

ECE 137 A Mid-Term Exam

Wednesday, February 8, 2023

Do not open exam until instructed to.

Closed book: Class crib sheet and 1 page (both sides) personal notes permitted

There are 3 problems on this exam, and you have 75 minutes.

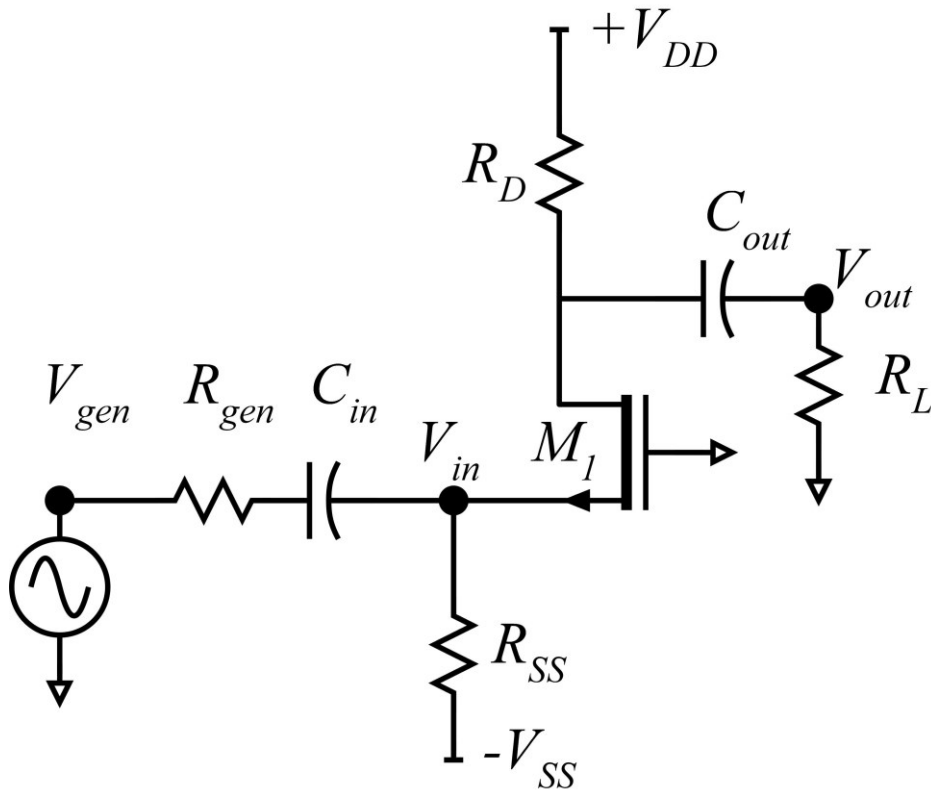
Use any and all reasonable approximations (5% accuracy is fine.),
AFTER STATING and approximately Justifying them.

Name: _____

Part	Points Received	Points Possible	Part	Points Received	Points Possible
1a		10	2e		3
1b		5	3a		8
1c		5	3b		8
1d		10	3c		4
1e		2			
1f		15			
2a		10			
2b		5			
2c		5			
2d		10			
TOTAL					100

Problem 1, 47 points

You will be working on the circuit below:



The transistor has

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

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

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

The supplies are +1.0V and -1.0 V

You are to bias the transistor at 2mA drain current, with -0.4 V DC source voltage, and with +0.5 V drain voltage

$$R_{gen} = 500 \, \Omega, R_L = 10 \text{k}\Omega$$

C_{in} and C_{out} are very large (AC short-circuits at the signal frequency)

Part a, 10 points

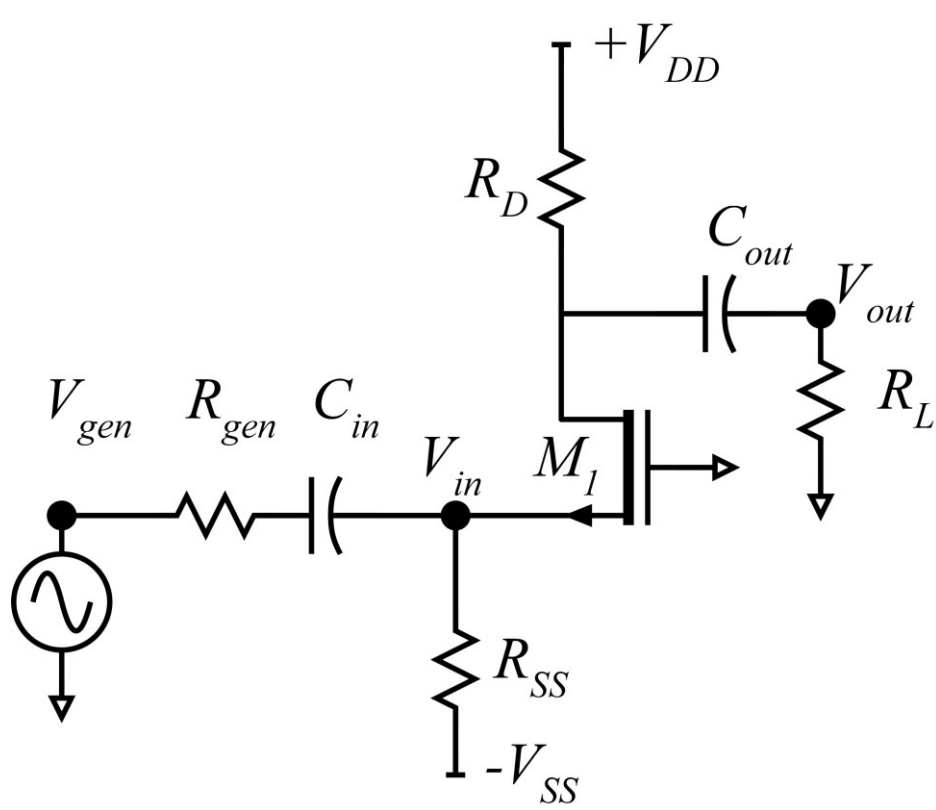
DC bias.

Find the following:

FET gate width W_g = _____ R_{ss} = _____ R_{DD} = _____

Part b, 5 points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes** and the DC currents through **ALL resistors**, give **all resistor values**, and give the **FET width**.

Part c, 5 points

Find the FET small signal parameters

$g_m =$ _____ $r_{ds} =$ _____

Part d, 10 points.

Find the small signal voltage gain V_{out}/V_{in} and the amplifier small-signal input resistance.

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

$R_{in, \text{ amplifier}} =$ _____

Part e, 2 points

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

$(V_{in}/V_{gen}) =$ _____

$(V_{out}/V_{gen}) =$ _____

Part f, 15 points

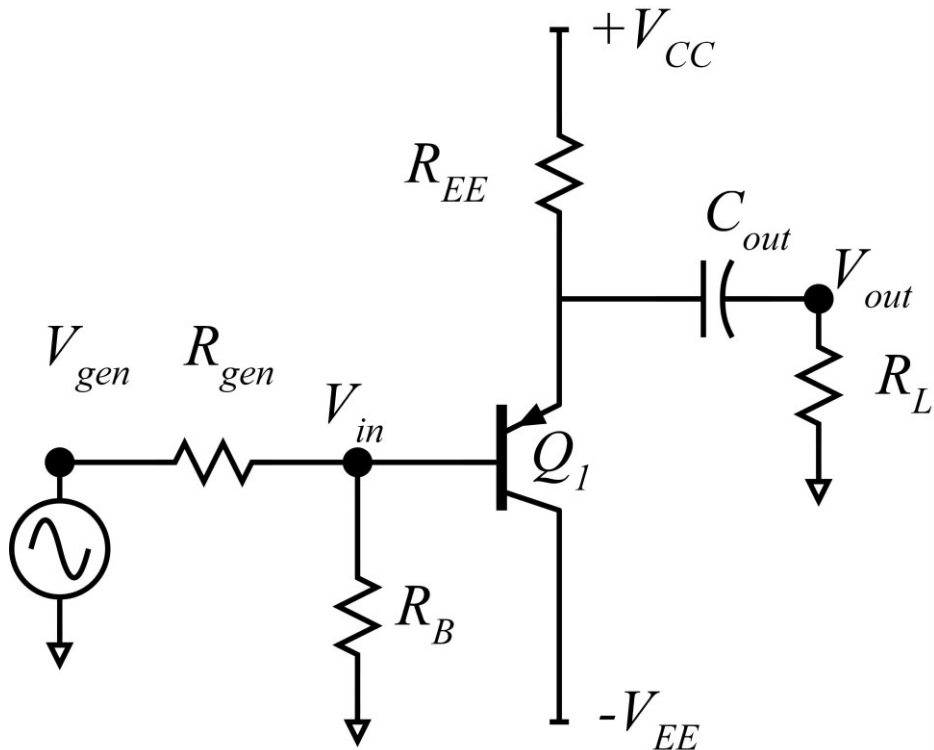
Now you must find the maximum signal swings. Find the output voltage due to the knee voltage and cutoff in M1. ***Give the sign (+ or -) in your answers below.***

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

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

Problem 2, 33 points

You will be working on the circuit below:



Q1: $\beta = 100$, $V_A = \text{infinity V}$, $V_{ce,sat} = 0.5\text{V}$

The supplies are $+5\text{V}$ and -5V .

You will bias the transistor with 3mA collector current.

R_L is $1\text{ k}\Omega$, R_{gen} is $5\text{ k}\Omega$, R_B is $20\text{ k}\Omega$,

C_{out} is very large (AC short-circuit at the signal frequency)

Part a, 10 points

DC bias.

Find the following:

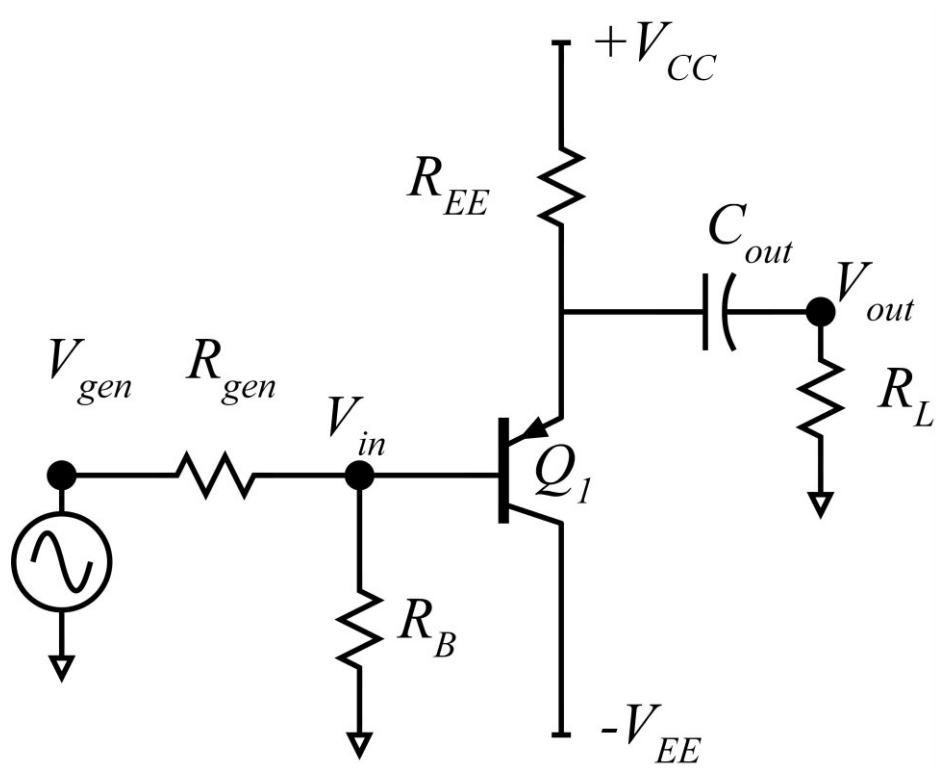
$R_{EE} =$ _____

DC voltage at the base of Q1: $V_{DC_base} =$ _____

Hint: there is no DC blocking capacitor in series with Vgen or Rgen.

Part b, 5 points

DC bias



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

Part c, 5 points

Find the small signal parameters of Q1.

$g_m =$ _____ $R_{ce} =$ _____ $R_{be} =$ _____

Part d, 10 points.

Find the small signal voltage gain (V_{out}/V_{in}) of Q1 and the amplifier small-signal input resistance.

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

$R_{in,amp} =$ _____

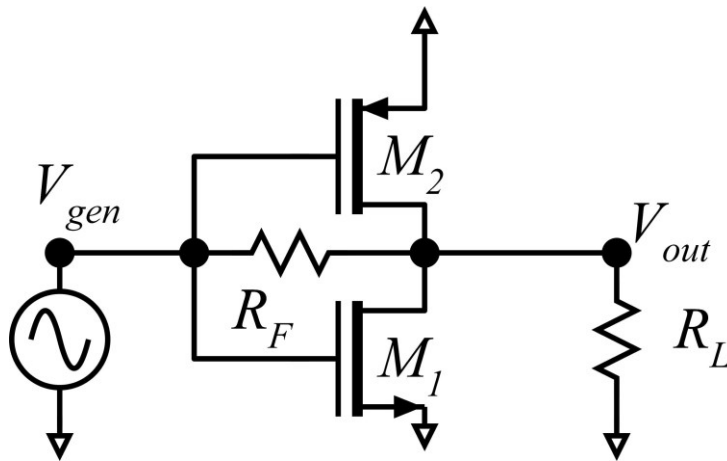
Part e, 3 points

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

$(V_{in}/V_{gen}) =$ _____

$(V_{out}/V_{gen}) =$ _____

Problem 3, 20 points
nodal analysis



You will be working on the circuit to the left.

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

The transistors M1 and M2 have transconductance

$$g_{m1} = g_{m2} = g_m$$

The drain-source resistances are $R_{DS1} = R_{DS2} = R_{DS} = \infty \Omega$ (so you don't need to draw them!)

Part a, 8 points

Draw the small-signal equivalent circuit

Part b, 8 points

Find, by nodal analysis, a small-signal expression for $A_v = V_{\text{out}}/V_{\text{in}}$.

$A_v =$ _____

Part c, 4 points

$g_m = 1 \text{ mS}$, $R_F = 1 \text{ k}\Omega$, $R_L = 2 \text{ k}\Omega$.
Give a numerical value for A_v .

$A_v =$ _____