The NMOSFETs and the PMOSFETS have a 0.25 V threshold, a 22nm gate length, 300 cm$^2$/Vs mobility, $v_{inj} = 10^7$cm/s, and $1/\lambda = 3$ Volts.

**Problem 1:**
The supply voltage is 5.0V. The bjt have $I_s = J_s A_{E}$, where $J_s$ is the same for all transistors. Q1,2,3,5 all have a 130nm (width) x 5 $\mu$m(length) emitter area. R2, R3, and R5 are to have 100mV DC voltage drop. Pick R1 to bias Q1 at 1mA emitter current. Pick the emitter length of Q4 and the value of R5 to bias Q4 at 0.5mA emitter current. Pick R4 to bias Q5 at 0.1mA emitter current. The BJTs have beta=100 and infinite Early voltage. Pick the widths of Q6,8,9 so that they operate with $|V_{gs}|=0.3V$. Pick the width of Q7 so that its drain current is 0.1mA. Make the widths of Q10 and Q11 equal, picking them so that the drain current is 0.2mA.

**Problem 2:** All transistors have beta=100 and $V_a=100$ V. The supplies are +/-5 V. This is an op-amp....it has to be biased using a feedback network: bias conditions have to be worked assuming that the differential input voltage is whatever is required to make $V_{out}=0$ volts DC. Q12 and Q13 are diode-connected transistors. R2 is to have 300 mV DC voltage drop. $Ic_1=200$ uA. $Ic_9=200$ uA. $Ic_{10}=5$ mA. $Ic_2=0.5$ mA. $Ic_4=Ic_{11}=1$mA. Find all resistor values and all collector currents. Find the DC input voltage necessary to obtain $V_{out}=0$ volts. Given a 10kOhm load, find the differential voltage gain, the CMRR and the max. peak-peak signal swing. Inputs are biased at ~0V DC.
Problem 3: The NMOSFETs and the PMOSFETS have a 0.25 V threshold, a 22nm gate length, 300 cm²/Vs mobility, \( v_{inj} = 10^7 \text{cm/s} \), and \( 1/\lambda = 3 \text{ Volts} \). The supplies are +/- 1.5 V. Pick all FET widths so that Vgs is 0.1V beyond threshold. Set the resistor R2 to zero. Ignore the effects of lambda in DC analysis but not in AC analysis. Q4,5 are to be biased at 50μA each, as are Q2 and Q3. The DC inputs are at zero volts. (a) find all FET widths, resistor values and all DC bias currents and voltages. b) Given an INFINITE load resistance, find the differential voltage gain, the CMRR and the max. peak-peak signal swing. Inputs are biased at ~0V DC.

Problem 4: Nodal Analysis exercise: a transconductance-transimpedance amplifier. Ignore DC bias analysis. You don’t need it. The two transistors have transconductance \( g_m1 \) and \( g_m2 \) respectively. Their output resistances \( R_{ds1} \) and \( R_{ds2} \) are both infinity. The capacitor C has value= zero Farads. (a) Find, by nodal analysis, a small-signal expression for \( V_{out}/V_{in} \). (b) \( g_m1 = 10 \text{ mS} \). \( g_m2 = 50 \text{ mS} \). \( R = 1 \text{kOhm} \). Again find \( V_{out}/V_{in} \).