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

2. An $n$-channel MOSFET has $K = 125 \, \mu A/V^2$, $V_{TO} = 1 \, V$, and $\lambda = 0.02 \, V^{-1}$. 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 $\mu_F$ 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 $\mu_F$ before solving for $I_D$. [1.25 A]

3. An $n$-channel MOSFET has a resistor $R_D = 60 \, k\Omega$ connected between its drain and a power supply voltage $V^+ = 18 \, V$. At what Q-point will $r_0 || R_D = 50 \, k\Omega$ if the transistor has $\lambda = 0.02 \, V^{-1}$? Use the relations $r_0 = (\lambda^{-1} + V_{DS}) / I_D$, and $V_{DS} = 18 - I_D R_D$. [0.189 mA, 6.67 V]

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

5. For $K = 1.78 \, mA/V^2$, $V_{TO} = 1.5 \, V$, $V^+ = 18 \, V$, $R_1 = 110 \, k\Omega$, $R_2 = 68 \, k\Omega$, $R_D = 0$, and $R_S = 1 \, k\Omega$, solve for $I_D$ and verify that the MOSFET is biased in the saturation region, i.e. its active mode. [$I_D = 3.897 \, mA$, $V_{DS} = 14.10 \, V$, $V_{GS} - V_{TO} = 1.480 \, V$]

6. Add a resistor $R_3 = 20 \, k\Omega$ from gate to source for the circuit in problem 5. Solve for $I_D$ and verify that the MOSFET is biased in the saturation region. [$I_D = 0.492 \, mA$, $V_{DS} = 17.41 \, V$, $V_{GS} - V_{TO} = 0.526 \, V$]


9. Problem 4.35 in Jaeger. Assume $K' = 25 \times 10^{-6} \, A/V^2$. [(a) $I_D = 103 \, \mu A$, (b) $I_D = 104 \, \mu A$, (c) $I_D = 107 \, \mu A$]
10. Problem 4.41 parts (a) and (b) in Jaeger. Assume $K' = 25 \times 10^{-6} \text{A/V}^2$. Hint: Show first that the device is operated in the triode region.

11. It is given that $K = 0.001 \text{A/V}^2$, $V_{TH1} = 1.25 \text{V}$, $V_{TH2} = -1.25 \text{V}$, $V^+ = +24 \text{V}$, $V^- = -24 \text{V}$, $R_1 = 100 \text{k}\Omega$, $R_3 = 1 \text{k}\Omega$, and $R_6 = 200 \text{\Omega}$. We desire $I_{D1} = 1.5 \text{mA}$, $I_{D2} = 5 \text{mA}$, and $V_{DS2} = 12 \text{V}$. Show that $R_2 = 1.108 \text{M}\Omega$, $R_4 = 1.324 \text{k}\Omega$, $R_5 = 7 \text{k}\Omega$, and $V_{SD1} = 44.514 \text{V}$. Verify that both MOSFETs are in the saturation region.

![Circuit Diagram](image)

12. Assume that you are given the values for $V^+$, $V^-$, and all the resistor values in the circuit for problem 11. Solve for $I_{D1}$, $I_{D2}$, and verify that both MOSFETs are in the saturation region.

13. Problem 13.76 in Jaeger. [$I_D = 1.25 \text{mA}$, $W/L = 250$]

14. Problem 13.81 in Jaeger. Assume that a resistor $R_D$ connects from the MOSFET drain to $V^+$, the MOSFET source is grounded, and $V_{DS} = V^+/2$. Solve for $I_D$ such that $R_{out} = r_0||R_D = 50 \text{\Omega}$. 

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