Solutions EE466: Homework 1

1.

2.2 In (a), the transistor sees $V_{gs} = V_{DD}$ and $V_{ds} = V_{DS}$. The current is

$$I_{DS1} = \frac{\beta}{2}\left(V_{DD} - V_t - \frac{V_{DS}}{2}\right)V_{DS}$$

In (b), the bottom transistor sees $V_{gs} = V_{DD}$ and $V_{ds} = V_1$. The top transistor sees $V_{gs} = V_{DD} - V_1$ and $V_{ds} = V_{DS} - V_1$. The currents are

$$I_{DS2} = \beta\left(V_{DD} - V_t - \frac{V_1}{2}\right)V_1 = \beta\left(\left(V_{DD} - V_1\right) - V_t - \frac{\left(V_{DS} - V_1\right)}{2}\right)\left(V_{DS} - V_1\right)$$

Solving for V_1, we find

$$V_1 = \left(V_{DD} - V_t\right) - \sqrt{\left(V_{DD} - V_t\right)^2 - \left(V_{DD} - V_t - \frac{V_{DS}}{2}\right)V_{DS}}$$

Substituting V_1 indo the I_{DS2} equation and simplifying gives $I_{DS1} = I_{DS2}$.

2. *C*permicron = ε*L*/*tox* = 3.9 * 8.85e-14 F/cm * 90e-7 cm / 16e-4 µm= 1.94 fF/µm.

3.

2.6 The new threshold voltage is found as

$$\phi_s = 2(0.026)\ln\frac{2 \bullet 10^{17}}{1.45 \bullet 10^{10}} = 0.85V$$

$$\gamma = \frac{100 \bullet 10^{-8}}{3.9 \bullet 8.85 \bullet 10^{-14}}\sqrt{2\left(1.6 \bullet 10^{-19}\right)\left(11.7 \bullet 8.85 \bullet 10^{-14}\right)\left(2 \bullet 10^{17}\right)} = 0.75V^{1/2}$$

$$V_t = 0.7 + \gamma\left(\sqrt{\phi_s + 4} - \sqrt{\phi_s}\right) = 1.66V$$

The threshold increases by 0.96 V.

4.

2.11 The nMOS will be off and will see $V_{ds} = V_{DD}$, so its leakage is

$$I_{leak} = I_{dsn} = \beta v_T^2 e^{1.8} e^{\frac{-V_t}{n v_T}} = 69\,pA$$

5 (a) (1.2 - 0.3)2 / (1.2 - 0.4)2 = 1.26 (26%)

(b) $$\frac{e^{\frac{-0.3}{1.4 \bullet 0.026}}}{e^{\frac{-0.4}{1.4 \bullet 0.026}}} = 15.6$$

(c) $v_T = kT/q = 34$ mV; $\dfrac{e^{\frac{-0.3}{1.4 \bullet 0.034}}}{e^{\frac{-0.4}{1.4 \bullet 0.034}}} = 8.2$; note, however, that the total leakage will normally be higher for both threshold voltages at high temperature.