EE330
Section 5, 8:00 am
Homework 10

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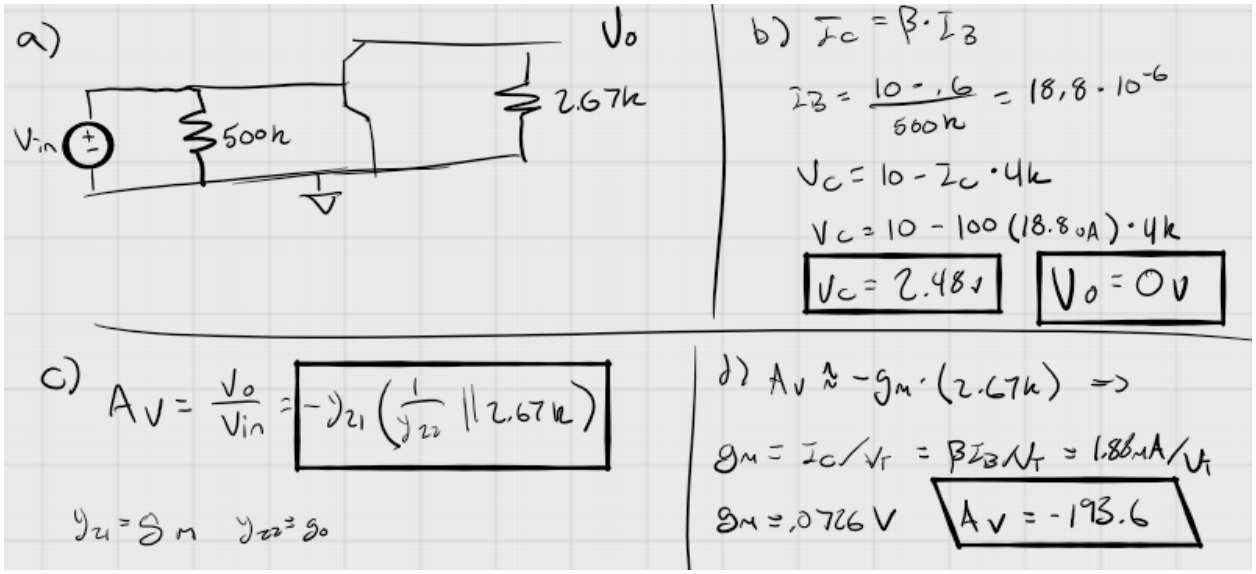
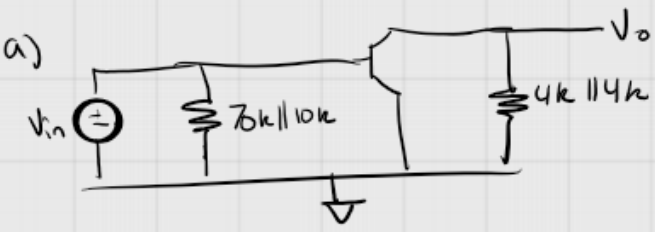
1.



2.

a)



b) $V_B = 32 \cdot \left(\frac{10k}{70k+10k}\right) = 4V$

$I_C = \frac{V_B - .6}{2k} = 1.7mA$

$V_{CQ} = 32 - 4k \cdot 2_C = \boxed{25.2V}$

$\boxed{V_o = 0V}$

c) $A_V = \frac{V_o}{V_{in}} \qquad V_o = -g_M \cdot V_{in} \cdot \left(\frac{1}{g_o} \| R_L\right)$

$$\boxed{A_V = -g_M\left(\frac{1}{g_o} \| R_L\right)}$$

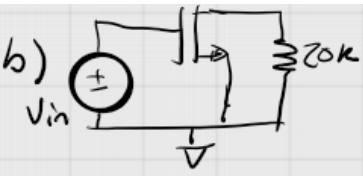
d) $A_V = \frac{I_C \cdot R}{2 \cdot V_T} \Rightarrow$

$$\frac{1.7mA \cdot (4k \| 4k)}{2 \cdot (.0259)} = \boxed{65.64}$$

3.

a) $1mA = (100 \cdot 10^{-6})\left(\frac{\omega}{2 \cdot 50}\right)(1.5 - .8)^2$ $\boxed{\omega = 20.41}$

b)



3.

4.

a) $y_{11} = \frac{\partial \bar{I}_1}{\partial V_1} \Rightarrow V_2^2$ $\quad y_{12} = \frac{\partial \bar{I}_1}{\partial V_2} = 2 \cdot V_1 \cdot V_2$

$y_{21} = \frac{\partial \bar{I}_2}{\partial V_1} \Rightarrow .04 V_1 \cdot V_2 \cdot e^{2V_1^2 \cdot V_2}$ $\quad y_{22} = \frac{\partial I_2}{\partial V_2} = .02 \cdot V_1^2 \cdot e^{.2V_1^2 \cdot V_2}$

b) $y_{11} = (1)^2 = 1$ $\quad y_{12} = 2(5)(1) = 10$

$y_{21} = .04(5)(1) \cdot e^{2(5)^2(1)} = 29.68$ $\quad y_{22} = .02(5)^2 e^{2(5)^2(1)} = 74.21$

c) $I_1 = 5(1)^2 = 5$ $\quad I_2 = .02(5)^2 e^{2(5)^2(1)} = 14.84$

d) $i_1 = y_{11}(1 mV_{RMS}) + y_{12}(2 mV_{RMS}) = 21 mV_{RMS}$

$i_2 = y_{21}(1 mV_{RMS}) + y_{22}(2 mV_{RMS}) = 178.1 mV_{RMS}$

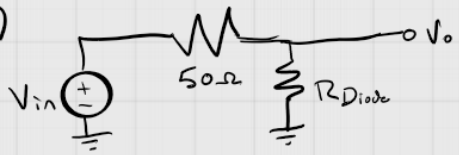
5.

a) $I_D = 1mA = J_S A_D \cdot e^{\frac{V_D}{V_T}}$ $\quad V_T = T(8.615 \cdot 10^{-5}) \Rightarrow 300(8.615 \cdot 10^{-5}) = 25.85 mV$

$V_D = V_0 \Rightarrow \frac{I_D}{J_S \cdot A_D} = e^{V_D/V_T} \Rightarrow V_D = V_T \cdot \ln\left(\frac{I_D}{J_S \cdot A_D}\right) \Rightarrow$

$V_0 = (25.85 mV) \cdot \ln\left(\frac{1mA}{.5 fA/um^2 \cdot 100 um^2}\right) = \boxed{.613V}$

b)



c) $V_0 = V_{in}\frac{R_D}{R_D + 50} \Rightarrow A_V = \frac{R_D}{R_D + 50}$ $\quad R_D = \frac{V_T}{I_D} = \frac{25.85}{1mA} = 25.85$

$A_V = \frac{25.85}{25.85 + 50} = \boxed{.34}$

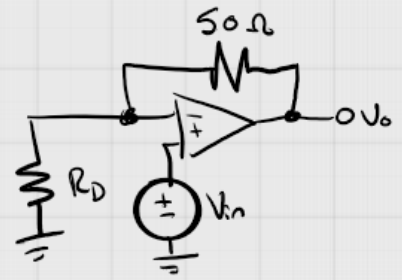
d) $R_D = \frac{25.85}{5 mA} = 5.17$ $\quad A_V = \frac{5.17}{5.17 + 50} = \boxed{.094}$

6.

a) $A_V = \frac{V_o}{V_{in}} = 1 + \frac{50}{R_D}$

$R_D = V_T / I_D = \frac{25.85\,mV}{1\,mA} = 25.85\,\Omega$

$A_V = 1 + \frac{50}{25.85} = \boxed{2.93}$



b) $R_D = \frac{25.85}{10\,mV} = 2.59$ $\quad A_V = 1 + \frac{50}{2.59} = \boxed{20.34}$

7.
Huh?

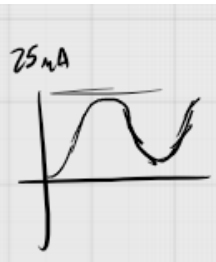
8.

$V_o = V_i \cdot A_V \Rightarrow A_V = -g_M (\frac{1}{g_o} \| R_L) \approx -g_M \cdot R_L$

$V_o = -g_M \cdot R_L \cdot (V_M \cos(\omega t + \theta))$

9.

Mosfet acts as a resistor here, with $R_M = \frac{1}{I_D}$



$$R_M = \frac{1}{(uC_{ox})\left(\frac{W}{L}\right)(V_{gs} - V_T)^2} \qquad V_{gs} = 2 + V_{in}$$

When $V_{in} = 0$: $R_M = \frac{1}{(100 \cdot 10^{-6})\left(\frac{8}{4}\right)(2 - .8)^2} = 3472.22\ \Omega$

When $V_{in} = .25$: $R_M = \frac{1}{(100 \cdot 10^{-6})\left(\frac{8}{4}\right)(2.25 - .8)^2} = 2378.12\ \Omega$

Then, A_V @ 0: $-\frac{15k}{3472.22} = \boxed{4.32}$

A_V @ .25: $-\frac{15k}{2378.12} = \boxed{6.31}$

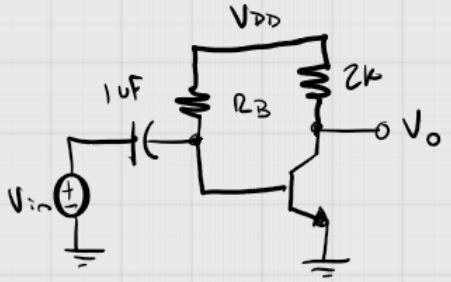
10.

Assuming this question actually refers to Q8 (Update yo shit Geiger)

$$I_D = \left(30 \cdot 10^{-6}\right)\left(\frac{6}{2.1}\right)(5 - V_o - .5)^2 = \left(100 \cdot 10^{-6}\right)\left(\frac{10}{2.2}\right)(2 - .5)^2 \Rightarrow$$

$$(9 \cdot 10^{-5})(4.5 - V_o)^2 = (5.625 \cdot 10^{-4}) \Rightarrow (4.5 - V_o)^2 = 6.25 \qquad \boxed{V_o = 2V}$$

11.

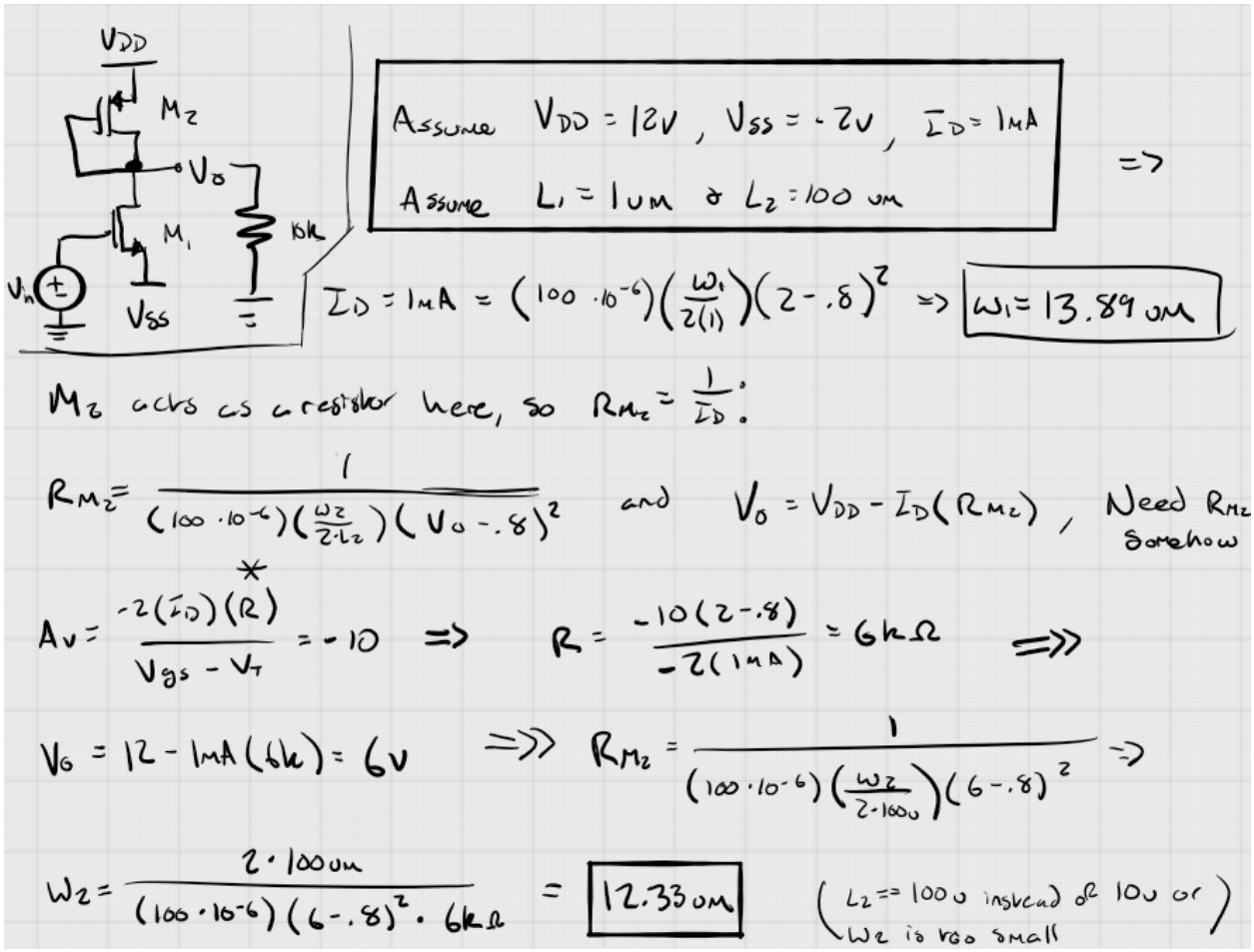


$$A_V = -5 = -\frac{I_C(2k)}{.0259} \qquad I_C = 6.48 \cdot 10^{-5}$$

$$I_C = \beta I_B \Rightarrow I_B = 6.48 \cdot 10^{-8}$$

$$I_B = \frac{V_{DD}}{R_B} \Rightarrow \boxed{\text{if } V_{DD} = 12\text{ V},\ R_B = 185\ M\Omega}$$

12.



Assume $V_{DD} = 12V$, $V_{SS} = -2V$, $I_D = 1mA$

Assume $L_1 = 1um$ & $L_2 = 100\ um$ $\Rightarrow$

$I_D = 1mA = (100 \cdot 10^{-6})\left(\frac{W_1}{2(1)}\right)(2-.8)^2 \Rightarrow \boxed{W_1 = 13.89\ um}$

M_2 acts as a resistor here, so $R_{M_2} = \frac{1}{I_D}$.

$R_{M_2} = \frac{1}{(100 \cdot 10^{-6})\left(\frac{W_2}{2 \cdot L_2}\right)(V_o - .8)^2}$ and $V_o = V_{DD} - I_D(R_{M_2})$, Need R_{M_2} somehow

$A_v = \frac{-2(I_D)(R)}{V_{gs} - V_T} = -10 \Rightarrow R = \frac{-10(2-.8)}{-2(1mA)} = 6k\Omega \Rightarrow\Rightarrow$ (*)

$V_G = 12 - 1mA(6k) = 6V \Rightarrow\Rightarrow R_{M_2} = \frac{1}{(100 \cdot 10^{-6})\left(\frac{W_2}{2 \cdot 100u}\right)(6-.8)^2} \Rightarrow$

$W_2 = \frac{2 \cdot 100um}{(100 \cdot 10^{-6})(6-.8)^2 \cdot 6k\Omega} = \boxed{12.33um}$

($L_2 = 100u$ instead of $10u$ or W_2 is too small)