Problem 1:
Consider the FET amplifier shown below for the case $V_t = 2 \text{ V}$, $k'_{n(W/L)} = 1 \text{ mA/V}^2$, $V_{GS} = 4 \text{ V}$, $V_{DD} = 10 \text{ V}$ and $R_D = 3.6 \text{ k\Omega}$.
(a) Find the DC quantities $I_D$ and $V_D$.
(b) Calculate the value of $g_m$ at the bias point.
(c) Calculate the value of the voltage gain.
(d) If the MOSFET has $\lambda = 0.01 \text{ V}^{-1}$, find $r_o$ at the bias point and calculate the voltage gain.

Problem 2:
For the NMOS amplifier shown, replace the transistor with its T equivalent circuit.
Derive expressions for the voltage gains $v_s/v_i$ and $v_d/v_i$.

Problem 3:
The figure below shows a discrete-circuit CS amplifier employing the classical biasing scheme. The input signal $v_{sig}$ is coupled to the gate through a very large capacitor (shown as infinite). The transistor source is connected to ground at signal frequencies via a very large capacitor (shown as infinite). The output voltage signal
that develops at the drain is coupled to a load resistance via a very large capacitor (shown as infinite).

(a) If the transistor has $V_t = 1\ V$, and $k_n' W/L = 2\ mA/V^2$, verify that the bias circuit establishes $V_{GS} = 2\ V$, $I_D = 1\ mA$, and $V_D = +7.5\ V$. That is, assume these values, and verify that they are consistent with the values of the circuit components and the device parameters.

(b) Find $g_m$ and $r_o$ if $V_A = 100\ V$.

(c) Draw a complete small-signal equivalent circuit for the amplifier assuming all capacitors behave as short circuits at signal frequencies.

(d) Find $R_{in}$, $v_{gs}/v_{sig}$, $v_o/v_{gs}$, $v_o/v_{sig}$.

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**Problem 4:**
The overall gain of the amplifier circuit shown was measured with a resistance $R_S$ of 1 kΩ in place and found to be $-10\ V/V$. When $R_S$ is shorted, but the circuit operation remained linear the gain doubled. What must $g_m$ be? What value of $R_S$ is needed to obtain the overall gain of $-8\ V/V$?
**Problem 5:**

The figure below shows a scheme for coupling and amplifying a high-frequency pulse signal. The circuit utilizes two MOSFETs whose bias details are not shown and a 50-Ω coaxial cable. Transistor Q₁ operates as a CS amplifier and Q₂ as a CG amplifier. For proper operation, transistor Q₂ is required to present a 50-Ω resistance to the cable. This situation is known as “proper termination” of the cable and ensures that there will be no signal reflection coming back on the cable. When the cable is properly terminated, its input resistance is 50 Ω. What must $g_{m2}$ be? If Q₁ is biased at the same point as Q₂, what is the amplitude of the current pulses in the drain of Q₁? What is the amplitude of the voltage pulses at the drain of Q₁? What value of $R_D$ is required to provide 1-V pulses at the drain of Q₂?

![Circuit Diagram](image)

**Problem 6:**

(a) The NMOS transistor in the source-follower circuit of figure (a) has $g_m = 5$ mA/V and a large $r_o$. Find the open-circuit voltage gain and the output resistance.

(b) The NMOS transistor in the common-gate amplifier of figure (b) has $g_m = 5$ mA/V and a large $r_o$. Find the input resistance and the voltage gain.

(c) If the output of the source follower in (a) is connected to the input of the common-gate amplifier in (b), use the results of (a) and (b) to obtain the overall gain $v_o/v_i$. 

![Circuit Diagram](image)
Problem 7:
The analysis of the high-frequency response of the common-source amplifier, is based on the assumption that the resistance of the signal source, $R_{\text{sig}}$, is large and, thus, that its interaction with the input capacitance $C_{\text{in}}$ produces the “dominant pole” that determines the upper 3-dB frequency $f_{\text{H}}$. There are situations, however, when the CS amplifier is fed with a very low $R_{\text{sig}}$. To investigate the high-frequency response of the amplifier in such a case, the figure below shows the equivalent circuit when the CS amplifier is fed with an ideal voltage source $V_{\text{sig}}$ having $R_{\text{sig}} = 0$. Note that $C_{L}$ denotes the total capacitance at the output node. By writing a node equation at the output, show that the transfer function $V_o/V_{\text{sig}}$ is given by

$$\frac{V_o}{V_{\text{sig}}} = -g_m R_L \frac{1 - s(C_{gd} / g_m)}{1 + s(C_L + C_{gd}) R_L}$$

At frequencies $\omega < < (g_m/C_{gd})$, the $s$ term in the numerator can be neglected. In such case, what is the upper 3-dB frequency resulting? Compute the values of $A_M$ and $f_{\text{H}}$ for the case: $C_{gd} = 0.5 \text{ pF}$, $C_L = 2 \text{ pF}$, $g_m = 4 \text{ mA/V}$, and $R'_{L} = 5 \text{ k}\Omega$.

Problem 8:
The NMOS transistor in the discrete CS amplifier circuit shown below is biased to have $g_m = 1 \text{ mA/V}$ and $r_o = 100 \text{ k}\Omega$. Find $A_M$. If $C_{gs} = 1 \text{ pF}$ and $C_{gd} = 0.2 \text{ pF}$, find $f_{\text{H}}$. 

![Discrete CS Amplifier Circuit](image.png)