

ECE 137 A Mid-Term Exam

Tuesday February 9, 2021

Closed book: Class crib sheet and 1 page personal notes permitted.

There are 2 problems on this exam, and you have 75 minutes.

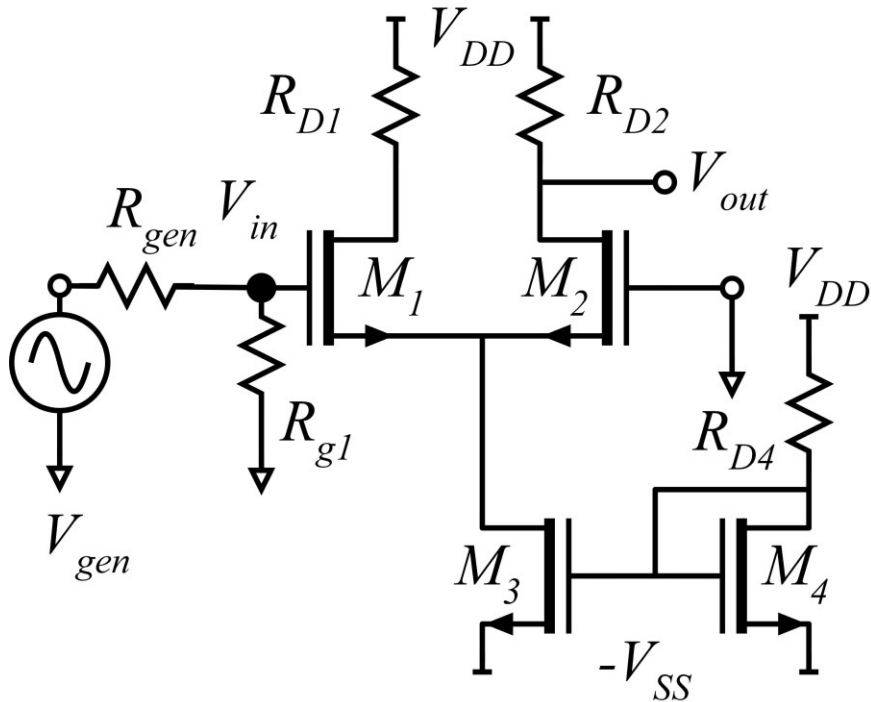
Use any and all reasonable approximations (5% accuracy is fine.), ***AFTER STATING and approximately Justifying them.***

Name: _____

Part	Points Received	Points Possible
1a		9
1b		5
1c		6
1d		15
1e		15
1f		6
1g		14
2a		12
2b		13
2c		5
TOTAL		100

Problem 1, 70 points

You will be working on the circuit below:



The transistors all have: $K_{\mu} = \mu c_{gs} W_g / 2L_g = 10\text{mA/V}^2 \cdot (W_g / 1\mu\text{m})$

$K_v = c_{gs} v_{inj} W_g = 2\text{mA/V} \cdot (W_g / 1\mu\text{m})$

$\Delta V = v_{inj} L_g / \mu = 0.1\text{V}$, $V_{th} = 0.3\text{V}$, $1/\lambda = 10\text{V}$

The supplies are +1V and -1V

$R_{gen} = 100\text{ k}\Omega$, $R_{g1} = 1\text{ M}\Omega$,

Part a, 9 points

DC bias.

The sources of M1 and M2 are to be biased at -0.35 Volts

The drains of M1 and M2 are to be biased at +0.5 volts.

The gates of M3 and M4 are to be biased at -0.65 Volts.

M1 and M2 are to be biased at 0.1 mA drain current

M4 is to be biased at 0.2 mA drain current .

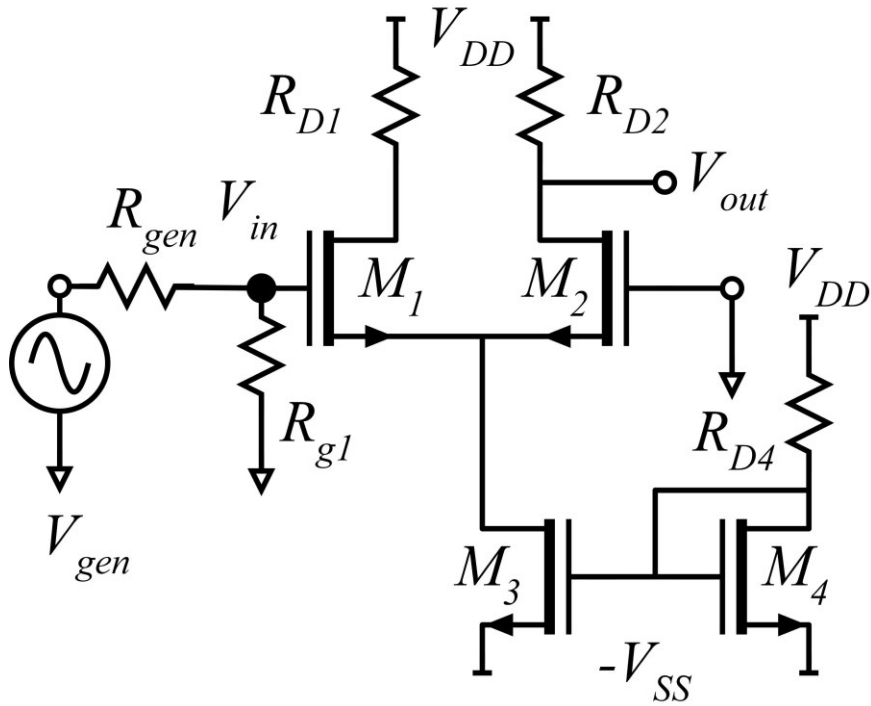
Find the following:

RD1=_____ RD2=_____ RD4=_____

Wg1=_____ Wg2=_____ Wg3=_____ Wg4=_____

Part b, 5 points

DC bias



On the circuit diagram above (or on a hand-redrawing of the figure), label the DC voltages at **ALL nodes** and the DC currents through **ALL resistors**. Also label all resistor values, and the width of all MOSFETs.

Part c, 6 points

Find the small signal parameters of all FETs

Transistor	M1	M2	M3	M4
g_m				
R_{DS}				

Part d, 15 points.

Find the small signal voltage gain (V_{d2}/V_{s2}) of M2 and M2's small-signal input resistance.

$V_{d2}/V_{s2} =$ _____

$R_{in,m2} =$ _____

Part e, 15 points

Find the small signal voltage gain (V_{s1}/V_{g1}) of M1 and the *** amplifier *** input resistance.

$V_{s1}/V_{g1} =$ _____

$R_{in, amplifier} =$ _____

Part f, 6 points

Find (V_{out}/V_{in}) , (V_{in}/V_{gen}) and (V_{out}/V_{gen})

$$(V_{out}/V_{in}) = \underline{\hspace{10cm}}$$

$$(V_{in}/V_{gen}) = \underline{\hspace{10cm}}$$

$$(V_{out}/V_{gen}) = \underline{\hspace{10cm}}$$

Part g, 14 points

Now you must find the maximum signal swings.

Give the sign (+ or -) in your answers below.

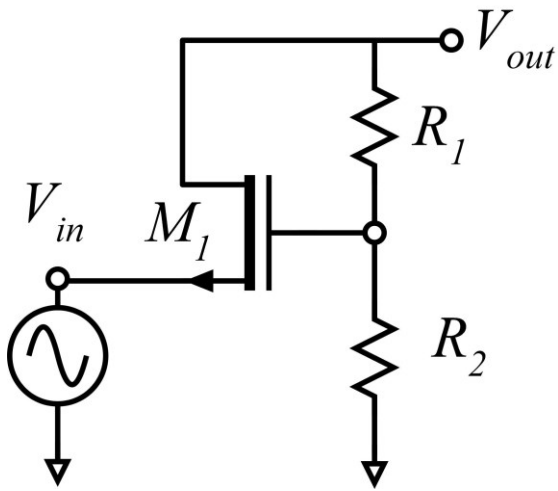
Cutoff of M1; Maximum ΔV_{out} resulting = _____

Knee voltage of M1; Maximum ΔV_{out} resulting = _____

Cutoff of M2; Maximum ΔV_{out} resulting = _____

Knee of M2; Maximum ΔV_{out} resulting = _____

Problem 2, 30 points
nodal analysis



You will be working on the circuit to the left.

Ignore DC bias analysis. You don't need it.

The transistor has transconductance g_{m1} .
The drain-source resistance R_{ds} is infinity
(so you don't need to draw it!)

Part a, 12 points

Draw the small-signal equivalent circuit

Part b, 13 points

Find, by nodal analysis, a small-signal expression for V_{out}/V_{in} .

$V_{out}/V_{in} =$ _____

Part c, 5 points

$g_m = 1 \text{ mS}$, $R_1 = 90 \text{ k}\Omega$, $R_2 = 10 \text{ k}\Omega$
Give a numerical value for V_{out}/V_{in} .

$V_{out}/V_{in} =$ _____