

## ECE 137 A Mid-Term Exam

February 7, 2005

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 50 minutes.

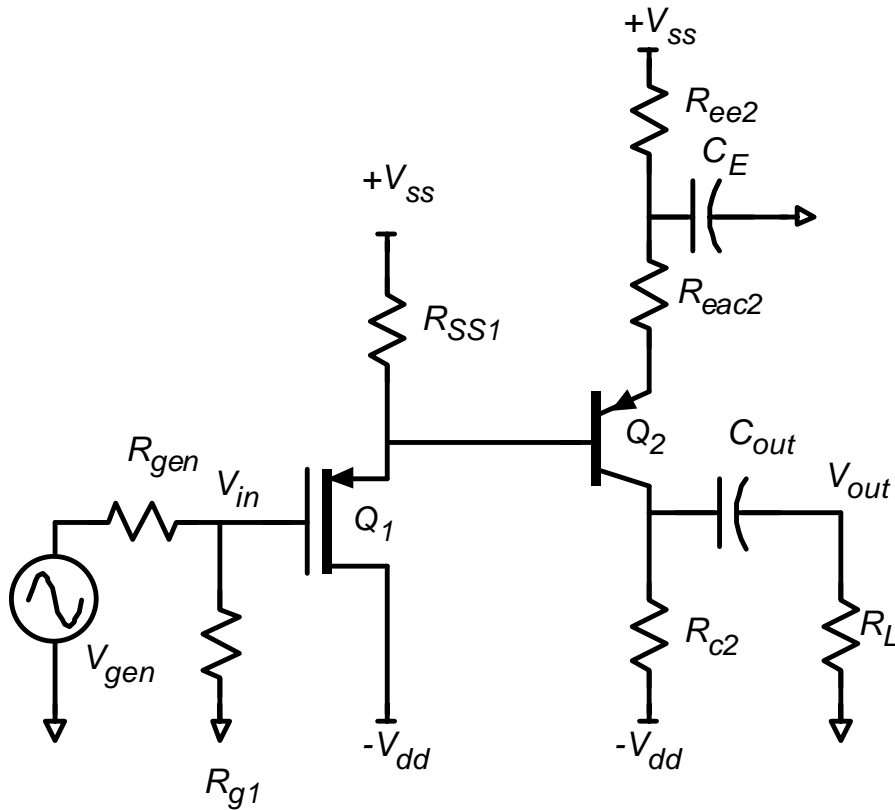
Use any and all reasonable approximations (5% accuracy is fine. ), ***AFTER STATING and approximately Justifying them.***

**Name:** \_\_\_\_\_

Problem	Points Received	Points Possible
1a		5
1b		5
1c		5
1d		15
1e		15
1f		5
1g		20
2a		12
2b		13
2c		5
total		100

**Problem 1, 70 points**

You will be working on the circuit below:



Q1 :  $|V_{th}|=1$  Volts.  $v_{sat} C_{ox} W_g = 2$  mA/V,  $\lambda = 0$  (P-channel enhancement mode device)

Q2:  $\beta = 200$ ,  $V_A = 75$  V

+V<sub>ss</sub>=+10 volts.

-V<sub>dd</sub>= -10 volts

R<sub>gen</sub>=1 MOhm

R<sub>L</sub>=500 Ohm

R<sub>g1</sub>=2 MOhm

R<sub>ea2</sub>=50 Ohm

R<sub>ss1</sub>= ???

R<sub>ee2</sub>= ???

R<sub>c2</sub>= ???

$C_E$  and  $C_{out}$  are very big and have negligible AC impedance.

Part a. 5 points

DC bias.

Q1 is to be biased with 3 mA source current.

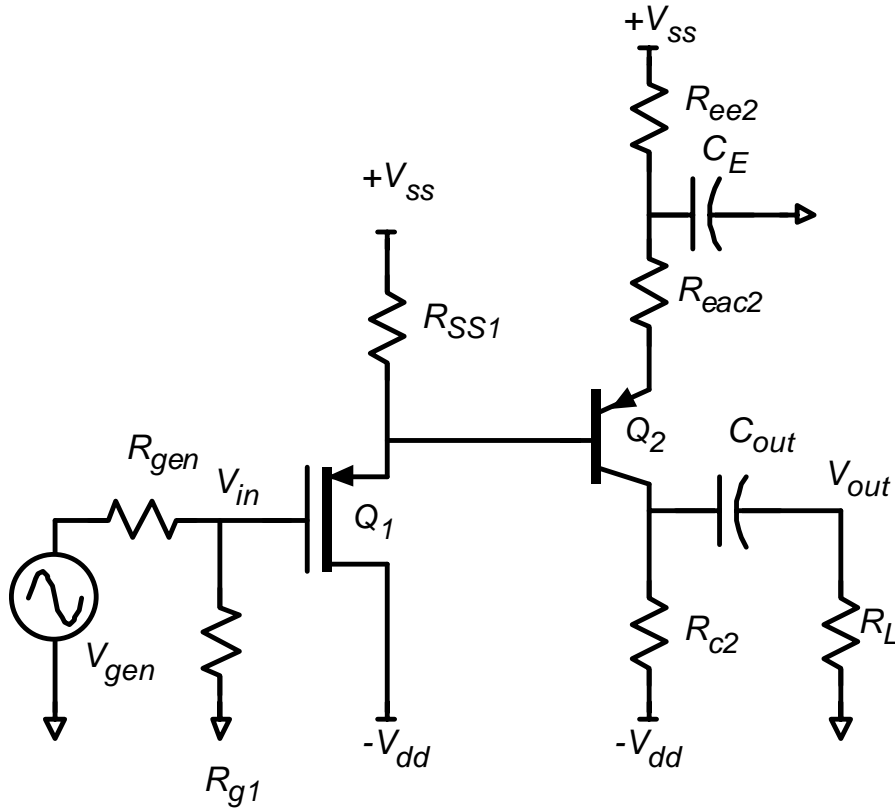
Q2 is to be biased with 10 mA emitter current.

The circuit is to be biased such that the DC collector voltage of Q2 is - 3 Volts.

Find:  $R_{ss1} =$  \_\_\_\_\_  $R_{ee2} =$  \_\_\_\_\_  $R_{c2} =$  \_\_\_\_\_

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**

Part c, 5 points

Find the small signal parameters of Q1 and Q2.

Transistor Q1:  $g_m =$  \_\_\_\_\_  $R_{ds} =$  \_\_\_\_\_

Transistor Q2:  $g_m =$  \_\_\_\_\_  $R_{ce} =$  \_\_\_\_\_  $R_{be} =$  \_\_\_\_\_

Part d, 15 points.

Find the small signal voltage gain ( $V_{c2}/V_{b2}$ ) of Q2 and Q2's small-signal input resistance.

$V_{c2}/V_{b2} =$  \_\_\_\_\_

$R_{in,q2} =$  \_\_\_\_\_

Part d, 15 points

Find the small signal voltage gain ( $V_{s1}/V_{g1}$ ) of Q1 and the \*\*\* amplifier \*\*\* input resistance.

$V_{s1}/V_{g1} =$  \_\_\_\_\_

$R_{in, amplifier} =$  \_\_\_\_\_

Part f, 5 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, 20 points

Find the maximum peak-peak output voltage (show all your work, specifically show the limits of the output swing arising from cutoff and saturation of Q1 and Q2)

Cutoff of Q1; Maximum  $\Delta V_{out}$  resulting = \_\_\_\_\_

Knee voltage of Q1; Maximum  $\Delta V_{out}$  resulting = \_\_\_\_\_

Cutoff of Q2; Maximum  $\Delta V_{out}$  resulting = \_\_\_\_\_

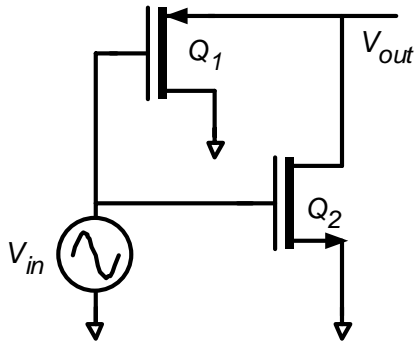
Saturation of Q2; Maximum  $\Delta V_{out}$  resulting = \_\_\_\_\_

Maximum Undistorted Sinusoidal Peak-Peak output = \_\_\_\_\_



**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 two transistors have transconductance  $g_{m1}$  and  $g_{m2}$  respectively. Their output resistances  $R_{ds1}$  and  $R_{ds2}$  are both infinity.

Part a, 12 points

Draw a small-signal equivalent circuit of the 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

$g_{m1} = 10 \text{ mS}$     $g_{m2} = 11 \text{ mS}$

Give a numerical value for  $V_{out}/V_{in}$ .

$V_{out}/V_{in} =$  \_\_\_\_\_