PHYSICS

BOOKS - VIKRAM PUBLICATION (ANDHRA PUBLICATION)

CURRENT ELECTRICITY

Problems

1. A 10Ω thick wire is stretched so that its length becomes three times. Assuming that

there is no change in its density on stretching, calculate the resistance of the stretched wire.

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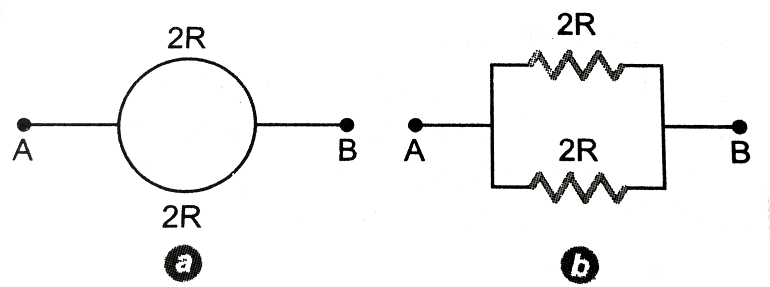
2. A wire of resistance 4R is bent in the form of a circle. What is the effective resistance between the ends of the diameter?



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3. Find the resistivity of a conductor which carries a current of density of $2.5 \times 10^6 Am^{-2}$ when an electric field of $15Vm^{-1}$ is applied across it.

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4. What is the color code for a resistor of resistance 350Ω with 5% tolerance?

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5. You are given 8Ω resistor, What length of wire of resistivity $120\Omega m$ should be joined in parallel with it to get a value of 6Ω?

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6. Three resistors $3\Omega, 6\Omega$ and 9Ω are connected a battery. In which of them will the power dissipation be maximum if:

(a) They all are connected in parallel

(b) They all are connected in series?

Given reasons.

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7. A silver wire has a resistance of 2.1Ω at $27.5^\circ C$ and a resistance of 2.7Ω at $100^\circ C$. Determine the temperature coeff. Of resistivity of silver.

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8. If the length of a wire conductor is doubled by strctching it while keeping the potential difference constant, by what factor will the drift speed of the electrons change?

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9. Two 120 V light bulbs, one of 25W and another of 200W are connected in series One bulb burnt out almost instantaneously. Which one was burnt and why?

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10. A cylindrical metallic wire is stretched to increase its length by 5%. Calculate the percentage change in resistance.

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11. Two wires A and B of same length and same material, have their cross sectional areas in the ratio 1:4. What would be the ratio of heat produced in these wires when the voltage across each is constant?

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12. Two bulbs whose resistances are in the ratio of 1 : 2 are connected in parallel to a source of constant voltage. What will be the ratio of power dissipation in these?

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13. A potentiometer wire is 5 m long and a potential difference of 6V is maintained between its ends. Find the emf of a cell which balance against a length of 180 cm of the potentiometer wire.

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14. A battery of emf 2.5 V and internal resistance r is connected is series with a resistor of 45 ohm through an ammeter of resistance 1 ohm. The ammeter reads a current of 50 mA. Draw the circuit diagram and calculate the value of r.

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15. The balancing point in meter bridge experiment is obtained at 30 cm from the left. If the right gap contains 3.5Ω, what is the resistance in the left gap?

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16. If the balancing point in a meter bridge from the left is 60 cm, compare the resistance in the left and right gaps of meter bridge.

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17. Amount of charge passing through the cross section of a wire is $q(t) = at^2 + bt + c$. Write the dimensional formula for a,b and c. If the values of a,b and C in SI units are 6,4,2 respectively, find the value of current at t = 6 seconds

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Very Short Anwer Questions

1. Define mean free path of electron in a conductor.

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2. State ohm's law and write it's mathematical form.

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3. Define resistively or specific resistance.

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4. Define temperature coefficient of resistance

.

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5. Under what conditions is the current through the mixed grouping of cells maximum ?

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6. When a wire is stretched to double its length, then

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7. Why is manganin used for making standard resistors?

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8. A box contains 3 blue,2 white and 4 red marbles. IF a marble is drawn at random from the box, what is the probability that it will be red?

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9. Write the color code of a carbon resistor of resistance 23 kilo ohms.

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10. If the voltage V applied across a conductor is increased to 2V, how will the drift velocity of the electrons change?

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11. Two wires of equal length, of copper and manganin, have the same resistance. Which wire is thicker?

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12. Why are household applicance connected in parallel?

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13. The electron drift speed in metals is small $(\sim ms^{-1})$ and the charge of the electron is also very small $(\sim 10^{-19}C)$, but we can still obtain a large amount of current in a metal. Why?

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Short Answer Question

1. A battery of emf 10 V internal resistance 3Ω is connected to a resistor R.

(i) If the current in the circuit is 0.5 A. calculate the value of R.

(ii) What is the terminal voltage of the battery when the cirucit is closed.

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2. State the working principle of potentiometer explain with the help of circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.

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3. Derive an expression for the effective resistance when three resistors are connected in (i) series (ii) parallel.

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4. m' cells each of emf E and internal resistance 'r' are connected in parallel. What is the total emf and internal resistance? Under what conditions is the current drawn from mixed grouping of cells maximum?

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5. Define electric resistance and write it's SI unit. How does the reisitance of a conductor vary if (a) conductor is stretched to 4 times of it's length (b) Temperature of a conductor is increased.

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6. When the resistance connected in series with a cell is halved, the current is equal to or slightly less ro slighty greater than double. Why?

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7. Two cells of emf 4.5 V and 6.0 V and internal resistance 6Ω and 3Ω respectively have their negative terminals joined by a wire of 18Ω and positve terminals by a wire of 12Ω resistance. A third resistance wire of 24Ω connects middle points of these wires. Using Kirchhoff's find the potential difference at the ends of this third wire.

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8. Three resistors each of resistance 10 ohm are connected, in turn, to obtain (i) minimum resistance (ii) maximum resistance. Complete (a) The effective resistance in each case (b) ratio of minimum to maximum resistance so obtained.

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9. State Kirchhoff's law for an electrical network. Using these laws deduce the conditions for balance in a wheatstone bridge.

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10. State the working principle of potentiometer explain with the help of circuit diagram how the emf of two primary cells are compared by using the potentiometer.

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11. State the working principle of potentiometer explain with the help of circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.

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12. Show the variation of current versus voltage graph for GaAs and mark the I Non-liner region (ii) Negative resistance region.

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13. A student has two wires of iron and copper of equal length and diameter. He first joins two wires in series and passes an electric current through the combination which increases gradually. After that he joins two wires in parallel and repeats the process of passing current. Which wire will glow first in each case?

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14. Three identical resistors are connected in parallel and total resistance of the circuit is R/3. Find the value of each resistance.

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Long Answer Questions

1. Under what condition is the heat produced in an electric circuit (a)

directly proportional

(b) inversely proportional to the resistance of the circuit?

Compute the ratio of the total quantitiy of heat produced in the two cases.

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2. Two metallic wires A and B are connected in parallel, wire A has length L and radius r wire B has a length 2L and radius 2r. Compute the ratio of the total resistance of the parallel combination and resistance of wire A.

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3. In a house three bulbs of 100w each are lighted for 4 hours daily and six tube lights of 20 W each are lighted for 5 hours daily and a refrigerator of 400 W is worked for 10 hours daily for a month of 30 days. Calculate the electricity bill if the cost of one unit is Rs 4.00

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4. Three resistors of 4 ohms and 12 ohms are connected in parallel. The combination of above resistors is connected in series to a resistance of 2 ohms and then to a battery of 6 volts. Draw a circuit diagram and calculate.

(a) Current in main circuit.

Current flowing through each of the resistors in parallel

(c) p.d and the power used by the 2 ohm resistor.

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5. Two lamps one rated 100Ω at 220 V and the other 60 W at 220 V are connected in parallel to a 220 volt supply. What current is drawn from the supply line?

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6. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area $3.0 \times 10^{-7} m^2$ carrying a current of 5A. Assume that each copper atom contributions roughly one conduction electron. The density of copper is $9.0 \times 10^3 kg/m^3$ and its atomic mass is 63.5 u.

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7. Compare the drift speed obtained above with

(i) Thermal speed of copper atoms at ordinary temperatures.

(ii) Speed of propagation of electric field along the conductor which causes the drift motion

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Textual Exercises

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

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2. A battery of emf 10 V internal resistance 3Ω is connected to a resistor R.

(i) If the current in the circuit is 0.5 A. calculate the value of R.

(ii) What is the terminal voltage of the battery when the cirucit is closed.

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3. Three resistors $1\Omega, 2\Omega$ and 3Ω are combined in series. What is the total resistance of the comination?

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

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5. Three resistors $2\Omega, 4\Omega$ and 5Ω are combined in parallel. What is the total resistance of the combination?

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6. 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.

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7. At room temperature $(27.0^{\circ} C)$ the resistance of a heating element is 100Ω. What is the temperature of the element if the resistance is found to be 117Ω, given that the temperature coefficeint of the material of the resistor is $1.70 \times 10^{-4} .^{\circ} C^{-1}$

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8. A negligibly small current is passed through a wire of length 15 m and unifrom cross-section $6.0 \times 10^{-7} m^2$ and its resistance is measured to be 5Ω. What is the resistivity of the material at the temperature of the experiment?

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9. A silver wire has a resistance of 2.1Ω at $27.5^\circ C$, and a resistance of 2.7Ω at $100^\circ C$. Determine the temperature coefficient of resistivity of silver.

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

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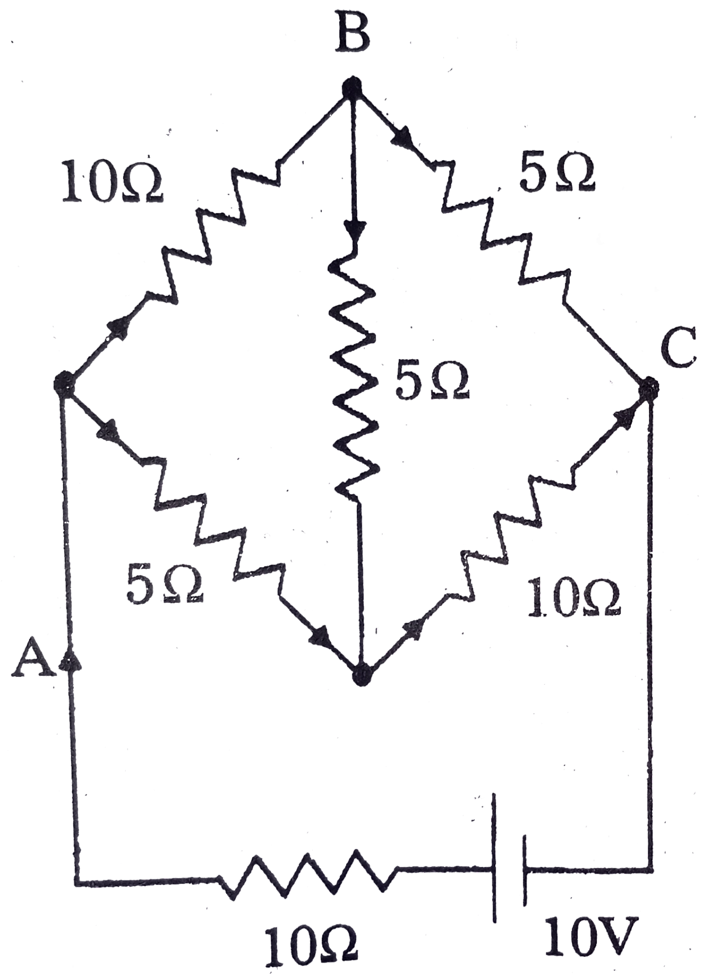
11. Determine the current in each branch of the network shown in fig.



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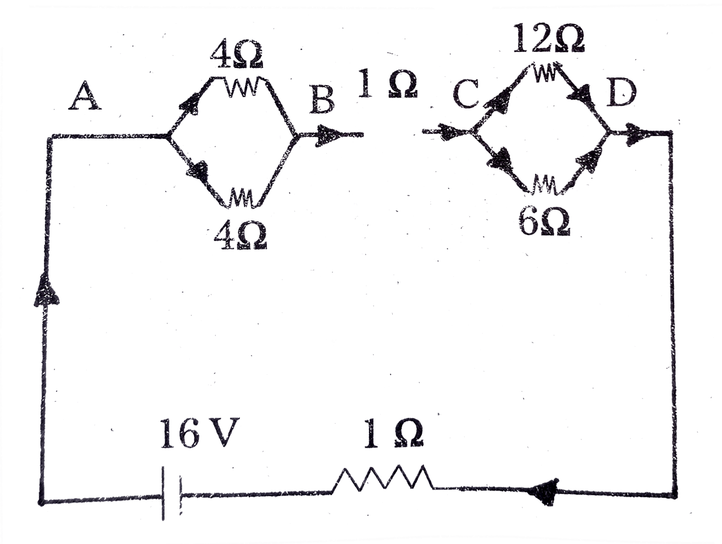
12. In a meter bridge the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5Ω. Determine the resistance of x. why are the connections between resistors in a wheatstone or meter bridge made of thick copper strips?



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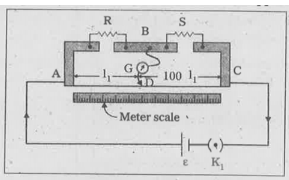
Determine the balance point of the bridge above if X and Y are interchanged.



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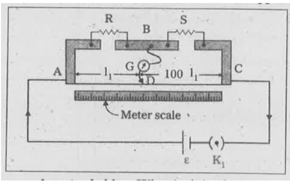
14. In a meter bridge the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5Ω. Determine the resistance of x. why are the connections between resistors in a wheat stone or meter bridge made of thick copper strips?

What happens if the galvanometer and cell are interchanged at the balance point of the bridge ? Would the galvaometer show any current?



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15. A storage battery of emf 0.8 V and internal resistance 0.5Ω is being charged by a 120 V do supply using a series resistor of 15.5Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

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16. In a potentiometer arrangment, 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 ?

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17. The number density of free electrons in a copper conductor estimated in textual

example 6.1 is $8.5 \times 10^{28} m^{-3}$. How long does an electrons 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 $2.0 \times 10^{-6} m^2$ and it is carrying a current of 3.0 A

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18. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area $1.0 \times 10^{-7} m^2$ carrying a current of 1.5 A. Assume that each copper atom contributes roughly one conduction electron. The density of copper is $9.0 \times 10^3 kg/m^3$ and its atomic mass is 63.5 u.

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19. Compare are drift speed obtained above with (i) thermal speeds of copper atoms at ordinary temperatures (ii) speeds of propagation of electric field along the conductor which causes the drift motion.

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20. In Textual Example 1, the electron drift speed is estimated to be only a few mms^{-1} for currents in the range of a few amperes? How then is current established almost the instant a circuit is closed?

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21. The electron drift arises due to the force experienced by electrons in the electric field inside the condcutor. But force should cause acceleration. Why then do the electrons acquire a steady average drift speed?

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22. The electron drift speed in metals is small $(\sim ms^{-1})$ and the charge of the electron is also very small $(\sim 10^{-19} C)$, but we can still obtain a large amount of current in a metal. Why?

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23. when electrons drift in a metall from lower to higher potential does it mean that all the free electrons of the metal are moving in the same direction?

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24. Are the paths of electrons straight line between successive collisions (with the positive ions of the metal) in the (i) absence of electric field (ii) presnece of electric field?

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25. An electric toaster uses nichrome for its heating element. When a negligibly small current passes through it, its resistance at room temperature $(27.0^\circ C)$ is found to be 75.3Ω. When the toaster is connected to a 230 V supply, the current settles, after a few seconds, to a steady value of 2.68 A. what is the steady temperature of the nichrome element? The Temperature coefficient of resistance of nichrome averaged over the temperature range involved is $1.70 \times 10^{-4} . ^{\circ} C^{-1}$.

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26. The resistance of the platinum wire of a platinum resistance thermometer at the ice point is 5Ω and at steam point is 5.39Ω. When the thermometer is inserted in a hot bath, the resistance of the platinum wire is 5.795Ω. Calculate the temperature of the bath.

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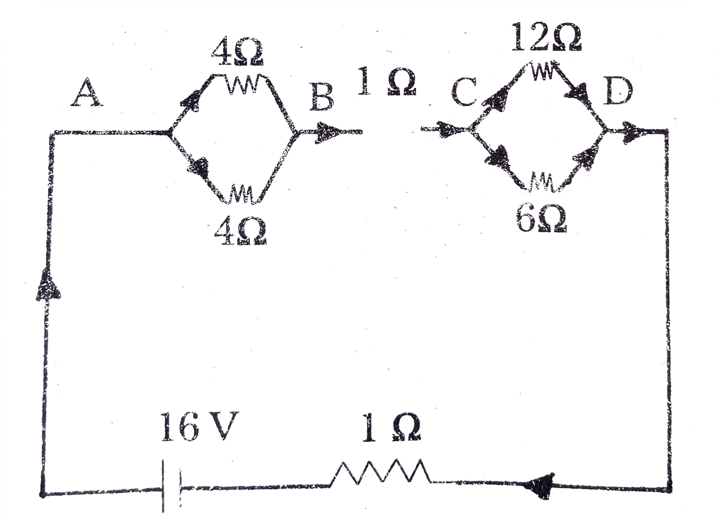
27. A network of resistor is connected to a 16 V battery with internal resistance of 1Ω, a shown in fig.

(a) complete the equivalent resistance of the network.



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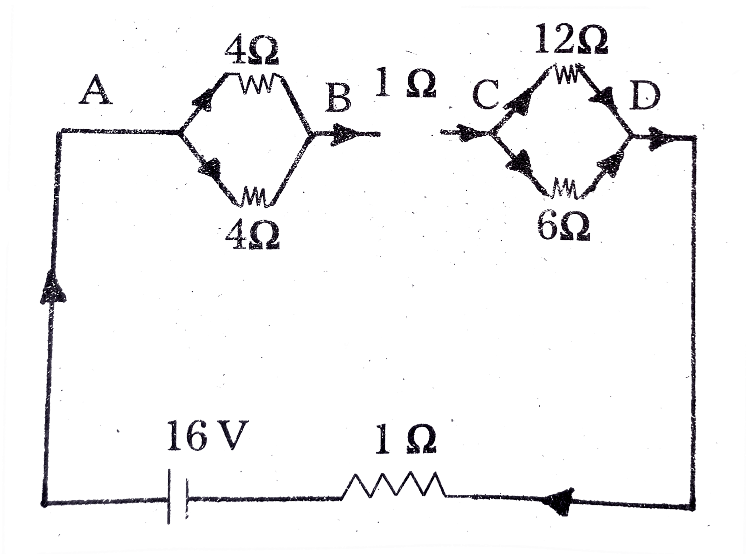
28. A network of resistor is connected to a 16 V battery with internal resistance of 1Ω, a shown in fig.

Obtain the current in each resistor.



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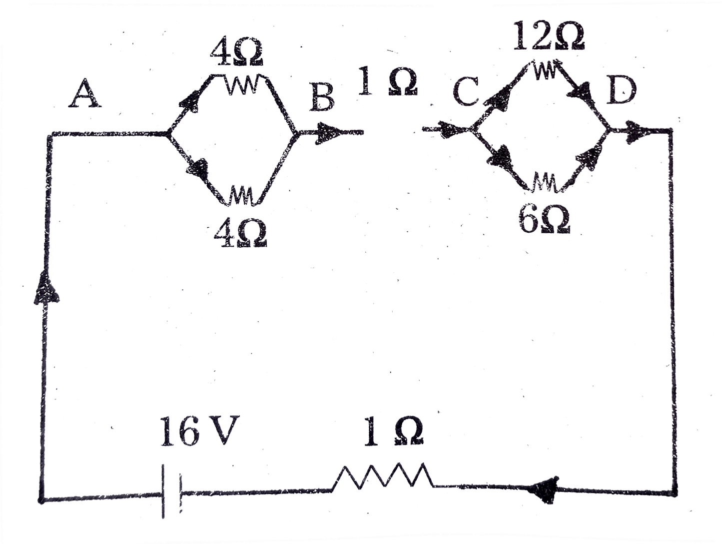
29. A network of resistor is connected to a 16 V battery with internal resistance of 1Ω, a shown in fig.

Obtain the voltage drops V_{AB}, V_{BC} and V_{CD}



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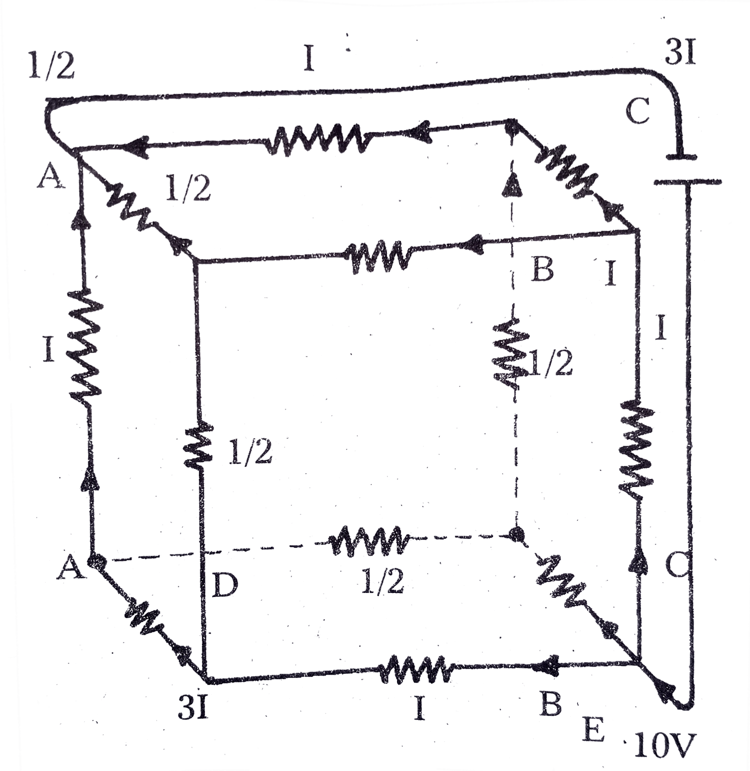
30. A battery of 10 V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors each of resistance 1Ω Fig. Determine the equivalent resistance of the network and the current along each edge of the cube.



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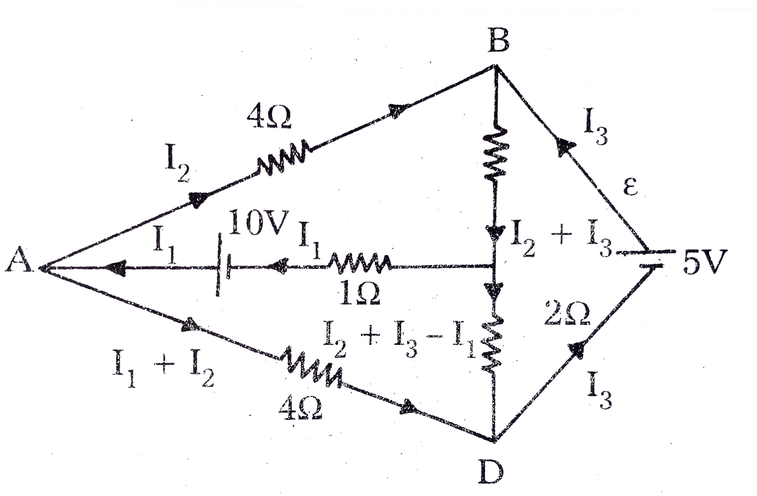
31. Determine the current in each branch of the network shown in fig.



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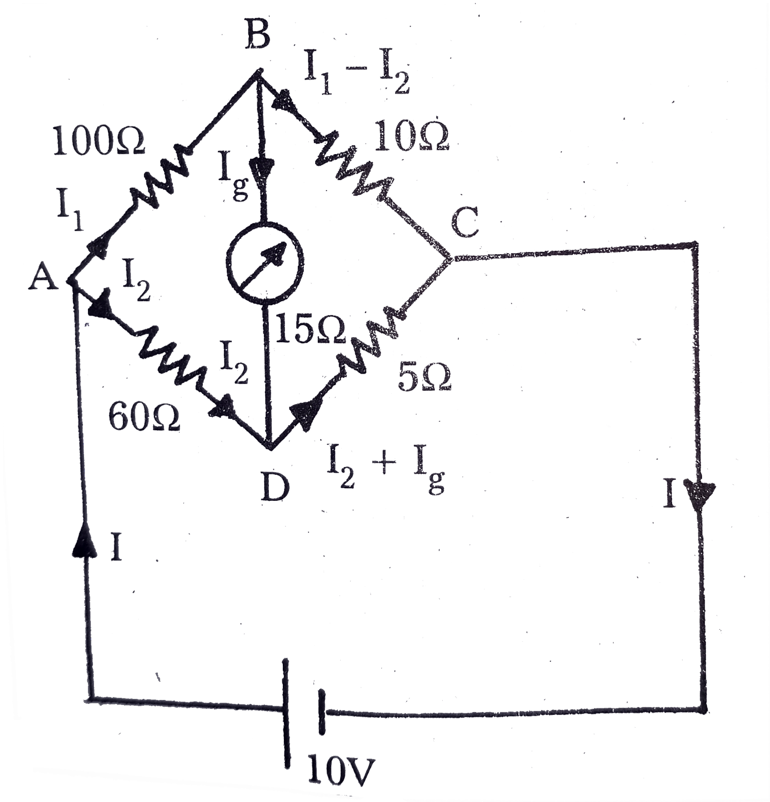
32. The four arms of a Wheatstone bridge have the following resistance :

$AB = 100\Omega$, $BC = 10\Omega$, $CD = 5\Omega$, and $DA = 60\Omega$



A galvanometer of 15Ω resistance is connected across BD. Calculate the current through the galvanometer when a potential difference of 10 V is maintained across AC.

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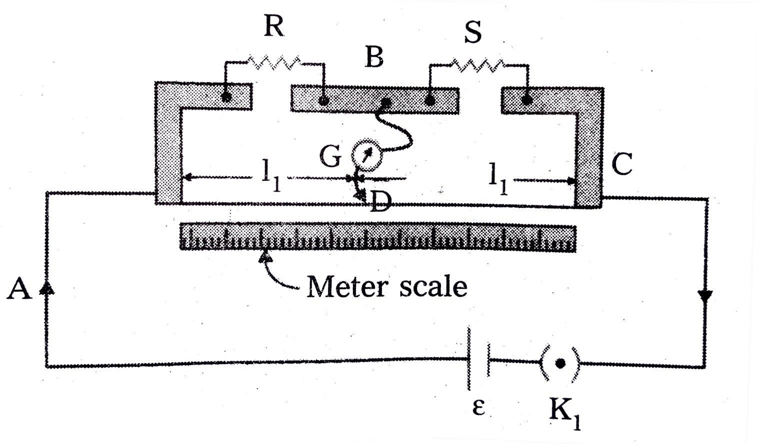
33. In a meter bridge , the null point is found at a distance of 36.7 cm from A. If now a resistance of 12Ω is connected in parallel with S, the null point occurs at 51.9 cm. Determine the value of R and S.



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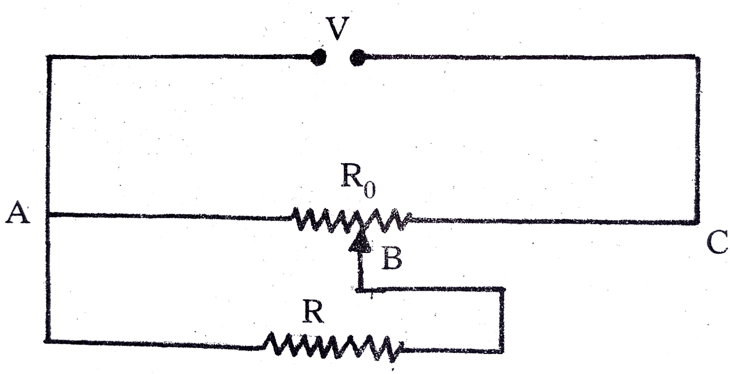
34. A resistance of $R\Omega$ draws current from a potentiometer. The potentiometer has a total resistance $R_0\Omega$. A voltage V is supplied to the potentiometer. Dervie can expression for the voltage across R when the sliding contact is in the middle of the potentiometer.



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Additional Exercises

1. 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 condutivity 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 (This never happens in parctice there is a mechanism to replenish electric charges, namely the continual thunderstorms and lightning in different parts of the globe). (Radius of earth $= 6.3 \times 10^6 m$)

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2. 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 provide a supply to a resistance of 8.5Ω. What are the current drawn from the supply and its terminal voltage?

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3. 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?

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4. Two wires of equal length, one of aluminium and the other of copper have the same resistance. Which of the two wire is lighter? Hence explain why aluminium wires are preferred for overhead power cables. $(\rho_{Al} = 2.63 \times 10^{-8} \Omega m, \rho_{Cu} = 1.72 \times 10^{-8} \Omega m$ Relative density of Al = 2.7 of Cu = 8.9)

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5. 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

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6. 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?

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7. Is Ohm's law universally applicable for all condcuting elements? If not, give examples of elements which do not obey Ohm's law.

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8. A low voltage supply from which one needs high currents must have very low internal resistance. Why?

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

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10. Choose the correct alternative:

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

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

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

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

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

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12. Given the resistances of $1\Omega, 2\Omega, 3\Omega$ how will be combine them to get an equivalent resistance of (i) (11/3) Ω (ii) (11/5) Ω (iii) 6Ω (iv) (6//11) Ω

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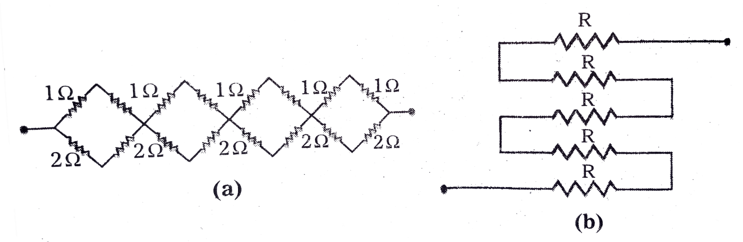
13. Determine the equivalent resistance of networks shown in Fig.



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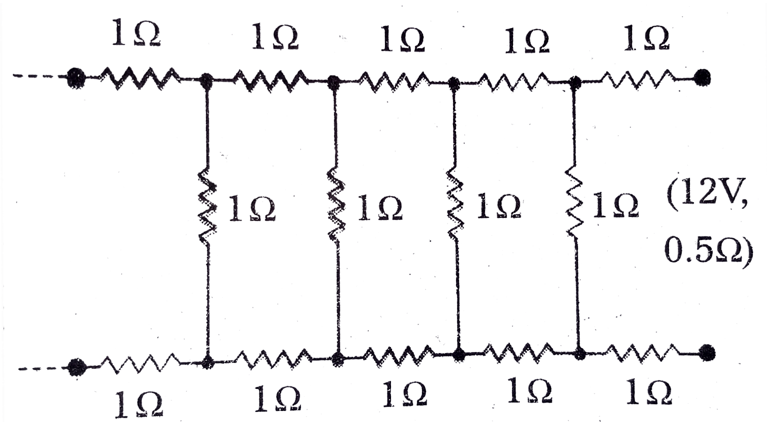
14. Determine the current drawn from a 12 V supply with internal resistance 0.5Ω by the infinite network shown in Fig. Each resistor has 1Ω resistance.



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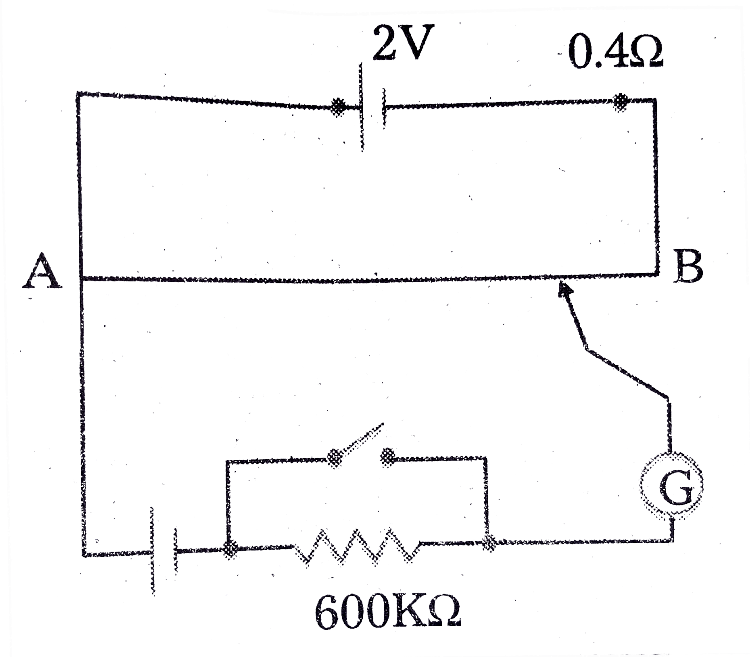
15. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



What is the value ε ?

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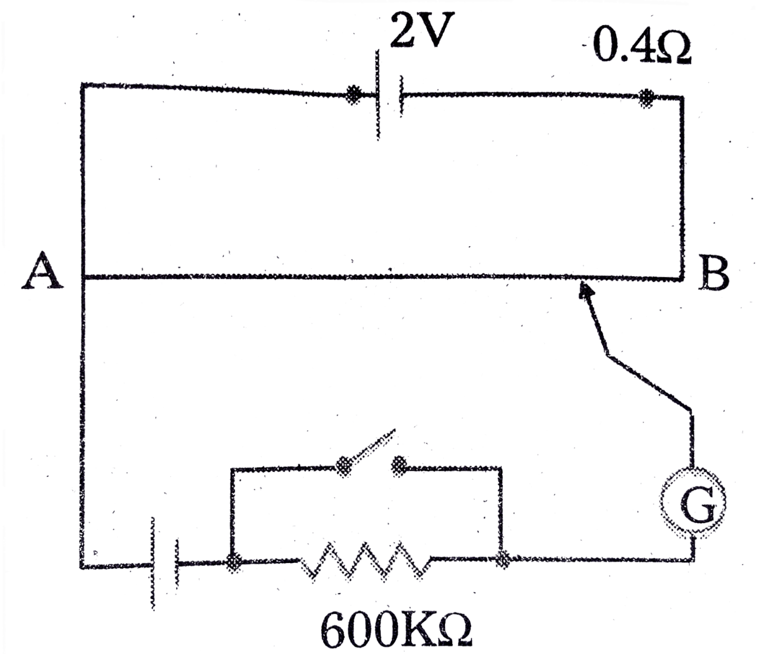
16. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



What purpose does the high resistance of 600 k Ω have?

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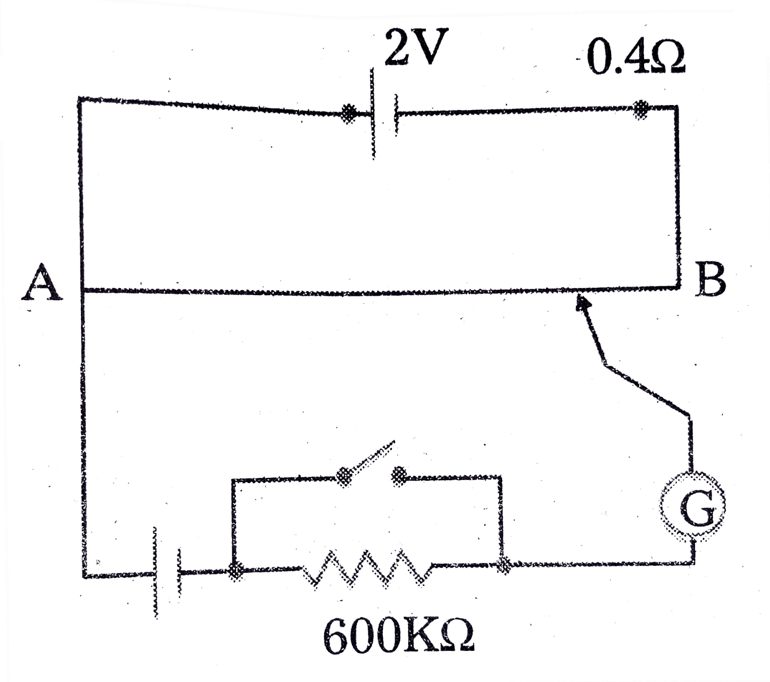
17. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



Is the balance point affected by this high resistance?

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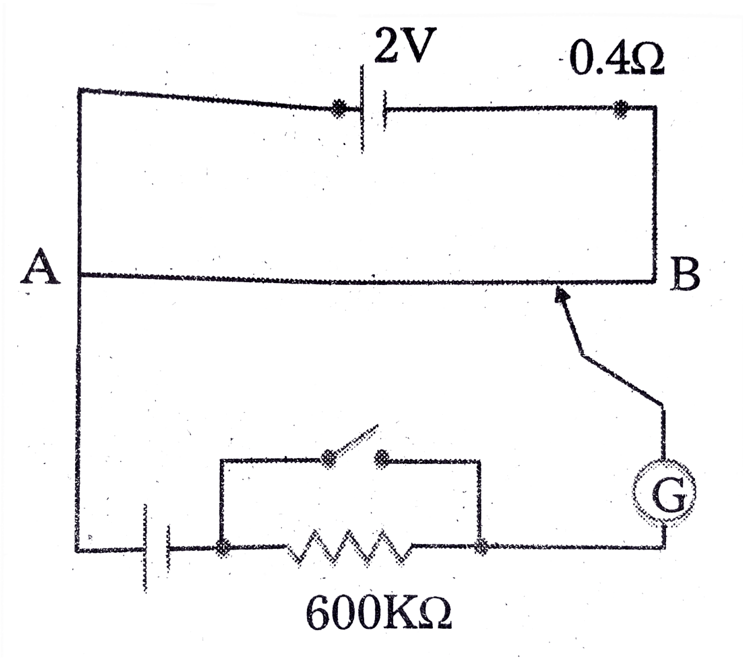
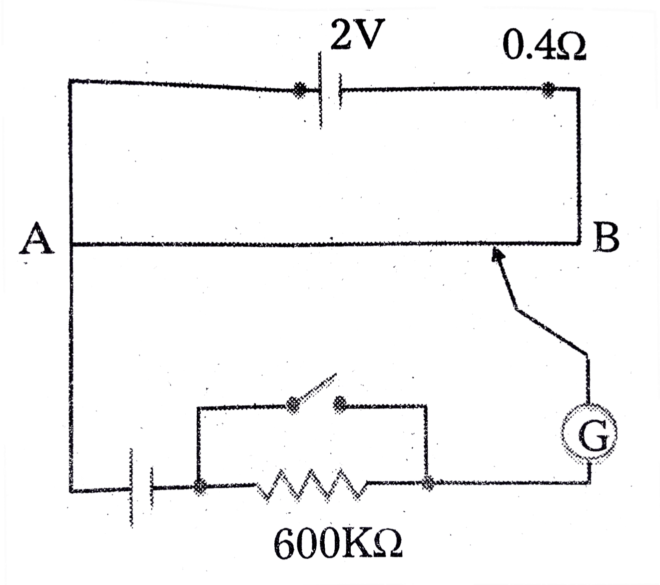
18. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



Is the balance point affected by the internal resistance of the driver cell.

19. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain 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 balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



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?

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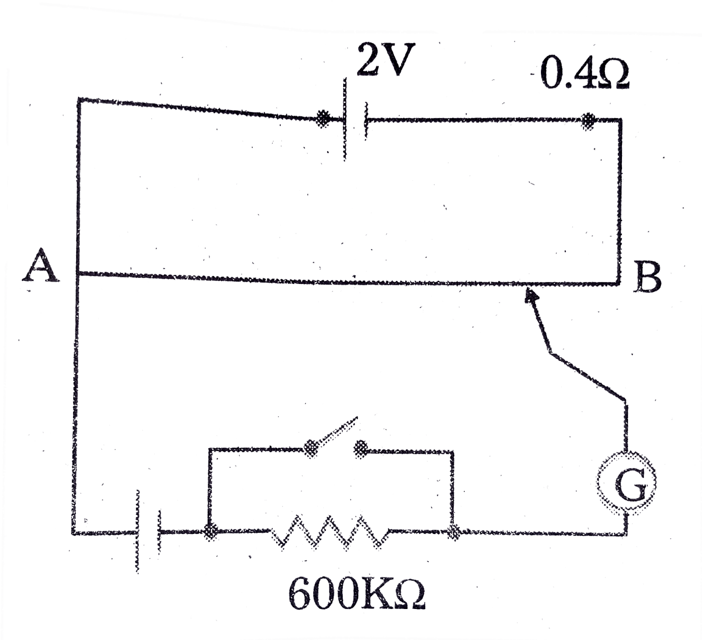
20. Figure shows a potentiometer with a cell of 2.0 V and internal resistance 0.40Ω maintain a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balances point at 63.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600Ω is put is series with it, which is shortedd 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.



Would the circuit work well for determining an extermely small emf, say of the order of a few mV (such as the typcial emf a thermo-couple)? if not, how will you modify the circuit?

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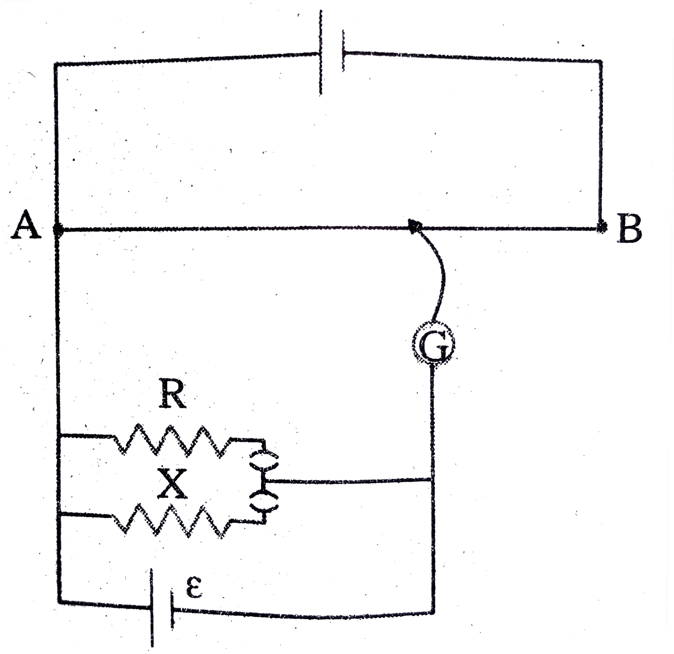
21. Figure shows a potentiometer circuit for comprasion of two resistances. The balance point with a standard resistor $R = 10.0\Omega$ is found to be 58.3 cm, while that with the unknown resistance X is 68.5 Cm. determine the value of X. What might you do if you failed to find a balance point with the given cell of emf ε ?



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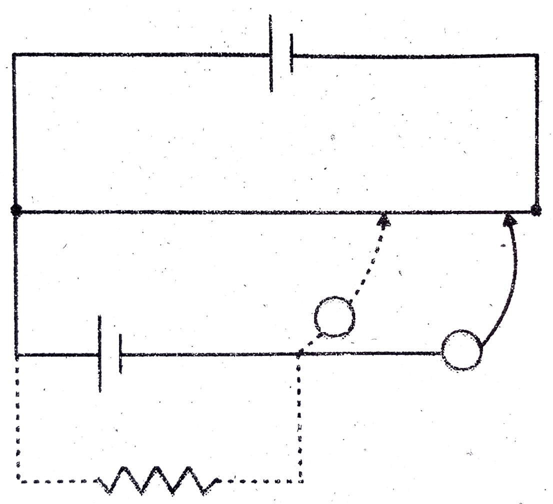
22. Figure shows a 2.0 V potentiometer used

for the determination of internal resistance of a 1.5 V cell. The balance point of the cell in open circuit is 76.8 cm. when a resistor of 9.5Ω is used in the external circuit of the cell, the balance point shifts to 64.8 cm length of the potentiometer wire. Determine the internal resistance of the cell.



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