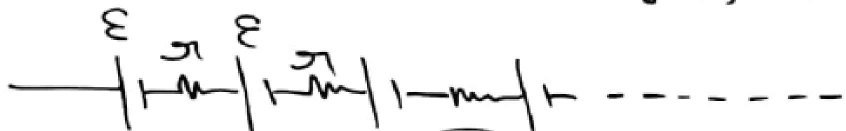
# Series Connection of battery :-

# n- cell are connected in series with polarity.




n cell

$\varepsilon_{net} = n\varepsilon$

$r_{net} = nr$

$\varepsilon_{net} = 6\varepsilon - 2\varepsilon$

$= (6-2)\varepsilon = 4\times 5$

$= 20\,Volt$

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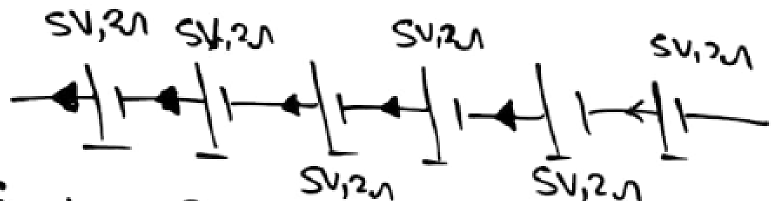


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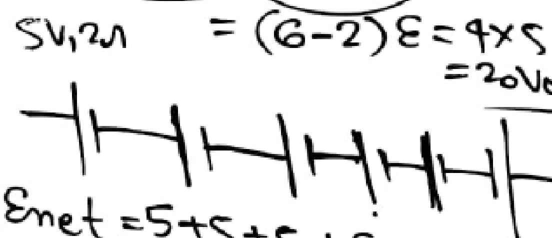
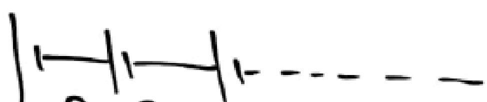



$\varepsilon_{net} =$ $\varepsilon_{net} = 6\times 5 = 30\,Volt$

$\varepsilon_{net} = 5+5+5+5+5-5$

$= 20\,Volt$

≡ 

n cell → m- cell reverse.

$\varepsilon_{net} = n\varepsilon$

$\varepsilon_{net} = n\varepsilon - 2m\varepsilon = (n-2m)\varepsilon$

# Series Connection of battery-1

⇒ 20 cell each of Emf 10 Volt & internal resistance 2Ω connected in series. (a) find Enet & rnet.

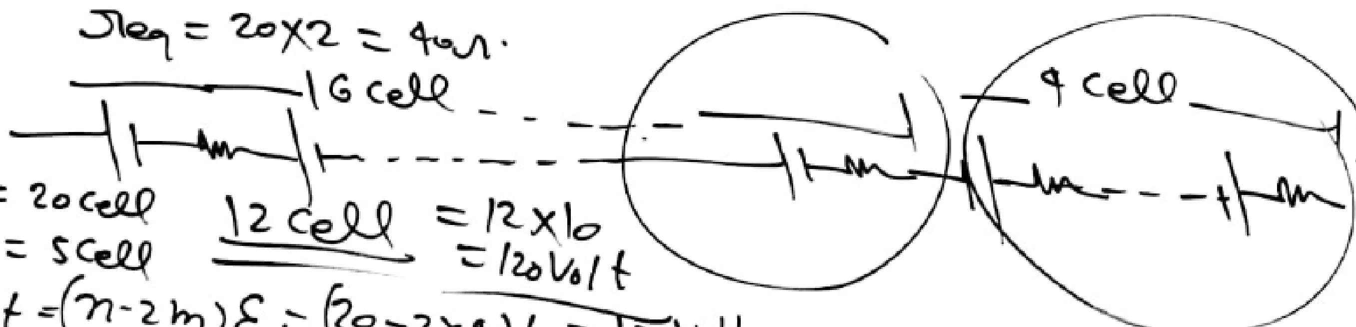
(b) If 4 cell is connect opposite polarity in out of 20 then find (a) net Emf of Combination of cell, & rnet.

Sol) (a)


$\varepsilon_{net} = 20 \times 10 = 200$ Volt

$r_{eq} = 20 \times 2 = 40\Omega$.

(b)




$n = 20$ cell

$m = 5$ cell

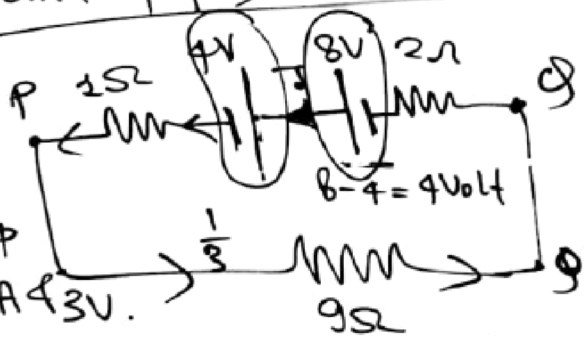
12 cell $= 12 \times 10 = 120$ Volt

$\varepsilon_{net} = (n - 2m)\varepsilon = (20 - 2 \times 4)10 = 120$ Volt

# Series Connection of battery :

AIPMT

Q) Two batteries of Emf 4V & 8V with internal resistance 1Ω & 2Ω are connected in a ckt with resistance of 9Ω as shown in figure. The current & potential difference b/w the point P & Q are.




(a) $\frac{1}{3}$A & 3V.

(b) $\frac{1}{6}$A & 4V.

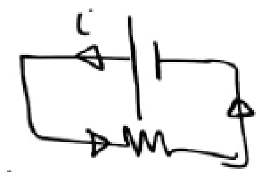
(c) $\frac{1}{9}$A & 9V.

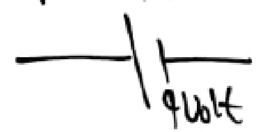
(d) $\frac{1}{12}$A & 12V.

$E_{net} = 8 - 4 = 4$ Volt

$R_{eq} = 12\,\Omega$

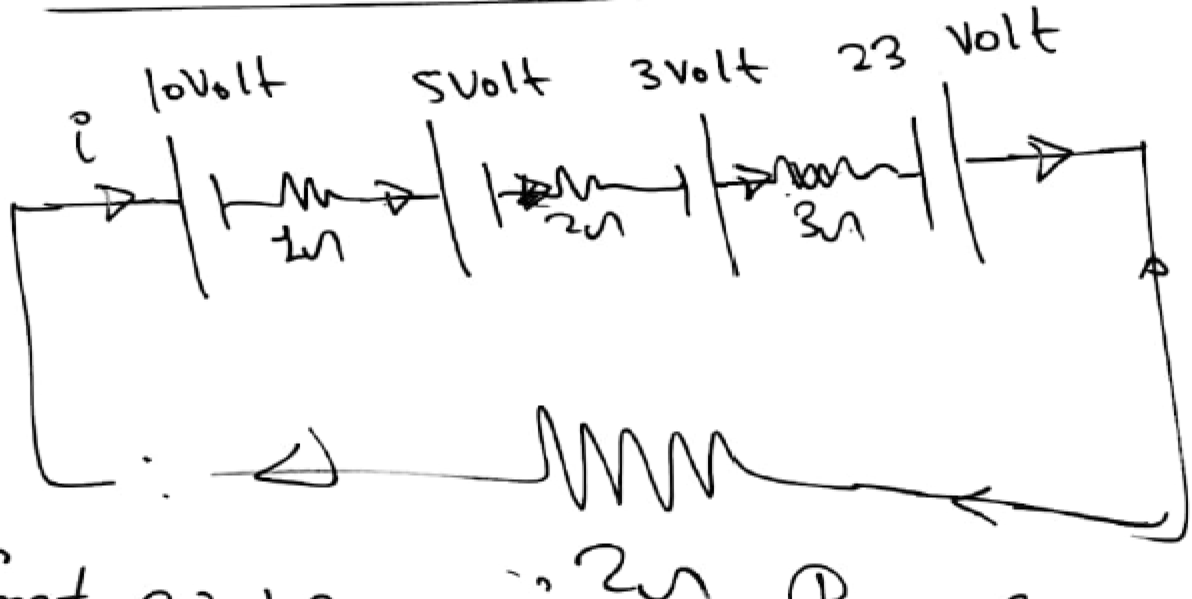
$i = \frac{E_{net}}{R_{net}} = \frac{4}{12} = \frac{1}{3}$ Amp




$V_P - V_Q = \frac{1}{3} \times 9 = 3$ Volt

# Series connection of battery :-



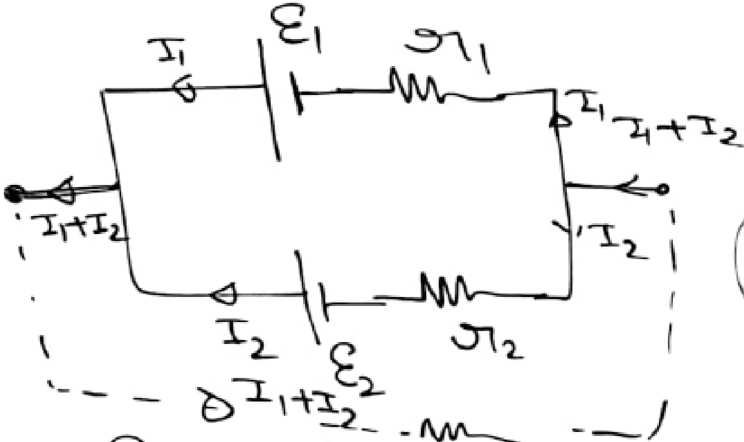

$$E_{net} = 23 + 3 - 5 - 10$$

$$R_{eq} = 8\,\Omega$$

$$E_{net} = 11\ \text{Volt}$$

$$i = \frac{E_{net}}{R_{eq}} = \frac{11}{8}\ \text{Amp}$$

# Parallel Connection




$r_{eq} = ?$

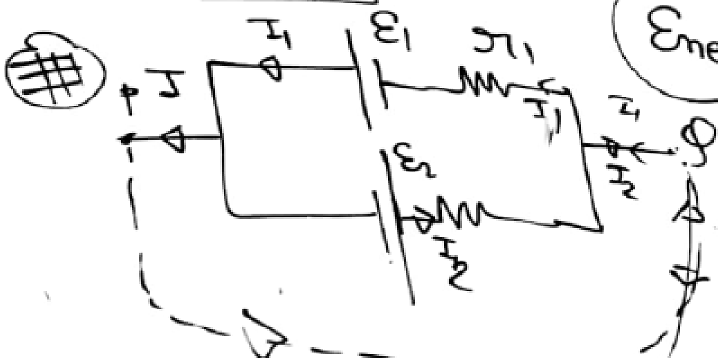
$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} \Rightarrow r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

$$\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

$\Rightarrow$ $\varepsilon_{net} = ?$

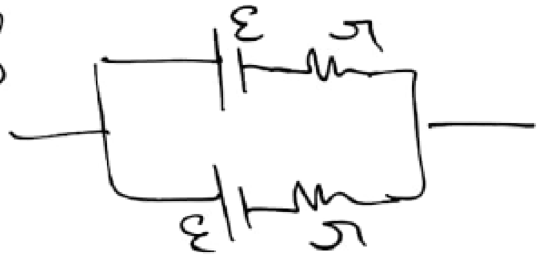
$$\varepsilon_{net} = \frac{\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 r_2}}{\frac{r_2 + r_1}{r_1 r_2}} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$$

$$\varepsilon_{net} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$$




$$\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{\varepsilon_1 r_1 - \varepsilon_2 r_2}{r_1 + r_2}$$

# Parallel Connection

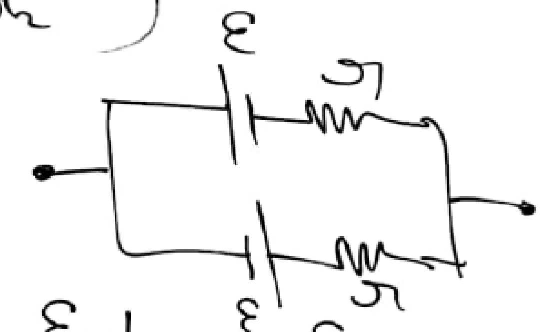



$\equiv$


$$\Rightarrow \varepsilon_{net} = \frac{\varepsilon r + \varepsilon r}{r + r} \quad \left[ \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \right]$$

$$\varepsilon_{net} = \frac{2\varepsilon r}{2r} = \varepsilon$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} \Rightarrow r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$




$$\varepsilon_{net} = \frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2} = 0$$

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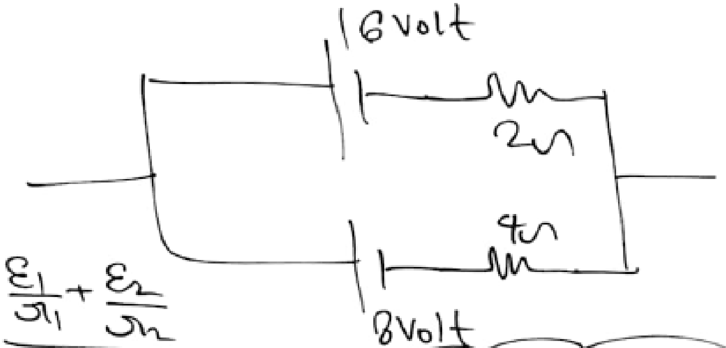


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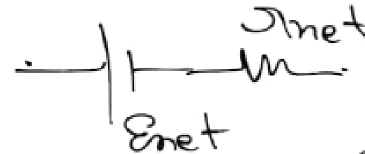



$\varepsilon_1 = 16$ Volt $\quad r_1 = 2\Omega$

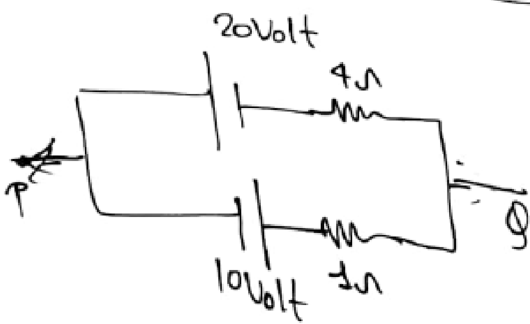
$\varepsilon_2 = 8$ Volt $\quad r_2 = 4\Omega$

$$\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

$$\varepsilon_{net} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{16 \times 4 + 8 \times 2}{6} = \frac{64 + 16}{6} = \frac{80}{6}$$

$$= \frac{40}{3} = \underline{13.33 \text{ Volt}}$$

Q2)




= $\underline{\varepsilon_{net}}$ & $\underline{r_{net}}$

$\varepsilon_1 = 20\,\text{Volt}$ $\quad$ $\varepsilon_2 = -10\,\text{Volt}$

$r_1 = 4\Omega$ $\quad$ $r_2 = 1\Omega$

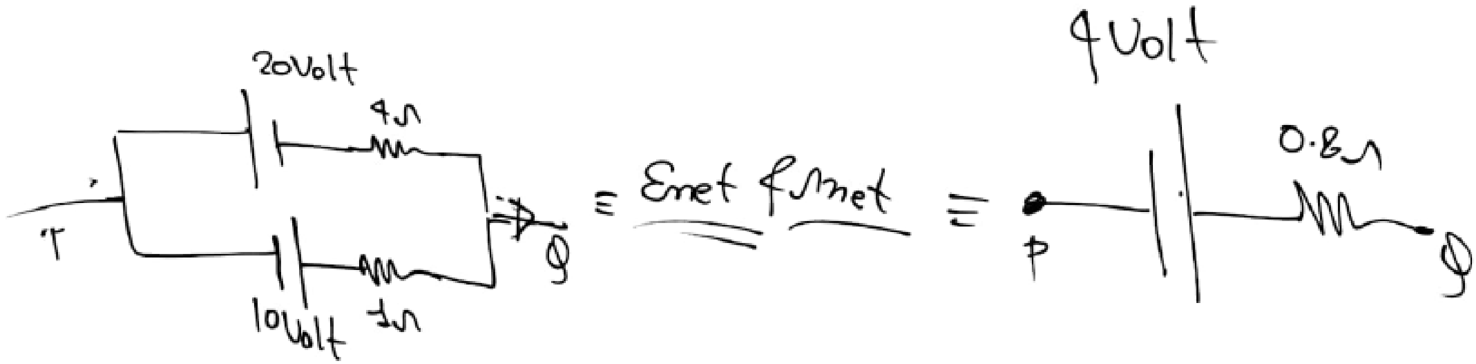
$$\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \varepsilon_{net}$$

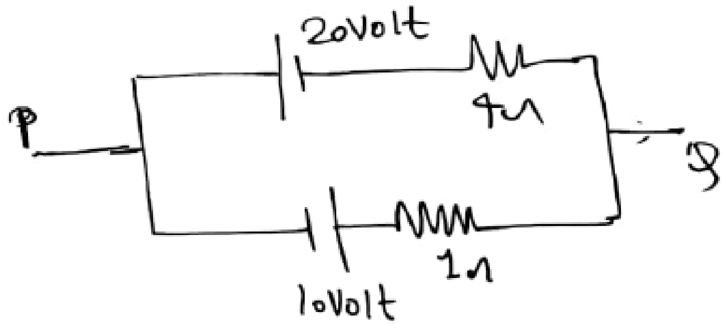
$$\frac{20 \times 1 + (-10) \times 4}{4+1} = \frac{20-40}{5}$$

$$= \frac{-20}{5} = -4\,\text{Volt}$$

$$\left(R_{eq} = \frac{4 \times 1}{4+1} = \frac{4}{5} = 0.8\Omega\right.$$

Q2)






Let current flow from P to Q.

$\varepsilon_1 = 20\text{Volt}$ $\quad r_1 = 4\Omega$

$\varepsilon_2 = -10\text{Volt}$ $\quad r_2 = 1\Omega$

Q2)

$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{20\times1 - 10\times4}{5}$$

$$\varepsilon_{net} = -4\text{Volt}$$

let dirn of current from Q to P

$\varepsilon_1 = -20$ $\quad r_1 = 4\Omega$

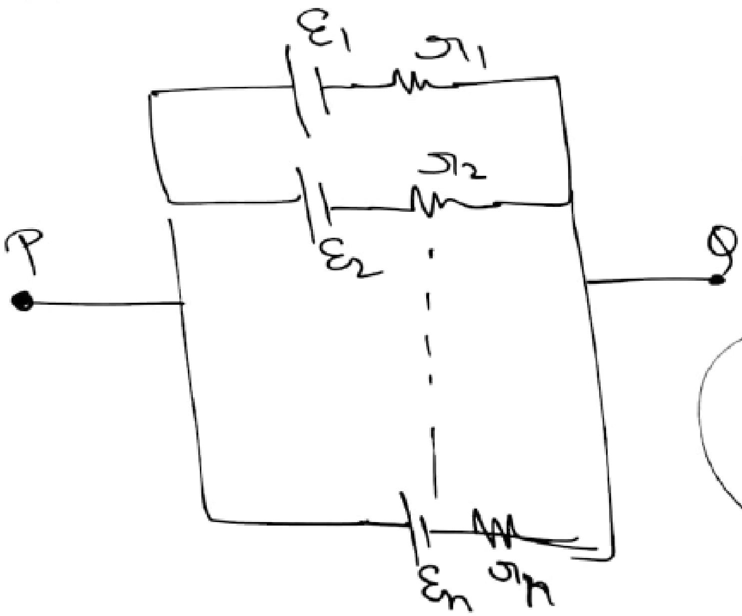
$\varepsilon_2 = 10\text{Volt}$ $\quad r_2 = 1\Omega$

$$\Rightarrow \varepsilon_{net} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$$

$$= \frac{-20\times1 + 10\times4}{4+1}$$

$$= \frac{+20}{5} = 4\text{Volt}$$

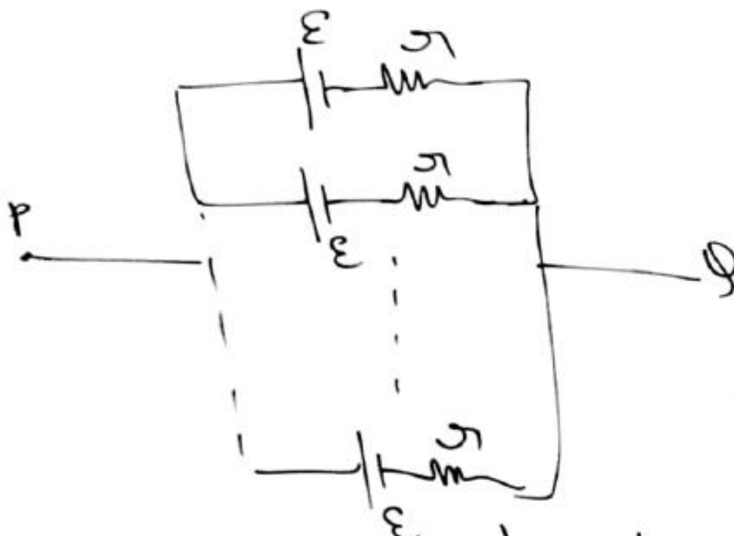
# n- Cell Connected with parallel Combination for same polarity.

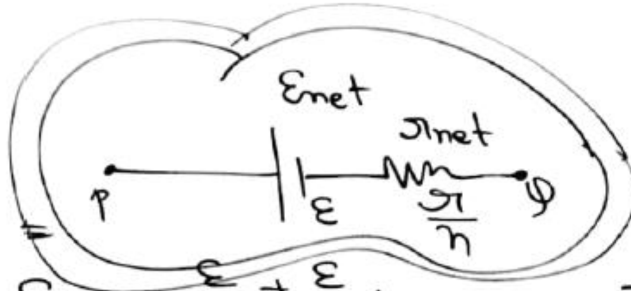



$$\mathcal{E}_{net} = \frac{\frac{\mathcal{E}_1}{r_1} + \frac{\mathcal{E}_2}{r_2} + \cdots + \frac{\mathcal{E}_n}{r_n}}{\frac{1}{r_1} + \frac{1}{r_2} + \cdots + \frac{\mathcal{E}_n}{r_n}}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \cdots + \frac{1}{r_n}$$

# If n- cell have same Emf & same internal resistance. find Equivalent Emf & Equivalent resistance.




$$E_{net} = \frac{\frac{E}{r}+\frac{E}{r}+ - - - - + \frac{E}{r}}{\frac{1}{r}+\frac{1}{r}+\frac{1}{r}+ - - - - + \frac{1}{r}}$$

$$E_{net} = \frac{\frac{nE}{r}}{\frac{n}{r}} = E_{net}$$

$$\frac{1}{r_{eq}} = \frac{1}{r}+\frac{1}{r}+ - - - \text{ n time}$$

$$\frac{1}{r_{eq}} = \frac{n}{r} \quad \therefore \quad r_{eq} = \frac{r}{n}$$