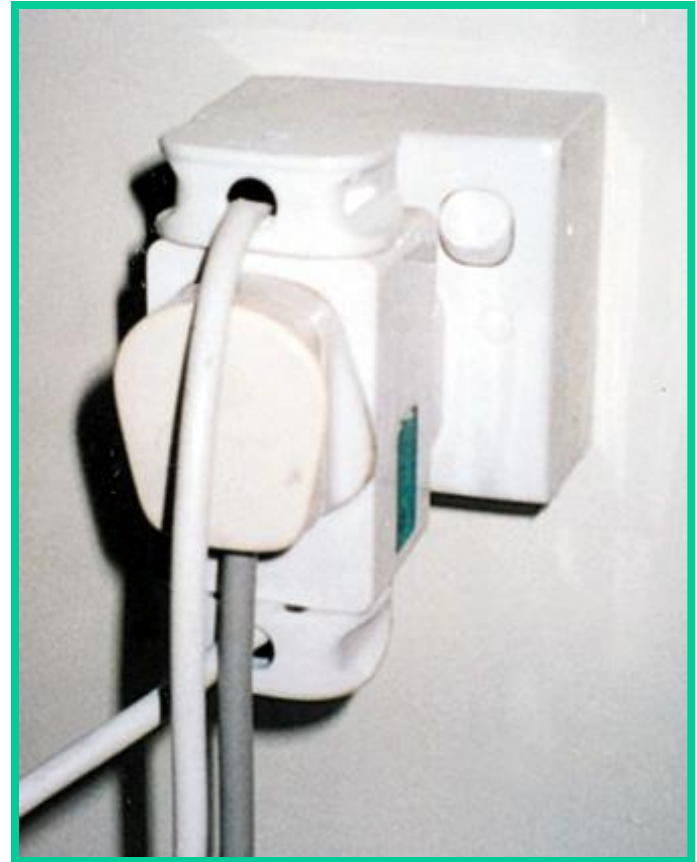
Short-circuit

- When live wires come into contact with the neutral wires .
- A large current will flow through the wires causing the wires to overheat and a fire may start.

Dangers/Hazards of Electricity

Overloading

- Overloading occurs if too many electrical appliances are connected to the same socket and used at the same time
- the total current drawn by them through the electric cable from the mains supply may be very large
- cable becomes overloaded and overheated, which may result in a fire



Dangers/Hazards of Electricity

damp conditions

- dry skin has a resistance of 100 000 Ω or more
- wet skin lowers resistance of human body
- water especially with sweat, contains salts of good conductivity may cause resistance to fall to a few hundred ohms



Dangers/Hazards of Electricity

Physiological Effect of electric shock

<i>Current (approx) mA</i>	<i>Effect</i>
1	Threshold- no pain below this point
5	A frightening but harmless shock
10 - 20	Uncontrolled muscular contractions- you can't let go
50	Pain and exhaustion. Breathing affected.
100 - 300	Uncoordinated contraction of the heart leading to death