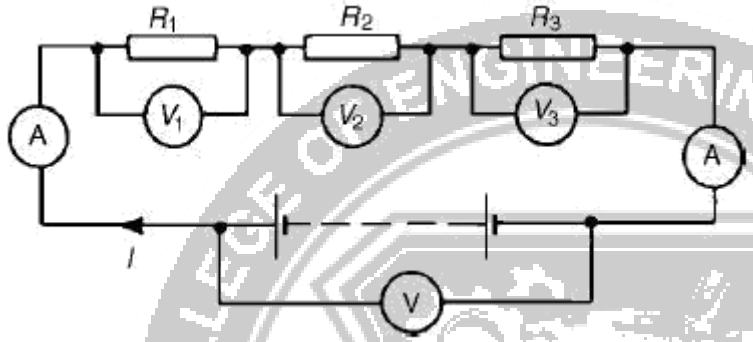
Resistors in series and parallel circuits:

Series circuits:

Figure shows three resistors R1, R2 and R3 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 V1, V2 and V3



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.

V = V1 +V2 +V3

From Ohm's law:

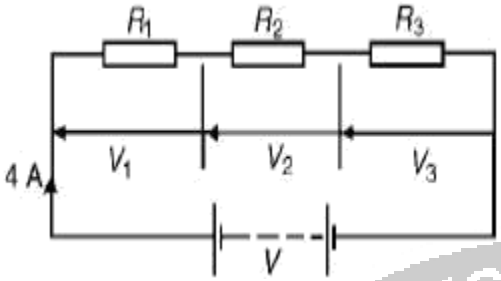
V1 = IR1, V2 = IR2, V3 = IR3 and V = IR where R is the total circuit resistance.

Since V =V1 + V2 + V3

then IR =IR1 + IR2 + IR3 Dividing throughout by I gives R = R1 + R2 + R3

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

Problem 1: For the circuit, 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 p.d.'sR1, R2acrossandR3are5V, 2V and 6V respectively.



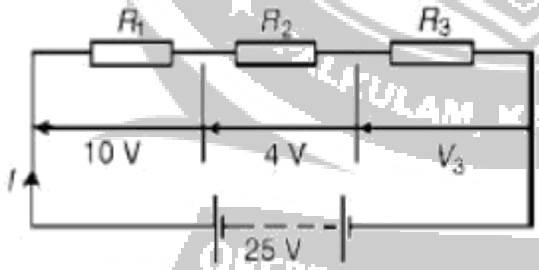
(a) Battery voltage V =V1 + V2 + V3 =5 + 2 + 6=13V
(b)Total circuit resistance R= V/ I
= 13/4=3.25Ω
(c) Resistance R1 = V1/ I
= 5/4

=1.25 Ω Resistance R2 = V2/ I

= 2/4 =0.5 Ω

Resistance R3 = V3/ I = 6/4 =1.5 Ω

Problem 2. For the circuit shown in Figure determine the p.d. across resistor *R*3. If the total resistance of the circuit is 100_, determine the current flowing through resistor *R*1. Find also the value of resistor *R*2.



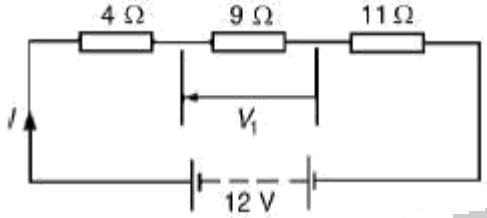
P.d. across R3, V3 =25 −10 −4=11V Current I = V/ R

= 25/100

=0.25A, which is the current flowing in each resistor Resistance R2 = V2/ I

= 4/0.25 =16 Ω

Problem 3: A 12V battery is connected in a circuit having three series-connected resistors having resistances of 4 Ω, 9 Ωand 11 Ω. Determine the current flowing through, and the p.d. across the 9 Ωresistor. Find also the power dissipated in the 11 Ωresistor.



Total resistance R=4 + 9 + 11=24 Ω Current I = V/ R

= 12/24

=0.5A, which is the current in the 9 Ω resistor.

P.d. across the 9 Ω resistor, $V1 = I \times 9 = 0.5 \times 9$

= 4.5V

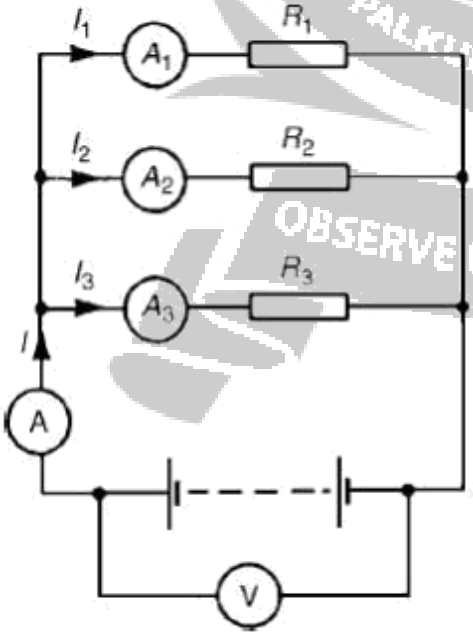
Power dissipated in the 11 Ω resistor, $P = I2R$=0.52(11)

= 0.25(11)

= 2.75W

PARALLEL NETWORKS:

Problem 1: Figure shows three resistors, R1, R2 and R3 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 I1, I2 and I3 is equal to the total circuit current, I, i.e. I =I1 +I2 +I3, and

the source p.d., V volts, is the same across each of the
From Ohm's law:
I1 = V/R1
I2 = V/R2

I3 = V/R3 and I = V/R

where R is the total circuit resistance. Since I =I1 + I2 + I3

then

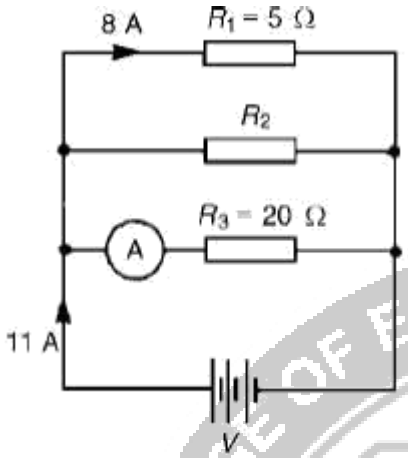
V/R= V/R1+ V/R2+ V/R3 Dividing throughout by V gives:

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

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

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

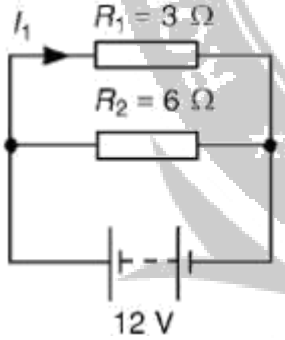
Problem 2: For the circuit shown in Figure , determine (a) the reading on the ammeter, and (b) the value of resistor R2.



P.d. across R1 is the same as the supply voltage V.
Hence supply voltage, V =8 × 5=40V

(a) Reading on ammeter, I = V R3= 40/20=2A

Current flowing through R2
=11−8−2=1A Hence, R2 = V/I2=
40/1=40 Ω

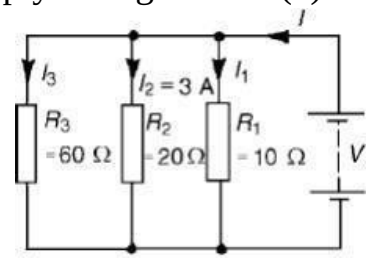


(a) The total circuit resistance R is given by 1/R= 1/R1+ 1/R2=

1/3+ 1/6 1/R= 2 + 1/6= 3/6 Hence, R = 6/3= 2 Ω

(b) Current in the 3 Ω resistance, I1 = V R1= 12/3= 4A

Problem 3: For the circuit shown in Figure find (a) the value of the supply voltage V and (b) the value of current I.



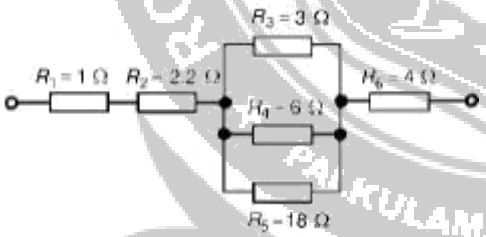
(a) P.d. across 20 Ω resistor = I2R2 = 3× 20 = 60V, hence supply voltage V =60V since the circuit is connected in parallel.

(b) Current
I1 = V/R1= 60/10= 6A;
I2 = 3A
I3 = V/R3= 60/60= 1A

Current I =I1+I2+I3 and hence I =6+3+1=10A Alternatively,

1/R= 1/60+ 1/20+ 1/10= 1 + 3 + 6/60= 10/60 Hence total resistance R= 6010=6 Ω Current I = V/R= 60/6=10A

Problem 4: Find the equivalent resistance for the circuit shown in Figure



*R*3, *R*4 and*R*5 are connected in parallel and their equivalent resistance *R* is given by: 1/*R*= 1/3+ 1/6+ 1/18=6 + 3 + 1/18= 10/18

Hence *R*= 18/10=1.8 Ω

The circuit is now equivalent to four resistors in series and the equivalent circuit resistance =1+2.2+1.8+4=9 Ω