Serial-Parallel Circuits

Introduction

- A series-parallel configuration is one that is formed by a combination of series and parallel elements.
- A complex configuration is one in which none of the elements are in series or parallel.

Reduce and Return Approach

- Reduce:
  - Reduce the circuit to its simplest form across the source and then determine the source current (I_s).
- Return:
  - Using the resulting source current (I_s) to work back to the desired unknown.

Problem 11. Resistances of 10 Ω, 20 Ω and 30 Ω are connected (a) in series and (b) in parallel to a 240 V supply. Calculate the supply current in each case.

(a) The series circuit is shown in Fig. 5.21
The equivalent resistance
$R_T = 10\,\Omega + 20\,\Omega + 30\,\Omega = 60\,\Omega$

Supply current $I = \dfrac{V}{R_T} = \dfrac{240}{60} = 4\,\text{A}$

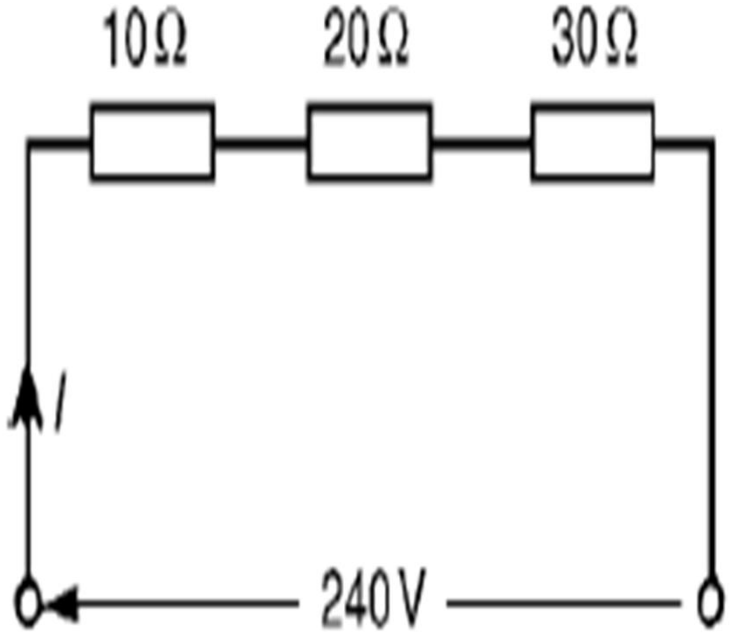


Figure 5.21

B – When the Resistances are connected in parallel

$$\frac{1}{R_T} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30} = \frac{6+3+2}{60} = \frac{11}{60}$$

hence $R_T = \frac{60}{11}\,\Omega$

Supply current

$$I = \frac{V}{R_T} = \frac{240}{\frac{60}{11}} = \frac{240 \times 11}{60} = 44\,\text{A}$$

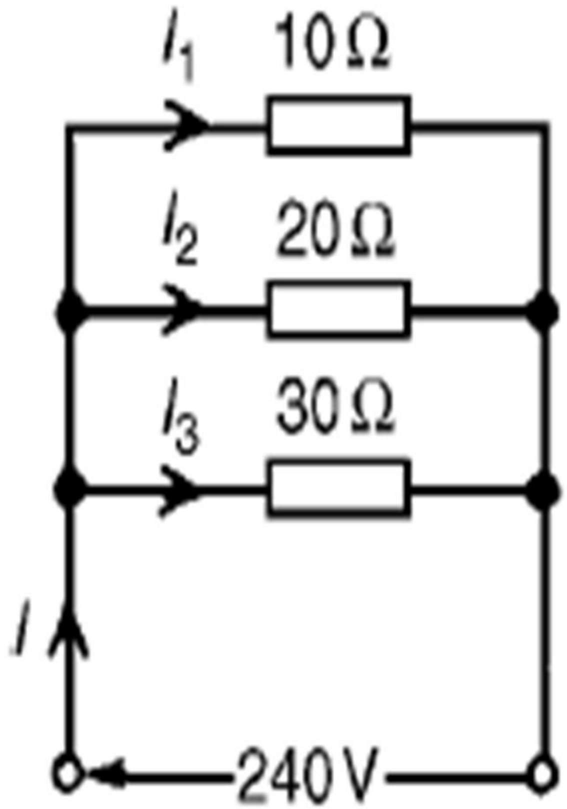


Figure 5.22

Problem 12. For the series-parallel arrangement shown in Fig. 5.24, find (a) the supply current, (b) the current flowing through each resistor and (c) the p.d. across each resistor.

p.d. : potential difference

p.d.يقصد فرق الجهد

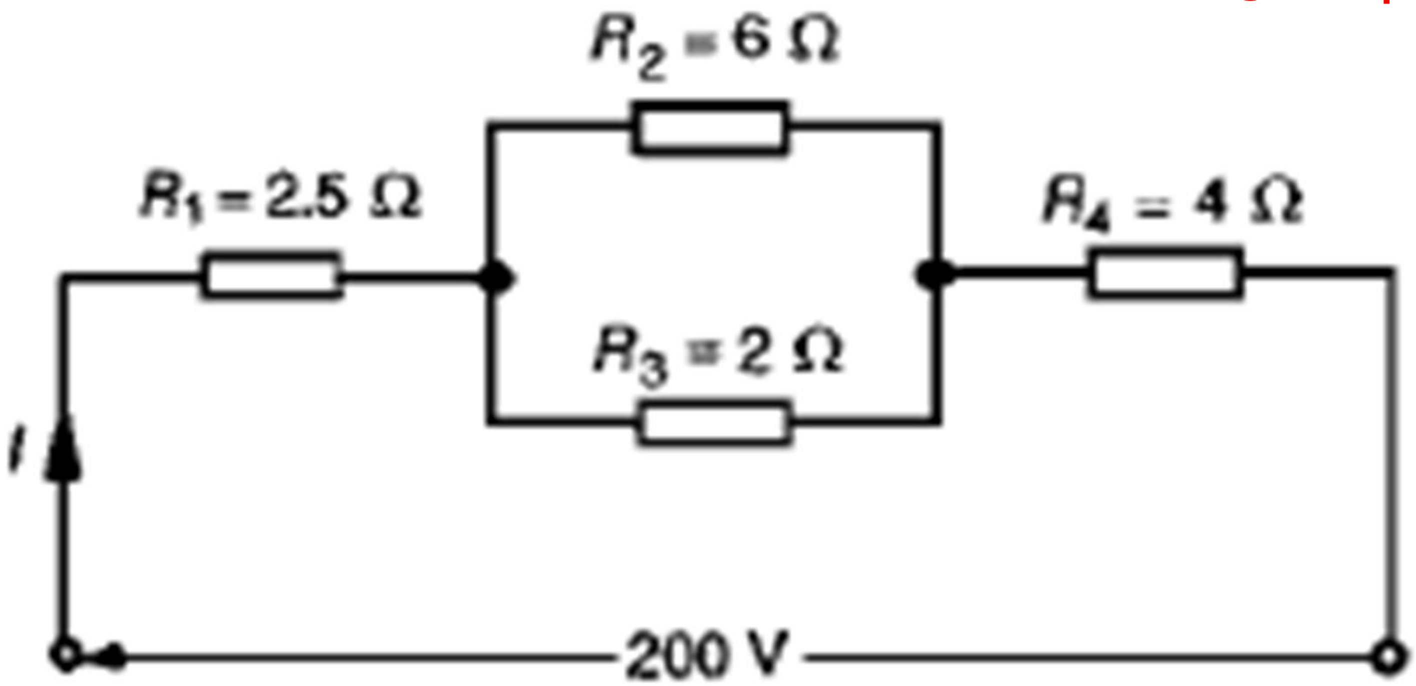


Figure 5.24

(a) The equivalent resistance R_x of R_2 and R_3 in parallel is:

$$R_x = \frac{6 \times 2}{6+2} == 1.5\,\Omega$$

The equivalent resistance R_T of R_1, R_x and R_4 in series is:

$$R_T = 2.5 + 1.5 + 4 = 8\,\Omega$$

Supply current

$$I = \frac{V}{R_T} = \frac{200}{8} = 25\,\text{A}$$

(b) The current flowing through R_1 and R_4 is 25 A. The current flowing through

$$R_2 = \left(\frac{R_3}{R_2 + R_3}\right) I = \left(\frac{2}{6+2}\right) 25$$

$$= \mathbf{6.25\,A}$$

The current flowing through

$$R_3 = \left(\frac{R_2}{R_2 + R_3}\right) I$$

$$= \left(\frac{6}{6+2}\right) 25 = \mathbf{18.75\,A}$$

p.d. across R_1, i.e.

$$V_1 = IR_1 = (25)(2.5) = \mathbf{62.5\,V}$$

p.d. across R_x, i.e.

$$V_x = IR_x = (25)(1.5) = \mathbf{37.5\,V}$$

p.d. across R_4, i.e.

$$V_4 = IR_4 = (25)(4) = \mathbf{100\,V}$$

Hence the p.d. across R_2

$= \text{p.d. across } R_3 = \mathbf{37.5\,V}$

Problem 13. For the circuit shown in Fig. 5.26 calculate (a) the value of resistor R_x such that the total power dissipated in the circuit is 2.5 kW, (b) the current flowing in each of the four resistors.

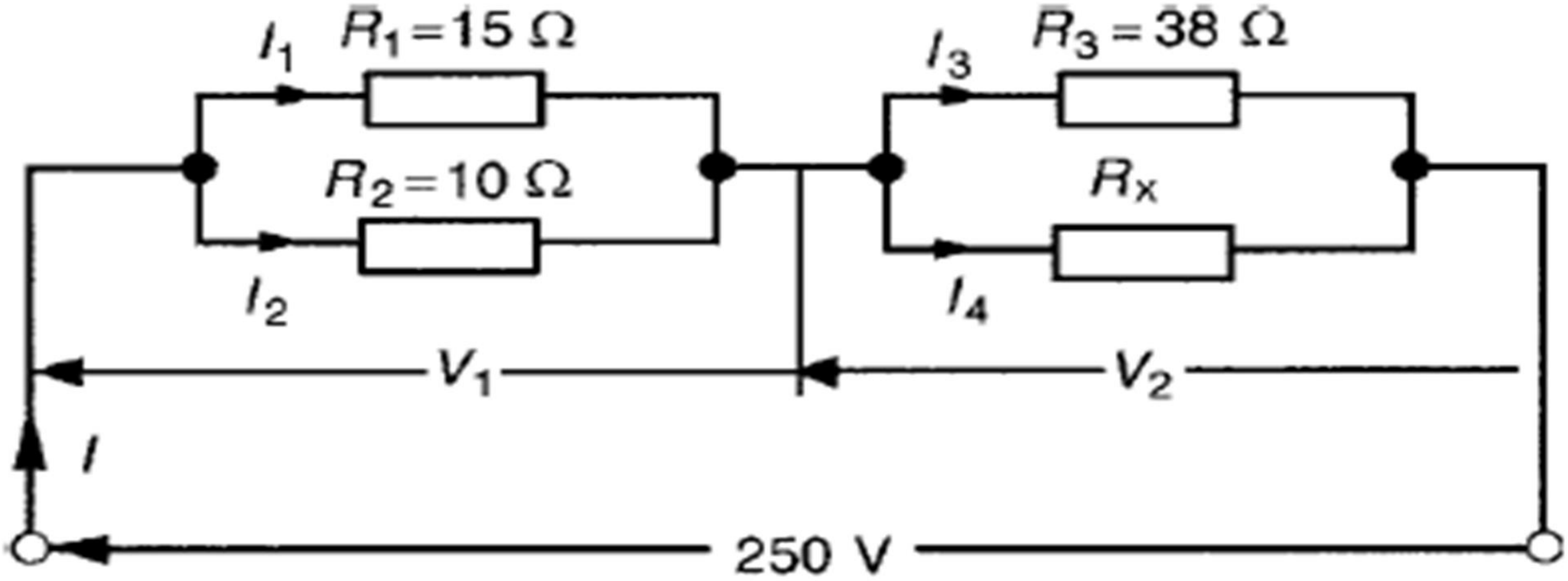


Figure 5.26

(a) Power dissipated $P = VI$ watts, hence
$2500 = (250)(I)$

$$\text{i.e. } I = \frac{2500}{250} = 10\,\text{A}$$

From Ohm's law,

$$R_T = \frac{V}{I} = \frac{250}{10} = 25\,\Omega,$$

where R_T is the equivalent circuit resistance. The equivalent resistance of R_1 and R_2 in parallel is

$$\frac{15 \times 10}{15 + 10} = \frac{150}{25} = 6\,\Omega$$

The equivalent resistance of resistors R_3 and R_x in parallel is equal to $25\,\Omega - 6\,\Omega$, i.e. $19\,\Omega$.

The voltage $V_1 = IR$, where R is $6\,\Omega$, from above, i.e. $V_1 = (10)(6) = 60\,\text{V}$. Hence

$$V_2 = 250\,\text{V} - 60\,\text{V} = 190\,\text{V}$$

$$= \text{p.d. across } R_3$$

$$= \text{p.d. across } R_x$$

$$I_3 = \frac{V_2}{R_3} = \frac{190}{38} = 5\,\text{A}.$$

Thus $I_4 = 5\,\text{A}$ also, since $I = 10\,\text{A}$. Thus

$$R_x = \frac{V_2}{I_4} = \frac{190}{5} = 38\,\Omega$$

Problem 14. For the arrangement shown in Fig. 5.27, find the current I_x.

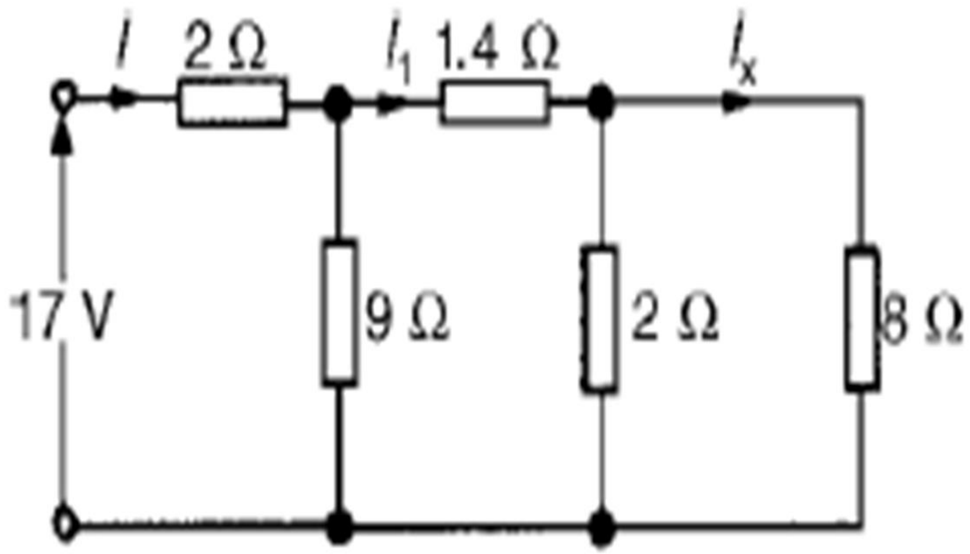


Figure 5.27

$$I = \frac{17}{4.25} = 4\text{ A}$$

From Fig. 5.28(b),

$$I_1 = \left(\frac{9}{9+3}\right)(I) = \left(\frac{9}{12}\right)(4) = 3\text{ A}$$

From Fig. 5.27

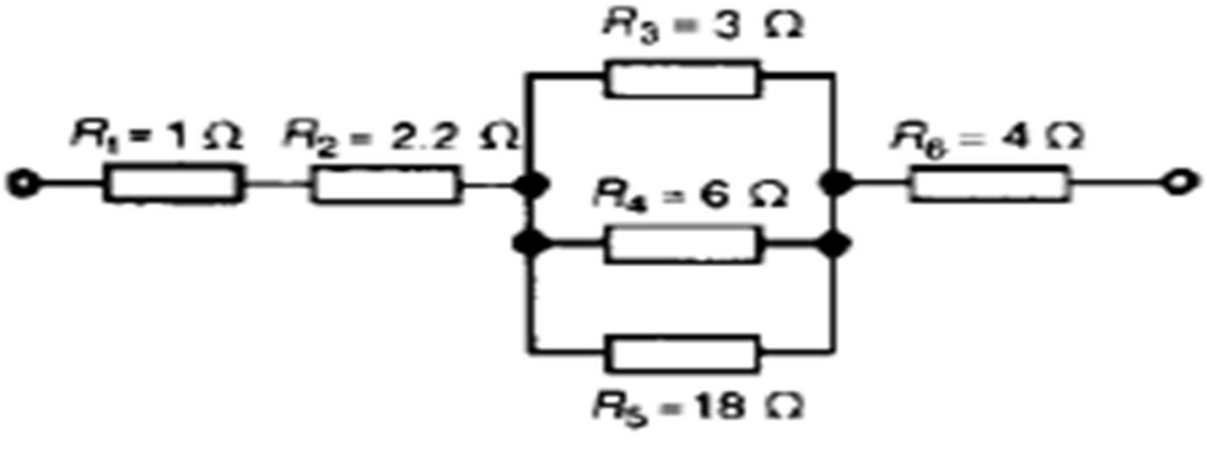
$$I_x = \left(\frac{2}{2+8}\right)(I_1) = \left(\frac{2}{10}\right)(3) = \mathbf{0.6\text{ A}}$$

Example – 35 find total Resistance

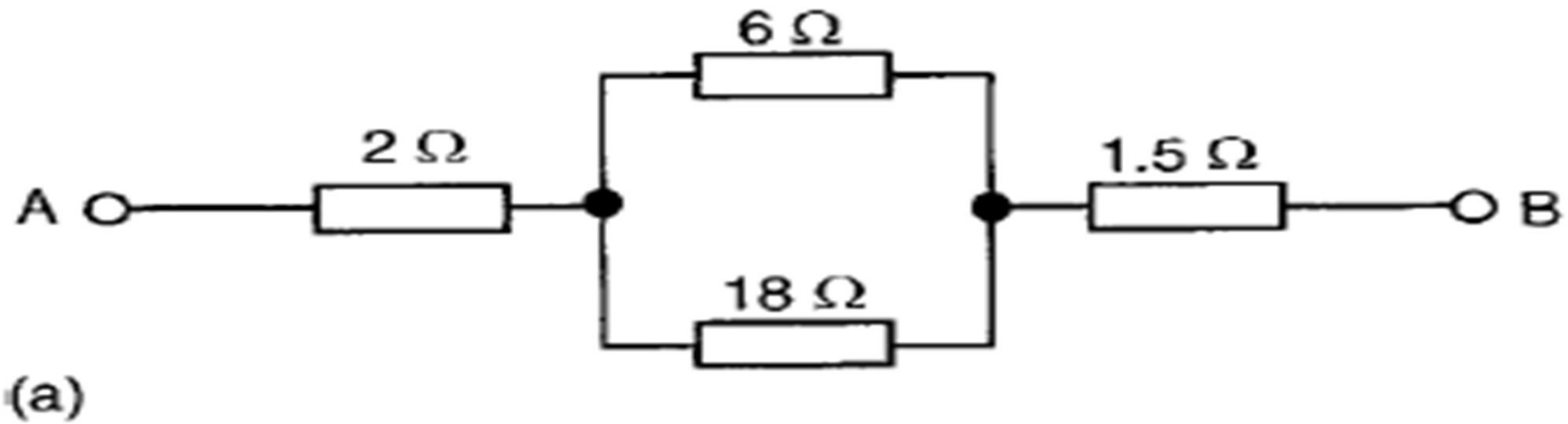
R_3, R_4 and R_5 are connected in parallel and their equivalent resistance R is given by

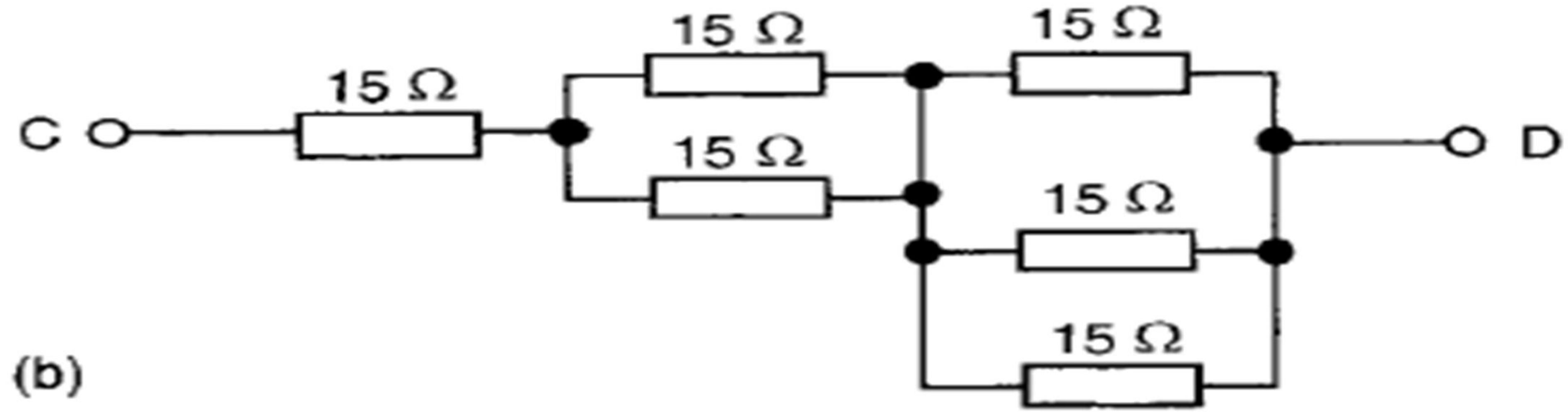
$$\frac{1}{R} = \frac{1}{3} + \frac{1}{6} + \frac{1}{18} = \frac{6+3+1}{18} = \frac{10}{18}$$

hence $R = (18/10) = 1.8\,\Omega$. The circuit is now equivalent to four resistors in series and the **equivalent circuit resistance** $= 1 + 2.2 + 1.8 + 4 = \mathbf{9\,\Omega}$

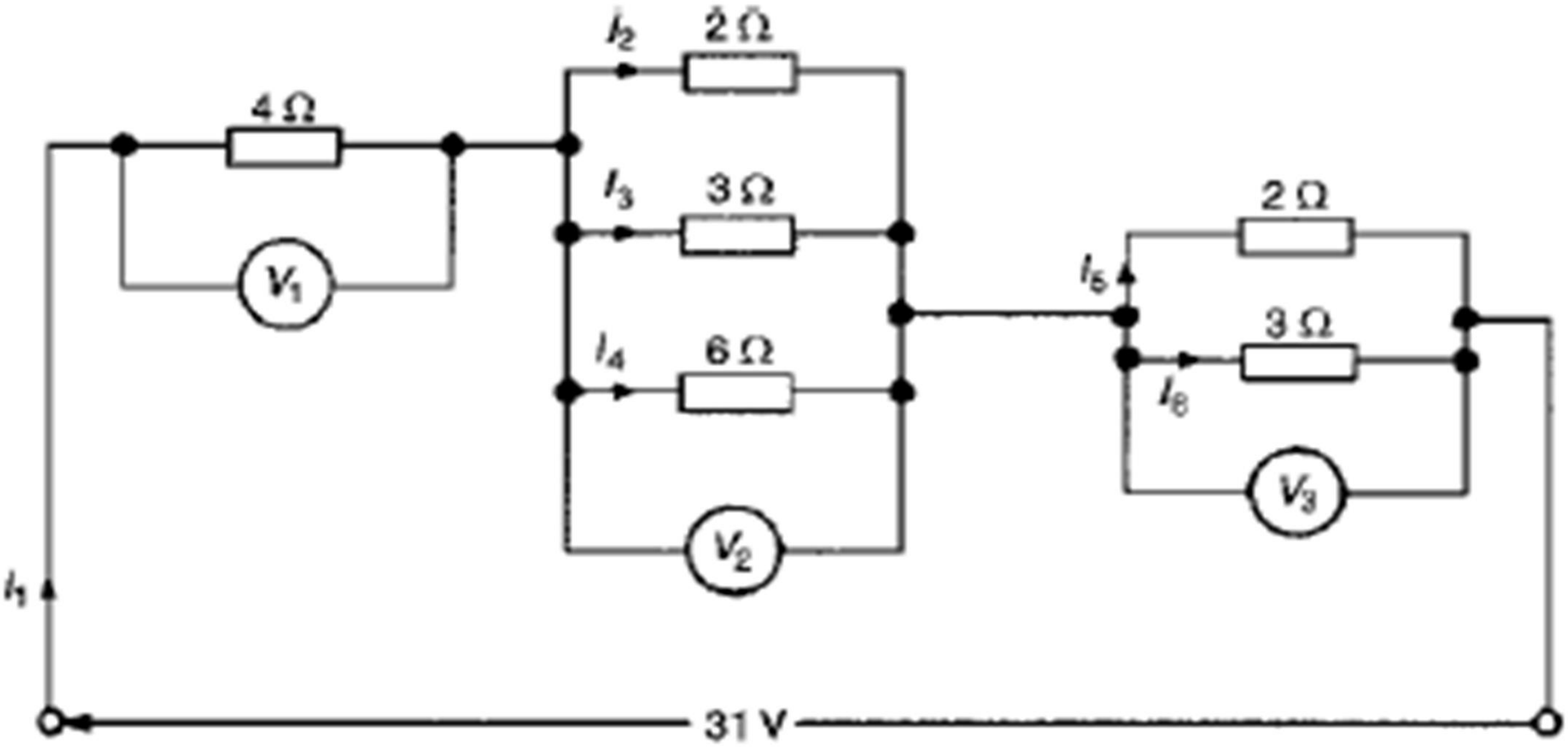


Example :36 Find the total Resistance (H.W)

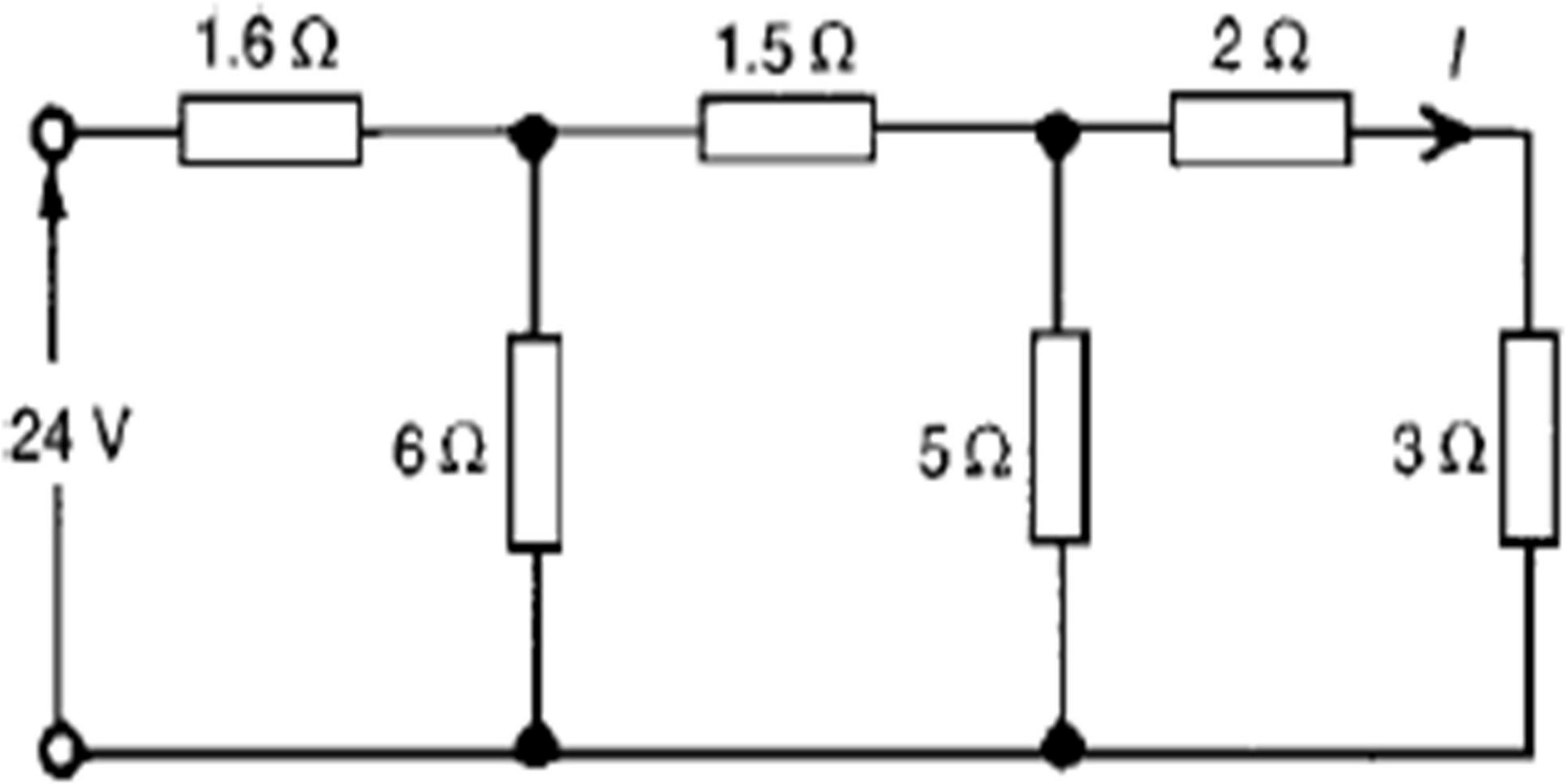




Example : 37 Determine the currents and voltages indicated in fig : (H.W)



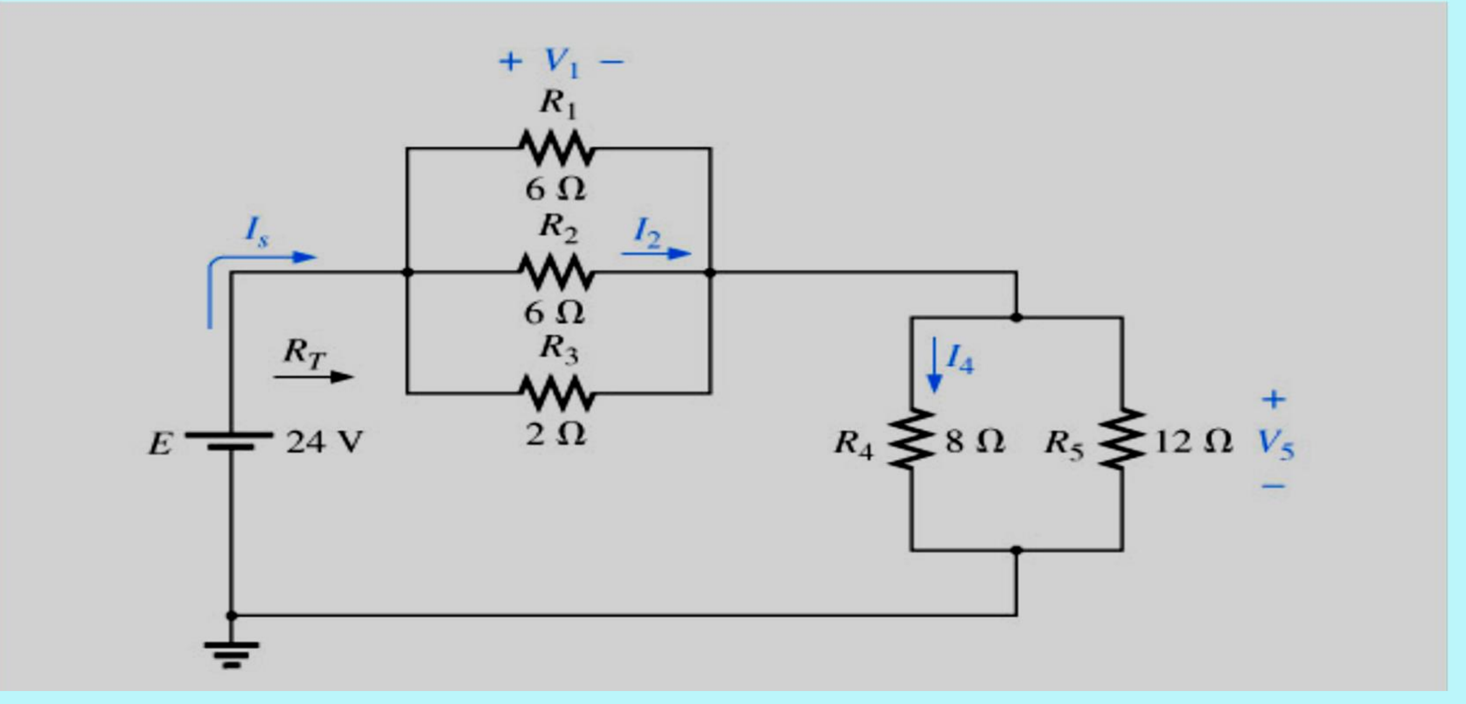
Example : 38 find the current (I) in fig . Shown:(H.W)



Example – 39

H.W

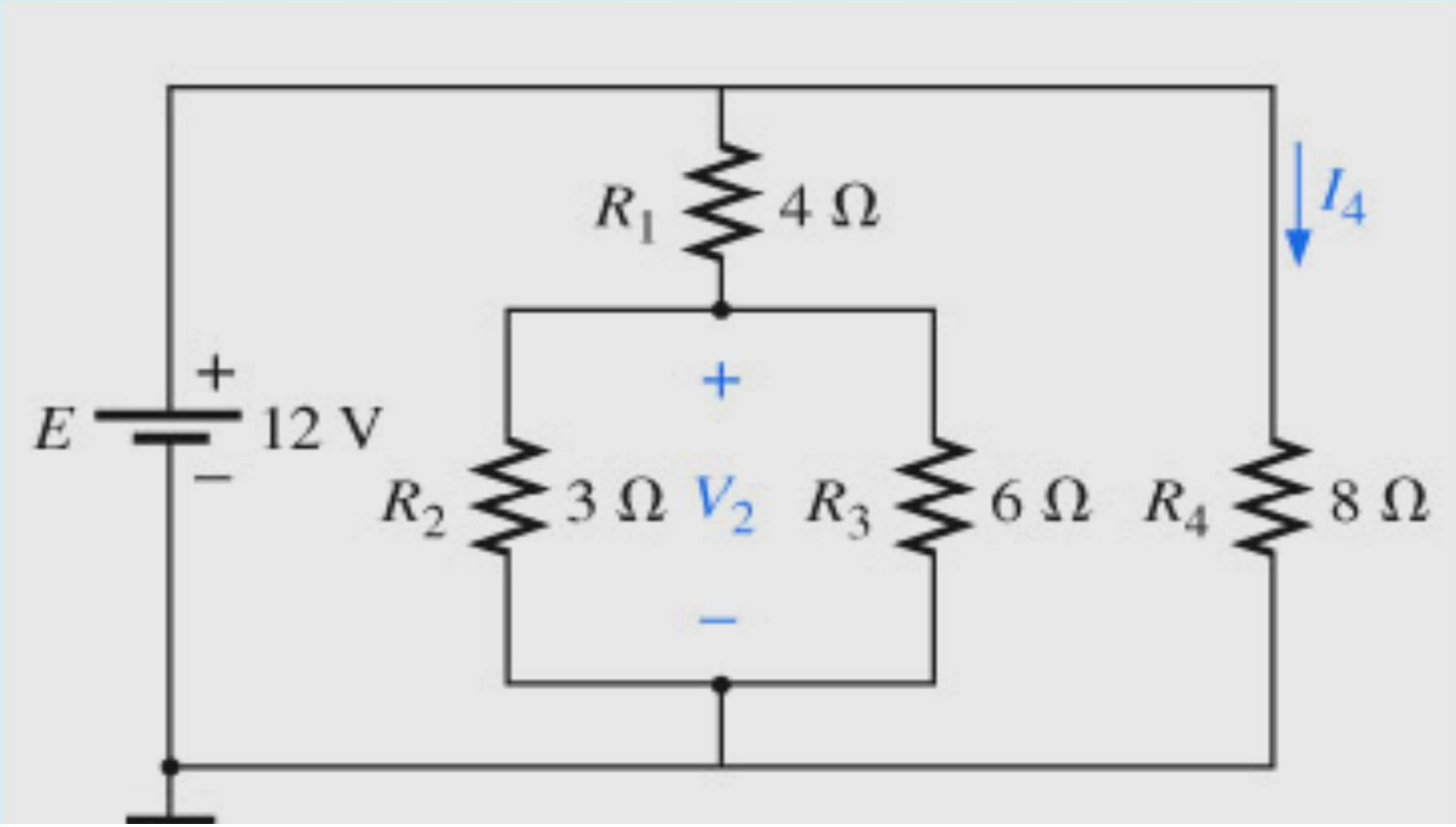
Find the indicated currents and voltages for the network shown in Fig.



Example – 40

H.W

- Find the current I_4 and the voltage V_2 for the network shown in fig .

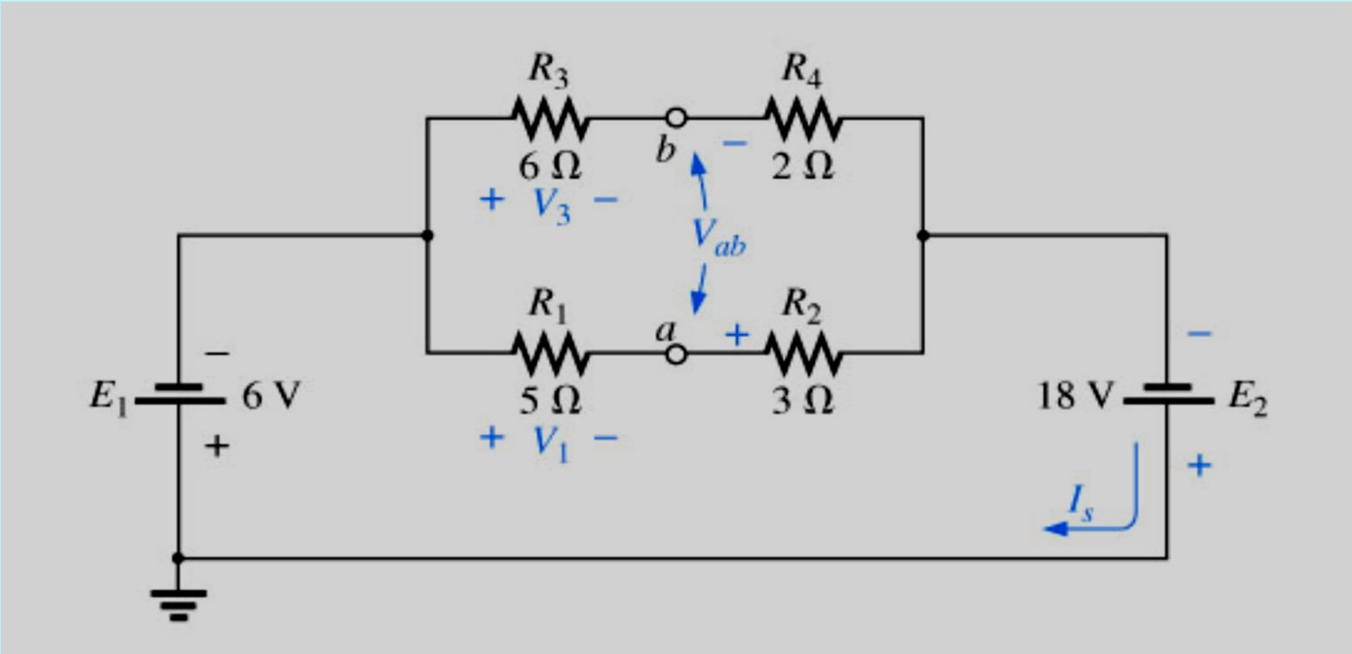


Example – 41

H.W

a. Find the voltages V_1, V_2 and V_{ab} for the network in Fig.

b. Calculate the source current I_s .



Example – 42

H.W

Calculate the indicated currents and voltage in Fig.

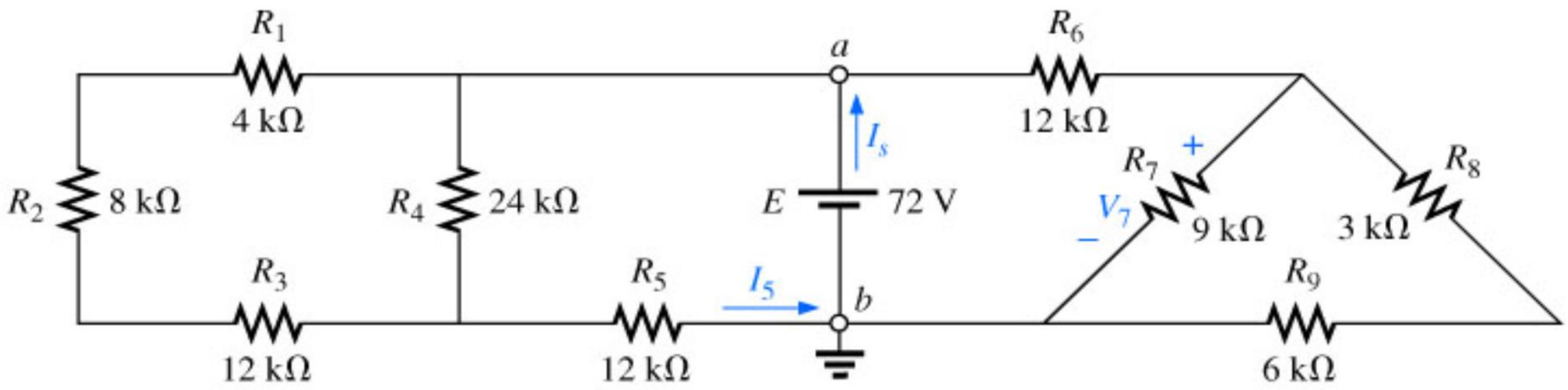


FIG. 7.22

Example 7.9.