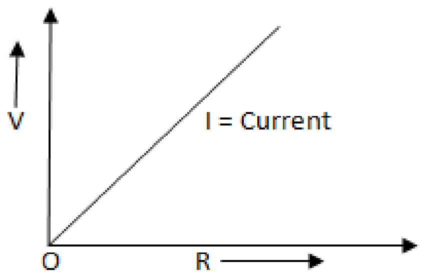
Q9.A cell of emf 'E' and internal resistance 'r' is connected across a variable resistor 'R'. Plot a graph showing the variation of terminal potential 'V' with resistance R. Predict from the graph the condition under which 'V' becomes equal of 'E'.

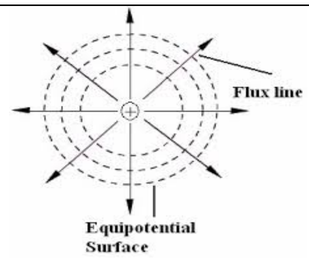
Potential drop across external resistance increases if resistance increases however because of internal resistance there is also potential drop inside the battery, considered as wastage. If no external current flows through the circuit then potential drop inside batter (Ir) becomes zero and Applied emf becomes equal to Potential drop across external resistance. Applied emf The graph between V and R is shown as

V= E-Ir , when I=0 then V=E



Q10.(I) Can two equi-potential surfaces intersect each other? Give reasons.

(II) Two charges –q and +q are located at points A (0, 0, -a) and B (0, 0, +a) respectively. How much work is done in moving a test charge from point P (7, 0, 0) to Q (-3, 0, 0)?

(I) We know that E= - dv/dr , electric intensity is defined as potential gradient. In case two equipotential surfaces intersect at the point of intersection we can draw two tangents and this will give two directions of intensity at the single point, this is not possible, hence equipotential surface do not intersect.	

(II) We know that Work done = Charge X Potential Difference = q ($V_2 - V_1$)

Potential at P (7, 0, 0) is

$$V_1 = \frac{-q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{(7-0)^2+0+(-a-0)^2}} + \frac{q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{(7-0)^2+0+(a-0)^2}}$$

$$= \frac{-q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{49+a^2}} + \frac{q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{49+a^2}} = 0$$

Potential at Q (-3, 0, 0) is

$$V_2 = \frac{-q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{(-3-0)^2+(-a)^2}} + \frac{q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{(-3-0)^2+(a)^2}}$$

$$= \frac{-q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{9+a^2}} + \frac{q}{4\pi\varepsilon_0} \cdot \frac{1}{\sqrt{9+a^2}} = 0$$

$$\therefore \text{Workdone} = q(V_2 - V_1) = q\,(0-0) = 0$$

Hence w = 0.

Q11. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21%?

Ans. The distance (d) of TV coverage is given by

$$d = \sqrt{2hR} \ldots \ldots \ldots (i)$$

When height of the tower (h) is increased by 21%, h_1 = h + 21h/100 =1.21 h

$$\therefore d_1 = \sqrt{2h_1R}$$

$$d_1 = \sqrt{2 \times 1.21\ hR} = 1.1\sqrt{2hR}$$

$$d_1 = 1.1\ d = 1.10\ d$$

$\therefore$ TV coverage is increased by 10%.

Q12. Derive an expression for drift velocity of free electrons in a conductor in terms of relaxation time.

Ans. **Expression for drift velocity:**

Let V = potential difference applied across the ends of the conductor

L = length of the conductor

m = mass of an electron then magnitude of electric field E is $E = \frac{V}{l}$

The direction of this electric field is from positive end to negative end of the conductor. Since the charge on the electron is (-e), then the force experienced in the conductor is

$$\vec{F} = -e\,\vec{E} \ldots \ldots \ldots \ldots \ldots (i)$$

Hence acceleration of each electron

$$m\,\vec{a} = -e\,\vec{E} \Rightarrow \vec{a} = \frac{e\,\vec{E}}{m} \ldots\ldots\ldots\ldots\ldots (ii)$$

$$[\because F = ma]$$

Due to this acceleration, the free electron apart from this thermal velocity, acquires additional velocity component in a direction opposite to the direction of electric field.

At any instant of time, the velocity acquired by electron having thermal velocity $\vec{u}_1$ is

$$\vec{v}_1 = \vec{u}_1 + \vec{a}\,\tau_1$$

Where, τ_1 is the time elapsed. Similarly, the velocities acquired by other electrons in the conductor is

$$\vec{v}_2 = \vec{u}_2 + \vec{a}\,\tau_2 \ \ and\ so\ on.$$

$$\therefore\ \vec{v}_n = \vec{u}_n + \vec{a}\,\tau_n$$

The average velocity of all the free electrons in the conductor is the drift velocity $\vec{v}_d$ of free electrons.

$$\therefore\ \vec{v}_d = \frac{\vec{v}_1+\vec{v}_2+ \ldots\ldots\ldots\ldots + \vec{v}_n}{n}$$

$$= \frac{(\vec{u}_1+\vec{a}\,\tau_1)+(\vec{u}_2+\vec{a}\,\tau_2)+ \ldots\ldots + (\vec{u}_n+\vec{a}\,\tau_n)}{n}$$

$$= \left(\frac{\vec{u}_1+\vec{u}_2+ \ldots\ldots + \vec{u}_n}{n}\right) + \ \vec{a}\ \left(\frac{\tau_1+\tau_2+ \ldots\ldots + \tau_n}{n}\right)$$

$$= 0 + \vec{a}\,\tau = \ \vec{a}\,\tau \ldots\ldots\ldots\ldots\ldots (iii)$$

[Since average thermal velocity of electrons is zero.]

Where, $\tau = \frac{\tau_1+\tau_2+ \ldots\ldots + \tau_n}{n}$ is called relaxation time. Its value is of the order of 10^{-14} seconds.

Putting the value of a in (iii), we get

$$\vec{v}_d = \frac{-e\,\vec{E}}{m}\,\tau$$

Hence average drift speed, $v_d = \frac{eE}{m}\,\tau$