ENGR 305 – Homework 4 solutions

5.17

$V_{tn} = 0.4\ V$ and $k_n = 2\text{mA/V}^2$

$i_D = \frac{1}{2}k_n v_{ov}^2 = 0.05\text{ mA} = \frac{1}{2} \times 2\text{mA/V}^2 \times v_{ov}^2$

$\Rightarrow\ v_{ov} = 0.22\ V\ and\ v_{DS} \geq 0.22\ V$

$v_{GS} = 0.4 + 0.22 = 0.62\ V$

If $i_D = 200\mu A = 0.2\ mA = \frac{1}{2} \times 2\text{mA/V}^2 \times v_{ov}^2$

$\Rightarrow\ v_{ov} = 0.45\ V\ and\ v_{DS} \geq 0.45\ V$

$v_{GS} = 0.4 + 0.45 = 0.85\ V$

5.44

Since $V_{DG} > 0$, the MOSFET is operating in saturation.

Then, $I_D = \frac{1}{2}k_n(V_{GS} - V_t)^2 = \frac{1}{2} \times 4\ mA/V^2 \times (0.55\ V - 0.4\ V)^2 = 0.045$ mA

$R_D = \frac{1 - V_D}{I_D} = \frac{(1-0.1)V}{0.045\ mA} = \frac{0.9V}{0.045\ mA} = 20\ \text{k}\Omega$

$R_S = \frac{-0.55V - (-1V)}{0.045\ mA} = \frac{0.45\ V}{0.045\ mA} = 10\ k\Omega$

For I_D to remain unchanged from 0.045 mA, the MOSFET must remain in saturation. This in turn can be achieved by ensuring that V_D does not fall below V_G (which is zero) by more than V_t (0.4 V). At this point, V_D would be equal to $V_G - V_t = 0\text{ V} - 0.4\text{ V} = -0.4\text{ V}$. And then

$1\ V - I_D R_{Dmax} = -0.4\ V.\ and\ R_{Dmax} = \frac{1.4\ V}{0.045\ mA} = 31.1\ k\Omega$

5.47

$V_{ov} = V_{GS} - V_t = 1.2\text{ V} - 0.4\text{ V} = 0.8\text{ V}$

To operate at the edge of saturation, we must have V_D (= V_{DS} here) = V_{OV} = 0.8 V.

Then $R_D = \frac{1.2\ V - 0.8\ V}{0.05\ mA} = 8\ k\Omega$