Sub.: LD

(Lecture 6 Rough)

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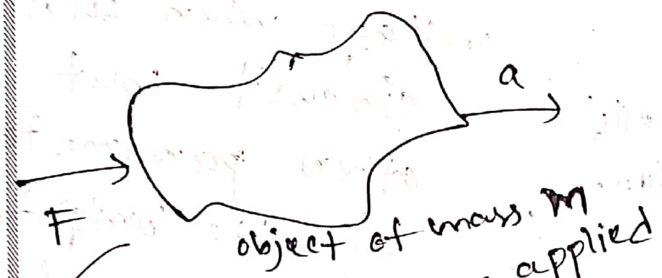
Lumped Matter Abstraction:

→ making something easier or removing something to make something simple.
[that is just focusing the important part. & and ignoring other stuff.]

Newton's law



→ force applied

$a = \frac{F}{m}$

↓ acceleration ↓ mass

Here we ignore:
1. shape of object
2. Temparature
3. colours.

etc.

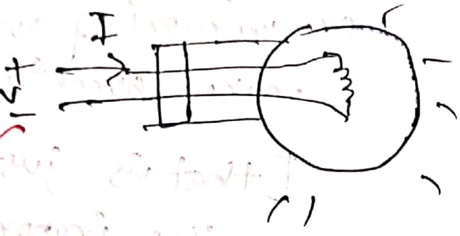
only considering mass of object and ignoring other stuff.
so this is kind of abstraction.
or point mass abstraction.

↓

Thats why we represent them as a point of mass.

suppose now the shape of object is ~~triangle~~ trianglular but same mass m, so in this case if F is equal same. The a will not change.

similarly for electrical circuit:



we only consider here the current and voltage when solving circuit but other parameter like the brightness ~~of~~, temp of light we ignore

"Actual way" → maxwell's equation.

more general

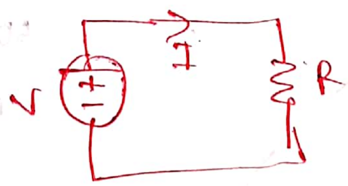
$$\nabla \cdot \bar{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \times \bar{E} = \frac{\delta B}{\delta t}$$

same answer

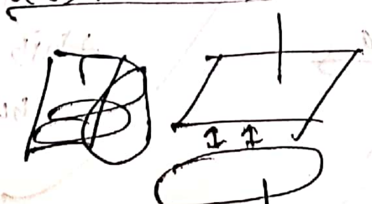
"Easy way" — ohm's law.

→ convert the physical circuit to simplified way with resistor without considering the materials.



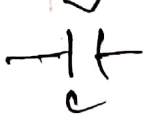
⇓ This is called Lumped ~~matter~~ matter abstraction.

For example:



two physical plate

⇓



modeling just as a capacitor

Now How can we characterize the Capasitance C, Resistance R of Resistor?

For characterization, we need some distinct features.

For example:

Triangle → 3 corner

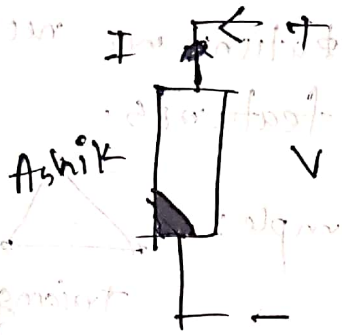
square → 4 corner

For unique characterization we need clear defination of the distinct features.

Similarly for circuit elements like Resistor, ~~etc~~ capasitor, voltage source, current source, etc. we ~~need to~~ ~~ct~~ use IV characteristic to characterize the element.

I-V characterization:

lets we make a device Name Ashik.



How can we charaterize Ashik?

⇒ if we know the relation between current I and voltage V we can charactewrize Ashik.

IV characteristic is relation between voltage and current.

Lets say we get for device Ashik

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

And it is similiar to $I = \frac{V}{R}$

so we can see its like a resistor. so we can say device Ashik = resistor. (—ww—)

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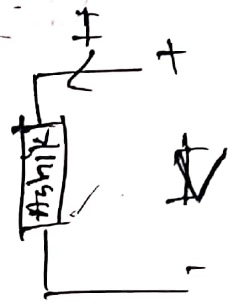
Representation of IV characteristic:

(1) Tabular form

(2) not efficient (what if infinite length table?)

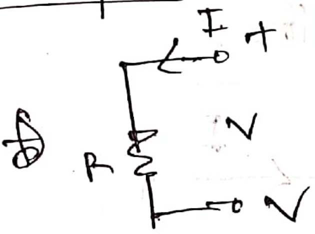
V	I (mA)
1	0.5
2	1
-1	2



(2) Functional form

$$I = f(V) \quad \text{or} \quad V = f(I)$$

* For example.



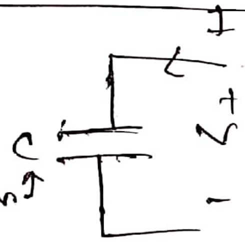
$f(x) = ?$

$$I = \frac{1}{R} V$$

$$y = f(x) = \frac{1}{R} x$$

---

* capacitor



$$\Rightarrow I = C \frac{dv}{dt}$$

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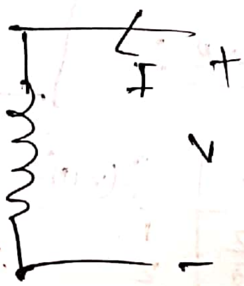
inductor



$$\Rightarrow V = L \frac{dI}{dt}$$

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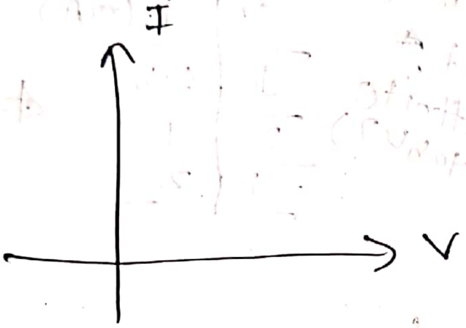
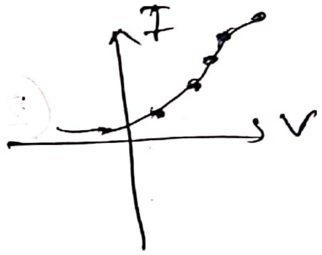
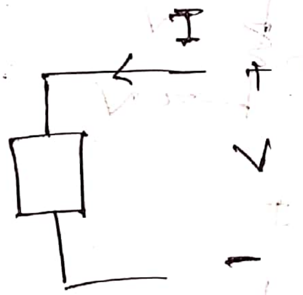
(3) Graphical form:



we can also draw the graph from Tabular form



sign convention:

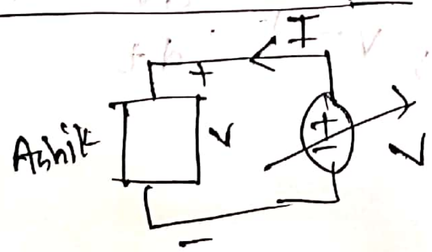


passive sign convention.
↳ current flows from positive to negative terminal.

or

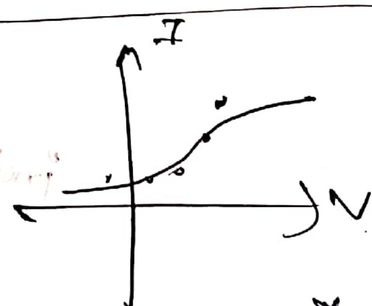
~~current~~ current enters through the positive terminal.

How to find IV curve:



V	I(mA)
2	1
3	2
4	3
5	-4
⋮	⋮

⟹ plot



IV characteristic of simple linear device:

why linear ⇒ because their IV characteristic can be drawn using single straight line.

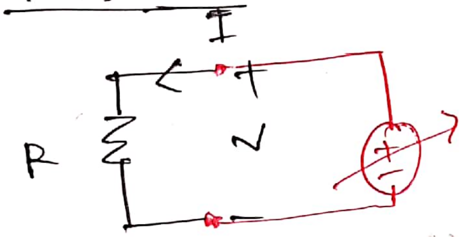
① IV char. of Resistor

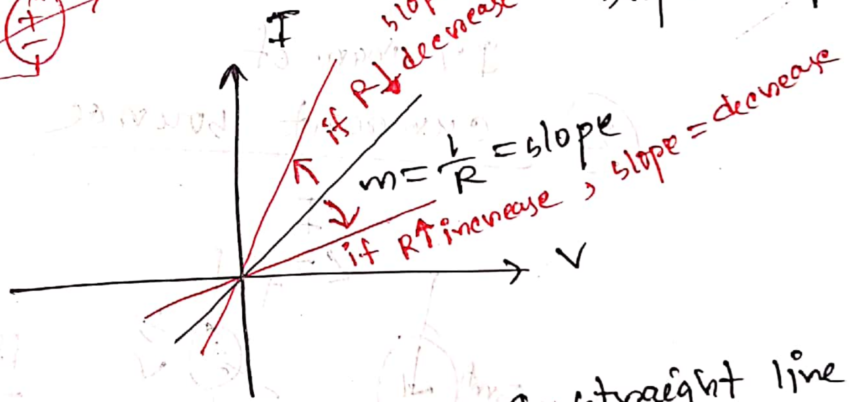
$$\boxed{I = \frac{1}{R}V}$$

$I \to y$, $\frac{1}{R} \to m$, $V \to x$

$y = mx$

where slope $m = \frac{1}{R}$



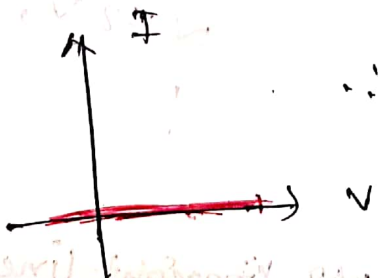


→ a straight line
→ through origin
→ slope = $\frac{1}{R}$

Two extremes

ⓐ Now if $R = \infty$

$\therefore I = 0$



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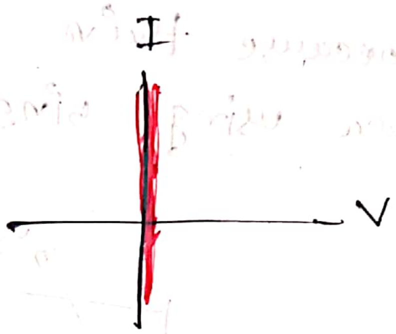
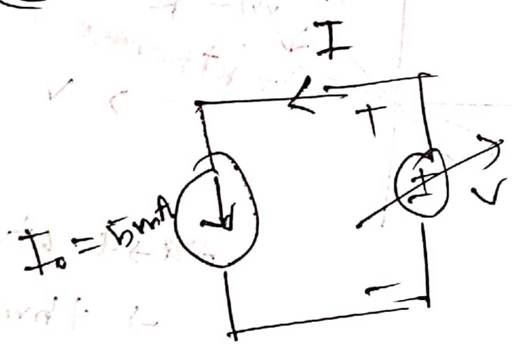
* if $R=0$

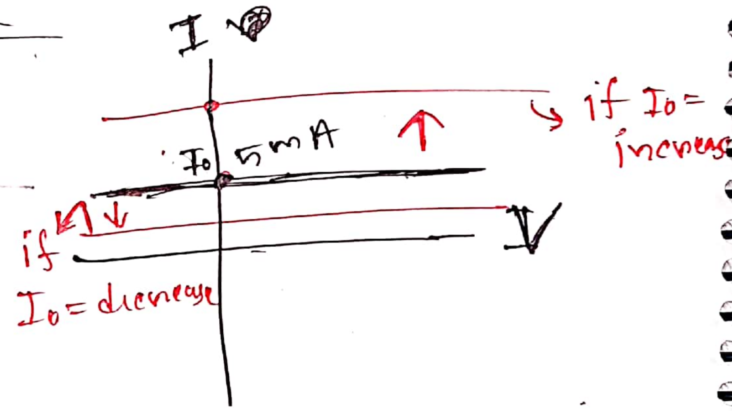


so,
$V=0$

IV char. of

(2) current source





Now
if $V = 1V$, $I = 5mA$
$V = 2V$, $I = 5mA$
$I = 5mA$
$I = 5mA$

∴ $\boxed{I = I_0}$

** But Here polarity matters.

→ so straight line parallel to x axis (voltage axis)
→ cuts the y axis (current axis) at I_0 (value of current source)

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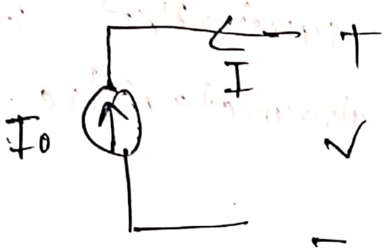
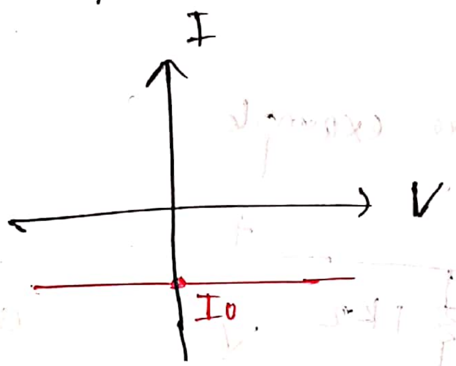
lets its like .

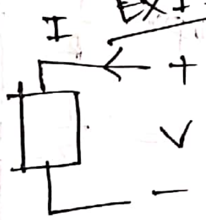


$\boxed{I = -I_0}$

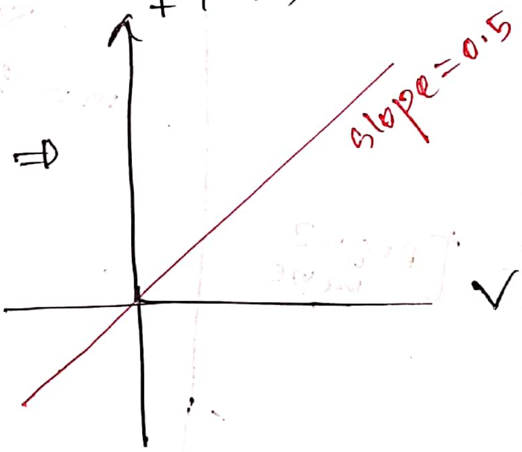


Example:

Ex1:



$\Rightarrow$



Ques1: what is the model of this device?

Ans: —/\/\/\— R

Ques2: what are the parameters?

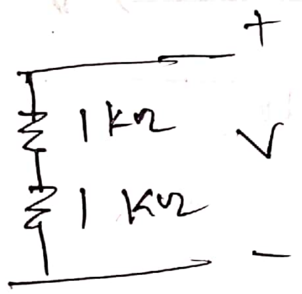
Ans: 1 ~~R~~ parameter. that is R.

$\because R = \frac{1}{\text{slope}} = \frac{1}{0.5} = 2\ k\Omega$ (since current mA)

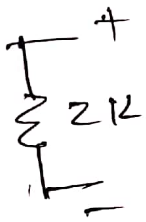
Equivalent circuit

★★★ Two circuit will be called equivalent if they have same IV characteristic.

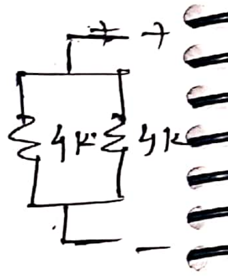
For example



or



or



⇓

$m = \text{slope} = \frac{1}{R}$

$= \frac{1}{2}$ [Req = 2 here

⇓

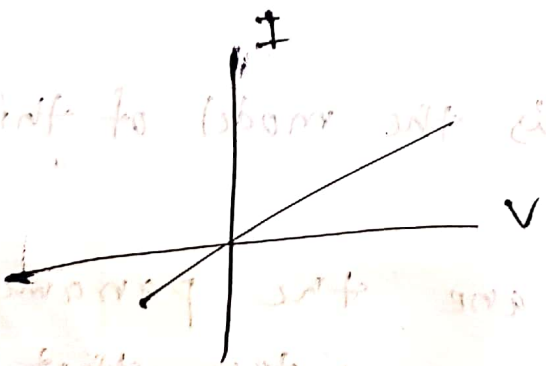
$m = \text{slope} = \frac{1}{R}$

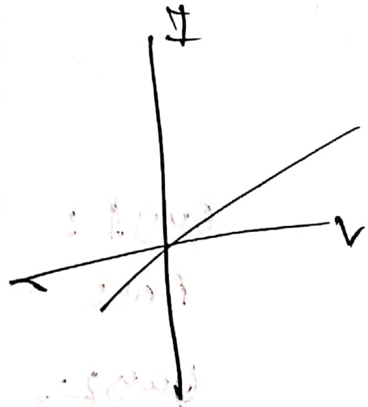
$= \frac{1}{2}$

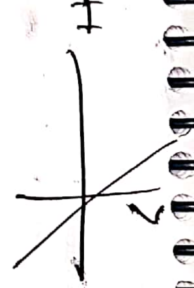
⇓

$m = \text{slope}$

$= \frac{1}{2}$







So these circuit are equivalent.

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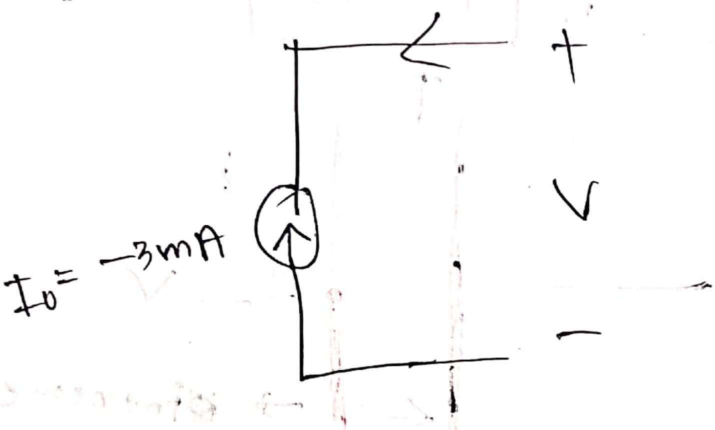
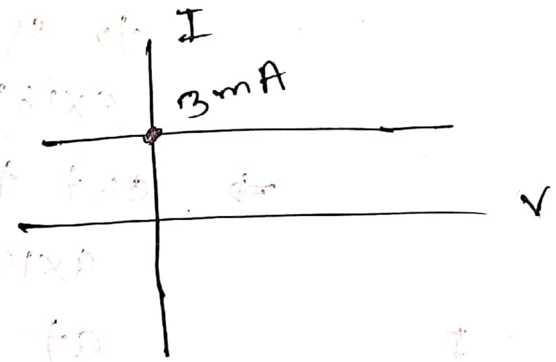
~~(2) IV char. of~~

EX2:



Q: Draw it IV curve?

Soln:



$\therefore$ Here $I = -I_0$

$= -(-3)$

$= 3\ mA$

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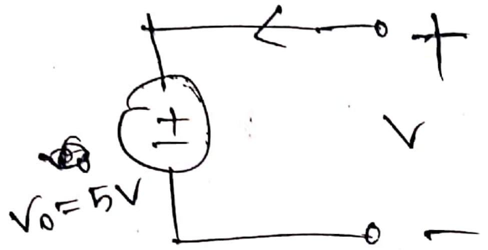
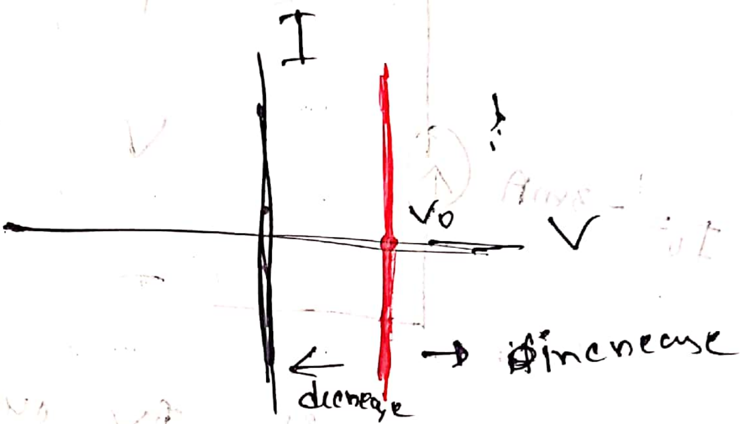
(3) Voltage source :



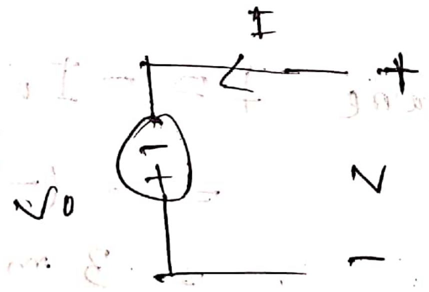
$\therefore$ $\boxed{V = V_0}$



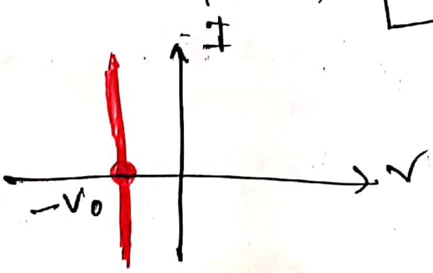
⇒ straight line parallel to y axis (current axis)

⇒ cut the voltage axis (x-axis) at V_0

Now if



then, $\boxed{V = -V_0}$



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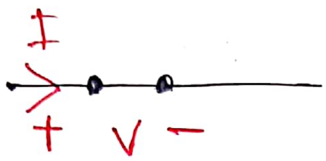
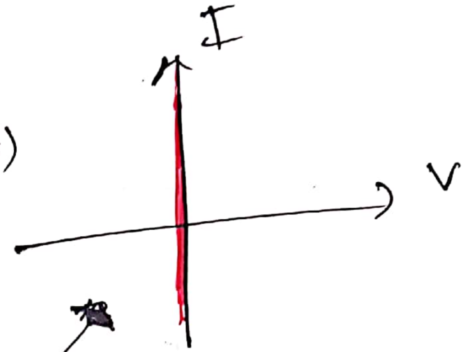
(4) IV of Short circuit



$\boxed{V=0}$ =>

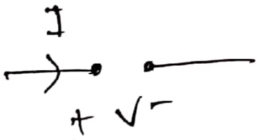


∵ From resistor's IV char. can say here

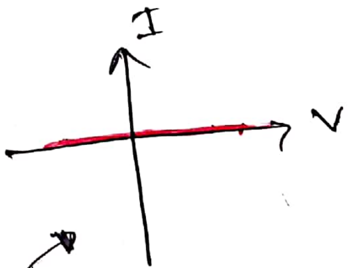
$R=0$

so short circuit, Resistor $R=0$ circuit and voltage source $V_0=0$ V are equivalent because same IV

(5) IV of open circuit:



$\boxed{I=0}$ =>



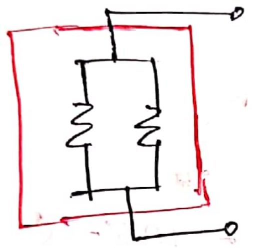
∵ From resistor's IV char. can say here

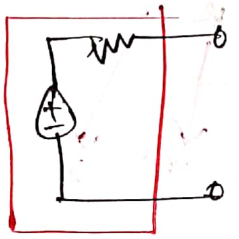
$R=\infty$

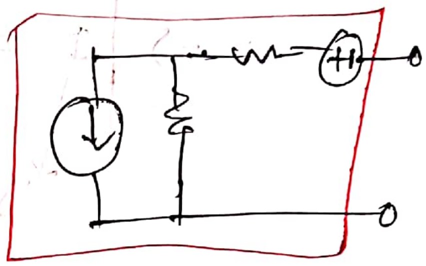
similarly, open circuit, Resistor $R=\infty$ circuit and ~~voltage~~ current source with $I_0=0$ are equivalent circuit. [Same IV]

CamScanner

IV characteristic of compound linear devices:

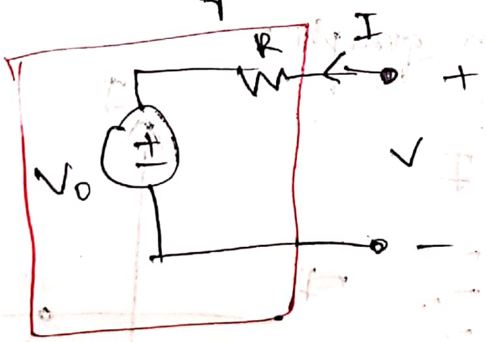




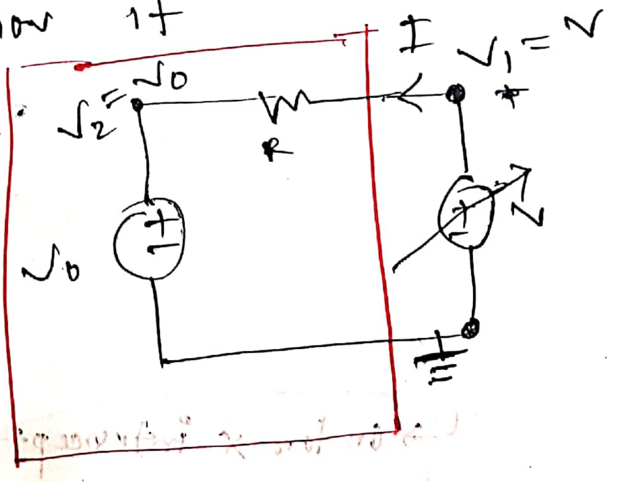


So thousands of combination possible. But ~~we~~ if we know just two ~~best~~ circuits IV char. we can then find any others circuits IV char easily. These two are:

(1) voltage source in series with resistors.



now if



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$$\therefore I = \frac{V_1 - V_2}{R} = \frac{V - V_0}{R}$$

$$\Rightarrow \boxed{I = \frac{1}{R} \cdot V - \frac{V_0}{R}}$$

$I \to y$, $\frac{1}{R} \to m$, $V \to x$, $\frac{V_0}{R} \to c$

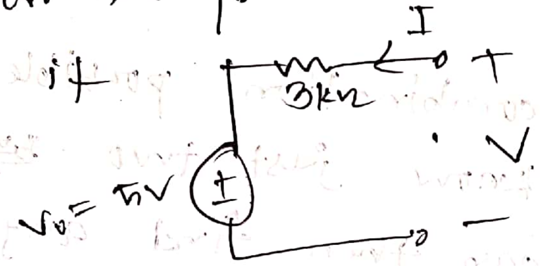
$\therefore y = mx - c$

$m = \text{slope} = \frac{1}{R}$

$-c = \text{y intercept} = -\frac{V_0}{R}$

For example:

if

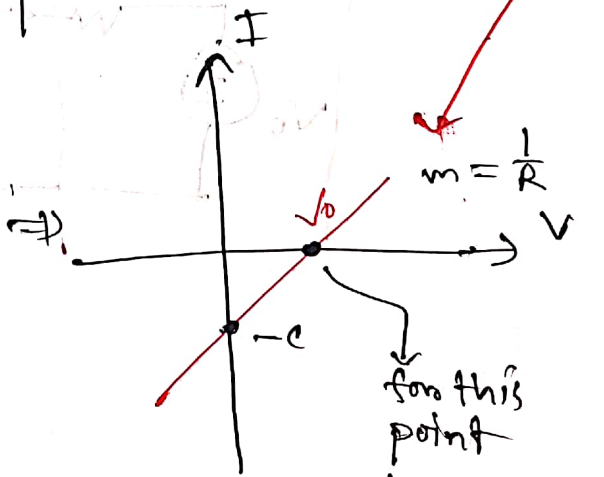


$$\therefore I = \frac{1}{3} \cdot V - \frac{5}{3}$$

From this we can create table

from graph:

V	I
2	– –
3	– –
⋮	– –



→ for for x intercept

$y = 0$ or $I = 0$

$\therefore 0 = mx - c$

$\Rightarrow x = \frac{c}{m} = \frac{V_0 R}{\frac{1}{R}} = V_0$ $\quad \therefore$ $\boxed{\text{X intercept at } V_0}$

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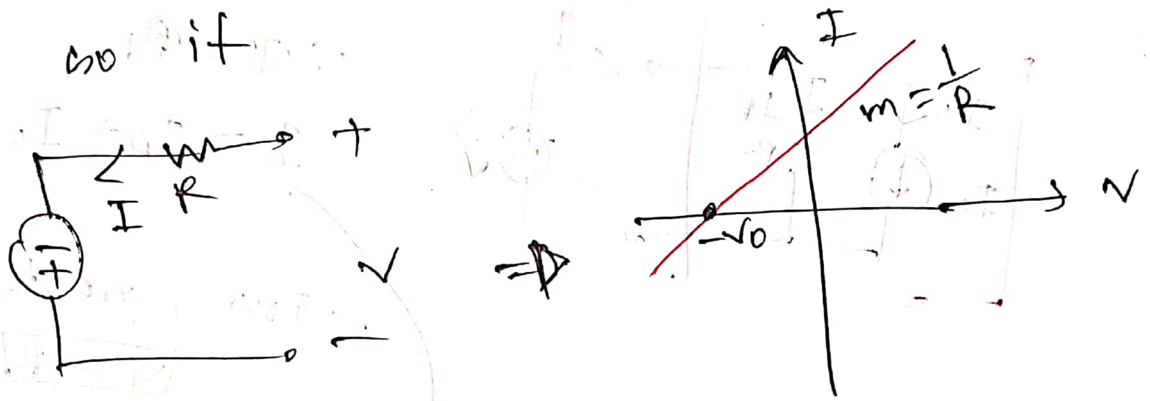
Here polarity of voltage source matters.

So if



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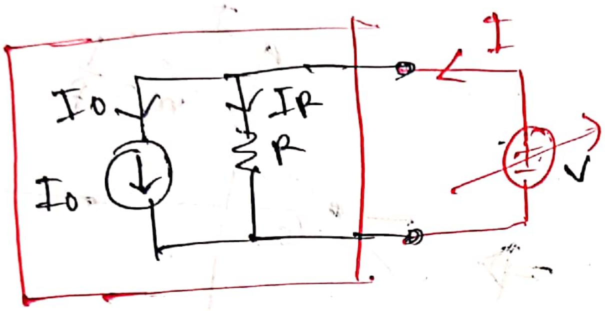
(2) current source in parallel with resistor:



$\because$ ~~I = I_R~~

$$I = I_R + I_0$$

$\because$ For resistor

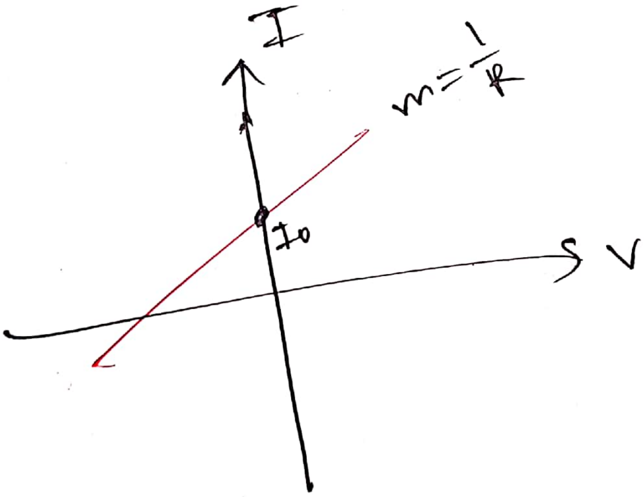
$$\boxed{V = IR}$$

$$\therefore I_R = \frac{V}{R}$$

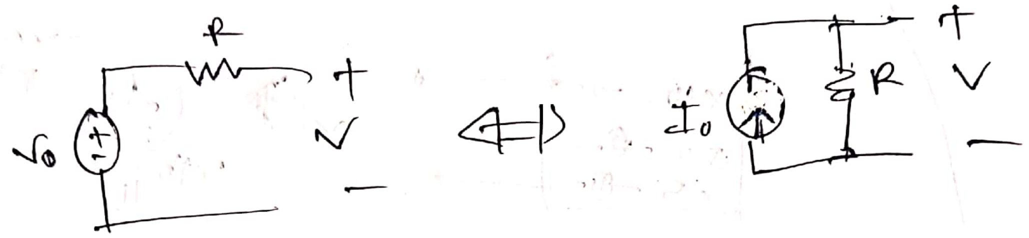
$$I = \frac{V}{R} + I_0$$

$$\Rightarrow \boxed{\underbrace{I}_{y} = \underbrace{\frac{1}{R}}_{m}\underbrace{V}_{x} + \underbrace{I_0}_{c}}$$

$$y = mx + c$$

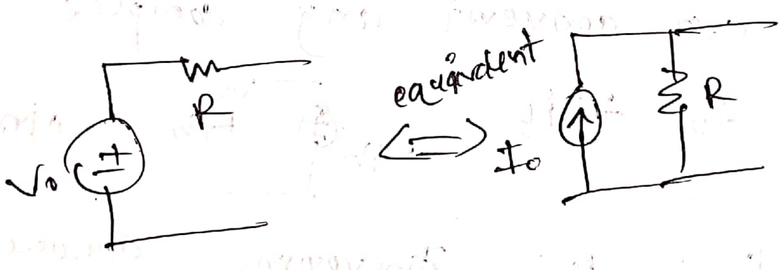


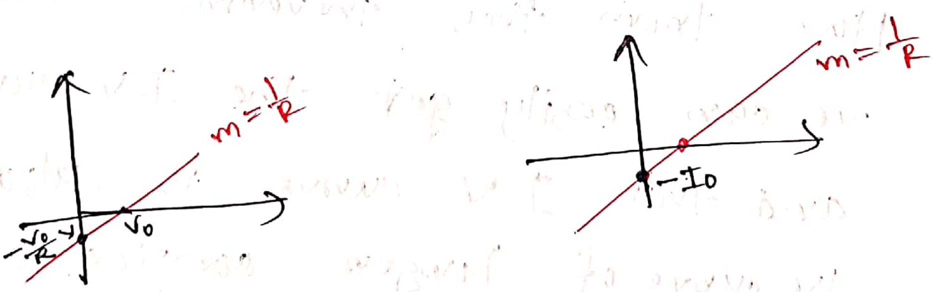
These two circuits are equivalent.



'cause same IV curve can possible.
~~by source transformation,~~ under certain condition.

source transformation

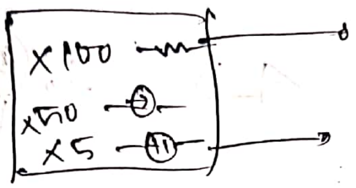


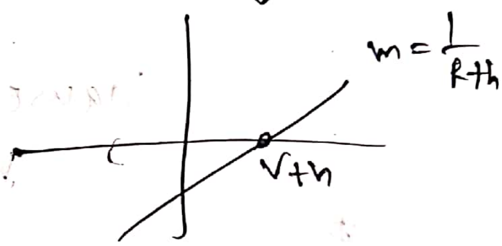


$$\therefore -\frac{V_0}{R} = -I_0$$

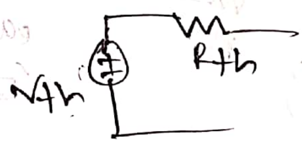
$$\therefore \boxed{V_0 = I_0 R}$$ equation of source transformation.

Thevinine and IV characteristic:





we can convert any complex circuit ~~with~~ to this



circuit.

Now from this Thevenine circuit we can easily get the IV curve. and this IV curve is also the IV curve of larger complex circuit. because that larger circuit and the Thevenine circuit are equivalent.