Test Instructions: On your test provide the last four digits of your UT student identification number in the space provided at the top right of each page. Do not include your name on the test, just the last four digits your UT ID#. Carefully read the question before solving the problem. Show all your work in the space provided. Note the following suggestions:

- If necessary, write on the back of the problem page, but indicate where your work is continuing for that problem.
- If you are unable to obtain an intermediate value that is needed for subsequent steps in a problem, make an assumption, state it, and use your assumption for the subsequent steps.
- If you realize that your final answer is wrong, but you run out of time to fix it or are unable to find the mistake, indicate that you believe your answer to be wrong and why.
- Clearly mark your final answer with a box or circle.

Calculators are allowed, but they may not have any communication capability. Additional scratch paper is available on request.

1. (25 points) Consider the circuit at right. Use the parameters below.
   - \( K_N = 500 \mu A/V^2 \); \( V_{TN} = 0.6 \) V
   - \( \lambda = 0.02 \) V\(^{-1}\)
   - \( R_1 = R_2 = 1 \) M\(\Omega\)

   a) Find values of \( R_3 \) and \( R_4 \) that set the drain current \( I_D \) to 1 mA and \( V_{DS} \) to 3 V. Neglect channel-length modulation for this part.

   \[ R_3 = \quad \text{and} \quad R_4 = \quad \]

   b) Find the small-signal parameters \( g_m \) and \( r_o \).

   \[ r_o = \quad \text{and} \quad g_m = \quad \]
2. (30 points) Consider the amplifier at right. Assume that the DC operating point is known and that the transistor operates in the forward active region. Use these parameters:

- $I_C = 100 \, \mu A; \quad \beta = 50$
- $R_E = 5 \, k\Omega; \quad R_L = 1000 \, \Omega$
- $R_{B1} = 44 \, k\Omega; \quad R_{B2} = 67 \, k\Omega$
- $R_S = 1 \, k\Omega; \quad R_C = 45 \, k\Omega$
- $V_{CC} = V_{EE} = 5 \, V$
- $C_1$ and $C_2$ are very large
- Neglect the Early effect.

a) Find $g_m$ and $r_\pi$ of the transistor

\[ g_m = \quad r_\pi = \]

b) Find the input resistance as seen looking into the amplifier from $C_1$

\[ R_{in} = \]
c) Find the overall small-signal gain $v_o/v_i$. Your answer should be a number in linear units (i.e. not dB). Neglect the Early effect.

$A_V = \underline{\phantom{1000}}$

d) Where would you place an additional capacitor to increase the gain?
3. (25 points) Consider the multi-stage amplifier below. Use the parameters below.
   • $g_{m1} = 25 \mu S; g_{m2} = 10 \text{ mS}$
   • $R_1 = 1 \text{ k\Omega}$
   • $R_1 = R_2 = 10 \text{ k\Omega}$
   • $R_3 = 640 \text{ k\Omega}; R_4 = 100 \text{ k\Omega}$
   • $R_5 = R_6 = 1.28 \text{ M\Omega}$
   • $R_7 = 6 \text{ k\Omega}; R_L = 12 \text{ k\Omega}$
   • Neglect channel-length modulation.

   a) If the gain of the first stage ($v_x/v_i$) is 6.67, find the overall gain ($v_o/v_i$) of the amplifier. Assume all of the capacitors are very large for this part.
Last four digits of your I.D.#: _______________

b) Find a value for $C_1$ such that the low-frequency cutoff is well below 10 Hz.

c) Find a value for $C_2$ such that the low-frequency cutoff is well below 10 Hz.
4. (20 points) In the common-source amplifier shown below, the standard input (labeled $v_i$) is driven into the gate. For this problem assume that $v_i$ is grounded and an undesired AC noise signal $v_x$ is superimposed onto the negative supply. That is, the voltage at the node labeled (1) consists of a DC voltage $-V_{EE}$ and the AC voltage $v_x$. Find the gain $A_{V,PS}$ from the negative power supply to the output $v_o$ ($A_{V,PS} = v_o / v_x$). Assume that the DC operating point is known and that the transistor operates in the forward active region. Use these parameters:

- $V_{GG}$ is set to an appropriate DC bias voltage such that $g_m = 5\, \text{mS}$
- $R_I = 5\, \text{k}\Omega$; $R_G = 1\, \text{M}\Omega$; $R_L = 50\, \text{k}\Omega$
- $R_D = 10\, \text{k}\Omega$; $R_S = 2\, \text{k}\Omega$
- All capacitors are very large
- Neglect channel-length modulation.

$A_{V,PS} = \ldots$
Last four digits of your I.D.#: ______________

\[ V_G = \] 

\[ R_D = \] 

Additional workspace