EECS105 Name_____
Final
5/13/11 SID_____

NO CALCULATORS – This is a hint. If you feel like you need to use a calculator, you're probably doing the problem wrong!

1	/20
2	/20
3	/10
4	/20
5	/20
6	/20
7	/10
8	/30
Total	

1. Give a short answer to each question

4 a. Your friend from Stanford says that to maximize the power delivered to an 8 Ohm load from a 10V source you should use a voltage source with an 8 Ohm output impedance. Do you agree? Why?

4 b. You build a common source amplifier with a gain of -20 and C_{gs}=50fF, C_{gd}=10fF. What is the input capacitance?

4 c. You build a common drain amplifier with a gain of 0.9 using the same transistor (C_{gs}=50fF and C_{gd}=10fF). What is the input capacitance?

4 d. You have an amplifier with a gain A=100. You put it into feedback with a feedback factor f=0.1. What is the closed loop gain of the system, accurate to a percent or two?

4 e. With the same amplifier, you change the feedback factor to 0.001. What is the closed loop gain, accurate to a few percent?

2.

(a.) You have a common source amplifier with an input bias point V^*_G that gives an output bias point V^*_D and a DC gain of -10, and an output resistance of 1MΩ. The load capacitance is 1pF. If you give the amplifier an input of

$V_{IN} = V^*_G + (1mV)\sin(t) + 1mV\ \sin(10^6 t) + 1mV\ \sin(10^7 t)$

What do you expect the output to be? All constants in your answer should be accurate to 10% (hint: you might want to sketch a Bode plot to help)

space
bold

10

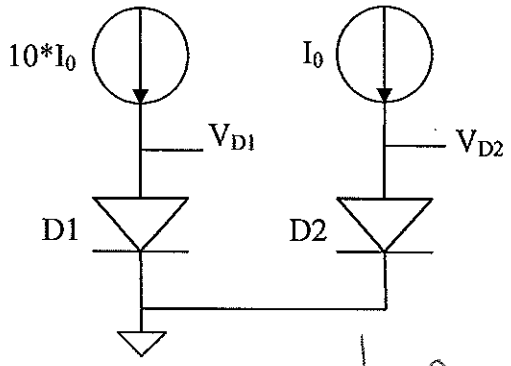
V_{OUT}

10

b. You make a parallel LC tank using a 1mH inductor and a 1nF capacitor. The inductor has a total wire resistance of 10 Ohms. What is the resonant frequency ω_p, and the complex impedance of the tank at 1 rad/sec, 0.1 ω_p, ω_p , and 10 ω_p ?

ω_p	**Z(1j)**
Z(0.1j ω_p)	**Z(j ω_p)**
Z(10j ω_p)	

3. You have two identical diodes, D1 and D2, and two different current sources which produce I_0 and $10*I_0$. The circuit below voltage difference between the two diodes is often called PTAT, or "proportional to absolute temperature". Write down an expression for the relationship between current and voltage in each diode, and then solve for the voltage difference $V_{PTAT} = V_{D1} - V_{D2}$. What is the voltage difference at room temperature, and what is the constant of proportionality in Volts/Kelvin?



On exam

2 **D1 I/V relationship**

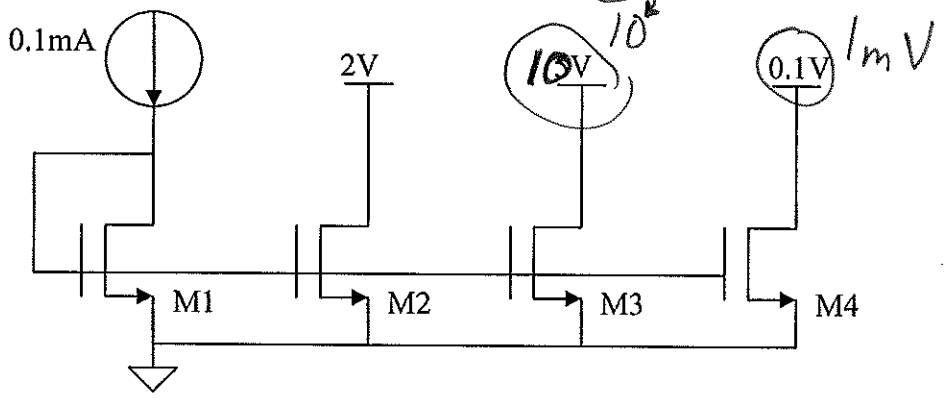
2 **D2 I/V relationship**

2 **V_{PTAT}=**

2 **V_{PTAT}(300K)=**

Constant[V/K]= 2

4. In the current mirror below, assume that $\mu_n C_{ox} = 200uA/V^2$, $\lambda=0.05/V$, and $V_{TN}=1V$. All transistors have W/L = 100u/1u. Calculate the gate bias voltage V_{GS1} resulting from the input current. Calculate the currents flowing in the drains of the other transistors. All calculations should be accurate to a few percent.



V_{GS1}=	I_{D2} =
I_{D3} =	I_{D4} =

5. Your partner built the common emitter amplifier below with a gain of A_0, and the only thing that your partner told you about the output bias point is that it's above 2V. All of your NPN transistors have with beta=200 and (magically) V_A=infinity.

You connect a wire between V_X and V_Y. You want to make sure that the magnitude of the impedance of C_{out} is always smaller than the 10 Ohm load resistance over the frequency range from 100 rad/sec to 100,000 rad/sec. Does that impose a minimum or maximum value on the capacitor? What is that value? If you use that capacitance value, what is the gain from V_{IN} to V_Z at 1,000 rad/sec? (Write your answer in terms of A_0, accurate to 10%).

C_{out} value is {min, max}?	**C_{out}**	**$A_{IN->Z}(j1000)$**

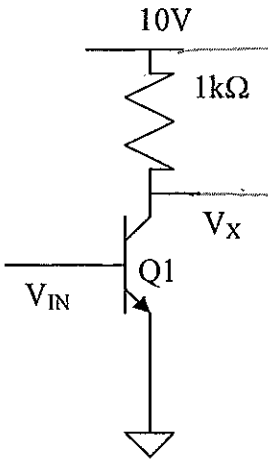
You don't like your answer above, and you have a box full of NPN transistors. Instead of a wire, you decide to design an emitter follower to connect V_X to V_Y. You want the gain of the emitter follower to be more than 0.9. What g_m and current do you need in your follower?

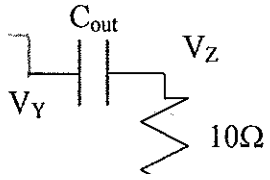
$g_{m,follower}$	**$I_{Cfollower}$**

Draw the follower and any bias circuitry in the figure below, between V_X and V_Y. If you use any passives, label their values. For your new circuit, what is the gain from V_{IN} to V_Z at 1,000 rad/sec? How much does the gain vary from 100 to 10,000 rad/sec?

New $A_{IN->Z}(j1000)$	**Gain variation**

6 pts





6. In the two circuits below, assume that all transistors are identical, with beta=100, V_A=infinite, and Q1 is biased with the same collector current in each circuit.

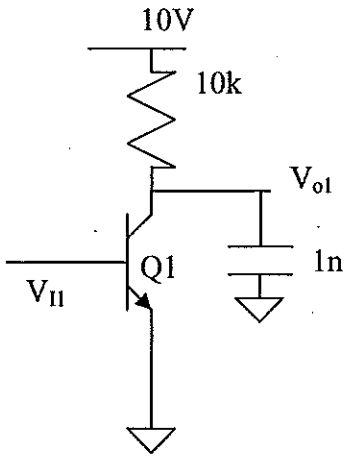
a. Calculate the block transconductance $G_{M,D}$ for the circuit on the right. To do this, think of Q2 as an emitter follower with Q1 as the load, and calculate the gain, A_{VQ2}, from V_{I2} to V_{B1}.

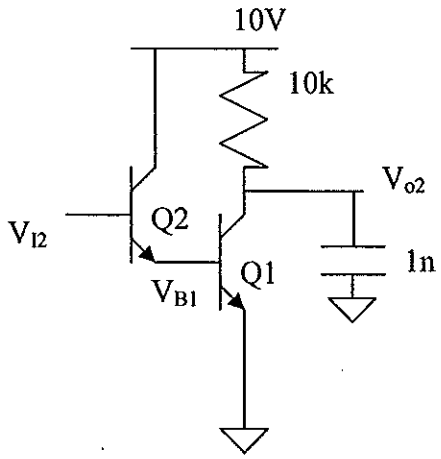
b. Which circuit has the bigger G_M? (circle one) LEFT RIGHT

c. Which circuit has the higher voltage gain? LEFT RIGHT

d. Which circuit has the higher input resistance? LEFT RIGHT SAME

e. Which circuit has the higher output resistance? LEFT RIGHT SAME

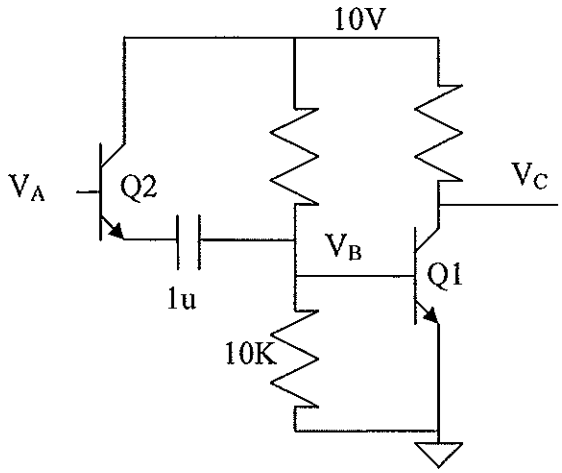




A_{VQ2}

$G_{M,D}$

7. Your friend made a mistake when building his amplifier. The circuit he built is shown below. What's wrong with it? Perhaps surprisingly, your friend still sees a reasonable voltage gain from V_A to V_C at some frequencies.
What is the DC current through Q2? What is the right small signal model to use for Q2 in this circuit? Draw it!
Estimate the frequency of the input pole from V_A to V_B, assuming that the bipolar transistor junctions have roughly 10pF capacitance at zero bias.



2 **What's wrong:**

2 **I_{C2}**

4 **Small signal model for Q2**

2 **ω_{pin}**

8. For the circuit below, each stage is a common source amplifier with an output resistance of 1kΩ, the input capacitance for each stage is 1pF, and the gain of each stage is -100. If R_{FB}=0 and CFB=1pF, what is the open loop DC gain from V_{IN} to V_{FB}, the frequency of the three poles, and the unity gain frequency? Estimate ω_{360}, the frequency at which the phase is 360, and estimate the gain at that frequency. Will this system oscillate if you close the feedback loop from V_{FB} to V_{IN}?

3pts each

Gain(0)	ω_p	ω_u
ω_{360}	**Gain($j\omega_{360}$)**	**Will it oscillate?**

If R_{FB}=100k and you want to change ω_u to be 10^8 rad/sec, what capacitor should you use for C_{FB}? Will this system oscillate when you close the feedback loop? Assuming that the system does not oscillate, if R_{SRC}=10k, what will the closed-loop gain from V_{SRC} to V_{out3} be? How accurate will that gain be (what's the percent error?)

C_{FB}=	**Will it oscillate?**
Closed-loop gain	**% error**