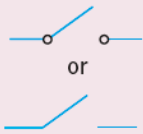
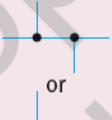
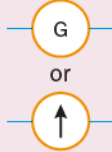





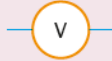









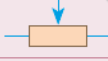


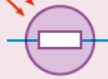




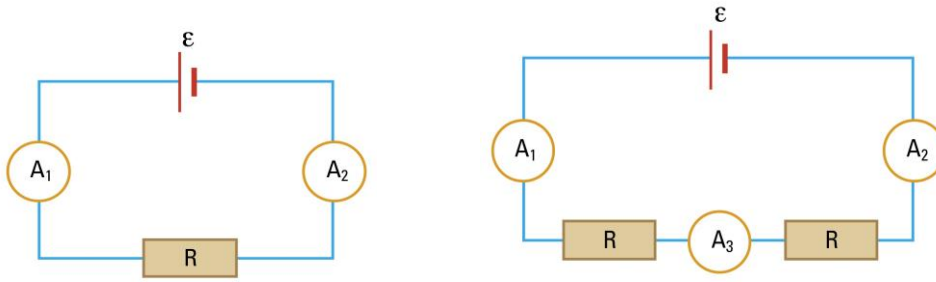
D.C. Circuits

- (a) draw circuit diagrams with power sources (cell, battery, d.c. supply or a.c. supply), switches, lamps, resistors (fixed and variable), variable potential divider (potentiometer), fuses, ammeters and voltmeters, bells, light-dependent resistors, thermistors and light-emitting diodes
- (b) state that the current at every point in a series circuit is the same and apply the principle to new situations or to solve related problems
- (c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and apply the principle to new situations or to solve related problems
- (d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit and apply the principle to new situations or to solve related problems
- (e) state that the potential difference across the separate branches of a parallel circuit is the same and apply the principle to new situations or to solve related problems
- (f) recall and apply the relevant relationships, including $R = V/I$ and those for current, potential differences and resistors in series and in parallel circuits, in calculations involving a whole circuit
- (g) describe the action of a variable potential divider (potentiometer)
- (h) describe the action of thermistors and light-dependent resistors and explain their use as input transducers in potential dividers
- (i) solve simple circuit problems involving thermistors and light-dependent resistors

Circuit Components

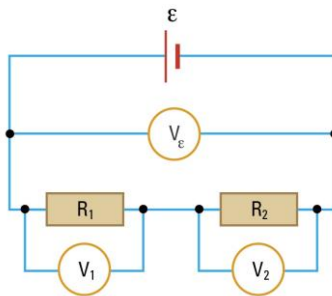
Symbol	Device	Symbol	Device	Symbol	Device
	switch		wires joined		galvanometer
	cell		wires crossed		ammeter
	battery		fixed resistor		voltmeter
	d.c. power supply		variable resistor (rheostat)		two-way switch
	a.c. power supply		fuse		earth connector
	light bulb		coil of wire		capacitor
	potentiometer		transformer		thermistor
	light-dependent resistor (LDR)		semiconductor diode		bell

Current in a series circuit



Current in a series circuit is the _____ throughout.

Potential difference in a series circuit



In a series circuit, the _____ of the potential difference across **each component** is equal to the potential difference **across the _____ circuit (= emf of the source)**.

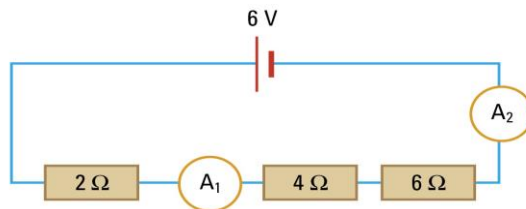
i.e. $V_{\epsilon} = V_1 + V_2 = \epsilon$

Resistance

$$R = \frac{V}{I}$$

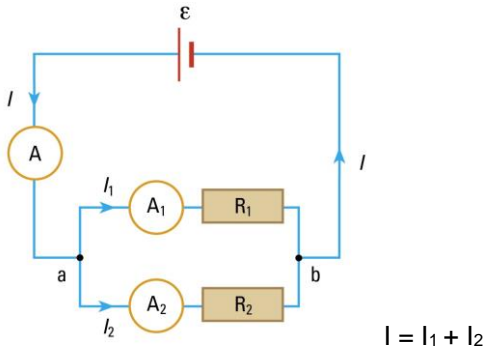
Total resistance in series:

Example 1

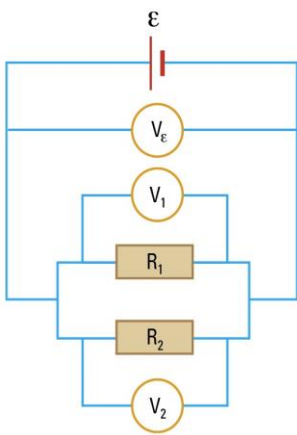


- a) What is the total resistance in the circuit shown above?
- b) What are the readings shown on ammeters A₁ and A₂?
- c) What is the p.d. across each resistor?

Current in a parallel circuit



Potential difference in a parallel circuit

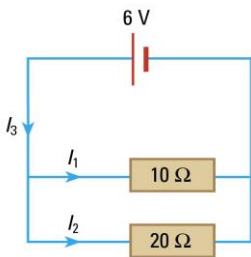


Potential difference across components in parallel is equal

$$V_{\epsilon} = V_1 = V_2 = \epsilon$$

Total resistance in parallel

Example 2



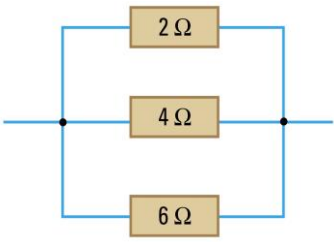
a) Find the currents I_1 , I_2 , I_3

b) What is the voltage or potential difference across the $10\ \Omega$ and $20\ \Omega$ resistors?

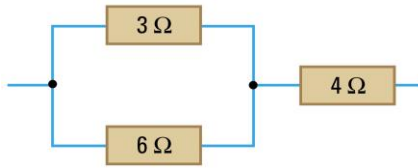
c) Calculate the effective resistance of the $10\ \Omega$ and $20\ \Omega$ resistors.

Find the effective resistance of each of the following:

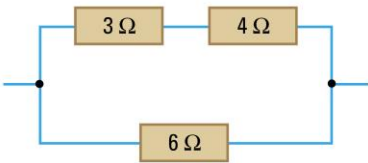
a)



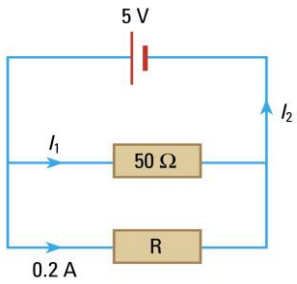
(b)



(c)

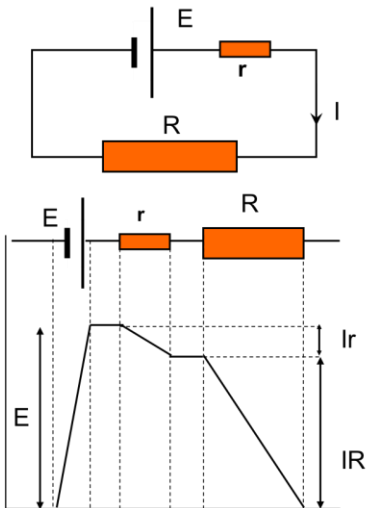


Example 3



Find I_1 , I_2 and R

Potential Difference in terms of energy

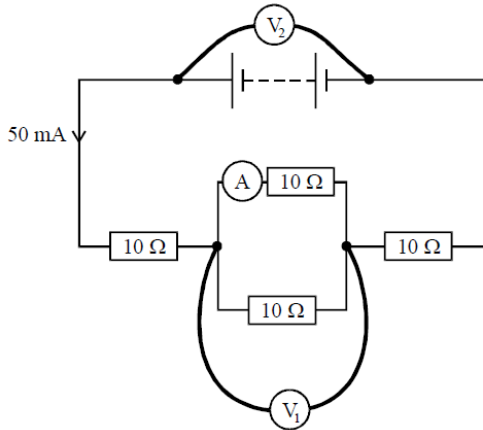


$E = \text{electromotive force}$
 Ir and $IR = \text{potential difference}$
 $E = Ir + IR$

(resourcefulphysics.org)

Example 4

Determine the reading on V_1 , V_2 and A.



Example 5

The circuit shows a light bulb connected to 3 resistors and a 12 V source. Initially, all the switches are opened.

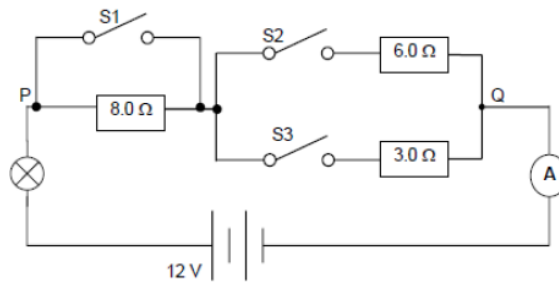


Fig 7

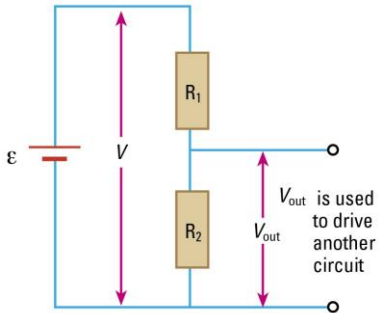
- (a) S_1 is opened and S_2 and S_3 are closed.
- (i) Calculate the total resistance between points P and Q.
 - (ii) The ammeter registers a reading of 0.3 A. Calculate the resistance of the light bulb.
 - (iii) The lamp is switched on for 2 minutes. Calculate the amount of energy consumed by the lamp.
- (b) S_1 , S_2 and S_3 are now closed. Describe and explain how the brightness of the lamp has changed as compared to (a).
-
-
-
- (c) The 8Ω resistor is a cylindrical wire of length L and radius R made from a certain type of material. It is replaced by another resistor of the same type but with 3 times the length and twice the radius. Calculate its resistance.

Variable potential divider (voltage divider or potentiometer)

- It is a circuit with resistors arranged in series.
- With it, we can divide a main voltage into two or more voltages.

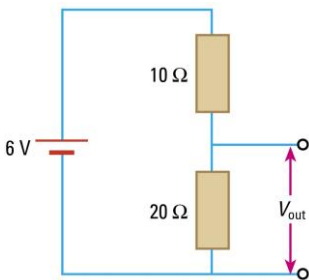
Uses: e.g. street lamps, burglar alarms, thermostats

Type I (2 fixed resistors)

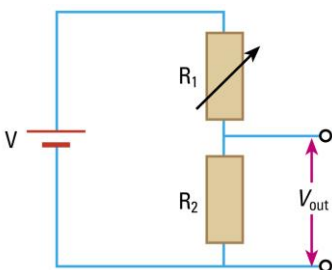


Question 1

Calculate V_{out} .

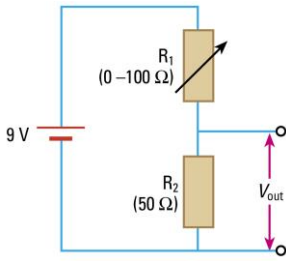


Type II (Replace one of the fixed resistors with a variable resistor)

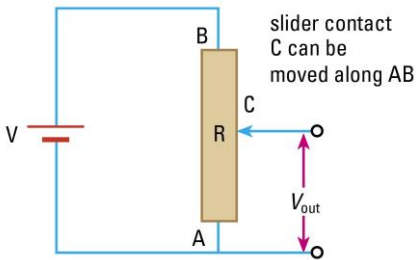


Question 2

The circuit shows a 9 V battery connected in series with a variable resistor R_1 and a $50\ \Omega$ resistor R_2 . The resistance of the variable resistor R_1 can vary from 0 to $100\ \Omega$. What are the maximum and minimum output voltages?



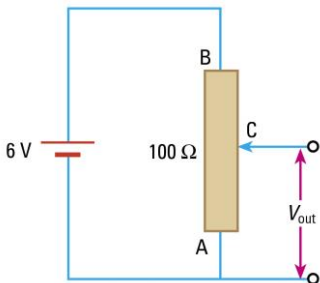
Type III (Replacing the two resistors with a potentiometer)



- The position of sliding contact C determines the ratio of the resistance since $R \propto l$ for a fixed cross-sectional area.
- To obtain a larger output voltage, the slider contact C is moved **towards** _____.

Question 3

A 6 V battery of negligible internal resistance is connected to a potentiometer with a maximum resistance of 100 Ω. Calculate the output voltage V_{out} when the slider contact is at



- (a) A,
- (b) the midpoint between A and B.
- (c) B.

Type IV (Replacing one of the resistors with an input transducer)

Transducers – Electrical or electronic devices that convert energy from one form to another.

- They respond to physical quantities like light and temperature.
- Input transducers – convert **non** electrical energy to electrical energy

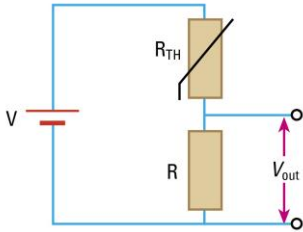
e.g. microphones, thermistors, light dependent resistors, photocells, thermocouples, pressure sensors and stress sensors

- Output transducers – convert electrical energy to other forms of energy

e.g. loudspeakers, lamps, LEDs, voltmeters and ammeters

NTC (negative temperature coefficient) Thermistor:

- Hot (more mobile electrons) – resistance decreases
- Cool (fewer mobile electrons) – resistance increases

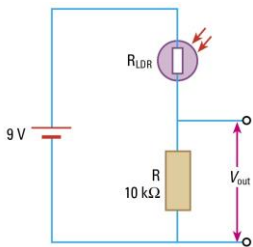


e.g. air conditioner connected to V_{out}

When temperature increases > preset temperature $\rightarrow R_{TH}$ drops $\rightarrow V_{TH}$ drops $\rightarrow V_{out}$ increases $\rightarrow V_{out}$ switches on cooling unit in the air conditioner which lowers temperature.

LDR (light dependent resistor):

- Brightness increases (more mobile electrons) – resistance decreases;
- When brightness decreases (fewer mobile electrons) – resistance increases

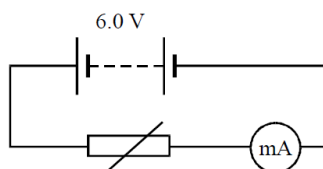


e.g burglar alarm

Burglar shines a light on safe which has a LDR $\rightarrow R_{LDR}$ decreases $\rightarrow V_{LDR}$ decreases $\rightarrow V_{out}$ increases – alarm activated

Question 4

A **negative temperature coefficient thermistor** is used in the following circuit to make a temperature sensor.



Explain how the circuit works.

.....

.....

.....

Question 5

Fig 5.1 shows a circuit whose output potential difference, V_{AIR} varies with the surrounding air temperature. Fig 5.2 shows how the resistance of the air temperature sensor varies with temperature.

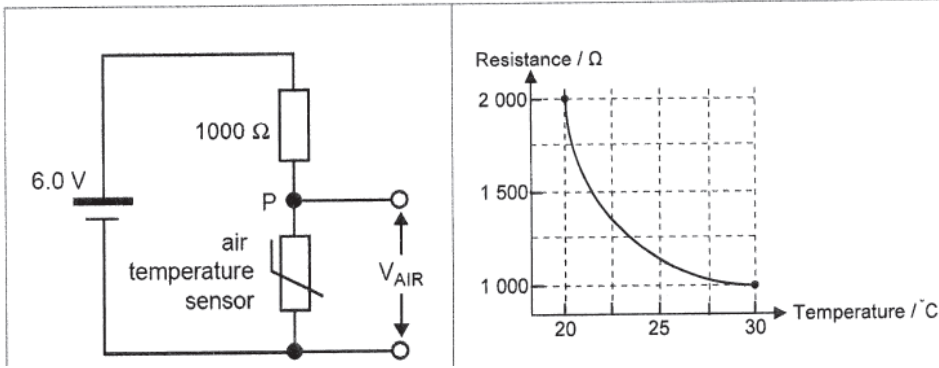


Fig 5.1

Fig 5.2

- (a) Name the input transducer that can be used as an air temperature sensor.
.....
- (b) Show that at a temperature of 20°C, the potential difference across the air temperature sensor, V_{AIR} is 4.0 V.
- (c) Calculate the current in the circuit when the air temperature is 20°C. Express your answer in units of mA.
- (d) How much power is dissipated in the 1000 Ω resistor when the air temperature is 20°C?
($P = I^2R$)

Question 6

A student wants to provide lighting for a model house which she has made. She needs 3.0 V for her lamps but only has a 9.0 V battery, so she uses a linear resistor AB in the circuit below. The linear resistor is made from a high resistance uniform conductor.

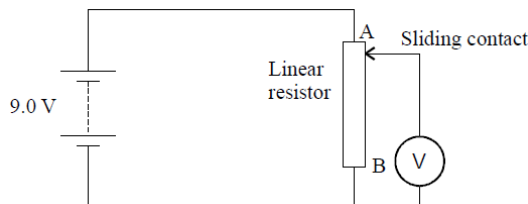


Fig 7

- (a) What is the name of the device AB when used in this manner?
.....
- (b) State the voltmeter reading when the sliding contact is at:
 - (i) A
 - (ii) B

- (c) Indicate on Fig 7 with the letter X to show where the sliding contact should be positioned such that the voltmeter reading is 3.0 V..
- (d) The student replaces the voltmeter with a 3.0 V lamp but the lamp does not light. Explain why the lamp does not light.

.....

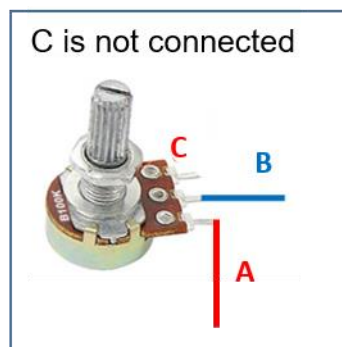
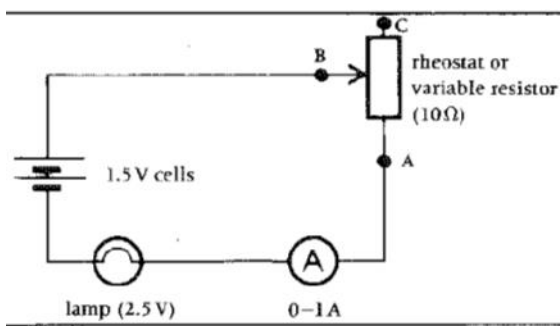
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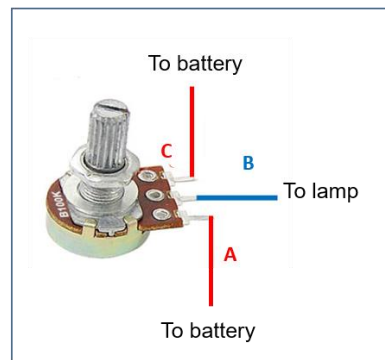
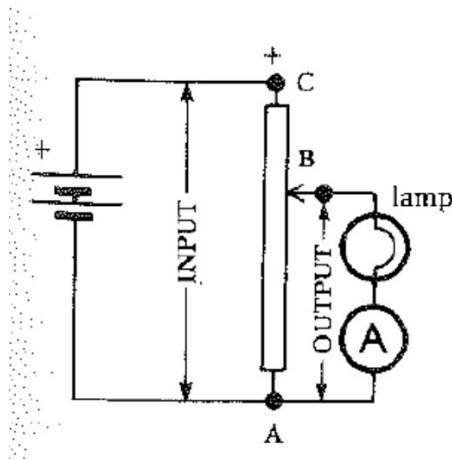
Difference between a rheostat and potential divider

A rheostat uses only two terminals of a variable resistor while a potential divider uses all three terminals

Rheostat



Potential divider



This means that when in use, the current in the lamp connected to a rheostat will never drop to 0 A while the current in the lamp connected using a potentiometer circuit can be reduced to 0 A. (Why?)