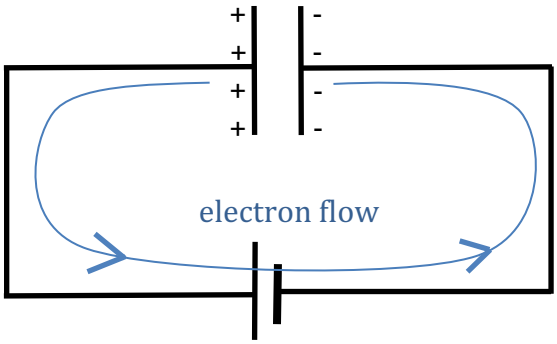
7.8.1 The parallel plate capacitor

videos

A capacitor is a device which is used to store electric charge. The simplest capacitor consists of two metal plates separated by an air gap. If the plates are connected to a battery, electrons are removed from one plate and moved around the circuit to the other plate. This leaves the first plate with a positive charge and the other with a negative charge. There is an equal and opposite charge on both plates. The bigger the voltage supplied the bigger the charge that accumulates.



Symbol for a capacitor.

If the area of the plates is increased, more charge can be stored for the same applied voltage. The capacitance (C) is a measure of the amount of charge (Q) that can be stored for a given voltage (V):

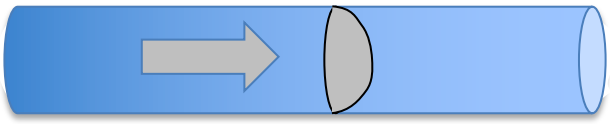
$$C = \frac{Q}{V}$$

Capacitance is measured in farads (F). The farad is, practically, quite a large value for capacitors that are used in everyday circuits. We are more likely to see values in micro-farads (μF) and pico-farads (pF).

(1) A capacitor with a value of 900pF is fully charged by a 9V battery. What charge is stored on the capacitor?

A water model of a capacitor

An analogy for a capacitor is a rubber membrane stretched across a pipe containing water. Water flow is analogous to electric current. Current will continue to flow until the membrane is fully stretched. At this point current flow will stop.



The pressure of water is analogous to the voltage. As the membrane becomes more and more stretched the pressure builds up.

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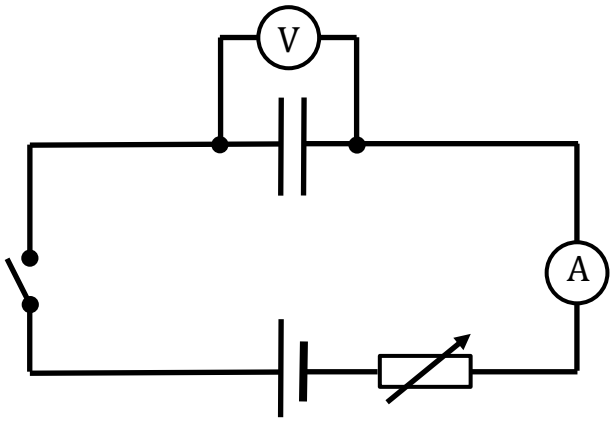
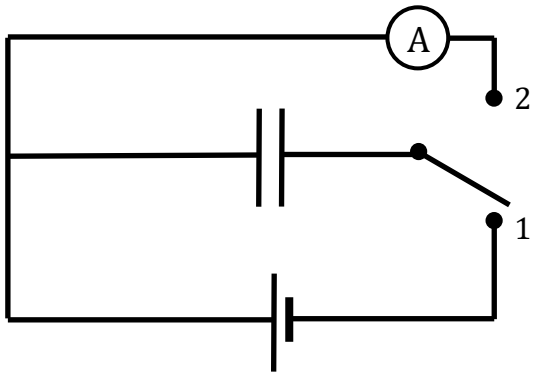
One method to explore the behaviour of a capacitor is to use the following circuit:



A <u>constant current</u> can be maintained by adjusting the variable resistor. Readings of voltage can be taken at different times as the capacitor charges up. The switch can be opened at certain times to take a reading.

(2) A capacitor is charged by means of a constant current of 0.7μA for 60 seconds and a voltage of 4.5V is recorded. Calculate the charge stored and, hence, work out the capacitance of the capacitor.



In the circuit, left, a two way switch can be used to connect the capacitor to connector 1 or 2.

(3) Describe what happens when the switch is in position 1.

(4) Describe what happens when the switch is in position 2.

(5) Do some research and find out some of the uses of capacitors in circuits.

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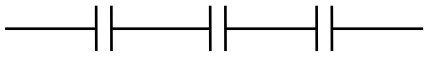
Combining capacitors in series and parallel

When capacitors are combined in <u>series,</u> the total capacitance C_T is given by the following:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

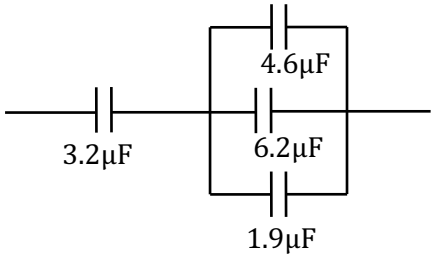
(6) Work out the total capacitance for the following combination:



When capacitors are combined in parallel, the total capacitance C_T is given by the following:

$$C_T = C_1 + C_2 + C_3 + \cdots$$

(7) Work out the total capacitance for the following combination:



(8) How does adding capacitors in series and parallel compare to adding resistors in series and parallel?

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