ECE3050 Homework Set 4

1. (a) Calculate the drain current in an NMOS transistor if $K = 125\,\mu\text{A}/\,\text{V}^2$, $V_{TO} = -2\,\text{V}$, $\lambda = 0$, $V_{GS} = 0\,\text{V}$, and $V_{DS} = 6\,\text{V}$. [0.5 mA] (b) Repeat assuming $\lambda = 0.025\,\text{V}^{-1}$. [0.575 mA]

2. An n-channel MOSFET has $K = 125\,\mu\text{A}/\,\text{V}^2$, $V_{TO} = 1\,\text{V}$, and $\lambda = 0.02\,\text{V}^{-1}$. At what drain current will the MOSFET no longer be able to provide any voltage gain when connected as a common-source amplifier? Note, the maximum gain is denoted by μ_F and it is given by $\mu_F = g_m r_0$. The object here is to determine the maximum I_D such that $\mu_F \leq 1$. This will require you to select V_{DS} that minimizes μ_F before solving for I_D. [1.25 A]

3. A common-source amplifier has the drain load resistance $R_D = 60\,\text{k}\Omega$ and a power supply voltage $V^+ = 18\,\text{V}$. At what Q-point will $r_{out} = 50\,\text{k}\Omega$ if the transistor has $\lambda = 0.02\,\text{V}^{-1}$? Use the relations $r_0 = \left(\lambda^{-1} + V_{DS}\right)/I_D$, $V_{DS} = 18 - I_D R_D$, and $r_{out} = r_0 \| R_D$. [0.189 mA, 6.67 V]

4. The drain current in an n-channel JFET is given by $i_D = I_{DSS}\left(1 - v_{GS}/V_P\right)^2$ for $v_{GS} > V_P$ and $i_D = 0$ for $v_{GS} \leq V_p$, where $I_{DSS} = I_{DSS0}\left(1 + \lambda v_{DS}\right)$. For the n-channel JFET, $V_P < 0$. Show that the expression for the JFET current can be represented in exactly the same form as that of the MOSFET using the substitution $V_{TO} = V_P$ and $K = I_{DSS}/V_P^2$.