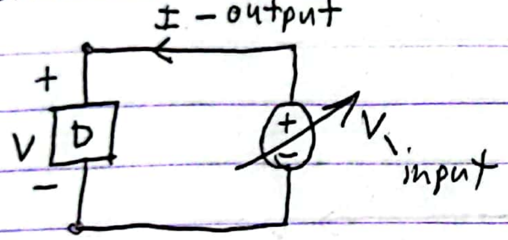
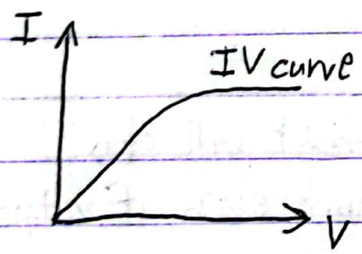
IV Characteristics of a device:

- It is the relationship between current and voltage across a device, it is used to describe the characteristics of the device.
- A table of I-V is made by connecting a voltage source across the device and variying the voltage. Like:



V	I
⋮	⋮

- It can also be done using a graph which would look like:



- I-V Char is also known as Input-output relation of a device.

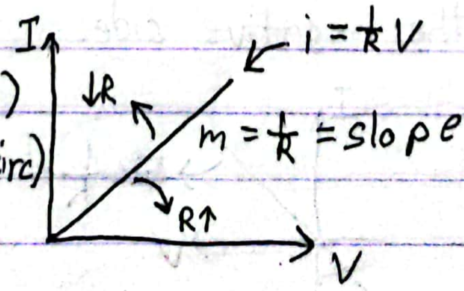
Lecture - 3 (P - 2)

I-V Char of simple linear elements:

* A device is linear if the relation between I-V is a straight line graph. eg: resistor ($V = IR$ eqn) $\Rightarrow V \propto I$

* I-V curve of resistor:

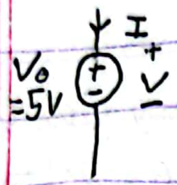
- If $R = \infty$, m (slop) = 0 (open circ)
- " $R = 0$, " " $= \infty$ (short circ)

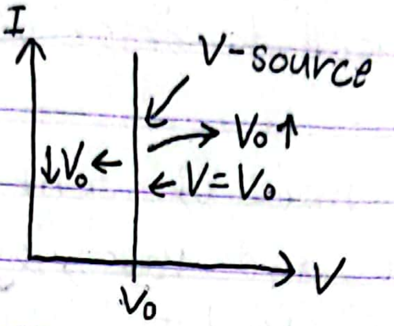


I-V Char of independent sources:

* V-source (V_0 = constant):

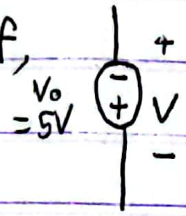
- Graph:



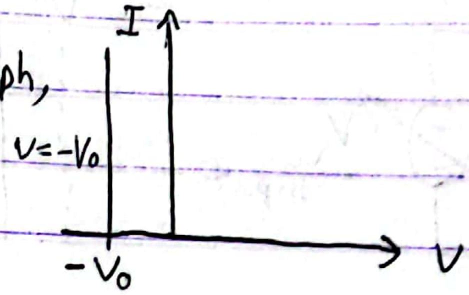


- What ever the current is, voltage will always stay the same.

- If,

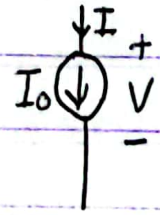


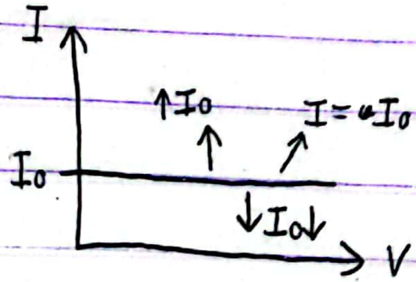
then graph,



I-Source (I_0 = constant):

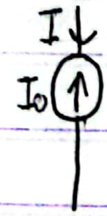
- Graph:

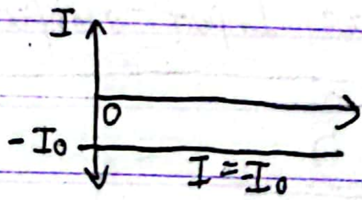




- Current will stay same even if voltage changes.

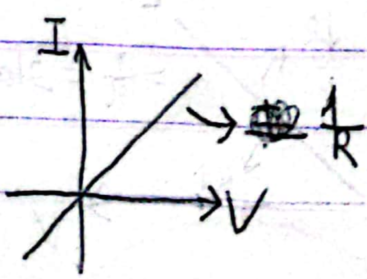
- If,





If polarity and source direction is same then the straight line will be in the positive side otherwise it will be on the negative side.

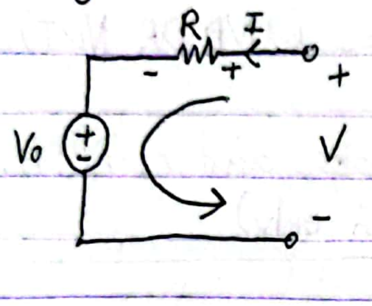
Resistance:



I-V char of Compound elements:

* Compound elements = combination of simple elements.

* Voltage source in series with resistance.



K.V.L,

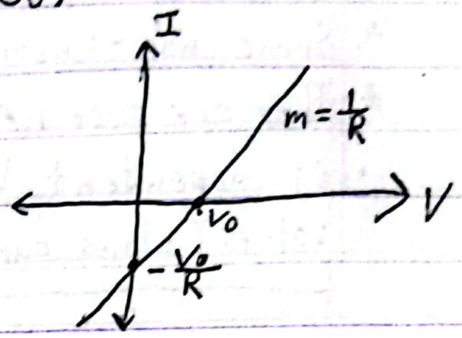
$V = V_R + V_0$

$\Rightarrow V = IR + V_0$

$\Rightarrow I = \left(\frac{1}{R}\right)V - \frac{V_0}{R}$

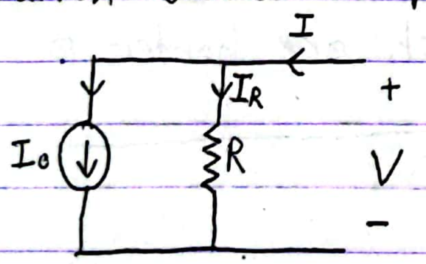
$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

$y = m\,x - c$



- To find the x-intercept put $I = 0$ in $I = \left(\frac{1}{R}\right)V - \frac{V_0}{R}$.

* Current source in parallel with resistance.



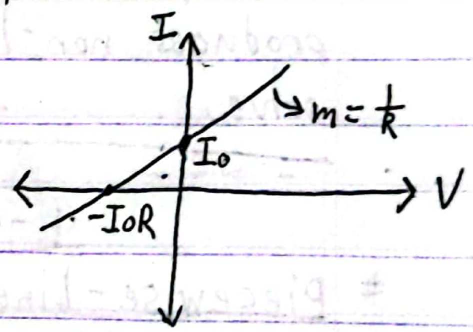
K.C.L,

$I = I_0 + I_R$

$I = \left(\frac{1}{R}\right)V + I_0$

$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

$y = m\,x + c$



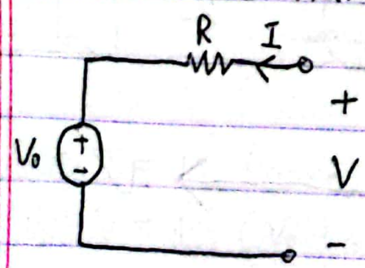
- To find the x-intercept put $I = 0$ in $I = \left(\frac{1}{R}\right)V + I_0$.
- If I-source is reversed, The eqn becomes, $I = \left(\frac{1}{R}\right)V - I_0$.
- ☆ If V-source is " , " " " , $I = \left(\frac{1}{R}\right)V + \frac{V_0}{R}$.

L-3 (P-5)

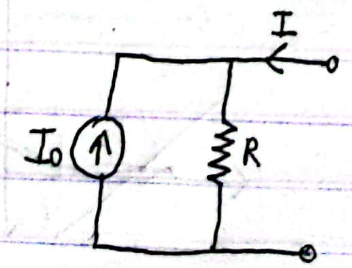
Equivalent Circuit:

* If 2 devices have the same I-V relation they are called equivalent circuit.

*



$\equiv$



if $\boxed{V_0 = I_0 R}$, this is also known as source transformation.

Non-Linear Devices:

* Devices whose I-V ~~curve~~ graph is not a single straight line.
* They are required to implement non-Linear operations.
* Some non-linear devices are logic gates (AND, OR, NOT)
* They are also needed to control I/V.
* eg: dependent V-sources and I-sources, and switch, valves (alows current to flow in 1 direction only).

L-4 (P-2)

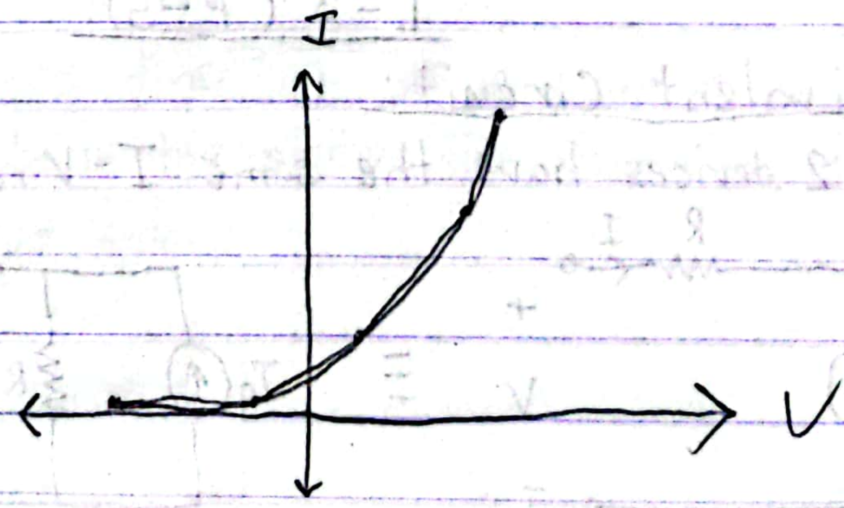
Problems with Non-Linear devices:

* They produce non-linear I-V which ~~intern~~ inturn produces non-linear equation which are harder to solve.

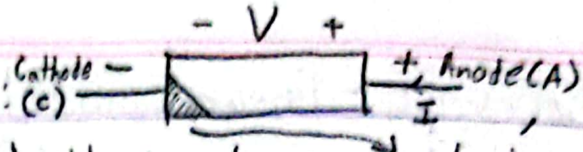
L-4 (P-3)

Piecewise-Linear approximation:

* It is a technique used to solve non-linear eqn.
* Here a curve in divided into segments of straight lines.
* The more pieces the graph is broken into the more accurate it is.



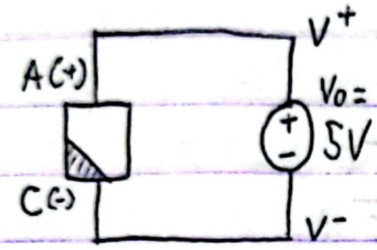
* Symbol of non-linear device :



, $V = V_A - V_c$

* They have polarity, The (-ve) side is always marked.
* If $V > 0 \Rightarrow V_A > V_c \Rightarrow$ Forward Bias

" $V \leq 0 \Rightarrow V_A \leq V_c \Rightarrow$ Reverse "

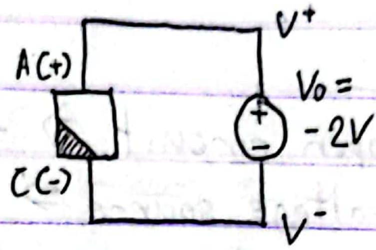


Forward Bias

$V_o = V^+ - V^-$

$= V_A - V_c$

$= 5V$

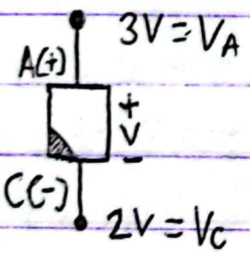


Reverse Bias

$V_o = V^+ - V^-$

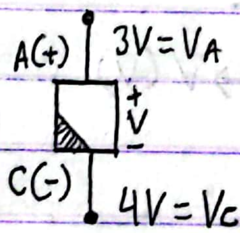
$= V_A - V_c$

$= -2V$



$V = V_A - V_c$

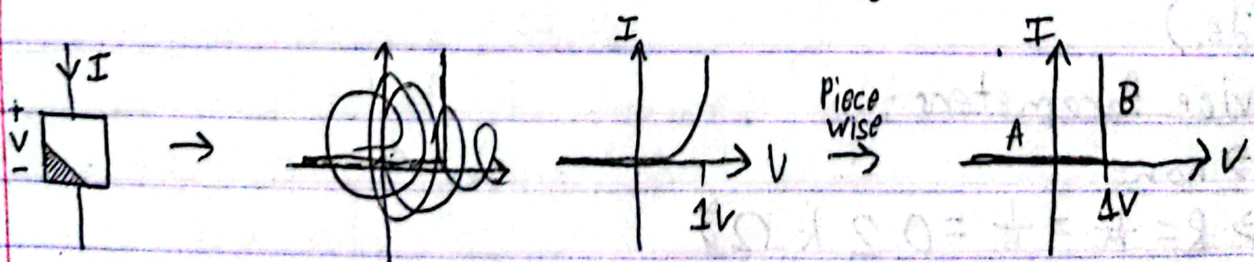
$= 1V$ (F.B)



$V = V_A - V_c$

$= -1V$ (R.B)

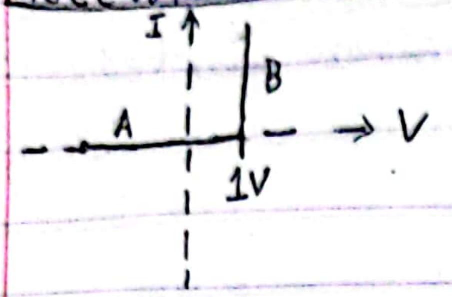
* In a non-linear device 'I' enters through the anode.
*

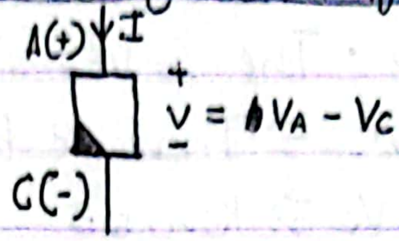


A ⇒ I = 0, (open circuit)

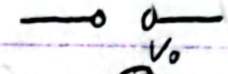
B ⇒ V = 1, (Voltage source)

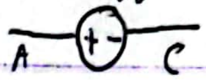
Piecewise - linear modelling example:

① 



* Device modelling:

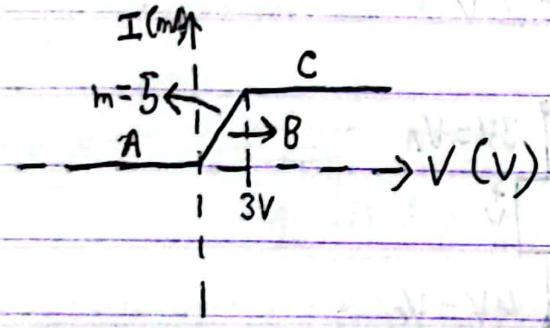
A ⇒ $V \leq 1$ ⇒ open circuit ⇒ 

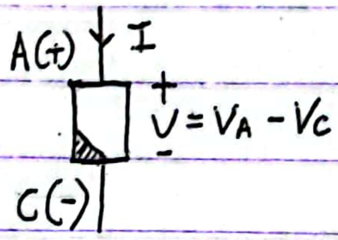
B ⇒ $I > 0$ ⇒ voltage source ⇒ 

* Device parameters:

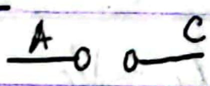
A ⇒ no parameters

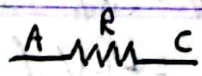
B ⇒ $V_0 = 1\ V$

② 

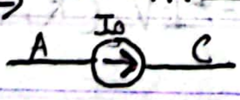


* Dev modelling:

A ⇒ $V \leq 0V$ ⇒ 

B ⇒ $0 < V < 3V$ ⇒ 

$(R = \frac{1}{m} = \frac{1}{5} = 0.2\ k\Omega)$

C ⇒ $V > 3V$ ⇒ 

(Direction of I is Anode to cathode because the line 'C' intercepts the y-axis in the positive side.)

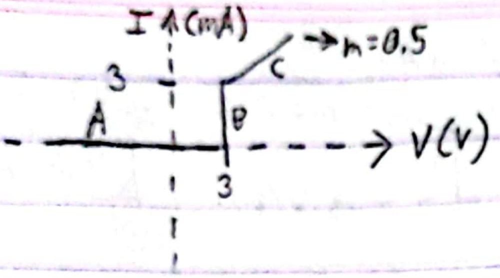
* Device Parameters:

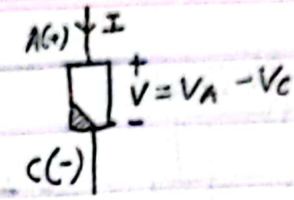
A ⇒ none

B ⇒ $R = \frac{1}{m} = \frac{1}{5} = 0.2\ k\Omega$

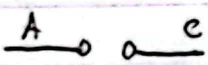
C ⇒ $y = mx = 5 \times 3 = 15\ mA$

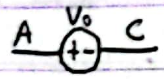
③

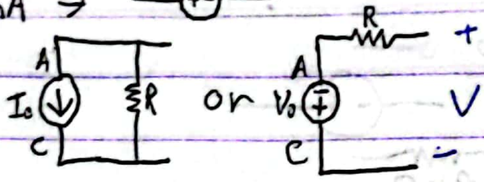




* **Device Model:**

A ⇒ $V \leq 3V$ ⇒ 

B ⇒ $0 < I \leq 3mA$ ⇒ 

C ⇒ $V > 3V$ ⇒ 

* **~~A~~ Parameters:**

A ⇒ none

B ⇒ $V_0 = 3V$

C ⇒ $y = mx + c$ ⇒ $3 = 0.5 \times 3 + c$ ⇒ $c = 1.5$, ∴ $y = 0.5x + 1.5$

$R = \frac{1}{m} = \frac{1}{0.5} = 2\ k\Omega$.

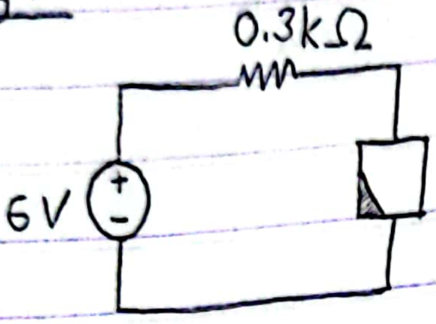
- For current source with parallel resistor, put $x = 0$ in $y = 0.5x + 1.5$
∴ $y = 1.5$, ∴ $I = 1.5\ mA$
- For voltage source with resistor in series, put $y = 0$ in $y = 0.5x + 1.5$
∴ $x = -3V$

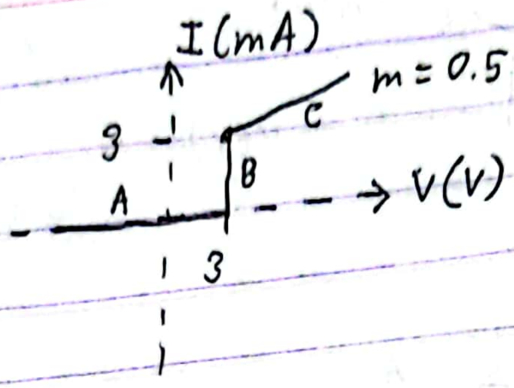
L-4 (P-7)

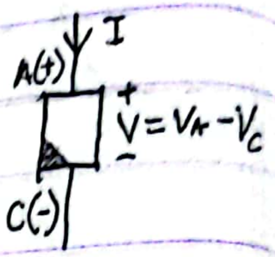
\# **Methode of Assumed State:**

① Assume a state of the device.
② Solve the circuit using that model.
③ Check the soln.
④ Repeat (1-3) if mismatch.

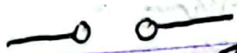
Eg:

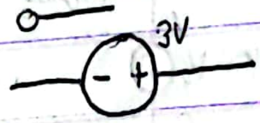






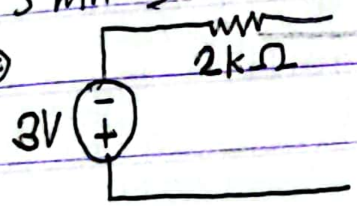
Modeling:

$A \Rightarrow V \leq 3V \Rightarrow$ 

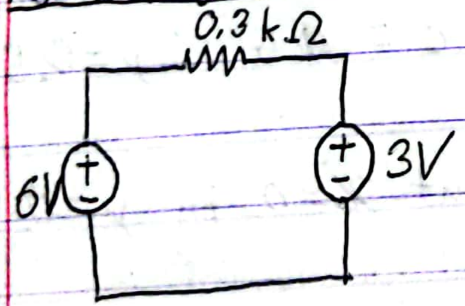


$B \Rightarrow 0 < I < 3\,mA \Rightarrow$

$C \Rightarrow V > 3V \Rightarrow$



① Assuming device working in B region:



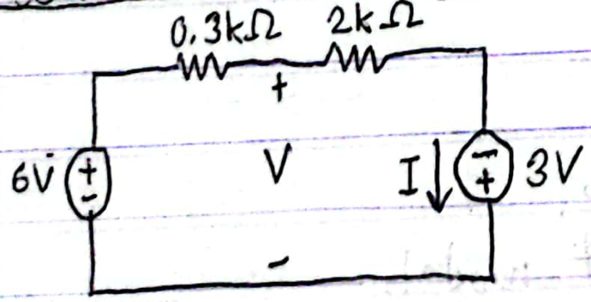
$I = \frac{6-3}{0.3} = 10\,mA$

$V = 3V$

- Soln not correct because $0 < I < 3\,mA$, as it should have been in the B region.

$\therefore$ Assumption is wrong.

② Assume in C region:



$I = \frac{6+3}{0.3+2} = 3.6\,mA$

$K.V.L \Rightarrow V = 2I - 3 = 4.2V$

Assumption correct as $V > 3V$ in C region.