EECS170A Fall 2011 **Final Exam** Name:_____

12/07/2011 4:00pm to 6:00pm ID no.:_____

Professor Peter Burke

1	2	3	4	Total
/30	/40	/20	/10	/100

DO NOT BEGIN THE EXAM UNTIL YOU ARE TOLD TO DO SO.

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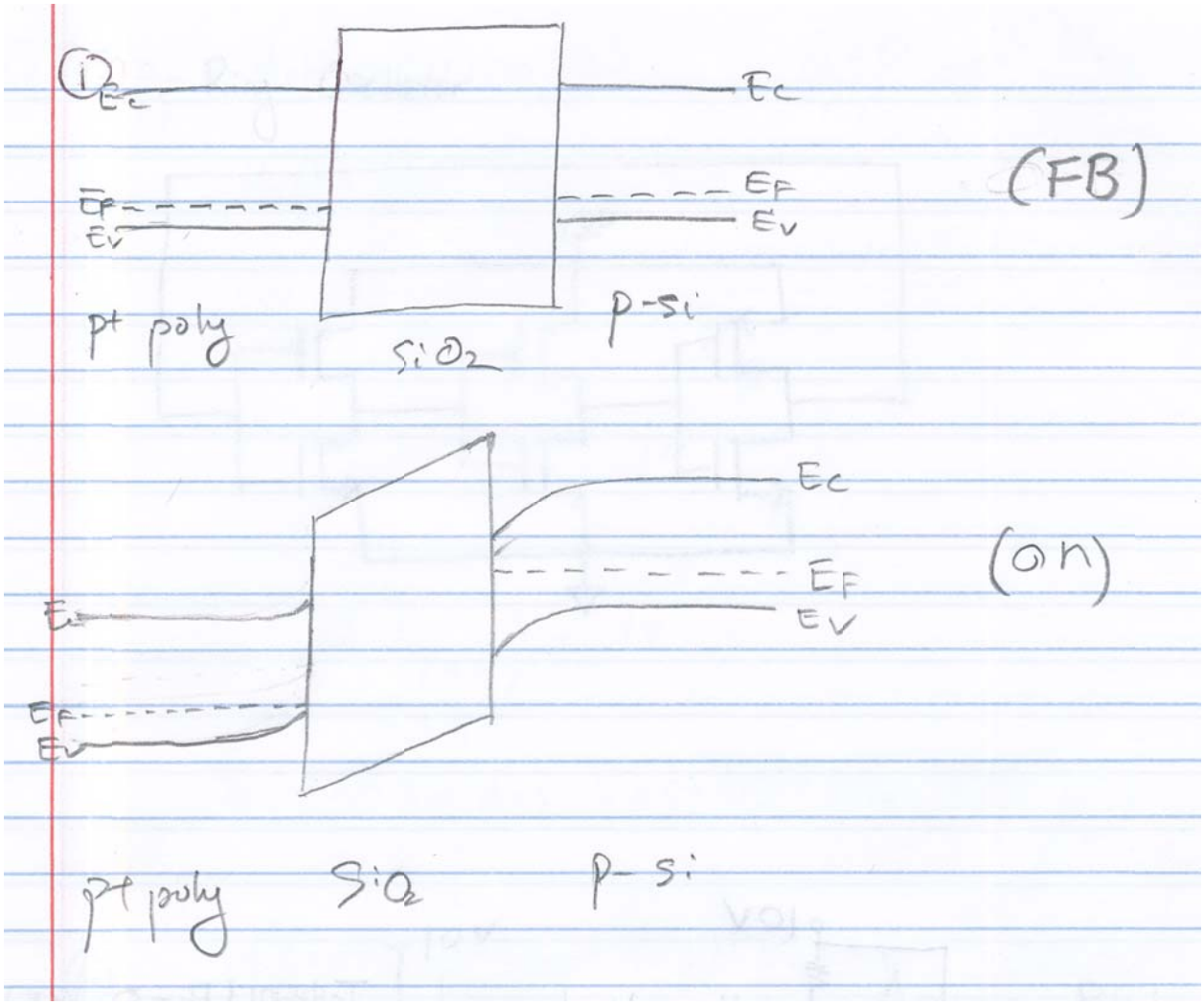
PROBLEM ONE: (30 points)

Draw the Band Diagram of an n-channel MOSFET with p^+ polysilicon gate in

a) The Flat Band state.

b) The ON state.



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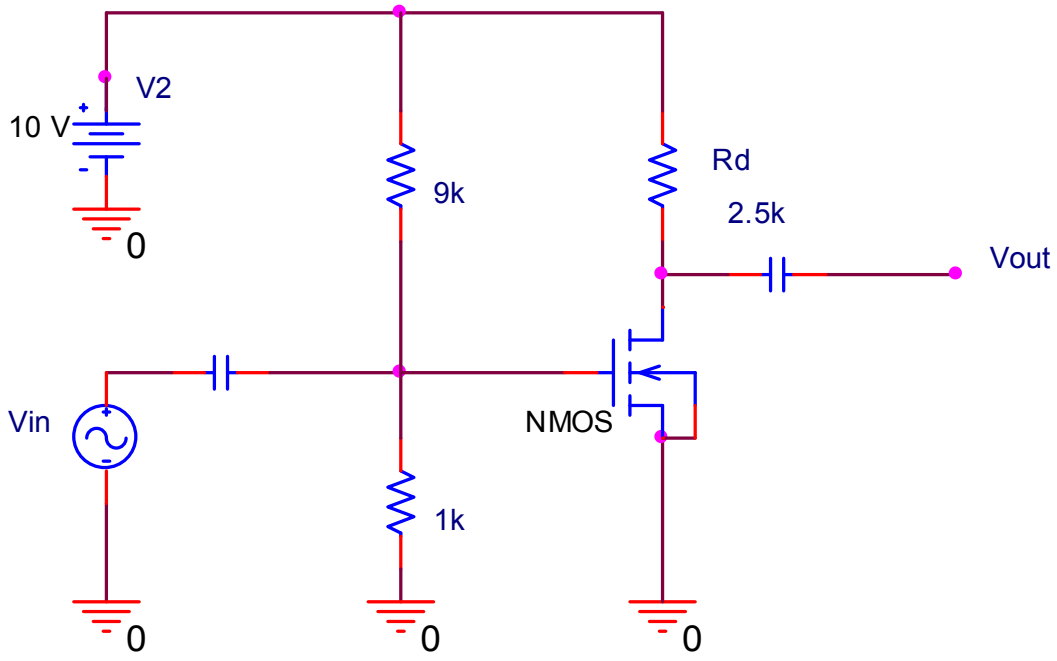
PROBLEM TWO(40 points):

Find the voltage gain of the NMOS amplifier below. (where $V_t = 0$, $W = 10\,\mu m$, $L = 1\,\mu m$ $\mu_{eff} = 600\frac{cm^2}{V-s}$, and oxide thickness is 10nm). Also, $\varepsilon_{ox} = 4\varepsilon_o$.

Recall that:

$$g_m = \mu_{eff} C_{ox} \frac{W}{L}(V_{gs} - V_t)$$



(2) $g_m = \mu_{eff} C_{ox} \frac{W}{L}(V_{GS} - V_t)$ $\quad V_t = 0 \quad W = 10\mu m \quad L = 1\mu m$

$\mu_{eff} = 600 cm^2/V\text{-}s$

$C_{ox} = \frac{\varepsilon_{ox}}{T_{ox}} = \frac{K\varepsilon_0}{10nm} = \frac{4 \cdot 8.85\times10^{-12}\ F/m}{10\times10^{-9}}$

$= 3.54\times10^{-3}\ F/m^2$

$V_{GS} = 10 \cdot \left(\frac{1}{1+9}\right) = 1V$

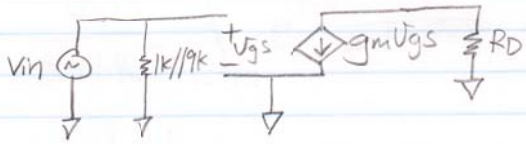
$g_m = (600\ cm^2/V\text{-}s)(3.54\times10^{-3}\ F/m^2)\left(\frac{10}{1}\right)(1-0)$

$= (600\times10^8\ \mu m^2/V\text{-}s)(3.54\times10^{-15}\ F/\mu m^2)(1V)\times\frac{10}{1}$

$= 2124\mu A/V$

small signal Model

AC gain:



$V_{gs} = V_{in}$

$\frac{V_{gs}}{V_{in}} = -g_m R_D$

$= -g_m \cdot 2.5k\Omega$

$= -2124\mu A/V \cdot 2.5k\Omega = \boxed{-5.31}$

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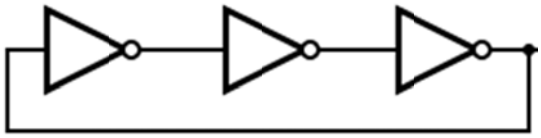
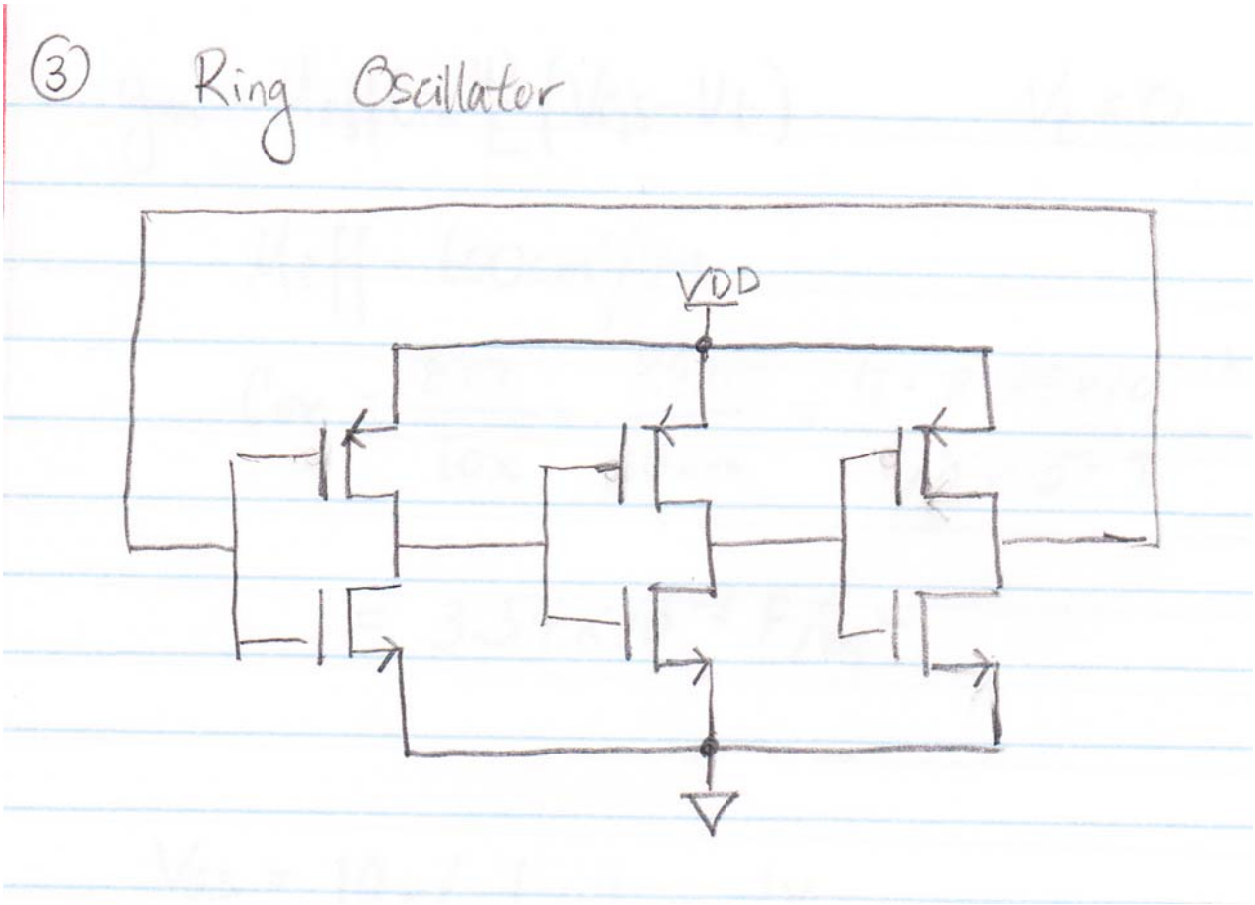
PROBLEM THREE(20 points):



Three inverters in series form a ring oscillator. Draw the transistor level circuit diagram for a ring oscillator.



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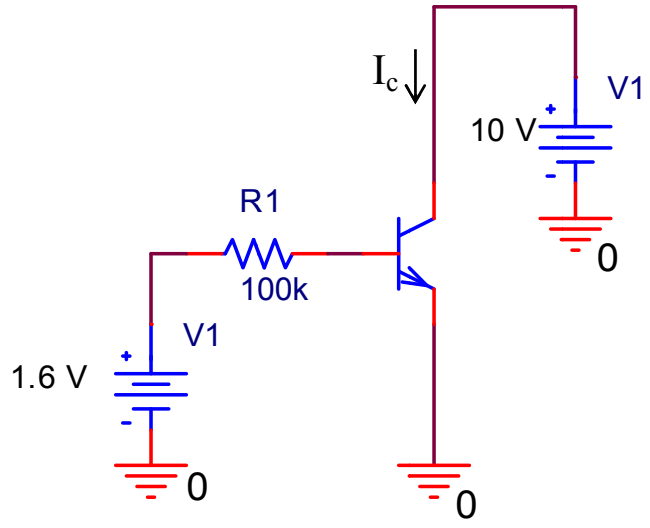
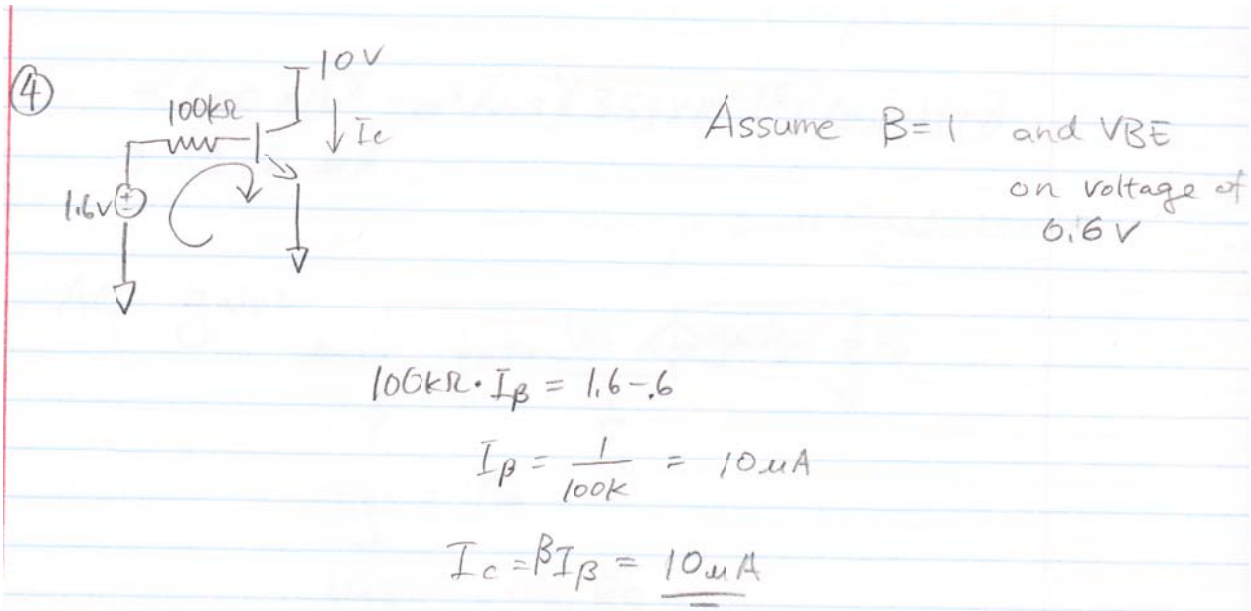
PROBLEM FOUR(10 points):



For the amplifier circuit above, assume $\beta = 1$ and the turn-on voltage for V_{BE} is 0.6 V. Find the collector current I_c.



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PHYSICAL CONSTANTS

Symbol	Name	Value
q	Electronic charge (magnitude)	1.60×10^{-19} coul
ε_0	Permittivity of free space	8.85×10^{-14} farad/cm
k	Boltzmann constant	8.617×10^{-5} eV/K
h	Planck constant	6.63×10^{-34} joule-sec
m_0	Electron rest mass	9.11×10^{-31} kg

Effective density of states (cm^{-3})

Conduction band, N_c: 3.2×10^{19}

Valence band, N_v: 1.8×10^{19}

Effective mass

$m_n^* / m_o = 1.08$

$m_p^* / m_o = 0.56$