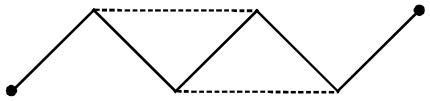
Exercise - IV (Tough Subjective Problems)

1. A triangle is constructed using the wires AB, BC & CA of same material and of resistance α, 2α & 3α respectively. Another wire of resistance $\alpha/3$ from A can make a sliding contact with wire BC. Find the maximum resistance of the network between points A and the point of sliding wire with BC.

2. (a) The current density across a cylindrical conductor of radius R varies according to the equation $J = J_0\left(1-\frac{r}{R}\right)$, where r is the distance from the axis. Thus the current density is a maximum J_0 at the axis r = 0 and decreases linearly to zero at the surface r = R. Calculate the current in terms of J_0 and the conductor's cross sectional area is $A = \pi R^2$.

(b) Suppose that instead the current density is a maximum J_0 at the surface and decreases linearly to zero at the axis so that $J = J_0\frac{r}{R}$. Calculate the current.

3. What will be the change in the resistance of a circuit consisting of five identical conductors if two similar conductors are added as shown by the dashed line in figure



4. The current I through a rod of a certain metallic oxide is given by $I = 0.2\ V^{5/2}$, where V is the potential difference across it. The rod is connected in series with a resistance to a 6V battery of negligible internal resistance. What value should the series resistance have so that

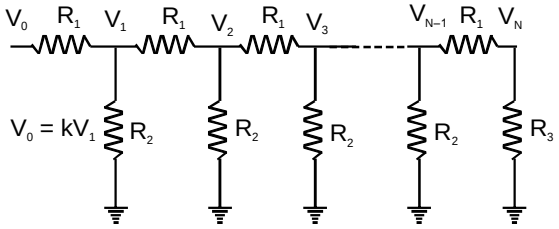
(i) the current in the circuit is 0.44

(ii) the power dissipated in the rod is twice that dissipated in the resistance.

5. A piece of resistive wire is made up into two squares with a common side of length 10 cm. A current enters the rectangular system at one of the corners and leaves at the diagonally opposite corners. Show that the current in the common side is 1/5th of the entering current. What length of wire connected between input and output terminals would have an equivalent effect.

6. A network of resistance is constructed with R_1 & R_2 as shown in the figure. The potential at the points 1,2,3,.., N and V_1, V_2, V_3,....., V_n respectively each having a potential k time smaller than previous one.

Find (i) $\frac{R_1}{R_2}$ and $\frac{R_2}{R_3}$ in terms of k

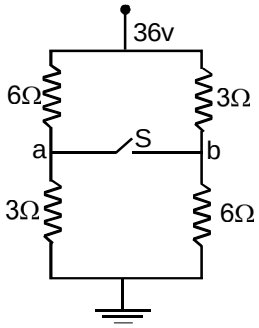


(ii) current that passes through the resistance R_2 nearest to the V_0 in terms V_0, k & R_3.

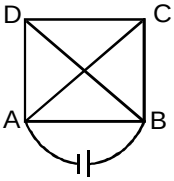
7. A person decides to use his bath tub water to generate electric power to run a 40 watt bulb. The bath tube is located at a height of 10m from the ground & it holds 200 litres of water. If we install a water driven wheel generator on the ground, at what rate should the water drain from the bath tube to light bulb ? How long can we keep the bulb on, if the bath tub was full initially. The efficiency of generator is 90%.($g = 10 m/s^{-2}$)

8. In the circuit shown in figure, calculate the following

(i) Potential difference between points a and b when switch S is open. (ii) Current through S in the circuit when S is closed.



9. The circuit shown in figure is made of a homogeneous wire of uniform cross-section. ABCD is a square. Find the ratio of the amounts of heat liberated per unit time in wire A-B and C-D.

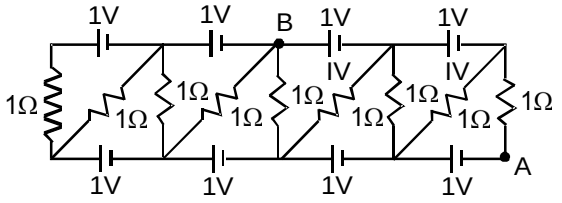


10. A rod of length L and cross-section area A lies along the x-axis between x = 0 and x = L. The material obeys Ohm's law and its resistivity varies along the rod according to $\rho(x) = \rho_0 e^{-x/L}$. The end of the rod at x = 0 is at a potential V_0 and it is zero at x = L.
(a) Find the total resistance of the rod and the current in the wire.
(b) Find the electric potential in the rod as a function of x.

11. An ideal cell having a steady emf of 2 volt is connected across the potentiometer wire of length 10 m. The potentiometer wire is of magnesium and having resistance of 11.5 Ω/m. An another cell gives a null point at 6.9 m. If a resistance of 5Ω is put in series with potentiometer wire, find the new position of the null point.

12. An enquiring physics student connects a cell to a circuit and measures the current drawn from the cell to I_1. When he joins a second identical cell is series with the first, the current becomes I_2. When the cells are connected are in parallel, the current through the circuit is I_3. Show that relation between the current is $3 I_3 I_2 = 2 I_1 (I_2 + I_3)$

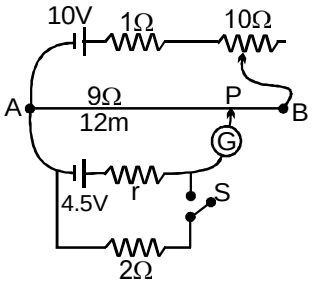
13. Find the potential difference $V_A - V_B$ for the circuit shown in the figure.



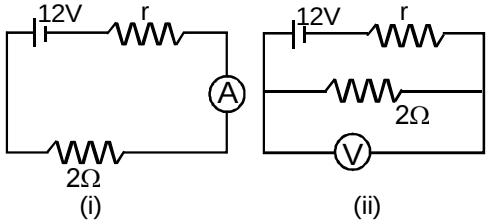
14. A resistance R of thermal coefficient of resistivity = α is connected in parallel with a resistance = 3R, having thermal coefficient of resistivity = 2α. Find the value of α_{eff}.

15. A galvanometer having 50 divisions provided with a variable shunt s is used to measure the current when connected in series with a resistance of 90 Ω and a battery of internal resistance 10 Ω. It is observed that when the shunt resistance are 10Ω, 50Ω, respectively the deflection are respectively 9 & 30 divisions. What is the resistance of the galvanometer ? Further if the full scale deflection of the galvanometer movement is 300 mA, find the emf of the cell.

16. In the primary circuit of potentiometer the rheostat can be varied from 0 to 10Ω. Initially it is at minimum resistance (zero)
(a) Find the length AP of the wire such that the galvanometer shows zero deflection.
(b) Now the rheostat is put at maximum resistance (10 Ω) and the switch S is closed. New balancing length is found to 8m. Find the internal resistance r of the 4.5 V cell.



17. A galvanometer (coil resistance 99Ω) is converted into a ammeter using a shunt of 1Ω and connected as shown in the figure (i). The ammeter reads 3A. The same galvanometer is converted into a voltmeter by connecting a resistance of 101 Ω in series. This voltmeter is connected as shown in figure (ii). Its reading is found to be 4/5 of the full scale reading. Find



(a) internal resistance r of the cell
(b) range of the ammeter and voltmeter
(c) full scale deflection current of the galvanometer