3

Current Electricity

TEXTBOOK Questions

3.1. The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω, what is the maximum current that can be drawn from the battery?

Ans. Given, $E = 12$ V, $r = 0.4\ \Omega$, $I_{max} = ?$

Using, $I = \dfrac{E}{R+r}$

For maximum current, $R = 0$.

So, $I_{max} = E/r = 12/0.4 = 30$ A.

3.2. A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed?

Ans. Given, $E = 10$ V, $r = 3\ \Omega$, $I = 0.5$ A, $R = ?$, $V = ?$

Using, $I = \dfrac{E}{R+r}$

or $R = (E/I) - r = (10/0.5) - 3$

$= 20 - 3 = 17\ \Omega$

and $V = IR = 0.5 \times 17 = 8.5$ V.

3.3. (a) Three resistors 1 Ω, 2 Ω and 3 Ω are combined in series. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.

Ans. (a) $R_s = 1 + 2 + 3 = 6\ \Omega$

(b) $I = \dfrac{12}{6} = 2$ A

Potential drop across resistor is:

$R_1 = 1 \times 2 = 2$ V

$R_2 = 2 \times 2 = 4$ V

$R_3 = 3 \times 2 = 6$ V

3.4. (a) Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.

Ans. (a) Given, $R_1 = 2\ \Omega$, $R_2 = 4\ \Omega$, $R_3 = 5\ \Omega$, $R_P = ?$

Using, $\dfrac{1}{R_P} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

$= \dfrac{1}{2} + \dfrac{1}{4} + \dfrac{1}{5}$

$$= \frac{10+5+4}{20} = \frac{19}{20}$$

$$R_P = \frac{20}{19}\ \Omega.$$

(*b*) $V = 20$ V, $I_1 = ?, I_2 = ?, I_3 = ?, I = ?$

Using, $$I = \frac{V}{R}$$

$$I_1 = \frac{V}{R_1} = \frac{20}{2} = 10 \text{ A}$$

$$I_2 = \frac{V}{R_2} = \frac{20}{4} = 5 \text{ A}$$

$$I_3 = \frac{V}{R_2} = \frac{20}{5} = 4 \text{ A}$$

As $I = I_1 + I_2 + I_3$

(for parallel connection)

$$= 10 + 5 + 4 = 19 \text{ A}$$

3.5. At room temperature (27.0°C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 177 Ω, given that the temperature coefficient of the material of the resistor is 1.70 × 10^{-4} °C^{-1}.

Ans. Given: $R_1 = 100\ \Omega$, $R_2 = 117\ \Omega$

$\alpha = 1.7 \times 10^{-4}$ °C^{-1}, $t_1 = 27$ °C, $t_2 = ?$

By formula,

$$R_2 = R_1 [1 + \alpha(t_2 - t_1)]$$

$$\Rightarrow R_2 - R_1 = R_1\alpha(t_2 - t_1)$$

or $$t_2 = \frac{R_2 - R_1}{R_1 \alpha} + t_1$$

$$= \frac{117-100}{100\times1.7\times10^{-4}} + 27$$

$$= \frac{17\times10^4}{100\times1.7} + 27$$

$$= 1000 + 27 = 1027\text{°C}.$$

3.6. A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6.0 × 10^{-7}m^2, and its resistance is measured to be 5.0 Ω. What is the resistivity of the material at the temperature of the experiment?

Ans. Length of the wire, l =15 m

Area of cross-section of the wire,

$a = 6.0 \times 10^{-7}$ m^2

Resistance of the material of the wire,

$R = 5.0\ \Omega$

Let resistivity of the material of the wire $= \rho$

We know that

$$R = \rho\frac{l}{A}$$

or $$\rho = \frac{RA}{l} = \frac{5\times6\times10^{-7}}{15}$$

$$= 2 \times 10^{-7}\ \Omega\text{m}$$

Hence, the resistivity of the material is $2 \times 10^{-7}\ \Omega$m.

3.7. A silver wire has a resistance of 2.1 Ω at 27.5 °C, and a resistance of 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver.

Ans.

$$R_t = R_0 (1 + \alpha t)$$

$$R_{27.5} = R_0 (1 + 27.5\ \alpha) \quad \text{... (}i\text{)}$$

$$R_{100} = R_0 (1 + 100\ \alpha) \quad \text{... (}ii\text{)}$$

$R_{27.5} = 2.1\ \Omega$ and $R_{100} = 2.7\ \Omega$

Putting these values in (*i*) and (*ii*) and then dividing them, we get,

$$\frac{1+100\alpha}{1+27.5\alpha} = \frac{2.7}{2.1}$$

On solving we get, $\alpha = 0.0039$°C^{-1}

3.8. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0°C? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is 1.70 × 10^{-4}°C^{-1}.

Ans. Supply voltage, $V = 230$ V

Initial current drawn, $I_1 = 3.2$ A

Let initial resistance be R_1, which is given as,

$$R_1 = \frac{V}{I} = \frac{230}{3.2}$$
$$= 71.87\ \Omega$$

Steady value of the current, $I_2 = 2.8$ A

Let resistance at the steady state be R_2, which is given as

$$R_2 = \frac{230}{3.2} = 82.14\ \Omega$$

Temperature co-efficient of nichrome, $\alpha = 1.70 \times 10^{-4}\ °C^{-1}$

Initial temperature of nichrome, $T_1 = 27.0°C$

Let the steady temperature of the heating element be T_2

T_2 can be calculated by the relation,

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

or $$T_2 - 27°C = \frac{82.14 - 71.87}{71.87 \times 1.7 \times 10^{-4}}$$
$$= 840.5$$

$\Rightarrow$ $$T_2 = 840.5 + 27$$
$$= 867.5°C$$

Therefore, the steady temperature of the heating element is 867.5°C.

3.9. Determine the current in each branch of the network shown in the figure 3.30.

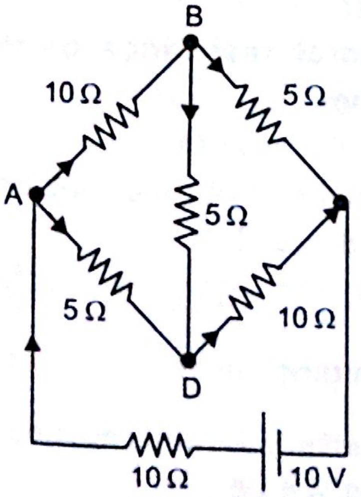
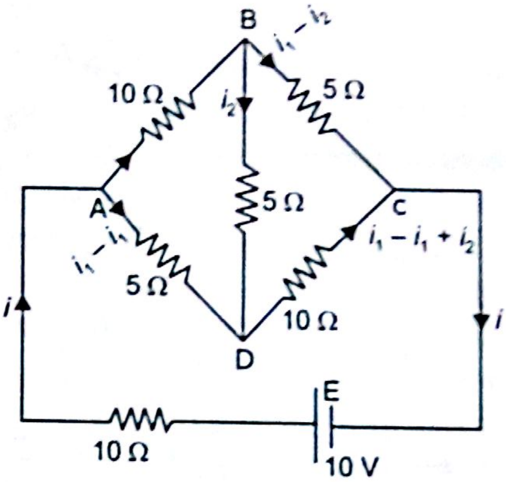


Figure 3.30

Ans. The given Wheatstone bridge is not balanced.



So, we solve it by using Kirchhoff's loop rule.

Consider the loop ABDA.

$10i_1 + 5i_2 - 5(i - i_1) = 0$

On solving it, we get

$3i_1 + i_2 = i$ ...(*i*)

Consider the loop BCDB.

$5(i_1 - i_2) - 10(i - i_1 + i_2) - 5i_2 = 0$

On solving we get

$3i_1 - 4i_2 = 2i$ ...(*ii*)

From equations (*i*) and (*ii*), we get

$$i_1 = \frac{2}{5}i$$

and $$i_2 = -\frac{1}{5}i$$

Now, consider the loop ADCEA

$5(i - i_1) + 10(i - i_1 + i_2) + 10i = 10$

$\Rightarrow 5i - 3i_1 + 2i_2 = 2$ ...(*iii*)

On substituting values of i_1 and i_2 in equation (*iii*), we get

$$5i - 3\left(\frac{2}{5}i\right) + 2\left(-\frac{i}{5}\right) = 2$$

$$i\left(\frac{17}{5}\right) = 2$$

$\therefore$ Total current,

$$i = \frac{10}{17}\ \text{A}$$

$$i_1 = \frac{2}{5}\left(\frac{10}{17}\right)\text{A} = \frac{4}{17}\ \text{A}$$

$$i_2 = -\frac{1}{5}\left(\frac{10}{17}\right) A$$

$$= -\frac{2}{17} A$$

Hence, current in branch AB $= \frac{4}{17}$ A

In AD $= \frac{10}{17} - \frac{4}{17} = \frac{6}{17}$ A

In BC $= \frac{4}{17} - \left(\frac{-2}{17}\right) = \frac{6}{17}$ A

In CD $= \frac{10}{17} - \frac{4}{17} + \left(\frac{-2}{17}\right) = \frac{4}{17}$ A

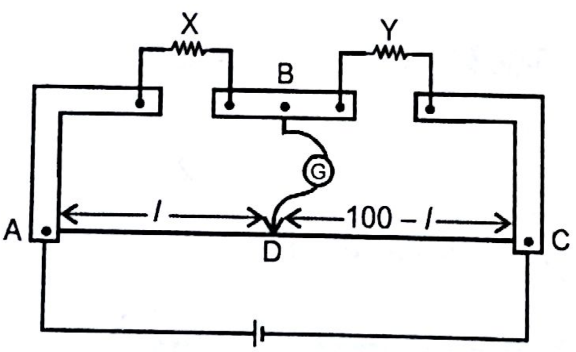
[In branch DC it is $\frac{4}{17}$ and in CD $= -\frac{4}{17}$]

In BD $= \frac{-2}{17}$ A

3.10. (*a*) **In a meter bridge shown below, the balance point is found to be at 39.5 cm from the end *A*, when the resistor *Y* is of 12.5 Ω. Determine the resistance of *X*. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?**

(*b*) **Determine the balance point of the bridge above if *X* and *Y* are interchanged.**

(*c*) **What happens if the galvanometer and cell are interchanged at the balance point of the bridge? Would the galvanometer show any current?**



Ans. (*a*) l = 39.5 cm, Y = 12.5 Ω, X = ?

$$\frac{X}{Y} = \frac{l}{100 - l}$$

$$X = \left(\frac{l}{100 - l}\right) Y$$

$$= \left(\frac{39.5}{100 - 39.5}\right) \times 12.5$$

$$X = 8.16\ \Omega \approx 8.2\ \Omega$$

Thick copper strips are used to minimise resistance of the connections as they are not to be included.

(*b*)
$$\frac{Y}{X} = \frac{l'}{(100 - l')}$$

$$(100 - l')Y = l'X$$

$$l'(X + Y) = 100\,Y$$

$$l' = \frac{100\,Y}{X + Y}$$

$$= \frac{100 \times 12.5}{8.16 + 12.5}$$

$$l' = 60.5 \text{ cm}$$

(*c*) The interchange of the cell and galvanometer does not affect the balance equation. The galvanometer shows no deflection, *i.e.* no current flows through it.

3.11. **A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?**

Ans. The total resistance of the circuit becomes

15.5 + 0.5 = 16 Ω.

The total emf of circuit will be

120 – 8 = 112 V

(Battery emf opposing supply emf)

∴ Charging current $= \frac{112}{16} = 7.0$ A

For battery being charged, terminal voltage will be,

$V = E + Ir = 8.0 + 7.0 \times 0.5 = 11.5$ V.
A series resistor is used to limit the current drawn to a proper value.

3.12. In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

Ans.
$$\frac{E_2}{E_1} = \frac{l_2}{l_1}$$
$$E_2 = \frac{63}{35} \times 1.25 = 2.25 \text{ volt}$$

3.13. The number density of free electrons in a copper conductor estimated in Example 3.1 is 8.5×10^{28} m^{-3}. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section of the wire is 2.0×10^{-6} m^2 and it is carrying a current of 3.0 A.

Ans. Length of the copper wire, $l = 3.0$ m
Area of cross-section of the wire,
$$A = 2.0 \times 10^{-6} \text{ m}^2$$
Number density of free electrons in a copper conductor,
$$n = 8.5 \times 10^{28} \text{ m}^{-3}$$
Current carried by the wire, $I = 3.0$ A, which is given as
$$I = nAev_d$$
where, e = electric charge
$= 1.6 \times 10^{-19}$ C
Now, v_d = drift velocity
$$= \frac{\text{Length of the wire(l)}}{\text{Time taken to cover l (t)}}$$
Hence, we can write
$$I = nAe\frac{l}{t}$$
$$t = \frac{nAel}{I}$$
$$= \frac{8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19} \times 3}{3.0}$$
$$= 2.7 \times 10^4 \text{ s}$$
Therefore, the time taken by an electron to drift from one end of the wire to the other is 2.7×10^4 s.

3.14. The earth's surface has a negative surface charge density of 10^{-9} Cm^{-2}. The potential difference of 400 kV between the top of the atmosphere and the surface results (due to the low conductivity of the lower atmosphere) in a current of only 1800 A over the entire globe. If there were no mechanism of sustaining atmospheric electric field, how much time (roughly) would be required to neutralise the earth's surface? (Radius of earth = 6.37×10^6 m)

Ans. Given: $R = 6.37 \times 10^6$ m, $\sigma = 10^{-9}$ Cm^{-2}, $I = 1800$ A.
Area of globe, $A = 4\pi R^2$
Total charge on the globe,
$$Q = \sigma A$$
As
$$I = \frac{Q}{t}$$
$$t = \frac{Q}{I} = \frac{\sigma A}{I}$$
$$t = \frac{\sigma 4\pi R^2}{I}$$
$$= \frac{10^{-9} \times 4 \times 3.14 \times (6.37 \times 10^6)^2}{1800}$$
$$t = 283.1 \text{ s}$$

3.15. (*a*) Six lead-acid type of secondary cells each of emf 2.0 V and internal resistance 0.015 Ω are joined in series to provide a supply to a resistance of 8.5 Ω. What are the current drawn from the supply and its terminal voltage?

(*b*) A secondary cell after long use has an emf of 1.9 V and a large internal resistance of 380 Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

5. (*a*) Number of secondary cells, $n = 6$
emf of each secondary cell,
$E = 2.0$ V
Internal resistance of each cell,
$r = 0.015\ \Omega$
Resistance of the resistor joined in series, $R = 8.5\ \Omega$
Let current drawn from the supply = I, which is

$$I = \frac{nE}{R + nr} = \frac{6 \times 2}{8.5 + 6 \times 0.015}$$

$$= \frac{12}{8.59} = 1.39 \text{ A}$$

Now, Terminal voltage,

$$V = IR$$

$$= 1.39 \times 8.5 = 11.81 \text{ A}$$

Hence, the current drawn from the supply is 1.39 A and terminal voltage is 11.81 A.

(*b*) Maximum current = $\frac{1.9}{380}$ = 0.005 A
A large current (≈ 100 A) is required by a motor starter for a few seconds. So, it cannot be used in a car.

.16. Two wires of equal length, one of aluminium and other of copper have the same resistance. Which of the two wires is lighter? Hence explain why aluminium wires are preferred for overhead power cables. (ρ_{Al} = 2.63 × 10^{-8} Ωm, ρ_{Cu} = 1.72 × 10^{-8} Ωm, Relative density of Al = 2.7, Cu = 8.9.)

Ans. Using, $R = \rho\frac{l}{A} = \rho\frac{l^2}{Al} = \rho\frac{l^2}{V} = \frac{\rho l^2 d}{m}$

where, $V = Al$ = volume of wire,
m = mass of wire,
d = density of wire material.

For aluminium wire,

$$R_{Al} = \frac{\rho_{Al}\, l_{Al}^2\, d_{Al}}{m_{Al}}$$

For copper wire, $R_{Cu} = \dfrac{\rho_{Cu}\, l_{Cu}^2\, d_{Cu}}{m_{Cu}}$

For equal length and resistance,

$$\frac{\rho_{Al}\, d_{Al}}{m_{Al}} = \frac{\rho_{Cu}\, d_{Cu}}{m_{Cu}}$$

$$\frac{m_{Cu}}{m_{Al}} = \frac{\rho_{Cu}\, d_{Cu}}{\rho_{Al}\, d_{Al}}$$

$$\frac{m_{Cu}}{m_{Al}} = \frac{1.72 \times 10^{-8} \times 8.9}{2.63 \times 10^{-8} \times 2.7}$$

$$= \frac{172 \times 89}{263 \times 27}$$

$$= 2.1558 \approx 2.2$$

Aluminium wires are preferred for overhead cables because the ratio shows that aluminium wire is lighter than copper wire.

3.17. What conclusion can you draw from the following observations on a resistor made of alloy manganin?

Current (A)	Voltage (V)	Current (A)	Voltage (V)
0.2	**3.94**	**3.0**	**59.2**
0.4	**7.87**	**4.0**	**78.8**
0.6	**11.8**	**5.0**	**98.6**
0.8	**15.7**	**6.0**	**118.5**
1.0	**19.7**	**7.0**	**138.2**
2.0	**39.4**	**8.0**	**158.0**

Ans. As the ratio of V/I is a constant, Ohm's law is valid as resistance is not changing with the value of current. It implies that resistivity of the alloy is not effected by the temperature during the experiment.

3.18. Answer the following questions.

(*a*) A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

(*b*) Is Ohm's law universally applicable for all conducting elements? If not, give examples of elements which do not obey Ohm's law.

(c) **A low voltage supply from which one needs high currents must have very low internal resistance. Why?**

(d) **A high tension (HT) supply of, say, 6 kV must have a very large internal resistance. Why?**

Ans. (a) Only current. Rest of all depend upon area of cross-section inversely.

(b) No, Ohm's law is not universally applicable for all conducting elements. Vacuum diode semi-conductor is a non-ohmic conductor for which ohm's law is not valid.

(c) Because maximum current drawn from a source is V/R. So, if V is low, R must be low so that high current can be drawn.

(d) If the short circuit occurs, the current drawn will exceed safety limits in case internal resistance is not large.

3.19. Choose the correct alternative.

(a) Alloys of metals usually have (greater/less) resistivity than that of their constituent metals.

(b) Alloys usually have much (lower/higher) temperature coefficients of resistance than pure metals.

(c) The resistivity of the alloy manganin is nearly independent of/increases rapidly with increase of temperature.

(d) The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of ($10^{22}/10^{23}$).

Ans. (a) greater

(b) lower

(c) nearly independent of

(d) 10^{22}

3.20. (a) Given n resistors each of resistance R, how will you combine them to get (i) maximum (ii) minimum effective resistance? What is the ratio of the maximum to minimum resistance?

(b) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will you combine them to get an equivalent resistance of:

(i) $\frac{11}{3}$ Ω, (ii) $\frac{11}{5}$ Ω,

(iii) 6 Ω (iv) $\frac{6}{11}$ Ω?

(c) Determine the equivalent resistance of network shown in figures.

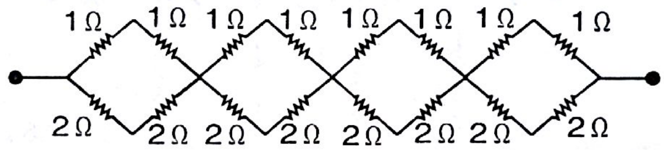


Figure 3.31 (a)

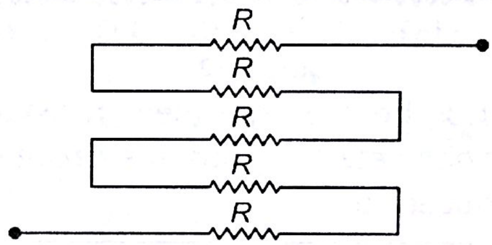


Figure 3.31 (b)

Ans. (a) (i) All in series

(ii) All in parallel

$$R_s = nR;$$

$$R_P = \frac{R}{n}$$

$$\frac{R_s}{R_P} = n^2$$

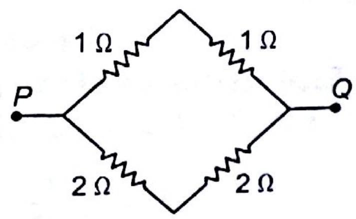
(b) (i) Join 1 Ω, 2 Ω in parallel and the combination in series with 3 Ω.

(ii) Parallel combination of 2 Ω and 3 Ω in series with 1 Ω.

(iii) All in series.

(iv) All in parallel.

(c) (a) Resistance of a single unit



$$R_1 = \frac{2\times4}{6} = \frac{8}{6} = \frac{4}{3}\ \Omega.$$

As four such combinations are in series

$$\therefore\quad R_{eq} = 4\times\frac{4}{3} = \frac{16}{3}\Omega$$

(*b*) $R_T = R + R + R + R + R = 5R$

3.21. Determine the current drawn from a 12 V supply with internal resistance 0.5 Ω by the infinite network shown in figure. Each resistor has 1 Ω resistance.

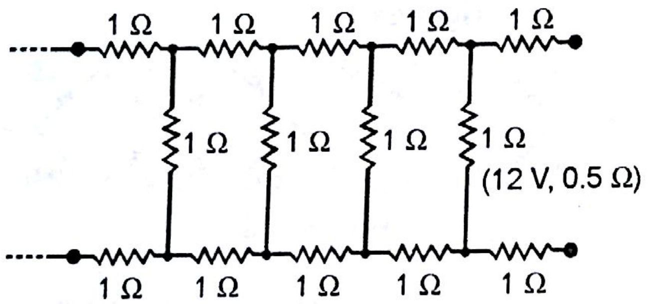
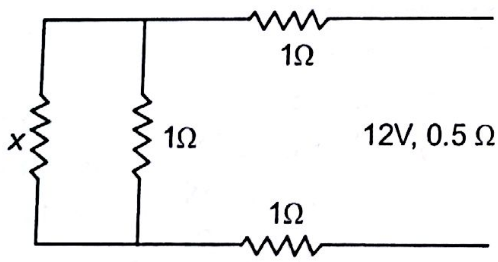


Figure 3.32

Ans. Let '*x*' be the equivalent resistance of infinite network. Thus, the circuit can be reduced to



$$\frac{1}{R_P} = \frac{1}{x} + \frac{1}{1} = \frac{1+x}{x}$$

or, $$R_P = \frac{x}{1+x}$$

We can write

$$x = 2 + \frac{x}{1+x}$$

$$x^2 - 2x - 2 = 0$$

$$x = 1 \pm \sqrt{3}$$

As value of resistance cannot be –ve.

$$x = 1+\sqrt{3} = 2.73\ \Omega$$

∴ Total resistance of the circuit

$= 2.73 + 0.5 = 3.23\ \Omega$

$$I = \frac{12}{3.23} = 3.72\ \text{A}$$

3.22. Figure below shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire *AB*. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

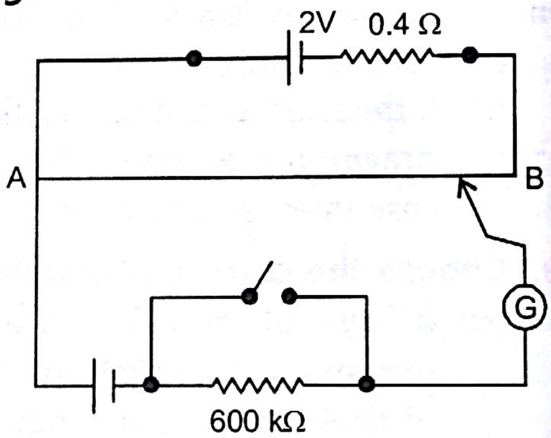


Figure 3.33

(*a*) What is the value ε?

(*b*) What purpose does the high resistance of 600 kΩ have?

(*c*) Is the balance point affected by this high resistance?

(*d*) Is the balance point affected by the internal resistance of the driver cell?

(*e*) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0 V instead of 2.0 V?

(*f*) Would the circuit work well for determining an extremely small emf say of the order of a few mV (such as the typical emf of a thermo-couple)? If not, how will you modify the circuit?

Ans. We have $l_1 = 67.3$ cm, $l_2 = 82.3$ cm, $\varepsilon_1 = 1.02$ V

(*a*) $$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$$

$$\varepsilon_2 = \frac{l_2}{l_1} \times \varepsilon_1 = \frac{82.3}{67.3} \times 1.02$$

$$\varepsilon_2 = 1.247 \text{ V}$$

(*b*) It is to allow very small current to flow through the galvanometer, when the movable contact is far from the balance point.

(*c*) No, because there is no flow of current through the standard cell branch.

(*d*) No, the balance point is not affected.

(*e*) No. If ε is greater than emf of the driver cell of the potentiometer, there will be no balance point on the wire AB.

(*f*) Circuit would not be suitable because the balance point (for ε of the order of a few mV) will be very close to the end A and the percentage error in measurement will be very large.

The circuit is modified by putting a suitable resistor *R* in series with the wire AB so that potential drop across AB is only slightly greater than the emf to be measured. Then the balance point will be at larger length of the wire and the percentage error will be much smaller.

3.23. Figure 3.34 shows a potentiometer circuit for comparison of two resistances. The balance point with a standard resistor R = 10.0 Ω is found to be 58.3 cm, while that with the unknown resistance *X* is 68.5 cm. Determine the value of *X*. What might you do if you failed to find a balance point with the given cell of emf ε?

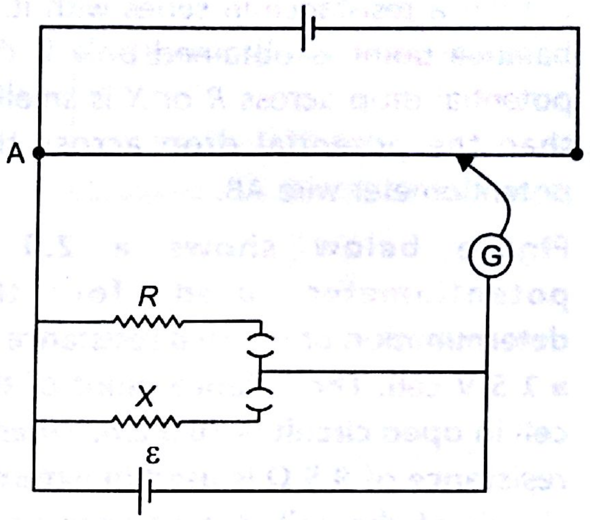


Figure 3.34

Ans. Resistance of the standard resistor, $R = 10.0\ \Omega$

Balance point for this resistance, $l_1 = 58.3$ cm

Let current in the potentiometer wire be *i*.

Hence, potential drop across *R* will be $\varepsilon_1 = iR$

Resistance of the unknown resistor = *X*

Balance point for this resistor, $l_2 = 68.5$ cm

Hence, potential drop across *X* will be $\varepsilon_2 = iX$

The relation connecting emf and balance point is,

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

$$\frac{iR}{iX} = \frac{l_1}{l_2}$$

$$X = \frac{l_2}{l_1} \times R$$

$$= \frac{68.5}{58.3} \times 10$$

$$= 11.749\ \Omega \approx 11.75\ \Omega$$

Hence, the value of the unknown resistance *X*, is 11.75 Ω.

If we fail to find a balance point with the given cell of emf ε, then the potential drop across *R* and *X* must be reduced by putting a resistance in series with it. A balance point is obtained only if the potential drop across *R* or *X* is smaller than the potential drop across the potentiometer wire AB.

3.24. Figure below shows a 2.0 V potentiometer used for the determination of internal resistance of a 1.5 V cell. The balance point of the cell in open circuit is 76.3 cm. When a resistance of 9.5 Ω is used in external circuit of the cell, the balance point shifts to 64.8 cm length of the potentiometer. Determine the internal resistance of the cell.

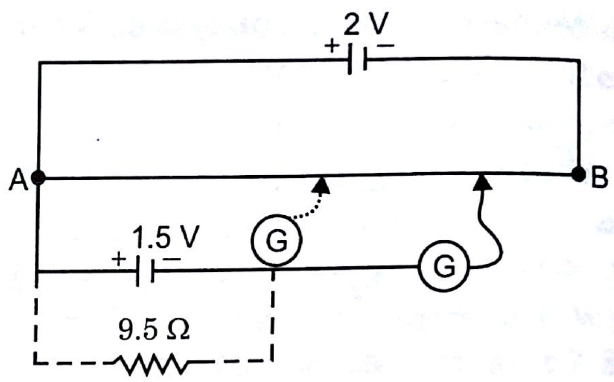


Figure 3.35

Ans. The internal resistance of the cell,

$$r = R\left(\frac{l_1 - l_2}{l_2}\right)$$

$$= 9.5\left(\frac{76.3 - 64.8}{64.8}\right)$$

$$= 1.68\ \Omega \approx 1.7\ \Omega$$