EE 105 Midterm 1 NAME______________________________ SID_____________________________
Spring 2010

P1	/20
P2	/20
P3	/20
P4	/20
P5	/20
Total	/100

Problem 1: Design an RC low-pass filter with a pole at 10^6 radians/sec.

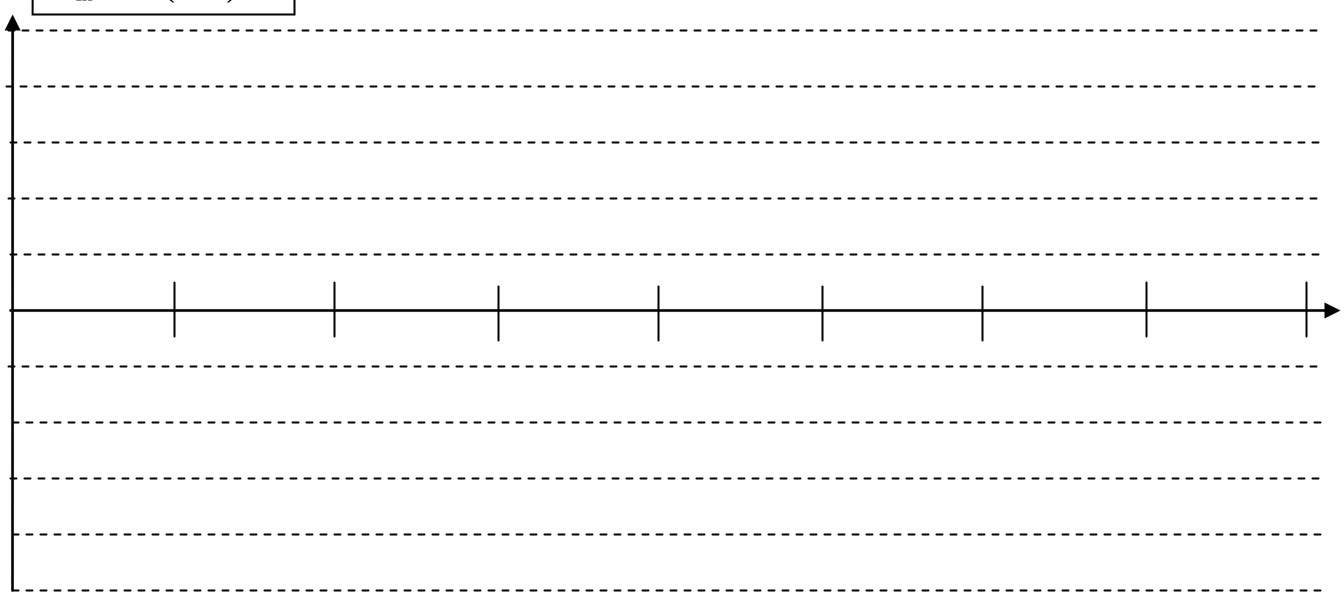
a) Draw the filter, and label input and the output, and the capacitor and resistor values.

b) if you drive the input to your filter with $V_{in}(t) = \sin(10^6 t) + 5\sin(100t) + 10\sin(10^7 t)$, what will the output waveform be?

V_{out} =

c) **Carefully** sketch a single cycle of the input and output sine waves for $V_{in} = \sin(10^6 t)$. I want it to be very clear what the magnitude and phase of the output is relative to the input. **Label the axes clearly.**

$V_{in} = \sin(10^6 t)$



Problem 2: Assume room temperature for this problem.
A pn junction has $N_D=10^{20}$ cm^{-3} and $N_A=10^{15}$ cm^{-3}
a) What is the built-in potential V_0?

V_0=

b) What is the approximate concentration of n and p carriers on each side of the junction?

n_n =	n_p =
p_n =	p_p =

c) For a particular junction area, the total zero-bias capacitance is measured to be C(0V) = 10pF. With a reverse bias of 10V, what is the approximate capacitance of this particular junction?

C(-10V) =

d) In a different junction with the same area, the donor concentration is decreased 10x to $N_D=10^{19}$ cm^{-3}, and the acceptor concentration is increased 10x to $N_A=10^{16}$ cm^{-3} . What is the change in the built-in potential?
What is the approximate change in the zero-bias capacitance?

V_0=

C(0V) =

e) When you forward bias a particular diode at 700mV you measure a current of 0.5mA. What bias voltage is needed to achieve a current of 5mA? What bias voltage is needed to achieve a current of 10mA? Your answers should be accurate to within 5mV.

V_{BE}(5mA) =

V_{BE}(10mA) =

Problem 3:

a) Assuming that T=300K, what is V_{TH}? (to within 1mV)

V_{TH}=

Approximately what is V_{TH} ln(10)? (to within 1mV)

V_{TH} ln(10)=

Approximately what is exp(60mV/V_{TH})? (to within5%)

exp(60mV/V_{TH})=

b) In a bipolar junction transistor, most of the current flow through the base region is due to (circle one) majority or minority carriers?

These carriers move mostly due to (circle one) drift or diffusion?

c) In a MOSFET, most of the current flowing in the channel region is due to (circle one) majority or minority carriers?

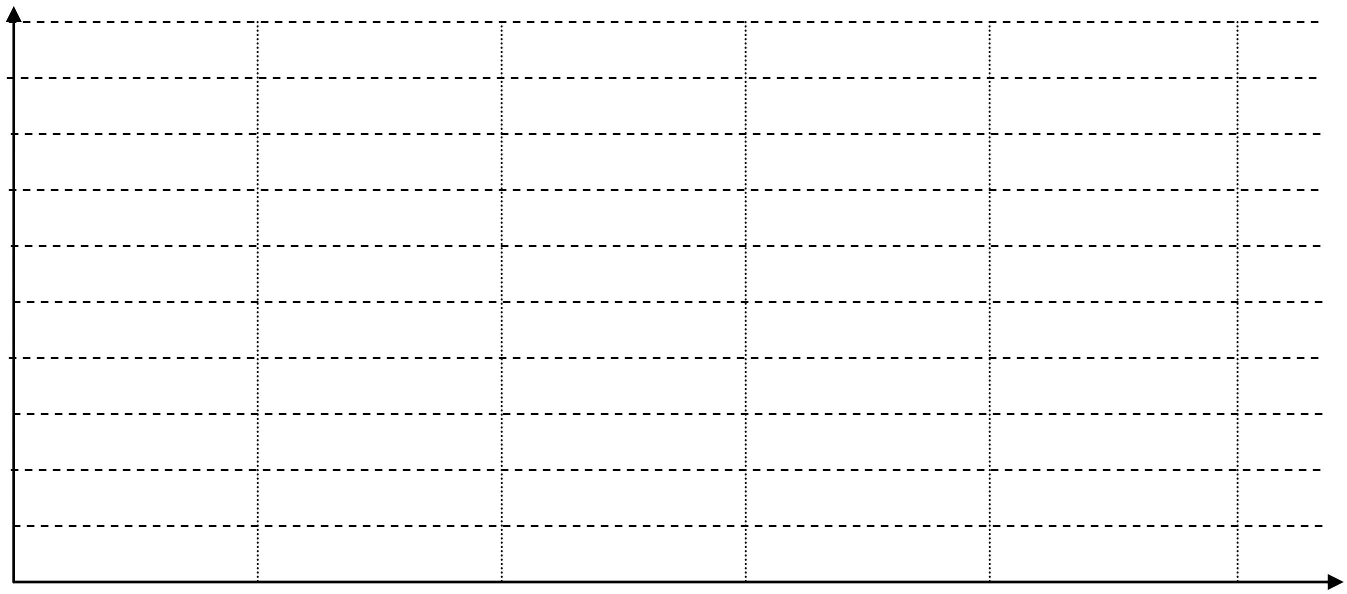
These carriers move mostly due to (circle one) drift or diffusion?

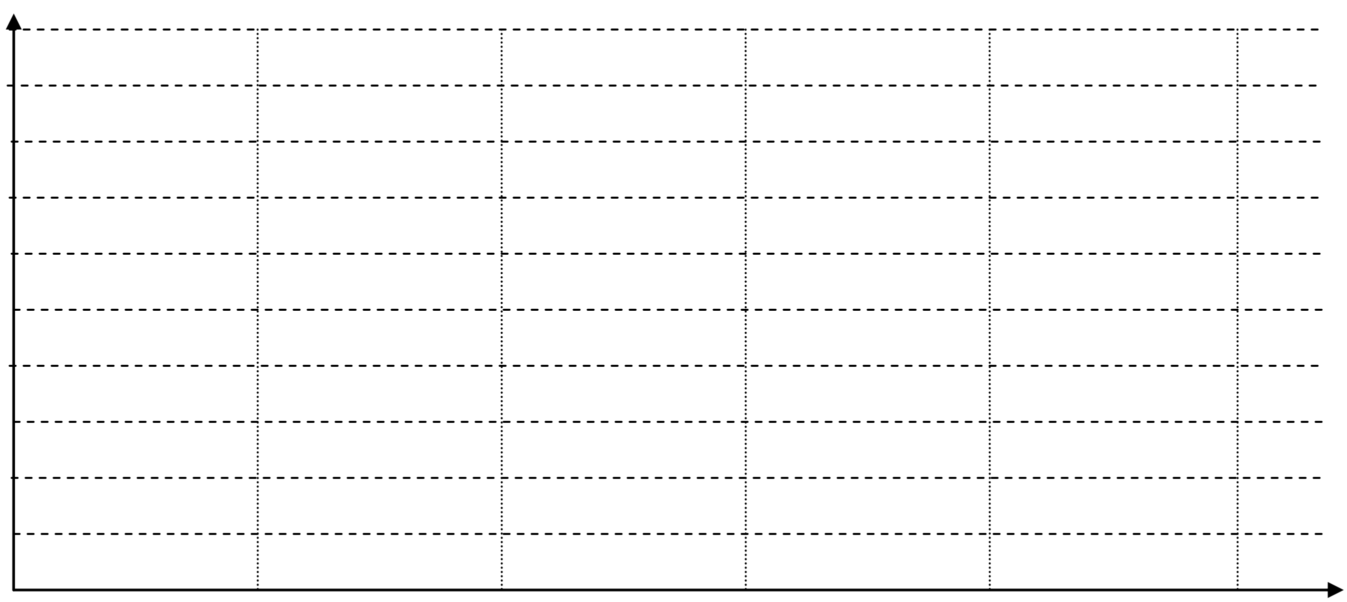
Problem 4: Carefully draw the normal IV curves for an NPN BJT and an NMOS FET with the following assumptions:

a) For the BJT, $I_S=10^{-18}$A, V_A=50V. Draw the curves for V_{BE} = 600mV, 620mV, 640mV, 660mV with V_{CE} running from 0 to 5V.

b) For the FET, u_nC_{ox}=200uA/V^2, V_t = 0.5V, λ=0.05 V^{-1}, W/L=5u/0.5u . Draw the curves for V_{GS} = 0.5, 1.5, 2.5, 3.5V, with V_{DS} running from 0 to 5V.

Clearly label all curves and axes.





Problem 5:

a) For a BJT with the same specs as in the previous problem, when I_C = 1μA, calculate the small-signal parameters and draw the small-signal model. Assume β=100.

parameters	model

b) For a MOSFET with the same specs as in the previous problem, when I_D =12.5μA and V_{DS}=5V, calculate the small-signal parameters and draw the small-signal model.

Clearly label all circuit elements and terminals.

parameters	model