Wrong sign -1

$-\frac{\pi}{4}, +\frac{\pi}{4}, \ldots$ -2

$+\frac{\pi}{4}$ if $\frac{\pi}{4}, \ldots$ -4
without derivation

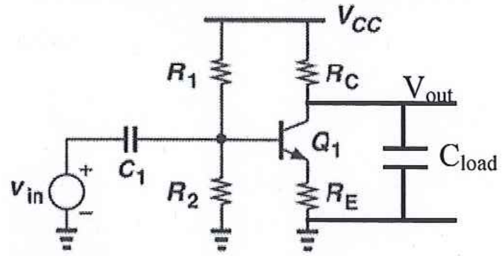
EEC S105 Spring 2011 Midterm 2
Open book, open notes, no silicon.

Name Key

SID____________________________

Prob.	Score
1	/20
2	/20
3	/15
4	/20
5	/25
Total	/100

1) In the circuit below with R_E=10k, R_C=100k and C_{load}=1pF, calculate the frequency ω_p of the output pole, and the magnitude and phase of the transfer function from v_{in} to v_{out} at the output pole frequency, accurate to 10%. Sketch the output waveform in response to an input V_{in}=1mV sin(ω_pt). I've drawn the input waveform and labeled the axes. Draw the output waveform and **label the right axis**. Assume the bias point for V_E is 0.5V, V_{CC}=10V, V_A=100V, and the input pole is at very low frequency.



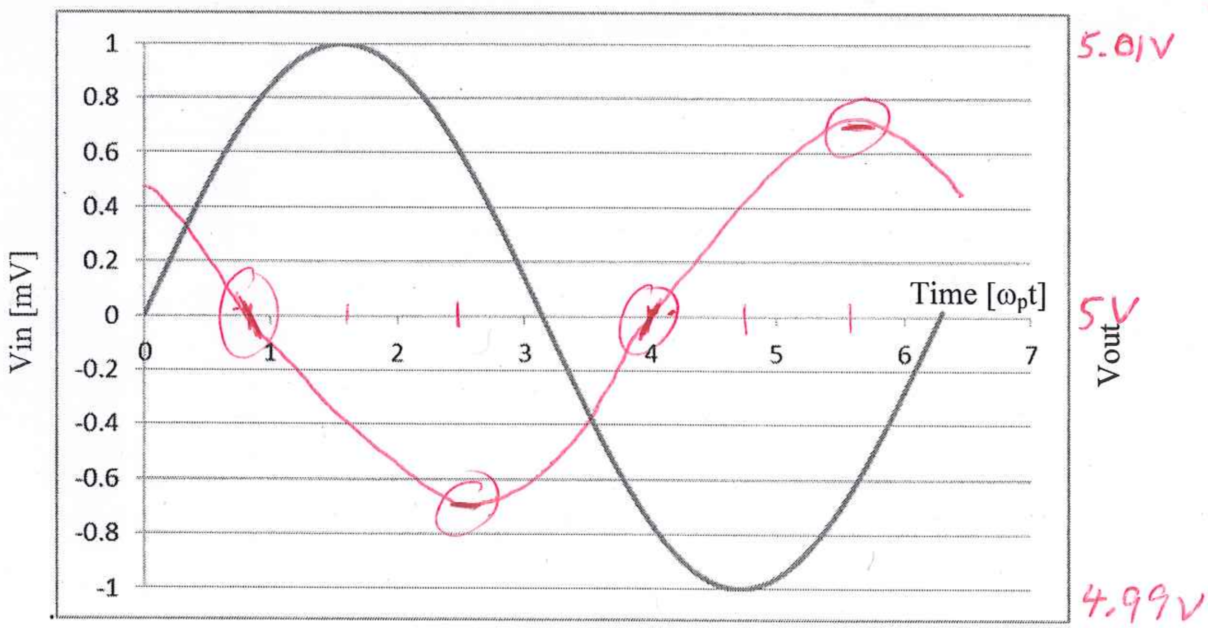
(a)

ω_p= 10^7 rad/sec

$|H(j\omega_p)|$= +7

Angle($H(j\omega_p)$)= $-\frac{5\pi}{4}$, $\frac{3\pi}{4}$, -225, +135

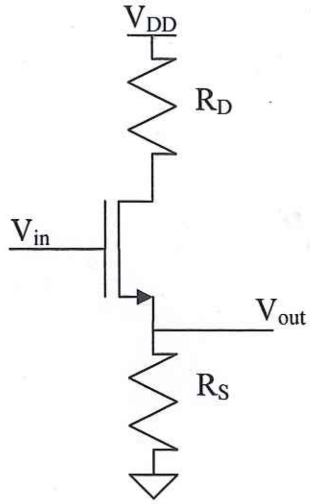
+10 -2
+0.7 -2
negative ~~positive~~ -1
-10 -3
-7 -1
-0.7 -3



amplitude 2
offset 1
phase 2

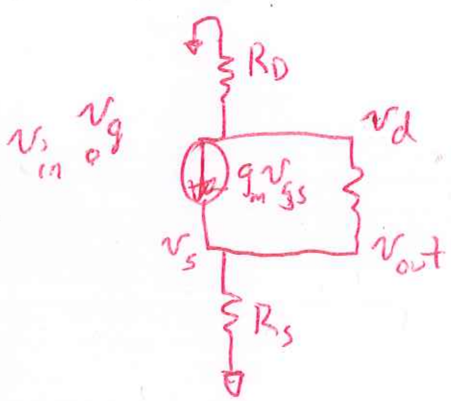
no labels -2 if at "0.7"
-3 otherwise

2) For the source follower circuit below,

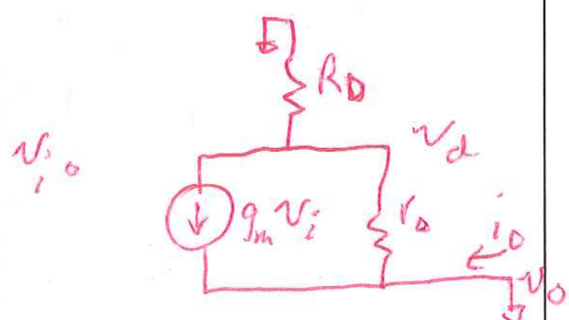


2A) Draw the small signal model for this circuit. Label every node.
2B) Simplify the circuit assuming that you want to calculate G_M. **State the assumption that allows the simplification.**
2C) Write down KCL at the output node.
2D) Solve for the transconductance, G_M. (no credit on this one without showing your work).

2A) Small signal model



2B) Simplified for G_M calculation
Assuming: $v_o = 0$ 1 pt



2C) KCL @ v_o

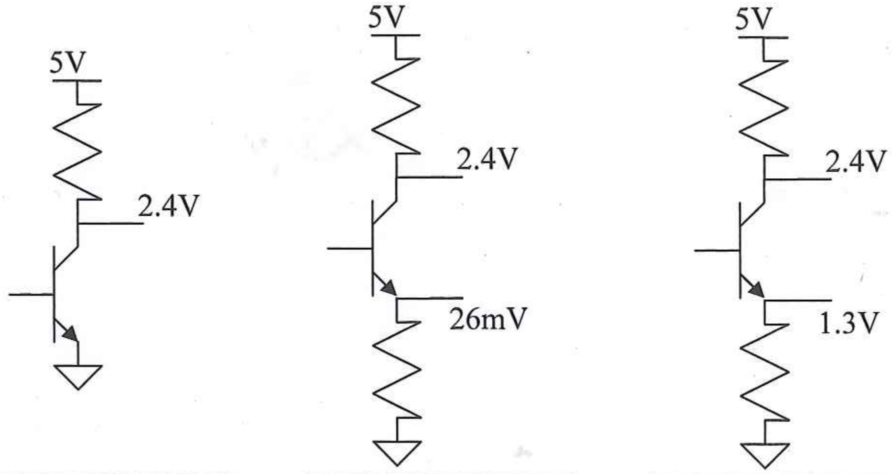
$$i_o + g_m v_i + \frac{1}{r_o} v_{ds} = 0$$

$$v_d = i_o R_D \qquad i_o + \frac{1}{r_o}(i_o R_D) = -g_m v_i$$

$$\left(1 + \frac{R_D}{r_o}\right) i_o = -g_m v_i$$

2D) $G_M =$ $\dfrac{-g_m}{1 + \dfrac{R_D}{r_o}} = \dfrac{-g_m r_o}{r_o + R_D}$

3) For the common emitter amplifiers below, given the bias points as shown, calculate the gain for each amplifier, accurate to 10%. The transistor is a 2n3904 like you've used in lab. You should be able to get a numerical answer.

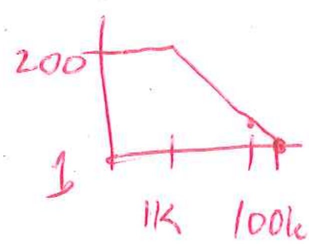


Av= -100	Av= -50	Av= -2
	-100 -3	

- no negative -1'
- 2nd. |Av| = 100 -3'
- 5' for each.

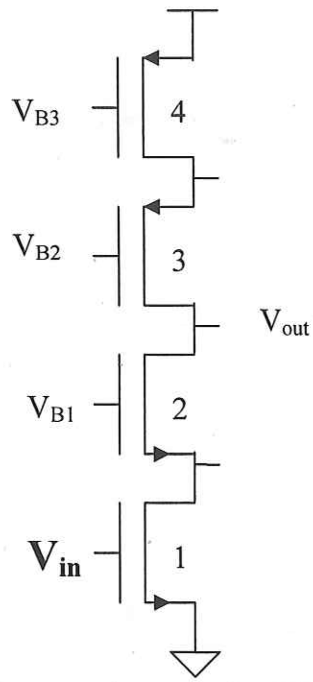
4) You have a single-pole amplifier with a low frequency gain of 200, and a gain of 2 at 100kHz. What is the gain at the frequencies below?

Frequency	Gain
10 Hz	200
10kHz	20
200kHz	1
2MHz	0.1



- minus sign -1'
- 5' for each.

5A) For the circuit below, calculate the transconductance, output resistance. Write your answer in terms of g_{m1}, g_{m2}, r_{o1}, etc. Assume that $g_m r_o >> 1$ for all combinations of g_m and r_o, and simplify your answers. Then calculate the voltage gain with the additional assumption that all transconductances are equal to g_m and all output resistances are equal to r_o, and simplify.



4'

$G_M = g_{m1}$

Rup - 3'

Rdown - 3'

Rtot = Rup // Rdown 2'

$R_o = g_{m2} r_{o2} r_{o1} \,||\, g_{m3} r_{o3} r_{o4}$

$A_V = -\frac{1}{2}(g_m r_o)^2$

o 4'

o No negative -1'

9 (3' for each)

5B) If you increase the boron (acceptor) doping level in the P-type substrate of an NMOS transistor, the

i) Surface potential with V_{GS}=0 will ~~go increase~~ or decrease?

ii) Electric field in the oxide with V_{GS}=0 will increase or decrease?

iii) Threshold voltage will increase or decrease?