

ECE 137 A Mid-Term Exam

Wednesday February 9, 2022

Do not open exam until instructed to.

Closed book: Crib sheet and 1 page personal notes permitted

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

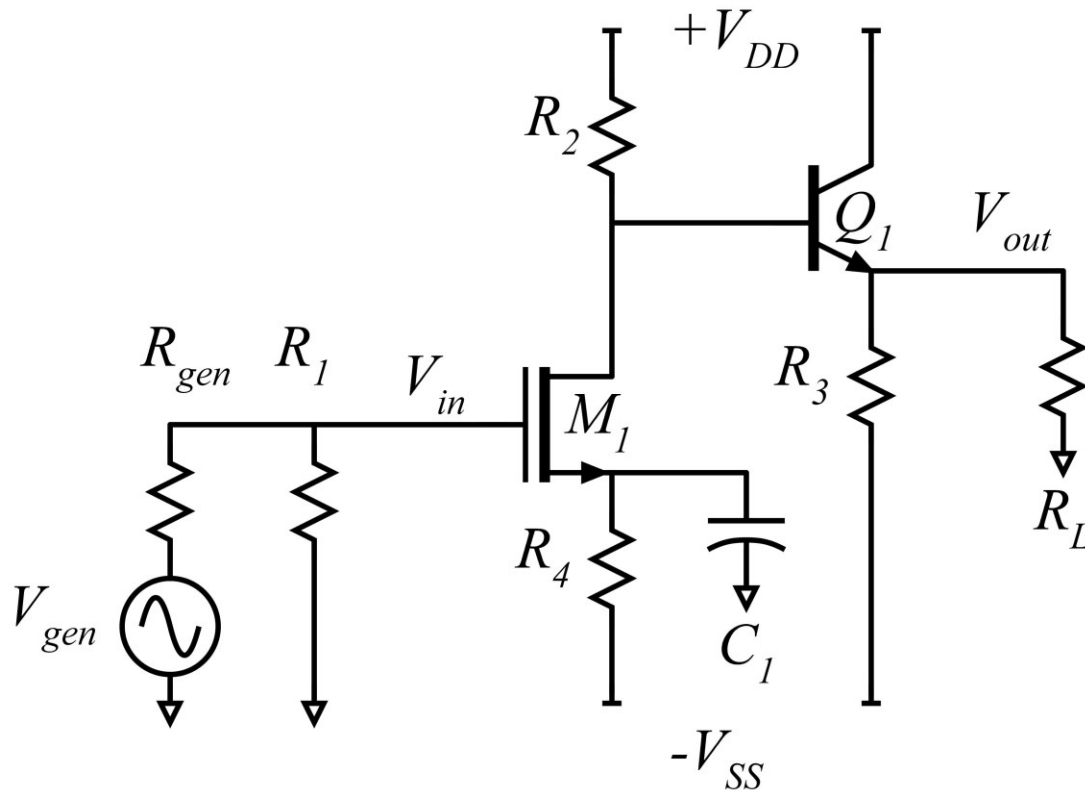
Use any and all reasonable approximations (5% accuracy is fine.), ***AFTER STATING and approximately Justifying them.***

Name: _____

Part	Points Received	Points Possible
1a		7
1b		7
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:



$$M1: K_{\mu} = \mu c_{gs} W_g / 2L_g = 10 \text{mA/V}^2 \cdot (W_g / 1\mu\text{m})$$

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

$$\Delta V = v_{inj} L_g / \mu = 0.1 \text{V}, V_{th} = 0.3 \text{V}, 1/\lambda = 4 \text{V}$$

$$Q2: \beta = 250, V_A = 100 \text{V}$$

The supplies are +2V and -2V

Rgen=1000 Ohms, RL=1,000 Ohms. R1=10kOhms,

C1 is very large (AC short-circuit)

Part a, 7 points

DC bias.

M1 is to be biased at 1 mA drain current and $V_{gs}=0.4$ Volts.

Q1 is to be biased at 2 mA collector current.

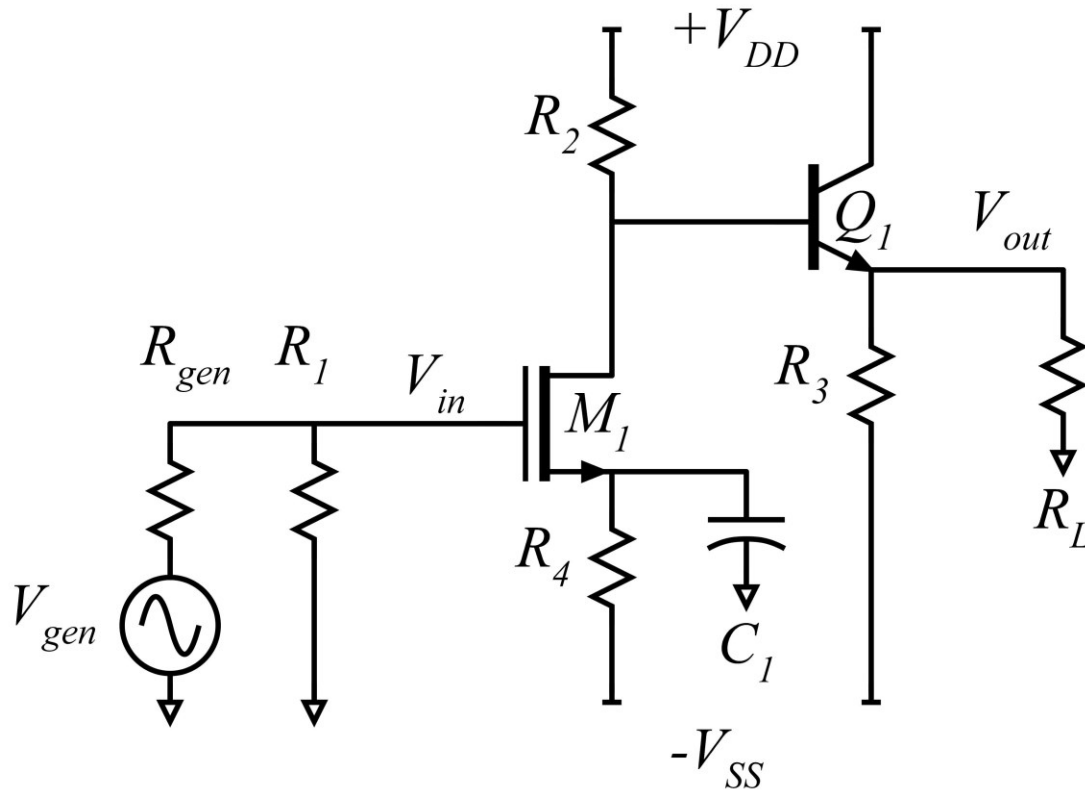
The DC value of V_{out} is *zero volts*.

Find the following:

$W_{g1} =$ _____ $R2 =$ _____ $R3 =$ _____ $R4 =$ _____

Part b, 7 points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes** and the DC currents through **ALL resistors**

Part c, 6 points

Find the small signal parameters of Q1 and M1.

Transistor M1: $g_m =$ _____ $R_{ds} =$ _____

Transistor Q1: $g_m =$ _____ $R_{ce} =$ _____ $R_{be} =$ _____

Part d, 15 points.

Find the small signal voltage gain (V_{e1}/V_{b1}) of Q1 and Q1's small-signal input resistance.

$V_{e1}/V_{b1} =$ _____

$R_{in,q1} =$ _____

Part e, 15 points

Find the small signal voltage gain (V_{d1}/V_{g1}) of M1 and the *** amplifier *** input resistance.

$V_{d1}/V_{g1} =$ _____

$R_{in, amplifier} =$ _____

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. Find the output voltage due to saturation and cutoff in Q1, and saturation and the knee voltage of M1. **Give the sign (+ or -) in your answers below.**

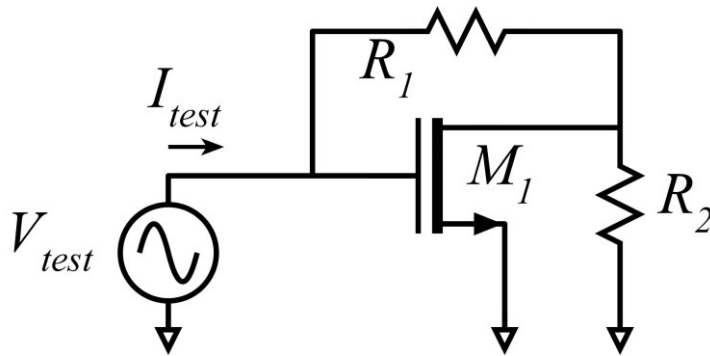
Cutoff of Q1; Maximum ΔV_{out} resulting = _____

Saturation of Q1; Maximum ΔV_{out} resulting = _____

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

Knee voltage of M1; 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.

Transistor M1 has transconductance g_{m1} .

The drain-source resistance R_{ds} of M1 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 $R_{in,transistor} = V_{test}/I_{test}$

$R_{in,transistor} = V_{test}/I_{test} =$ _____

Part c, 5 points

$g_{m1} = 1 \text{ mS}$, $R_1 = 2\text{k}\Omega$, $R_2 = 1\text{k}\Omega$

Give a numerical value for $R_{in,transistor}$

$R_{in,transistor} = V_{test}/I_{test} = \underline{\hspace{2cm}}$