

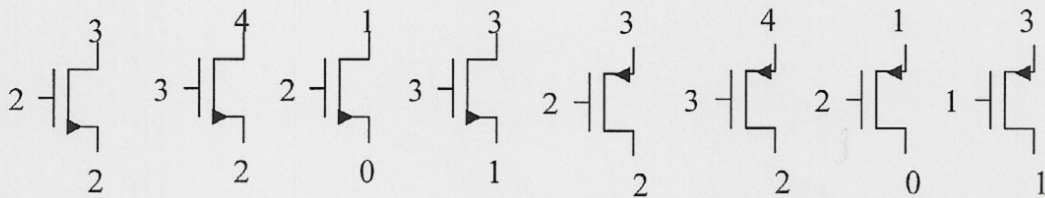
EECS140
Fall 2009
Midterm 1

Name Key

SID _____

Prob.	Score
1	/15
2	/15
3	/25
4	/15
5	/30
Total	

1) For the following problems, the drain, gate, and source voltages are given. You may assume that $V_{SB}=0$. Indicate if the devices are off, in the linear or triode region, or in saturation. If the devices are in saturation, calculate $|V_{dsat}|$.



OFF								
LIN	OFF	SAT	BP	SAT	SAT	LIN	SAT	SAT
SAT			LIN			SAT	OFF	LIN
V_{dsat} (if SAT)		0.5		1.5	0.5			1.5

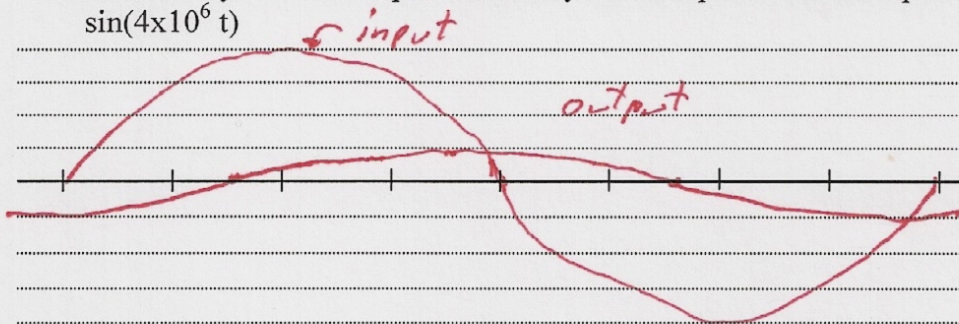
1 pt each

wrong $\omega_p: -5$

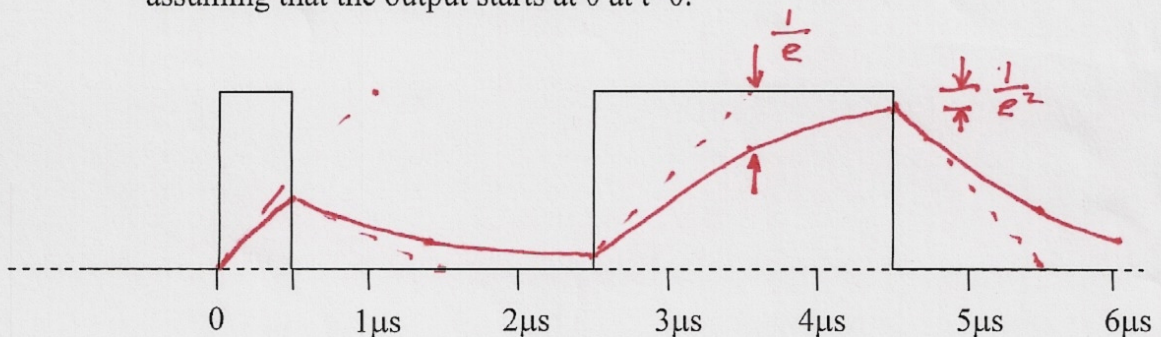
2) You have an RC lowpass filter with a $1M\Omega$ resistor and a $1pF$ capacitor.
a. Sketch a cycle of the input and steady state output when the input is $\sin(4 \times 10^6 t)$

$RC = 10^{-6}$
 $\omega_p = 10^6$
 $|A(\omega)| \approx \frac{1}{4}$

Mag 3 pts
 phase 4 pts
 $45 < \phi < 90$ 4
 $25 < \phi < 45$ 2
 $0 < \phi < 25$ 1
 $\theta \leq 0$ } 0
 $\theta \geq 90$ } 0
 $\theta = 90$ 2



b. Sketch the transient response from 0 to $6\mu s$ to the following input assuming that the output starts at 0 at $t=0$.



3) For a common emitter amplifier like what some of you used in the audio amplifier lab,
 a) Choose the value of R_C to give a small signal gain of approximately -10

5 pts

$R_C = 100K$ or " $10 \times R_E$ "

b) What is the approximate range of V_B for which this circuit gives a gain of approximately -10? You may assume that the input signals are less than 10mV.

5 pts

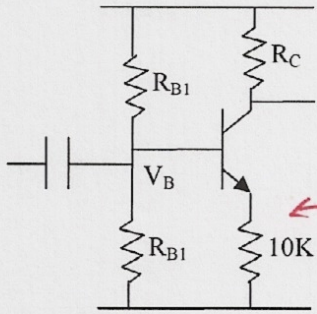
$V_B = 0.8$ to 1.6
 or 0.9 to 1.7

Start w/ V_E : max V_E is $< 1V$ since V_C drops $10 \times V_E$
 min V_E set by $G_m = \frac{g_m}{1 + g_m R_E} \approx \frac{1}{R_E}$

c) What is the purpose of the capacitor?

5 pts

DC blocking - input can be at any DC value and bias point is unaffected. so need $g_m R_E \gg 1$



$\leftarrow 0.2 \rightarrow 1 + 0.6$
 ≈ 0.7
 V_{BE}

$\frac{I_C \cdot R_E}{V_{TH}} \gg 1$
 $\frac{V_E / R_E \cdot R_E}{V_{TH}} \gg 1$
 $\frac{V_E}{V_{TH}} \gg 1$ so need
 $V_E > 200mV$ or so.

oops - 2 problem #3 s.

3) Fill in the following table where each row is a different single-pole amplifier

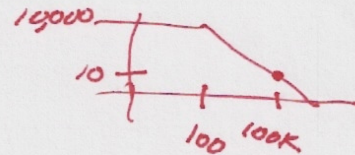
G_m [S]	R_o [Ω]	C_L [F]	A_v	ω_p [rad/s]	ω_u [rad/s]
1u	10M	50f	10	$\frac{1}{500} \cdot 10^9 = 200M$	20M
4mS	100K	1p	400	10M $\tau = 10^{-7}$	4G
100m	100	$\frac{10^{-1}}{10^{10}} = 10p$ 10p	10	1G	10G
10 μ	1M	10f	10	100M	1G

2 pts each

4) You have a single-pole amplifier with a gain of 10 at 100kHz, and a low frequency gain of 10,000. What is the gain at 10 Hz, 20kHz, and 500 kHz?

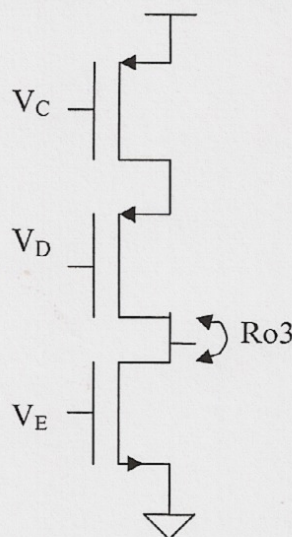
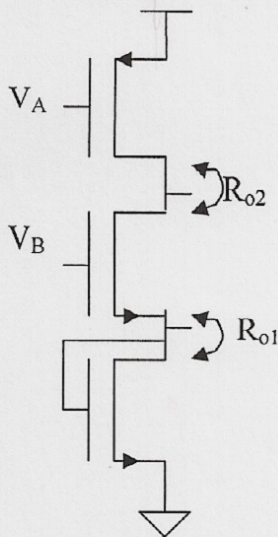
Frequency	Gain
10 Hz	10,000
20 kHz	50
500 kHz	2

6 pts each



- 5) What is the total low frequency impedance and the low frequency impedance seen "looking up" and "looking down" at the output node indicated in each circuit? Assume that all devices have transconductance g_m and output resistance r_o , and that $g_m * r_o \gg 1$. Write the simplified expression for up and down, and then the simplified total impedance. You may ignore all capacitors.

	Simplified expression	Simplified expression for R_o
$R_{o1, up}$	$\frac{2}{g_m}$	$\frac{1}{g_m} \parallel \frac{2}{g_m} = \frac{2}{3} \frac{1}{g_m}$
$R_{o1, down}$	$\frac{1}{g_m}$	
$R_{o2, up}$	r_o	$\frac{2}{3} r_o$
$R_{o2, down}$	$r_o (1 + g_m \frac{1}{g_m}) = 2r_o$	
$R_{o3, up}$	$g_m r_o^2$	r_o
$R_{o3, down}$	r_o	



2 pts each must be simplified

- 5B) [10pts] What is the low-frequency capacitance seen looking into V_B ?

$$C_{IN} = \left[1 + \frac{g_m r_o}{3} \right] C_{sd} + \left(\frac{2}{3} \right) C_{gs}$$

5 pts for each coeff.
no points for formulas.

$$A_{V_B \rightarrow 1} : G_m = \frac{-g_m}{1 + \frac{R_o}{r_o}} = -\frac{g_m}{2} \quad A_V = + \frac{g_m \frac{2}{3} r_o}{g_m} = \frac{1}{3}$$

$$A_{V_B \rightarrow 2} : G_m = \frac{g_m}{1 + g_m \frac{1}{g_m}} = \frac{g_m}{2} \quad A_V = -\frac{g_m r_o}{3}$$