EE473/538 CAD Lab1
Due Tuesday, Jan. 25th, 2022

1.15 An NMOS transistor has parameters $W = 10\ \mu m$, $L = 1\ \mu m$, $k' = 194\ \mu A/V^2$, $\lambda = 0.024\ V^{-1}$, $t_{ox} = 80$ Å, $\phi_f = 0.3$ V, $V_{t0} = 0.6$ V, and $N_A = 5 \times 10^{15}$ atoms/cm^3. Ignore velocity saturation effects.

(a) Sketch the I_D-V_{DS} characteristics for V_{DS} from 0 to 3 V and $V_{GS} = 0.5$ V, 1.5 V, and 3 V. Assume $V_{SB} = 0$.

(b) Sketch the I_D-V_{GS} characteristics for $V_{DS} = 2$ V as V_{GS} varies from 0 to 2 V with $V_{SB} = 0$, 0.5 V, and 1 V.

The NMOS transistor drain current in saturation is modeled as $I_D = \frac{k'}{2}\frac{W}{L}(V_{GS} - V_t)^2(1 + \lambda V_{DS})$.

The drain current in triode region is modeled as $I_D = k'\frac{W}{L}\left[(V_{GS} - V_t - \frac{V_{DS}}{2})V_{DS}\right](1 + \lambda V_{DS})$.

Device parameters are $k' = 194\mu A/V^2$, $W = 10\mu m$, $L = 1\mu m$, and $\lambda = 0.024V^{-1}$.

Given $V_{SB} = 0$, the threshold voltage is simplified to $V_t = V_{t0} = 0.6V$. The drain current is rewritten with the above parameters such that $I_D = 0.97 \cdot 10^{-3}(V_{GS} - 0.6)^2(1 + 0.024V_{DS})$. This can be further simplified to $I_D \approx (V_{GS} - 0.6)^2 mA$ for this V_{GS} sweep.

At $V_{GS} = 0$, the device is turned off.

At $V_{GS} = 1.5, 3V$ the device first enters the triode region, then moves to saturation when $V_{GS} - V_t \leq V_{DS}$.

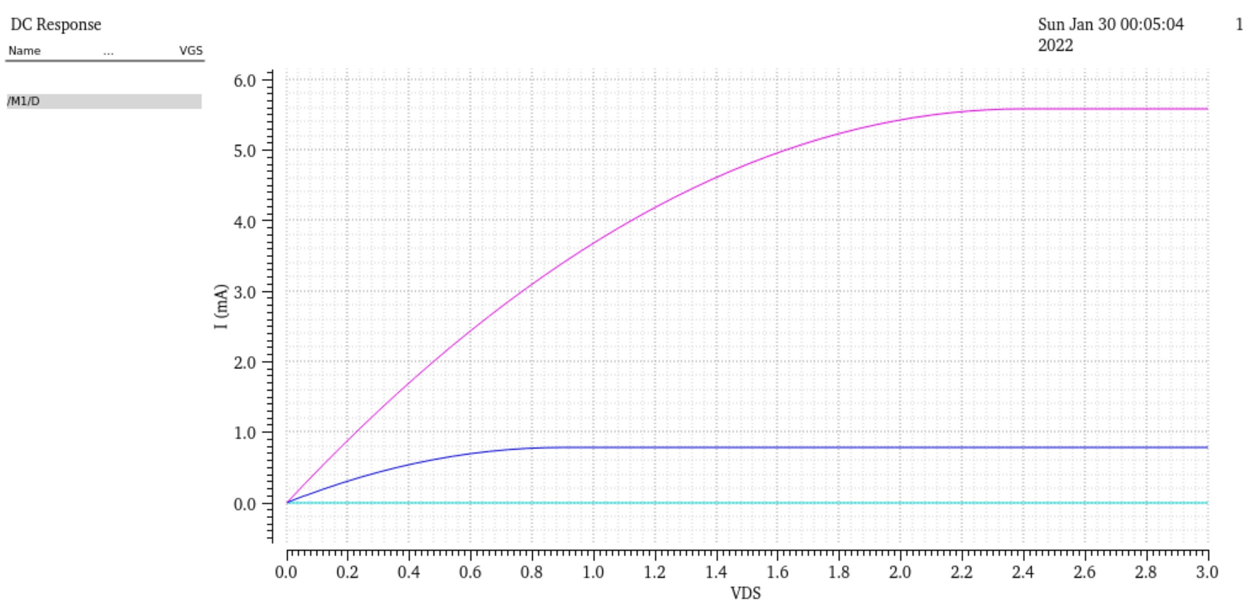

Figure 1: NMOS Drain Current: VGS=[0.5, 1.5, 3]V

The body voltage is no longer neglected. The threshold voltage is modeled as
$V_t = V_{t0} + \gamma(\sqrt{2\phi_f + V_{SB}} - \sqrt{2\phi_f}) \geq 0.6V$.

The drain currents will be less than the previous plots for the same values of V_{GS}.

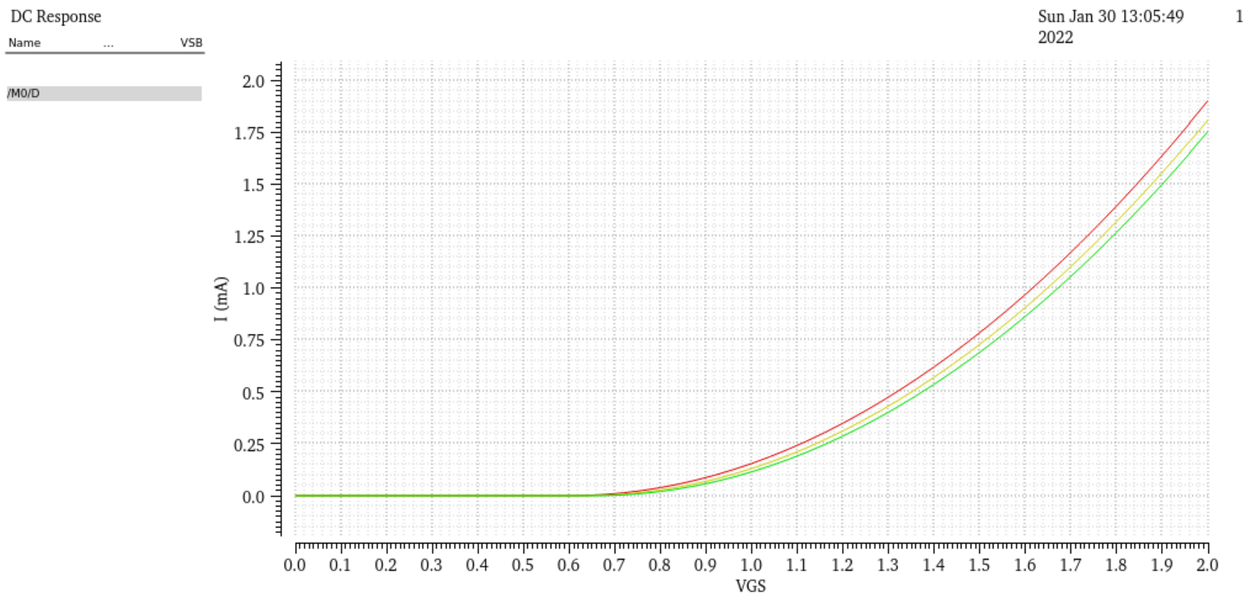

Figure 2: NMOS Drain Current: VSB=[0, 0.5, 1]V