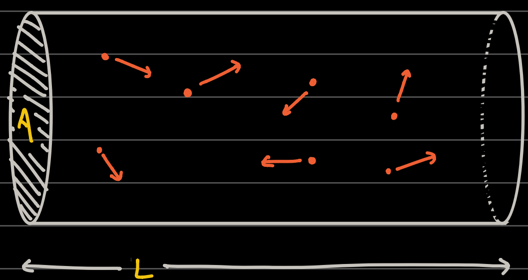
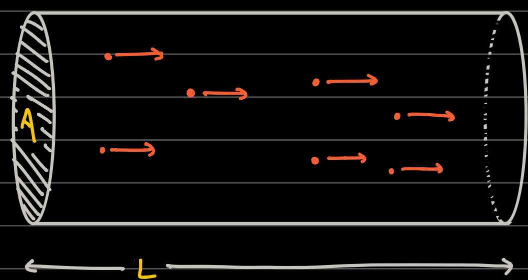
CONCEPT OF DRIFT VELOCITY



Battery NOT connected



Battery connected

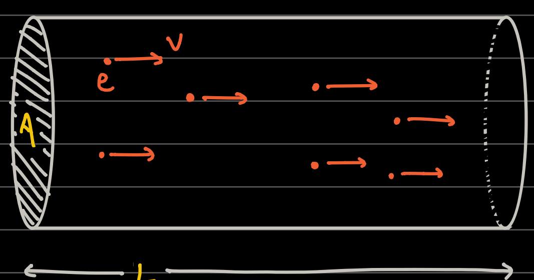
- The diagram shows a metal conductor of length L and cross sectional area A.

- When no potential difference is applied, the electrons in the conductor move randomly such that the net current flowing through this conductor is taken to be 0 Amperes.

- When the ends of the conductor are now connected to a power supply, the battery creates an electric field across the ends of the conductor

- The electric field influences all the electrons to now move in one particular direction

- The speed with which the electrons now move is known as the drift velocity of the electrons.



Battery connected

L : Length
A : Area
e : Charge of Electron
n : Number of electrons present per unit volume
v : Drift velocity

$$\text{Current} = \frac{\text{Total Charge passing through a certain point}}{\text{Time elapsed}}$$

charge per electron

no. of electrons per unit volume

$$I = \frac{enAL}{t}$$

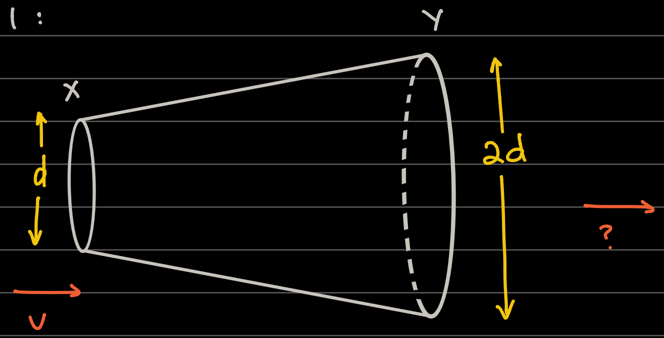
volume

If the electron travels from one end of the conductor to the other end at a (drift) velocity of v, time elapsed can be expressed as $\frac{L}{v}$

$$I = \frac{venA\cancel{L}}{L} \qquad t = \frac{L}{v}$$

[I = venA] Derived Formula

Example 1 :



$I = evAn$

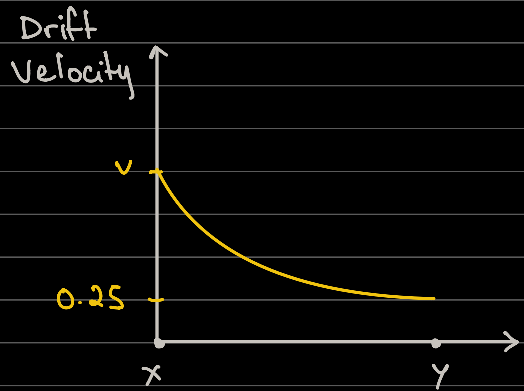
$\frac{I}{e\uparrow An} = v$

As d doubles, A increases by a factor of 4

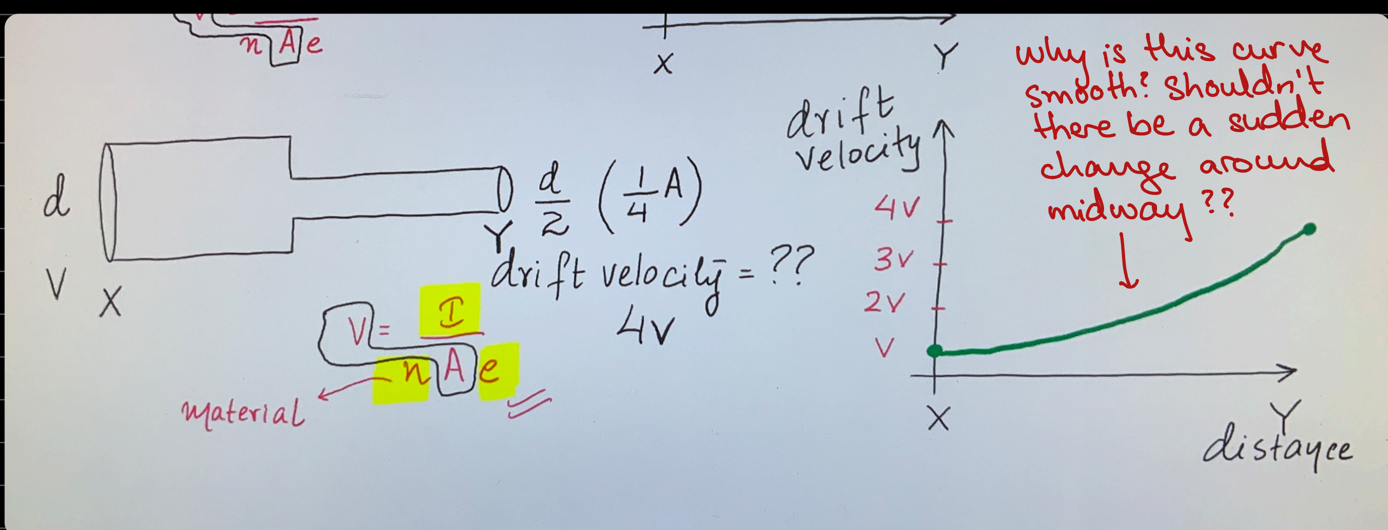
$\frac{I}{e\uparrow An} = v\downarrow$

As drift velocity v and area A are inversely proportional, v decreases by a factor of 4

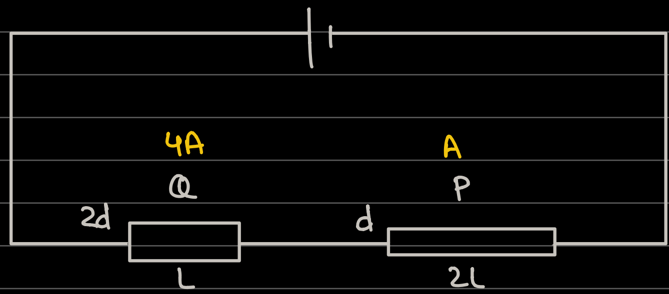
$\therefore$, final drift velocity is $\frac{v}{4}$



Example 2 :



Example 3 :



Both resistors are of the same material

Calculate ratio $\frac{V_P}{V_Q}$

$I = VenA$

$I = eVAn$

$V = \frac{I}{eAn}$

Since both materials are the same, the value of 'n' (number of electrons per unit volume) is the same for both of them

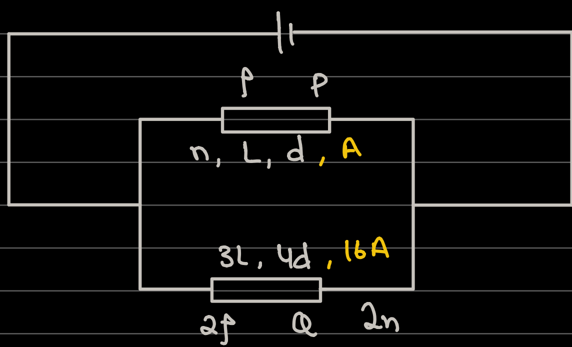
$$\frac{V_P}{V_Q} = \frac{\frac{\boxed{I}}{eAn}}{\frac{\boxed{I}}{e4An}} = \frac{4}{1}$$

Ans

and e is also constant

I is also constant for both

Example 4 :



The two resistors are made up of different materials

i) $\frac{R_P}{R_Q}$ ii) $\frac{I_P}{I_Q}$ iii) $\frac{V_P}{V_Q}$

(i) Resistence = $\frac{\rho \cdot \text{Length}}{\text{Area}}$

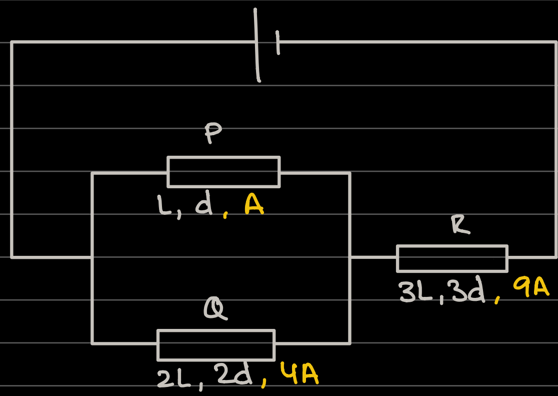
$$\frac{R_P}{R_Q} = \frac{\frac{\rho L}{A}}{\frac{2\rho \cdot 3L}{16A}} = \frac{16}{6} = \frac{8}{3} \longrightarrow \text{Ans (i)}$$

(ii) Remember, in a parallel arrangement, the more resistance a path has the less current that it gets

Hence $\frac{I_P}{I_Q}$ = reciprocal of $\frac{R_P}{R_Q} = \frac{3}{8} \longrightarrow$ Ans

(iii) $\dfrac{V_P}{V_Q} = \dfrac{\frac{3I}{nAe}}{\frac{8I}{2n16Ae}} = \dfrac{12}{1} \rightarrow \underline{\underline{\text{Ans}}}$

Example 5 :



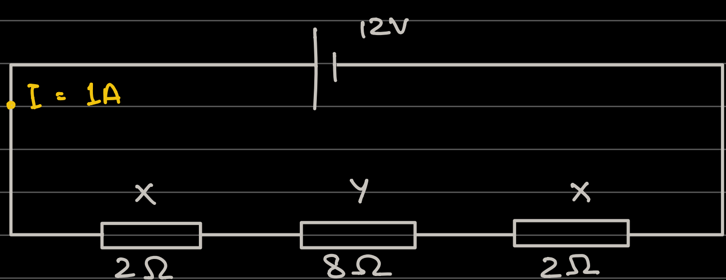
All resistors made up of the same materials
Meaning that their resistance and 'n' value is equal.

i) $\dfrac{R_P}{R_Q} = \dfrac{\frac{\rho L}{A}}{\frac{\rho 2L}{4A}} = \dfrac{2}{1} \rightarrow \underline{\underline{\text{Ans}}}$

ii) $\dfrac{I_P}{I_Q} = \dfrac{1}{2} \rightarrow \underline{\underline{\text{Ans}}}$

iii) $\dfrac{V_Q}{V_R} = \dfrac{\frac{2I}{e4An}}{\frac{3I}{e9An}} = \dfrac{3}{2} \rightarrow \underline{\underline{\text{Ans}}}$

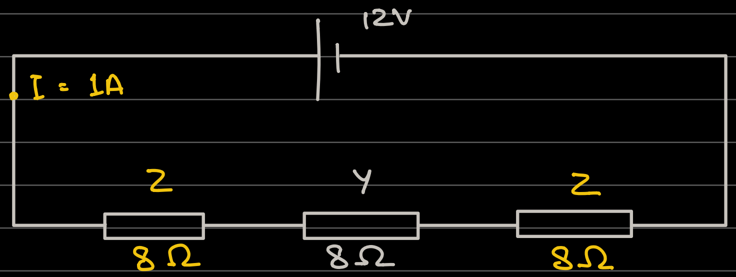
Example 6 : How to compare drift velocity in circuits where resistance changes



$V = IR$
$12 = I(12)$
$1A = I$

Q i) X is replaced with Z. X had a diameter d and Z has a diameter of ½d. Calculate the value for the new current in the circuit.

New Circuit



$X \longrightarrow Z$

$R = \frac{\rho L}{A}$

$4\times \uparrow R = \frac{\rho L}{A \downarrow 4\times}$

$V = IR$

$12 = I(24)$

$\frac{1}{2} A = I \longrightarrow$ Ans

The new value of current

iii) Comment on the drift velocity in Z when compared to the drift velocity of X.

	Current	Area
X	1A	4
Z	½A	A

$$\frac{V_Z}{V_X} = \frac{\frac{I}{nAe}}{\frac{2I}{n4Ae}} = \frac{2}{1} \longrightarrow \text{Ans}$$

Explanation: Current is only halved but area is one-quarter, hence the impact of area outweighs the impact of current.

$v \propto \frac{1}{A}$ ∴, as $A \downarrow$, $v \uparrow$