Chapter 19. Electric Circuit

Contents:

New word list:

Fuse Junction generator motor transformer relay
Mains electricity mains supply graphite short circuit open circuit closed circuit

4.3 Electric circuits

4.3.1 Circuit diagrams and circuit components

Core

1 Draw and interpret circuit diagrams containing cells, batteries, power supplies, generators, potential dividers, switches, resistors (fixed and variable), heaters, thermistors (NTC only), light-dependent resistors (LDRs), lamps, motors, ammeters, voltmeters, magnetising coils, transformers, fuses and relays, and know how these components behave in the circuit

Supplement

2 Draw and interpret circuit diagrams containing diodes and light-emitting diodes (LEDs), and know how these components behave in the circuit

4.3.2 Series and parallel circuits

Core

1 Know that the current at every point in a series circuit is the same

Supplement

8 Recall and use in calculations, the fact that:

(a) the sum of the currents entering a junction in a parallel circuit is equal to the sum of the currents that leave the junction

(b) the total p.d. across the components in a series circuit is equal to the sum of the individual p.d.s across each component

(c) the p.d. across an arrangement of parallel resistances is the same as the p.d. across one branch in the arrangement of the parallel resistances

2 Know how to construct and use series and parallel circuits
3 Calculate the combined e.m.f. of several sources in series
4 Calculate the combined resistance of two or more resistors in series
5 State that, for a parallel circuit, the current from the source is larger than the current in each branch
6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself
7 State the advantages of connecting lamps in parallel in a lighting circuit
9 Explain that the sum of the currents into a junction is the same as the sum of the currents out of the junction
10 Calculate the combined resistance of two resistors in parallel

4.3 Electric circuits continued

4.3.3 Action and use of circuit components

Core

1 Know that the p.d. across an electrical conductor increases as its resistance increases for a constant current

Supplement

2 Describe the action of a variable potential divider

3 Recall and use the equation for two resistors used as a potential divider

$$\frac{R_1}{R_2} = \frac{V_1}{V_2}$$

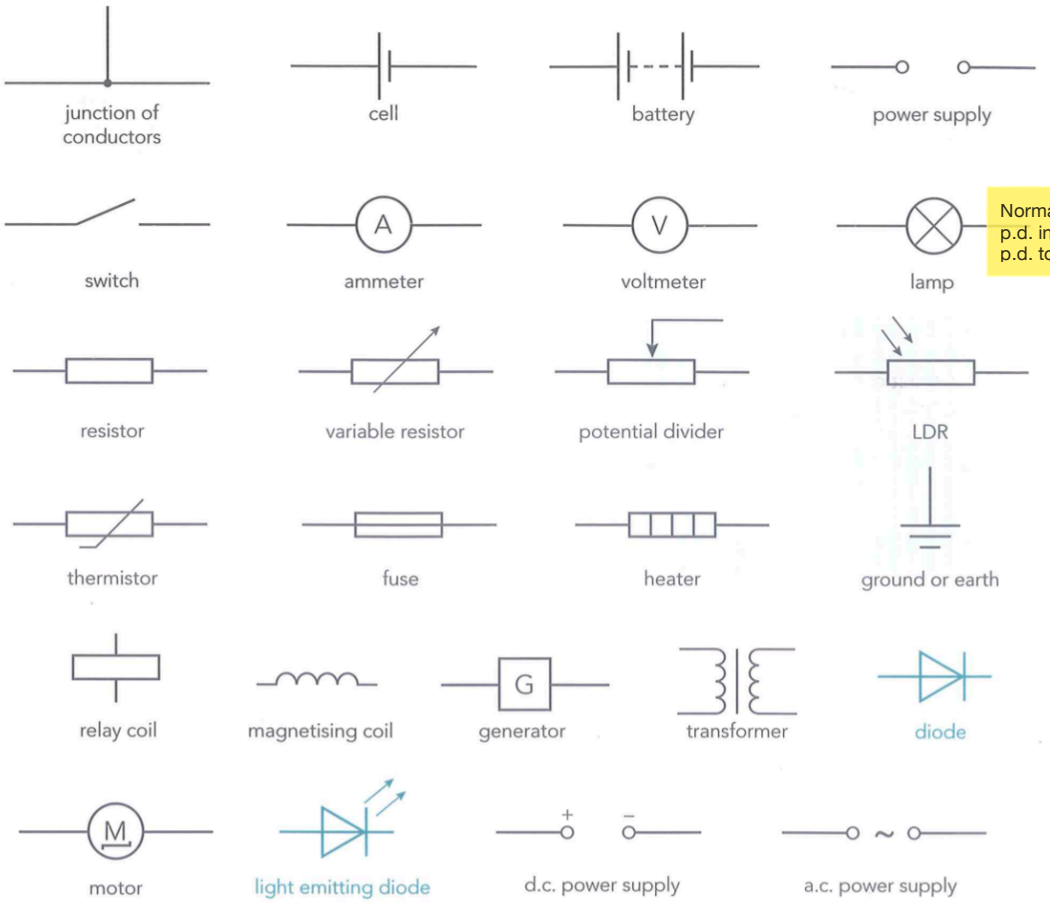
4.4 Electrical safety

Core

1 State the hazards of:
(a) damaged insulation
(b) overheating cables
(c) damp conditions
(d) excess current from overloading of plugs, extension leads, single and multiple sockets
when using a mains supply
2 Know that a mains circuit consists of a live wire (line wire), a neutral wire and an earth wire and explain why a switch must be connected to the live wire for the circuit to be switched off safely
3 Explain the use and operation of trip switches and fuses and choose appropriate fuse ratings and trip switch settings
4 Explain why the outer casing of an electrical appliance must be either non-conducting (double-insulated) or earthed
5 State that a fuse without an earth wire protects the circuit and the cabling for a double-insulated appliance

Supplement

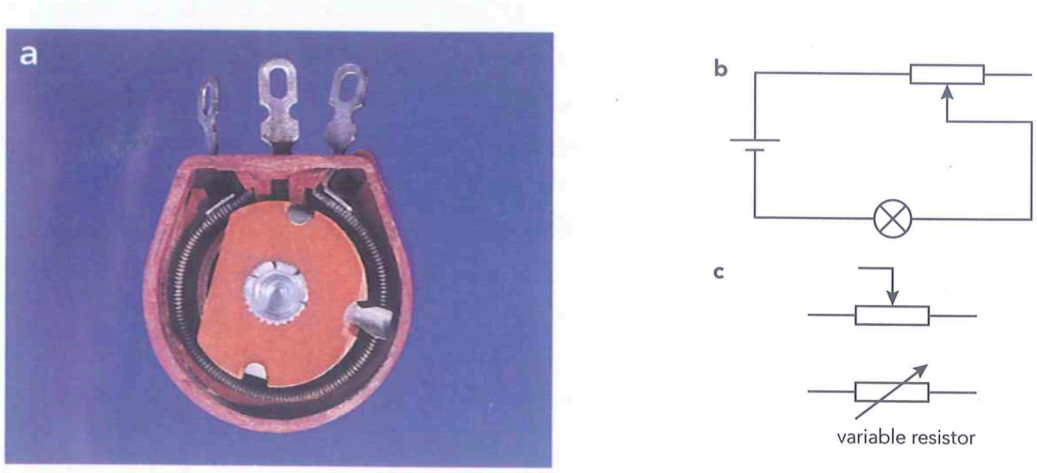
19.1 Circuit components



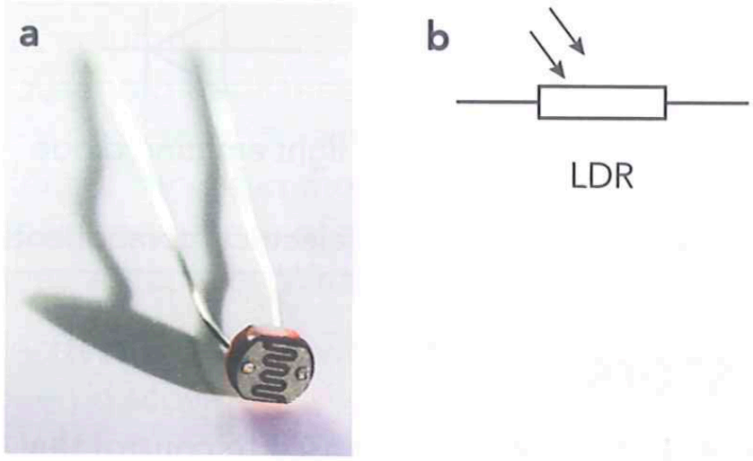
Normal brightness;
p.d. increase => brightness increase
p.d. too large => lamp will blow

resistors & variable resistor

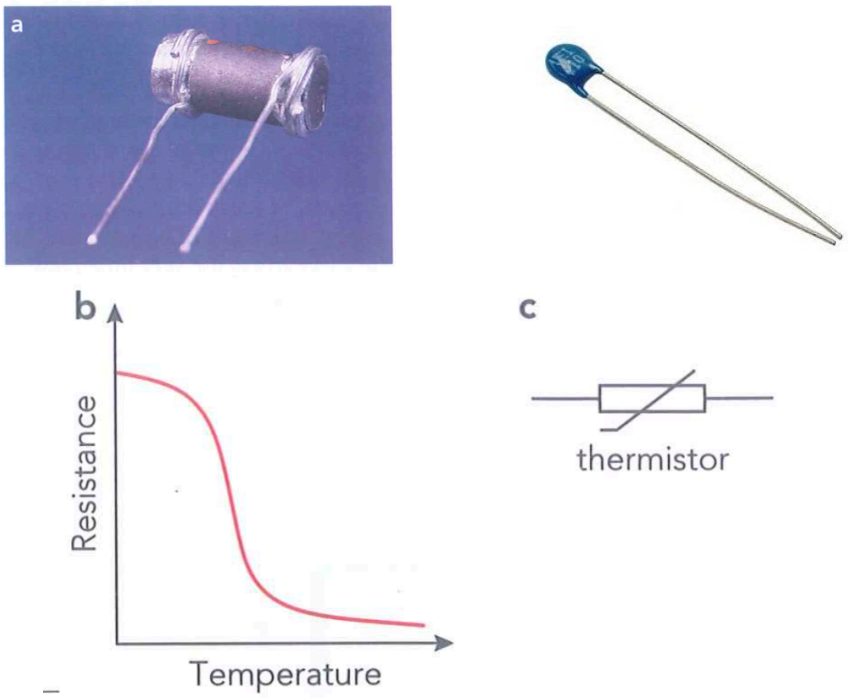
Resistor material: Metal(aluminum, copper, etc.), graphite



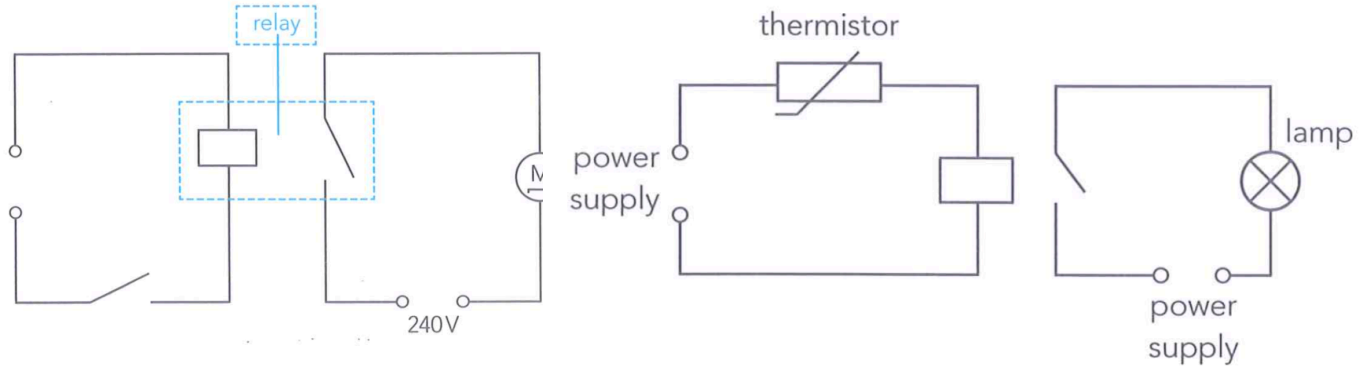
light-dependent resistor (LDR)



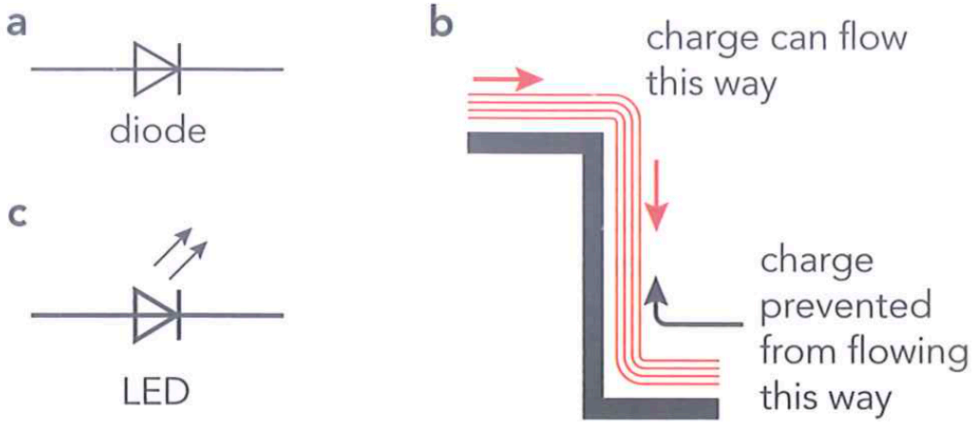
Thermistor



relay



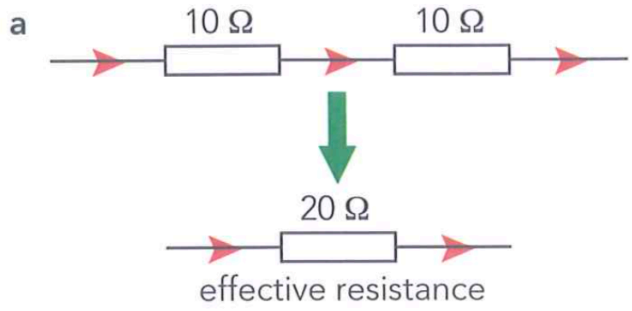
Diode & light-emitting diode (LED)



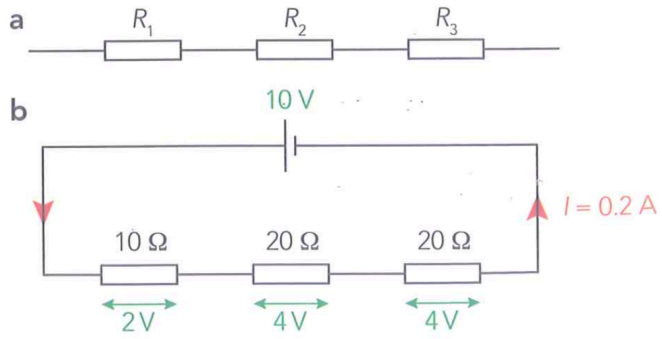
19.2 Combinations of resistors

Effective resistance: 等效电阻

Resistors in series:



Proof: $IR = V = V_1 + V_2 = IR_1 + IR_2 \quad => \quad R = R_1 + R_2$



$I = I_1 = I_2$ (charge conservation)

$V = V_1 + V_2$ (energy conservation)

$R = R_1 + R_2$

$V_1 = \frac{R_1}{R_1 + R_2} V$

$P = P_1 + P_2$

Characteristics

- Always switched on/off at the same time;
- One breaks, others won't work;
- Share voltage

Exercise:

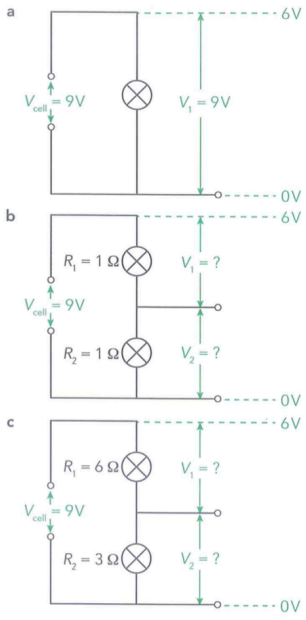
One 4 ohms resistor and one 6 ohms resistor are connected in a series circuit with a 6 V power supply. Calculate:

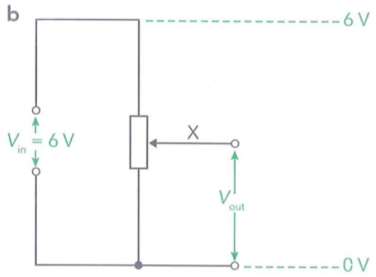
1, The combined resistance of the two resistors

2, The current that flows in the circuit

3, The p.d. across each resistor

Potential divider circuit



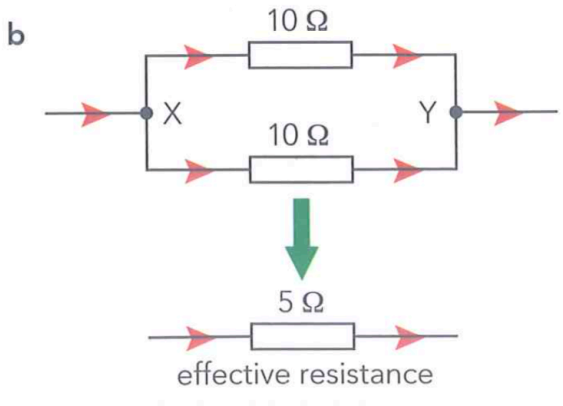


$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

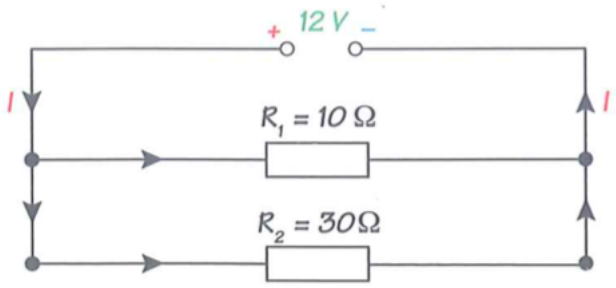
Exercise:

A potential divider circuit is required to produce an output voltage of 8V across a resistor, R1, of 600 ohms. The supply voltage is 12V. What is the required value of the series resistor, R2?

Resistors in parallel:



Proof: $I = I_1 + I_2 => \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} => \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$



$I = I_1 + I_2$
$V = V_1 = V_2$
$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
$P = P_1 + P_2$

Characteristics

- Can be switched on/off separately
- One breaks, others still work
- Can have full voltage

in particular:

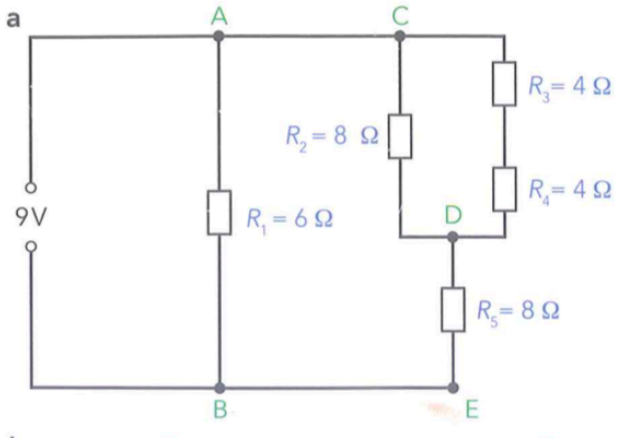
N R in parallel:

$$R_{tot} = \frac{R}{n}$$

Putting it all together:

Work out the current through, and the voltage across, each lamp in the circuit.

Summarize your result in the table below.



$$V_{AB} = e.m.f. = 9.0V = V_{CE}$$

$$I_{AB} = \frac{V_{AB}}{R_1} = 1.5A$$

$$R_{34} = R_3 + R_4 = 8\,\Omega$$

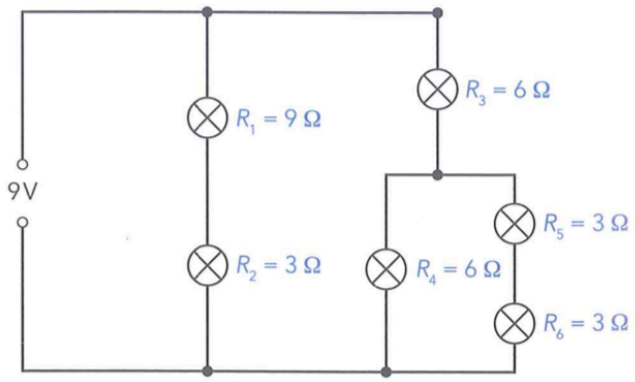
$$R_{CD} = 4\,\Omega$$

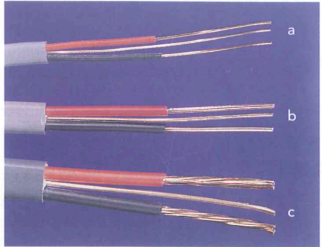
$$R_{CE} = 12\,\Omega\; V_{CE} = 9.0\,V\; I_{CE} = \frac{V_{CE}}{R_{CE}} = 0.75\,A = I_{DE}$$

$$I_2 = I_3 = I_4 = \frac{I_{DE}}{2} = 0.375\,A$$

Resistor	Source	1	2	3	4	5
Voltage	9.0V	9.0V	3.0V	1.5V	1.5V	6.0V
Current	2.25A	1.5A	0.375A	0.375A	0.375A	0.75A

Exercise:



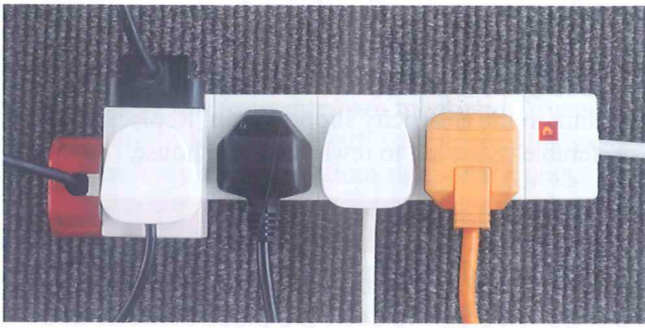


19.3 Electrical safety

Electrical hazards

Fire <= Overheating of wire, Excess current from overloading

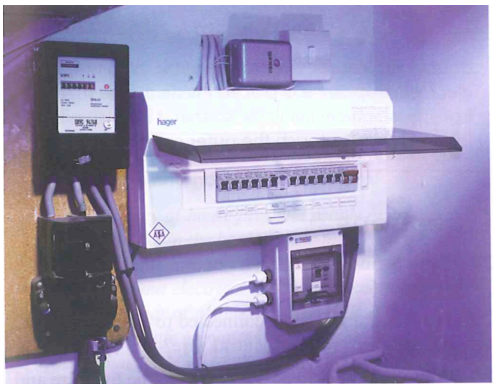
Electrical shock <= Damaged insulation, Damp condition



Solutions:

1. Earthing

2. Use fuse / trip switch



3. Double insulation