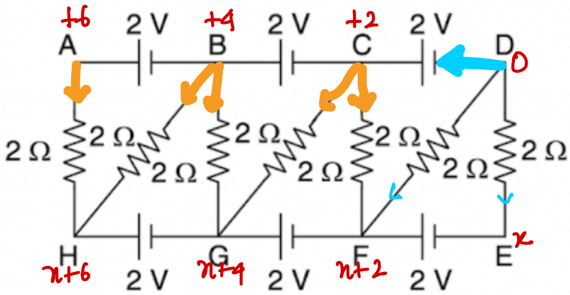
In given circuit, 7 resistors 2 Ω each and 6 batteries of 2 V each, are joined together.



The current through branch BG is:

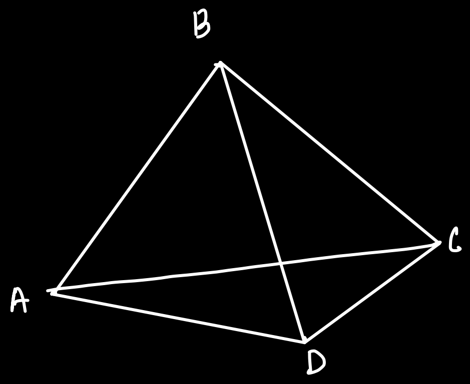
(*a*) 1 A (*b*) 0.2 A

(*c*) 0.4 A (*d*) 0.6 A

At D $\quad \frac{0-x}{2} + \frac{0-(x+2)}{2} + \frac{-x}{2} - \frac{(x+2)}{2} - \frac{x}{2} - \frac{(x+2)}{2} - \frac{x}{2} = 0$

$x = -\frac{6}{7}$

Problems related to Symmetry in circuits

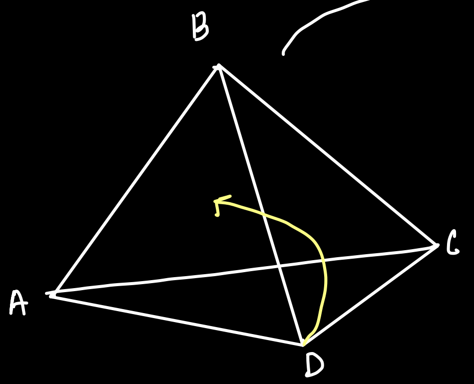


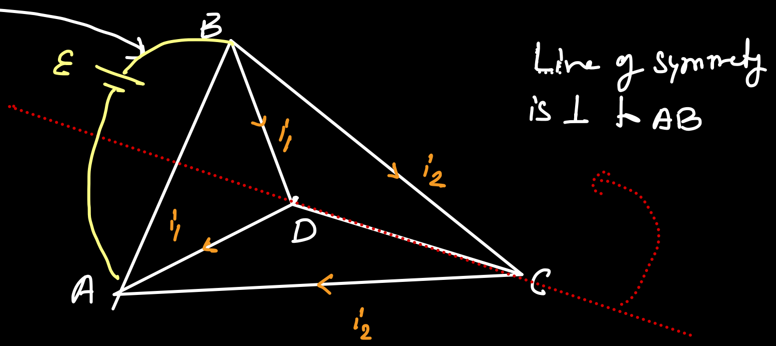
Each side has a resistance R

Find the equivalent resistance across A & B

method 1

flatten it



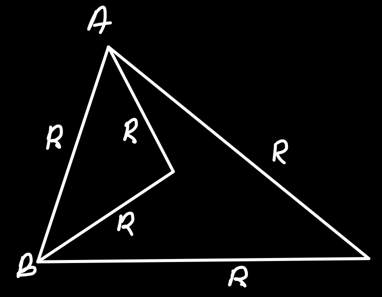


Line of symmetry is ⊥ to AB

By symmetry $\quad i_{BD} = i_{DA} \Rightarrow i_{CD} = 0$

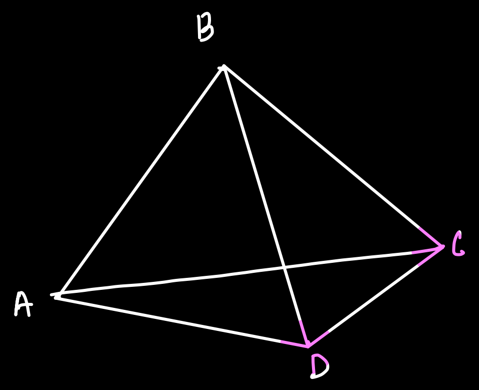
$i_{BC} = i_{CA}$

we can remove CD



$R_{eq} = \frac{R}{2}$

method 2 — Method of equipotential points



paths of C & D to A are identical

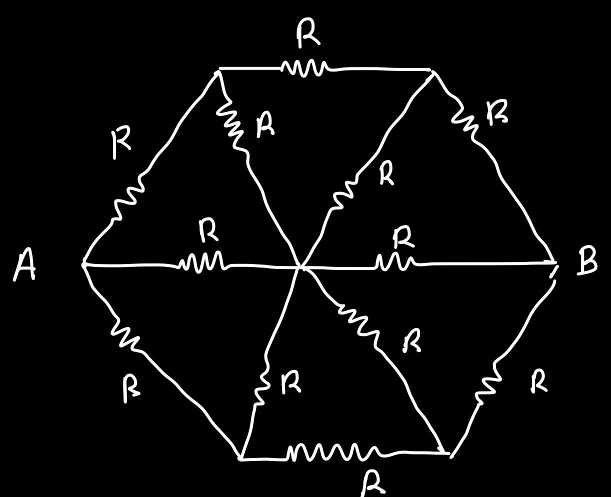
&

paths of C & D to B are identical

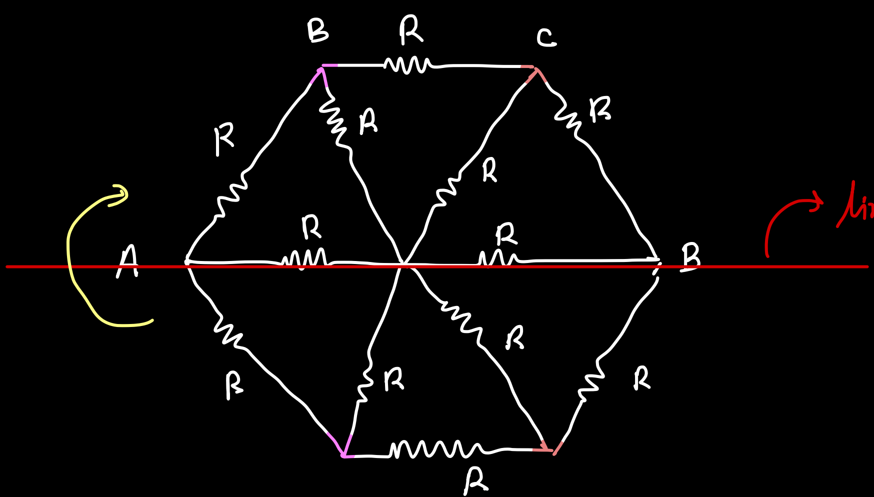
$\Downarrow$

C & D are at same potential

Ex



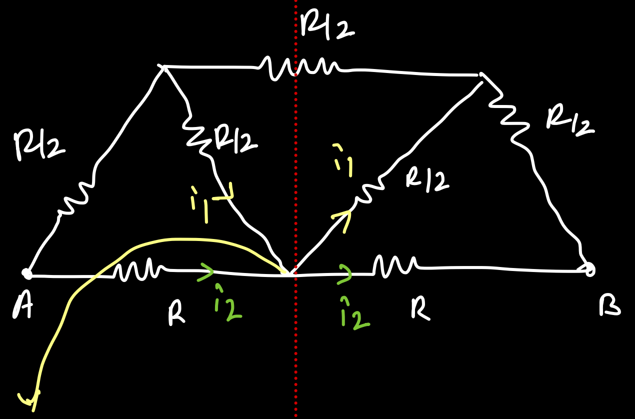
Find eq. resistance about AB



line of symmetry passes through AB

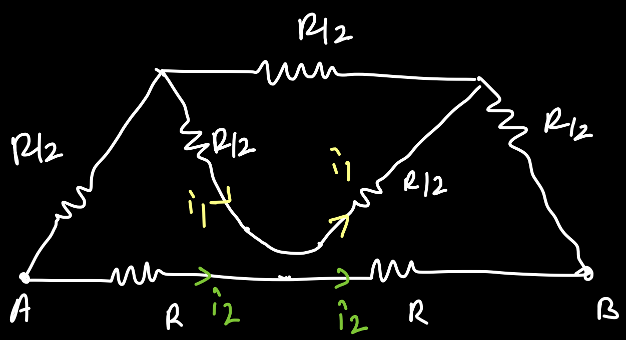
FOLDING SYMMETRY

After folding



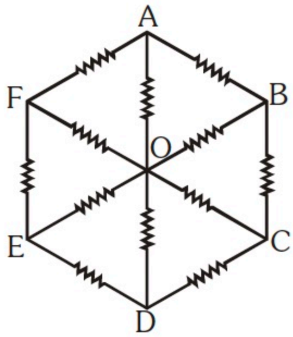
Junction can be removed

line of symmetry ⊥ to AB



$$R_{eq} = \frac{4R}{5}$$

Twelve wires of equal resistance R are placed in a given arrangement as shown in figure. Then find



2. Equivalent resistance between A & B is

(A) $\frac{11R}{20}$ (B) $\frac{10R}{20}$ (C) $\frac{R}{20}$ (D) $\frac{3R}{2}$

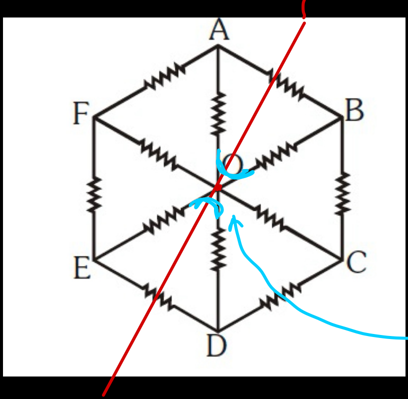
3. Equivalent resistance between A & C is

(A) $\frac{3R}{4}$ (B) $\frac{R}{4}$ (C) $\frac{5R}{6}$ (D) $\frac{3R}{5}$

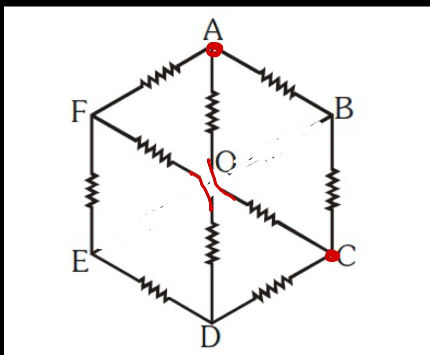
4. Equivalent resistance between A & O is

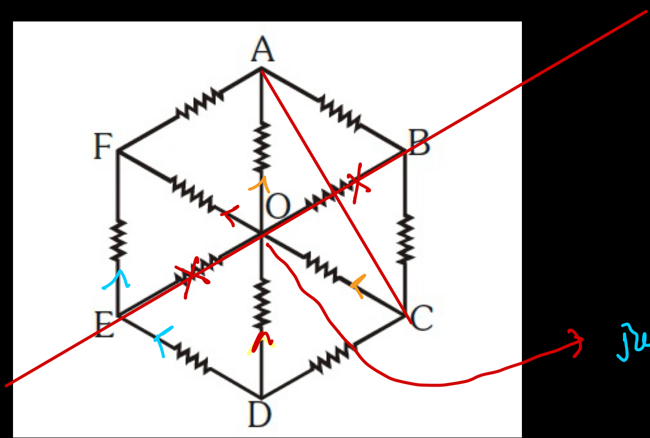
(A) $\frac{19R}{41}$ (B) $\frac{20R}{41}$ (C) $\frac{18R}{23}$ (D) $\frac{9R}{20}$

line of symmetry $\perp$ to AB

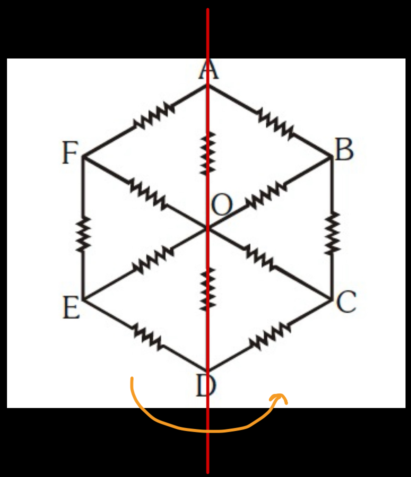


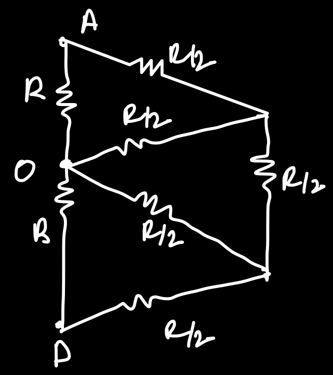
these junctions can be disconnected





junction can be disconnected

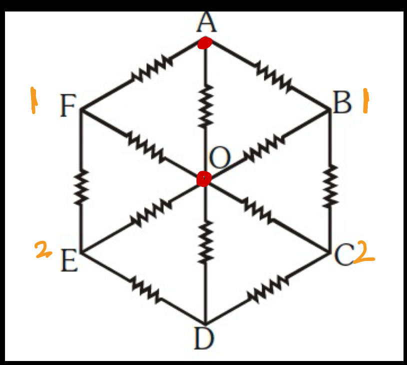


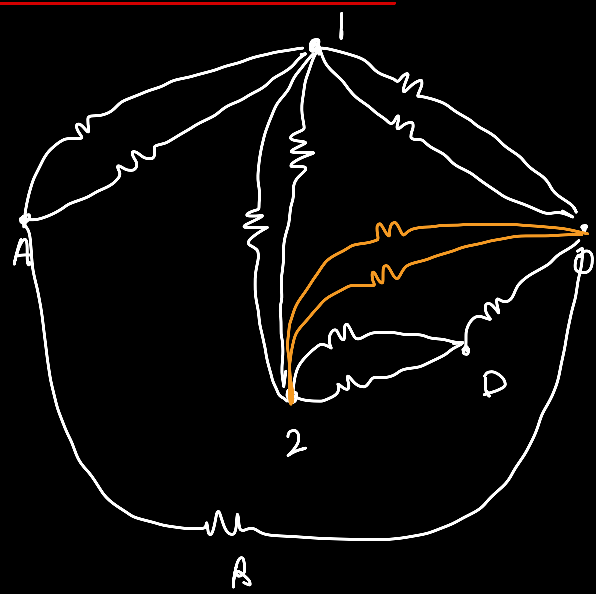


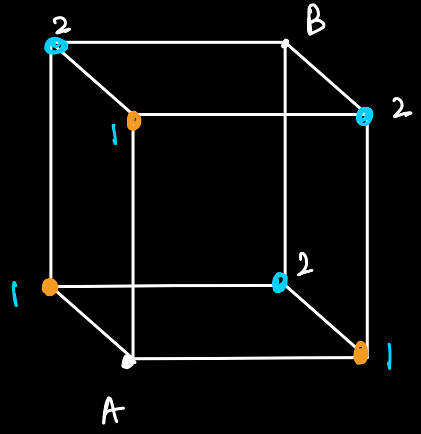
line of symmetry pass through

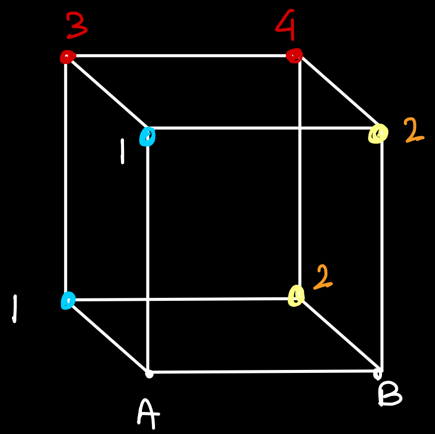
A to D folding symmetry

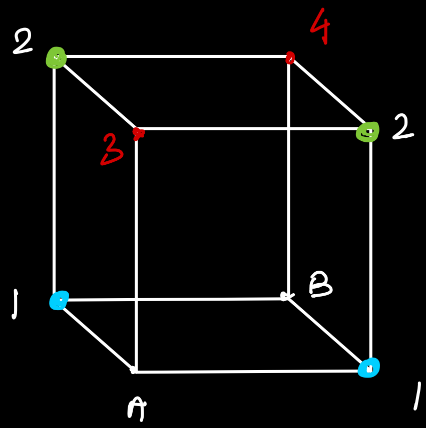
method of equipotentials / redrawing the circuit

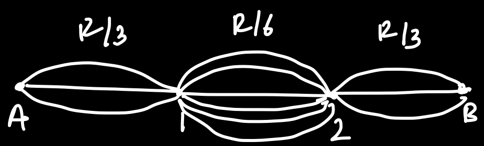




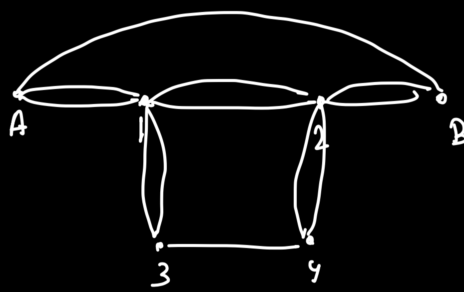




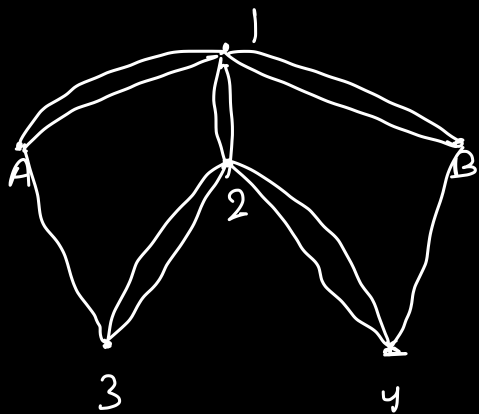




$R_{eq} = \frac{5R}{6}$



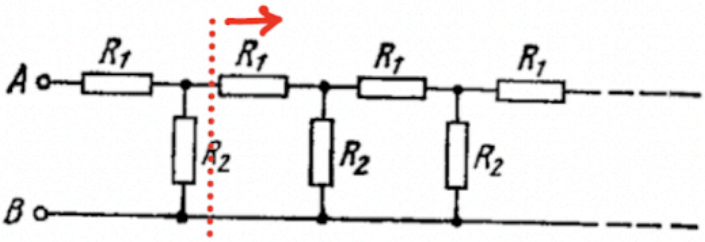
$R_{eq} = \frac{7R}{12}$



$R_{eq} = \frac{3R}{4}$

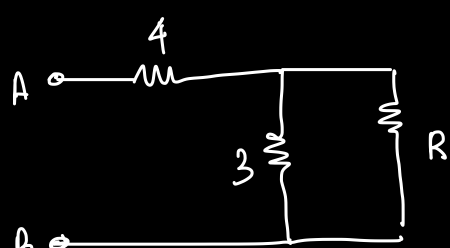
Infinite ladder circuits

3.152. Fig. 3.37 shows an infinite circuit formed by the repetition of the same link, consisting of resistance $R_1 = 4.0\,\Omega$ and $R_2 = 3.0\,\Omega$. Find the resistance of this circuit between points A and B.

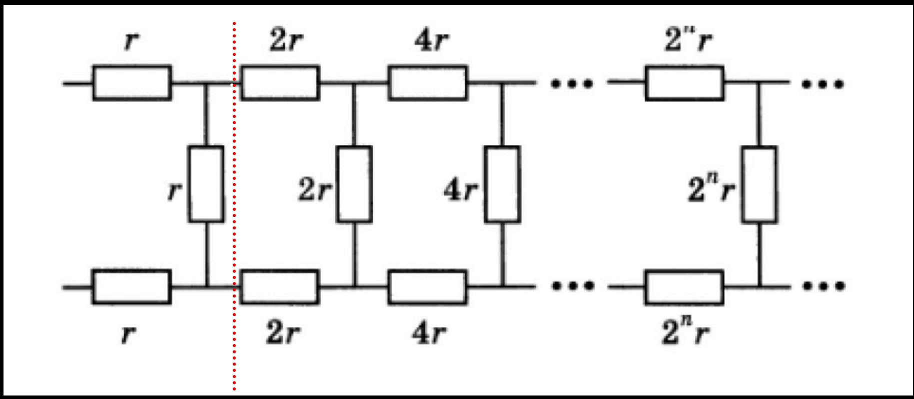


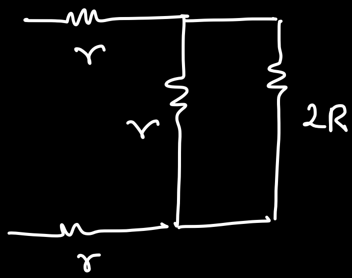
Ans: $6\,\Omega$

If equivalent resistance is R



$$\frac{3R}{3+R} + 4 = R$$





$$\frac{2R\,r}{2R+r} + 2r = R$$

HW

19. Find equivalent resistance between the terminals A and B of the following infinite ladder networks.

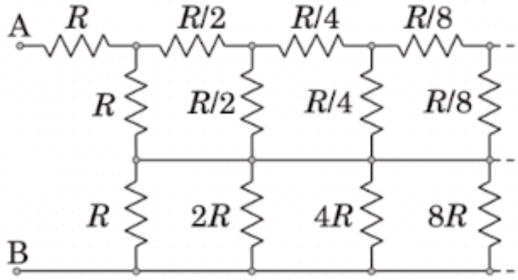


Figure-I

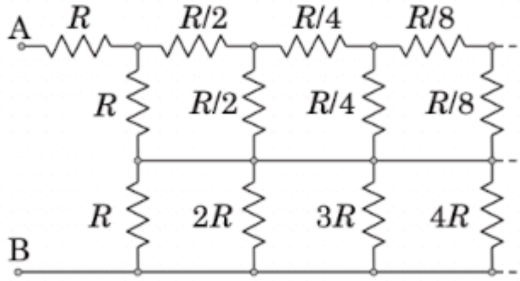
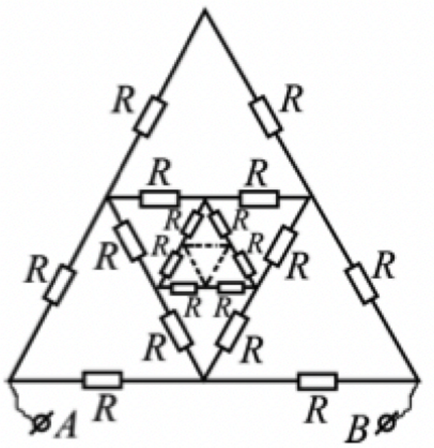
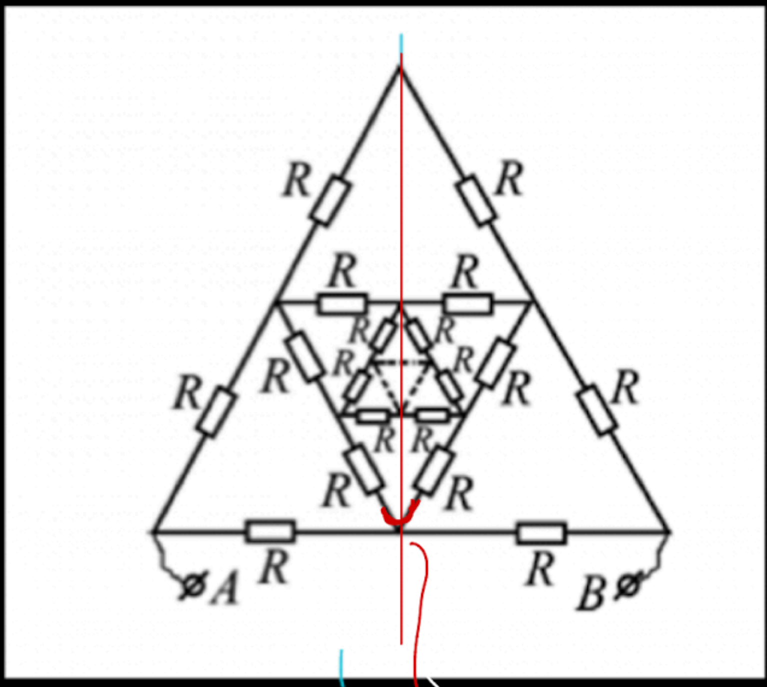


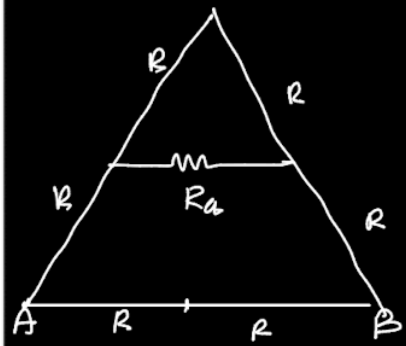
Figure-II

"**PROBLEM 71.** (*MOSH, 2010, 10*) Find the resistance between terminals A and B of the infinite circuit shown in the figure. The resistance of each resistor is equal to R."





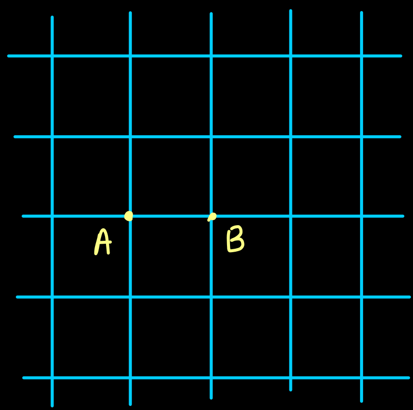
node can be detached

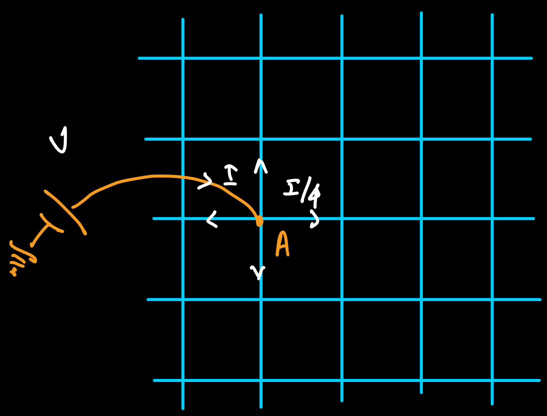


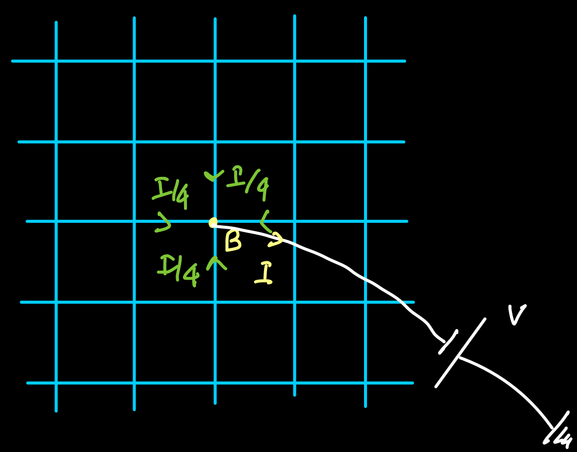
$R_{eq} = \frac{2R}{\sqrt{3}}$

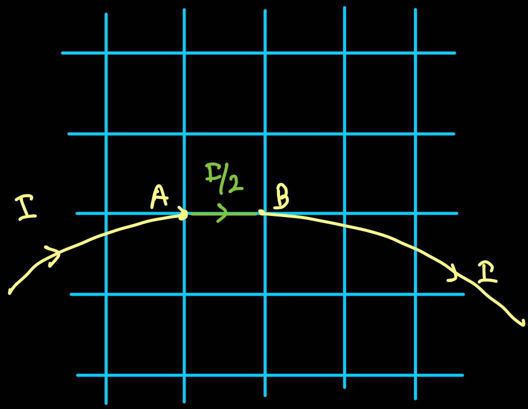
Infinite grid circuits

Find R_{eq}



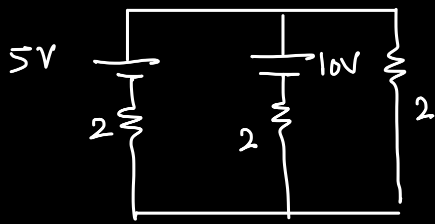


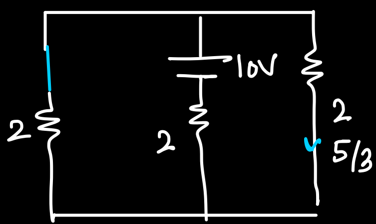


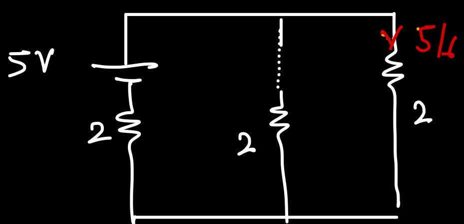


$$\Delta V_{A\to B} = I R_{eq} = \frac{I}{2} R \qquad \boxed{R_{eq} = \frac{R}{2}}$$

Elementary example of superposition

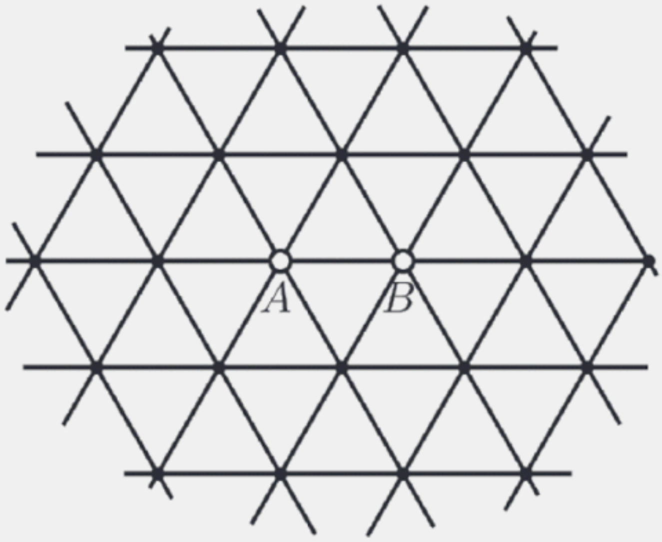






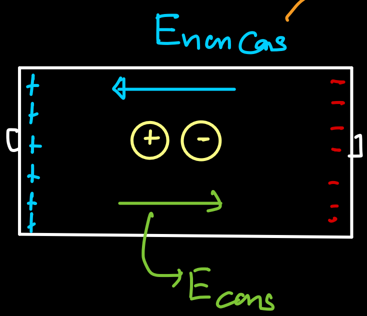
find current by each source individually and then superimpose the current to get the current as $\frac{5}{2}$ A

pr 31. Determine the resistance between two neigbouring nodes in an infinite triangular lattice, as shown in the figure below. The resistance of the wire connecting any two neighbouring nodes is 1 Ω. *Instructions:* Let C be a node that is infinitely far from nodes A and B. Now consider the currents flowing between these nodes.



Ans : R/3

Batteries / cells



Electric field non-electrostatic in origin drives the ions towards respective electrodes

Emf of battery : Work done per unit charge by non conservative electric field in moving the charge from one electrode to other

$$\mathcal{E} = \int \vec{E}_{non\,Cons} \cdot \vec{dl}$$

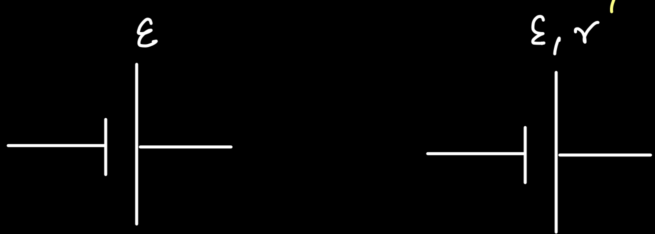
potential difference across a battery

$$\Delta V = -\int \vec{E}_{Cons} \cdot \vec{dl}$$

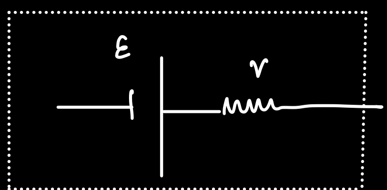
For ideal battery

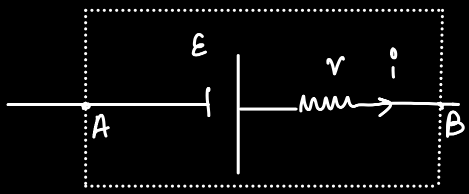
$$\boxed{\mathcal{E} = \Delta V}$$

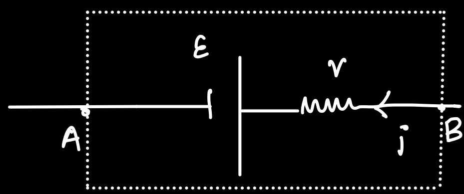
Non ideal battery



internal resistance







$$V_A + \varepsilon - iR = V_B$$

$$\boxed{V_B - V_A = \varepsilon - iR}$$

Battery is supplying energy to circuit

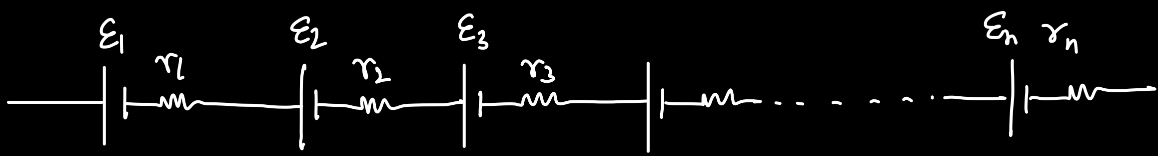
$$V_A + \varepsilon + iR = V_B$$

$$\boxed{V_B - V_A = \varepsilon + iR}$$

Battery is absorbs energy from circuit

Combination of batteries

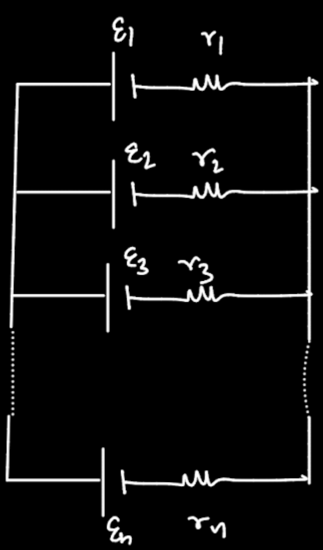
Series



$$\varepsilon_{eq} = \sum \varepsilon_i$$

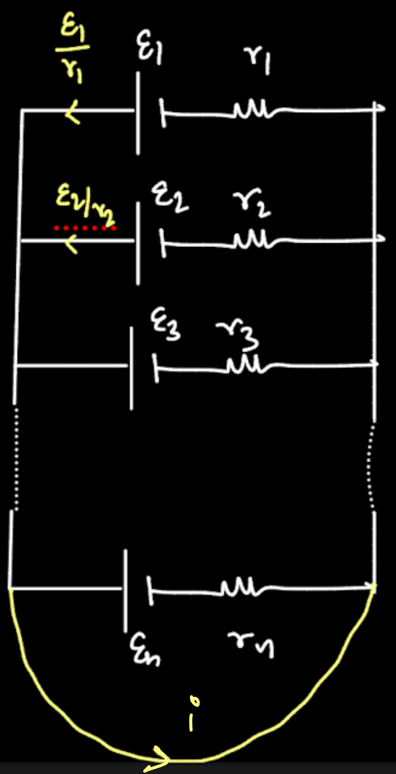
$$r_{eq} = \sum r_i$$

Parallel



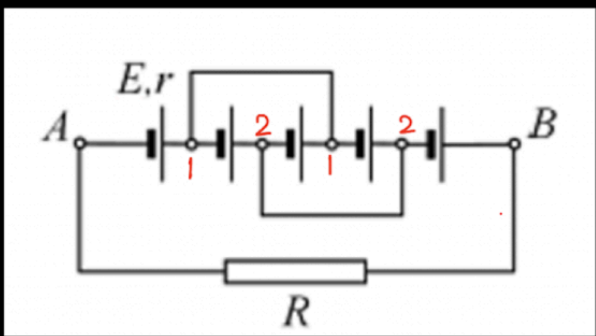
$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \cdots + \frac{\varepsilon_n}{r_n}}{\frac{1}{r_1} + \frac{1}{r_2} + \cdots + \frac{1}{r_n}}$$

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



$$i = \frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \dots + \frac{\varepsilon_n}{r_n}$$

PROBLEM 12. (Moscow School of Electrical Engineering, 2017, 11) Find the current I through a resistor with a resistance $R = 5$ Ohm in the circuit shown in the figure. All sources are the same and have an EMF $E = 15$ V and an internal resistance $r = 2$ Ohm. Neglect the resistance of the connecting wires.



Ans: $\frac{7E}{3R+7r}$