National 5 Physics

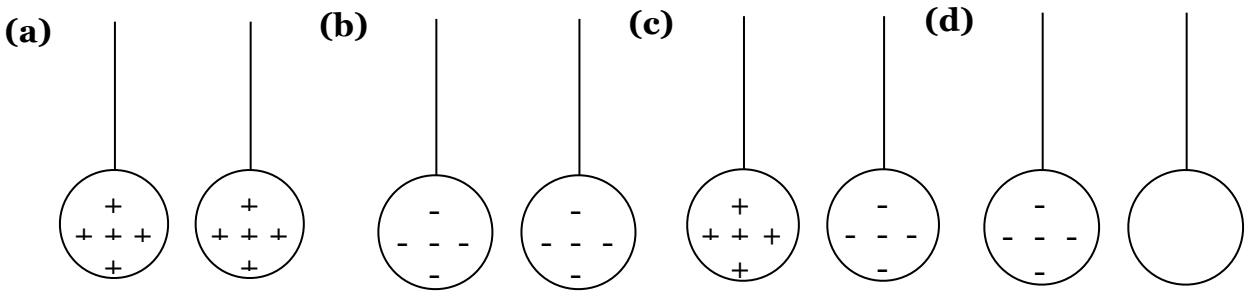
Electricity

Problem Booklet

Contents

Electrical Charge

1. In a classroom experiment, two polystyrene spheres coated with a layer of metal are hung from a thread, as shown below. Copy the diagrams below and use arrows to show the direction of movement of each sphere.



2. Explain how a photocopier uses a positively charged copy plate and negatively charged toner particles to create a copy of an image on a piece of paper.

3. Why will a static duster work better if it is 'fluffed up' or rubbed across a television screen before use?

4. Vehicle manufacturers charge the body of cars and use charged paint to give cars their final colour. By using your knowledge of electrostatics:

   a) Explain how this results in an even coat of paint over the whole surface of the car.

   b) Explain how this limits the amount of paint that is wasted.

5. Cling film is used to keep to keep food fresh. Cling film becomes sticky because of electrostatic charges.

   a) Describe how a piece of cling film becomes charged.

   b) Explain why cling film will stick to a plastic bowl for a long time but loses its sticking power quickly when placed on a metal bowl.

Electrical Current

1. What is an electrical current?

2. A current of 6.5 A flows through a hairdryer for 5 minutes. What is the charge that flows through the hairdryer during this time?

3. When playing a game, an Xbox 360 has 1368 coulombs of charge flowing through it an hour. What is the current flowing through the console?

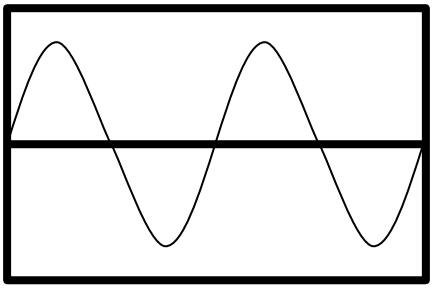
4. An electric kettle has 9.5 A of current flowing through it as it boils water. How long does it take the kettle to boil if 1995 C of charge flows through it before it switches off?

5. What is the difference between alternating and direct current?

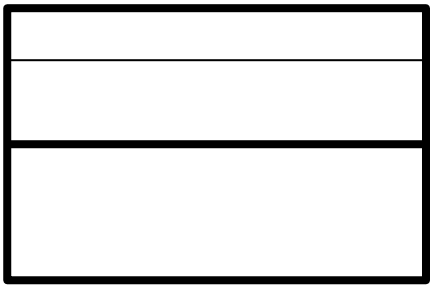
6. Copy and complete this table:

7. Copy these oscilloscope traces and indicate which one represents an alternating current and which one represents a direct current.

(a)

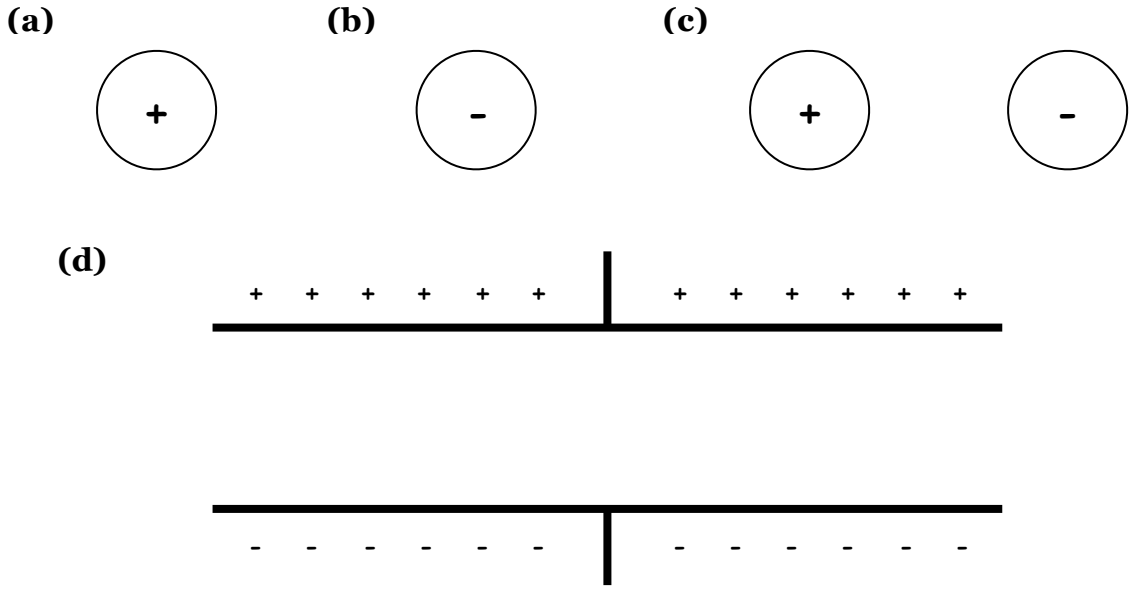


(b)

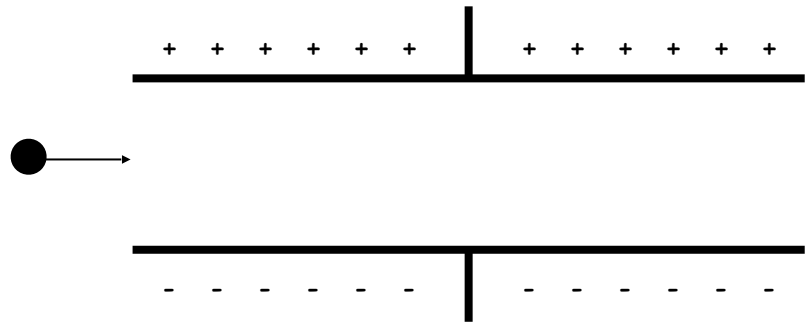


Charges in Electric Fields

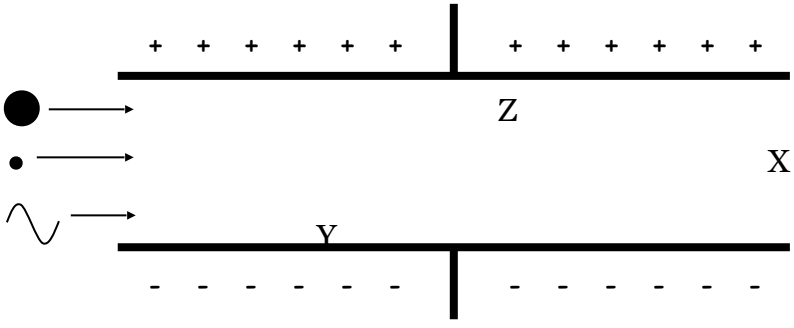
Copy and complete these diagrams to show the electric field lines.



Copy this diagram and add the paths of the following particles entering at right angles to the electric field: Electron, Proton, Neutron.

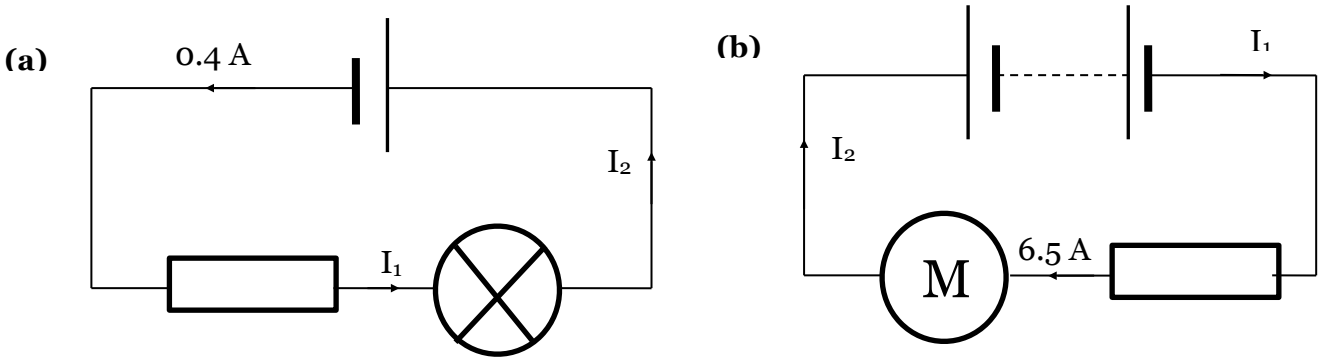


An alpha particle (positive), a beta particle (negative) and a gamma ray (neutral) enter an electric field at right angles to the field. Which letter shows the most likely position of the: Alpha particle, Beta particle, Gamma ray.

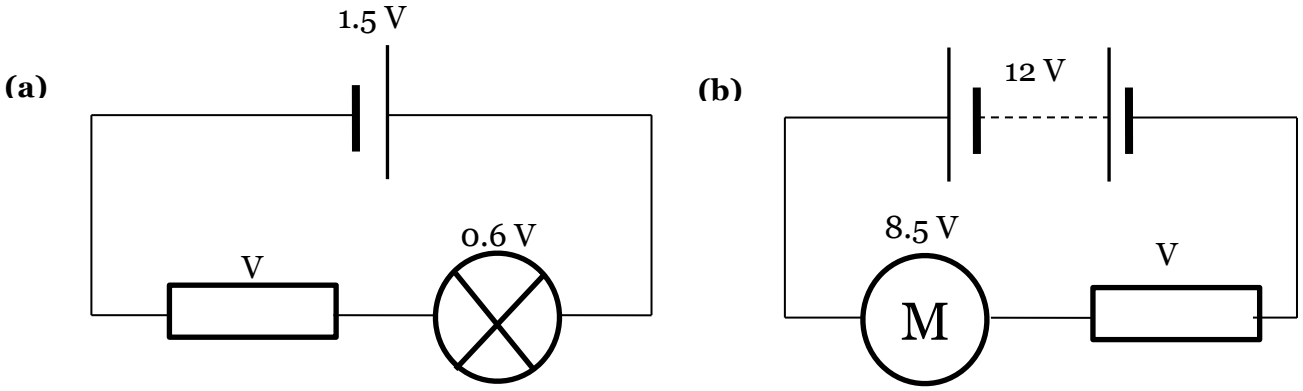


Series Circuits

1. Calculate the current at the given points in each series circuit.



2. Calculate the voltage across the resistor in each of these series circuits.



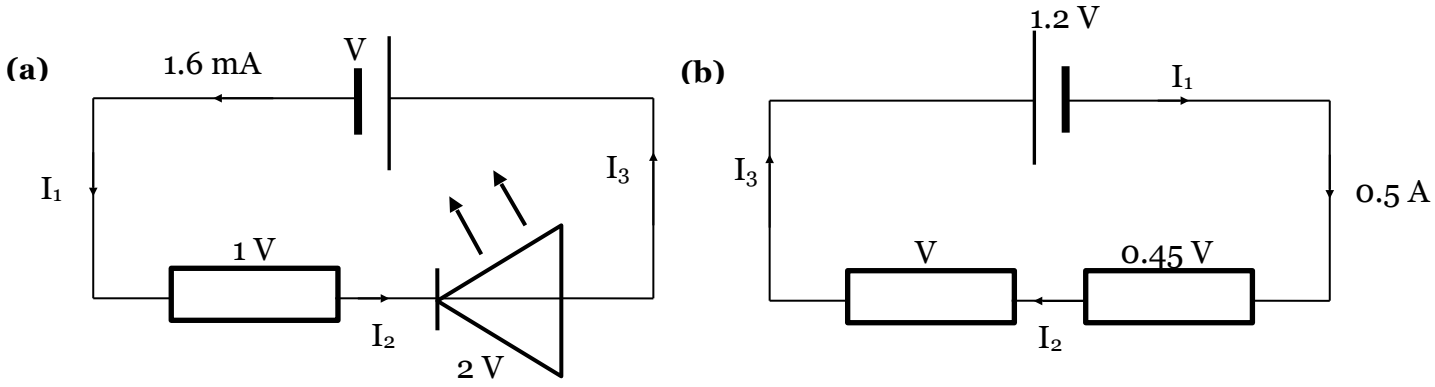
3. In the circuit in question 2 part (a), the lamp uses up 3600 J of electrical energy in one minute.

   a) How much electrical energy is converted in to heat energy by the resistor in one minute?

   b) How much electrical energy is given off by the cell in one minute?

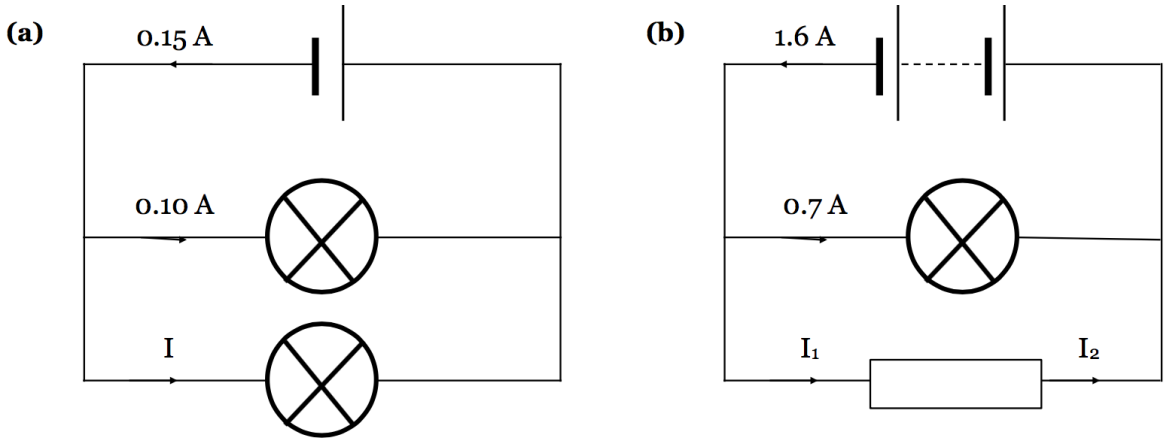
4. In an experiment, two identical resistors are connected to a 9.0 V power supply. Calculate the voltage across each resistor.

5. Calculate the missing currents and voltages in these series circuits.

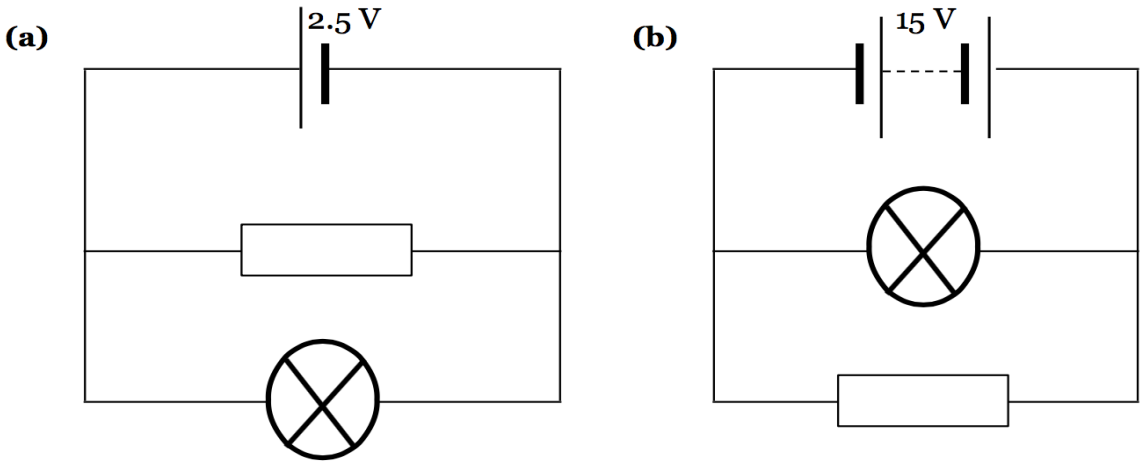


Parallel Circuits

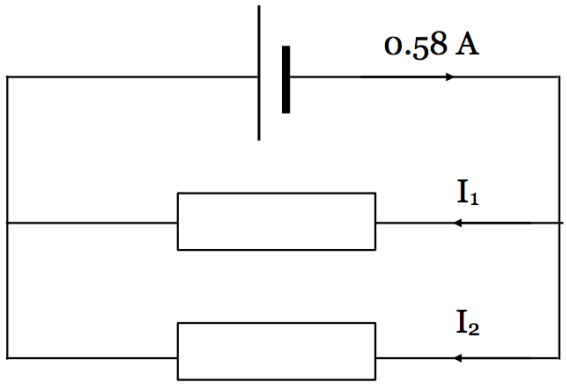
1. Calculate the current at the given points in each parallel circuit.



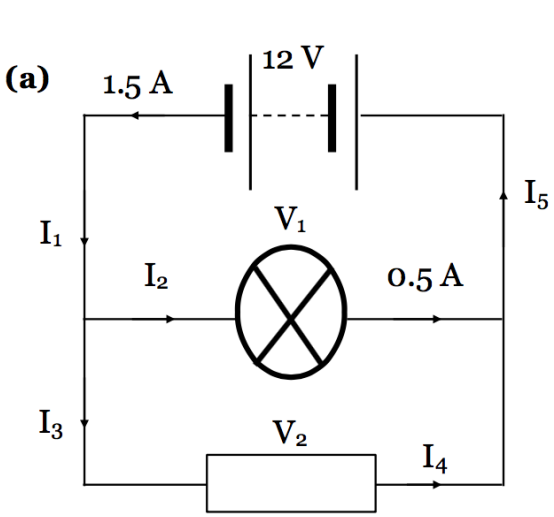
2. Calculate the voltage across the lamp in each of these parallel circuits.

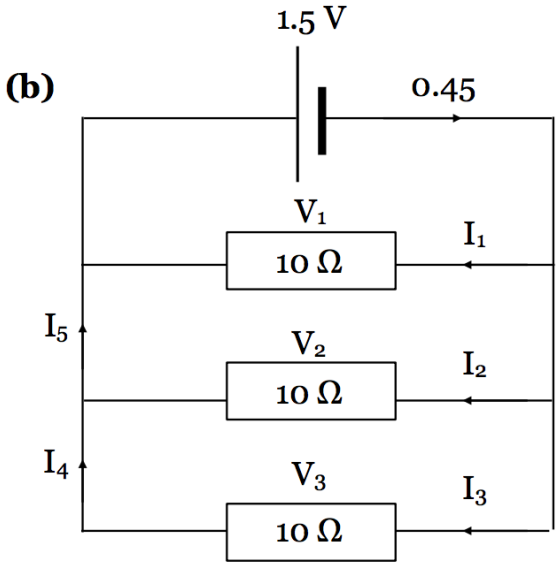


3. In an experiment, two identical resistors are connected in parallel to a power supply which has 0.58 A drawn from it. Calculate the current through each resistor.



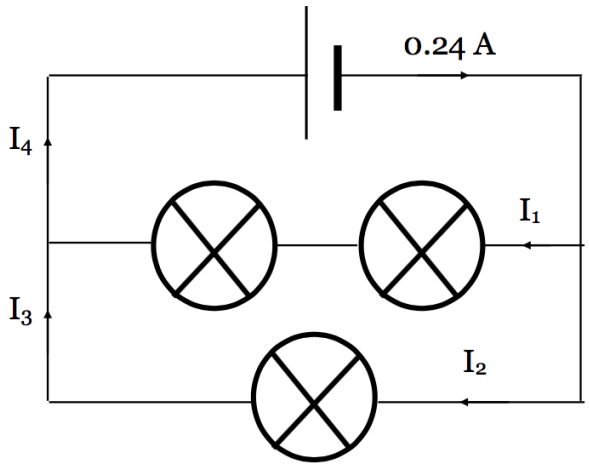
4. Calculate the missing currents and voltages in these parallel circuits.



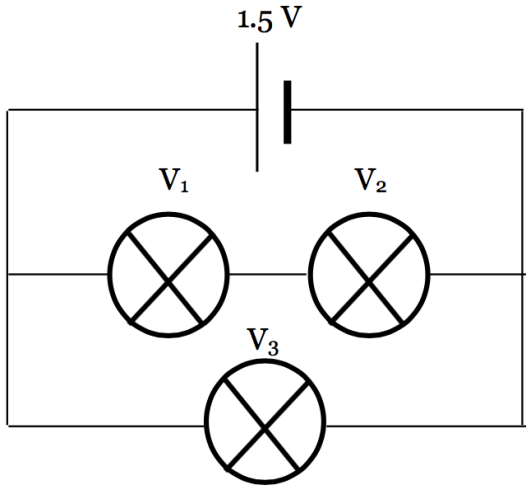


Mixed Circuits

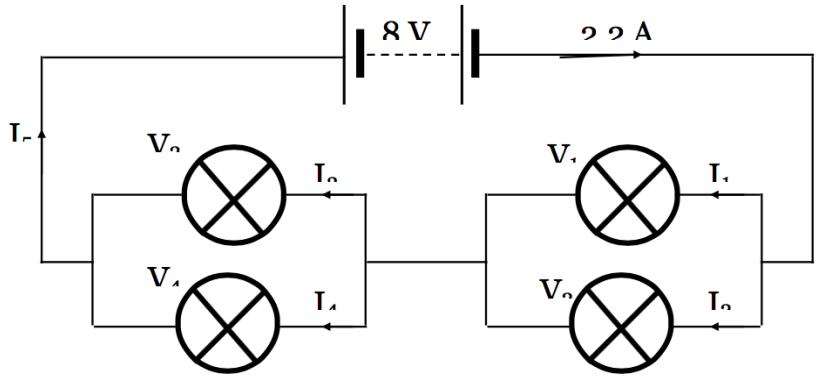
1. Calculate the missing currents in this circuit. Assume that all lamps are identical.



2. Calculate the missing voltages in this circuit.



3. Calculate the missing voltages and currents in this circuit. Assume that all lamps are identical.



Ohm's Law

1. What is meant by the 'resistance' of a component?

2. What is the meaning of the term 'voltage' or 'potential difference'?

3. What is the resistance of a lamp that allows 600 mA of current to flow through it when there is a potential difference of 12 V across it?

4. What is the current flowing through a piece of 10 kΩ resistance wire when a voltage of 15 V is across it?

5. What is the voltage across a 125 Ω lamp that has a current of 1.84 A flowing through it?

6. Copy and complete this table.

Voltage / V	Current / A	Resistance / Ω
	0.4	150
	0.05	40
12		60
8		400
230	5	
10	0.08	

7. In an experiment, a lamp is connected to a variable supply and left on for a few minutes until its brightness is constant. The voltage across the lamp is changed to different values and the current flowing through it is measured. The results are shown in the table below.

Voltage / V	Current / A
0	0
2	0.44
4	0.88
6	1.33
8	1.78
10	2.22

Draw a line graph of these results and use the gradient of the straight line to find the resistance of the lamp.

8. The same experiment is repeated except this time, the measurements are made immediately after turning on the lamp. The results are shown in the table.

Draw a line graph of these results and explain why a straight line is not found.

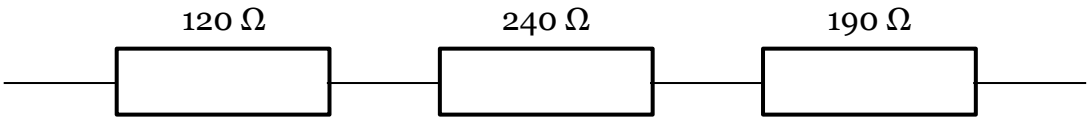
Voltage / V	Current / A
0	0
2	0.18
4	0.45
6	0.98
8	1.78
10	2.22

Resistors in Series

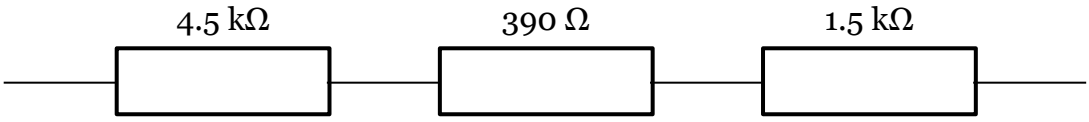
1. What happens to the total resistance of a circuit as more resistors are connected in series?

2. Calculate the total resistance of these combinations of resistors.

(a)



(b)



3. Copy and complete this table.

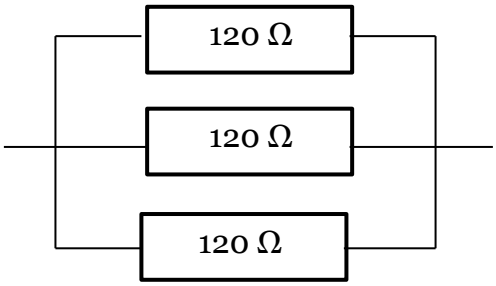
R_t / Ω	R_1 / Ω	R_2 / Ω	R_3 / Ω
	100	65	80
1450		250	250
2700	1320		550
1900	1230	45	

Resistors in Parallel

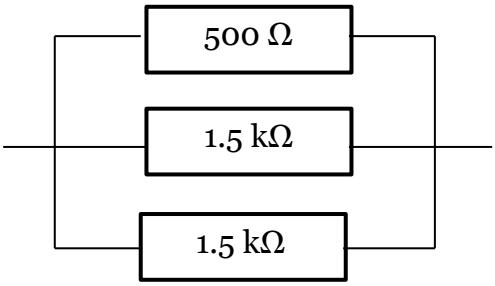
1. What happens to the total resistance of a circuit as more resistors are added in parallel?

2. Calculate the total resistance of these combinations of resistors.

(a)



(b)



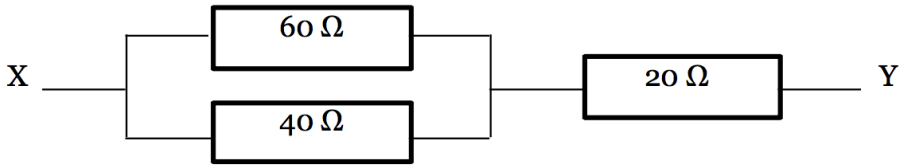
3. Copy and complete this table.

R_t / Ω	R_1 / Ω	R_2 / Ω	R_3 / Ω
	60	60	60
10		30	30
100	200		300
50	100	300	

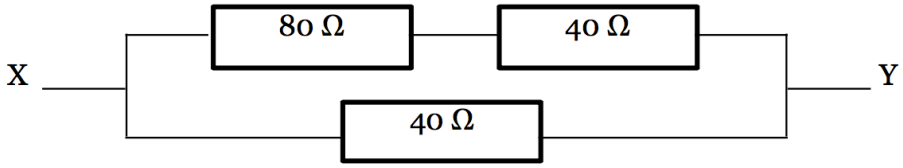
Resistors in Mixed Circuits

1. Calculate the total resistance between X and Y in these circuits:

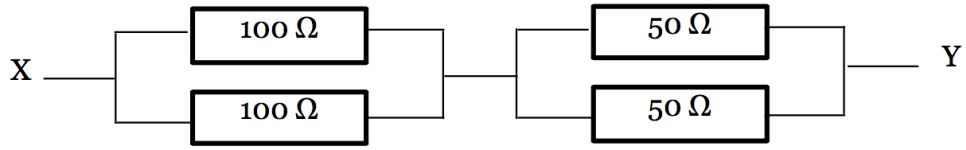
(a)



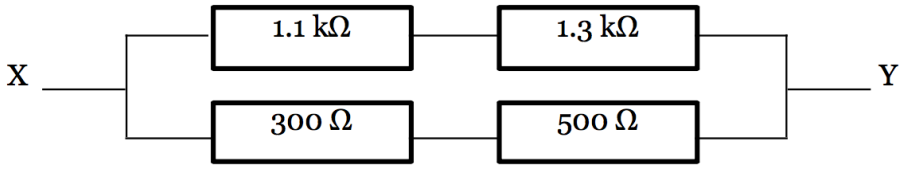
(b)



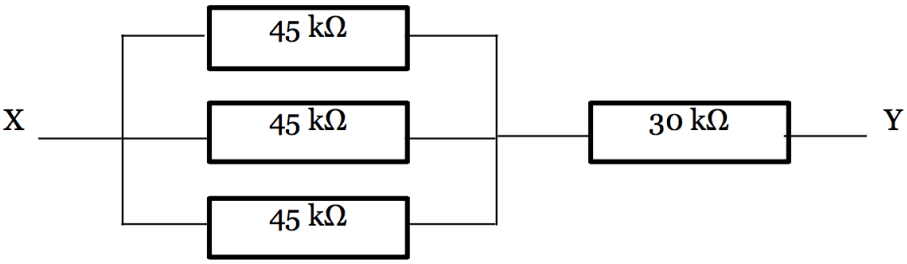
(c)



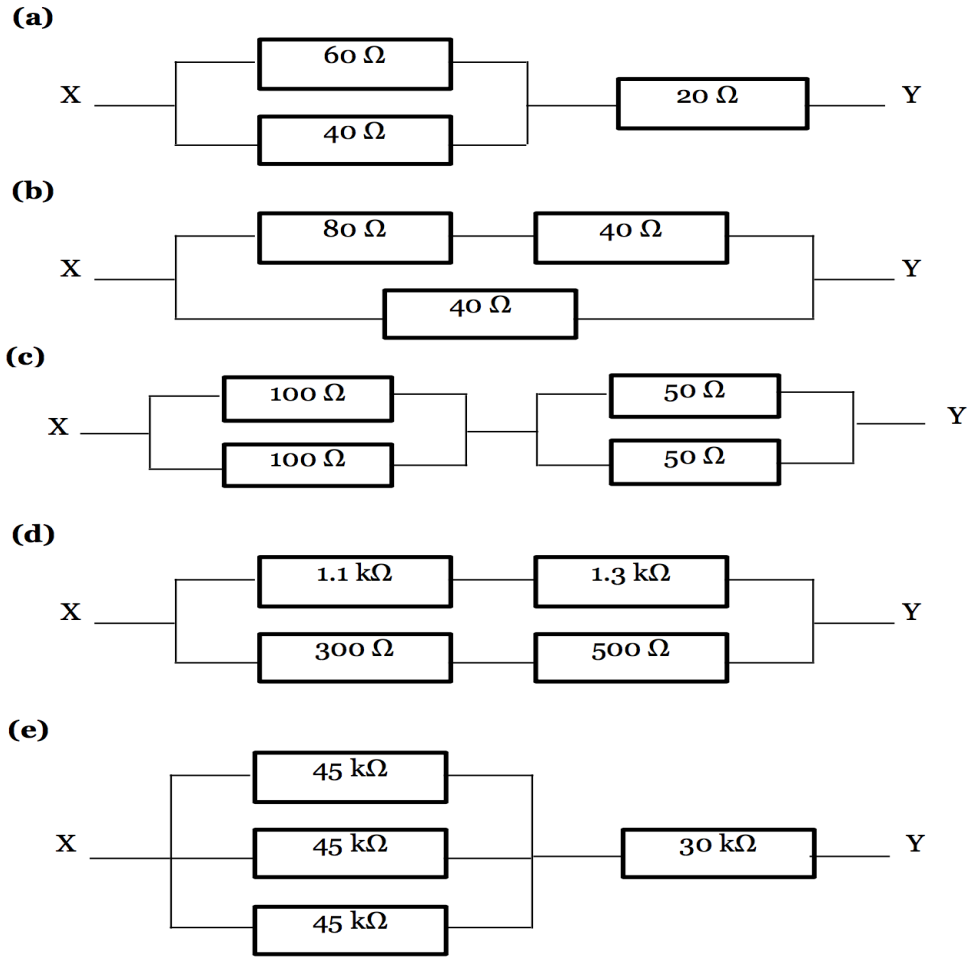
(d)



(e)



2. Show, by calculation, which resistor combination has the lowest resistance.



3. In a science lesson, a student is given three 1.2 kΩ resistors. What is the lowest possible resistance that the student could achieve by combining these resistors in to a circuit?

4. In another science lesson, a student is given five 40 Ω resistors. Show how the student could combine all five resistors so that the total resistance of the circuit is:

   a) 200 Ω

   b) 8 Ω

   c) 48 Ω

   d) 32 Ω

   e) 50 Ω

   f) 80 Ω

Electrical Power

1. A student makes a statement: “The power of a light bulb is 60 W.” What does this statement mean, in terms of energy?

2. What is the power of a radio that uses up 27 kJ of electrical energy in five minutes?

3. How much electrical energy is used up by a 725 W fridge in one day?

4. How long will it take a 1.2 kW vacuum cleaner to use up 720 kJ of electrical energy?

5. A 42 inch LED television has a power rating of 52W when it is fully operational. When it is on standby, the television has a power rating of 0.8W.

   a) How much electrical energy will the television use if it is fully operational for 4 hours?

   b) How much electrical energy will the television use if it is on standby for 10 hours?

   c) Will the television use up more electrical energy being on standby for two days or being fully operational for 45 minutes?

6. The power consumption of three game consoles is given in the table.

Games Console	Power Consumption (W)
Nintendo Wii U	33
Playstation 4	140
X Box One	120

   a) How much electrical energy will a Playstation 4 use up in 60 minutes?

   b) How long, in hours, will it take an X Box One to use up 792kJ of electrical energy?

   c) How much less energy does a Nintendo Wii U use if it is played for half an hour, compared to an X Box One?

7. Complete this table:

Power / W	Energy / J	Time / s
	800	10
	5,100	60
1500		30
1450		900
218	54,500	
1500	210,000	

8. A hairdryer is connected to a joulemeter and the amount of energy used up every 60 seconds is observed. The results are shown in the table.

   Draw a line graph of energy consumed against time, and use the gradient of the straight line to calculate the power rating of the hairdryer.

Power, Current and Voltage

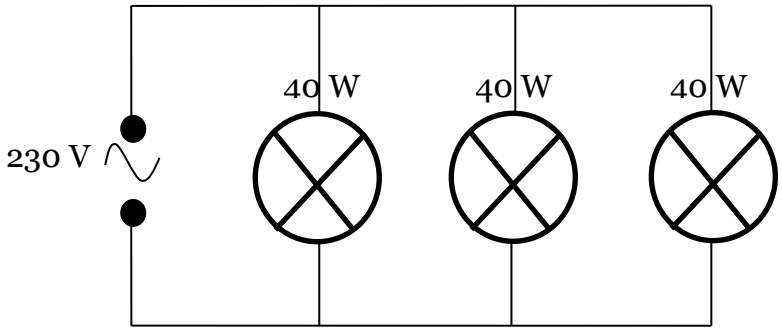
Note: Mains voltage in the UK is 230 V.

1. What is the power rating of a microwave that has a current of 3.3 A flowing through it when it is plugged in to the mains?

2. What is the current flowing through a 65 W laptop that has a potential difference of 18.5 V across it?

3. What is the voltage across a 6 W light bulb that has a current of 500 mA flowing through it?

4. Three 40 W light bulbs are connected in parallel with the mains power supply, as shown.



   What is the current drawn from the mains?

5. Copy and complete this table:

Power / W	Current / A	Voltage / V
	0.3	4.5
	1.5	12
750		25
1150		230
40	0.8	
30	0.75	

6. In an American school laboratory, a pupil measures the current flowing through some different mains appliances with given power ratings. The results of this experiment are shown below:

Power Rating of Appliance / W	Current / A
100	0.91
250	2.27
400	3.64
600	5.45
800	7.27
1250	11.36

Construct a line graph of power against current, and use the gradient of the straight line to calculate mains voltage in the USA.

Power and Resistance

1. Combine the equations $P = IV$ and $V = IR$ in order to derive the equation, $P=I^2R$.

2. What is the power rating of a lamp that has a resistance of 5 Ω and a current of 1.2 A flowing through it?

3. What is the current flowing through a 50 Ω heating element in a toaster if it has a power rating of 800 W?

4. What is the resistance of a 1200 W electric convection heater that has a current of 5.0 A flowing through it?

5. Copy and complete this table:

Power / W	Current / A	Resistance / Ω
	1.5	100
	0.8	50
500		125
34		850
735	7.0	
36	0.06	

Power and Resistance Continued

1. Combine the equations $P = IV$ and $I = V / R$ to derive the equation $P=V^2/R$.

2. What is the power rating of a mains television that has a resistance of 529 Ω?

3. What is the voltage across a portable electric shaver that has a resistance of 2.45 Ω and a power rating of 20 W?

4. What is the resistance of an 800 W mains powered coffee machine?

5. A 130 W tropical fish aquarium is connected to the mains.

   a) What is the resistance of the aquarium?

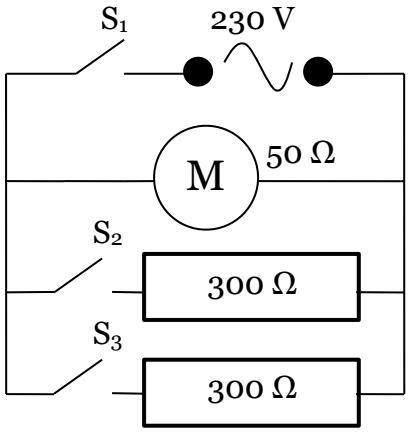
   b) What is the current flowing through the aquarium?

   c) How much energy is used up by the aquarium in 24 hours?

6. Copy and complete this table:

Power / W	Voltage / V	Resistance / Ω
	10	5
	6	72
25		9
1.8		20
20	20	
400	230	

7. A hairdryer has three heat settings: cold, warm and hot. The hairdryer is made up of two 300 Ω resistors and a 50 Ω motor that are connected in parallel with the mains supply, as shown.



a) What is the energy change that occurs when current flows through a resistor?

Time / s	Energy Consumed / J
0	0
60	78,000
120	156,000
180	234,000
240	312,000
300	390,000

b) Which switches are closed when the hairdryer is blowing out warm air?

c) How much current is drawn from the mains when the hairdryer is blowing out cold air?

d) What is the power rating of the hairdryer when it is blowing out cold air?

e) What is the total resistance of the hairdryer when it is blowing out hot air?

f) What is the power rating of the hairdryer when it is blowing out hot air?

g) How much electrical energy will the hairdryer use if it blows cold air for 1 minute and hot air for 8 minutes?

8. Why is it useful that electricity flows through transmission lines at a very high voltage?

9. Wires used in transmission lines have a resistance of 0.0025 Ω/m. How much power is lost by transmission lines carrying a current of 12 A if the length of the lines are:

   a) 1 m?

   b) 30 m?

   c) 2.5 km?