Final Exam, ECE 137A

Wednesday March 22, 2006 8-11 AM

Name: _____

Closed Book Exam: Class Crib-Sheet and 3 pages (6 surfaces) of student notes permitted
Do not open this exam until instructed to do so. Use any and all reasonable approximations (5% accuracy), ***after stating & justifying them***.
Show your work:
Full credit will not be given for correct answers if supporting work is missing.

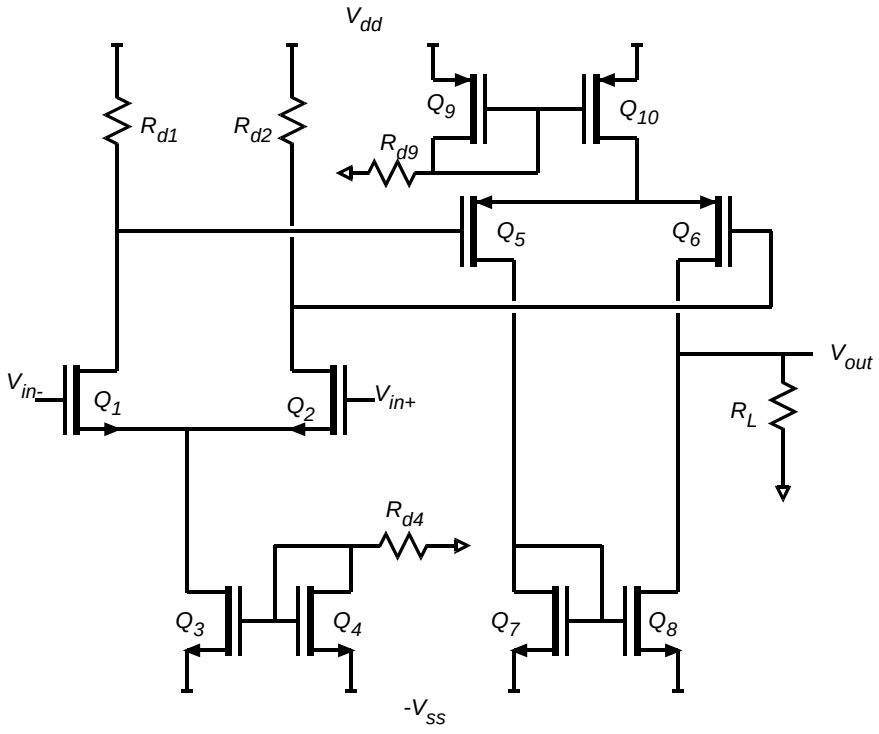
Good luck

Time function	LaPlace Transform
$\delta(t)$	1
U(t)	1/s
$e^{-\alpha t}U(t)$	$\frac{1}{s+\alpha}$
$e^{-\alpha t}\cos(\omega_d t)U(t)$	$\frac{s+\alpha}{(s+\alpha)^2+\omega_d^2}$
$e^{-\alpha t}\sin(\omega_d t)U(t)$	$\frac{\omega_d}{(s+\alpha)^2+\omega_d^2}$

Part	Points Received	Points Possible	Part	Points Received	Points Possible
1a		5	2b		10
1b		5	2c		15
1c		5	3a		7
1d		10	3b		8
1e		10	3c		7
2a		10	3d		8
TOTAL		100			

Problem 1, 35 points

(This ***NOT*** an Op-Amp)



N-channel devices: V_{th} =0.5 Volts. $v_{sat}C_{ox}W_g$ = 0.5 mA/V, $\lambda = 1/(20\text{ Volts})$

P-channel devices: $|V_{th}|$=0.5 Volts. $v_{sat}C_{ox}W_g$ = 0.5 mA/V, $\lambda = 1/(20\text{ Volts})$

Vdd=+5 volts. -Vss= -5 volts

RL=100 kOhm.

Input DC bias condition: Vin+=Vin- =zero volts

Part a, 5 points

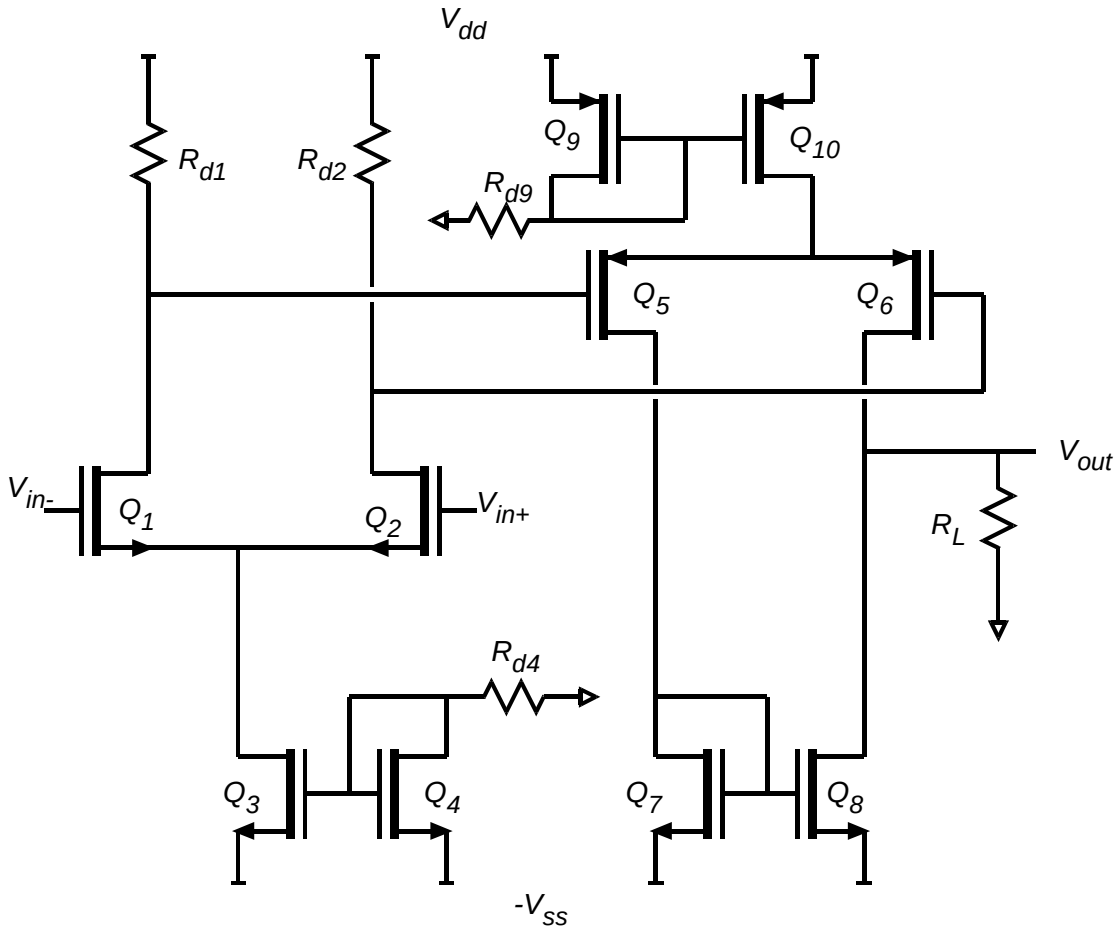
DC bias. *Ignore the λ factor during DC bias calculations*
The DC output voltage is to be zero volts if Vin+=Vin- =zero volts
Q1, Q5, Q5, and Q6 are all to be biased at 0.2 mA drain currrent.
The gates of Q5 and Q6 are to be biased at +3.5 Volts

Find: Rd1=_____ Rd2=_____

Rd4=_____ Rd9=_____

Part b, 5 points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes**, the DC currents through **ALL resistors,** and the DC drain currents of **all transistors**.

Input DC bias condition: Vin+=Vin- =zero volts

a

Part c, 5 points

Find the small signal parameters below

FETs	gm	Rds
Q1		
Q2		
Q3		
Q5		
Q6		
Q7		
Q8		
Q9		
Q10		

a

Part d, 10 points.

Given these definitions, find the following

	Gain
Differential Pair Q1/Q2	
Differential Pair Q5/Q6	
Overall Vout/Vin	

a

Part e, 10 points

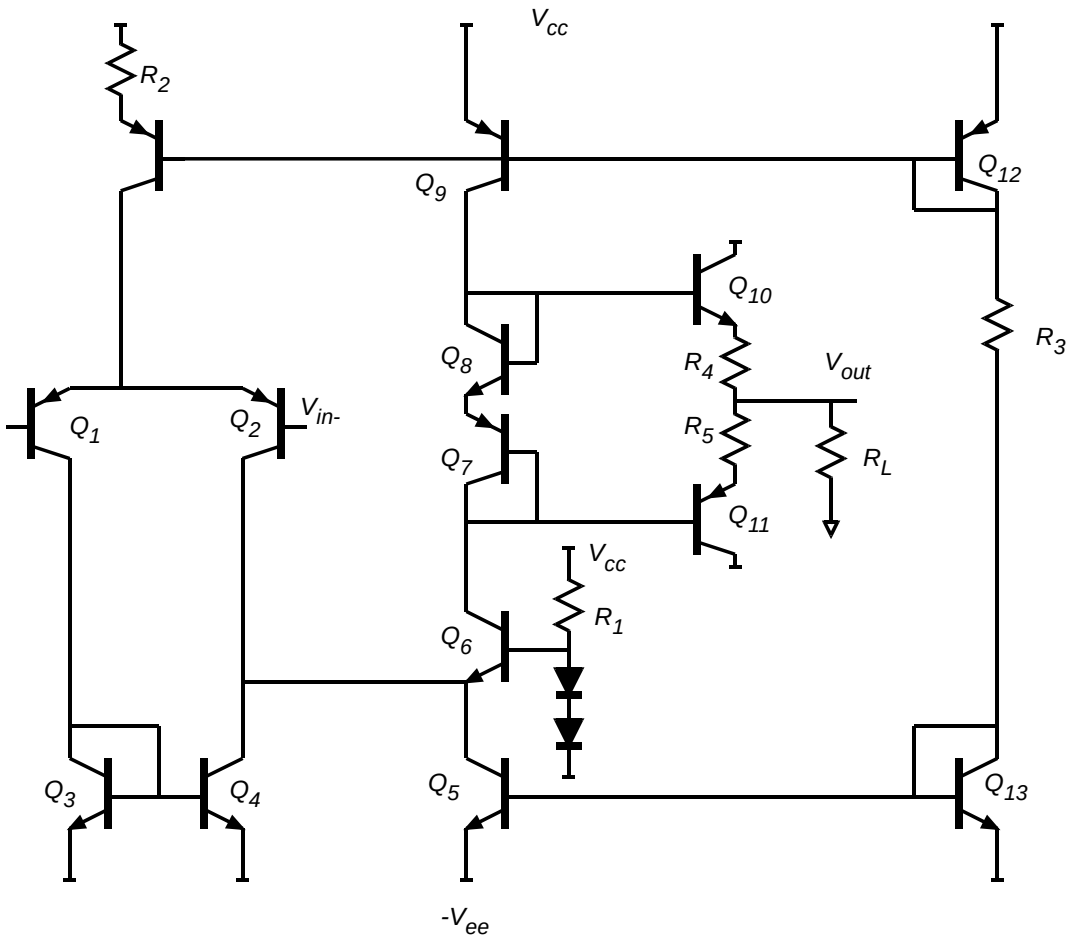
Maximum peak-peak output voltage (***show all your work***)

	magnitude and sign of maximum output signal swing due to ***cutoff***	magnitude and sign of maximum output signal swing due to: ***knee voltage*** (FETs)
Transistor Q5		----------N/A----------
Transistor Q6 x``		
Transistor Q8		

Problem 2, 35 points

This is an Op-Amp

Analyze under the assumption that the DC output is at zero volts



NPNs: beta=300, V_A =100 volts, all NPNs have equal I_s.

PNPs: beta=300, V_A =100 volts, all PNPs have equal I_s.

Except: the output transistors (Q10, Q11) have I_s 10:1 greater than all other transistors.

Vcc=+10 volts, -Vss=-10 volts, R_L =10 kΩ

Part a, 10 points

DC bias.

Q9 is to be biased at 2 mA collector current.

Q10 is to be biased at 2 mA collector current.

Q1 and Q2 are to be biased at 0.2 mA collector current.

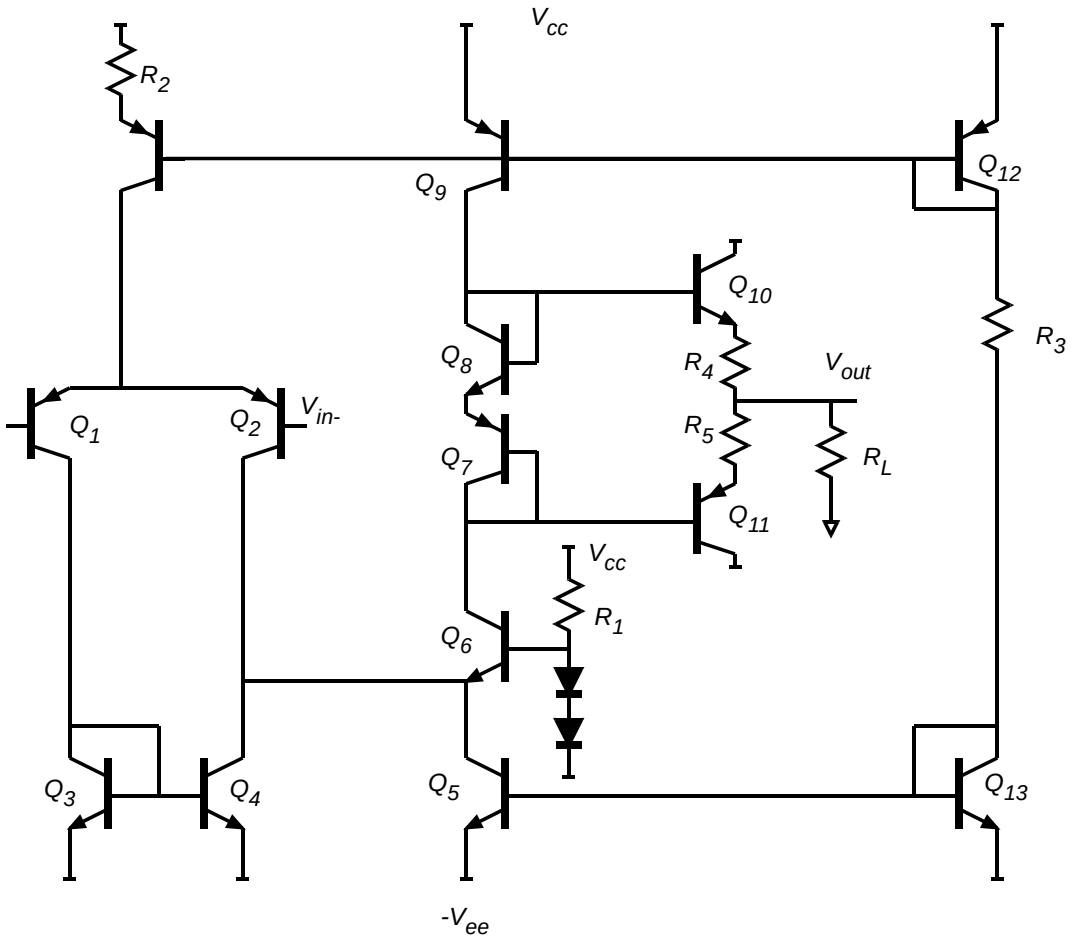
Find:

R1=_____ R2=_____

R3=_____ R4=_____ R5=_____

Part b, 10 points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes** and the drain currents of **ALL transistors**

a

Part c, 15 points.

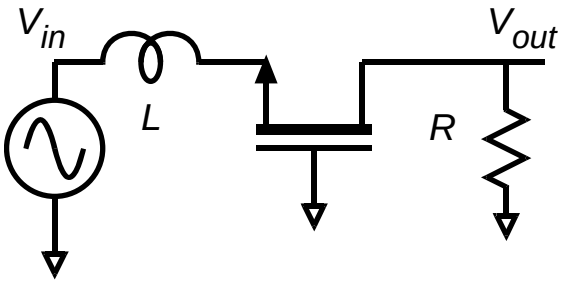
Find the following

	Voltage Gain	Input impedance
Transistor combination Q1, Q2, Q3, Q4		
Transistor Q6		
Push-pull state Q10/Q11		
Overall differential Vout/Vin		

a

a

Problem 3, 30 points



You will be working on the circuit to the left

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

The transistor has transconductance gm. Its output resistance Rds is infinity.

Part a, 7 points

Draw a small-signal equivalent circuit of the circuit.

Part b, 8 points

gm=10 mS. L=10 nH. R= 1000 Ohms
Find, by nodal analysis, a small-signal expression for Vout/Vin

Vout(s)/Vin(s)= _____

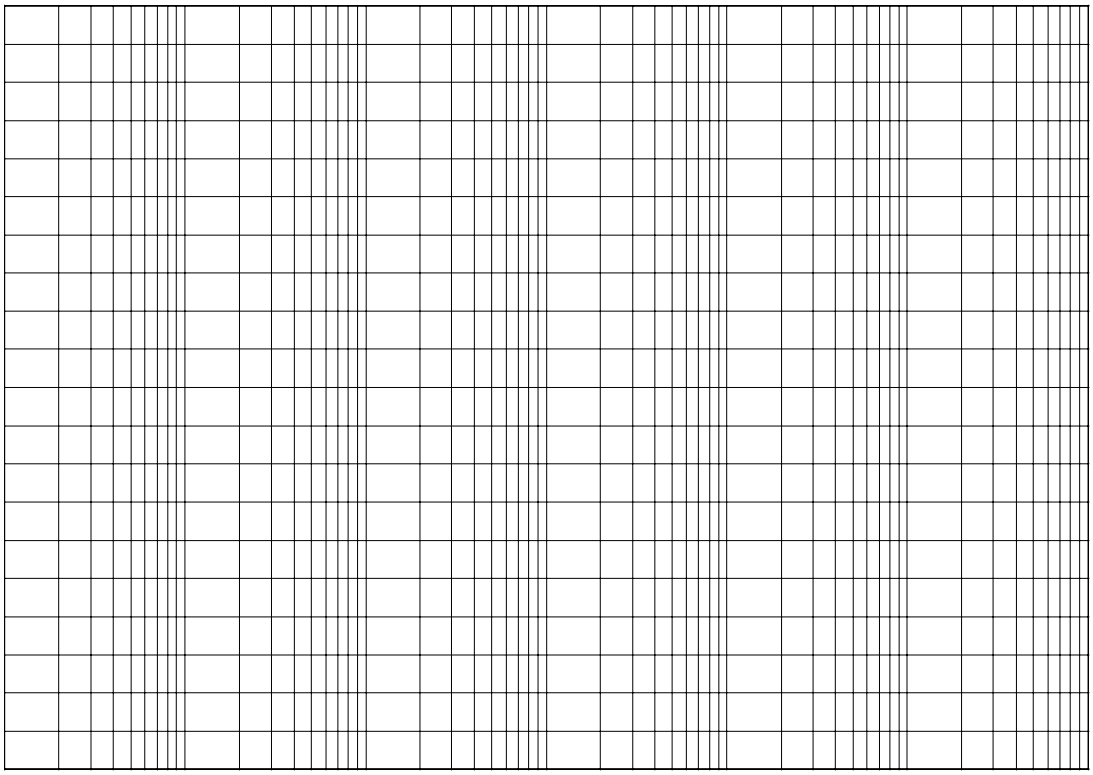
a

Part c, 7 points

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

_____,_____,_____,_____

Draw a clean Bode Plot of Vout/Vin,
LABEL AXES, LABEL all relevant gains and pole or zero frequencies, Label Slopes



a

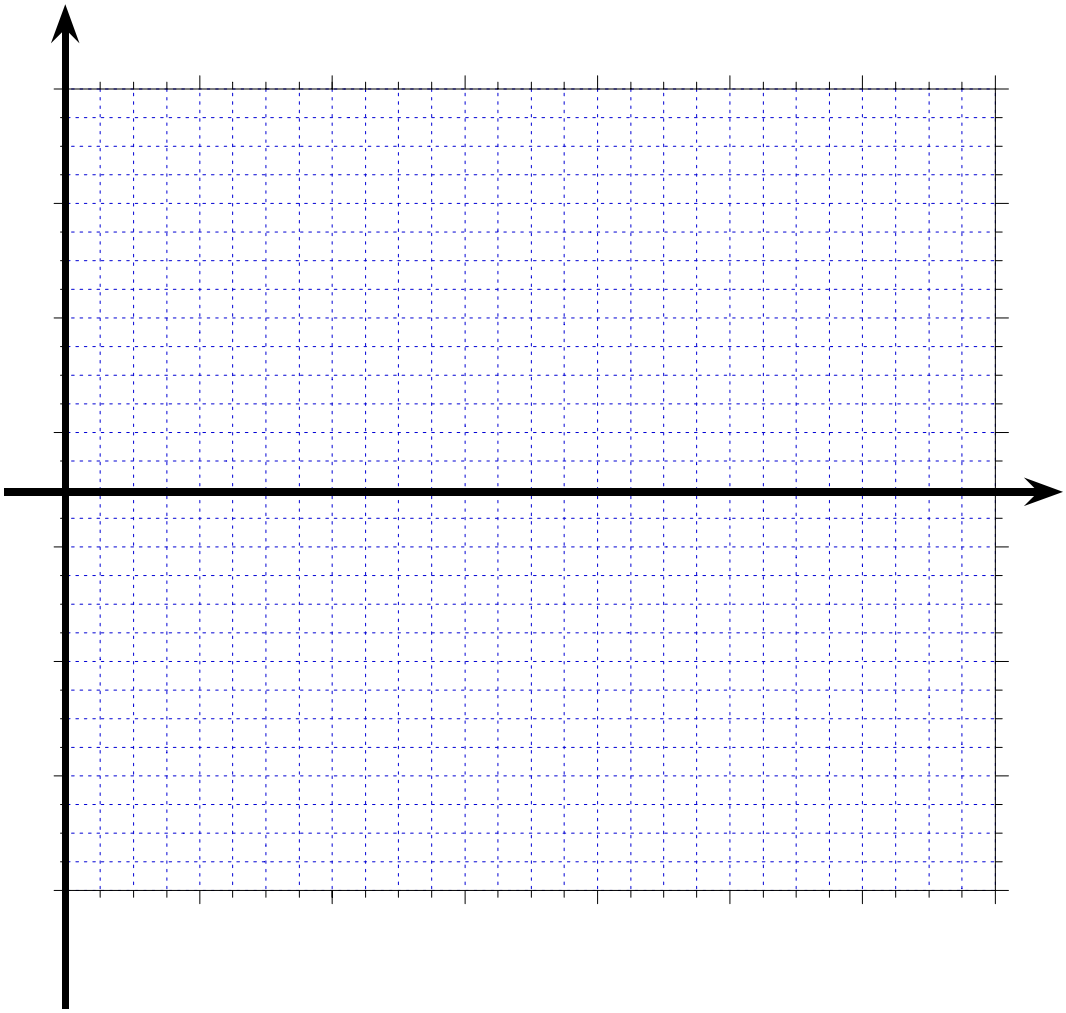
a

Part d, 8 points

Vin(t) is a 0.5 V amplitude step-function.

Find Vout(t)=_____

Plot it below. Label axes, show initial and final values, show time constants.



a