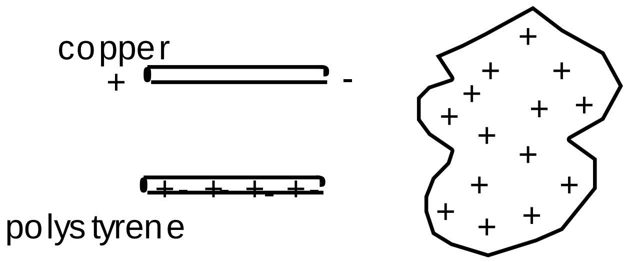
ELECTRIC FIELDS & RESISTORS IN CIRCUITS/ TUTORIAL ANSWERS

ANSWERS FOR TUTORIAL 1

1.



2. **X** = 15^{o} since the field is uniform.

3. The electric force on the drop is given by

$$F_e = Q \times E$$
$$= 3 \times 10^{-12} \times 4 \times 10^{4}$$
$$= 1.2 \times 10^{-7}$$

Since the drop is *floating*, the electric force, 1.2x10^{-7}N, is the same as its weight.

4. The electrical work done is given by W=QV

=5x10^{-12} H (150-10)

=7x10^{-10}

Since the motion is caused by the sphere's weight, the work done by the gravitational field is 7x10^{-10}J.

ANSWERS FOR TUTORIAL 2

1. a) P=VI gives 48=12xI
Thus I = 4
The current in the lamp is 4A

b)
$$\frac{V}{I} = R \Rightarrow \frac{12}{4} = R$$
$$\Rightarrow R = 3$$
The lamp's resistance is 3Ω

2. $$\frac{9.6}{I} = 2000 \Rightarrow I = 4.8 \times 10^{-3}$$

The current in the resistor is 4.8mA

3.
$$R = 3 \times 125 \times 10^{-3}$$
$$= 375 \times 10^{-3}$$

$$\frac{v}{4} = 375 \times 10^{-3} \Rightarrow v = 1.5$$

The wire has a p.d. of 1.5V across it.

ANSWERS FOR TUTORIAL 3

1. a)

$$W = QV \quad \Rightarrow \quad W = 15 \times 1200 = 1.8 \times 10^{4}$$

There are 18000J of work done.

b)

$$P = \frac{W}{t} \Rightarrow \quad P = \frac{1.8 \times 10^{4}}{600} = 30$$

It is a 30W device.

c)

$$I = \frac{Q}{t} \Rightarrow \quad I = \frac{15}{600} = 2.5 \times 10^{-2}$$

The current in the device is 25mA

d)

$$V \times I = \frac{\text{joules}}{\text{coulombs}} \times \frac{\text{coulombs}}{\text{sec}} = \frac{\text{joules}}{\text{sec}}$$

The product of *volts* and *amps* is *watts*.

2.

$$P = VI \Rightarrow \quad 24 = 12 \times I$$
$$\Rightarrow \quad I = 2$$

$$\frac{V}{I} = R \quad \Rightarrow \quad \frac{12}{2} = R$$
$$\Rightarrow \quad R = 6$$

The bulb has a resistance of 6Ω

3.

$$E = V + Ir \Rightarrow 12 = 9 + 3 \times r$$
$$\Rightarrow r = 1$$

The battery's internal resistance is 1Ω

4. a) E = IR + Ir

A 'short circuit' means that R = zero

Thus the equation above gives 12 = 0 + Ix0.001 or I = 1.2x10^4

The short circuit current is 12000A

b) 1.5 = 0 + Ix1.25

Thus I = 1.2

The short circuit current of a dry cell is 1.2A

5.

$$E = V + Ir \Rightarrow E = 5.7 + 1.5 \times r \text{ ------------- } (1)$$
$$\text{and} \quad E = 4.6 + 2 \times r \text{ ------------- } (2)$$
$$\text{Subtract :} \Rightarrow 0 = 1.1 - 0.5 \times r$$
$$\Rightarrow r = 2.2$$

Substitute this value of **r** in equation (1) to get

E= 5.7 + 1.5x2.2

=5.7 + 3.3

= 9

The e.m.f. of the power supply is **9V** and its internal resistance is **2.2Ω**.

ANSWERS FOR TUTORIAL 4

1.
$$R = R_1 + R_2 + R_3 \Rightarrow R = 10 + 200 + 1000$$
$$\Rightarrow R = 1210$$
The total resistance is 1210Ω

2.
$$R = R_1 + R_2 + R_3 \Rightarrow 250 = 95 + R + 115$$
$$\Rightarrow R = 40$$

The unknown resistance is 40Ω

3.
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \Rightarrow \frac{1}{R} = \frac{3}{900}$$
$$\Rightarrow R = \frac{900}{3}$$
$$= 300$$
The equivalent resistance is 300Ω

4.
$$\frac{1}{250} = \frac{1}{500} + \frac{1}{R} \Rightarrow \frac{1}{R} = \frac{1}{250} - \frac{1}{500} = \frac{1}{500}$$
$$\Rightarrow R = 500$$

The unknown resistance is 500Ω

5.

$$\frac{1}{R} = \frac{1}{200} + \frac{1}{300} + \frac{1}{600} = \frac{3+2+1}{600} = \frac{6}{600}$$
$$\Rightarrow R = \frac{600}{6} = 100$$
The equivalent resistance is 100Ω

6.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \Rightarrow \quad \frac{1}{R} = \frac{4}{4}$$

$$\Rightarrow \quad R = \frac{4}{4}$$

$$= 1$$

The equivalent resistance is 1Ω

7.

$$\frac{1}{18.75} = \frac{1}{75} + \frac{1}{R} \quad \Rightarrow \quad \frac{1}{R} = \frac{1}{18.75} - \frac{1}{75} = \frac{1}{25}$$

$$\Rightarrow \quad R = 25$$

The unknown resistance is 25Ω

ANSWERS FOR TUTORIAL 5

1.

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \Rightarrow \quad \frac{126}{147} = \frac{228}{R}$$

$$\Rightarrow \quad \frac{147}{126} = \frac{R}{228}$$

$$\Rightarrow \quad R = 266$$

The unknown resistance is 266Ω

2.

$$\frac{350}{1050} = \frac{R}{450} \quad \Rightarrow \quad R = 150$$

R has a value of 150Ω

3. Yes; the resistors do not have the same ratio in each branch and so the micro-ammeter registers a current which requires a p.d. across it. If you care to calculate the actual values, you find that **A** is at 8V and **B** at 6V. This gives a 2V p.d. between **B** and **A**.

ANSWERS FOR TUTORIAL 6

1. a) $R = R_1 + R_2 + R_3 \Rightarrow R = 2 + 4 + 6$

$\Rightarrow R = 12$

The total resistance for this circuit is 12Ω.

b) Ohm's law gives $I = \frac{24}{12} = 2$

The current is 2A

c) Apply Ohm's law to each resistor in turn to get:

V_2 = 2x2 = 4; V_4 = 2x4 = 8; V_6 = 2x6 = 12

The p.d.'s are 4V, 8V and 12V across the 2, 4 and 6Ω resistors respectively.

2. a)

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{6} \quad = 0.5 + 0.25 + 0.167 \quad = 0.917$$

$$\Rightarrow \quad R = \frac{1}{0.917} = 1.09$$

The total is 1.09Ω

N.B. When there are several resistors in parallel, their equivalent resistance is *always* a little less than the least resistance in use.

b) Apply Ohm's law to each resistor in turn.

$$I_2 = \frac{12}{2} = 6; \qquad I_4 = \frac{12}{4} = 3; \qquad I_6 = \frac{12}{6} = 2$$

The currents are 6A, 3A and 2A in the 2,4 and 6Ω resistors respectively.

3. a) The reading increases since the 1000Ω resistor which limits the ammeter current to 10μA has been removed.

b) It doubles the current in each branch of the network which still leaves the micro-ammeter reading zero.

4. Since the out-of-balance current and resistance are directly proportional,

$$\frac{I_1}{R_1} = \frac{I_2}{R_2} \quad \Rightarrow \quad \frac{30\times10^{-6}}{25} = \frac{36\times10^{-6}}{R_2}$$

$$\Rightarrow \quad R_2 = 30$$

The resistance is 30Ω.

5. The strain gauge is made into one arm of a Wheatstone bridge which is then balanced with another identical strain gauge in an unstrained position. This means that any future strain on the working gauge causes an out-of-balance resistance whose size can be measured from the size of the out-of-balance current. We then apply different weights to the hacksaw blade and use the out-of-balance current as a measure of the amount of bending.