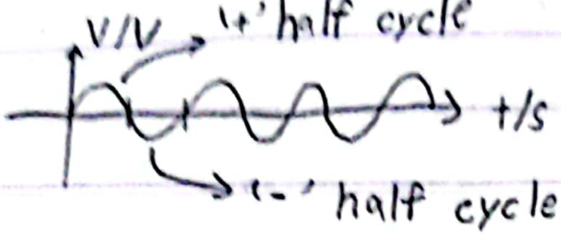
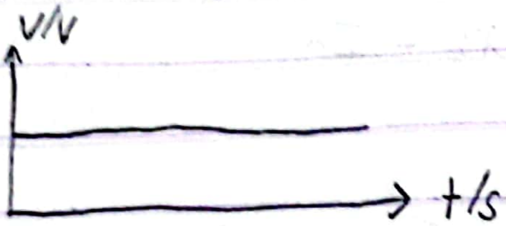
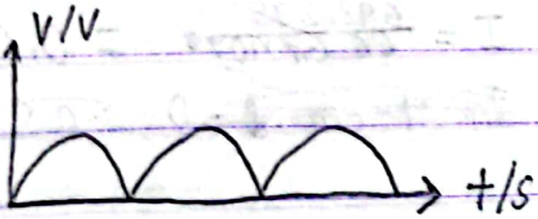
* AC → Current that changes direction.



* DC → Current's direction stays the same



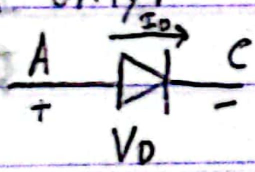
* Pulsating DC → Current that has 1 direction but different magnitude over time.



* Conversion of AC to pulsating DC: ~~is called Rectification.~~
- Step-1: Rectification (Converts AC to Pulsating DC).
- Step-2: Filtering (smoothing) (Reduces variation in magnitude).
- Step-3: Regulation (Decreases variation even more).

L-5 (P-2)

* Electronic valve alows current to flow in one direction only.



$V_D = V_A - V_C$

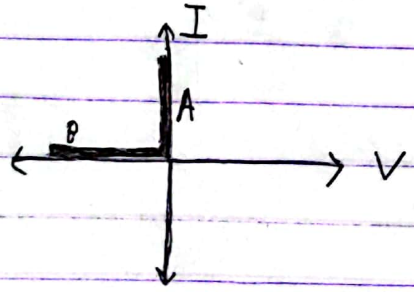
* 

→ Forward Bias → Short Circuit → 

* 

→ Reverse Bias → Open Circuit → 

* I-V Characterictic of Electronic valve / Diode :

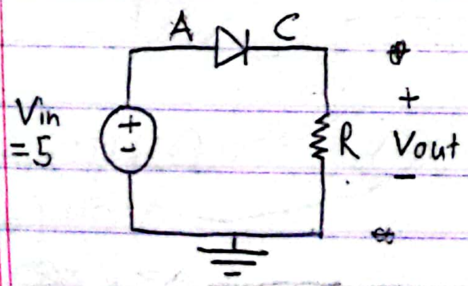


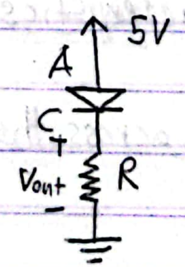
Region - A : F·B, I > 0, Short Circuit, V = 0

Region - B : R·B, V < 0, Open Circuit, I = 0

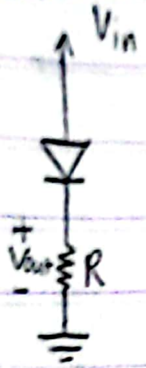
L-5 (P-3)

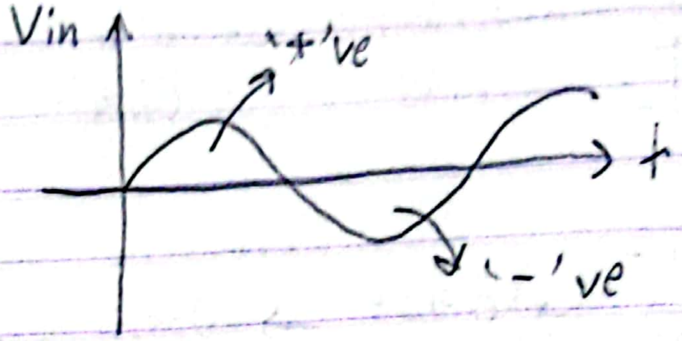
* Line diagram :

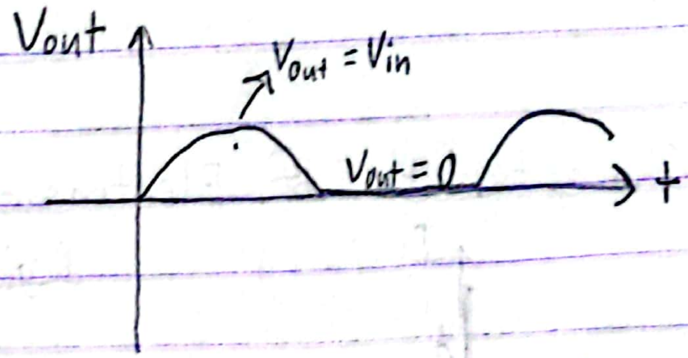


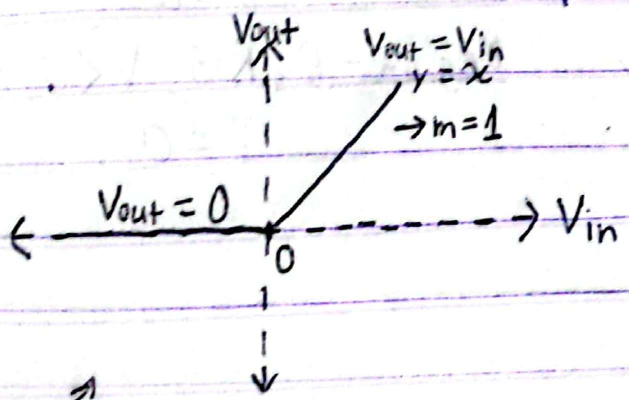
→


AC - source and diode: (Half Wave Rectifier):



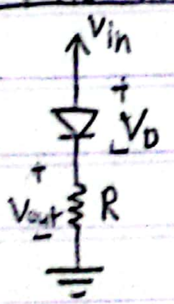


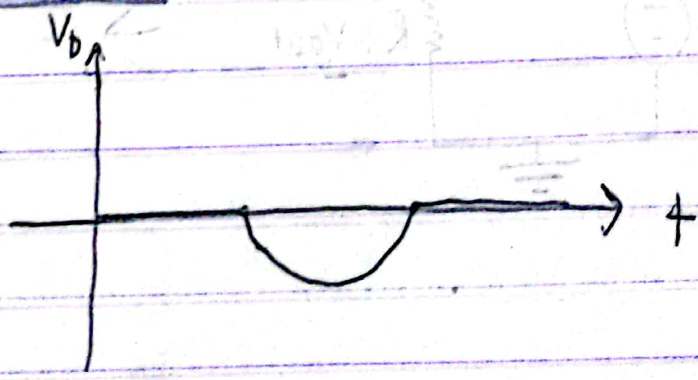




Transfer Characteristics

* To find voltage across the diode:





$V_{in} = V_D + V_{out} + 0$

$\Rightarrow V_D = V_{in} - V_{out}$

Logic Gates:

* Diodes can be used to represent 2 Logic gates:

1) AND gate – 1 only when all inputs are 1
2) OR gate – 0 " " " " " 0

* Logic Levels:

0 → False } will be represented
1 → True } with voltage

| 0 → 0 V / −5 V / +12 V
| 1 → 5 V / +5 V / −12 V

this will be used in this course

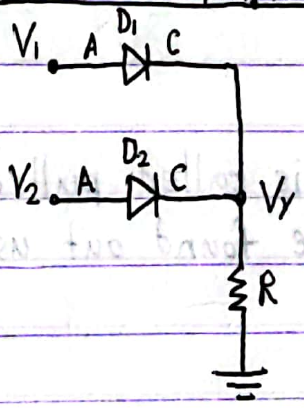
W-4 (L-6) (P-3)

OR Operation with Diode:

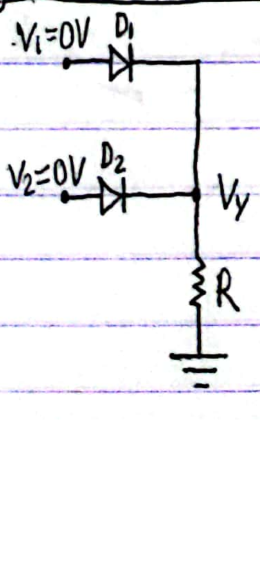
* Logical truth table:

x_1/V_1	x_2/V_2	y/V_y
0/0V	0/0V	0/0V
0/0V	1/5V	1/5V
1/5V	0/0V	1/5V
1/5V	1/5V	1/5V

* OR Gate Implimentation:

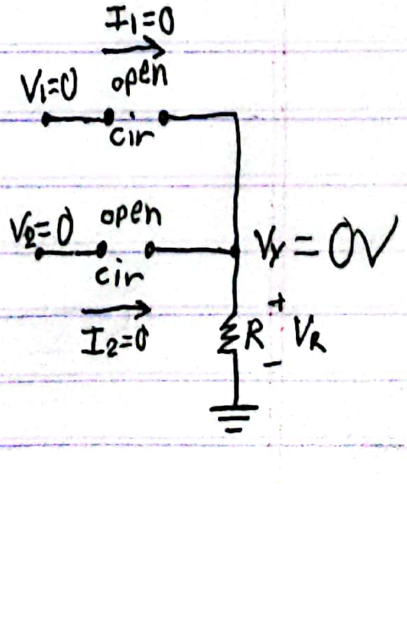


* For current to flow through 'R' $V_y > 0$.
* " diode to be in 'ON' state $V_A > V_C$. If $V_A \leqslant V_C$ diode is 'OFF'.
* Eg: ($V_1 = V_2 = 0$)

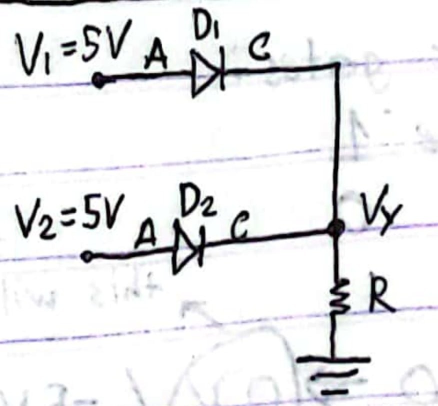


• Since for D_1, $V_A \leqslant V_C$, ∴ D_1 = OFF
and " D_2, $V_A \leqslant V_C$, ∴ D_2 = OFF

∴ Since $V_1 = 0$ and $V_2 = 0$,
$V_y = 0$. ∴ $V_R = V_y - 0$
$= 0 - 0 = 0V$



* Eg: ($V_1 = 5V = V_2$)



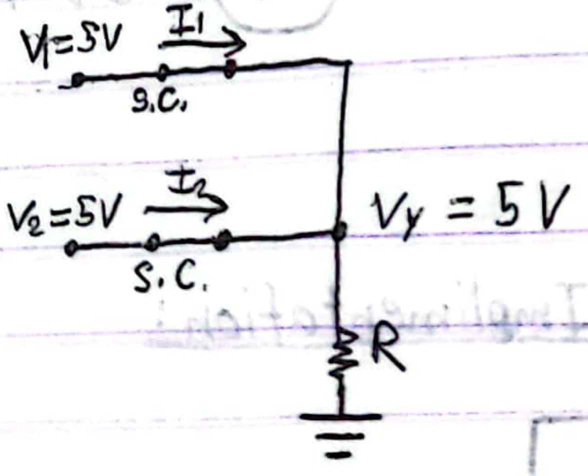
D_1:

$A = 5V$, $C = 0V$, $\therefore D_1 = ON$

D_2:

$A = 5V$, $C = 0V$, $\therefore D_2 = ON$

$\therefore V_y = 5V$

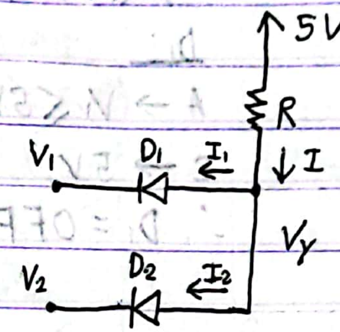


* The resistor, R is called pull down resistor.
* Max Voltage can be found out using this OR gate implementation.

AND operation with Diode :

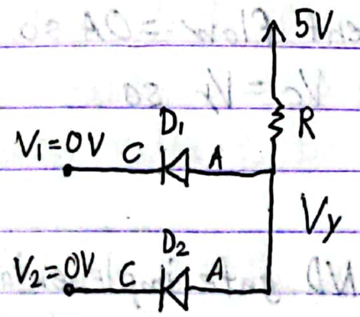
Truth Table :

V_1	V_2	V_y
0V	0V	0V
0V	5V	0V
5V	0V	0V
5V	5V	5V



~~$V_y \leq 5V$~~
~~D_1~~
~~$A \leq 5V,\ C = 0$~~

* E.g : $(V_1 = V_2 = 0V)$



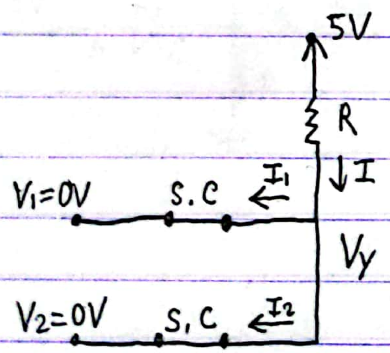
$V_y \leq 5V$

D_1 :

$A \leq 5V$, $C = 0V$, $\therefore$ ON

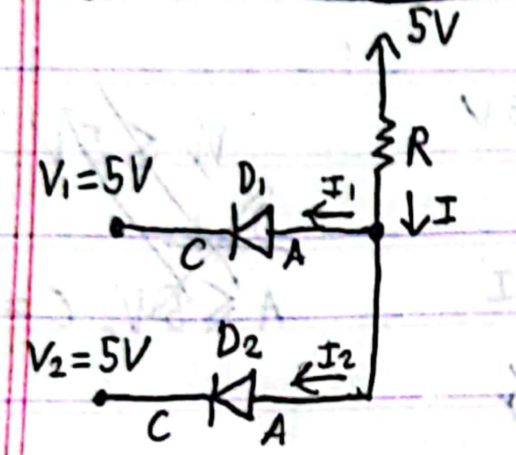
D_2 :

$A \leq 5V$, $C = 0V$, $\therefore$ ON



• Due to the short circuits $V_1 = V_2 = V_y = 0V$

* Eg: $(V_1 = 5V = V_2)$



$V_Y \leq 5V$ for current to flow

D1:

$A \rightarrow V_Y \leq 5V$

$C \rightarrow 5V$

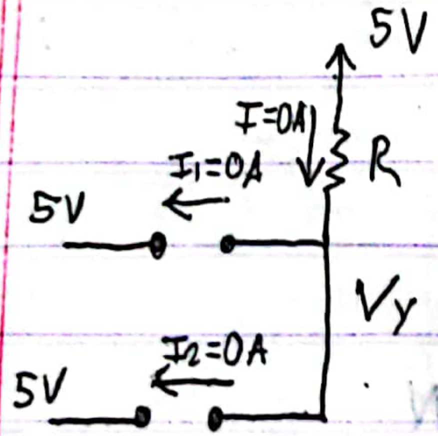
$\therefore D_1 = OFF$

D2:

$A \rightarrow V_Y \leq 5V$

$C \rightarrow$ ~~5V~~ $5V$

$\therefore D_2 = OFF$



- Since D_1 and D_2 are replaced with open circuit, $\therefore$ current flow = 0A so $V_A = V_C = 5V$, Since $V_C = V_Y$ so $V_Y = 5V$.

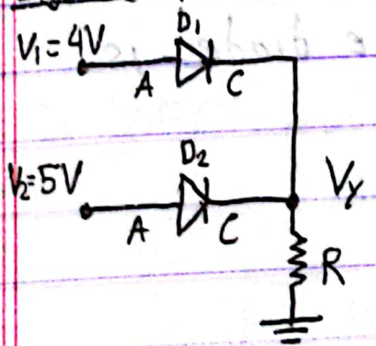
* Min Voltage can be found out using AND gate implementation.
* The resistor, R = Pull up resistor.

* If the voltages connected to the diode is not 0V and 5V then inorder to find if the diodes are ON or OFF, cases need to be solved. For example!

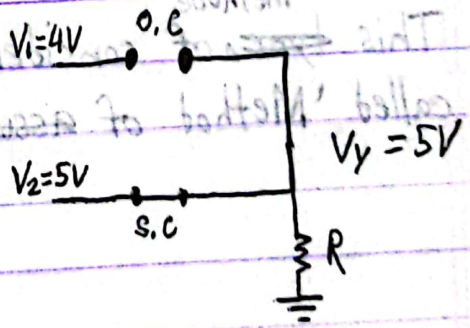
- Case - 1 ; D_1 = ON and D_2 = ON
- " - 2 : D_1 = ON " D_2 = OFF
- " - 3 : D_1 = OFF " D_2 = ON
- " - 4 : D_1 = OFF " D_2 = OFF

* There may be more than 2 diodes for both OR and AND operations.
* In case of OR operation choose the diode connected to the highest voltage to be ON and others to be OFF.
* In case of AND operation choose the diode connected to the lowest voltage to be ~~OFF~~ ON and others to be OFF.

* Eg: ($V_1 = 4V$ and $V_2 = 5V$) (OR)



Consider,
D_1 = OFF
D_2 = ON



$\underline{D_1:}$

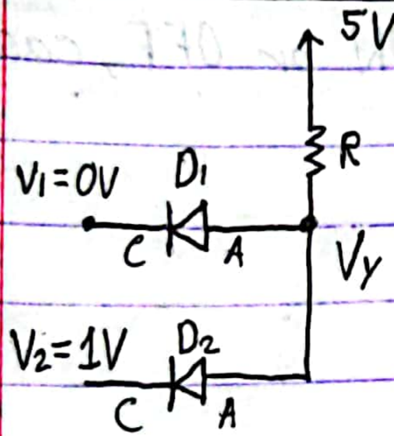
$A \rightarrow V_1 = 4V$

$C \rightarrow V_y = 5V$

$\therefore V_A < V_C$ so OFF

$\therefore$ Consideration was correct

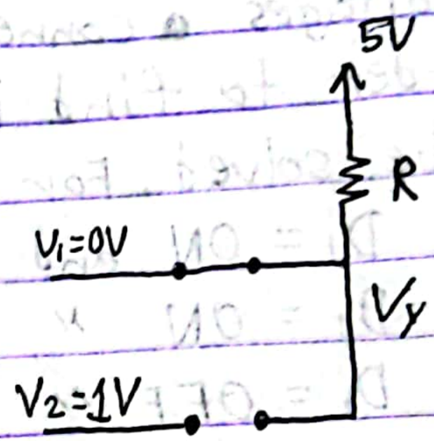
* Eg: ($V_1 = 0V$ and $V_2 = 1V$) (AND)



Consider,

$D_1 = ON$

$D_2 = OFF$



$V_y = V_1 = 0V$

D_2:

$A \rightarrow 0V$

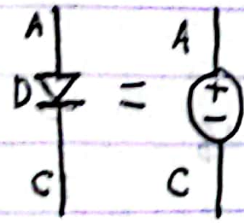
$C = 1V$

$V_A < V_C$, ∴ D_2 is OFF, so the consideration was correct.

* This ~~type~~ methode of considering the states of the diodes is called 'Method of ~~assup~~ Assumption'.

Non-Ideal diode:

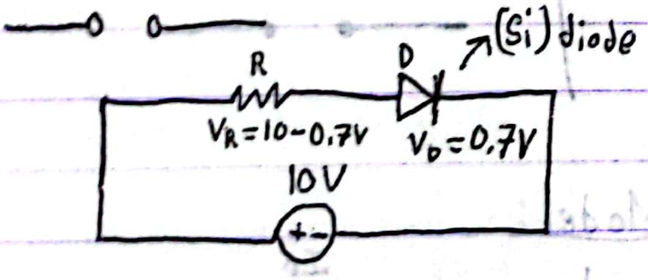
* In real life diode a bit of power is consumed when current flows through it which is proportional to the current that passes through it ($P \propto I_D$). Therefore we can say there is also a small voltage drop across the diode when current passes through it.
* The $P \propto I_D$ of a diode is similar to a voltage source where $P \propto I$.
* So when the diode is in 'ON' mode we can replace it with a V-source.



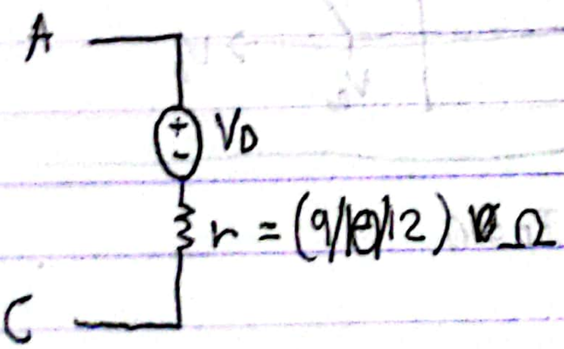
$V_D \approx 0.7V$ for (Si) diodes only

* In 'OFF' mode the diode is still replaced with open circuit.

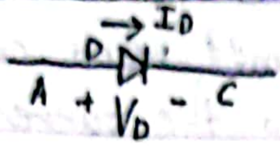
*

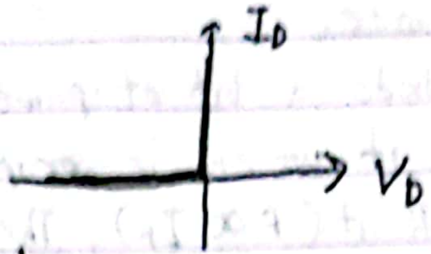


* More accurate model of Diode: (While it is ON)



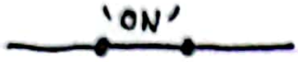
Ideal Diode Model:





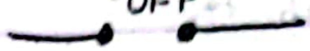
if $I_D > 0$, then $V_D = 0$

'ON'



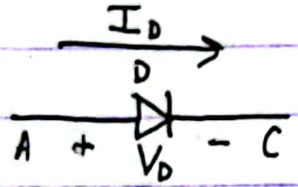
if $V_D < 0$, then $I_D = 0$

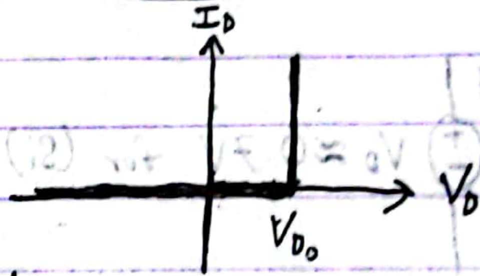
'OFF'



State Eqn

Constant Voltage Drop (C.V.D) model:





if $I_{D_o} > 0$, then $V_D = V_{D_o}$

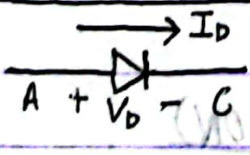
'ON'

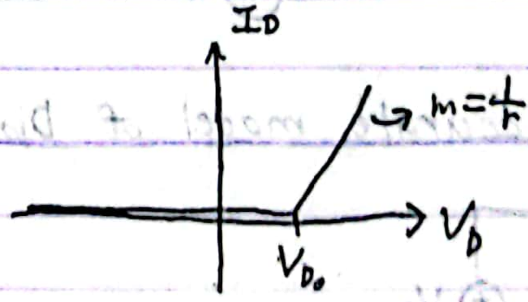
$V_{D_o} \approx 0.7\,V \rightarrow$ (Si) Diode

if $V_D < V_{D_o}$, then $I_D = 0$

'OFF'

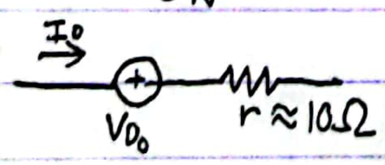
V-Source + Resistance Model:





if $I_D > 0$, then $V_D = V_{D_o} + I_D r$

'ON'



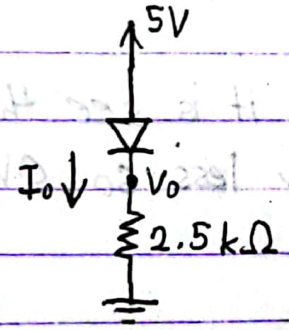
if $V_D < V_{D_o}$ then $I_D = 0$

'OFF'

* V_{D_o} = Cut in voltage

* For faster calculation use Ideal model.
* " accurate " " Voltage + resistance model (C.V.D + r).
* " bit of both " " C.V.D model.
* C.V.D will be used mostly in this course.

* Eg:



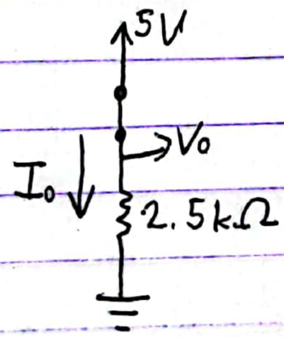
Find V_o and I_o using:

① Ideal diode model

⑪ C.V.D model ($V_{D0} = 0.7V$)

⑪ C.V.D + r model ($V_{D0} = 0.7V$ and $r = 10\Omega$)

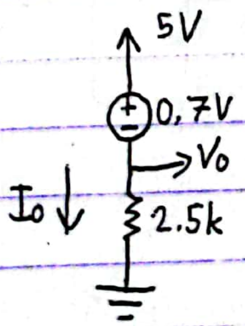
①



$V_o = 5V$

$I_o = \frac{5-0}{2.5} = 2 \text{ mA}$

⑪

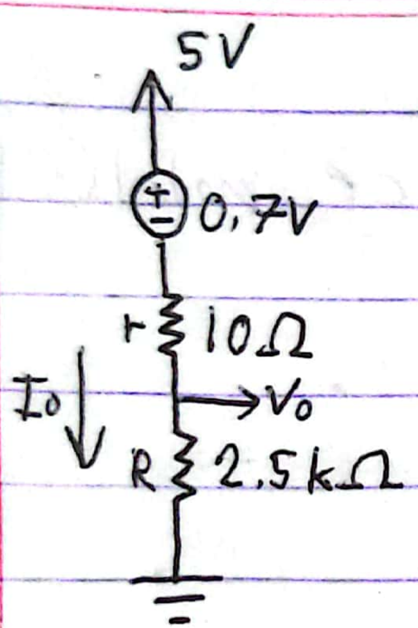


$5 - V_o = 0.7$

$V_o = 4.3V$

$I_o = \frac{4.3-0}{2.5} = 1.72 \text{ mA}$

(iii)



$$K.V.L \Rightarrow 5 = 0.7 + 0.01 I_o + 2.5 I_o$$

$$\Rightarrow I_o = 1.713 \text{ mA}$$

$$\cancel{\therefore V_o = I_o \times R \Rightarrow}$$

$$\therefore V_o - 0 = I_o R$$

$$V_o = 4.283 \text{ V}$$

* By ~~compat~~ comparing CVD and CVD+r models it is see that difference in the calculated values are very less so, CVD and Ideal models will be used mostly.

Real Diode:

* Are semiconductors (Si, Ge, ...)

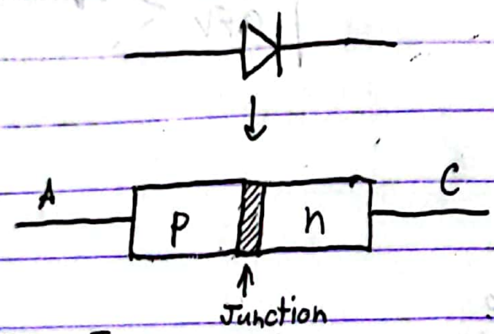
Ease of Current Flow

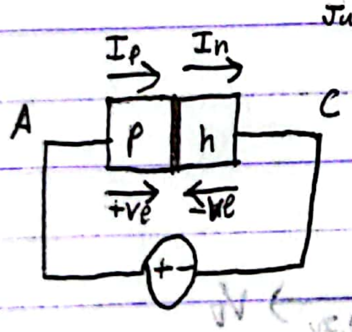
Conductors | Semiconductors | Insulators

Semiconductors → intrinsic (pure) / extrinsic (impure) ← mainly used

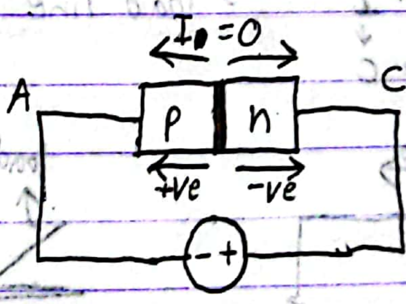
extrinsic → p ⇒ +ve charge carriers (hole) / n ⇒ -ve charge carriers (electron)

P-n Junction Diode:

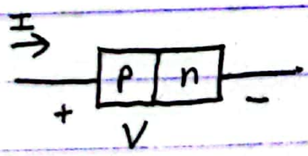


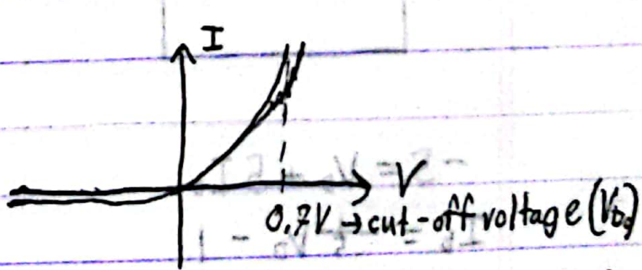


F.B



R.B

* 

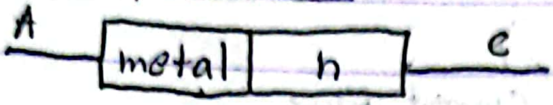


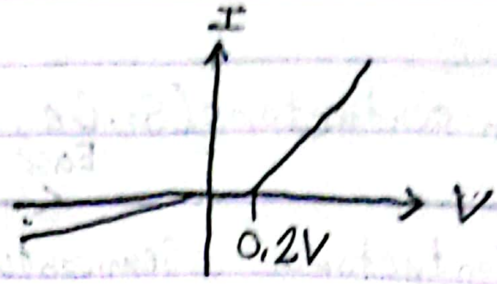
* $I = I_s\left(e^{\frac{V}{V_T}} - 1\right)$, I_s = Reverse saturation current = $10^{-12} \sim 10^{-9}$ A

V_T = Thermal voltage = 0.025 V

- I_s and V_T rises with temperature

Schottky Diode:



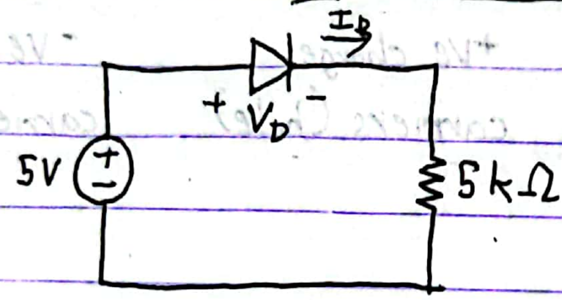


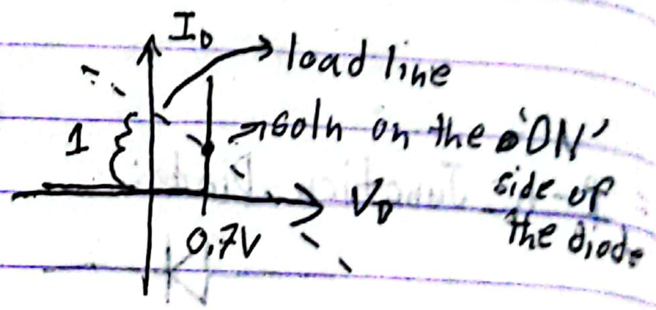
* **Disadvantage**

- Current is not 0 in R.B.

W-4 (L-7) (V-5)

*





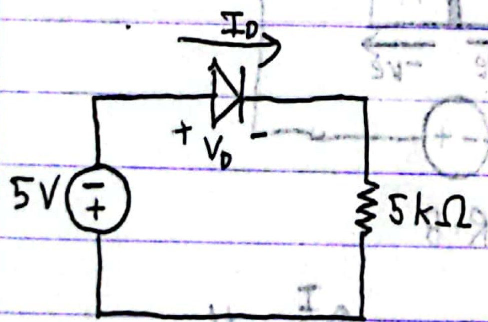
Diode = C.V.D,

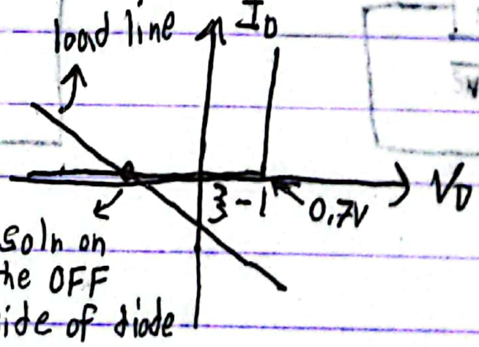
$5 = V_D + 5 I_D$

$I_D = -\frac{1}{5} V_D + 1$ → load line

$y = -\ m x + c$

*





$-5 = V_D + 5 I_D$

$I_D = -\frac{1}{5} V_D - 1$

* This approach works on simple circuits only.
* For complex circuits the Method of assumed state is used if Diode is involved.