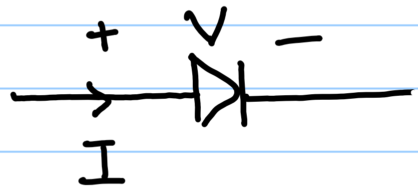
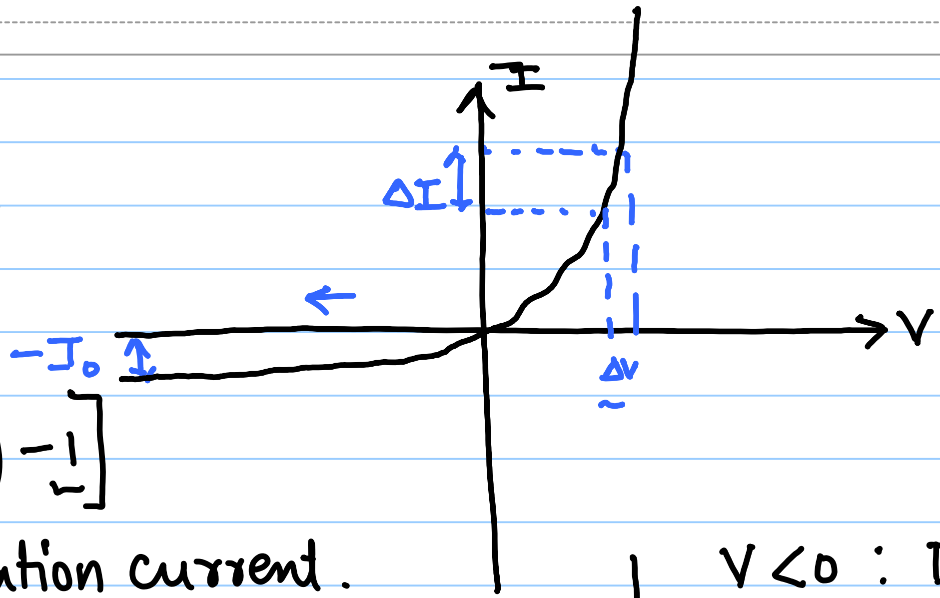
Note Title 06-08-2021

Lecture # 03





$$I = I_o \left[\exp\left(\frac{V}{V_T}\right) - 1 \right]$$

I_o : Reverse saturation current.

V : Potential difference across diode.

V_T : Thermal voltage

$$V_T = \frac{kT}{q} = 25.9 \text{ mV} \ @ \ 300 \text{ K}$$

k : Boltzmann's Constant

T : Temperature in Kelvin

q :

$V < 0$: Diode is reverse biased

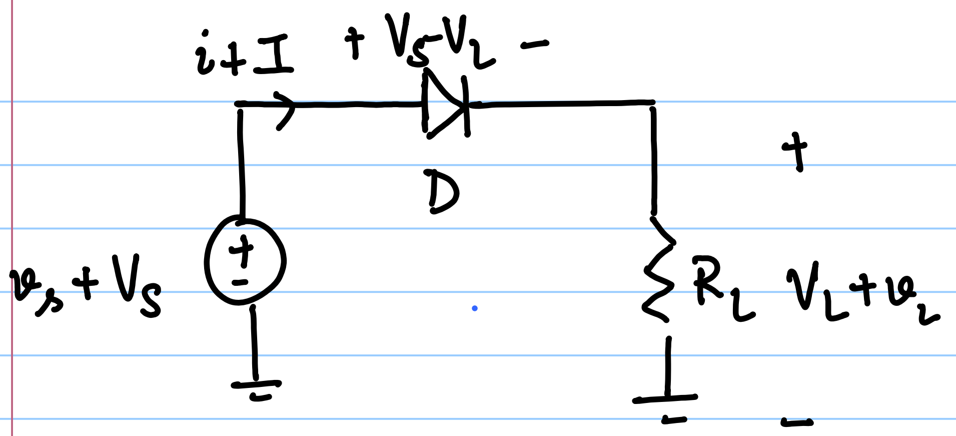
$V \geq 0$: Diode is forward biased.

$$I \approx I_o \exp\left(\frac{V}{V_T}\right)$$

$$V = V_T \ln\left(\frac{I}{I_o}\right)$$

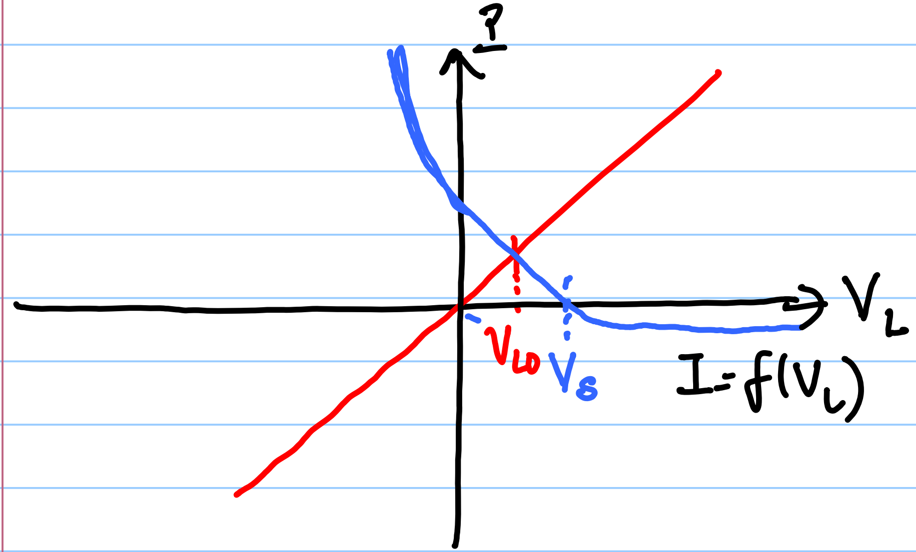
When I changes by 10x

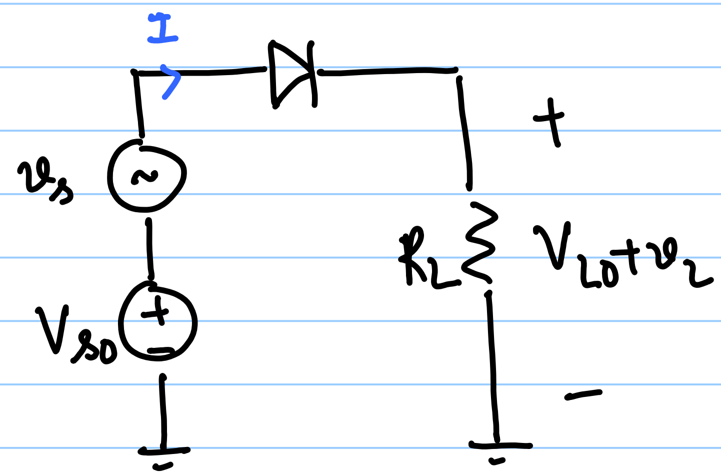
$$\Delta V = V_T \ln(10) = 60 \text{ mV}$$



$$I = I_0\left[\exp\left(\frac{V_S - V_L}{V_T}\right) - 1\right] = \frac{V_L}{R_L}$$

$$I_0\left[\exp\left(\frac{V_{S0} - V_{L0}}{V_T}\right) - 1\right] = \frac{V_{L0}}{R_L} \checkmark$$





$$I + i = I_0\left[\exp\left(\frac{V_{S0} + v_s - V_{L0} - v_L}{V_T}\right) - 1\right] = \frac{V_{L0} + v_L}{R_L}$$

#1. Operating point of non-linear system. V_{S0}, V_{L0} ✓

#2.

$$I = \underbrace{I_0\left[\exp\left(\frac{V_s - V_L}{V_T}\right) - 1\right]}_{f(x)}$$

$$I_b = I_0\left[\exp\left(\frac{V_{s0} - V_{L0}}{V_T}\right) - 1\right]$$

$I_0 = 10^{-14}$ A

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$$= I_0\left[\exp\left(\frac{V_{s0} - V_{L0}}{V_T}\right) - 1\right] + \frac{I_0}{V_T}\exp\left(\frac{V_{s0} - V_{L0}}{V_T}\right) \times \frac{v_s - v_L}{1!}$$

$$+ \frac{I_0}{V_T^2}\exp\left(\frac{V_{s0} - V_{L0}}{V_T}\right) \times \frac{(v_s - v_L)^2}{2!} + \cdots$$

$$= I_b + \frac{I_0 \exp\left(\frac{V_{s0} - V_{L0}}{V_T}\right)}{V_T}(v_s - v_L) +$$

$$\approx I_b + \frac{I_b}{V_T}(v_s - v_L) + \frac{I_b}{V_T^2}\frac{(v_s - v_L)^2}{2!} + \cdots$$

$$I_b + i \approx I_b + \frac{I_b}{V_T}(v_s - v_L)$$

$$I_b + i = I_b + \frac{I_b}{V_T}(v_s - v_L) = I_b + \frac{v_L}{R_L}$$

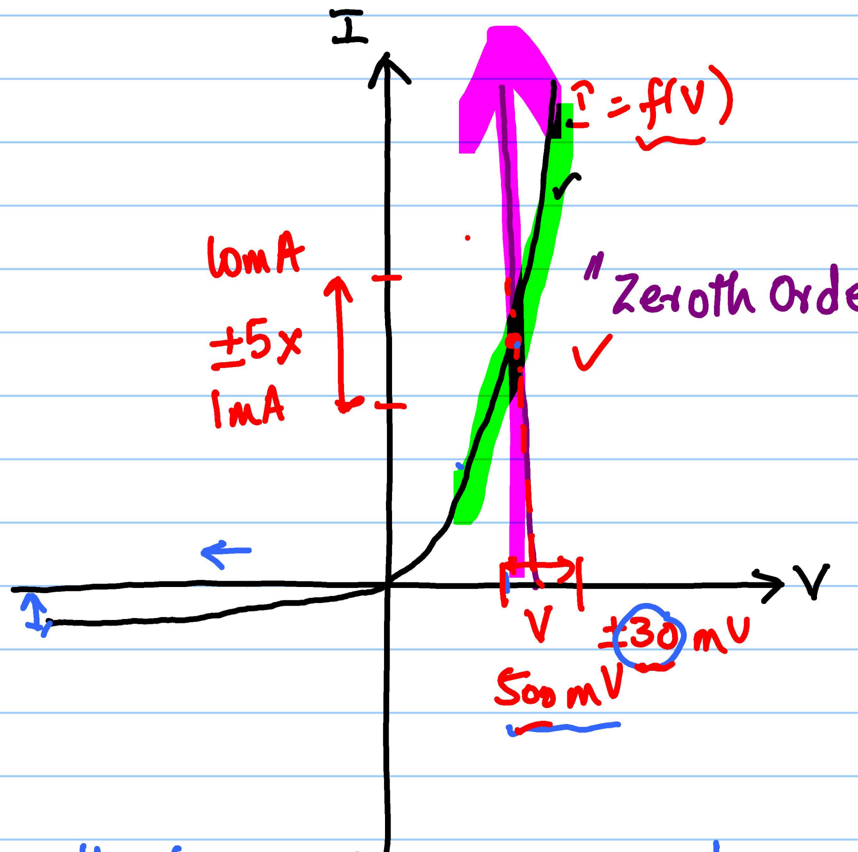
$$\frac{v_s - v_L}{R_D} = \frac{v_L}{R_L}$$

$$v_L = \frac{R_L}{R_L + R_D} v_s$$

$$I = f(v)$$

$$v_L = \frac{R_L}{R_L + \frac{1}{f'(v)}} \times v_s$$

$$R_D = \frac{1}{f'(\ )}$$



$$I = I_0 \left[\exp\left(\frac{V}{V_T}\right) - 1 \right]$$

\+ v −

—▷|—

Ex: $V = 500$ mV, $I = 1$ mA

$$\exp\left(\frac{V}{V_T}\right) = \exp\left(\frac{500}{25}\right)$$

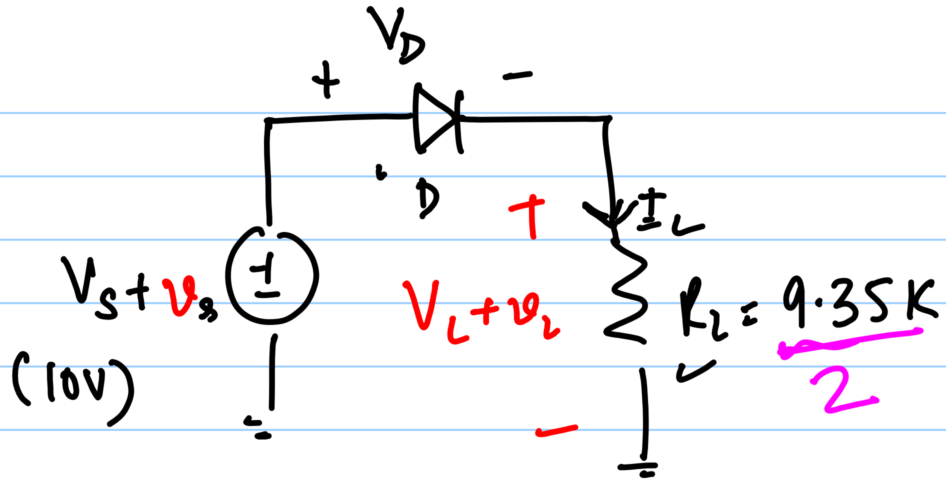
$$= 4.8 \times 10^8$$

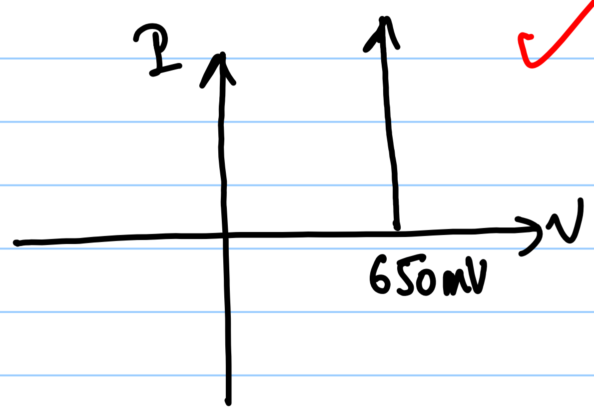
Small change in voltage ⇒ large change in current.

I: 1mA → 10 mA

$V = 60$ mV.

$$e^{\left(\frac{550}{25}\right)} = 35 \times 10^8$$





$$I_L = \frac{V_S - V_D}{R_L}$$

$$= \frac{10 - 0.65}{9.35K} = 1mA, \quad V_L = 9.35V$$

V_D : 0.65V

I :	V_D = 0.650 V
1mA	0.650 V ✓
2mA	—

Ex

$$I = \frac{10 - 0.65}{9.35/2} = 2mA$$

$$V = V_T \ln\left(\frac{I}{I_0}\right)$$

$$0.650 = 0.025 \ln\left(\frac{I}{I_0}\right) \xrightarrow{I \to 2I} \Delta V = 0.025 \ln(2) = 17.3mV$$