Lecture 2: Electrical Circuits

2.1 Series circuits

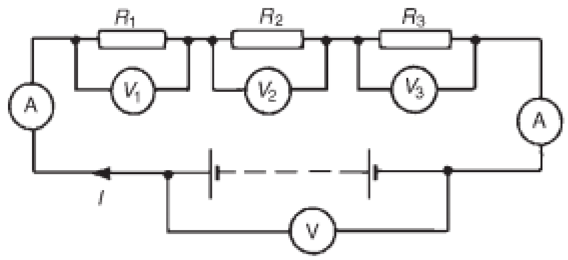

Figure 2.1

Figure 2.1 shows three resistors R_1, R_2 and R_3 connected end to end, i.e.,
in series, with a battery source of V volts. Since the circuit is closed a current I will flow and the p.d. across each resistor may be determined from the voltmeter readings V_1, V_2 and V_3.

In a series circuit;

(a) The current I is the same in all parts of the circuit and hence the same reading is found on each of the two ammeters shown, and

(b) The sum of the voltages V1, V2 and V3 is equal to the total applied voltage, V, i.e.

From Ohm's law:

$$V_1 = IR_1, V_2 = IR_2\,, V_3 = II_3 \; and \; V = IR$$

Where R is the total circuit resistance.

$$Since \; V = V_1 + V_2 + V_3$$

$$Then \; IR = IR_1 + IR_2 + IR_3$$

Dividing throughout by I gives,

$$R = R_1 + R_2 + R_3$$

Thus for a series circuit, the total resistance is obtained by adding together the values of the separate resistances.

Example 2.1

For the circuit shown in Figure 2.2, determine

(a) The battery voltage V,

(b) The total resistance of the circuit, and

(c) The values of resistance of resistors R1, R2 and R3, given that the Potential differences across R_1, R_2 and R_3 are 5V, 2V and 6V respectively.

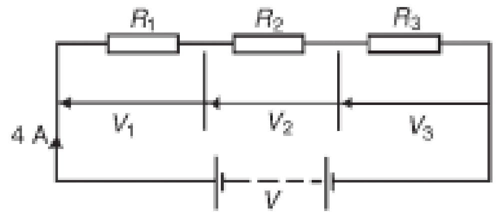

Figure 2.2

Solution

$$(a) Battery\ voltage\ V = V_1 + V_2 + V_3$$

$$= 5 + 2 + 6 + 13V$$

$$(b) Total\ circuit\ resistance\ R = \frac{V}{I} = \frac{13}{4} = 3.25\Omega$$

$$(c) Resistance\ R_1 = \frac{V_1}{I} = \frac{5}{4} = 1.25\Omega$$

$$Resistance\ R_2 = \frac{V_2}{I} = \frac{2}{4} = 0.5\Omega$$

$$Resistance\ R_1 = \frac{V_3}{I} = \frac{6}{4} = 1.5\Omega$$

2.2 Parallel networks

Figure 2.2 below shows three resistors, R_1, R_2 and R_3 connected across each other, i.e., in parallel, across a battery source of V volts.

In a parallel circuit:
(a) The sum of the currents I_1, I_2 and I_3 is equal to the total circuit current, I, i.e. $I = I_1 + I_2 + I_3$, and
(b) The source p.d., V volts, is the same across each of the resistors.
From Ohm's law:

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{V}{R_3}\ and\ I = \frac{V}{R}$$

Where R is the total circuit resistance.

$$Since\ I = I_1 + I_2 + I_3$$

$$then, \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Dividing throughout by V gives:

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

This equation must be used when finding the total resistance R of a parallel circuit. For the special case of two resistors in parallel,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}$$

$$R = \frac{R_2 + R_1}{R_1 R_2}$$

$$i.e, \frac{Product}{Sum}$$

Exercise 2.2

For the circuit shown in Figure 2.3, determine (a) the reading on the ammeter, and (b) the value of resistor R_2.

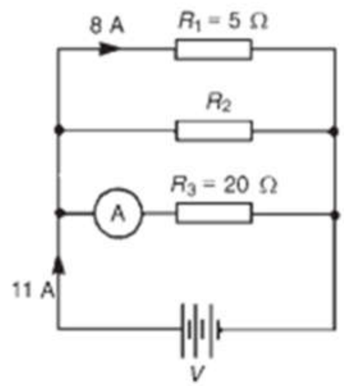

Figure 2.3

$$P.d\ across\ R_1\ is\ the\ same\ as\ the\ supply\ voltage\ V.$$

$$Hence\ supply\ voltage, V = 8 \times 5 = 40V$$

$$(a) Redading\ on\ ammeter, I = \frac{V}{R_3} = \frac{40}{20} = 2A$$

$$(b) Currentflowing\ through\ R_2 = \frac{V}{I_2} = \frac{40}{1} = 40\Omega$$