Nishant Jindal

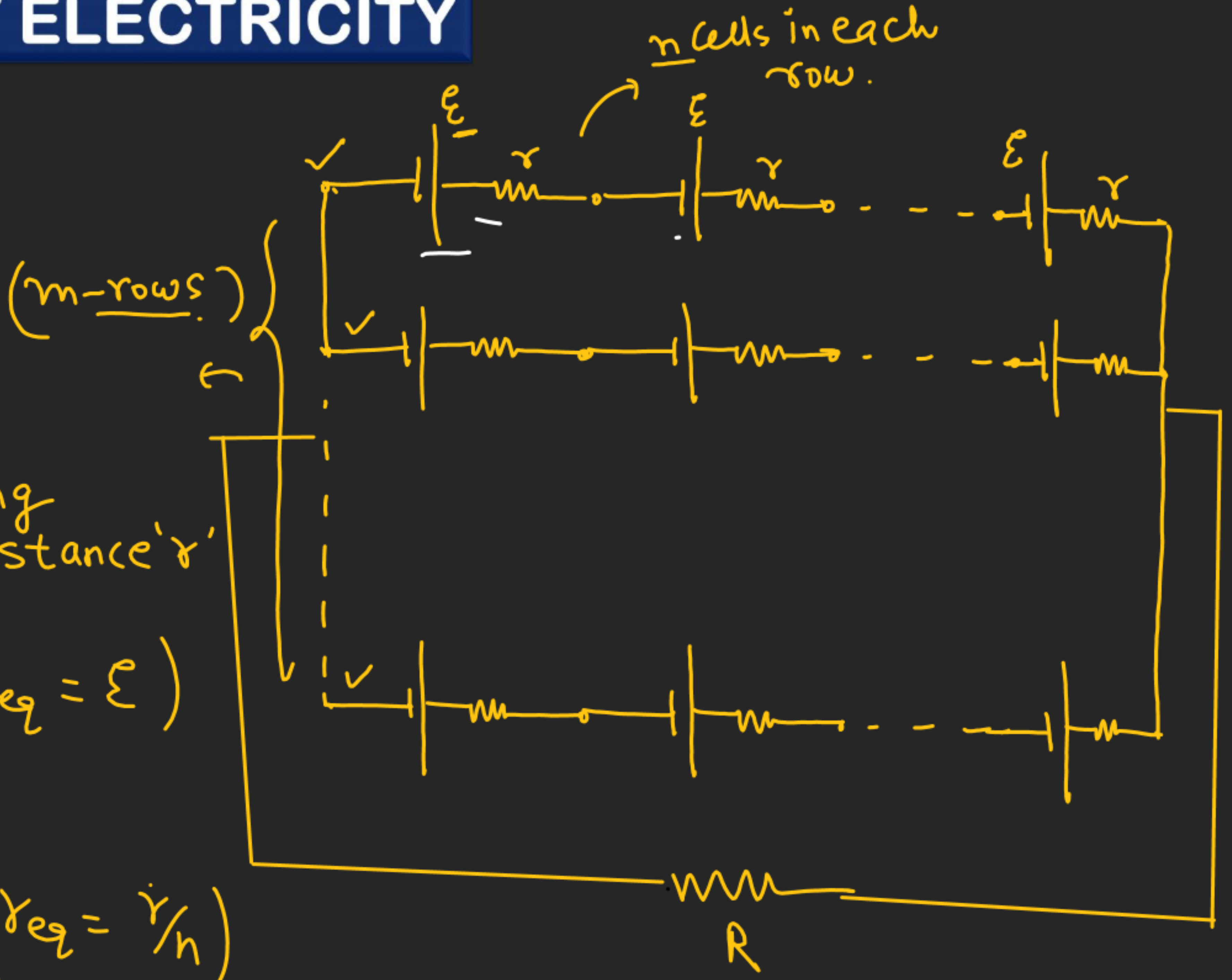
CURRENT ELECTRICITY

$$\varepsilon_{eq} = \left[\frac{\sum_{i=1}^{n} \varepsilon_i/r_i}{\sum_{i=1}^{n} 1/r_i}\right]$$

If all the Cells are identical having emf 'ε' and internal resistance 'r'

$$\varepsilon_{eq} = \left(\frac{\frac{\varepsilon}{r} + \frac{\varepsilon}{r} \dots + \frac{\varepsilon}{r}}{\frac{1}{r} + \frac{1}{r} + \dots + \frac{1}{r}}\right) \Rightarrow \left(\varepsilon_{eq} = \varepsilon\right)$$

$$\frac{1}{r_{eq}} = \left(\frac{1}{r} + \frac{1}{r} \dots \frac{1}{r}\right) = \frac{n}{r} \Rightarrow \left(r_{eq} = r/n\right)$$



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#4.

Power :-

↳ It is rate of change of heat dissipiated across the resistor w.r.t time

$$P = \left(\frac{dH}{dt}\right)$$ H = heat dissipiated

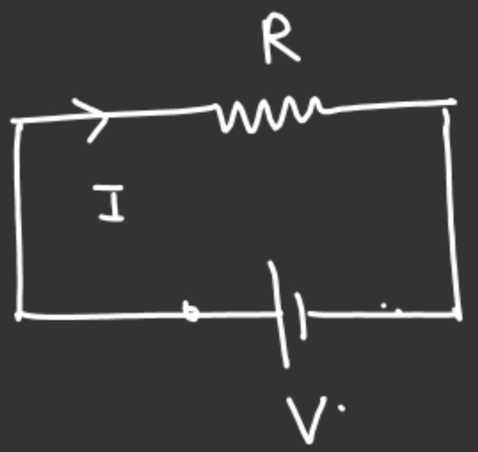
⇓

inst.

$$H = \underline{P}t = i^2Rt = \frac{V^2}{R}t$$

⇓

$\boxed{P = C}$



$V = IR$

$$\boxed{P = I^2R = V^2/R}$$

$$(P_{avg}) = \left(\frac{\int_0^t P\,dt}{\int_0^t dt}\right)$$

$\int_0^t P\,dt$ = Total heat in time 0 to t

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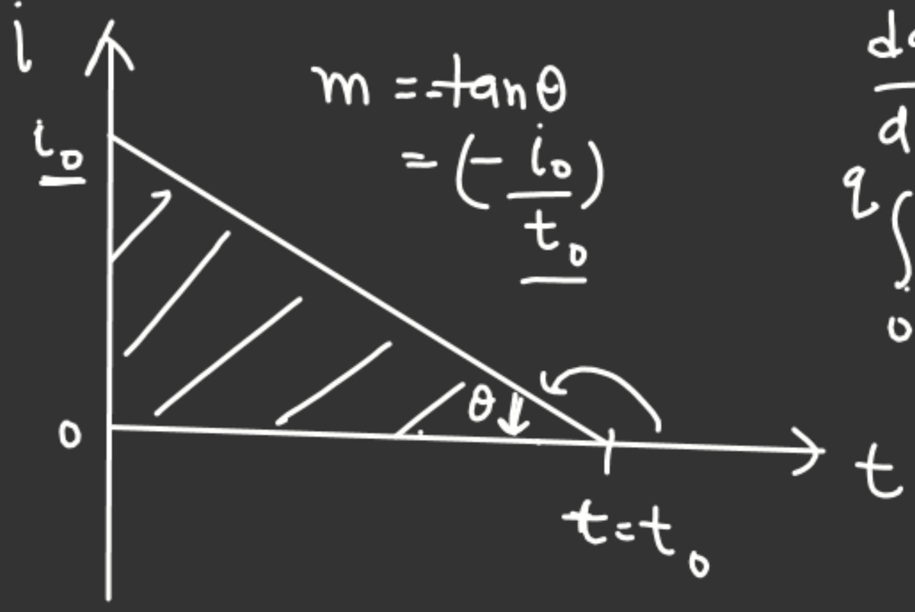
\# A Current flowing across the resistor is linearly decreases to zero from $t=0$ to $t=t_0$. If 'q' be the total charge flow in the interval $t=0$ to $t=t_0$. Find total heat dissipiated if R be the resistance of resistor.

Sol^n



$m = \tan\theta$
$= \left(-\frac{i_0}{t_0}\right)$

$\frac{dq}{dt} = i$

$\int_0^q dq = \int i\,dt$

$\Downarrow$

Area under i vs t graph.

$q = \frac{1}{2} t_0 \cdot i_0$

$i_0 = \left(\frac{2q}{t_0}\right)$

$i \to f(t)$

$i = \left(-\frac{i_0}{t_0}\right)t + i_0$

$P = i^2 R$

$P = \left[i_0 - \left(\frac{i_0}{t_0}\right)t\right]^2 \cdot R$

$\Downarrow$

$\frac{dH}{dt} = \left(i_0 - \left(\frac{i_0}{t_0}\right)t\right)^2 R$

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$$\frac{dH}{dt} = \left(I_0 - \left(\frac{I_0}{t_0}\right)t\right)^2 R$$

$$\int_0^H dH = R\int_0^{t_0}\left[\left(I_0 - \left(\frac{I_0}{t_0}\right)t\right)^2\right] dt.$$

$$H = R\int_0^{t_0}\left(I_0^2 + \frac{I_0^2}{t_0^2}t^2 - \frac{2I_0^2}{t_0}t\right) dt.$$

$$H = R\left[I_0^2\int_0^{t_0} dt + \frac{I_0^2}{t_0^2}\int_0^{t_0} t^2\,dt - \frac{2I_0^2}{t_0}\int_0^{t_0} t\,dt\right]$$

$$H = R\left[I_0^2 t_0 + \frac{I_0^2}{t_0^2}\times\frac{t_0^3}{3} - \cancel{\frac{2I_0^2}{t_0}}\times\cancel{\frac{t_0^2}{2}}\right]$$

$$H = R\left[\cancel{I_0^2 t_0} + \frac{I_0^2 t_0}{3} - \cancel{I_0^2 t_0}\right]$$

$$H = \left(\frac{I_0^2 t_0 R}{3}\right) = \left(\frac{2q}{t_0}\right)^2\times\frac{t_0 R}{3}$$

$$H = \frac{4q^2R}{3t_0}$$ ✓

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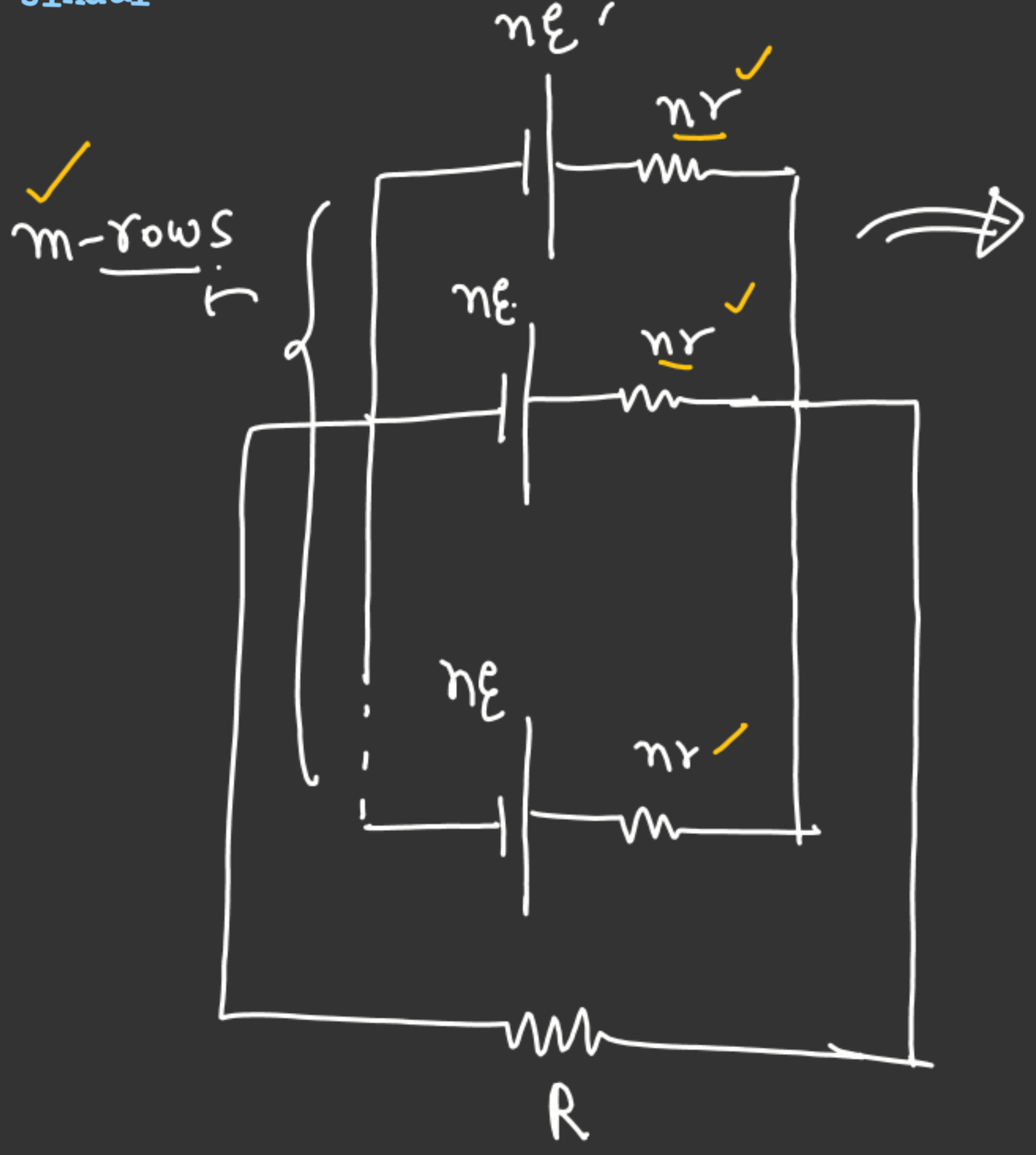

R → (Load resistance)

$$I = \left(\frac{n\varepsilon}{R + \frac{nr}{m}}\right)$$

$$\frac{1}{r_{eq}} = \left(\underbrace{\frac{1}{nr} + \frac{1}{nr} + \cdots + \frac{1}{nr}}_{m\text{-times}}\right)$$

$$\frac{1}{r_{eq}} = \left(m \times \frac{1}{nr}\right)$$

$$r_{eq} = \left(\frac{nr}{m}\right)$$

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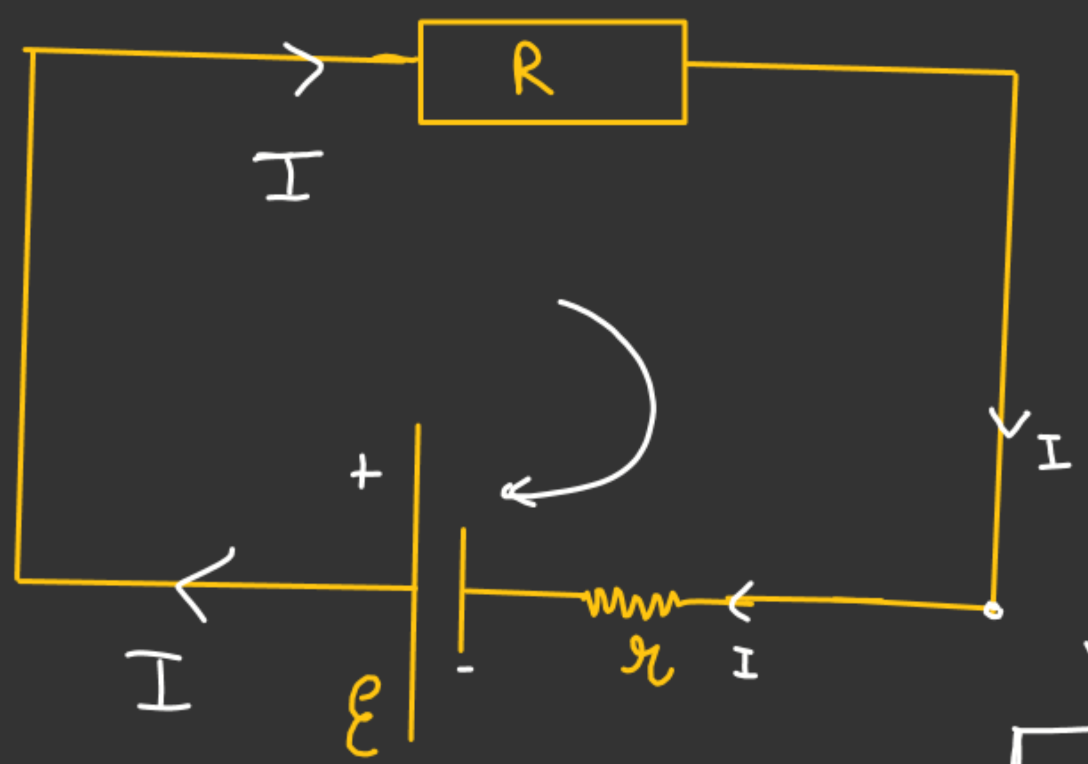
(A) Maximum power transfer theorem



$$-Ir+\mathcal{E}-IR=0.$$

$$I(R+r)=\mathcal{E}$$

$$I=\left(\frac{\mathcal{E}}{R+r}\right)$$

$$I=\left(\frac{\mathcal{E}}{R+r}\right)$$

$$P=I^2R.$$

$$P=\frac{\mathcal{E}^2R}{(R+r)^2}.$$

For P to be maximum
Value of $R=??$

$$\boxed{\frac{dP}{dR}=0.}$$

$$\mathcal{E}^2\frac{d}{dR}\left[\frac{R}{(R+r)^2}\right]=0$$

$$\frac{\mathcal{E}^2\left[(R+r)^2\frac{d(R)}{dR}-R\frac{d}{dR}(R+r)^2\right]}{((R+r)^2)^2}=0$$

$$(R+r)^2(1)-R\{2(R+r)\}\frac{d}{dR}(R+r)=0$$

$$(R+r)^2-2R(R+r)=0.$$

$$R+r=2R$$

$$\boxed{R=r}$$

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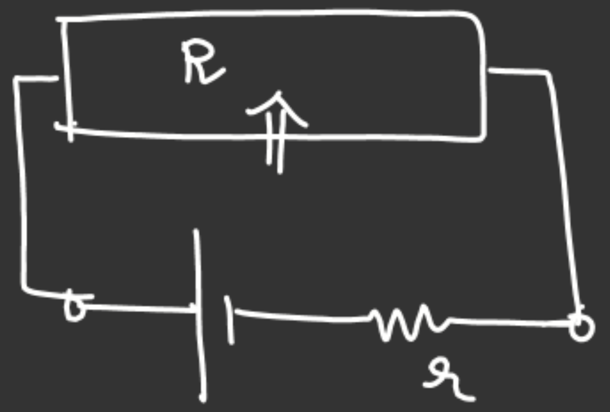
** [According to maximum power transfer theorem if load resistance is equal to internal resistance of battery then maximum power transfered]

⇒ Steps of maximum power transfer theorem

① Find the equivalent resistance across the the terminal of the battery.

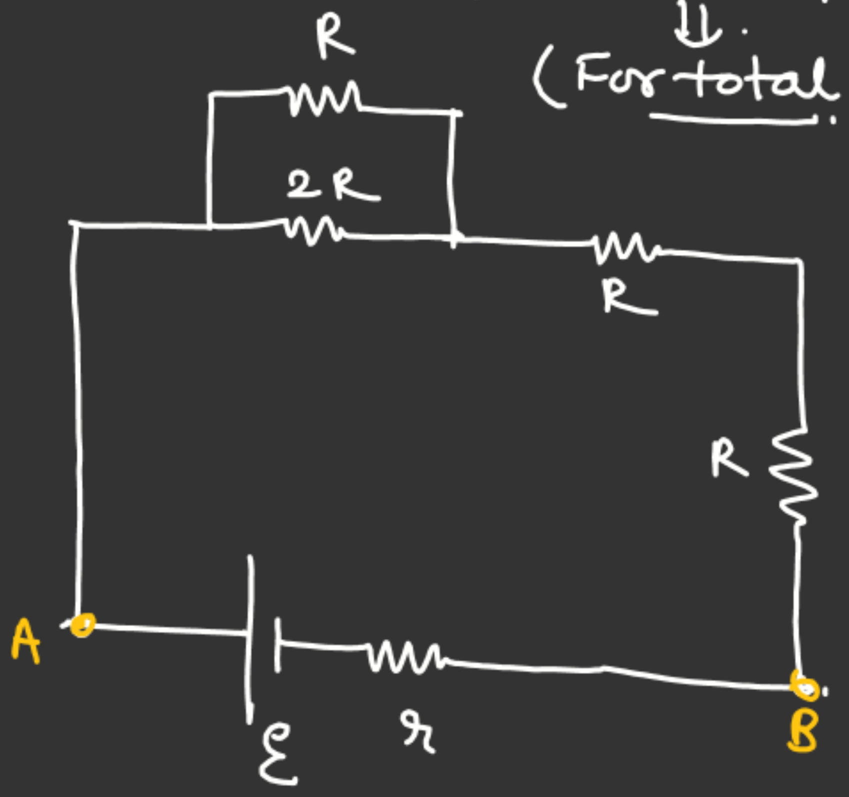


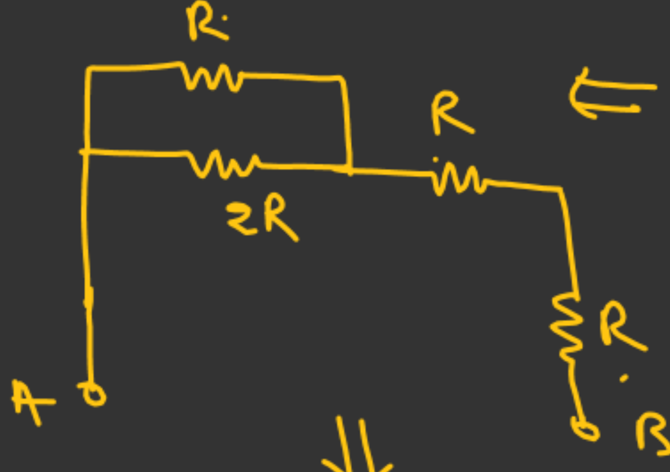
$\Rightarrow (R = r)$

\# Find R for (maximum power)

⇓

(For total ckt)

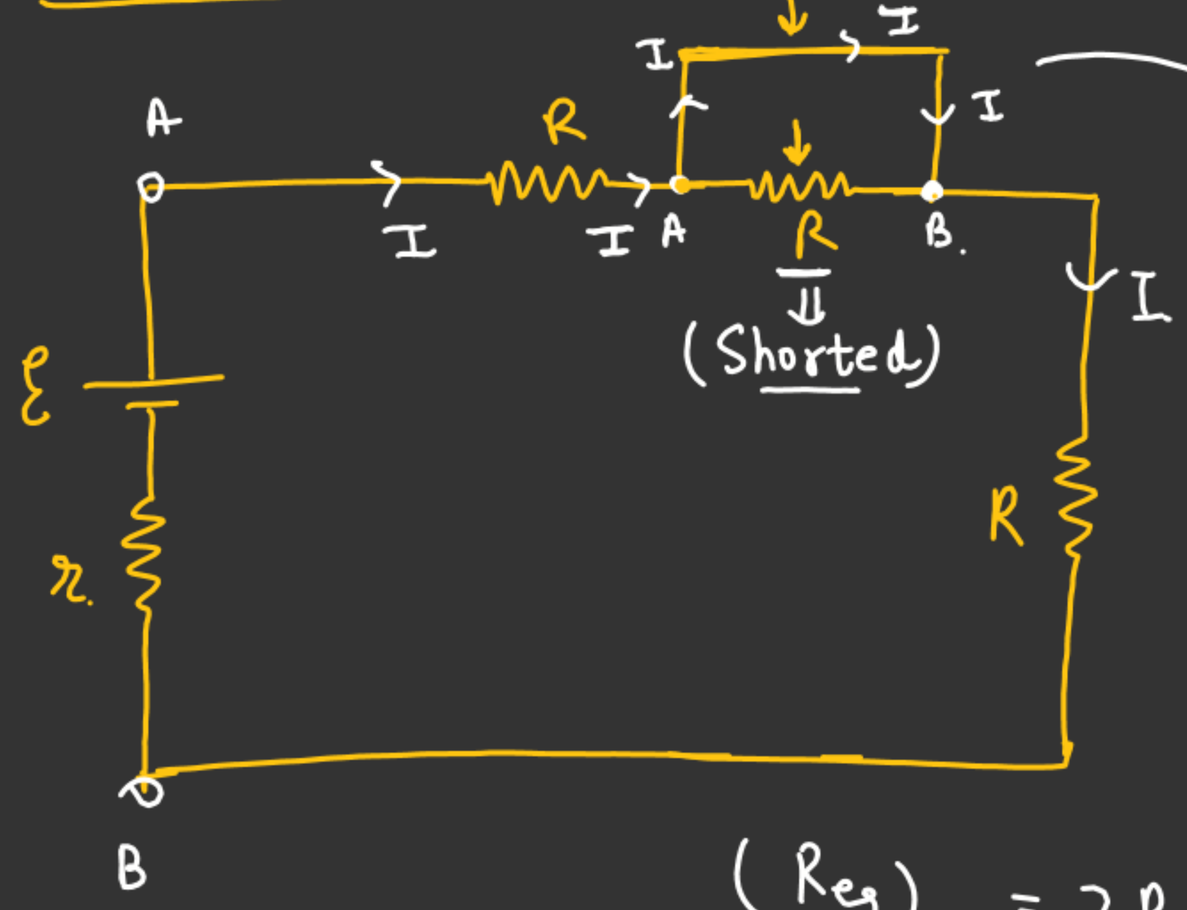




$$(R_{eq})_{AB} = \left(\frac{R \cdot 2R}{R+2R}\right) + 2R = \frac{2R}{3} + 2R = \left(\frac{8R}{3}\right) \checkmark$$

$$r = \frac{8R}{3} \Rightarrow R = \frac{3r}{8}$$

Q. Find 'R' for P_{max} (Zero resistance wire).



Shorting:-

↳ Current always prefer zero resistance path.

↳ $(V_A = V_B) \Rightarrow$ i.e no potential difference across the resistor. So $i = 0$.

$$(R_{eq})_{A-B} = 2R.$$

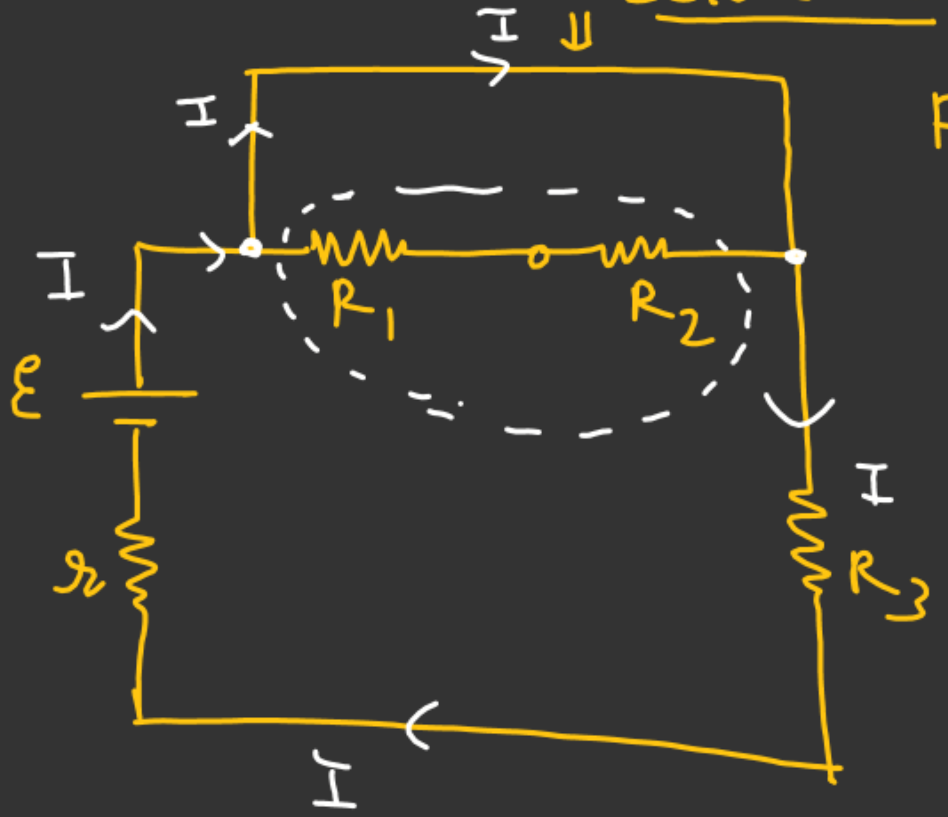
For P_{max}

$$(R_{eq})_{A-B} = r.$$

$$2R = r$$

$$\boxed{R = r/2}$$ ✓

\# Zero resitance



For P_{max}

$$\boxed{r = R_3}$$ ✓

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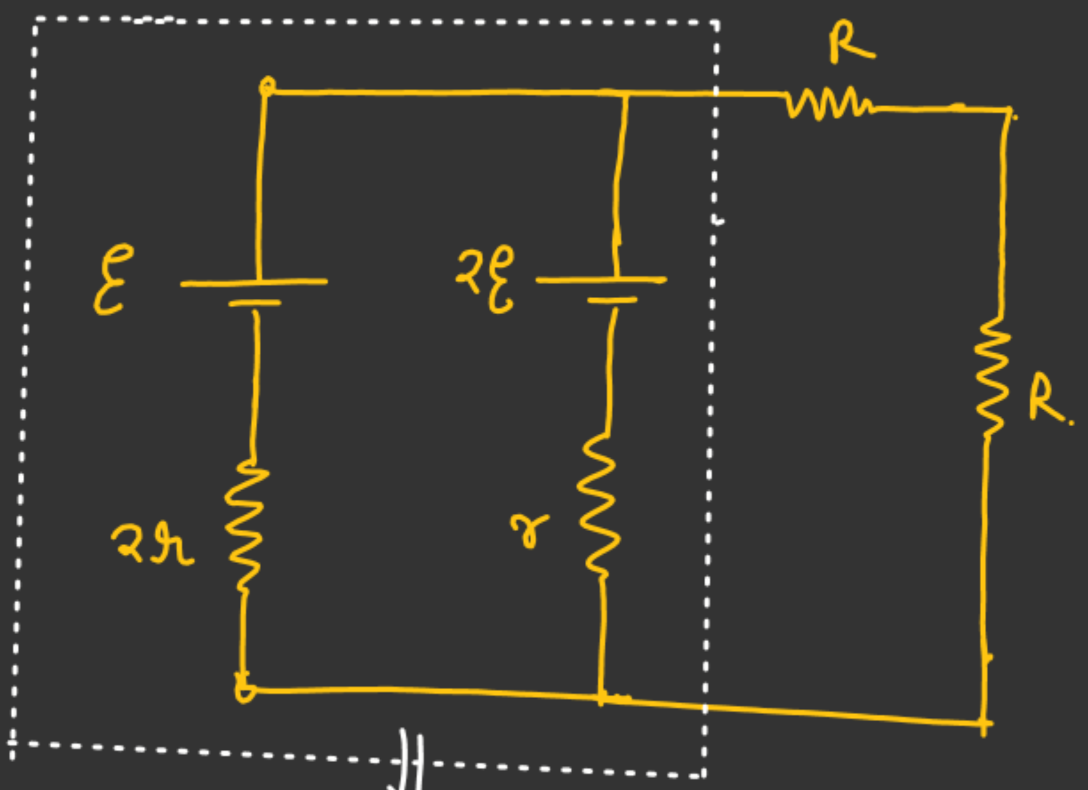
Find 'R' for $P_{max} = ??$

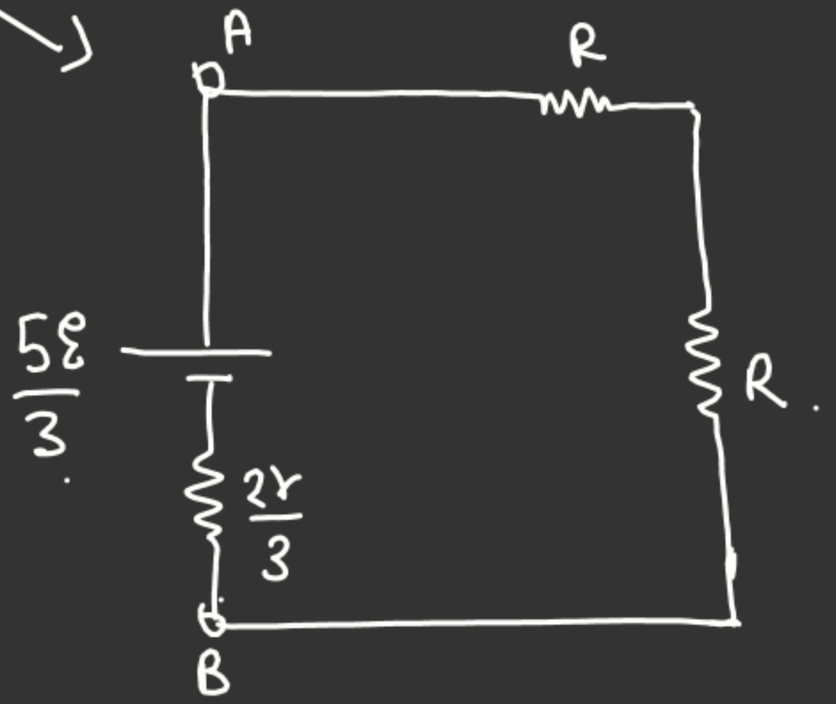


$$\frac{1}{r_{eq}} = \frac{1}{2r} + \frac{1}{r}$$

$$\frac{1}{r_{eq}} = \frac{1+2}{2r} = \frac{3}{2r}$$

$$r_{eq} = \left(\frac{2r}{3}\right)$$

$$\varepsilon_{eq} = \left(\frac{\frac{\varepsilon}{2r} + \frac{2\varepsilon}{r}}{\frac{1}{2r} + \frac{1}{r}}\right) = \frac{\frac{5\varepsilon}{2r}}{\left(\frac{3}{2r}\right)} = \left(\frac{5\varepsilon}{3}\right)$$



$$(R_{eq})_{AB} = 2R.$$

For P_{max}

$$2R = \frac{2r}{3}.$$

$$\boxed{R = \frac{r}{3}}$$

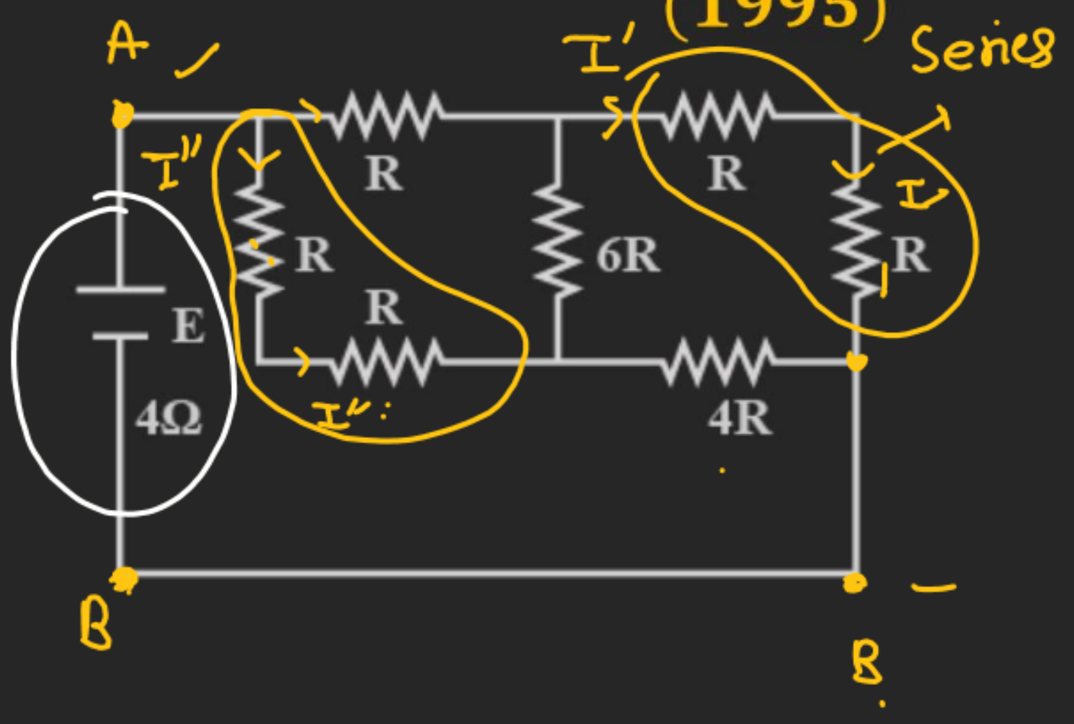
Q.1 A battery of internal resistance 4Ω is connected to the network of resistances as shown in the figure. In order that the maximum power can be delivered to the network, the value of R in Ω should be (1995)

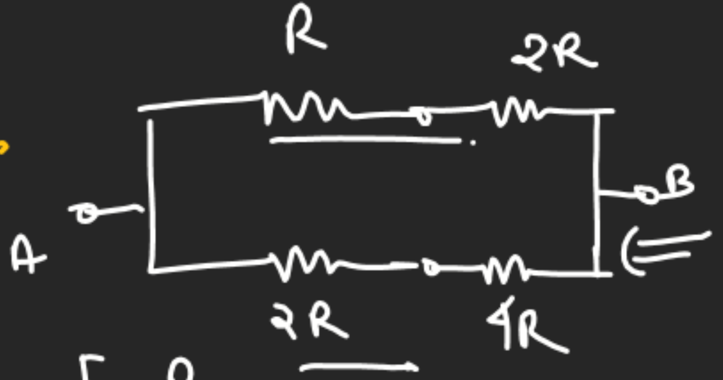
(A) $4/9$

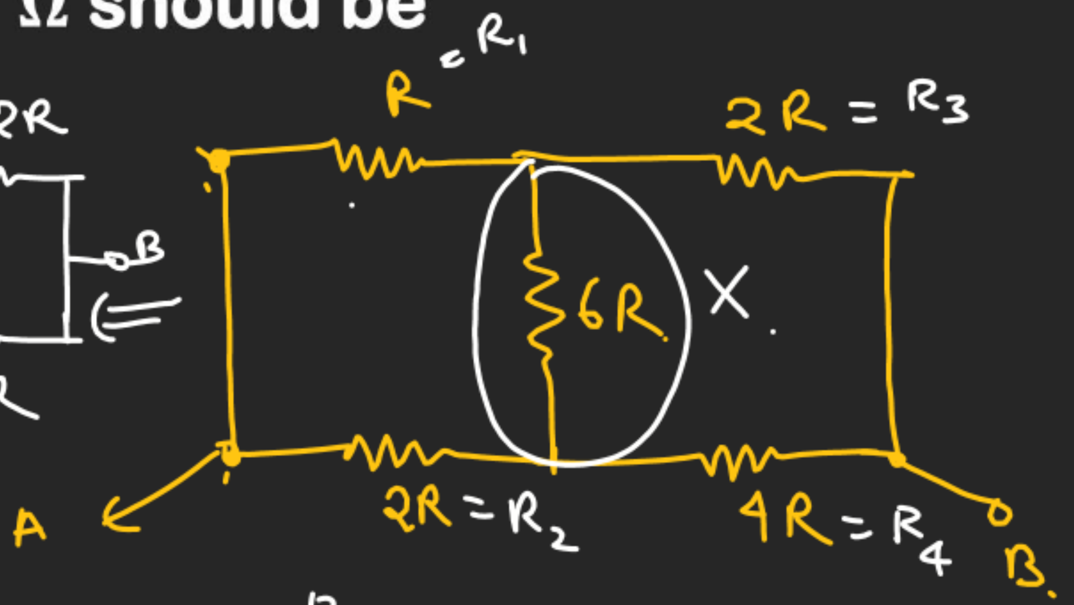
(B) 2

(C) $8/3$

(D) 18







For P_{max}

$(R_{eq})_{A-B} = 4$

$2R = 4$

$\boxed{R = 2}$

$\frac{R_1}{R_2} = \frac{1}{2}$, $\frac{R_3}{R_4} = \frac{1}{2}$

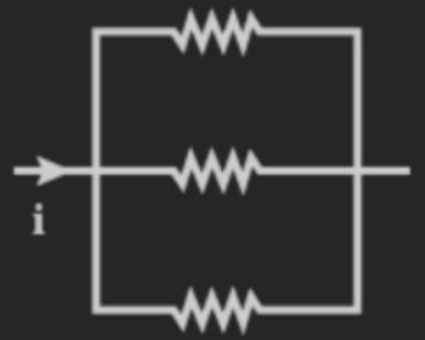
$$(R_{eq})_{A-B} = \frac{(3R)(6R)}{(3R+6R)} = \frac{18R^2}{9R} = 2R$$

Q.2 Three resistance of equal value are arranged in the different combinations as shown below. Arrange them in increasing order of power dissipation.

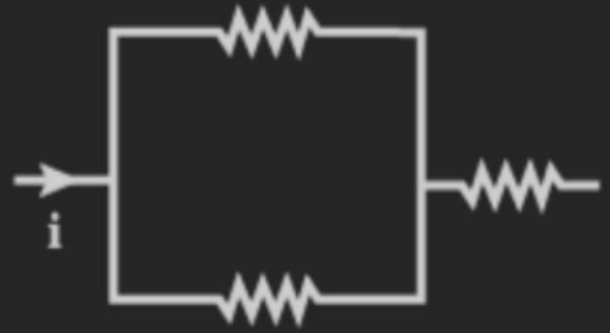
H.W

(I)

(II)



(III)



(IV)

Q.3 Six identical resistors are connected as shown in the figure. The equivalent resistance will be (2004)

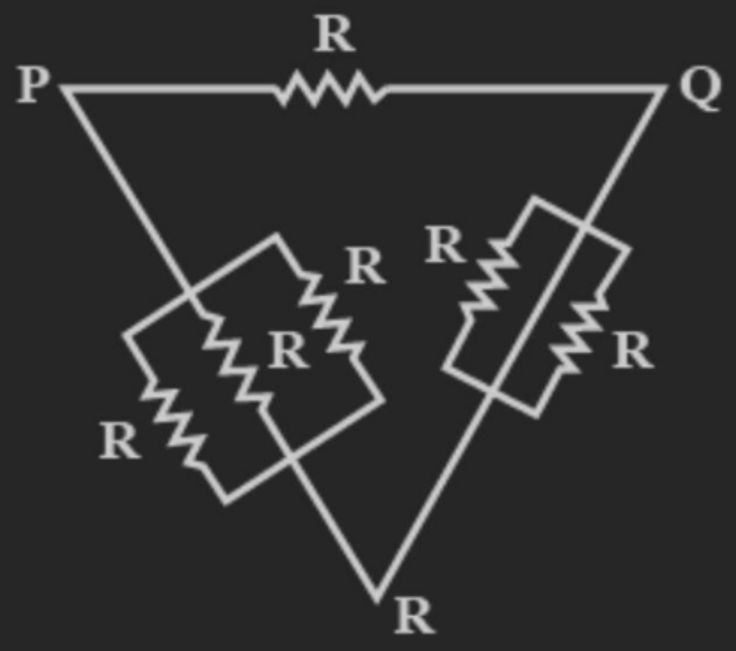
H.W

(A) maximum between P and R

(B) maximum between Q and R

(C) maximum between P and Q

(D) all are equal.



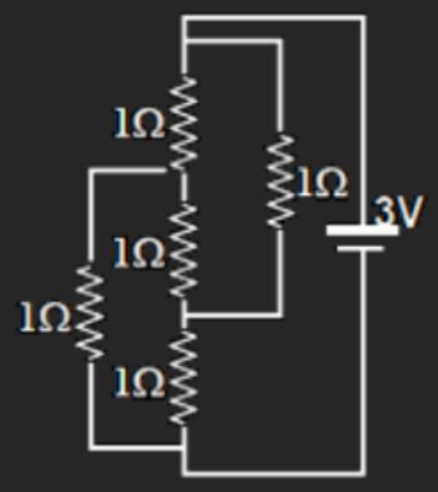
Q.4 H.W Figure shows three resistor configurations R_1 and R_2 and R_3 connected to $3\,V$ battery. If the power dissipated by the configuration R_1, R_2 and R_3 is P_1, P_2 and P_3 respectively, then **(2008)**

(A) $P_1 > P_2 > P_3$

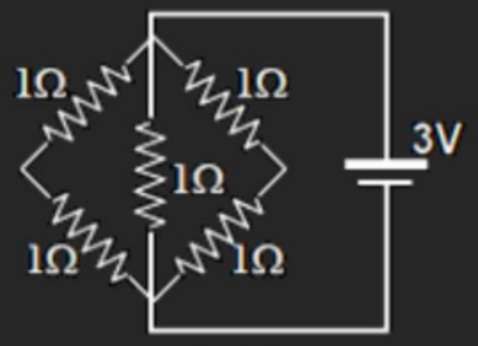
(B) $P_1 > P_3 > P_2$

(C) $P_2 > P_1 > P_3$

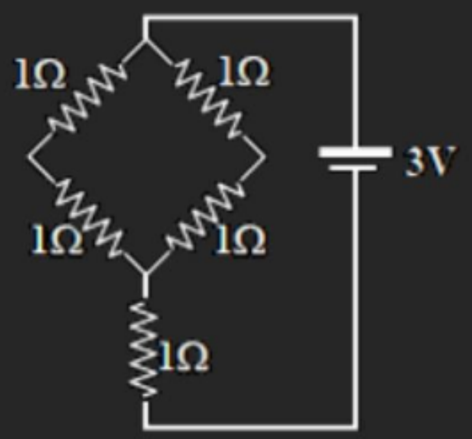
(D) $P_3 > P_2 > P_1$



R1



R2



R3

Q.5 In circuit-1 and circuit-2 shown in the figures, $R_1 = 1\Omega, R_2 = 2\Omega$ and $R_3 = 3\Omega$. P_1 and P_2 are the power dissipations in circuit-1 and circuit-2 when the switches S_1 and S_2 are in open conditions, respectively. Q_1 and Q_2 are the power dissipations in circuit-1 and circuit-2 when the switches S_1 and S_2 are in closed conditions, respectively. Which of the following statement(s) is(are) correct?

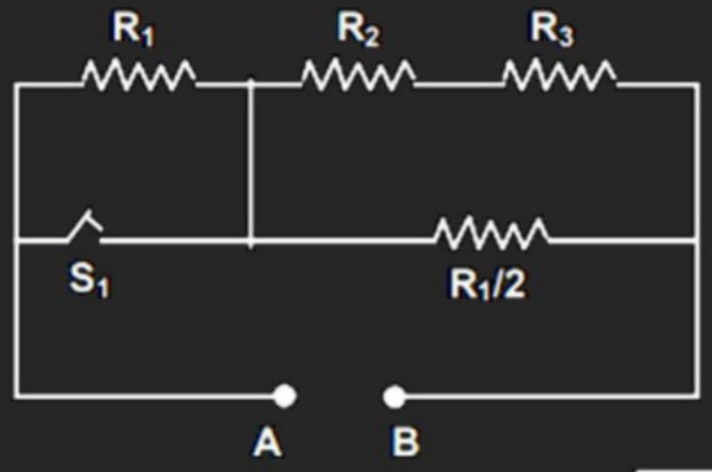
H.W

(A) When a voltage source of $6\ \mathrm{V}$ is connected across A and B in both circuits, $P_1 < P_2$.

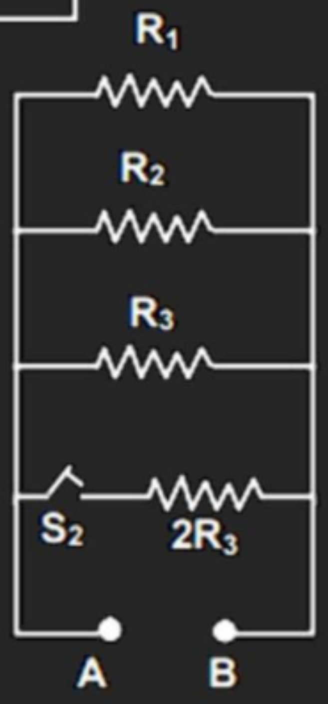
(B) When a constant current source of $2\mathrm{amp}$ is connected across A and B in both circuits, $P_1 > P_2$

(C) When a voltage source of $6\ \mathrm{V}$ is connected across A and B in Circuit-1, $Q_1 > P_1$.

(D) When a constant current source of 2 amp is connected across A and B in both circuits, $Q_2 < Q_1$.



Circuit-1



Circuit-2

(2022)