Electrical Circuits
Series dc Circuits

By

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الأفكار المركزية

1- connection and series CSC

2 – current in series circuits

3 - voltage in series circuits

4- Total Resistance for series circuits

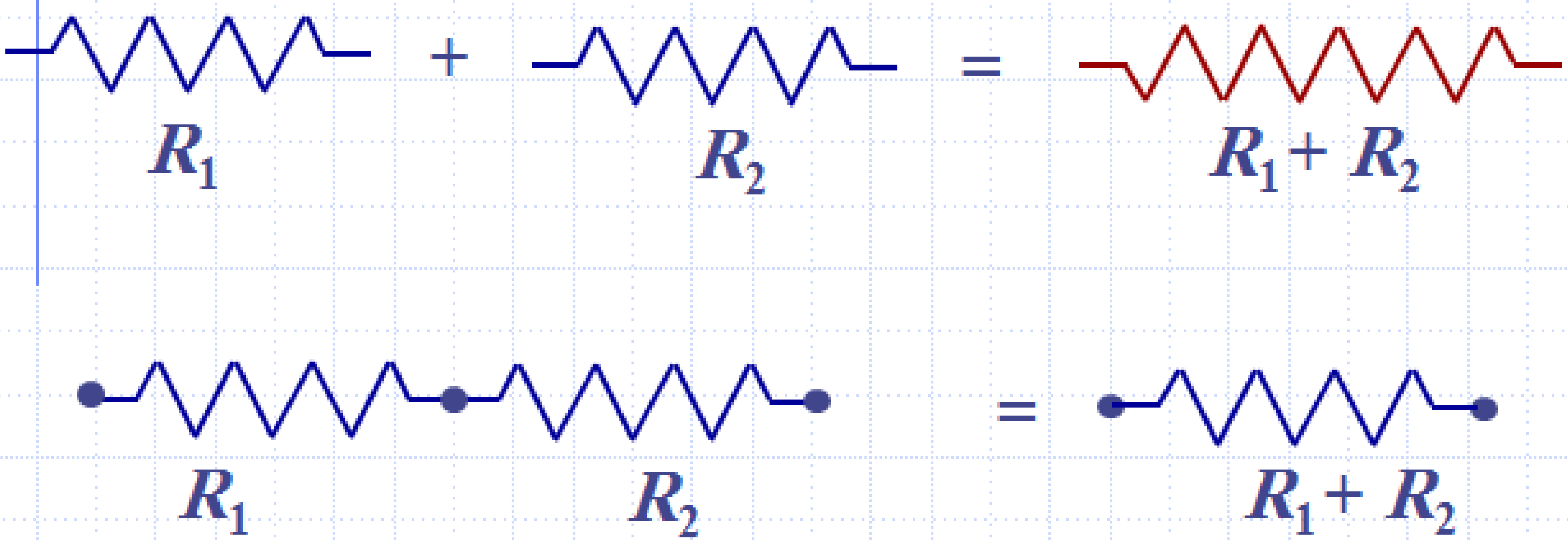
5 - Total power in series circuits

6 – Voltage divider

7 – Examples and Homeworks

Series Connection of Resistors

Here's How Resistors Add in Series



Equivalent Resistance

Q1- Write Series connection csc

1- Same current is flow in all Resistances it =i1=i2

2- Voltage is shared between the Resistances

3 – Voltage across each Resistor is given by ohm ,s Law
V = IR

4- Total voltage is equal to the sum of voltage s

$$E = V1 + V2 +$$

5- Total Resistance is the sum of series Resistances

6- Total power is the sum of powers in each Resistor

Series CSC.

5- Total Resistance is the sum of series Resistances

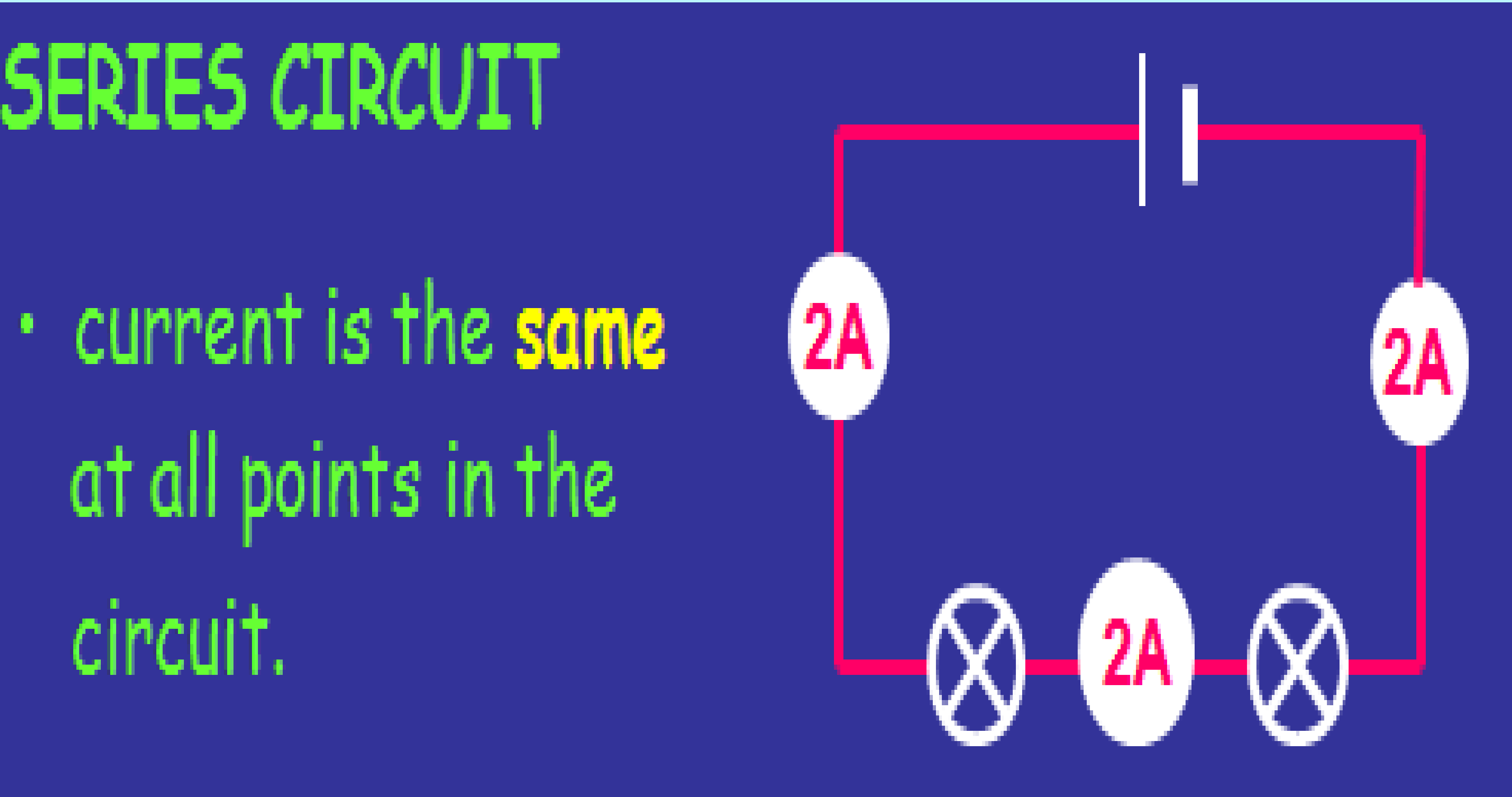
$$Rt = R1 + R2 + R3$$

6- For equal Resistors $Rt = N R$

7 - The smaller the Resistor , the smaller voltage drop

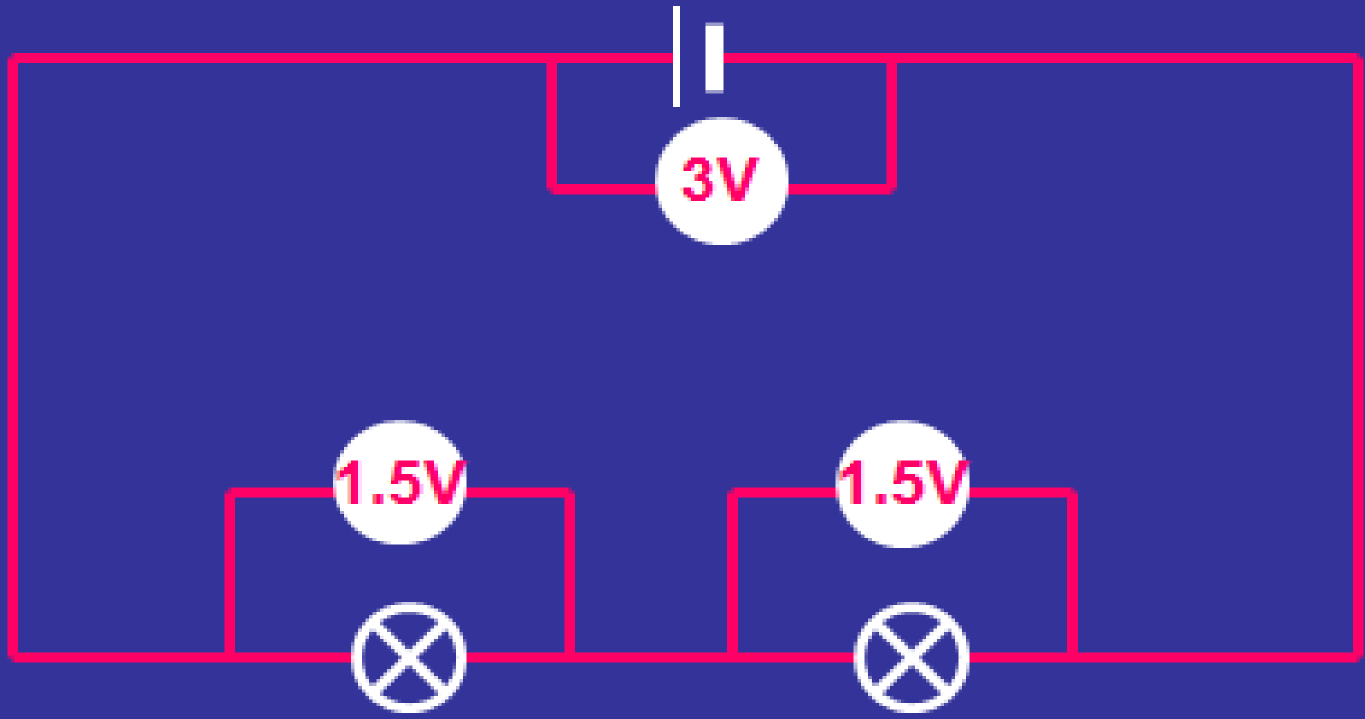
6- Total power is the sum of powers in each Resistor

1 - Same current flow in the circuit (I1 = I2 = I)



2A--Voltage is distributed between the components (E = V1 + V2)

- voltage is **shared** between the components



2 B – Voltage across a resistors is given by ohm,s law

$$V_1 = IR_1 \qquad V_2 = IR_2 \qquad V_3 = IR_3$$

- The polarity of the voltage across a resistor is determined by the direction of the current

3 - The total resistance of a series configuration is the sum of the resistance level.

$$R_T = R_1 + R_2 + R_3 + R_4 + \ldots + R_N$$

4 - Series Resistors

- When series resistors have the same value,

$$R_T = NR$$

- Where *N* = the number of resistors in the string.

5 - Power Distribution in a Series Circuit

- The power applied by the dc supply must equal that dissipated by the resistive elements.

$$P_E = P_{R_1} + P_{R_2} + \ldots + P_{R_N}$$

$$P1 = V1\, I1 = I^2 R1 = \frac{V1^2}{R1}$$

$$P2 = V2\, I2 = I^2 R2 = \frac{V2^2}{R2}$$

$$Pt = V\, I = I^2 Rt$$

6 – Voltage Division in a Series Circuit

- The voltage across the resistive elements will divide as the magnitude of the resistance levels.
  - The greater the value of a resistor in a series circuit, the more of the applied voltage it will capture.
- Voltage Divider Rule (VDR)
  - The VDR permits determining the voltage levels of a circuit without first finding the current.

$$V_X = R_X \frac{E}{R_T}$$

Problem 1. For the circuit shown in Fig. 5.2, determine (a) the battery voltage V, (b) the total resistance of the circuit, and (c) the values of resistors R_1, R_2 and R_3, given that the p.d.'s across R_1, R_2 and R_3 are 5 V, 2 V and 6 V respectively.

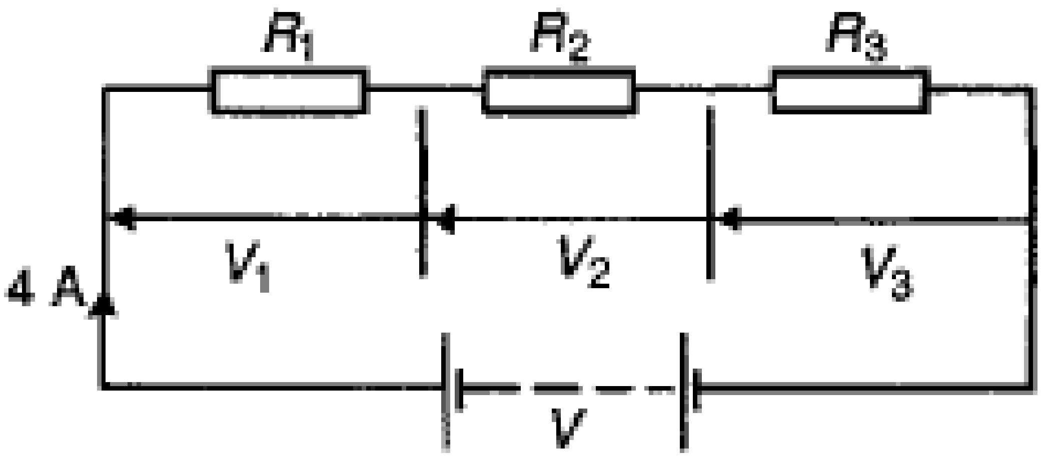


Figure 5.2

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

$$= 5 + 2 + 6 = 13\,\text{V}$$

(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 $R_3 = \frac{V_3}{I} = \frac{6}{4} = 1.5\,\Omega$

(Check: $R_1 + R_2 + R_3 = 1.25 + 0.5 + 1.5 = 3.25\,\Omega = R$)

Problem 2. For the circuit shown in Fig. 5.3, determine the p.d. across resistor R_3. If the total resistance of the circuit is $100\,\Omega$, determine the current flowing through resistor R_1. Find also the value of resistor R_2.

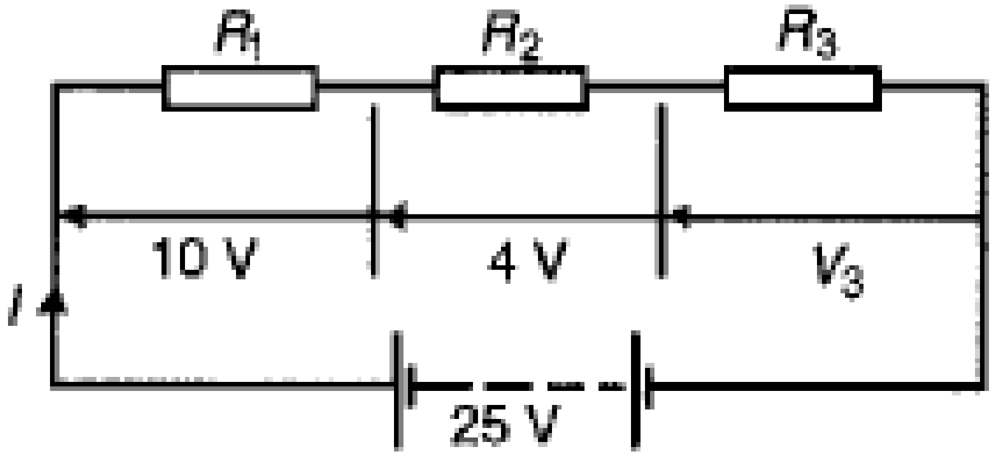


Figure 5.3

P.d. across R_3, $V_3 = 25 - 10 - 4 = 11\,\text{V}$

$$\text{Current } I = \frac{V}{R} = \frac{25}{100} = 0.25\,\text{A},$$

which is the current flowing in each resistor

$$\text{Resistance } R_2 = \frac{V_2}{I} = \frac{4}{0.25} = 16\,\Omega$$

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

The circuit diagram is shown in Fig. 5.4

Total resistance $R = 4 + 9 + 11 = 24\,\Omega$

$$\text{Current } I = \frac{V}{R} = \frac{12}{24} = \mathbf{0.5\ A},$$

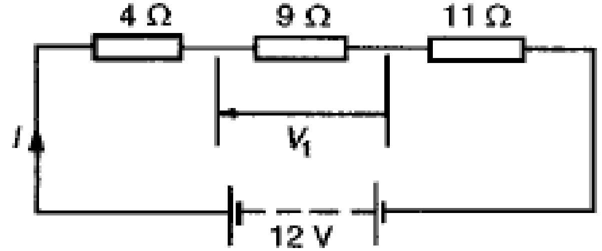


Figure 5.4

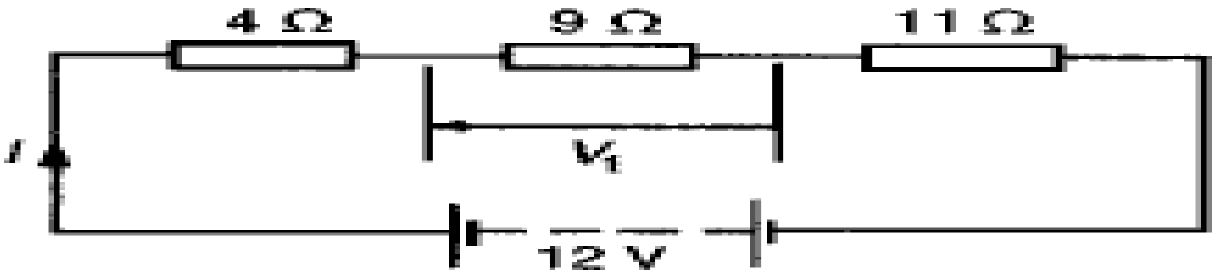


Figure 5.4

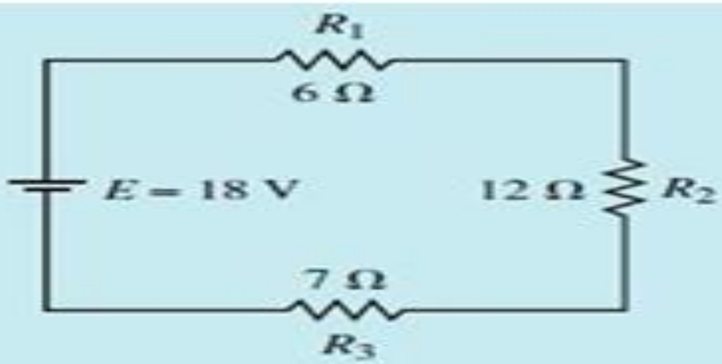
which is the current in the 9 Ω resistor.
P.d. across the 9 Ω resistor,

$$V_1 = I \times 9 = 0.5 \times 9 = \mathbf{4.5\ V}$$

Power dissipated in the 11 Ω resistor,

$$P = I^2R = (0.5)^2(11)$$
$$= (0.25)(11) = \mathbf{2.75\ W}$$

Example – 4 For the ckt find voltage drops across each resistor



Solution

$$R_T = 6\,\Omega + 12\,\Omega + 7\,\Omega = 25.0\,\Omega$$

$$V_1 = \left(\frac{6\,\Omega}{25\,\Omega}\right)(18\text{ V}) = 4.32\text{ V}$$

$$V_2 = \left(\frac{12\,\Omega}{25\,\Omega}\right)(18\text{ V}) = 8.64\text{ V}$$

$$V_3 = \left(\frac{7\,\Omega}{25\,\Omega}\right)(18\text{ V}) = 5.04\text{ V}$$

The total voltage drop is the summation

$$V_T = 4.32\text{ V} + 8.64\text{ V} + 5.04\text{ V} = 18.0\text{ V} = E$$

Problem 5. Two resistors are connected in series across a 24 V supply and a current of 3 A flows in the circuit. If one of the resistors has a resistance of 2 Ω determine (a) the value of the other resistor, and (b) the p.d. across the 2 Ω resistor. If the circuit is connected for 50 hours, how much energy is used?

The circuit diagram is shown in Fig. 5.8

(a) Total circuit resistance

$$R = \frac{V}{I} = \frac{24}{3} = 8\,\Omega$$

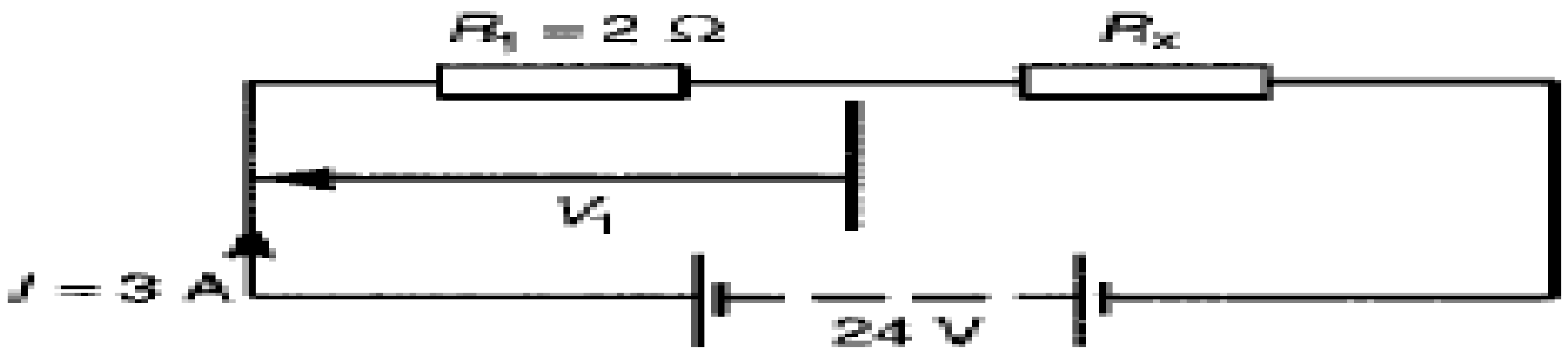


Figure 5.8

Value of unknown resistance,

$$R_x = 8 - 2 = 6\,\Omega$$

(b) P.d. across $2\,\Omega$ resistor,

$$V_1 = IR_1 = 3 \times 2 = 6\,\text{V}$$

Alternatively, from above,

$$V_1 = \left(\frac{R_1}{R_1 + R_x}\right) V$$
$$= \left(\frac{2}{2 + 6}\right)(24) = 6\,\text{V}$$

$$\begin{aligned}\text{Energy used} &= \text{power} \times \text{time}\\ &= (V \times I) \times t\\ &= (24 \times 3\,\text{W})(50\,\text{h})\\ &= 3600\,\text{Wh} = 3.6\,\text{kWh}\end{aligned}$$

Example - 6 find the voltage drops across each resistor by using VDR

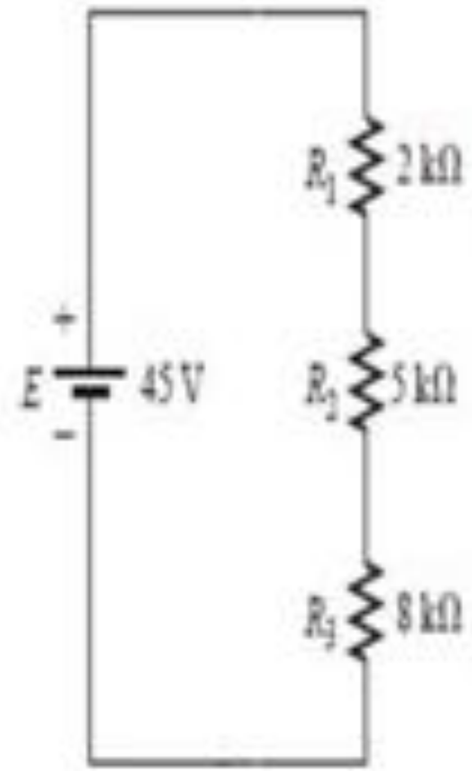
Solution:

$$V_1 = \frac{R_1 E}{R_T} = \frac{(2\ \text{k}\Omega)(45\ \text{V})}{2\ \text{k}\Omega + 5\ \text{k}\Omega + 8\ \text{k}\Omega} = \frac{(2\ \text{k}\Omega)(45\ \text{V})}{15\ \text{k}\Omega}$$

$$= \frac{(2 \times 10^3\ \Omega)(45\ \text{V})}{15 \times 10^3\ \Omega} = \frac{90\ \text{V}}{15} = 6\ \text{V}$$

$$V_3 = \frac{R_3 E}{R_T} = \frac{(8\ \text{k}\Omega)(45\ \text{V})}{15\ \text{k}\Omega} = \frac{(8 \times 10^3\ \Omega)(45\ \text{V})}{15 \times 10^3\ \Omega}$$

$$= \frac{360\ \text{V}}{15} = 24\ \text{V}$$



Example :

Three Resistances R1 = 2k Ω , R2 = 5 kΩ , R3 = 8 kΩ are connected inseries to E = 45 V supply Use voltage devider law determine the voltage V1 , V2 , V3

Solution :

Rt = 2k + 5k + 8k = 15 kΩ

$$V1 = \frac{R1}{Rt} E = \frac{2k}{15k} * 45 = 6V$$

$$V2 = \frac{R2}{Rt} E = \frac{5k}{15k} * 45 = 15V$$

$$V3 = \frac{R3}{Rt} E = \frac{8k}{15k} * 45 = 24 V$$

Example :

Two resistors $R1 = 4\ \Omega$.$R2 = 6\ \Omega$ are connected in series to supply 20 v calculate

1 – Total Resistance

2 – Total Current

3 – Voltage across each resistor

4 – Total Power

1 - $Rt = R1 + R2 = 4 + 6 = 10\Omega$

2 – $It = \frac{V}{Rt} = \frac{20}{10} = 2A$

3 - $V1 = I\ R1 = 2 * 4 = 8\ V$

$V2 = I\ R2 = 2 * 6 = 12\ V$

4 - $P1 = I^2\ R1 = 2^2 * 4 = 4 * 4 = 16\ W$

$P2 = I^2\ R2 = 2^2 * 6 = 4 * 6 = 24\ W$

$Pt = p1 + p2 = 16 + 24 = 40\ w$

$Pt = I^2\ Rt = 2^2 * 10 = 4 * 10 = 40\ w$

Example : 9 H.W

four resistors 5 , 10 ,15 , 20 Ω are connected in series to (100 v) supply determine

1 – Total Resistance

2 – Total current

3 – voltage drop across each resistor

4 - Total Power consumed

5 – Total Power deliverd

Example : 10 (H.W)

For the circuit shown in Fig. 5.9, determine the value of V_1. If the total circuit resistance is 36 Ω determine the supply current and the value of resistors R_1, R_2 and R_3

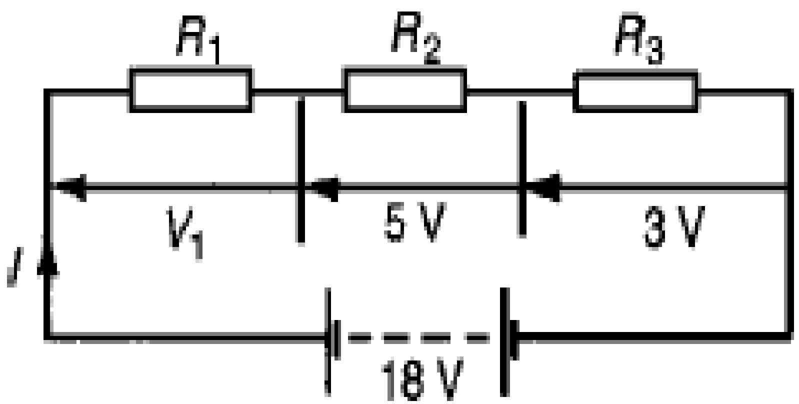


Figure 5.9

Example :11-When the switch in the circuit (5-10) is closed the reading on voltmrter 1 is 30 v and that on voltmeter 2 is 10 v Determine the reading on the ammeter and the value of resistor R2   (**H.W**)

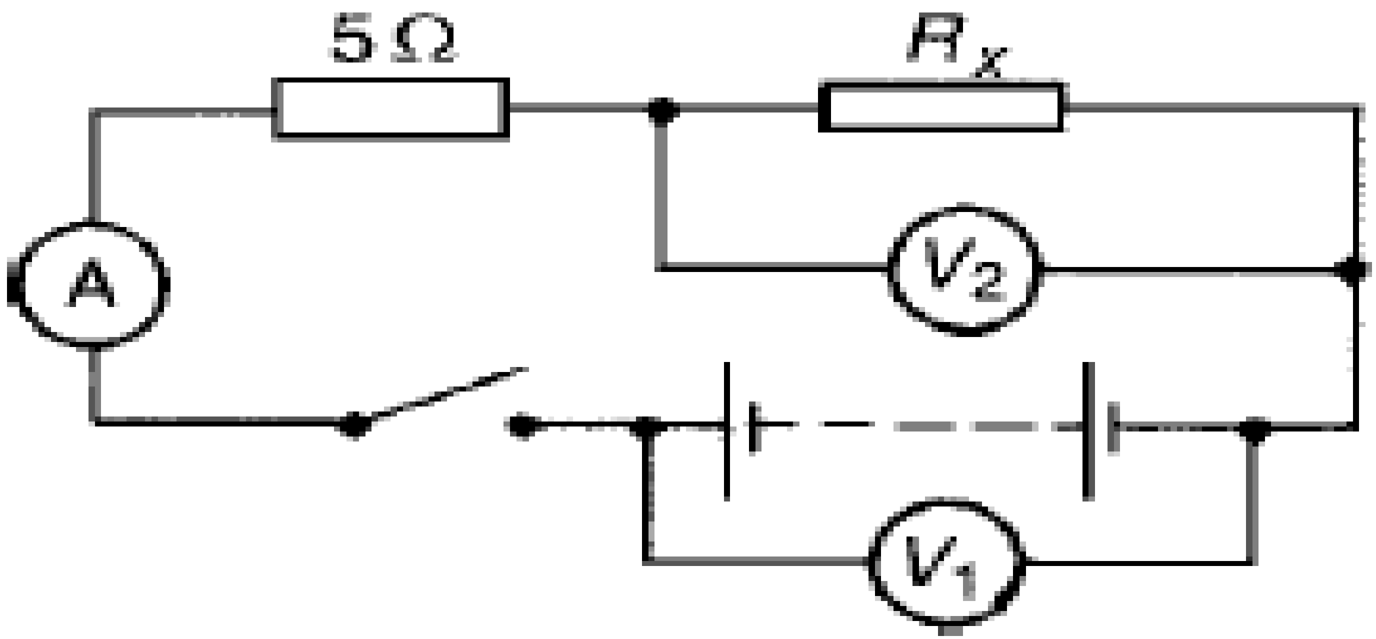


Figure 5.10