

$$N_D = 10^{15}$$

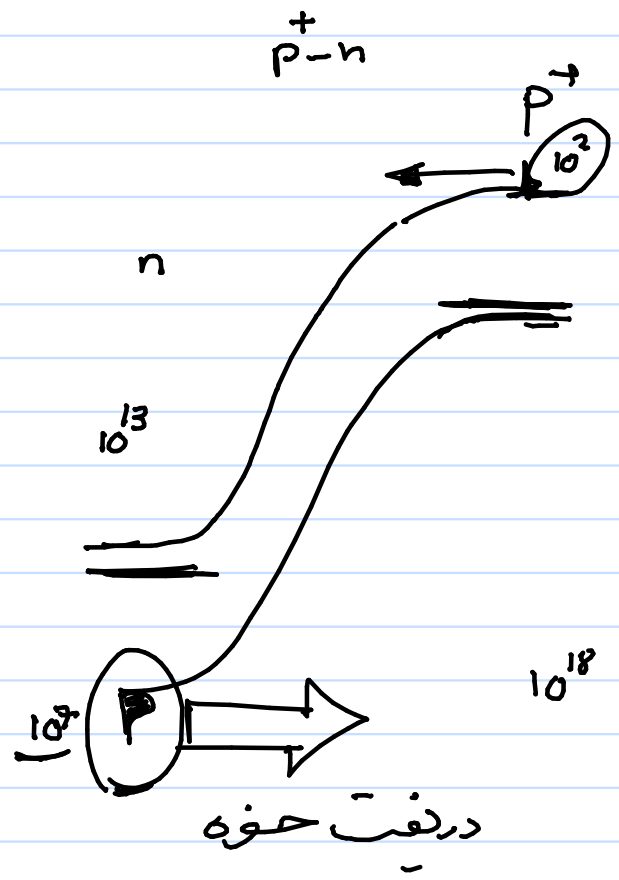
$$\theta = 20 \rightarrow 40$$

$\sqrt{n} = N_D = 10^{15} \Rightarrow n_i$

$n_p = n_i^2$

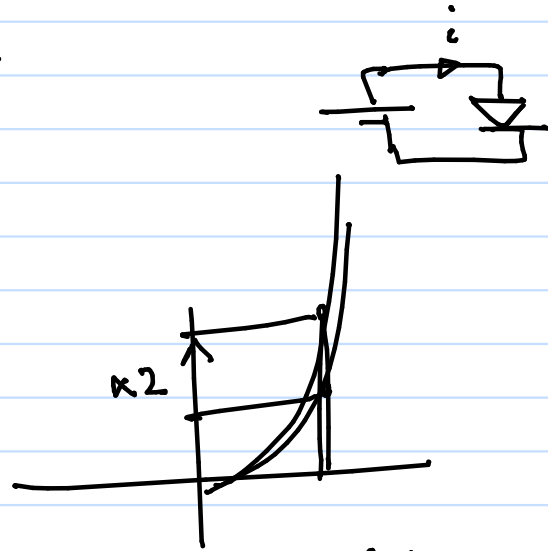
$n_p = n_i^2$

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$$\frac{i(\theta_1)}{i(\theta_2)} \Big|_{V=cte} = 2^{\frac{\theta_1 - \theta_2}{10}}$$

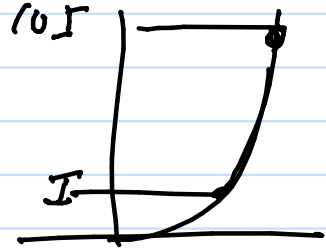
$$I_s \propto n_i^2 \propto e^{-\frac{E_g}{kT}}$$



$$I = I_s e^{\frac{V}{V_{th}}}$$

$$10I = I_s e^{\frac{V}{V_{th}}} e^{\frac{\Delta V}{V_{th}}}$$

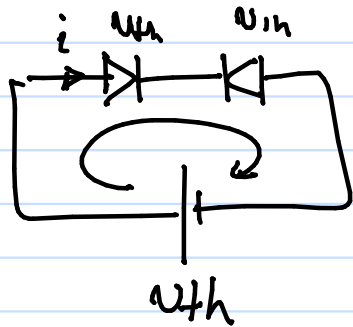
$$10 = e^{\frac{\Delta V}{V_{th}}} \rightarrow \Delta V = V_{th} \ln 10 = 60 \text{ mV}$$

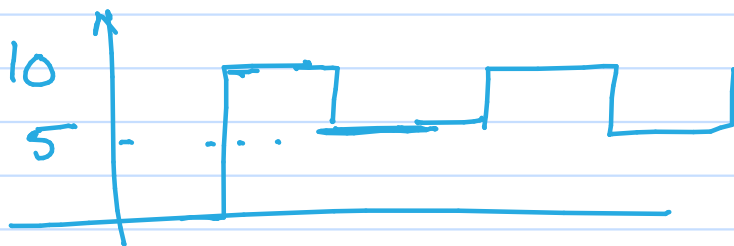
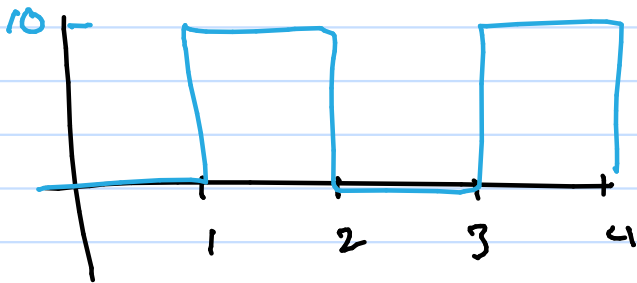
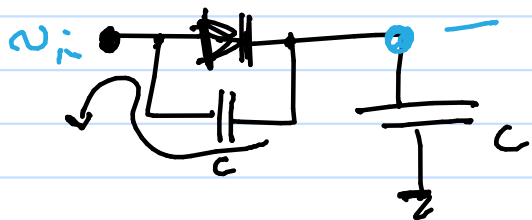


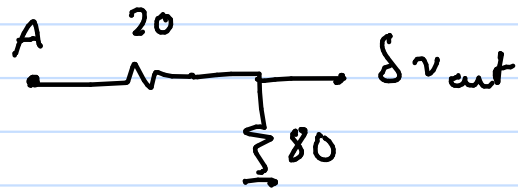
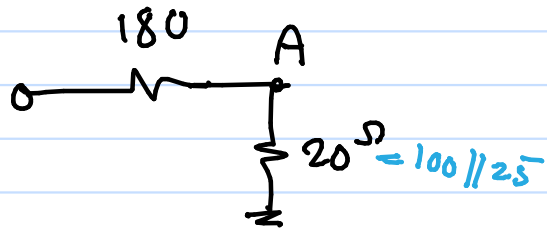
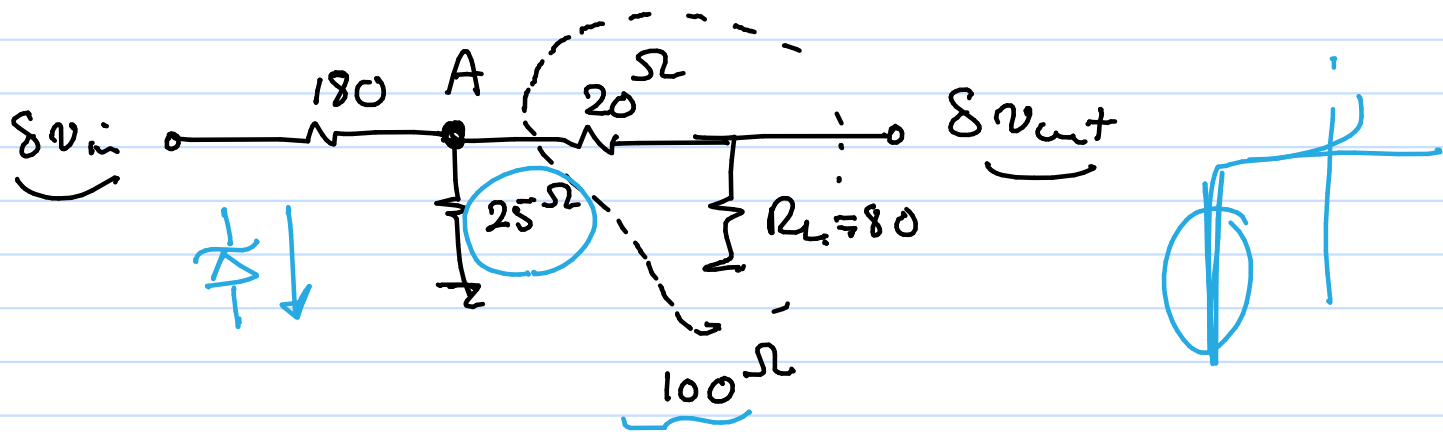
$$v_{th} = v_{th} \ln \left(\overbrace{\left(\frac{i}{I_s} + 1 \right)}^x \right) - v_{th} \ln \left(\overbrace{\left(\frac{-i}{I_s} + 1 \right)}^x \right)$$

$$1 = \ln \left(\frac{x+1}{-x+1} \right) \rightarrow \frac{x+1}{-x+1} = e$$

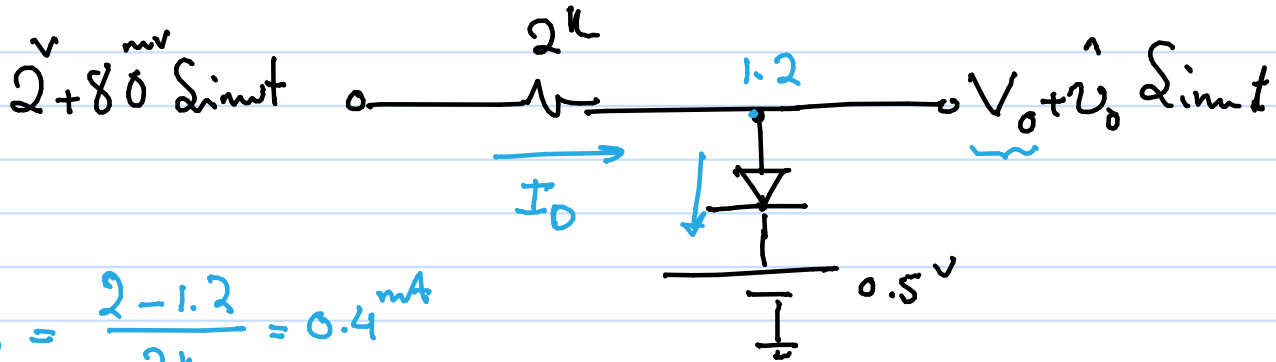
$$x = \frac{e-1}{e+1} = \frac{i}{I_s}$$





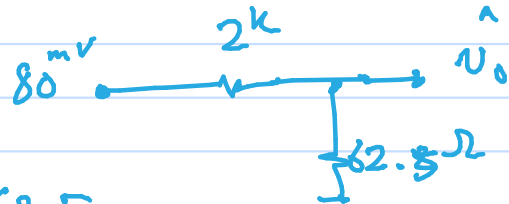


$$\frac{\Delta v_{out}}{v_{in}} = \frac{20}{180+20} \times \frac{80}{80+20} = \frac{16}{200} = \frac{8}{100}$$



$$I_D = \frac{2 - 1.2}{2k} = 0.4 \text{ mA}$$

$$r_d = \left(\frac{10k\Omega}{I_D} \right) = 62.5 \Omega$$

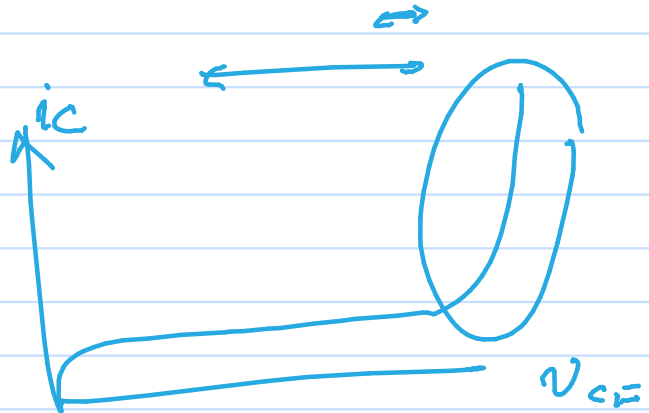


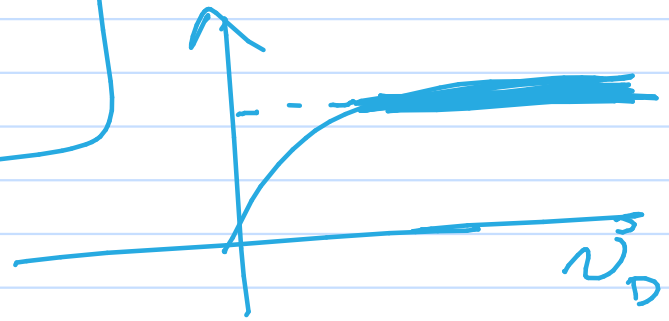
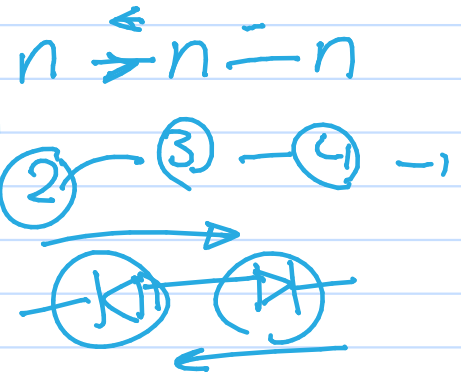
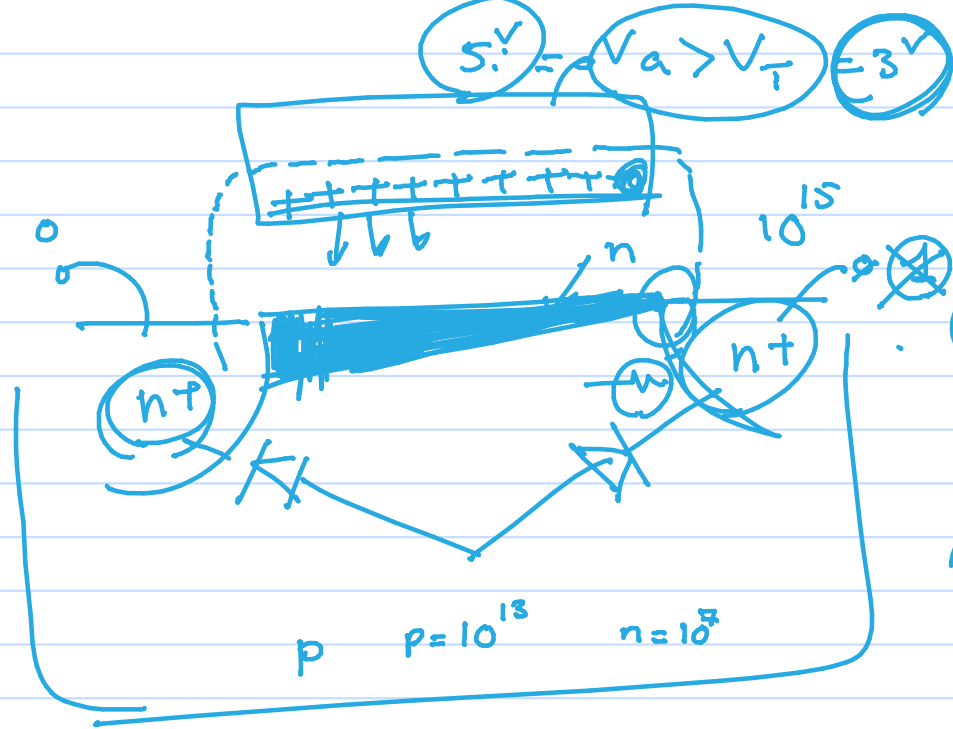
$$\hat{v}_o = 80 \text{ mV} \times \frac{62.5}{2062.5}$$

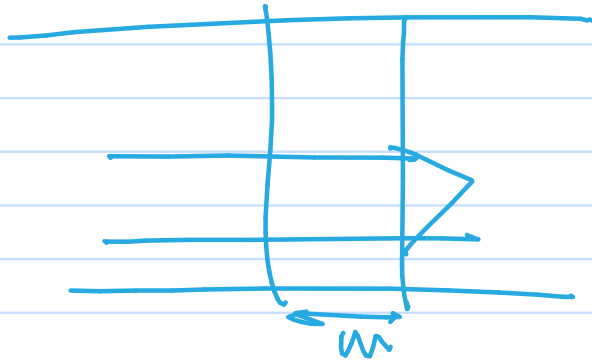
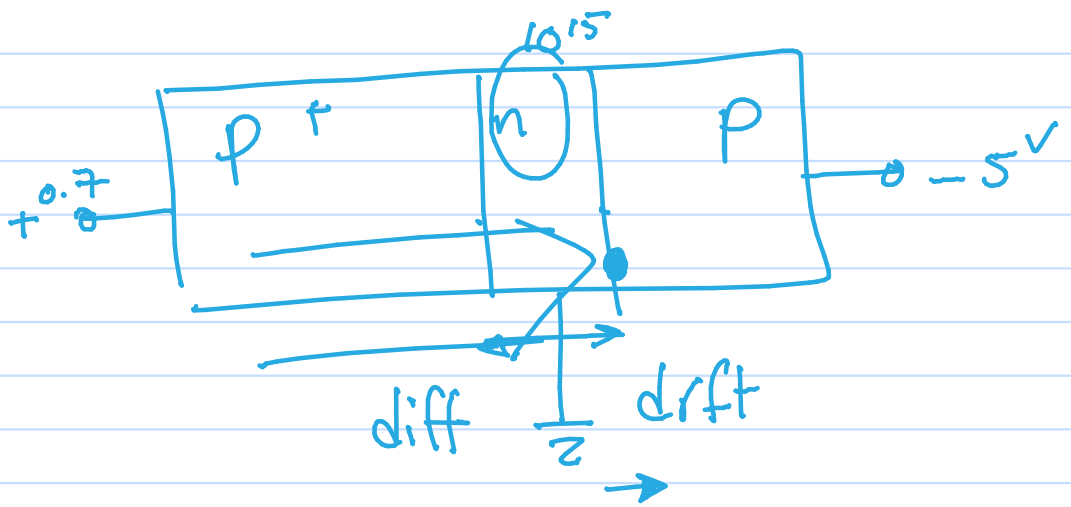
$$\hat{v}_o = 2.42 \pm 0.02$$

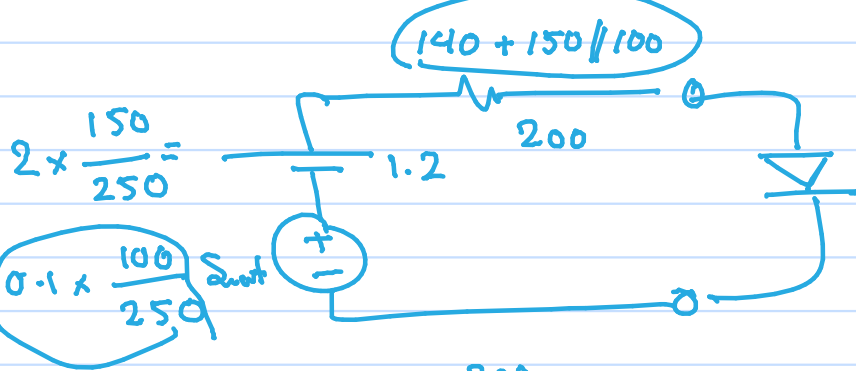
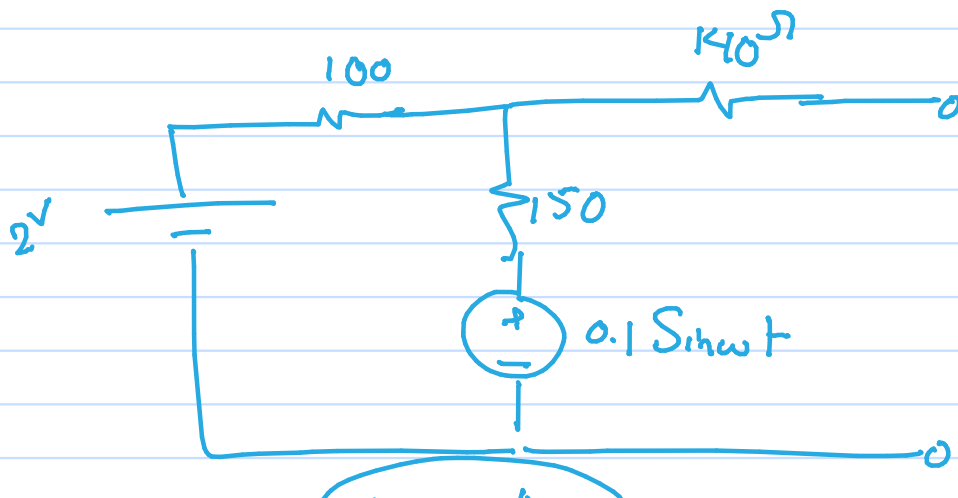


C









$$1.2^V = 200 \times i + V_T \ln\left(\frac{i}{10^{-6}} + 1\right)$$

0.6

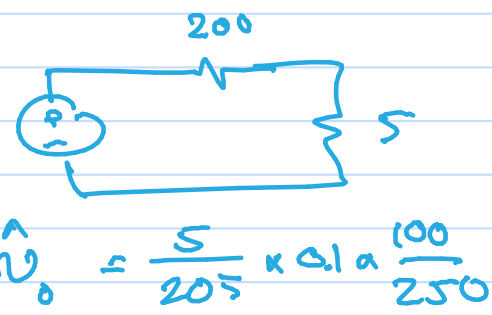
0.2

0.21

$$i = 3 \text{ mA}$$

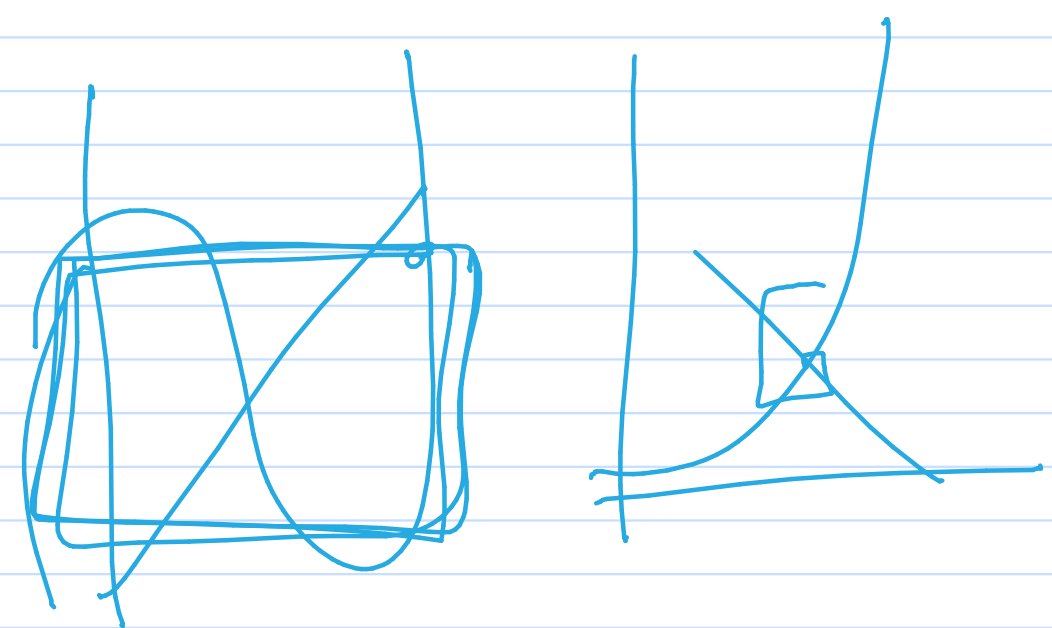
$$i = 5 \text{ mA}$$

$i = 5 \text{ mA}$



$$r_d = \frac{V_{th}}{i} = \frac{25}{5} = 5 \Omega$$

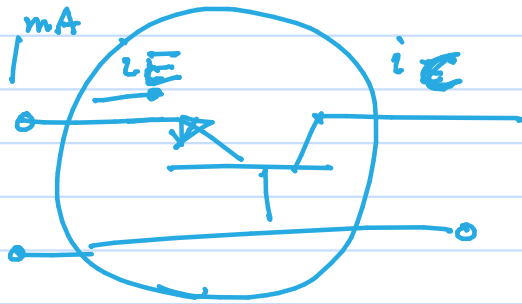
$$\hat{V}_0 = \frac{5}{205} \times 0.1 \times \frac{100}{250}$$



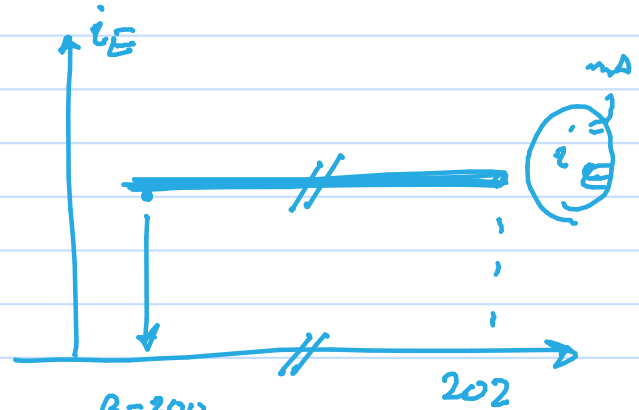
$$\frac{i_E}{i_C} = \frac{\beta}{1+\beta} \approx \alpha$$

$$i_E = i_C + i_B$$

$$i_C = \beta i_B$$

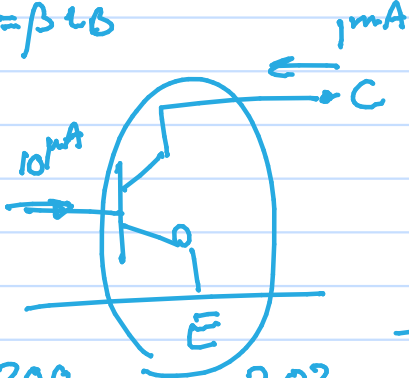


$$\alpha =$$



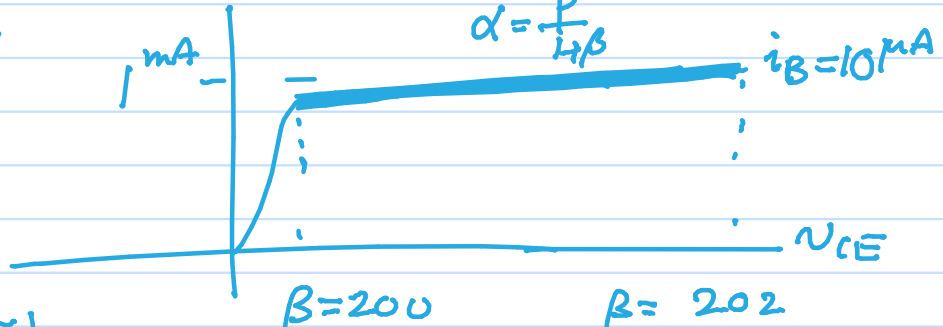
$$\beta = 200$$

$$\alpha = \frac{\beta}{1+\beta}$$



$$\alpha = \frac{200}{201} \approx 1$$

$$\frac{202}{203} \approx 1$$



$$\beta = 200$$

$$\beta = 202$$

$$\alpha \approx 1$$

$$\beta (V_C)$$

