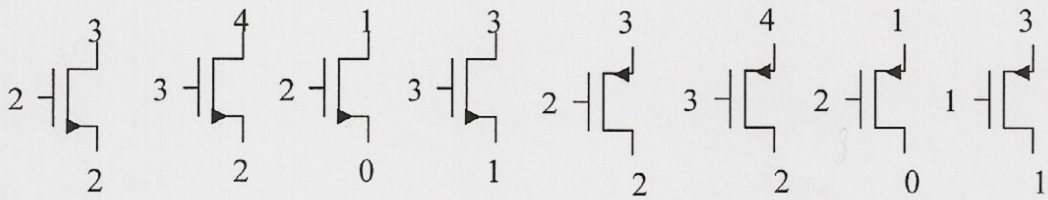
EECS140
Fall 2009
Midterm 1

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 $|V_{dsat}|$.




1 pt each

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| OFF LIN SAT | OFF | SAT | ~~BF~~ LIN | SAT | SAT | ~~LIN~~ SAT | ~~SAT~~ OFF | SAT ~~LIN~~ |
| $V_{dsat}$ (if SAT) | | 0.5 | | 1.5 | ±0.5 | 0.5 | ~~20.5~~ | ±1.5 |

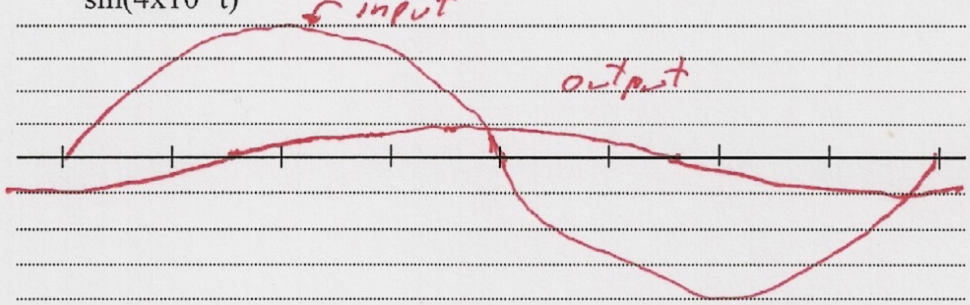
wrong $\omega_p$: −5

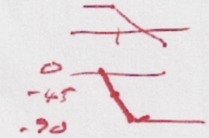
2) You have an RC lowpass filter with a 1MΩ resistor and a 1pF capacitor.

a. Sketch a cycle of the input and steady state output when the input is $\sin(4\text{x}10^6\, t)$

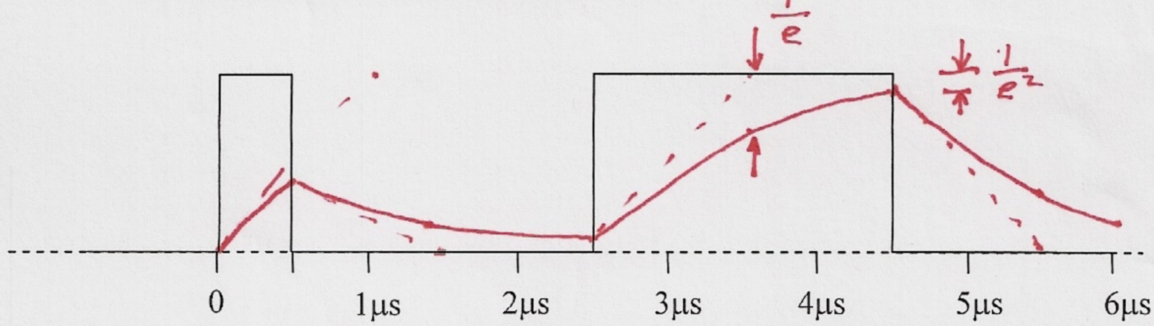
$RC = 10^{-6}$
$\omega_p = 10^6$
$|A(4\omega_p)| \approx \frac{1}{4}$

Mag 3 pts
phase 4 pts
$45 < \phi < 90$ 4
$25 < \phi \le 45$ 2
$0 < \phi < 25$ 1
$\theta \le 0$, $\theta \ge 90$ } 0
$\theta = 90$ 2




b. Sketch the transient response from 0 to 6us 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

5pts

| $R_C$= 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.

5pts

| $V_B$= 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 $G_m = \frac{g_m}{1+g_m R_E} \approx \frac{1}{R_E}$ so need $g_m R_E >> 1$

$\frac{I_C}{V_{TH}} \cdot R_E >> 1$

$\frac{V_E / R_E}{V_{TH}} \cdot R_E >> 1$

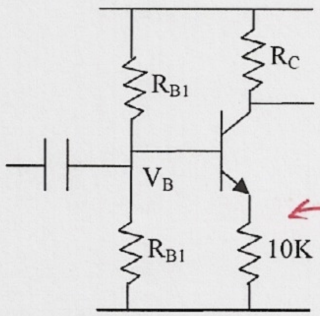
$\frac{V_E}{V_{TH}} >> 1$ so need

$V_E >$ 200mV or so.

c) What is the purpose of the capacitor?

5pts

DC blocking - input can be at any DC value and bias point is unaffected.




← 0.2 → 1 + 0.6 or 0.7 ($V_{BE}$)

→ oops – 2 problem #3 s.

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

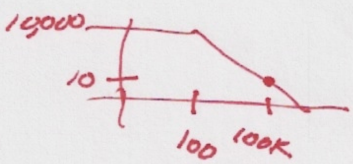
| $G_m$ [S] | $R_o$ [Ω] | $C_L$ [F] | Av | $\omega_p$ [rad/s] | $\omega_u$ [rad/s] |
|---|---|---|---|---|---|
| 1u | 10M | 50f | 10 | $\frac{1}{500} 10^9 =$ 2M | 20M |
| 4mS | 100K | 1p | 400 | 10M $\tau = 10^{-7}$ | 4G |
| 100m | 100 | $\frac{10^{-1}}{10^{10}} =$ 1p 10p | 10 | 1G | 10G |
| 10µ | 1M | 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?

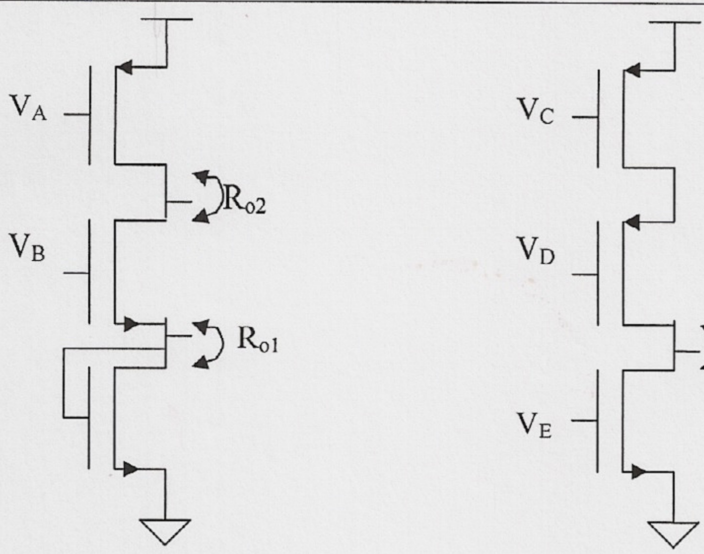
5 pts each

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



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 and that $g_m * r_o >> 1$. Write the simplified expression for up and down, and then the simplified total impedance. You may ignore all capacitors.

| | Simplified expression | Simplified expression for Ro |
|---|---|---|
| $R_{o1, up}$ | ~~[illegible]~~ $\frac{2}{g_m}$ | $\frac{1}{g_m} \parallel \frac{2}{g_m} = \frac{2}{3}\frac{1}{g_m}$ |
| $R_{o1, down}$ | $\frac{1}{g_m}$ | |
| $R_{o2,up}$ | $r_o$ | $\frac{2}{3} r_o$ |
| $R_{o2,down}$ | $r_o(1+g_m \frac{1}{g_m}) = 2r_o$ | |
| $R_{o3,up}$ | $g_m r_o^2$ | $r_o$ |
| $R_{o3,down}$ | $r_o$ | |




2 pts each
must be simplified

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

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

5 pts for each coeff.
no points for formulas.

$A_{v B\to 1}: G_m = \frac{-g_m}{1+\frac{R_D}{r_o}} = \frac{-g_m}{2}$ $\quad A_v = +\frac{g_m}{2}\frac{2/3}{g_m} = \frac{1}{3}$

$A_{v B\to 2}: G_m = \frac{G_m}{1+g_m\frac{1}{g_m}} = \frac{g_m}{2}$ $\quad A_v = -\frac{g_m r_o}{3}$