1. The amplifier in the figure below is biased to operate at \( g_m = 1 \, mA/V \). Neglecting \( r_d \),
   a. Find the mid-band gain.
   b. Find the full transfer function with \( C_s \) present. Is this circuit low-pass or high-pass?
   c. Find the value of \( C_s \) that places \( f_L \) at 200 Hz.
   d. With the value of \( C_s \) above, find \( v_o(t) \). Given that \( v_i(t) = V_0 + 10 \cos(10^6 \pi t) \) mV where \( V_0 \)
      is a constant.

2. The NMOS transistor in the discrete CS amplifier circuit shown below is biased to have \( g_m = 5 \, mA/V \). Find \( A_m, f_{p1}, f_{p2}, f_{p3}, \) and \( f_L \). Let \( R_{sig} = 100\,k\Omega, R_1 = 47M\Omega, R_2 = 10M\Omega, R_D = 4.7k\Omega, R_S = 2k\Omega, R_L = 10k\Omega, C_G = 0.01\mu F, C_S = 10\mu F, C_D = 0.1\mu F \)

Ignore parasitic capacitances of the transistor and channel-length modulation effect.
3. A discrete MOSFET common-source amplifier has $R_G = 1M\Omega$, $g_m = 5mA/V$, $r_o = 100k\Omega$, $R_D = 10k\Omega$, $C_{gs} = 2pF$, and $C_{gd} = 0.4pF$. The amplifier is fed from a voltage source with an internal resistance of 500 $k\Omega$ and is connected to a 10 $k\Omega$ load. Find:

a) The overall mid-band gain $A_M$

b) The upper 3-dB frequency $f_H$

Refer to Figs a and b for the complete setup and the small signal circuit at high frequency. Note: at high and mid-band frequency, coupling capacitor $C_{c1}$, $C_{c2}$, $C_S$ are shorted.

**Hint:** In part b), find $f_H$ using Miller’s theorem then apply open-circuit time constant approach.
4. Consider the common-emitter amplifier in the following figure, with $\beta = 100$, $V_A = 100V$, $C_n = 25fF$, $C_{\mu} = 10fF$.

a) Draw the small-signal model of this circuit. Apply Miller’s theorem to split $C_{\mu}$ to input and output nodes. Calculate the time constants at the input and output nodes, $\tau_{in}$ and $\tau_{out}$.

b) Based on the time constants from part a), calculate the input and output pole frequencies, $f_{in}$ and $f_{out}$. What is the dominant pole of this amplifier?

5. The figure below shows the high-frequency equivalent circuit of a CS amplifier with a resistance $R_s$, connected to S. The purpose of this problem is to show that the value of $R_s$, can be used to control the gain and bandwidth of the amplifier, specifically to allow the designer to trade gain for increased bandwidth.

a) Derive an expression for the low-frequency voltage gain (i.e. set $C_{gs}$ and $C_{gd}$ to zero).

b) To be able to determine $\omega_H$ using the open-circuit time-constants method, derive expressions for $R_{gs}$ and $R_{gd}$ (equivalent resistance seen by $C_{gs}$ and $C_{gd}$, respectively).
c) Let $R_{\text{sig}} = 100k\Omega$, $g_m = 4mA/V$, $R'_L = 5k\Omega$, and $C_{gs} = C_{gd} = 1pF$. Use the expressions found in a) and b) to determine the low-frequency gain and the 3-dB frequency $f_H$ for three cases: $R_s = 0\Omega$, $100\Omega$, and $250\Omega$. In each case, also evaluate the gain-bandwidth product.

6. Determine -3dB bandwidth of the circuits shown below. Assume MOS transistors in saturation and BJTs in forward active region with $r_{ds} = \infty$, $r_o = \infty$. Ignore intrinsic capacitances.

7. Approximate transfer function for the circuits below. Assume MOS transistors operate in saturation with $r_{ds} = \infty$, and BJTs in forward active region with $r_o = \infty$. 

![Circuit Diagrams](Image)