epiSTEMe
Study Booklet
Electricity:
electrical circuits

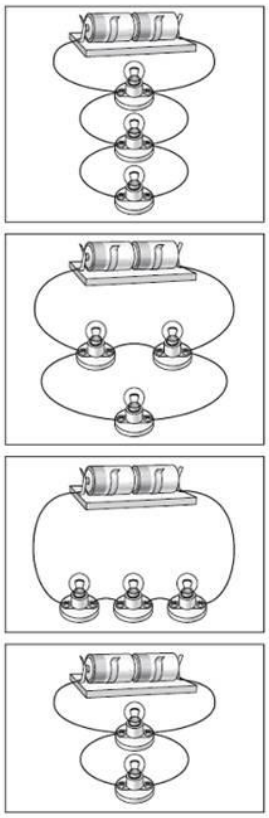
FIRST NAME

LAST NAME

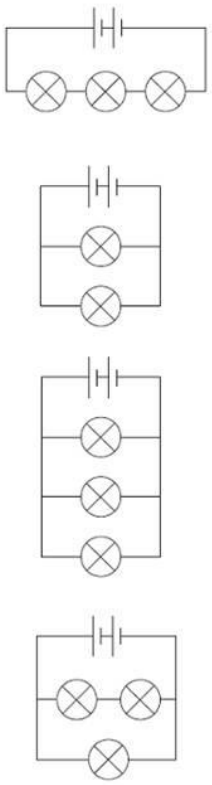
Four circuits

Draw a line from each electrical circuit to the correct circuit diagram. Draw only four lines.

electrical circuit

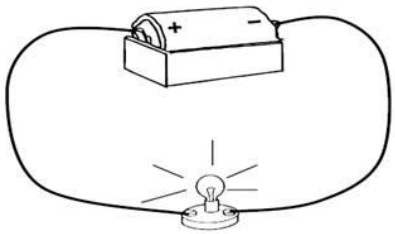


circuit diagram



Bulb light

This is a very simple electrical circuit.



EXPLAIN in as much detail as you can (thinking about both battery and bulb) why you think the bulb lights.

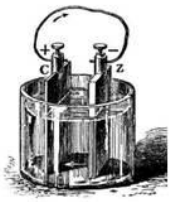
How would you change the circuit to make the bulb brighter? Explain why this would work.

If the circuit is left on, why will the battery go FLAT eventually?

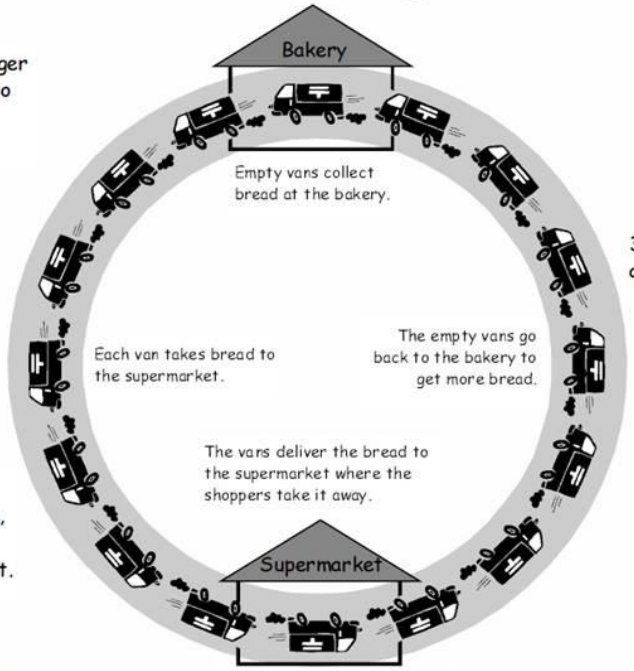
Alessandro Volta

What can you find out about Alessandro Volta?

What did the first electric batteries look like and what were they used for?



Supermarket delivery vans (2)



1. The bakery manager loads the bread onto the vans and sends them off.

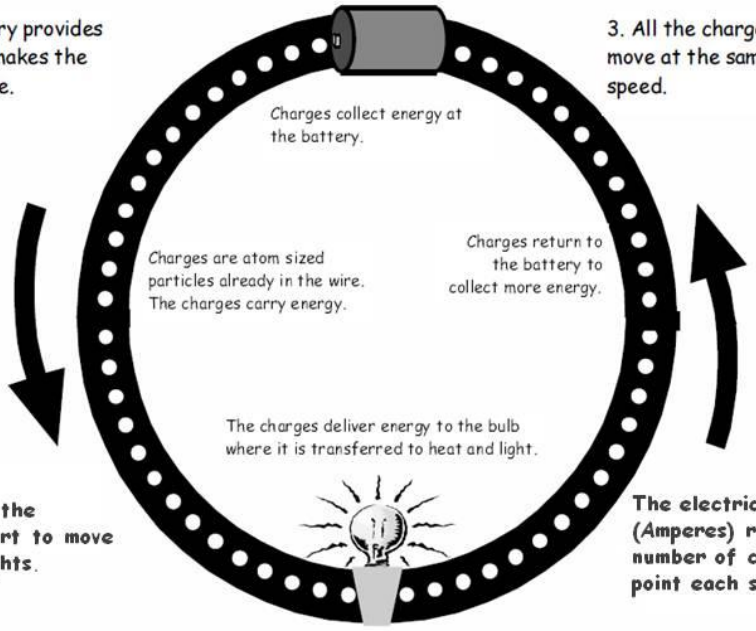
2. As soon as the vans start to move, bread is delivered to the supermarket.

3. All the vans move at the same speed.

4. If the vans travel faster, more bread is delivered to the supermarket in a certain time.

5. If the manager loads more bread on to each van, more bread is delivered to the supermarket in a certain time.

Supermarket delivery vans (3)



1. The battery provides energy and makes the charges move.

2. **As soon the charges start to move the bulb lights.**

3. All the charges move at the same speed.

The electric current (Amperes) reflect the number of charges passing a point each second.

4. If the charges move faster, more energy is transferred to the lamp in a certain time.

5. If more energy is carried by each charge, more energy is delivered to the bulb in a certain time.

Supermarket delivery vans (4)

1.The bakery is like the _____ in the circuit.

2.The vans are like the _____ in the wire.

3.The bread the vans are carrying is like the _____ carried by the _____ in the wire.

4.The supermarket is like the _____. Here, the bread is passed onto the customers just like the _____ carried by the charge is changed into _____ energy and _____ energy in the bulb.

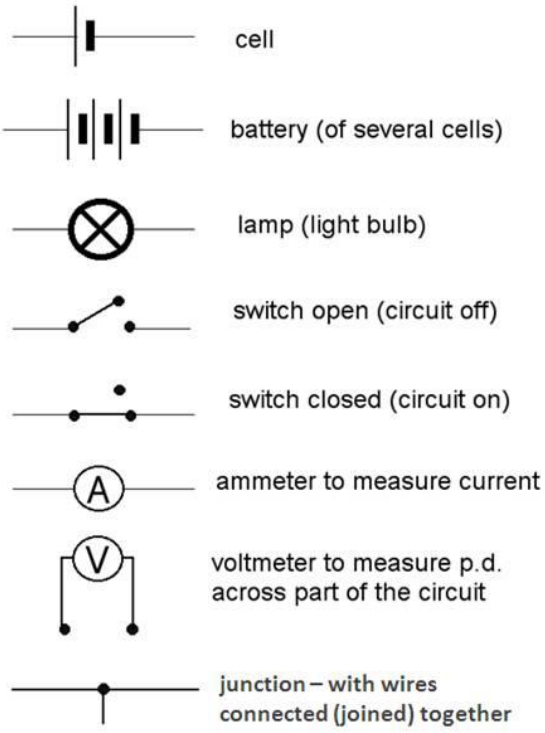
5.The empty vans return to the bakery for more bread. This is the same as the _____ going back to the _____ for more _____.

6.If the bakery manager sends vans from the bakery more often, bread arrives more often at the supermarket. This is like _____ arriving more quickly at the _____ in the circuit.

7.If the bakery manager loads more bread onto each van, then more bread is delivered to the supermarket in a certain time. This is like more _____ being delivered to the _____ in a certain time in the circuit.

8.The chain of moving vans is like a flow of _____ . In a circuit we call this an _____ _____.

Circuit diagrams

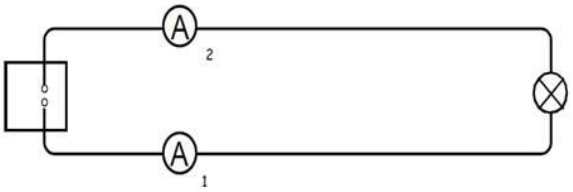


The BIG CIRCUIT diagram

Mr. Harris set up the BIG CIRCUIT in his laboratory. He measured the currents in two places and found:

Current 1 = 1.8 Amps

Current 2 = 1.8 Amps



Robbie says: "That is not right. The current gets used up in the bulb to give heat and light."

Is Robbie correct?

Explain why you think this. You might want to refer to the supermarket picture ideas.

Pros and cons of analogies

Can you think of any advantages of analogies?

Can you think of any disadvantages of analogies?

Can you make up your own science analogy?

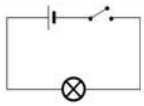
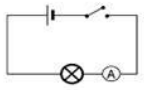
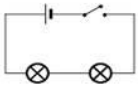
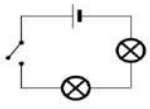
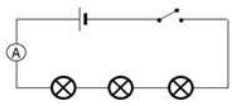
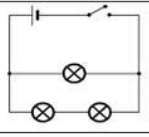
Electrical circuit analogy

Can you think of an analogy that explains how an electrical circuit works?

'An electrical circuit is like… because…'

Breaking the circuit code

Match the circuits set out around the room with the diagrams on the sheet.

A		Circuit No.
B		Circuit No.
C		Circuit No.
D		Circuit No.
E		Circuit No.
F		Circuit No.

Your alien pen pal

You have an alien pen friend who lives on a planet just like earth - with seas, and trees, and mountains, and fluffy clouds. However, animal life has ***evolved*** very differently on his planet and he has a very different ***anatomy*** to you - he is just like a big blob!

Your friend is intrigued when you write about parts of your body, as he does not have legs and arms or a nose or ears. Your friend wonders what teeth are like, what your pulse is like, what your skeleton is like, and so on.

Can you think of some things that these things are like and explain it to your friend in that way?

Use sentences like this one: Teeth are like _____ because _____

Remember, I am not asking you to describe teeth, pulse, skeleton, and so on, but to suggest things that are in some way ***like*** *these things to see if that helps your friend understand.*

Electric current

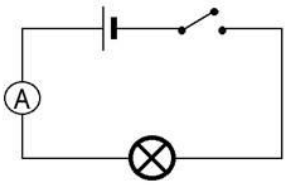
A bulb is connected to a battery. The bulb is lit.

☐	There is an electric current through one wire to the bulb. It is all used up in the bulb. So there is no current in the other wire.
☐	There is an electric current through one wire to the bulb. **Some** of it is used up in the bulb. So there is a **smaller current** in the other wire.
☐	There is an electric current through one wire to the bulb. It passes through the bulb and back to the battery. The current in the other wire is **the same size**.
☐	There are **two** electric currents from the battery to the bulb. They **meet** at the bulb and this is what makes it light.

Which of the following statements best describes the ***electric current*** *in the circuit? Tick one box.*

Electric current in a simple circuit (1)

1) Build the circuit on the right, with the switch open.



Circuit with switch open

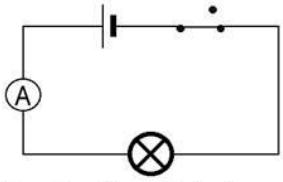
2) What is the reading on the ammeter? _____ Amperes

3) PREDICT what the reading will be if you close the switch (see on the right). Give reasons.

_____

_____

_____



Circuit with switch closed

4) OBSERVE what happens when you close the switch. What is the reading on the ammeter? _____ Amperes

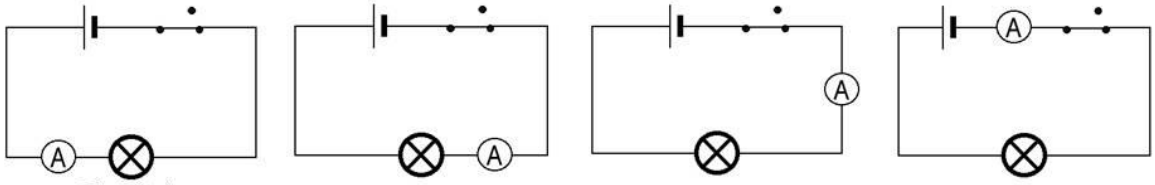
5) EXPLAIN why closing the switch has this effect.

_____

_____

Electric current in a simple circuit (3)

In the four circuits below, the ammeter is placed at different points in the circuit.



Circuit 1 Circuit 2 Circuit 3 Circuit 4

1) What do **you** think? Will the ammeter give the same or a different reading in the four circuits? Tick one box.

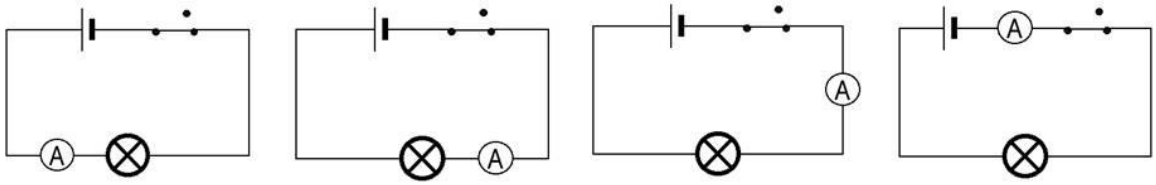
Same ☐ Different ☐

2) Now discuss in your **group** whether the ammeter will give the same or a different reading in the four circuits. Tick one box.

Same ☐ Different ☐

3) Try to reach an agreement and give reasons.

Electric current in a simple circuit (3) continued



Circuit 1 Circuit 2 Circuit 3 Circuit 4

1) PREDICT the ammeter reading when the switch is closed.

Circuit 1: ___ Amperes Circuit 2: ___ Amperes

Circuit 3: ___ Amperes Circuit 4: ___ Amperes

2) Build the circuit and OBSERVE the ammeter reading.

Circuit 1: ___ Amperes Circuit 2: ___ Amperes

Circuit 3: ___ Amperes Circuit 4: ___ Amperes

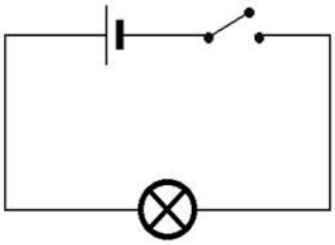
3) EXPLAIN the measurements that you have obtained. Give reasons.

_____

_____

Eddie/Edwina the electron in a simple circuit

Imagine you are Eddie/Edwina the electron, who 'lives' in the circuit shown here.



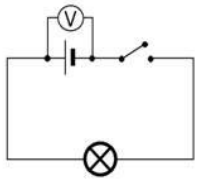
Describe a day in the 'life' of E.

Remember that E and his/her friends move very fast, and there are LOTS of them all around the circuit.

Also remember that E is set to work when the switch is closed, but has to stop when the switch is open.

p.d./voltage in a simple circuit (1)

1) Build the circuit on the right, with the switch open.



Circuit with switch open

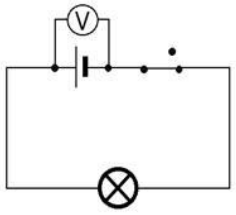
2) What is the reading on the voltmeter? _____ V

3) PREDICT what the reading will be if you close the switch (see on the right). Give reasons.

_____

_____

_____



Circuit with switch closed

4) OBSERVE what happens when you close the switch. What is the reading on the voltmeter? _____ V

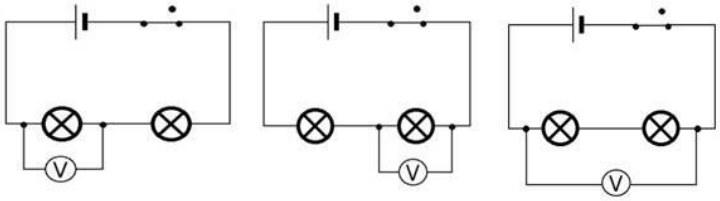
5) EXPLAIN why closing the switch has this effect.

_____

_____

p.d./voltage in a series circuit (2)

In the three circuits to the right, the voltmeter is placed at different points in the circuit.



Circuit 3 Circuit 4 Circuit 5

1) PREDICT the voltmeter reading for circuits 3, 4 and 5.

Circuit 3: _____ V Circuit 5: _____ V

Circuit 4: _____ V

2) Move the voltmeter to the points as shown in the diagrams and OBSERVE the voltmeter readings.

Circuit 3: _____ V Circuit 5: _____ V

Circuit 4: _____ V

3) EXPLAIN the readings. Include the words current, p.d. and energy in your explanation.

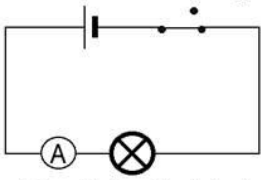
_____

_____

_____

Electric current in a series circuit (1)

1) Build circuit 1 on the right, with 1 bulb.



Circuit 1 with 1 bulb

2) What is the reading on the ammeter?

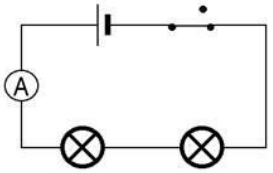
Circuit 1: _____ Amperes

3) PREDICT what the reading will be if you add another bulb (circuit 2 on the right). Give reasons.

_____

_____

_____



Circuit 2 with 2 bulbs

4) OBSERVE what happens when you add another bulb. What is the reading on the ammeter?

Circuit 2: _____ Amperes

5) EXPLAIN the reading. Include the words current, p.d. and energy in your explanation.

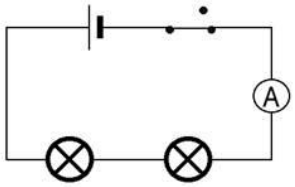
_____

_____

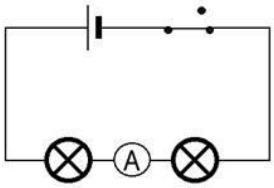
_____

Electric current in a series circuit (2)

In the two circuits below, the ammeter is placed at different points in the circuit.



Circuit 3



Circuit 4

1) PREDICT the ammeter reading for circuit 3 and circuit 4.

Circuit 3: _____ Amperes

Circuit 4: _____ Amperes

2) Move the ammeter to the points as shown in the diagrams and OBSERVE the ammeter reading.

Circuit 3: _____ Amperes

Circuit 4: _____ Amperes

3) EXPLAIN the reading. Include the words current, p.d. and energy in your explanation.

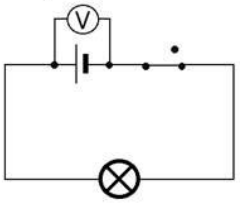
_____

_____

_____

p.d./voltage in a series circuit (1)

1) Build circuit 1 on the right, with 1 bulb.



Circuit 1 with 1 bulb

2) What is the reading on the voltmeter?

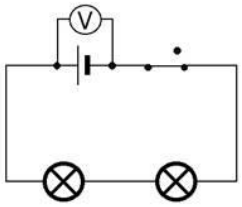
Circuit 1: _____ V

3) PREDICT what the reading will be if you add another bulb (circuit 2 on the right). Give reasons.

_____

_____

_____



Circuit 2 with 2 bulbs

4) OBSERVE what happens when you add another bulb. What is the reading on the voltmeter?

Circuit 2: _____ V

5) EXPLAIN the reading. Include the words current, p.d. and energy in your explanation.

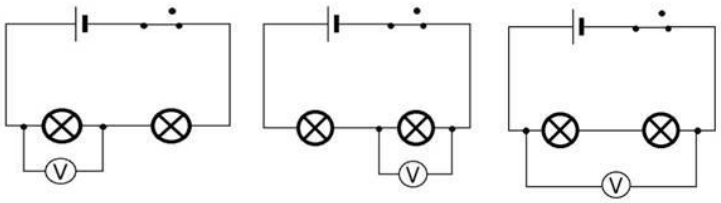
_____

_____

_____

p.d./voltage in a series circuit (2)

In the three circuits to the right, the voltmeter is placed at different points in the circuit.



Circuit 3 Circuit 4 Circuit 5

1) PREDICT the voltmeter reading for circuits 3, 4 and 5.

Circuit 3: _____ V Circuit 5: _____ V

Circuit 4: _____ V

2) Move the voltmeter to the points as shown in the diagrams and OBSERVE the voltmeter readings.

Circuit 3: _____ V Circuit 5: _____ V

Circuit 4: _____ V

3) EXPLAIN the readings. Include the words current, p.d. and energy in your explanation.

_____

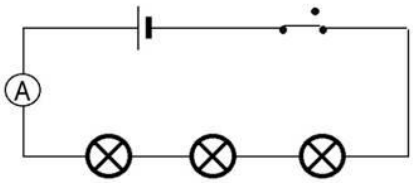
_____

_____

Electric current in a series circuit with three bulbs

1) Build circuit 1 on the right, with 3 bulbs.

2) What is the reading on the ammeter?



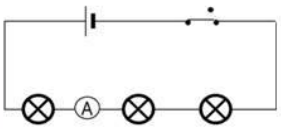
Circuit 1

Circuit 1: _____ Amperes

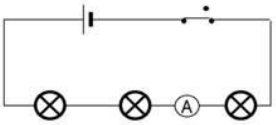
3) PREDICT what the reading will be if you move the ammeter around the circuit as shown below.

4) Move the ammeter to the points as shown in the diagrams and OBSERVE the ammeter reading.

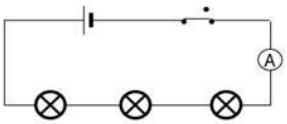
5) EXPLAIN the reading. Include the words current, p.d. and energy in your explanation.



Circuit 2



Circuit 3



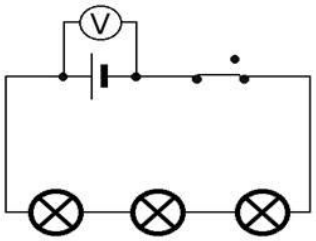
Circuit 4

Predicted	_____ Amperes	_____ Amperes	_____ Amperes
Observed	_____ Amperes	_____ Amperes	_____ Amperes

p.d./voltage in a series circuit with three bulbs

1) Build circuit 1 on the right, with 3 bulbs.

2) What is the reading on the voltmeter?



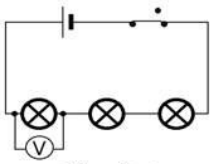
Circuit 1

Circuit 1: _____ V

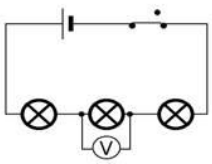
3) PREDICT what the reading will be if you move the voltmeter around the circuit as shown below.

4) Move the voltmeter to the points as shown in the diagrams and OBSERVE the ammeter reading.

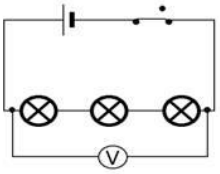
5) EXPLAIN the readings. Include the words current, p.d. and energy in your explanation.



Circuit 2



Circuit 3



Circuit 4

Predicted	_____ V	_____ V	_____ V
Observed	_____ V	_____ V	_____ V

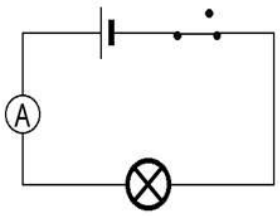
Electric current and p.d/voltage in a series circuit with several cells

What is different between circuit 1 and circuit 2?

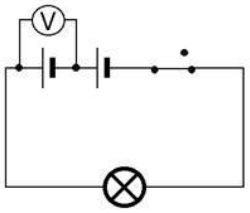
How will the current be affected?

What is different between circuits 3, 4, 5 and 6?

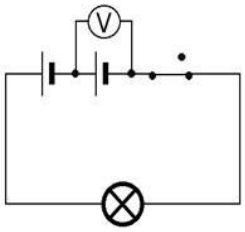
How will the p.d./voltage be affected?



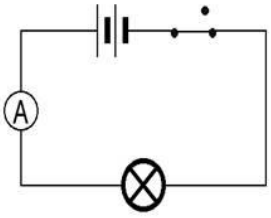
Circuit 1



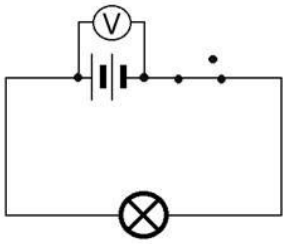
Circuit 3



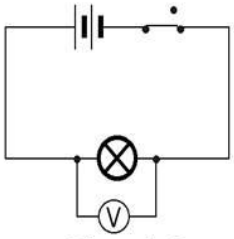
Circuit 5



Circuit 2



Circuit 4



Circuit 6

Modelling series circuits

What might the different arrows represent in these diagrams?

Which diagram is a better model of what you have found out?

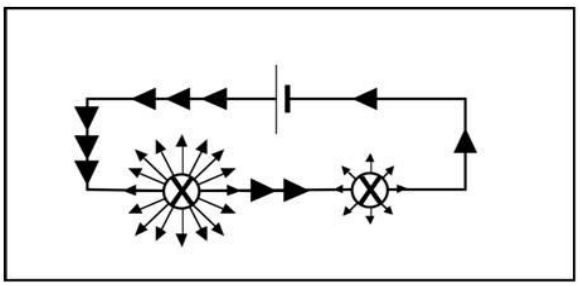


Diagram 1

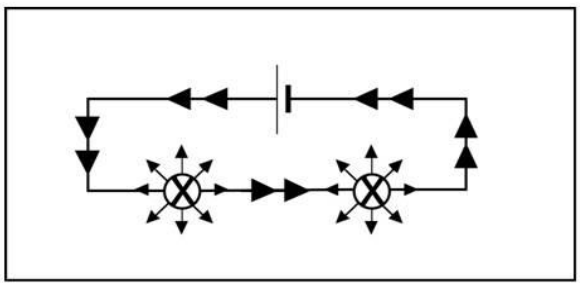


Diagram 2

Making sense of series circuits (1)

Using the supermarket delivery vans model, make complete sentences by matching the phrases on the left with those on the right. Use arrows.

1) The bakery stores the goods in a similar way to…
2) The roads have a similar role to…
3) The supermarket allows goods from the van to be widely spread…
4) The vans that move around the roads are like…
5) Each individual van with its load of goods is like…
6) Traffic lights are like…

A) …a single electron carrying some energy around the circuit.
B) …like a lamp spreads out energy brought by the current.
C) …a switch which can stop the current.
D) …the wires that provide a pathway for the current.
E) …the cell is a store of energy.
F) …the current that flows around the circuit.

Making sense of series circuits (2)

Using the supermarket delivery vans model, make complete sentences by matching the phrases on the left with those on the right. Use arrows.

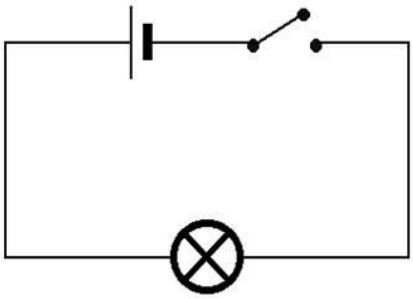
However, the supermarket delivery vans model is only a model, so…

1) Vans come in different shapes and sizes, ***whereas***…
2) Traffic lights only stop the vans in one place, ***whereas***…
3) Vans stop when drivers need rest or meals, ***whereas***…

A) …a switch will immediately stop current flowing all the way around the loop.
B) …the current does not stop as long as there is an energy source and a complete circuit.
C) …all the electrons moving around a circuit are identical.

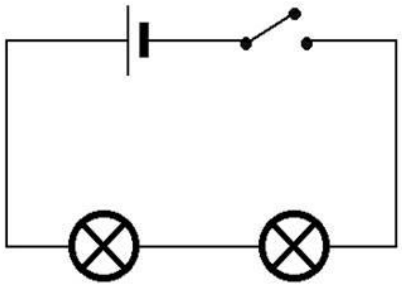
Supermarket delivery vans model in series circuits (1)

So far you have used the supermarket delivery vans model for series circuits that contain 1 bulb only, e.g. circuit 1 on the right side.



Circuit 1 with 1 bulb

Now, try to explain circuit 2 in terms of the supermarket delivery vans model.

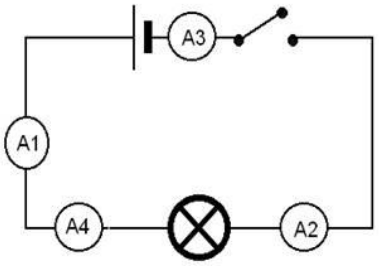


Circuit 2 with 2 bulbs

Supermarket delivery vans model in series circuits (2)

When the current was measured in circuit 1, it was found that the ammeters gave readings of

A1 = 0.25 A
A2 = 0.25 A
A3 = 0.25 A
A4 = 0.25 A

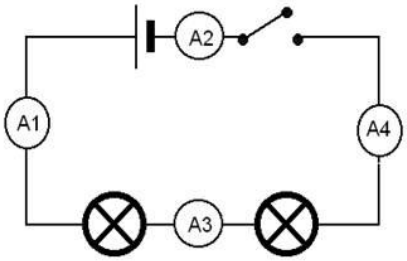


Circuit 1

Use the supermarket delivery vans model to explain what is going on in circuit 1.

Supermarket delivery vans model in series circuits (2) continued

What is different in circuit 2?



Circuit 2

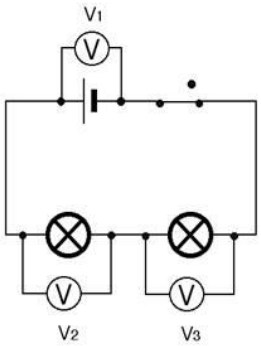
What effect will the second lamp have on the ammeter readings?

Use the supermarket delivery vans model to explain your answer.

Supermarket delivery vans model in series circuits (3)

When the p.d./voltage was measured in circuit 2, it was found that the voltmeters gave readings of

$V_1 = 1.3V$
$V_2 = 1.3V$
$V_3 = 2.5V$

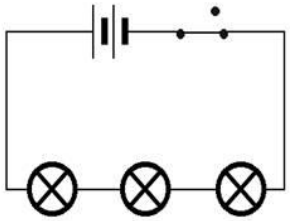


Circuit 2

Use the supermarket delivery vans model to explain what is going on in circuit 2.

Eddie/Edwina the electron in a series circuit

Imagine you are Eddie/Edwina the electron, who 'lives' in the circuit shown here.



Describe a day in the 'life' of E.

Remember that E and his/her friends move very fast, and there are LOTS of them all around the circuit.

Also remember that E has to use the energy the cells provide to get around the whole circuit.

Stairs and lights

In many houses there are lights above the stairs that have two switches.

This means that the light can always be turned on or off from either downstairs or upstairs. See if you can find out how this is done.

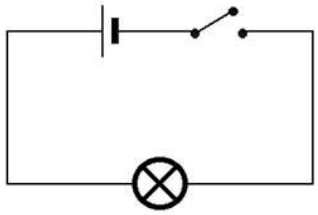
Draw a circuit diagram to the right with one lamp, one cell, and two switches, so that the lamp can always be turned on or off from either switch.

Explain how the two switches can 'independently' control the same lamp.

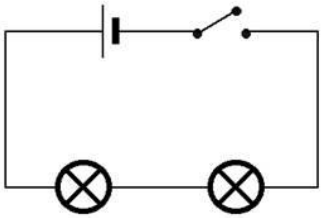
Introducing parallel circuits

What is similar between the circuits?

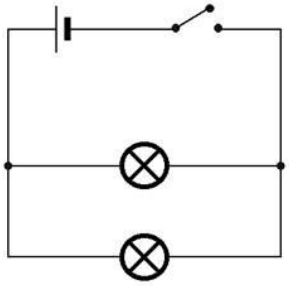
What is different between the circuits?



Circuit 1



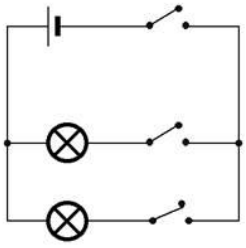
Circuit 2



Circuit 3

Electric current in a parallel circuit (1)

The circuit diagram shows a circuit with two lamps in parallel. There are three switches in the circuit.



Circuit 1

1) PREDICT which switches would need to be closed so that
a) each lamp glows alone
b) both lamps glow together.

a) _____

b) _____

2) Build the circuit and OBSERVE what happens.

_____

_____

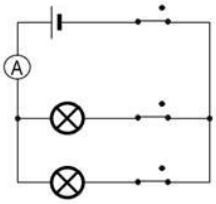
3) EXPLAIN your observations. Include the words 'parallel', 'current' and 'energy' in your explanation.

_____

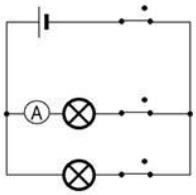
_____

_____

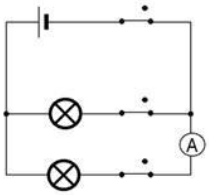
Electric current in a parallel circuit (2)



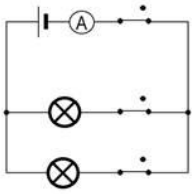
Circuit 1



Circuit 2



Circuit 3



Circuit 4

1) PREDICT whether the ammeters would all give the same readings. If not, would you expect any pattern in the readings? Give reasons.

2) Build the circuit, move the ammeter around as shown and OBSERVE the readings.

Circuit 1: _____ Amperes

Circuit 2: _____ Amperes

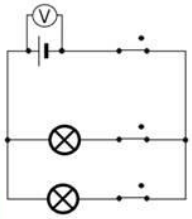
Circuit 3: _____ Amperes

Circuit 4: _____ Amperes

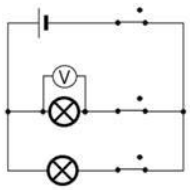
3) EXPLAIN your observations. Include the words 'parallel', 'current' and 'junction' in your explanation.

p.d./voltage in a parallel circuit

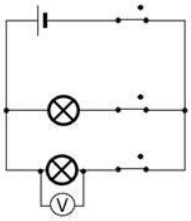
The voltmeter is reading p.d. across different components in each circuit .



Circuit 1



Circuit 2



Circuit 3

1) PREDICT whether the voltmeters would all give the same readings. If not, would you expect any pattern in the readings? Give reasons.

2) Build the circuit, then move the voltmeter around as shown and OBSERVE the readings.

Circuit 1: _____ V

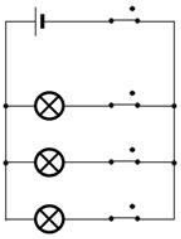
Circuit 2: _____ V

Circuit 3: _____ V

3) EXPLAIN your observations. Include the words 'parallel', 'p.d.' and 'energy' in your explanation.

Electric current and p.d./voltage in a parallel circuit

This circuit diagram shows a cell powering three lamps in parallel.



Circuit 1

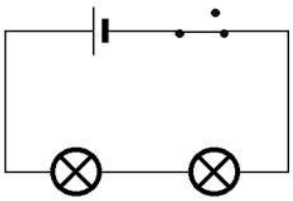
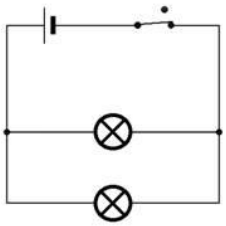
1) How will current vary around the circuit?

2) How will current flowing from the cell compare with current through each lamp?

3) How will the p.d. across each component in the circuit compare?

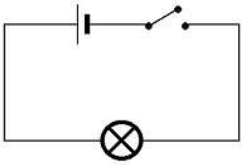
4) How you could test your predictions?

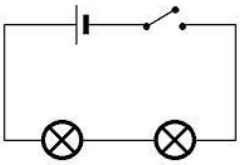
Summarising key ideas about series and parallel circuits

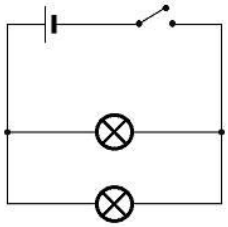
	Series 	**Parallel** 
current	The same through both lamps	Divided between the two branches
p.d.	Divided across the two lamps	The same across both lamps

Comparing circuits to the supermarket delivery vans model (1)

Use the supermarket delivery vans model to explain what goes on in each of the three circuits when the switches are closed.

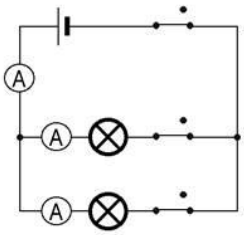






Comparing circuits to the supermarket delivery vans model (2)

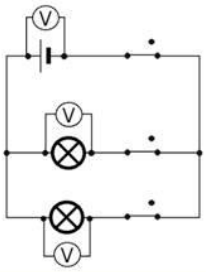
Recap: In a parallel circuit the current divides at a junction, with some current going along each wire. This means that there is less current passing through each lamp than left the cell.



Explain this by using the supermarket delivery vans model.

Comparing circuits to the supermarket delivery vans model (3)

Recap: Even though the current is split at a junction, the p.d. across each branch of the circuit is as much as the p.d. across the cell. That might sound like magic!



Explain how this is possible using the supermarket delivery vans model.

Christmas tree lights

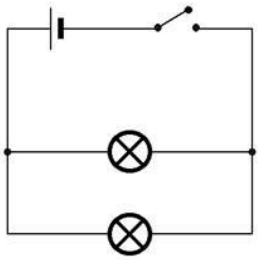
Mr Holiday had bought two Christmas trees – one for the lounge and one for the dining room. One of the trees had a set of lights connected in series. The other tree also had a set of lights, but connected in parallel.

By Boxing Day, one of the lamps on each tree had broken. However, all the lights had gone out on one of the trees.

Explain why all the lights had gone out on one of the trees but not on the other. In your explanation, use the words 'current', 'switch', 'series', 'conduct', 'parallel'.

Eddie/Edwina the electron in a parallel circuit

Imagine you are Eddie/Edwina the electron, who 'lives' in the circuit shown here.



Describe a day in the 'life' of E.

Remember that when E reaches a junction, E has to go one way or another. How does E decide?

Hint: Remember E and his/her friends move very fast, and there are LOTS of them all around the circuit.

Practicing parallel circuits

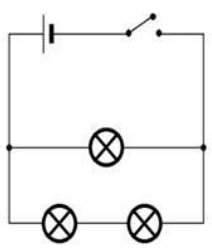
1) DESCRIBE the arrangement of components in each circuit (using the words 'series' and 'parallel').

2) PREDICT how the current passing through different parts of the circuit will compare when the switch is closed. Draw ammeters into the circuit diagram to show each of the positions you would place ammeters.

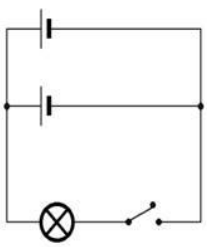
3) PREDICT how the p.d. measured across different components will compare when the switch is closed. Draw voltmeters into the circuit diagram to show each of the positions you would place voltmeters.

4) BUILD the circuit and CHECK your predictions. Record your readings next to the ammeters and voltmeters in the diagram.

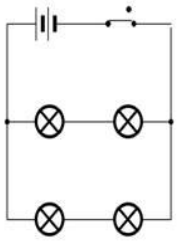
5) Explain your findings. Use the words 'current', 'series', 'parallel', 'p.d.', 'energy', 'junction'.



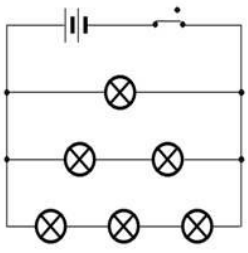
Circuit 1



Circuit 2



Circuit 3

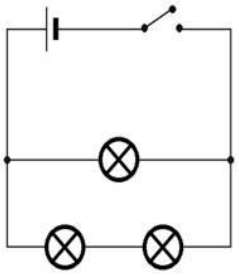


Circuit 4

Supermarket delivery vans model in complex parallel circuits (1)

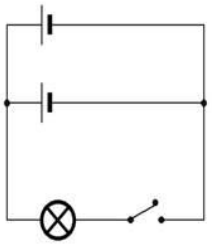
Use the supermarket delivery vans model to explain why when the switch is closed

- *one of the lamps glows more brightly than the other, even though they are connected to the same cell.*



Supermarket delivery vans model in complex parallel circuits (2)

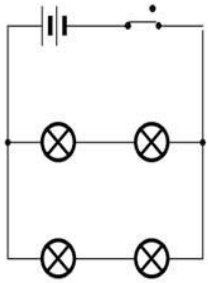
When the switch is closed in this circuit the lamp is at normal brightness even though it is connected to two cells (in parallel).



If the lamp is only transferring the 'normal' amount of energy, what does this suggest about the amount of energy being provided by each cell? Explain this by using the supermarket delivery vans model.

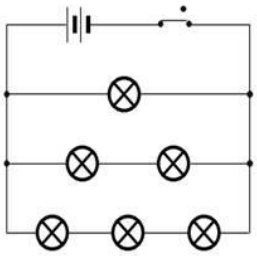
Supermarket delivery vans model in complex parallel circuits (3)

Use the supermarket delivery vans model to explain
- *why all the lamps are at the same brightness*
- *why each lamp is at normal brightness (as though connected to a single cell) even though there is a battery of two cells in the circuit*



Supermarket delivery vans model in complex parallel circuits (4)

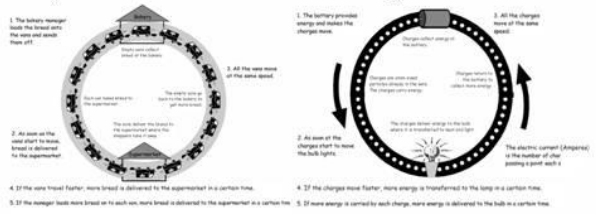
Use the supermarket delivery vans model to explain why
- *one lamp is brighter than normal*
- *two lamps are at normal brightness*
- *three lamps are less bright (dimmer) than normal.*



Analogies evaluation (1)

Which model(s) have you found most helpful in thinking about (predicting and explaining) circuits?

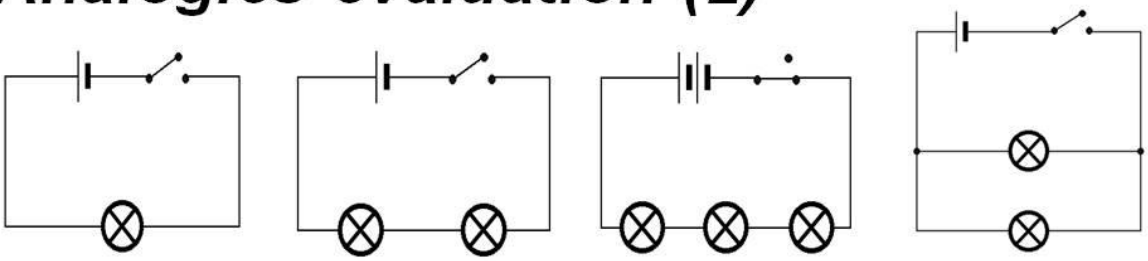
Supermarket delivery vans model



Rope-loop model

Role-play simulation

Analogies evaluation (2)



Circuit 1 Circuit 2 Circuit 3 Circuit 4

1) EXPLAIN what is happening in each of the four circuits by relating it to one of the three models.

2) Which model was the easiest to understand?

3) Why was it the easiest to understand?

4) Which model was most useful in explaining circuits?

Analogies evaluation (3)

Each of the three models can help us think about circuits. Models are useful in science because they give us ways of thinking about things. However models are never perfect - they are never exactly like the thing we want a model of!

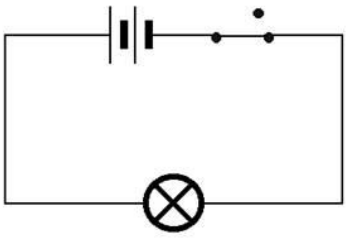
1) How can the three models be compared to a circuit?

2) How are electric circuits NOT like the models?

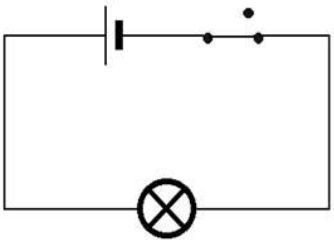
3) Which model would be most helpful if you had to explain circuits to a primary school student? Give reasons for your choice.

Circuits - odd one out

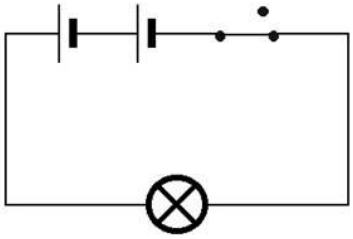
Which circuit is the odd one out? Give reasons.



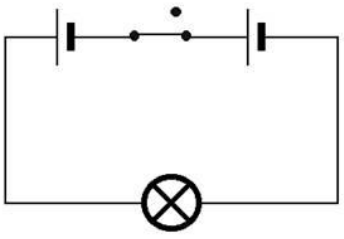
Circuit 1



Circuit 2



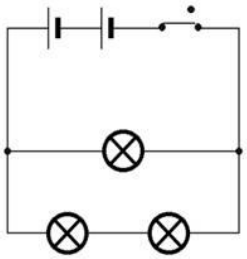
Circuit 3



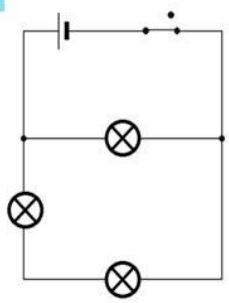
Circuit 4

Circuits - most alike

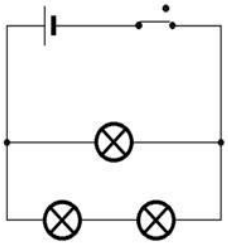
Which two circuits are most alike? Give reasons.



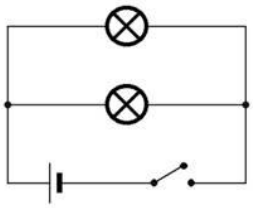
Circuit 1



Circuit 2

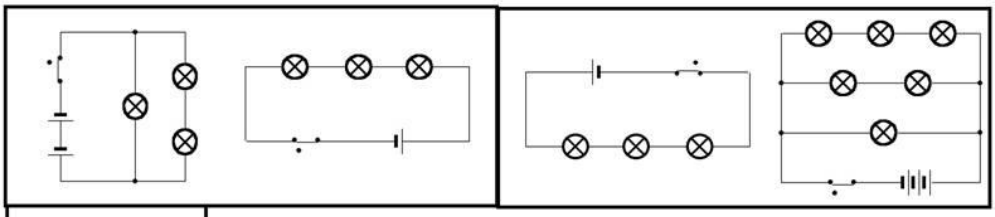


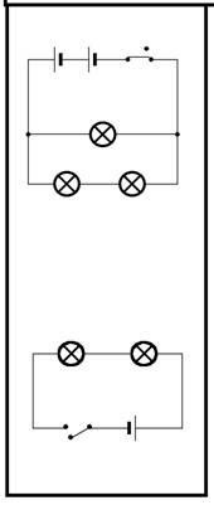
Circuit 3



Circuit 4

Circuit diagram domino





Circuit Diagram Dominoes

Dominoes/'tiles' are shared evenly among players.
Each player has a turn, when they can put down one or more of their tiles.
Once the first domino has been placed, tiles can only be laid down by matching the diagram at one end with a tile already on the table.
(In case of challenges, both sides must give their reasons. The teacher is the final judge is there is no agreement.)
The winner is the first player to have laid down all his/her tiles.