The problems below will use the following small signal model for the mosfet.

**Problem 1:** This is 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. $g_{m1}=40\, \text{mS}$. $g_{m2}=30\, \text{mS}$. $R=10\, \text{kOhm}$. $C=100\, \text{fF}$. $C_{gs}=0\, \text{fF}$

a) Draw a small-signal equivalent circuit of the circuit
b) Find, by nodal analysis, a small-signal expression for $V_{out}(s)/V_{in}(s)$

c) Find any/all pole and zero frequencies of the transfer function, in Hz:

d) Draw a clean Bode Plot of $V_{out}/V_{in}$, LABEL AXES, LABEL all relevant gains and pole or zero frequencies, Label Slopes

**Problem 2:** Here again is 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. $g_{m1}=40\, \text{mS}$. $g_{m2}=30\, \text{mS}$. $R=10\, \text{kOhm}$. $C=100\, \text{fF}$. $C_{gs}=0\, \text{fF}$

(a) Draw a small-signal equivalent circuit of the circuit

b) Find, by nodal analysis, a small-signal expression for $V_{out}(s)/V_{in}(s)$

c) Find any/all pole and zero frequencies of the transfer function, in Hz:

d) Draw a clean Bode Plot of $V_{out}/V_{in}$, LABEL AXES, LABEL all relevant gains
Problem 3: Ignore DC bias analysis. You don’t need it. The FETs have lambda=0 hence Gds=0. further, Cgs=Cgd=0 fF. But, C, R1, R2 are all nonzero
(a) Replacing the transistors with high frequency small-signal model, draw a small-signal equivalent circuit diagram.

(b) USING NODAL ANALYSIS, compute Vout(s)/Vin(s) in ratio-of-polynomials form
\[ V_{out}(s)/V_{in}(s) = \frac{A_{r, mid-band} \times (s \tau)^m}{1 + b_1 s + b_2 s^2 + \ldots} \times \frac{1}{1 + a_1 s + a_2 s^2 + \ldots} \]
where m, an integer, can be positive or negative or zero.
(c) \( g_{m1} = 10 \) mS. \( g_{m2} = 5 \) mS \( R_1 = 10 \) kOhm, \( R_2 = 20 \) kOhm, \( C = 0.1 \) pF
Find the frequencies of any zeros (there may be zero, one or two present ) in Vout(s)/Vin(s):
(d) Find any/all pole and zero frequencies of the transfer function, in Hz: Draw a clean Bode Plot on semilog paper of Vout/Vin, LABEL AXES, LABEL all relevant gains and pole or zero frequencies, Label Slopes (d) Vin(t) is a 100 mV amplitude step-function Find Vout(t), and plot it below. Label axes, show initial and final values, show time constants

Problem 4: Ignore DC bias analysis. You don’t need it. The transistor has transconductance gm. Its output resistance Rds is infinity. (a) Draw a small-signal equivalent circuit of the circuit. (b) gm=1 mS. C=10 pF. . Find, by nodal analysis, a small-signal expression for Vout(s)/Vin(s)
(c) Find any/all pole and zero frequencies of the transfer function, in Hz: Draw a clean Bode Plot on semilog paper of Vout/Vin, LABEL AXES, LABEL all relevant gains and pole or zero frequencies, Label Slopes (d) Vin(t) is a 100 mV amplitude step-function Find Vout(t), and plot it below. Label axes, show initial and final values, show time constants
Problem 5: Ignore DC bias analysis. You don’t need it. The two transistors have transconductance $g_m1$ and $g_m2$ respectively. Their drain-source resistances $R_{ds1}$ and $R_{ds2}$ are both infinity. (a) Draw a small-signal equivalent circuit of the circuit (t) Find, by nodal analysis, a small-signal expression for $V_{out}/V_{in}$

Problem 6: $R1=1$ KOhm, $R2=4$ kOhm, $R3=6$ kOhm, $R4=8$ kOhm, $C1=1$ fF, $C2=2$ fF
Using Nodal analysis, find the transfer function $V_{out}(s)/V_{gen}(s)$. Give the answer in standard form

$$\frac{V_{out}(s)}{V_{gen}(s)} = \frac{V_{out}}{V_{gen}} \bigg|_{DC} \frac{1 + b_1 s + b_2 s^2 + \ldots}{1 + a_1 s + a_2 s^2 + \ldots}$$