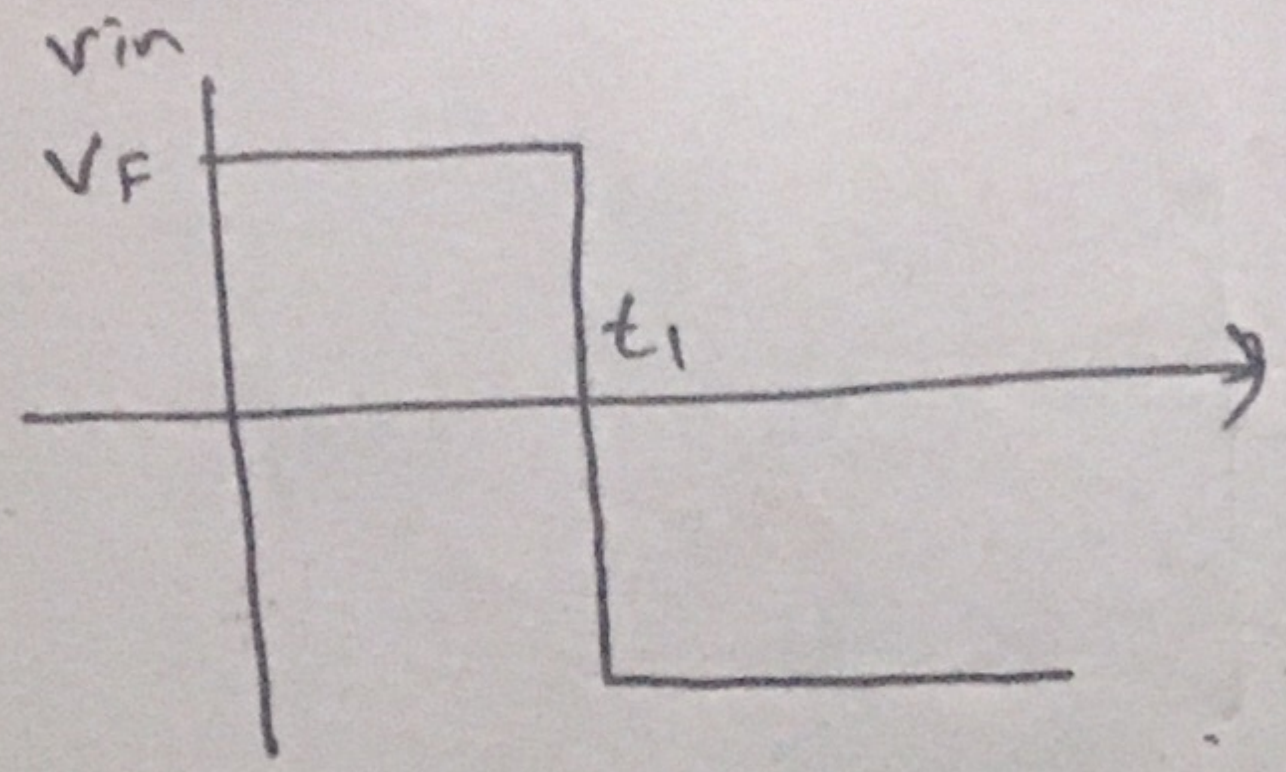
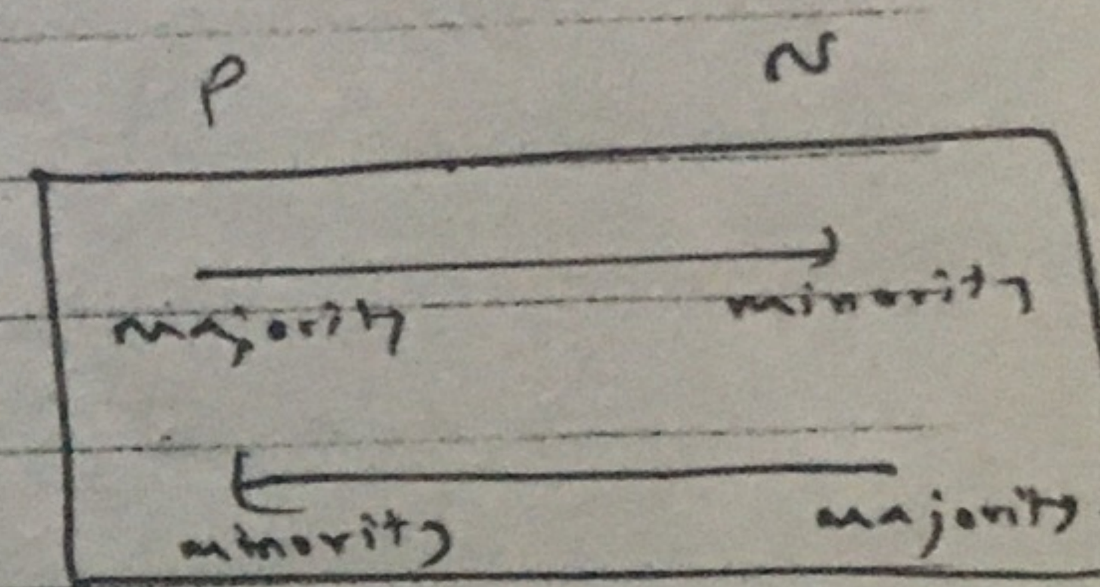
Diode Switching Times (Reverse Recovering Time)

⇒ When a diode is forward biased, it conducts current so, it can be called a ON switch. Similarly, when diode is reversed, it doesn't conduct current so, it can be called OFF switch.

⇒ When a forward biased diode (~~ON Switch~~ ON switch) is suddenly reversed biased, it cannot change it's state from ON switch (conduction state) to off



OFF switch (non- conduction state) instantaneously
Thus, a forward biased takes certain time to be reverse biased when it is suddenly reverse biased. This period of time is called diode switching time or reverse recovery time of diode.



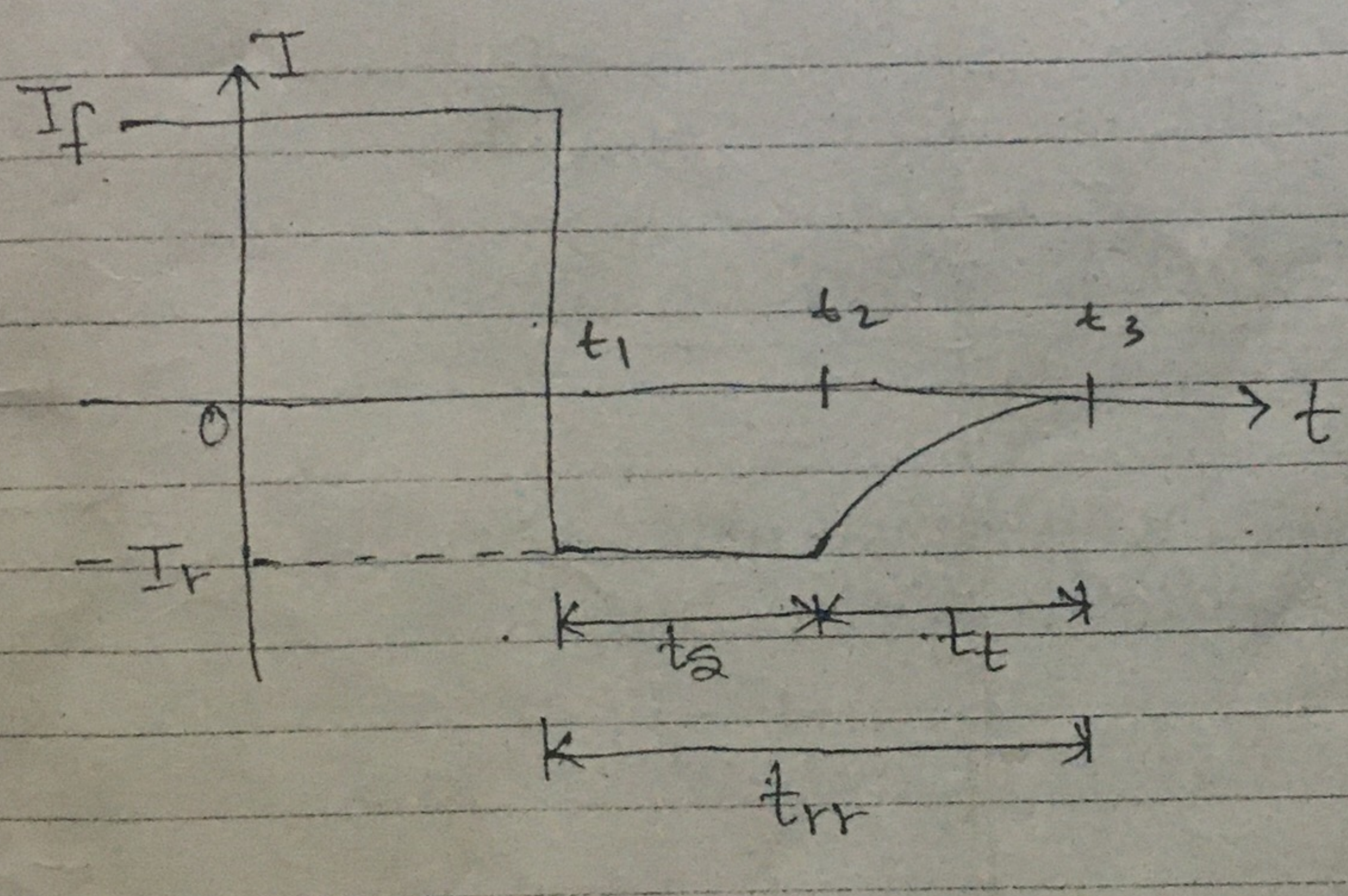


Fig:- Diode switching Times

⇒ When a forward biased diode is suddenly reverse biased, the current simply reverse and flow for certain period of time which is called storage time(t_s).

⇒ After the storage phase has passed, the current decreases gradually and becomes zero to take diode in reverse bias. This period of time is called transition time (t_t).

⇒ Thus, reverse recovering time of diode is the sum of storage time & transition time.

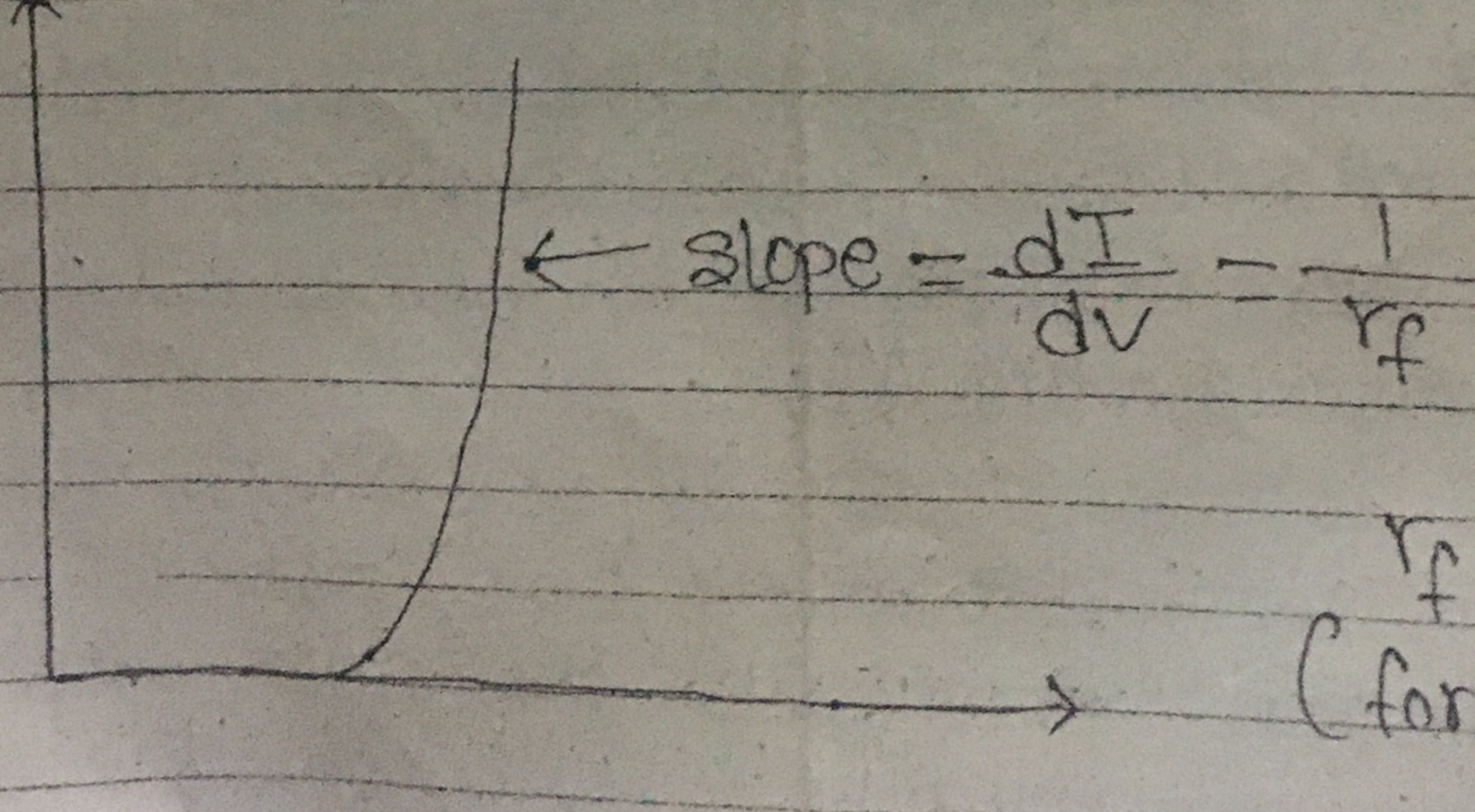
i.e. $t_{rr} = t_s + t_t$

Piecewise Linear Modeling of Diode

⇒ A diode is non-linear device. It's characteristic eqⁿ is given by

$$I = I_s\left(e^{V/\eta V_T} - 1\right) \quad \text{--- (1)}$$

Similarly, the VI-characteristic curve of diode is



$r_f = r_{ac}$
(forward resistance)

⇒ In piecewise linear modeling, we represent the non-linear characteristics of diode by two pieces of straight lines OA and AB as shown in figure below.

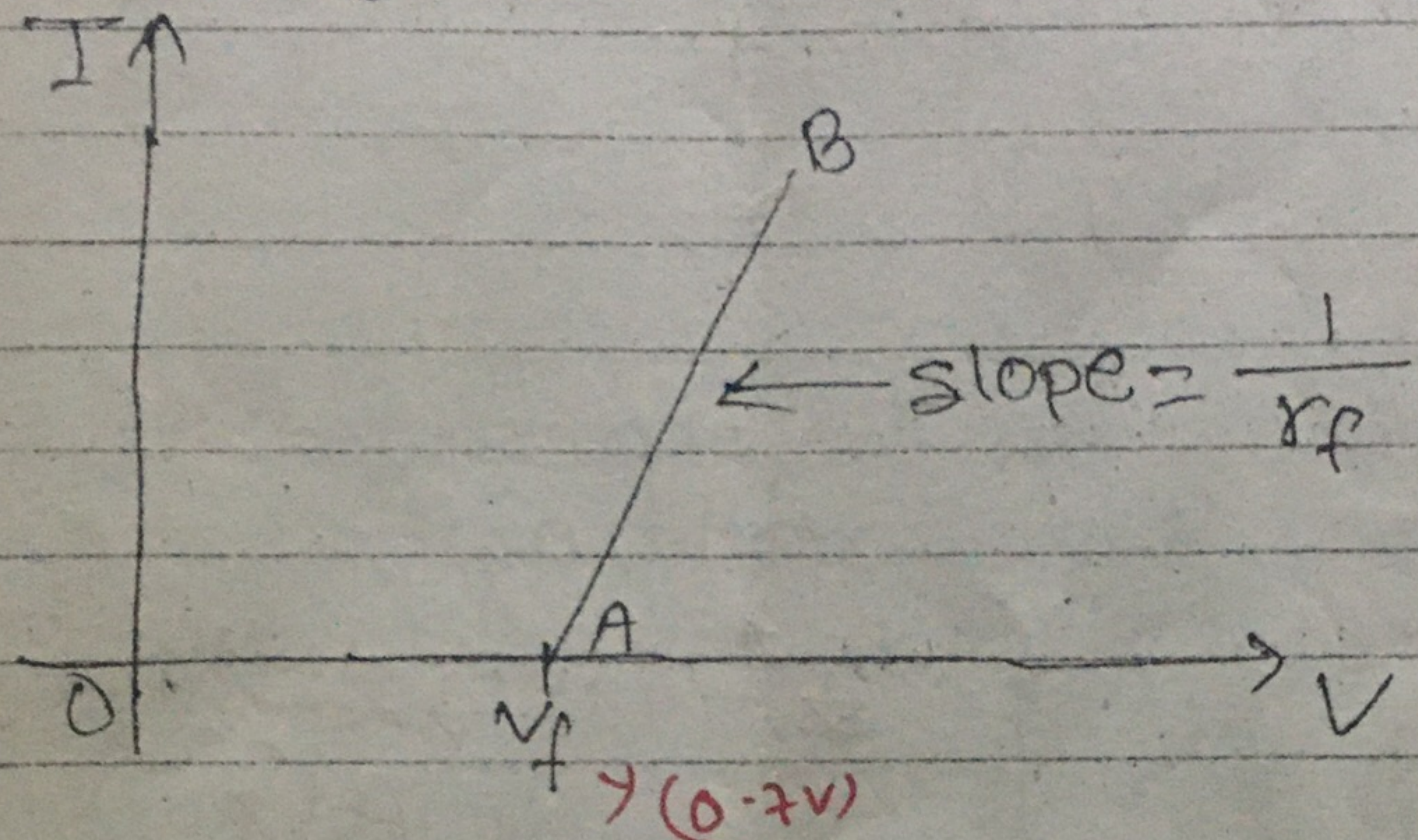


Fig:- Piecewise linear characteristics of diode

Here eq^n of OA = $I = 0$ for $V < V_f$

eq^n of AB = $\frac{V - V_f}{r_f}$ for $V > V_f$ —— (ii)

$I - 0 = \frac{V - V_f}{r_f}$

$\boxed{y - y_1 = m\, x - x_1}$

$I - 0 = \frac{1}{r_f}$

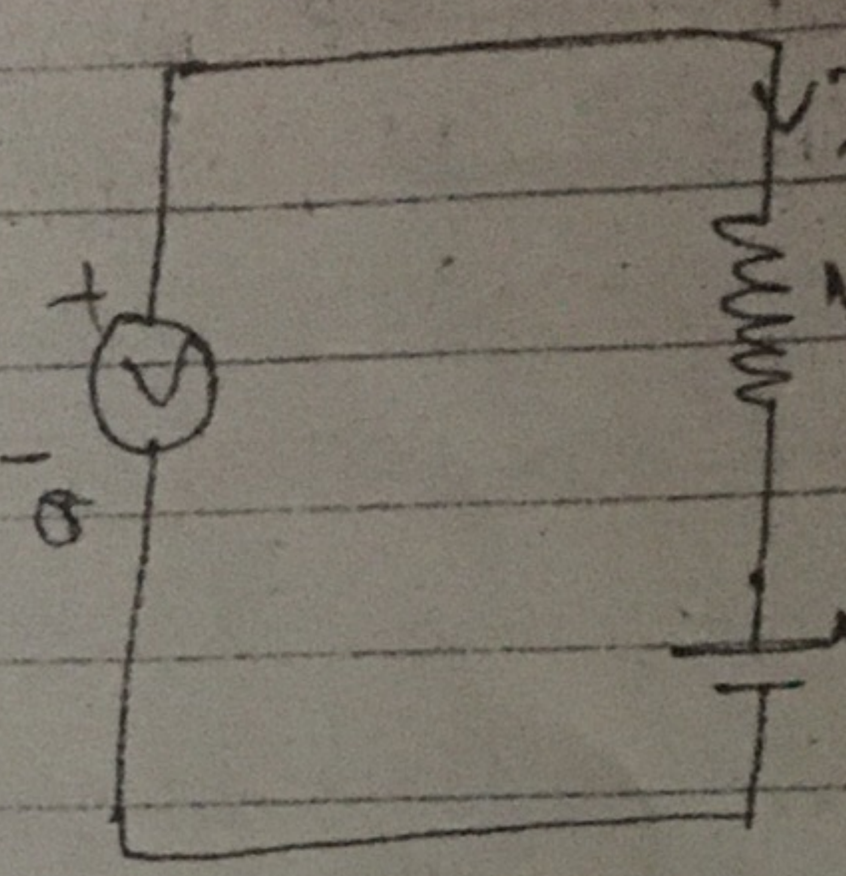
From eq^n (ii)

$$I = \frac{V - V_f}{r_f}$$

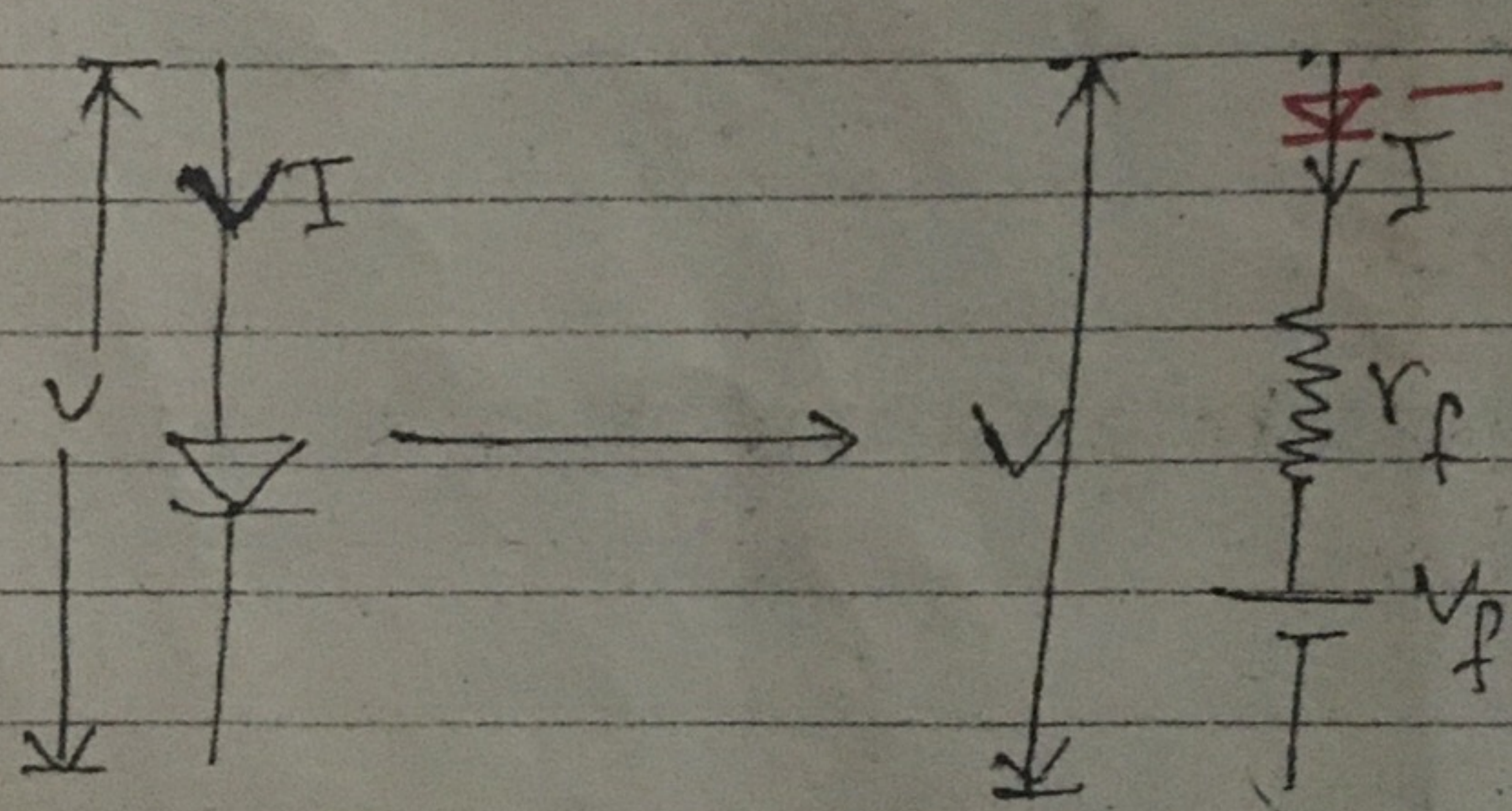
$$r_f \cdot I = V - V_f$$

$$\therefore V = I \cdot r_f + V_f \quad \text{—— (iii)}$$

We can draw the circuit of eq^n. (iii) as



Thus, A diode can be represented in piecewise linear model as:



ideal diode is included show that current flow only in forward direction

Also known as battery + resistance model

where, $r_f = r_{ac}$

$$\boxed{r_f = \frac{\eta V_T}{I}}$$

and, $\boxed{V_f = V - I.r_f}$ from eq^n. (iii)

Q. "Diode is non-linear device." Justify

Q. Find the piecewise linear model of silicon diode with $I_s = 10^{-11}$ A in the vicinity of operating point $I_D = 1$ mA [Take $\eta = 1.6$]

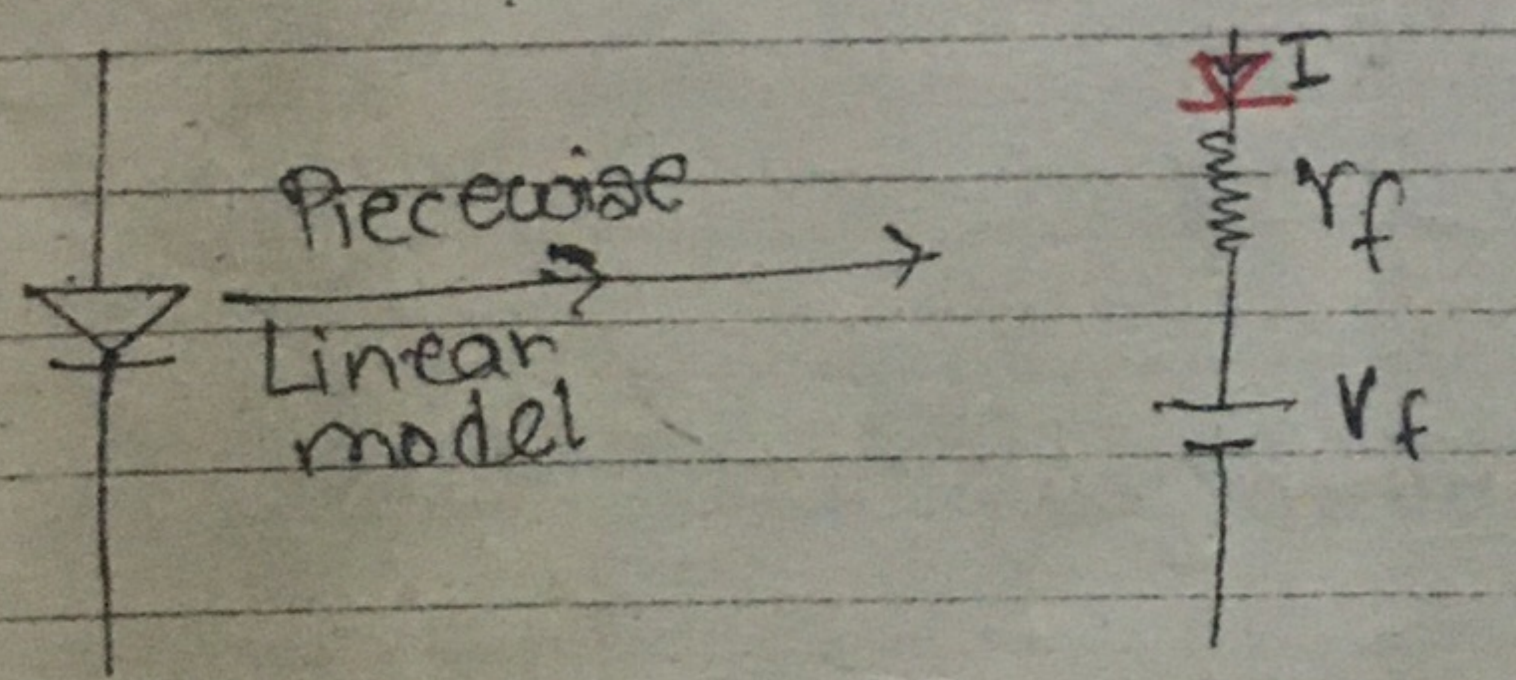
Soln:-

$I_s = 10^{-11}$ A

$I = I_D = 1$ mA $= 10^{-3}$ A

$\eta = 1.6$

The piecewise linear model of diode is:



we know that,

$$r_f = \frac{\eta V_T}{I}$$

$$r_f = \frac{1.6 * 0.026}{10^{-3}} \quad \left[\because V_T = 0.026V \text{ at room temp}\right]$$

$$\therefore r_f = 41.6\ \Omega$$

also,

$$V_f = V - I \cdot r_f \quad \left[\text{If } I_s \text{ not given } V = 0.7V \text{ for Si}\right]$$

This V is VD.

To find V:

$$I = I_s\left(e^{V/\eta V_T} - 1\right)$$

$$10^{-3} = 10^{-11}\left(e^{\frac{V}{1.6 * 0.026}} - 1\right)$$

$$10^{8} + 1 = e^{\frac{V}{1.6 * 0.026}}$$

$$\ln\left(10^{8} + 1\right) = \frac{V}{1.6 * 0.026}$$

$$\therefore V = 0.766\,V$$

Then,

$$V_f = V - I \cdot r_f$$

$$= 0.766 - 10^{-3} * \cancel{43}\ 41.6$$

$$\therefore V_f = 0.724\,V$$

$$\boxed{\text{Note:- If } I_s \text{ is not given then take } V = 0.7V}$$