Visualising Electric Circuits

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Electric circuits – the key idea

Electric circuits transfer energy

Electric circuits – the difficulties

Understanding relies on abstract concepts:

- Energy
- Particles

Energy cannot be ‘seen’

The particle model

"If in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the *atomic hypothesis* that *all things are made of atoms – little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*. In that one sentence, you will see there is an enormous amount of information about the world, if just a little imagination and thinking are applied."

Richard Feynman

Models and analogies

Models and ideas from other contexts can be used to help understand electric circuits, but nothing else quite behaves like electricity.

It is important for pupils to have an opportunity to think about different models, their role and their limitations.

Pupils' mental models

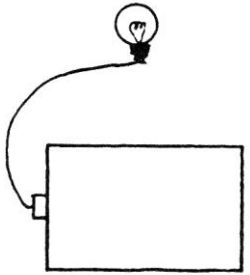

Figure 15.2 The unipolar model (A)

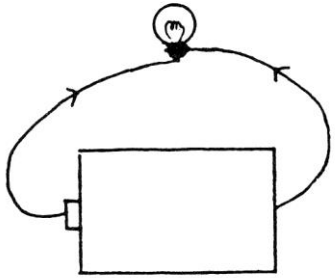

Figure 15.3 The clashing currents model (B)

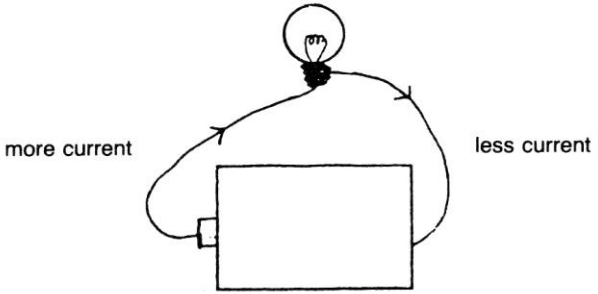

Figure 15.4 The current consumed model (C)

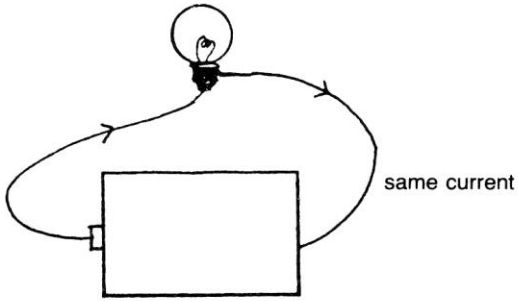

Figure 15.5 The scientists' model with current conserved (D)

Driver, R, et al. (1994) *Making Sense of Secondary Science.* pp 118-9.

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Pupils' mental models and age

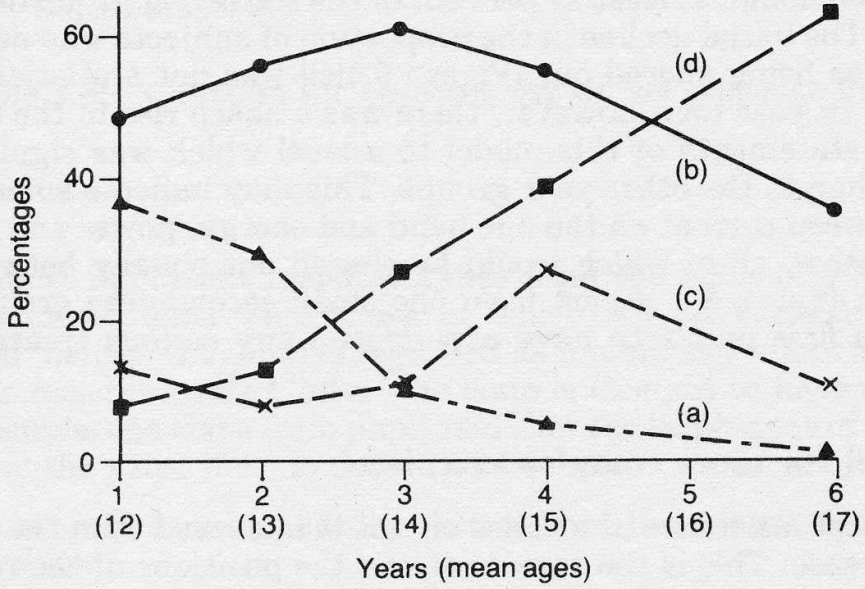
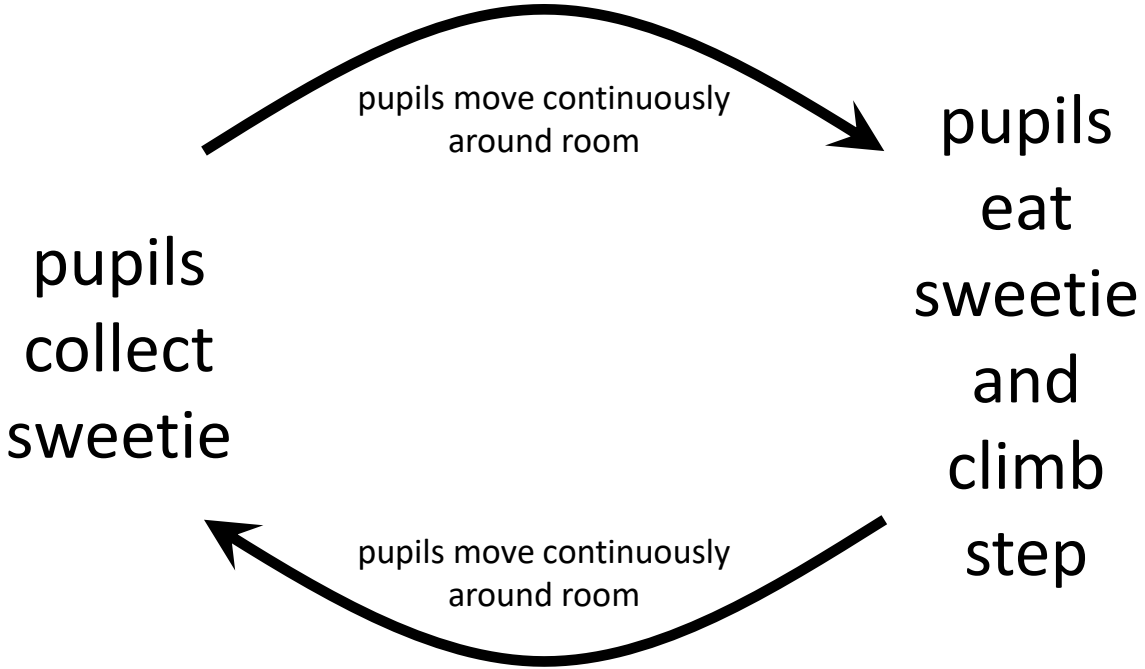


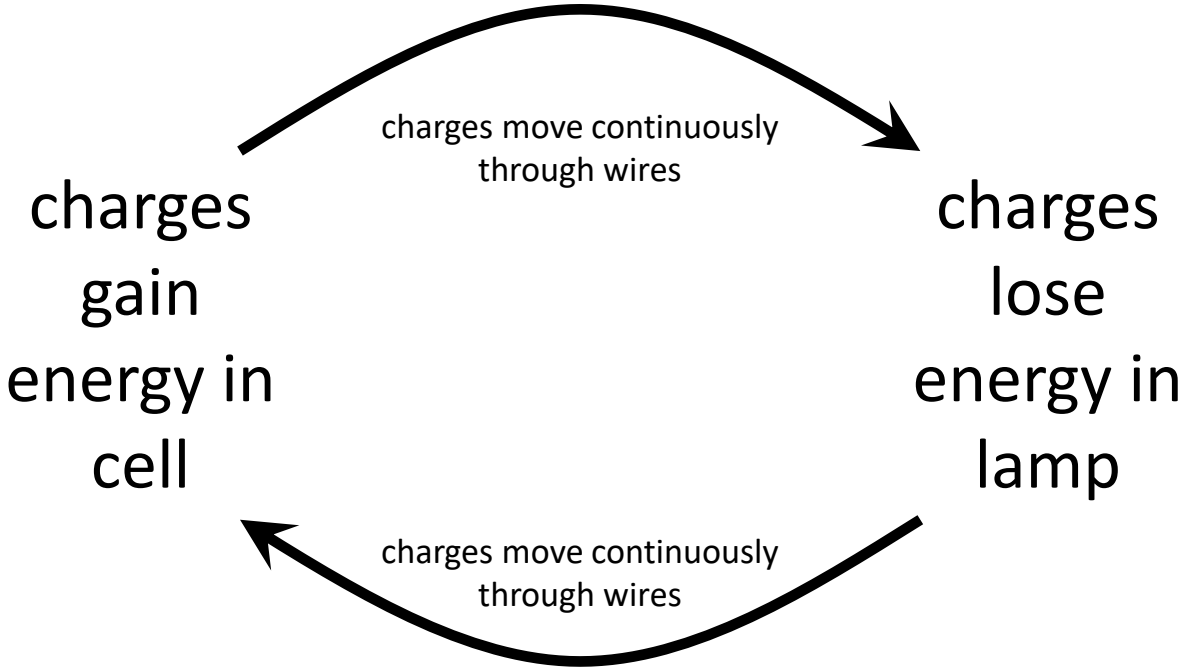
Figure 3.4: Variations in popularity of some conceptual models for current. (a) The clashing currents model, (b) all unidirectional non-conservation models, (c) the sharing model, (d) the scientific model.

Driver, R, et al. (1994) *Making Sense of Secondary Science.* pp 120.

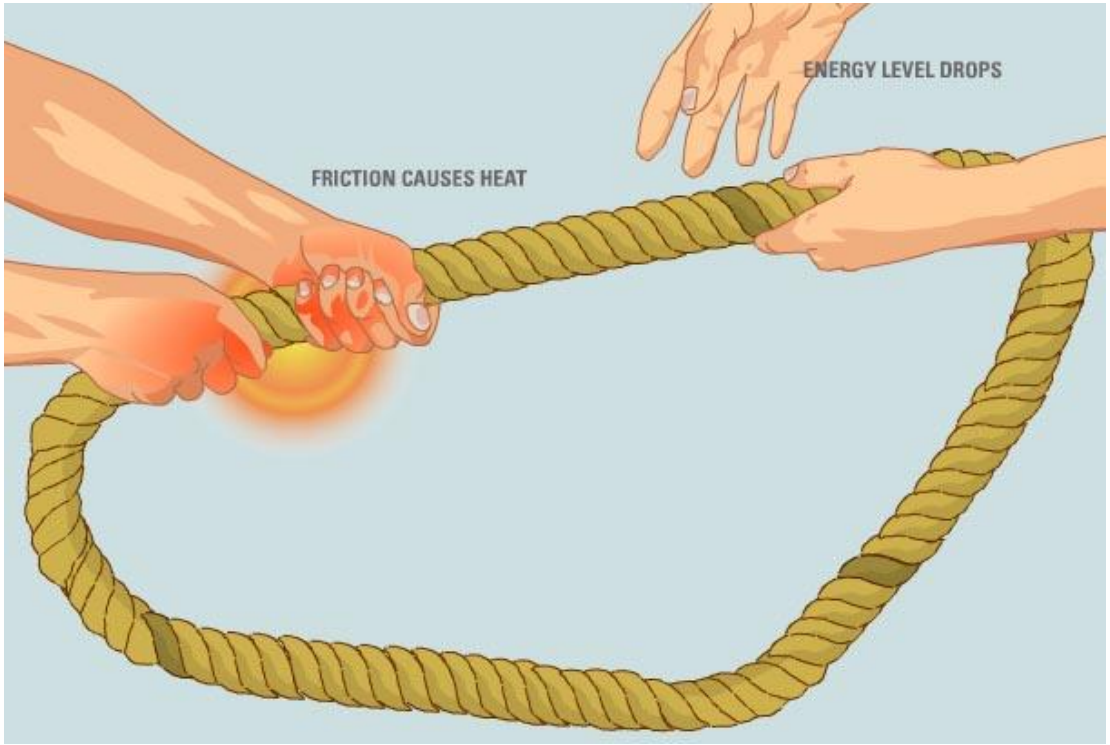
The ‘sweetie’ model



The ‘sweetie’ model



The rope loop model



https://spark.iop.org/collections/modelling-simple-electrical-loops-teaching-and-learning-issues

The rope loop model – the details (1)

- The complete circuit is represented by

the rope loop

The rope loop model – the details (2)

- The battery is represented by

the person pulling the rope loop

The rope loop model – the details (3)

- The lamp is represented by

the person holding the rope loop

The rope loop model – the details (4)

- The charged particles are represented by

the rope

The rope loop model – the details (5)

- The energy supplied by the battery is represented by

the energy supplied by the person pulling the rope

The rope loop model – the details (6)

- The energy converted to heat and light in the lamp is represented by

the energy converted to heat in the hand of person holding rope

The rope loop model – the details (7)

- The current (rate of flow of charge) in the circuit is represented by

the rate of movement of the rope

The rope loop model – the details (8)

- The resistance of the lamp is represented by

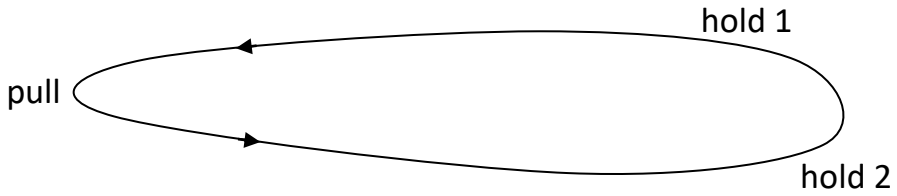
how tightly the person holds the rope

The rope loop model – the details (9)

- The voltage of the battery is represented by

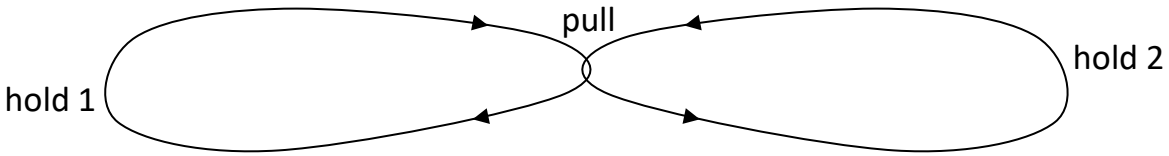
how hard the person pulls around the rope loop

The rope loop model – lamps in series



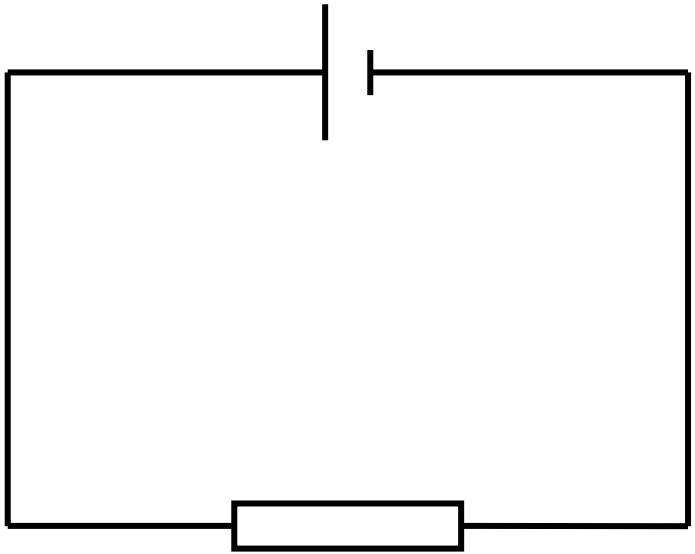
- Rope harder to pull around so it moves more slowly
- Heating effect split between two hands

The rope loop model – lamps in parallel

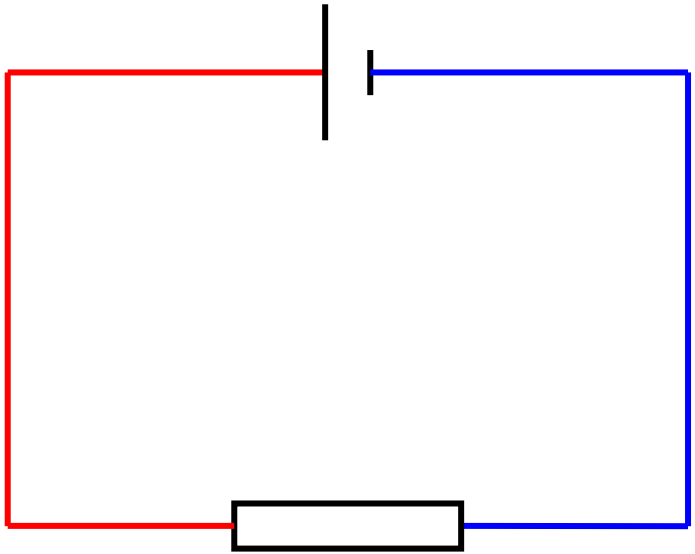


- Each rope just as easy to pull as if they were on own
- Twice as much energy needed to pull two ropes through at same time
- Currents add rather than split

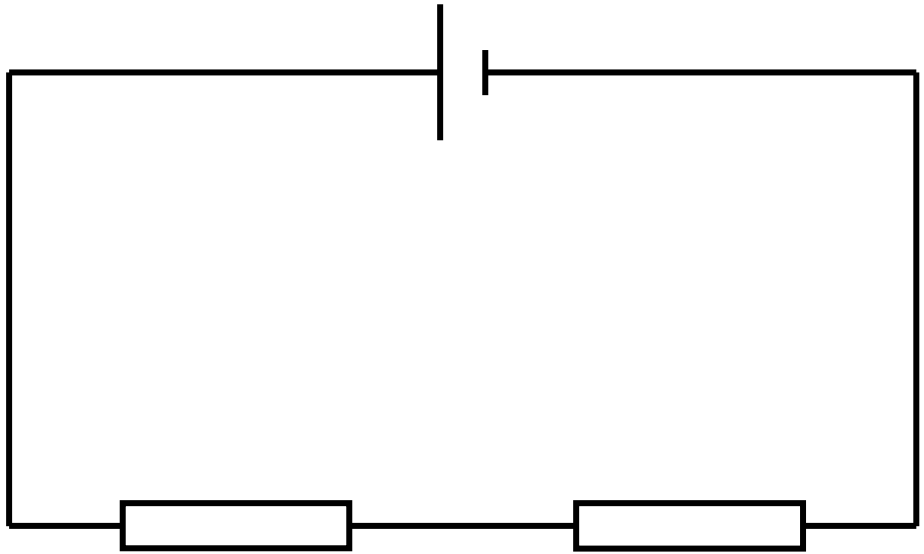
Circuit analysis – colouring potentials



Circuit analysis – colouring potentials



Circuit analysis – colouring potentials



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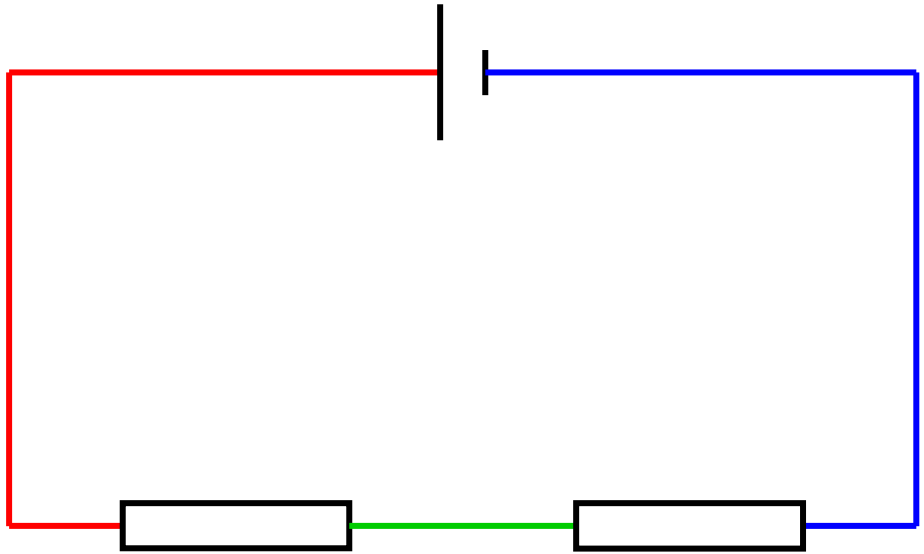

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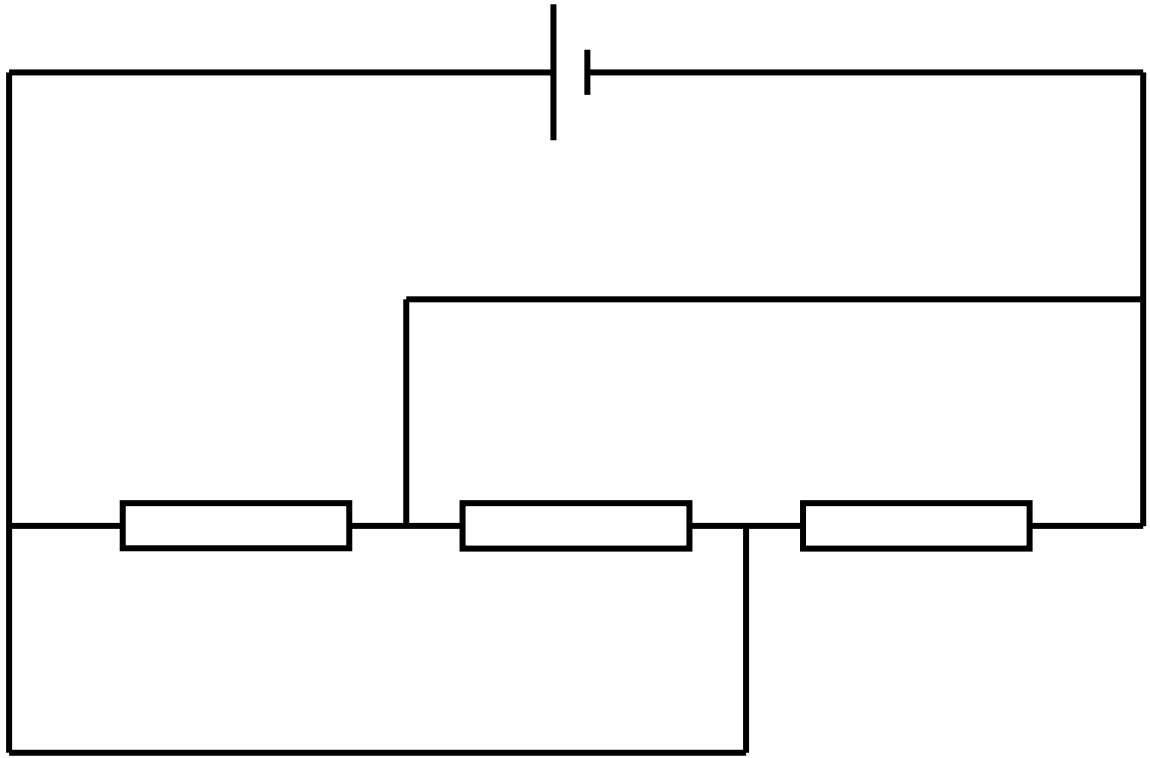

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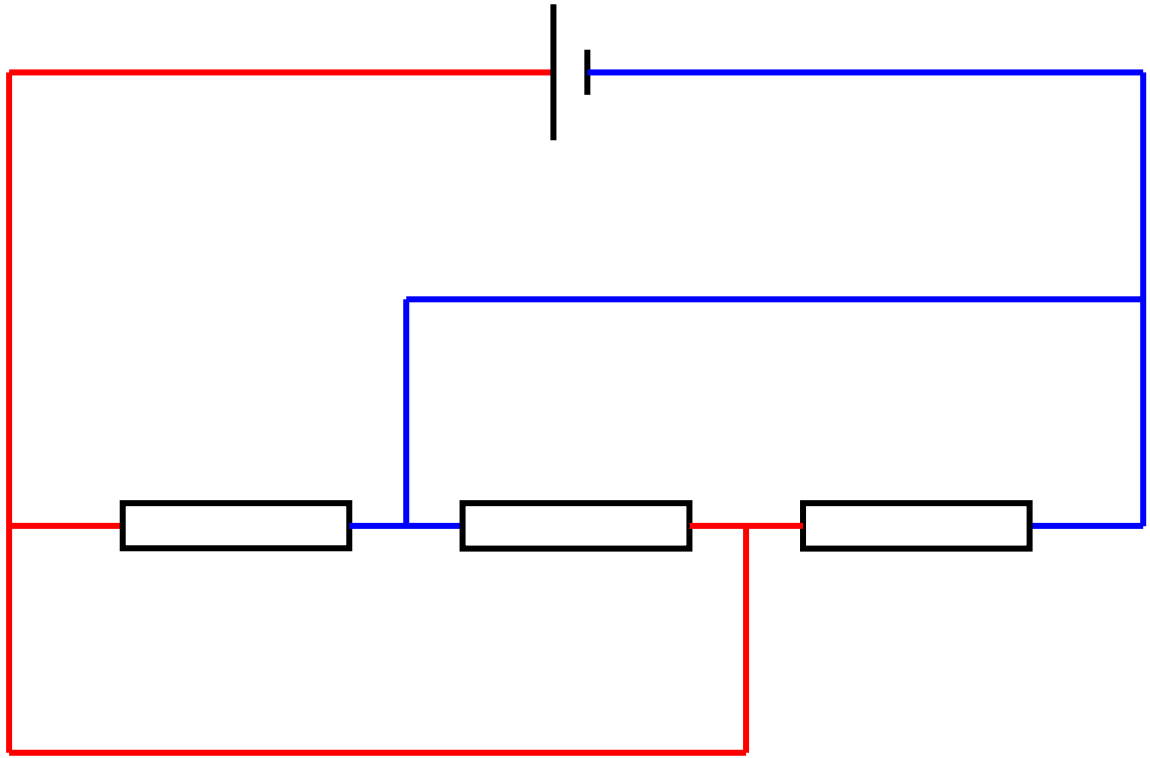

Questions and discussion ...

Thank you

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