1.

$\mu_n(I)$ has these components:

a) - lattice scattering

b) - impurity scattering

c) - carrier carrier scattering

d) - interface scattering

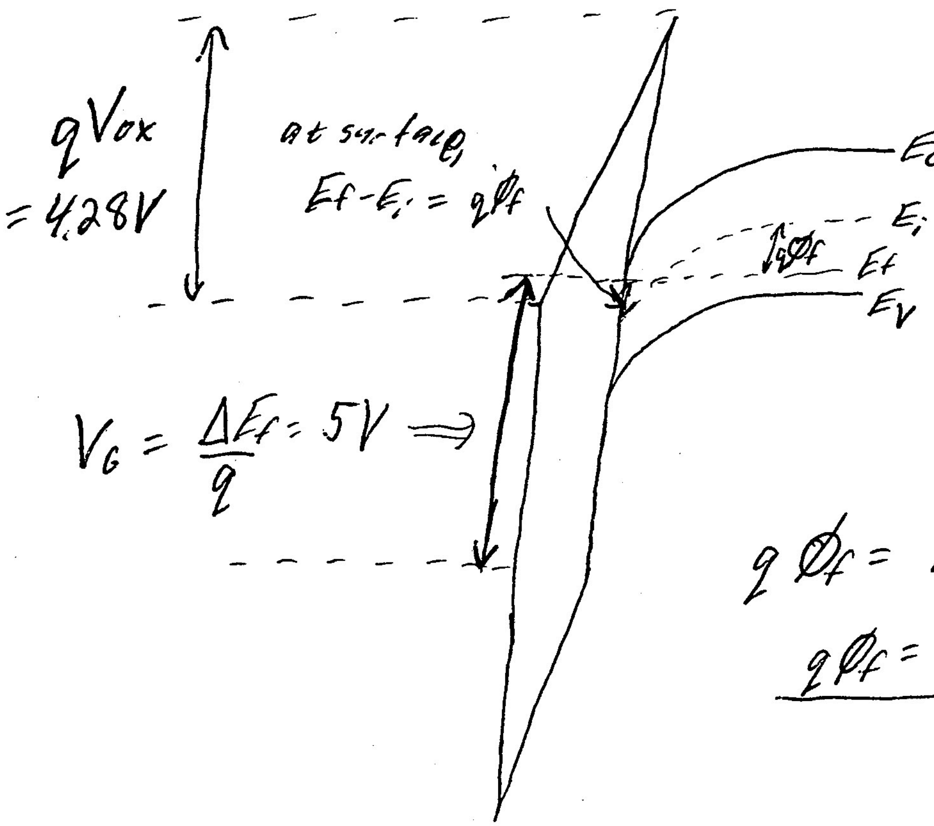
$\mu_n(I) > \mu_n(II) > \mu_n(III)$

$\Downarrow$ more of c) + d) than I

$\Downarrow$ more of b + c + d than I

more b than II

② Band Diagram "a"



$q\phi_f = kT \ln\left(\frac{N_a}{n_i}\right)$

$\underline{q\phi_f = .36\,eV}$

This is a band diagram of the transistor in <u>inversion</u>. ∴ ϕ_s, the surface potential, is equal to $2\phi_f$

$\phi_s = 2\phi_f = .72\,V$

qV_{ox} = Voltage dropped across oxide

$= V_g - \phi_s = 5V - .72V$

$qV_{ox} = 4.28V$

b.) Find Id

First we need to find the threshold voltages and channel length for the transistor

i.) $t_{ox_1} = 400\text{Å}$ $L_{eff_1} = 10\mu m - .3\mu m$
$= 9.7\mu m$

$$V_T = 2\phi_f + \frac{t_{ox}}{\epsilon_{ox}}\sqrt{2q\epsilon_{Si}N_a 2\phi_f}$$

$\phi_f = .36V$
$N_a = 10^{16}cm^{-3}$
$\epsilon_{Si} = 11.7\epsilon_0$
$\epsilon_{ox} = 3.9\epsilon_0$

$$= .72 + t_{ox}(1.42\times10^5)$$

$\underline{V_{T_1} = 1.30V}$

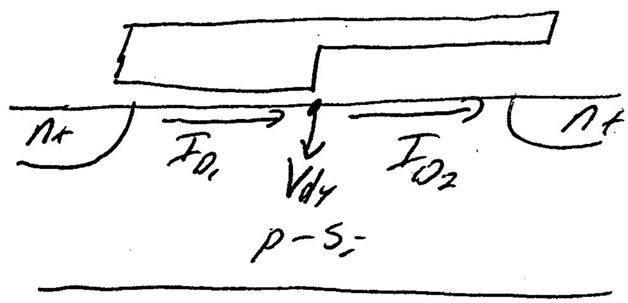
ii.) $t_{ox_2} = 800\text{Å}$ $L_{eff_2} = 10\mu m - .3\mu m$
$= 9.7\mu m$

$\underline{V_{T_2} = 1.86V}$

Since L is long + $V_D \ll V_{Dsat}$, the square law can be applied with reasonable accuracy.

The currents in each half of the channel must be equal. Therefore

$$I_{D_1} = I_{D_2}$$



We will introduce an intermediate voltage, V_{dy}, as the voltage at the border between the two transistor halves.

$$I_{D_1} = \frac{Z\mu_n C_{ox_1}}{L_{eff_1}}\left[(V_G - V_{T_1})V_{dy} - \frac{V_{dy}^2}{2}\right]$$

$$I_{D_2} = \frac{Z\mu_n C_{ox_2}}{L_{eff_2}}\left[(V_G - V_{T_2})(V_D - V_{dy}) - \frac{(V_D - V_{dy})^2}{2}\right]$$

letting Z, μ_n be equal in both halves of the transistor,

$$\frac{C_{ox_1}}{L_{eff_1}}\left[(V_G - V_{T_1})V_{dy} - \frac{V_{dy}^2}{2}\right] = \frac{C_{ox_2}}{L_{eff_2}}\left[(V_G - V_{T_2})V_D - (V_G - V_{T_2})V_{dy} - \frac{V_D^2}{2} + V_{dy}V_D - \frac{V_{dy}^2}{2}\right]$$

Plugging in the appropriate values, we get

$$8.1\,V_{dy}^2 - 204\,V_{dy} + 9.1 = 0$$

$$\underline{V_{dy} = .045\ V}$$

Now we can plug V_{dy} into either equation I_{D_1} or I_{D_2} to find I_D. For simplicity, let's use I_{D_1}.

$$I_D = \frac{Z \mu_n C_{ox_1}}{L_1}\left[(V_G - V_{T_1})V_{dy} - \frac{V_{dy}^2}{2}\right]$$

$$I_D = (1.25 \times 10^{-4})(.165\ V)$$

$$\boxed{I_D = 21\,\mu A}$$