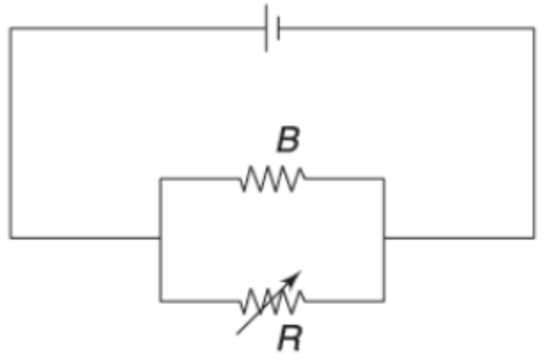
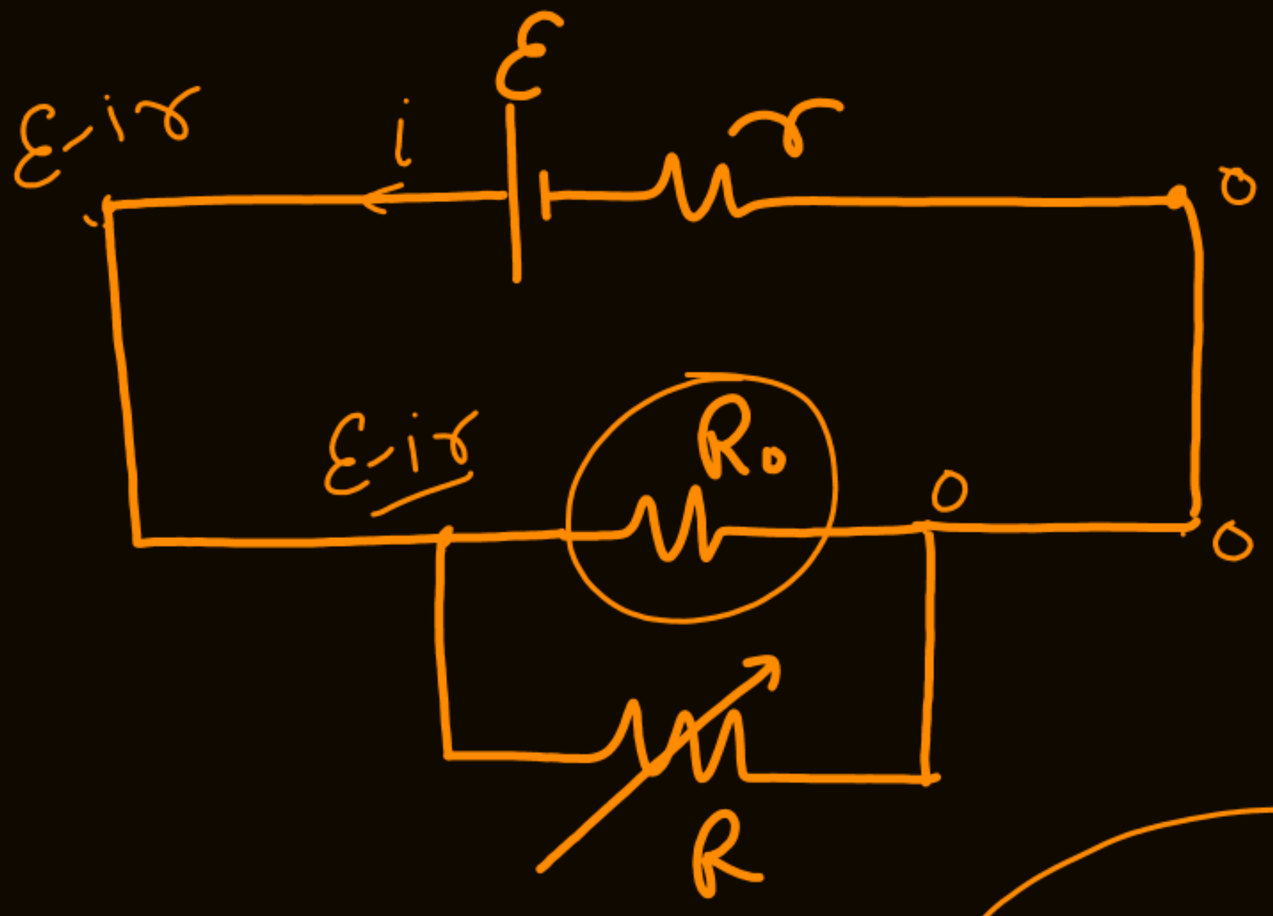
Q. 8: *A* bulb *B* is connected to a source having constant emf and some internal resistance. *A* variable resistance *R* is connected in parallel to the bulb. If the resistance *R* is increased, how will it affect the–

(a) Brightness of the bulb?

(b) Power spent by the source?

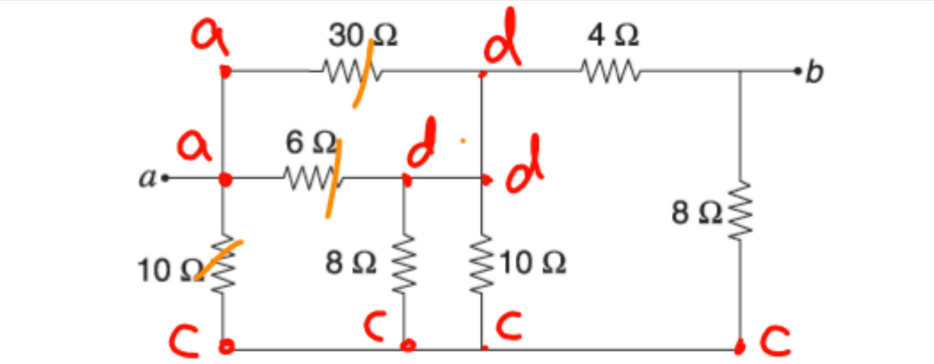




$\downarrow \; P = \varepsilon i$ $\quad i = \dfrac{\varepsilon}{R_{eq}} \downarrow$ $\quad \uparrow R_{eq} = \dfrac{R_0 R}{R_0 + R} + r$ $\quad R \uparrow$

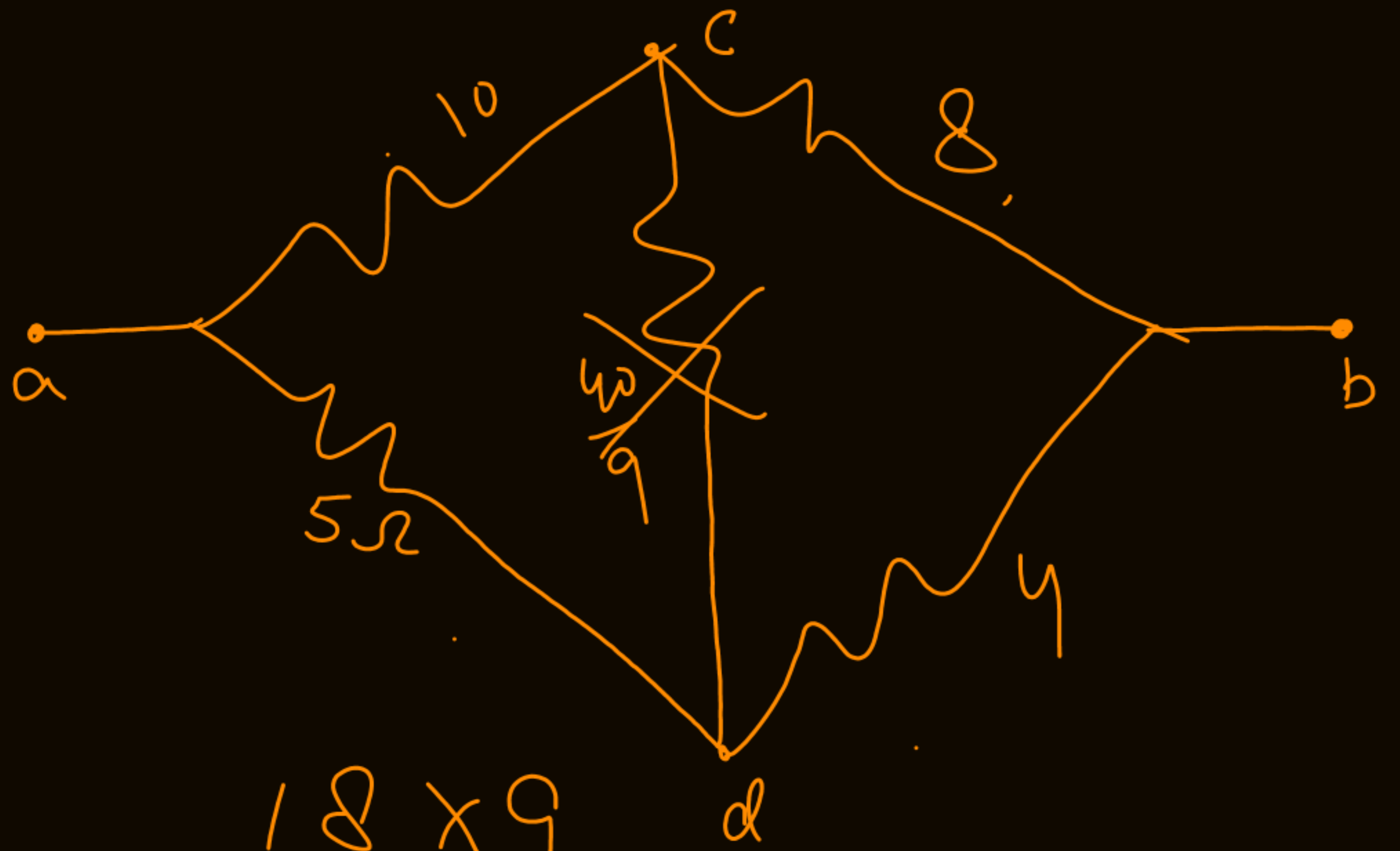
$P = (\varepsilon - ir) R_0$ $\uparrow$

Q. 10: Find the equivalent resistance between point a and b in the network shown in figure.



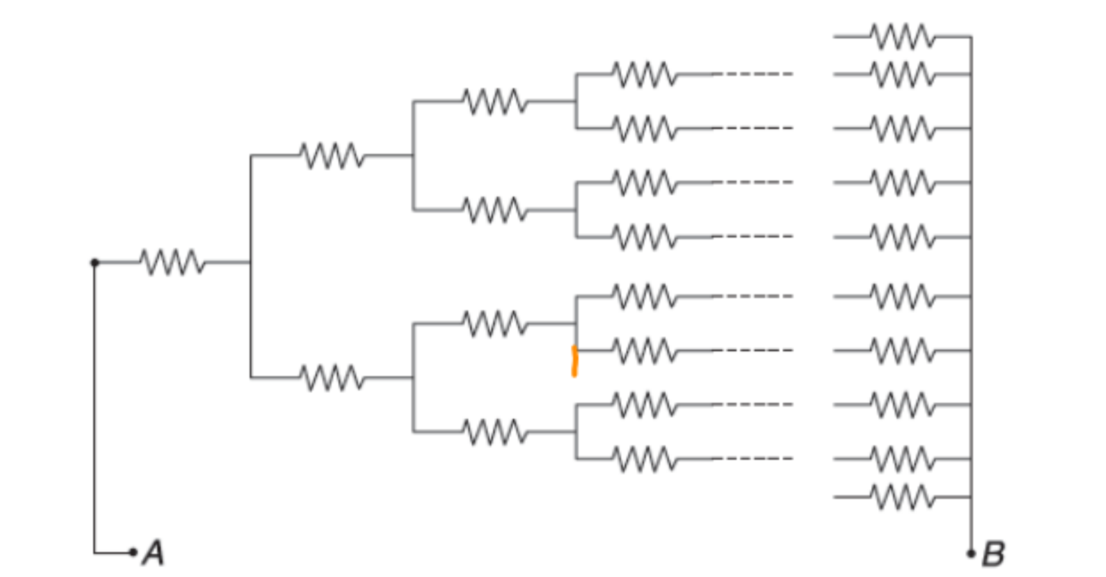
$$\frac{30\times 6}{30+6} = 5$$

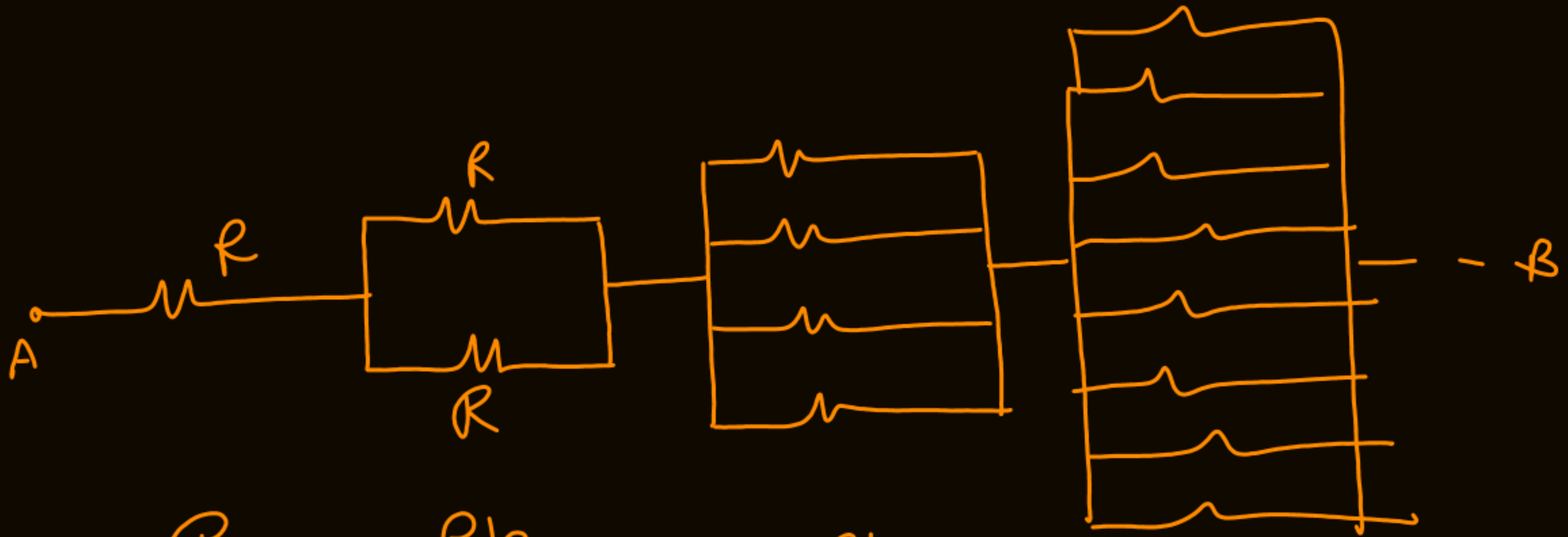
$$\frac{10\times \cancel{8}^{4}}{\cancel{18}_{9}} = \frac{40}{9}$$

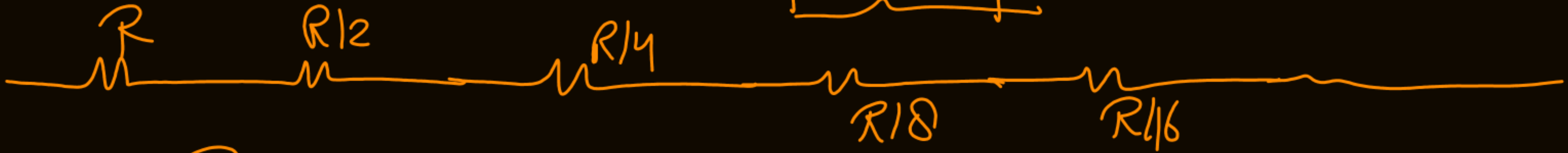


$$\frac{18\times 9}{18+9} = \frac{18\times 9}{27} = \underline{\underline{6\Omega}}$$

Q. 12: An infinite network of resistances has been made as shown in the Figure. Each resistance is R. Find the equivalent resistance between A and B.





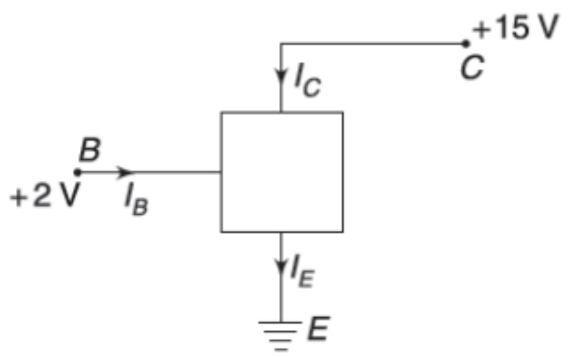


$$R_{eq} = R + R/2 + R/4 + R/8 + R/16$$

$$= R\left\{1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \cdots\right\} = R \times \frac{1}{1 - 1/2} = 2R.$$

Q. 18: The box shown in the figure has a device which ensures that $I_C = 0.9\ I_E$.

If a small change (ΔI_B) is made in I_B, calculate the corresponding change in I_C.



$$i_c + i_B = i_e$$

$$i_c + i_B = \frac{i_c}{0.9}$$

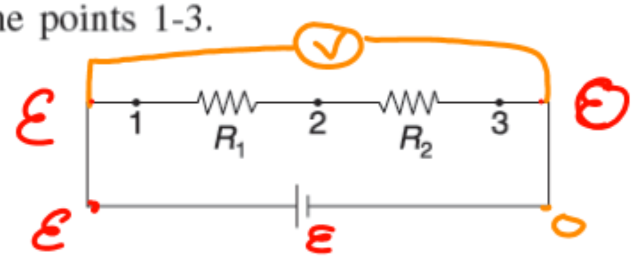
$$i_B = i_c\left\{\frac{10}{9} - 1\right\}$$

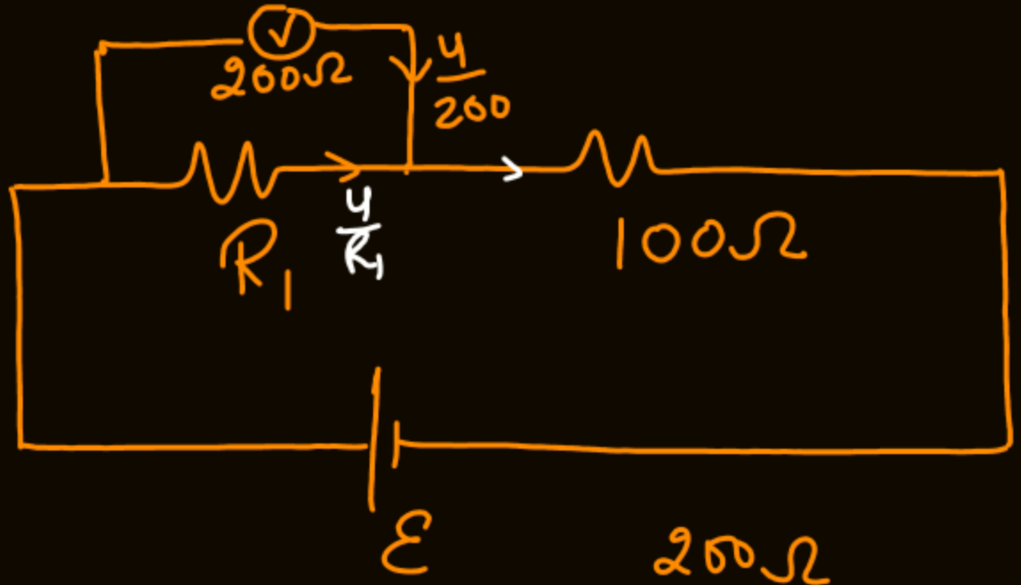
$$= \frac{i_c}{9}$$

$$i_c = 9\, i_B$$

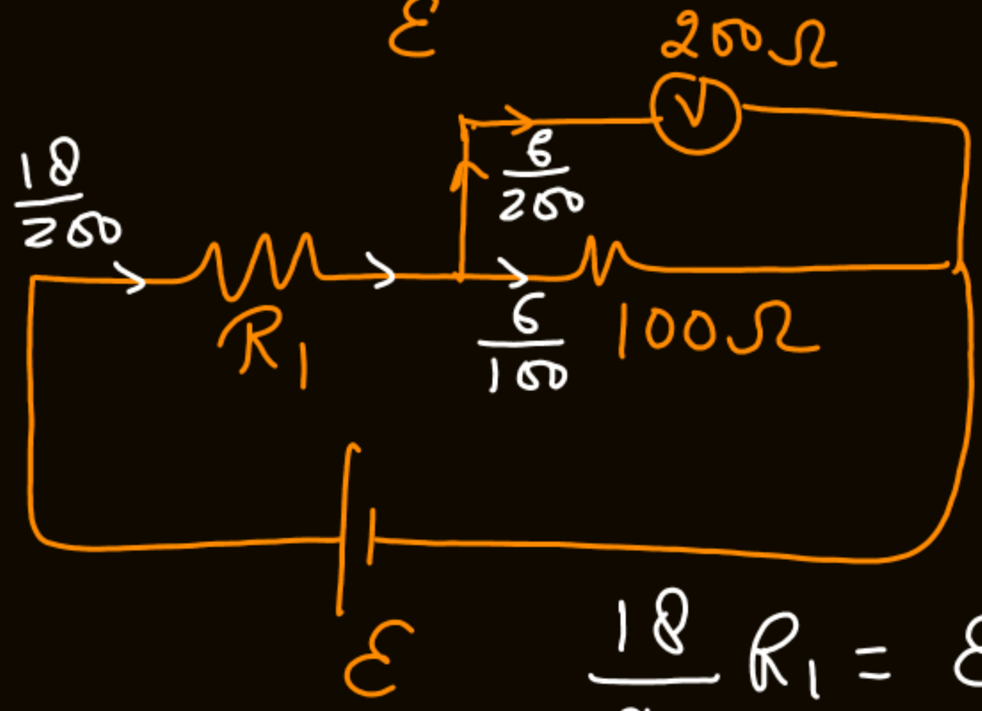
$$\boxed{\Delta i_c = 9\,\Delta i_B}$$

Q. 27: In the circuit shown in the Figure, cell is ideal and $R_2 = 100\ \Omega$. A voltmeter of internal resistance $200\ \Omega$ reads $V_{12} = 4$ V and $V_{23} = 6$ V between the pair of points 1-2 and 2-3 respectively. What will be the reading of the voltmeter between the points 1-3.





$$\left(\frac{4}{200}+\frac{4}{R_1}\right)\times 100 = \mathcal{E}-4 \quad (1)$$



$$\frac{6}{200}+\frac{6}{100}=\frac{18}{200} \Rightarrow$$

$$\frac{18}{200}R_1 = \mathcal{E}-6 \quad (2)$$

$$\mathcal{E} = \frac{18}{\cancel{200}}\times\frac{\cancel{200}}{3}+6 = 12=\mathcal{E}$$

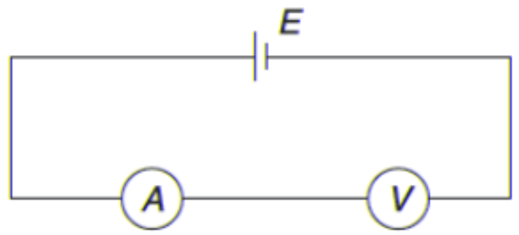
$$\cancel{4}+\frac{400}{R_1}+\cancel{4} = \mathcal{E} = \frac{18R_1}{200}+\cancel{6}$$

$$18R_1^2 = 200\times 400$$

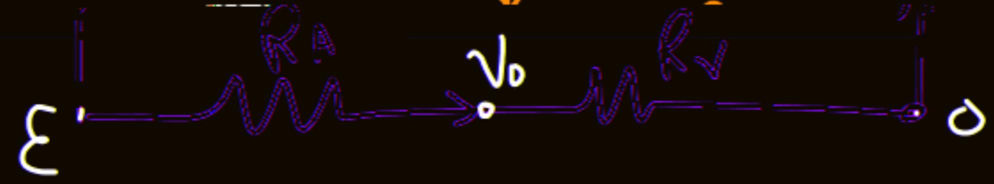
$$R_1^2 = \frac{200\times 200}{9}$$

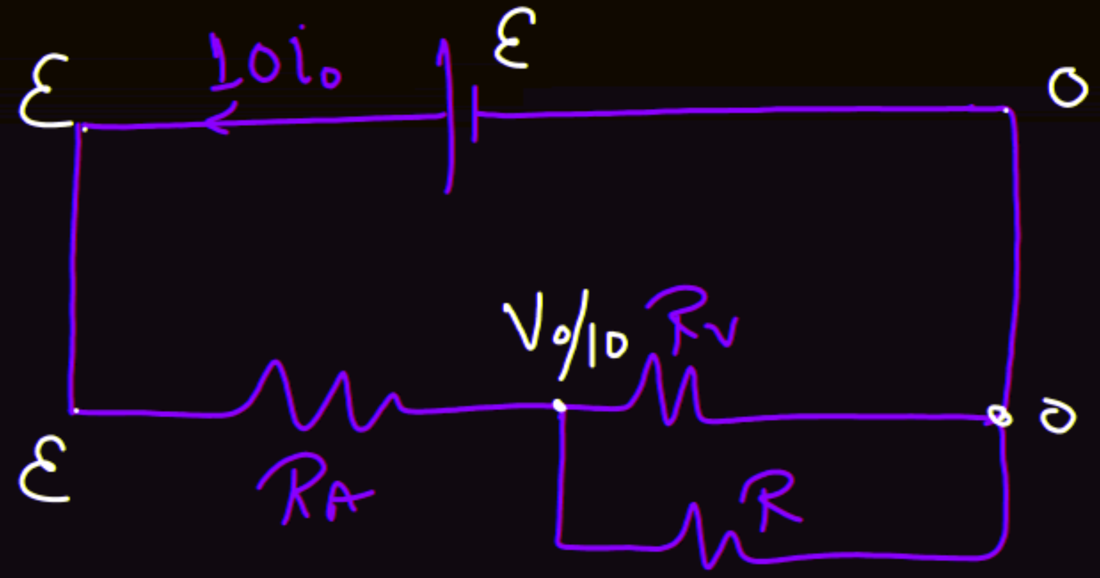
$$R_1 = \frac{200}{3}\ \Omega$$

Q. 28: In the circuit shown, an ideal cell of emf E is connected in series to a non-ideal ammeter and voltmeter. Reading of the voltmeter is V_0. When a resistance is added in parallel to the voltmeter its reading becomes $\frac{V_0}{10}$ and the reading of the ammeter becomes 10 times the earlier value. Find V_0 in terms of E.



$$i_0 = \frac{\mathcal{E} - V_0}{R_A}$$





$$i = \frac{\mathcal{E} - \frac{V_0}{10}}{R_A} = 10 i_0 = 10\,\frac{\mathcal{E} - V_0}{R_A}$$

$$\frac{10\mathcal{E} - V_0}{10\cancel{R_A}} = \frac{10\,\mathcal{E} - V_0}{\cancel{R_A}}$$

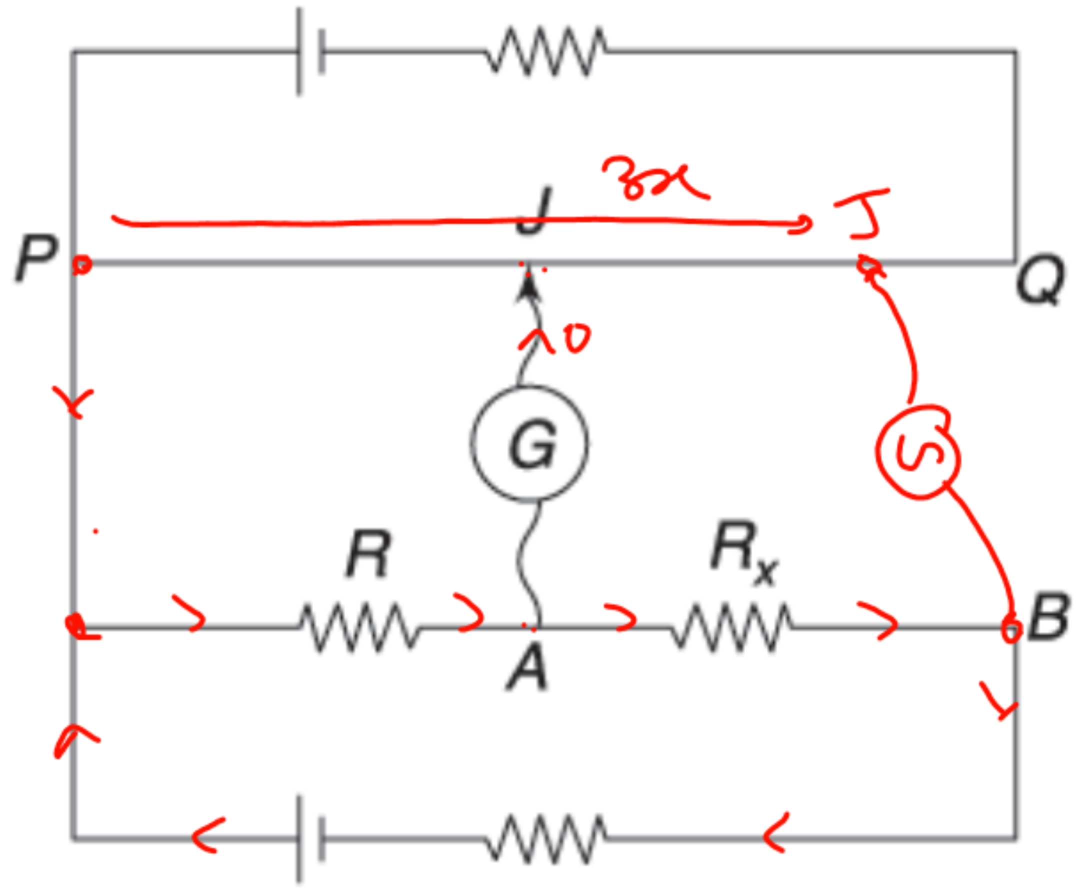
$$10\mathcal{E} - V_0 = 100\mathcal{E} - 100V_0$$

$$90\,\mathcal{E} = 99V_0$$

$$\boxed{V_0 = \frac{10\mathcal{E}}{11}}$$

Sol:

Q. 32: In the figure shown PQ is a potentiometer wire. When galvanometer is connected at A, it shows zero deflection when $PJ = x$. Now the galvanometer is connected to B and it shows zero deflection when $PJ = 3x$. Find the value of unknown resistance R_X in term of R.



$iR = Kx$

$i(R+R_x) = K\,3x$

$R+R_x = 3R$

$\boxed{R_x = 2R}$

Q. 38: In the circuit shown in Figure AB is a uniform wire of length $L = 5$m. It has a resistance of 2 Ω/m. When $AC = 2.0$ m, it was found that the galvanometer shows zero reading when switch s is placed in either of the two positions 1 or 2. Find the emf E_1.

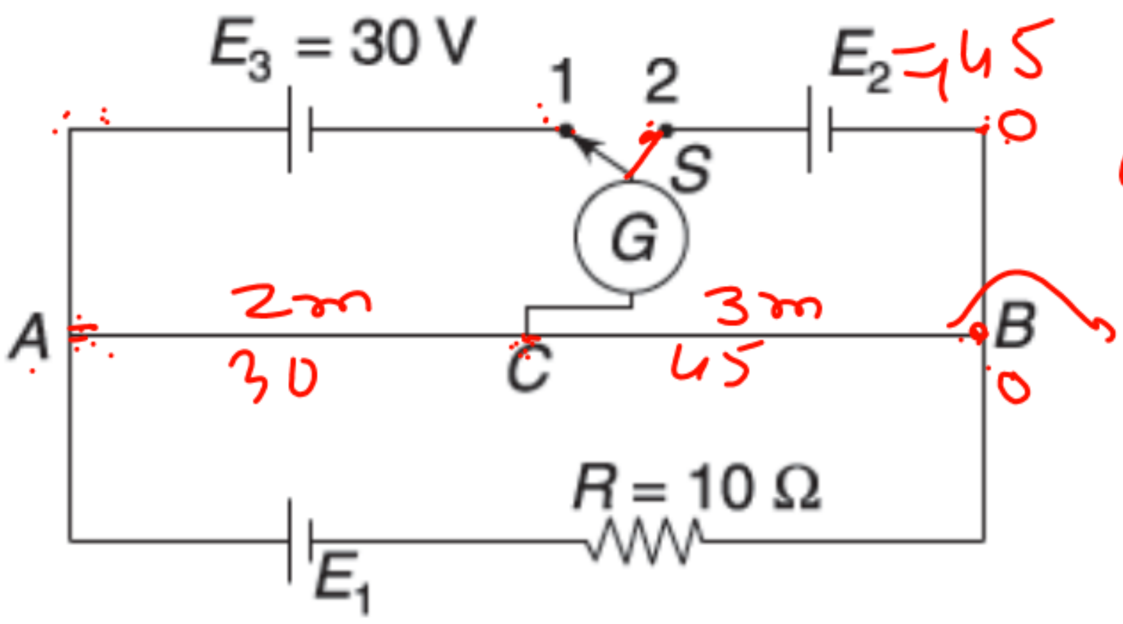
75V

$\mathcal{E}_2 = K \times 3$

$30 = K \times 2$

$\frac{\mathcal{E}_2}{30} = \frac{3}{2}$

$\mathcal{E}_2 = 45$



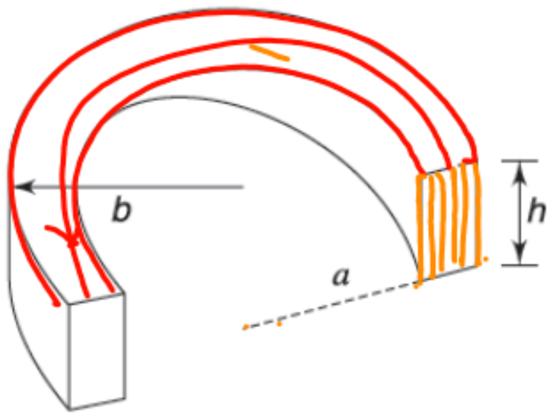
$i = \frac{75}{10} = 7.5A$

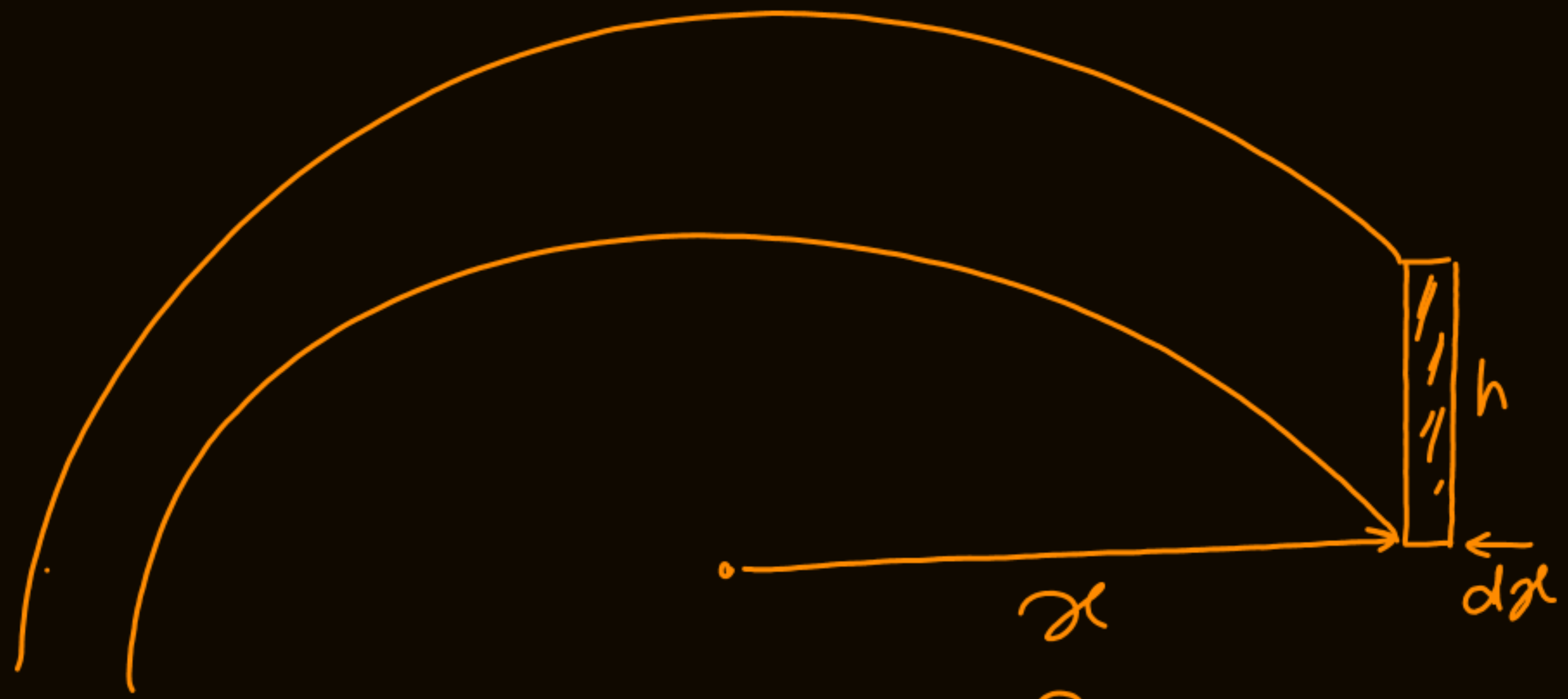
$i = \frac{\mathcal{E}_1}{20} \times 7.5$

$\mathcal{E}_1 = 20 \times 7.5$

$= 150V$

Q. 50: A conductor having resistivity ρ is bent in the shape of a half cylinder as shown in the figure. The inner and outer radii of the cylinder are a and b respectively and the height of the cylinder is h. A potential difference is applied across the two rectangular faces of the conductor. Calculate the resistance offered by the conductor.





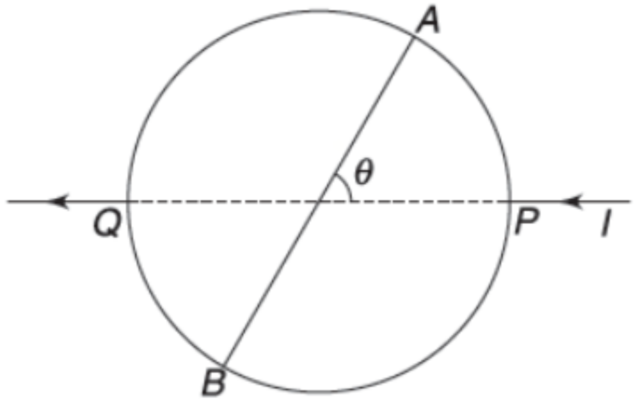
$$dR = \frac{\rho \pi x}{h\,dx}$$

$$\frac{1}{R_{eq}} = \int \frac{1}{dR} = \int_a^b \frac{h\,dx}{\rho \pi x}$$

$$\frac{1}{R_{eq}} = \frac{h}{\rho\pi}\int_a^b \frac{dx}{x} = \frac{h}{\rho\pi}\ln b/a$$

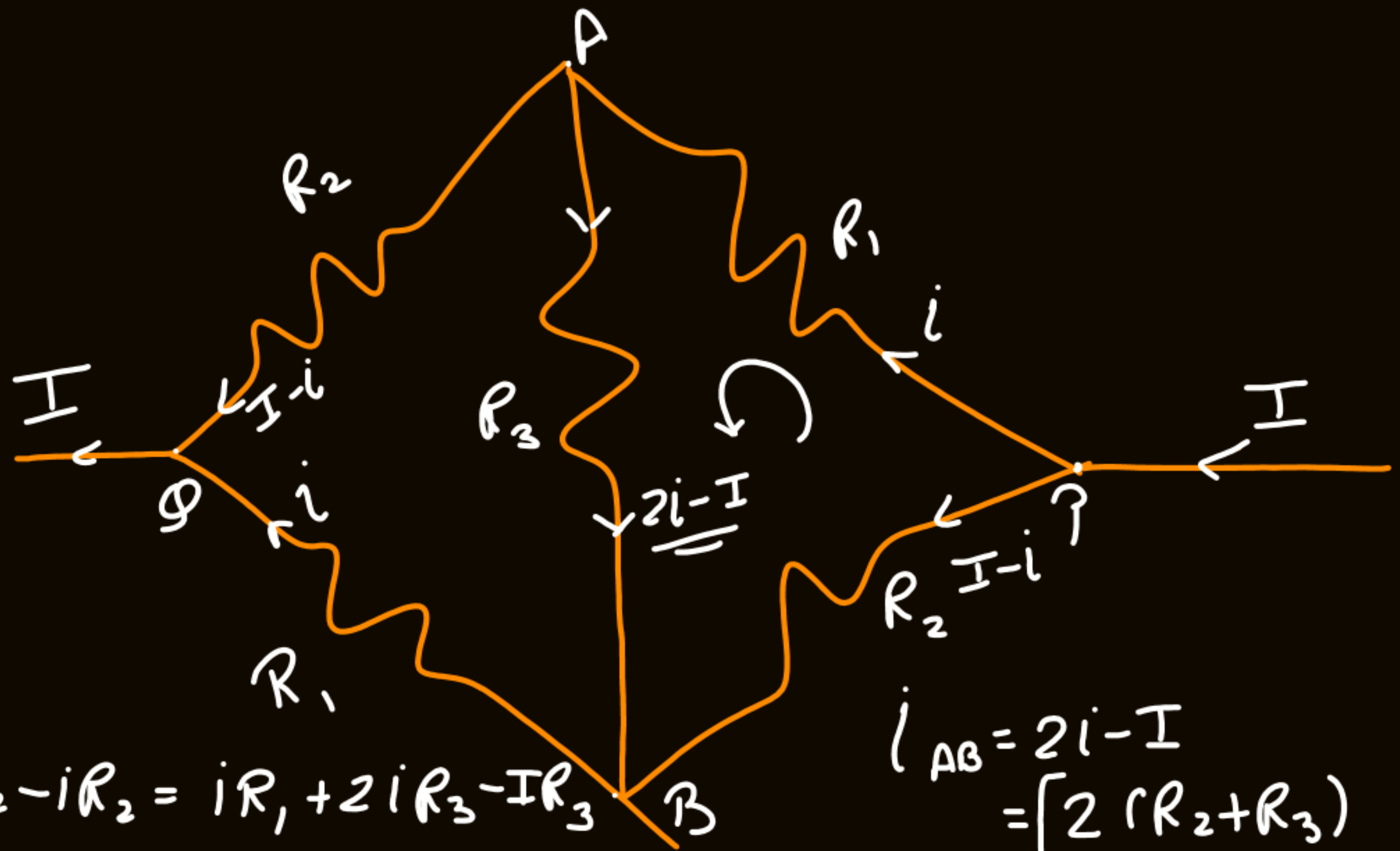
$$\boxed{R_{eq} = \frac{\rho\pi}{(h \ln b/a)}}$$

Q. 62: A uniform conducting wire is in the shape of a circle. The same wire has been used to make its diagonal *AB*. A current *I* enters at point *P* and leaves at the diagonally opposite point *Q*. *AB* makes an angle θ with the line *PQ*. Find current (i), through *AB* as a function of θ. Plot a graph showing variation of i with θ $(0^\circ \le \theta \le 90^\circ)$



$$(I-i)R_2 - iR_1 - (2i-I)R_3 = 0$$

$$i-(I-i) = 2i-I$$



$$IR_2 - iR_2 = iR_1 + 2iR_3 - IR_3$$

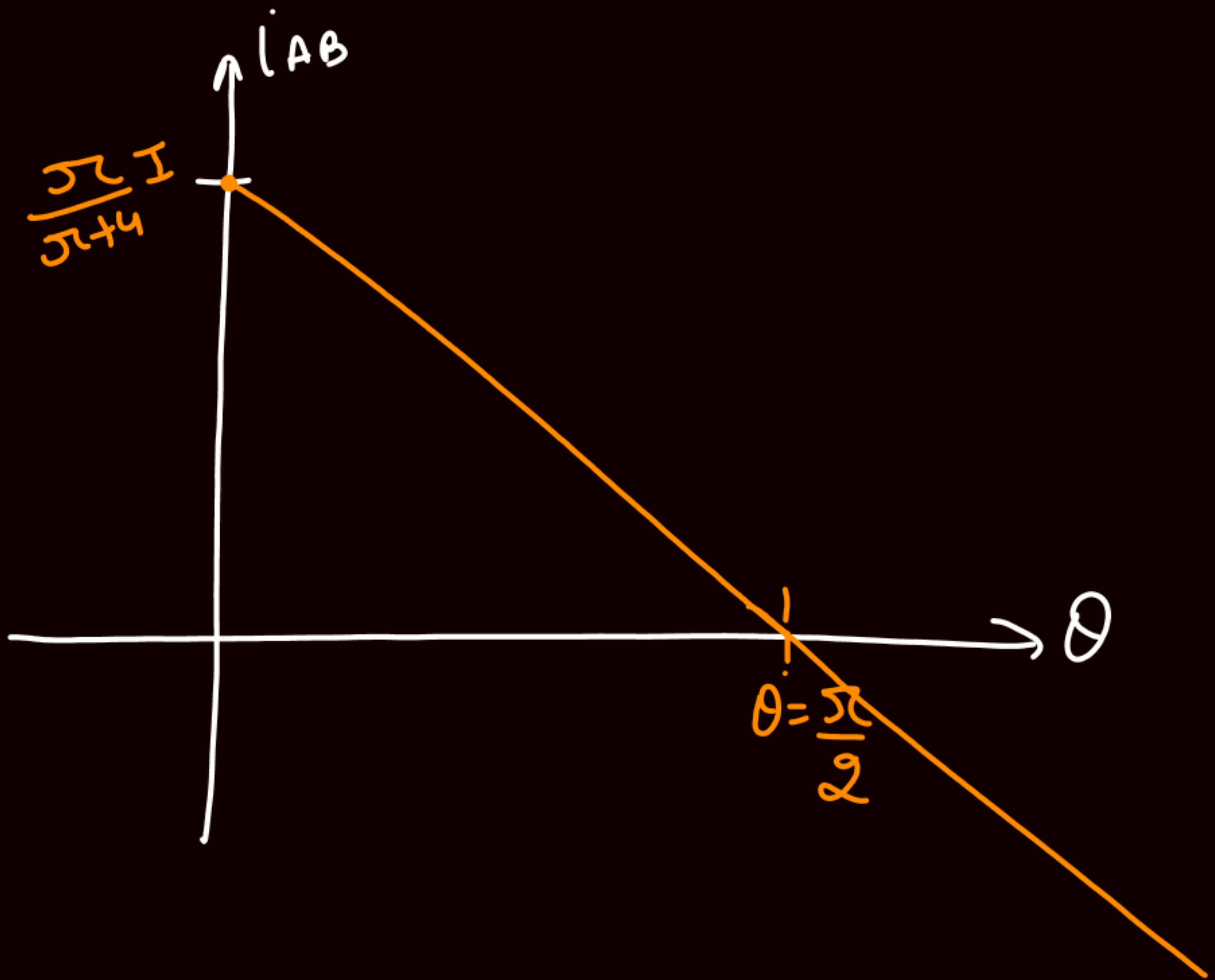
$$\frac{I(R_2+R_3)}{R_1+R_2+2R_3} = i$$

$$i_{AB} = 2i - I$$

$$= \left[\frac{2(R_2+R_3)}{R_1+R_2+2R_3} - 1\right] I = \frac{R_2-R_1}{R_1+R_2+2R_3} I$$

$$i_{AB} = \frac{r(\pi-\theta) - r\theta}{r\theta + r(\pi-\theta) + 2r\times 2} I$$

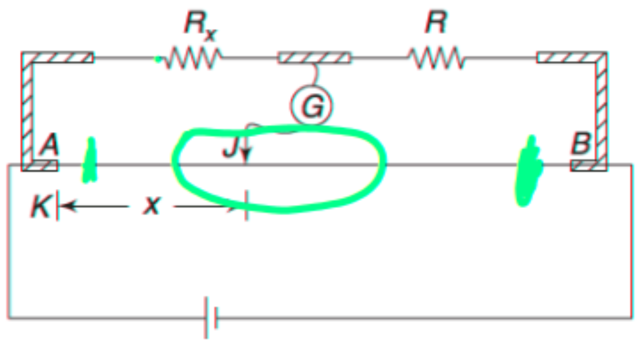
$$\boxed{i_{AB} = \frac{\pi - 2\theta}{\pi + 4} I}$$



Q. 75: Figure shows an experimental set up to find the value of an unknown resistance (R_x) using a meter bridge. AB is the uniform meter bridge wire of length L = 100 cm. When the sliding jockey is placed at J ($AJ = x$), the galvanometer shows zero deflection. $AJ = x$ is known as balancing length and is measured using a scale having 1 mm as least count.

(a) In one experiment known resistance R was taken to be 20 Ω and balancing length was measured as $x = (20.0 \pm 0.1)$ cm. Find the value of R_x.

(b) Show that fractional error in calculated value of R_x is least when $x = \frac{L}{2}$. What shall we do to ensure that x is close to $L/2$?



Sol:-

$$\frac{R_x}{R} = \frac{x}{100-x}$$

$$R_x = \frac{20}{80} \times 20\Omega = 5\Omega$$

$$R_x = x(100-x)^{-1}R$$

$$\ln R_x = \ln x - \ln(100-x) + \ln R$$

$$\frac{dR_x}{R_x} = \frac{dx}{x} + \frac{dx}{(100-x)} + \frac{dR}{R}$$

max^m possible error in $x \Rightarrow dx = 0.1$

max^m error in R

$dR \to 0$

$$\frac{dR_x}{5\Omega} = \frac{0.1\,cm}{20\,cm} + \frac{0.1\,cm}{80\,cm}$$

1cm

$$= \frac{0.5}{80} = \frac{dR_x}{R_x}$$

$$dR_x = \frac{0.5}{\cancel{80}\,16} \times \cancel{5}$$

$$= 0.03\Omega$$

$$\boxed{R_x = 5\Omega \pm 0.03\Omega}$$

$$\downarrow \frac{dR_x}{R_x} = \frac{100\,dx}{x(100-x)} = \frac{100\,cm \times 0.1\,cm}{x(100-x)} \uparrow$$

$$f(x) = x(100-x)$$

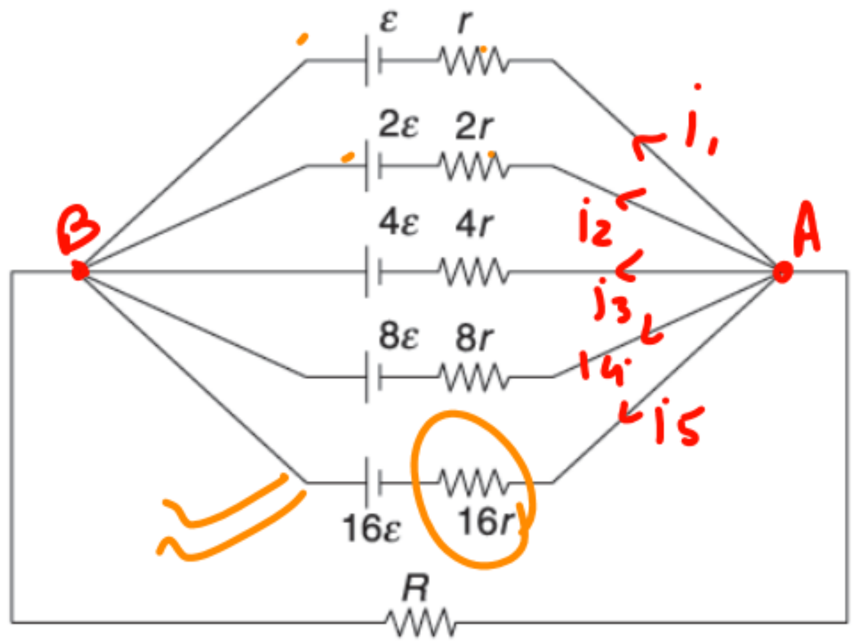
$$f'(x) = 100 - 2x = 0$$

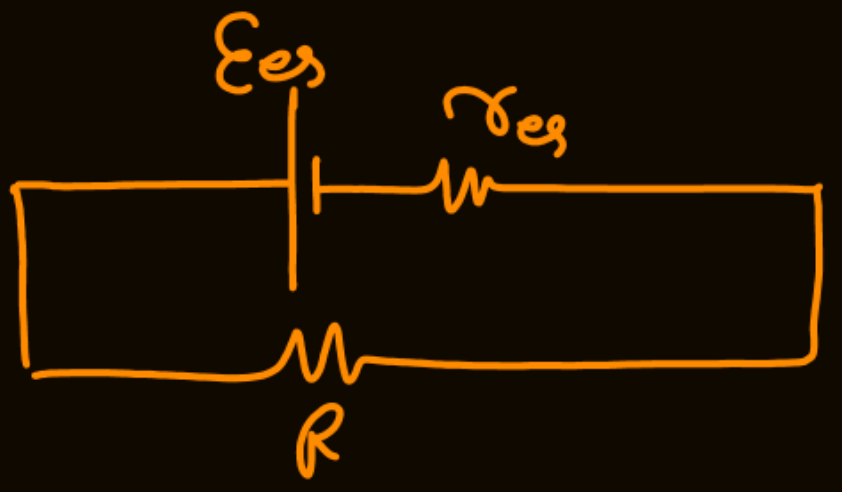
$$x = 50\,cm = \frac{L}{2}$$

Q. 77: Five cells have been connected in parallel to form a battery. The emf and internal resistances of the cells have been shown in figure. A load resistance R is connected to the battery.

(a) Which of the 5 cells will have maximum current flowing through it?

(b) Find the current through load resistance R.





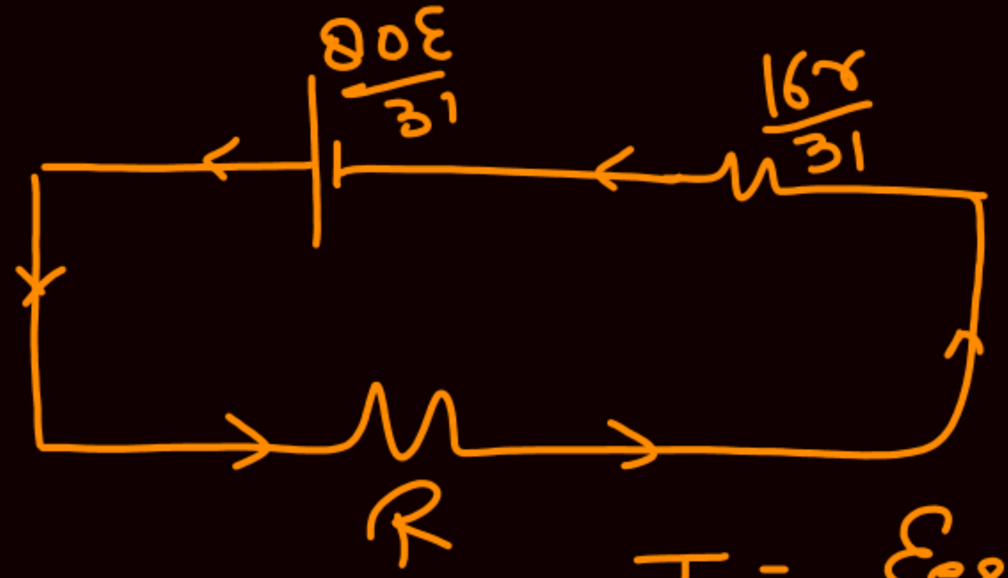
$$\frac{1}{r_{eq}} = \frac{1}{r} + \frac{1}{2r} + \frac{1}{4r} + \frac{1}{8r} + \frac{1}{16r}$$

$$= \frac{1}{r}\,\frac{16+8+4+2+1}{16}$$

$$\boxed{r_{eq} = \frac{16r}{31}}$$

$$\mathcal{E}_{eq} = \frac{\frac{\varepsilon}{r} + \frac{\varepsilon}{r} + \frac{\varepsilon}{r} + \frac{\varepsilon}{r} + \frac{\varepsilon}{r}}{\frac{31}{16r}} = \frac{5\varepsilon \times 16}{31}$$

$$= \frac{80\varepsilon}{31}$$



$$I = \frac{\varepsilon_{eq}}{R_{eq}}$$

$$= \frac{80\,\varepsilon}{31\left(R + \frac{16r}{31}\right)}$$

$$= \frac{80\,\varepsilon}{31R + 16r}$$

$$V_B - V_A = \varepsilon_n - i r_n$$

$$i r_n = \varepsilon_n - (V_B - V_A)$$

$$\boxed{i = \frac{\varepsilon_n - (V_B - V_A)}{r_n}}$$

$$\uparrow i = \frac{\varepsilon_n}{r_n} - \frac{V_B - V_A}{r_n} \uparrow \downarrow$$

same

$r_n \uparrow \; i \uparrow$