UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE40 Frank Liao
Summer 09

MIDTERM EXAMINATION #2
Time allotted: 100 minutes

NAME: _____ _____ _____
(print) Last First Student ID#

LAB SECTION: _____/_____
Days / Time

I acknowledge that the UC rules on academic honesty apply. _____
Signature

INSTRUCTIONS:
1. **SHOW YOUR WORK. Partial credit will be given only if your methods are clear to the grader.**
2. **Clearly mark (BOX or UNDERLINE) your answers.**
3. **Specify the units on answers whenever appropriate. Points will be deducted for missing units.**
4. **Closed book, closed notes. You are allowed TWO 8.5" x 11" sheet of notes. Calculators are allowed.**

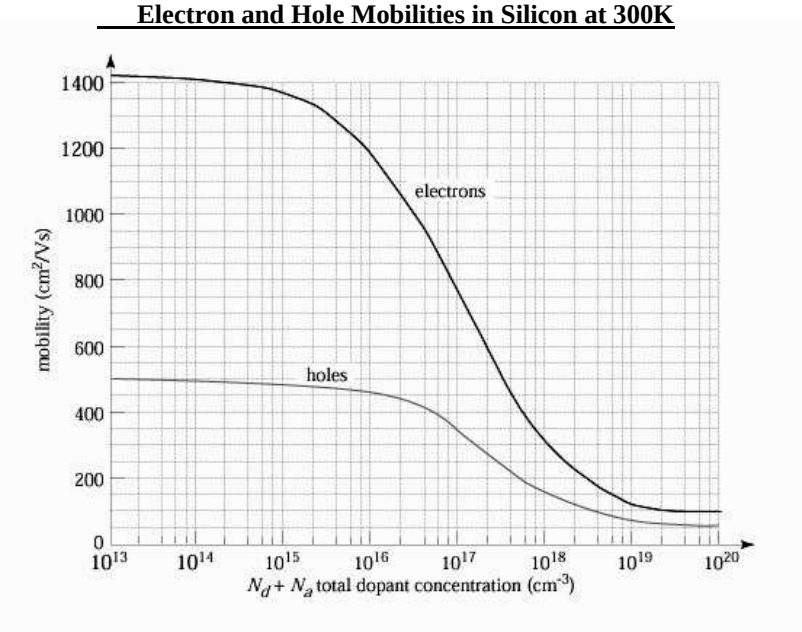
PHYSICAL CONSTANTS

Description	Symbol	Value
Electronic charge	q	1.6×10^{-19} C
Boltzmann's constant	k	8.62×10^{-5} eV/K
Thermal voltage at 300K	$V_T = kT/q$	0.026 V

PROPERTIES OF SILICON AT 300K

Description	Symbol	Value
Intrinsic carrier concentration	n_i	10^{10} cm^{-3}
Dielectric permittivity	ε_{Si}	1.0×10^{-12} F/cm

Electron and Hole Mobilities in Silicon at 300K



SCORE:
1 _____ / 10
2 _____ / 20
3 _____ / 30
4 _____ / 20
5 _____ / 20

TOTAL: _____ / 100

Problem 1 [10 points]: Basic concepts and EE Technology

a) True/False and Multiple Choice. Select only ONE choice. No credit will be given to multiple answers. **[2 pts each]**

T F LCD stands for Liquid Capacitance Display.

T F The MEMS accelerometer uses a differential capacitance to detect motion.

T F If an RC circuit has a large time constant, τ, then it takes a long time for the capacitor in that circuit to charge and discharge.

4) What kind of filter is this?

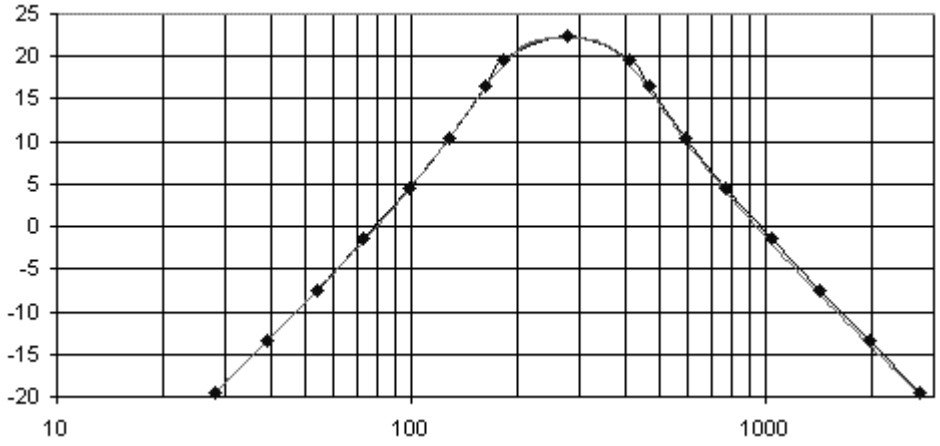
a) Lowpass

b) Highpass

c) Bandpass

d) Bandreject

Bode Plot of a Filter



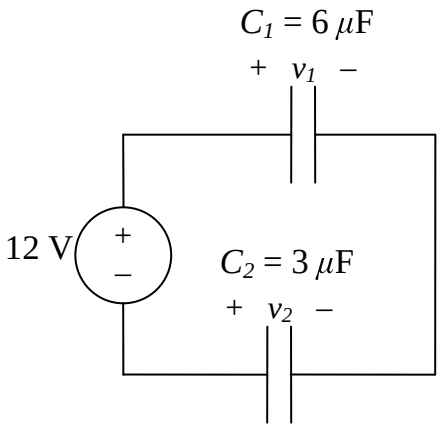
5) What is v_1, the voltage drop across C_1?

a) 4 V

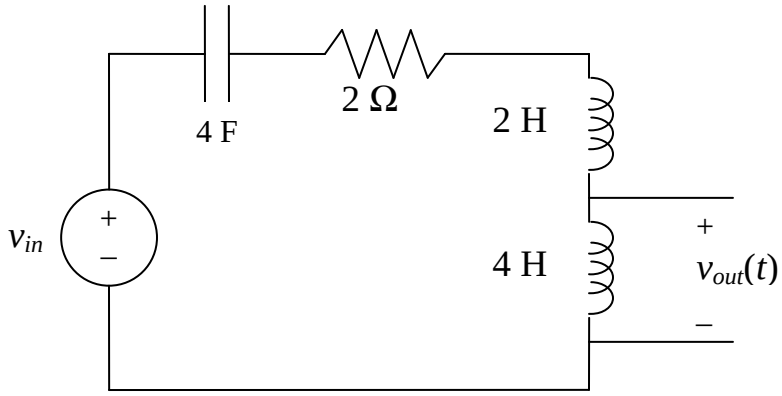
b) 8 V

c) -4 V

d) -8 V



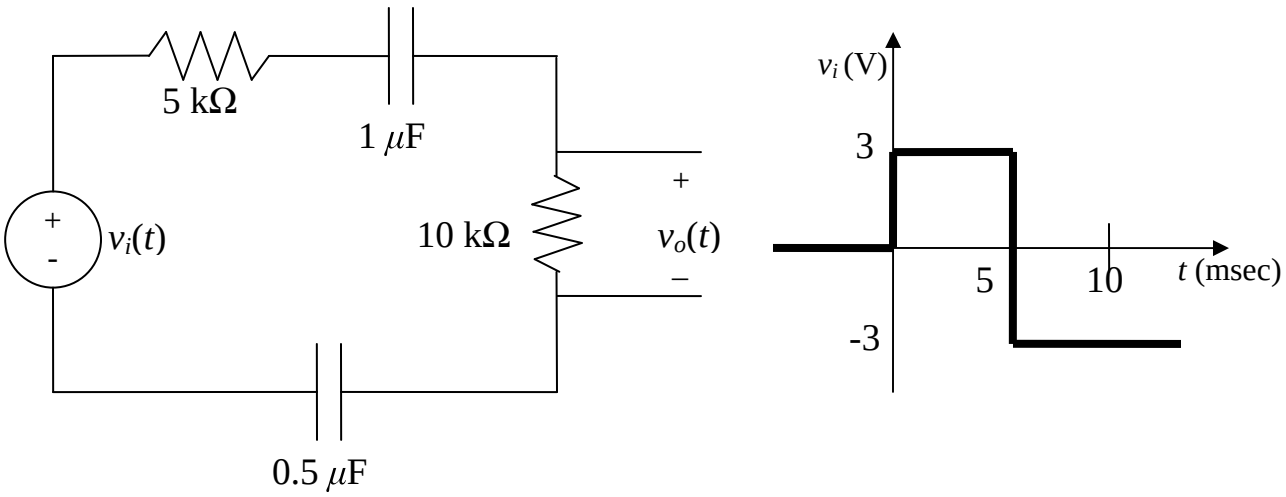
Problem 2 [20 points]: Phasor Analysis
In the circuit below, $v_{in}(t) = 2 \cos(0.1\,t + 30°)$.



a.) What is $v_{out}(t)$ in cosine form? **[10 pts]**

b.) If $v_{out} / v_{in} = (20 + j2\omega)(40 + j\omega) / j10\omega$, sketch the bode plot of the magnitude of the transfer function, **H**(ω). Label the axes appropriately, denoting critical angles, slopes and plateau values. **[10 pts]**

<u>Problem 3</u> [30 points]: First-Order Transients
Consider the circuit below:

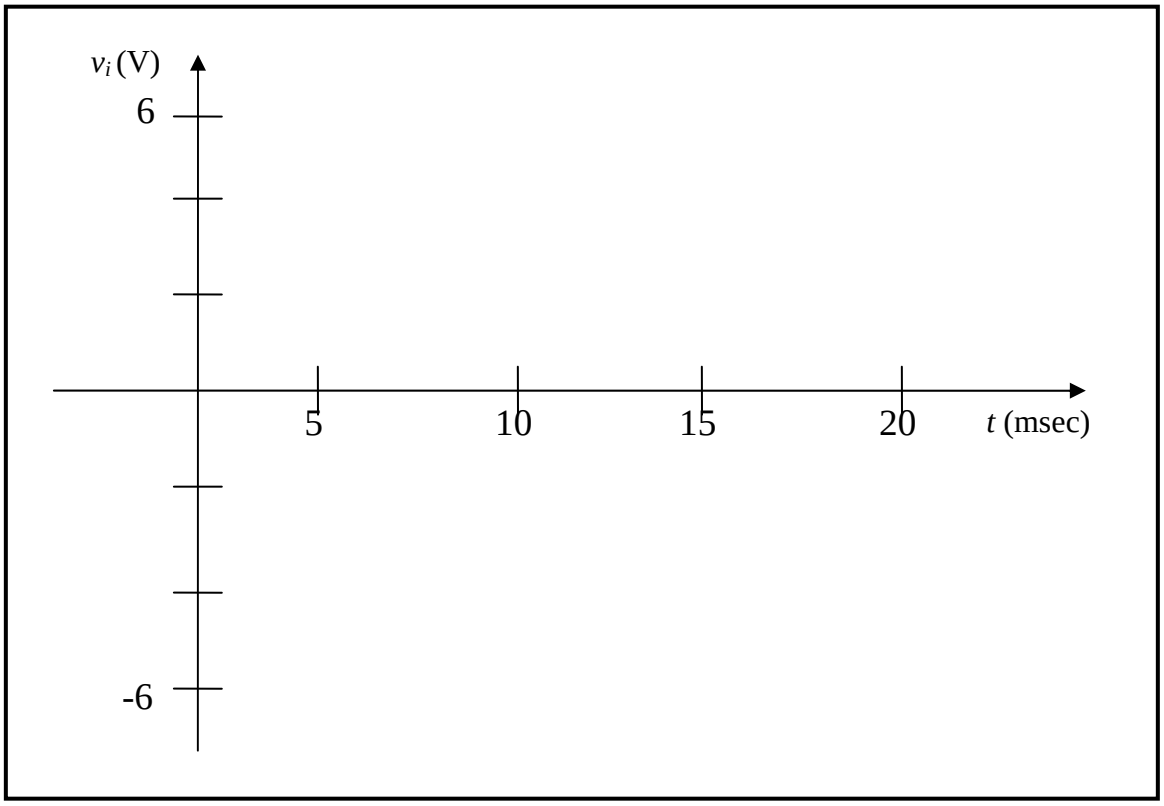


a.) Find the expression for $v_o(t)$ (piecewise expressions are acceptable) and plot $v_o(t)$ for 0 msec ≤ t ≤ 10 msec. Label the values of $v_o(0^+)$, $v_o(5^-)$, and $v_o(5^+)$. **[20 pts]**

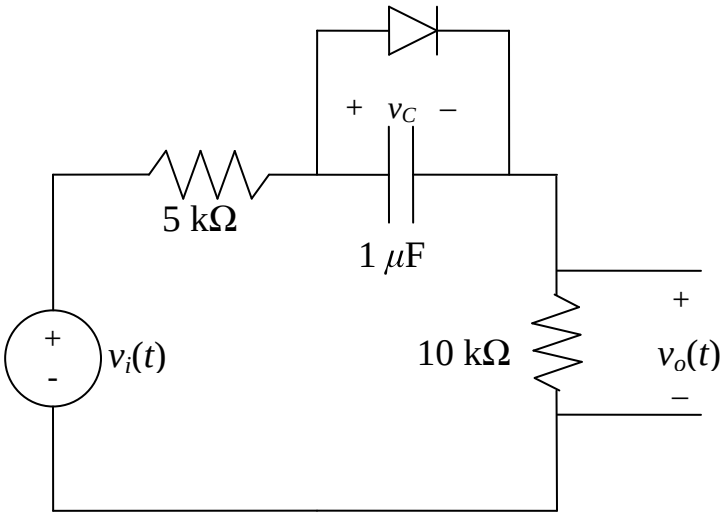
Show your work below. (Space for your answer is on the next page)

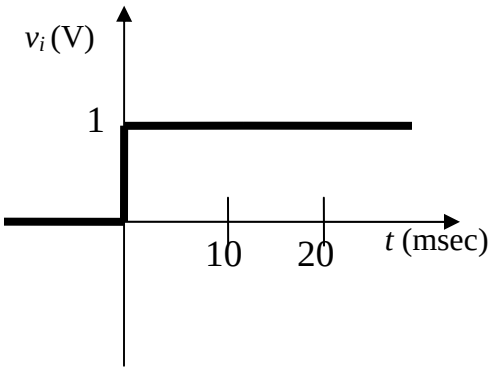
Answer:

Expression for $v_o(t)$:



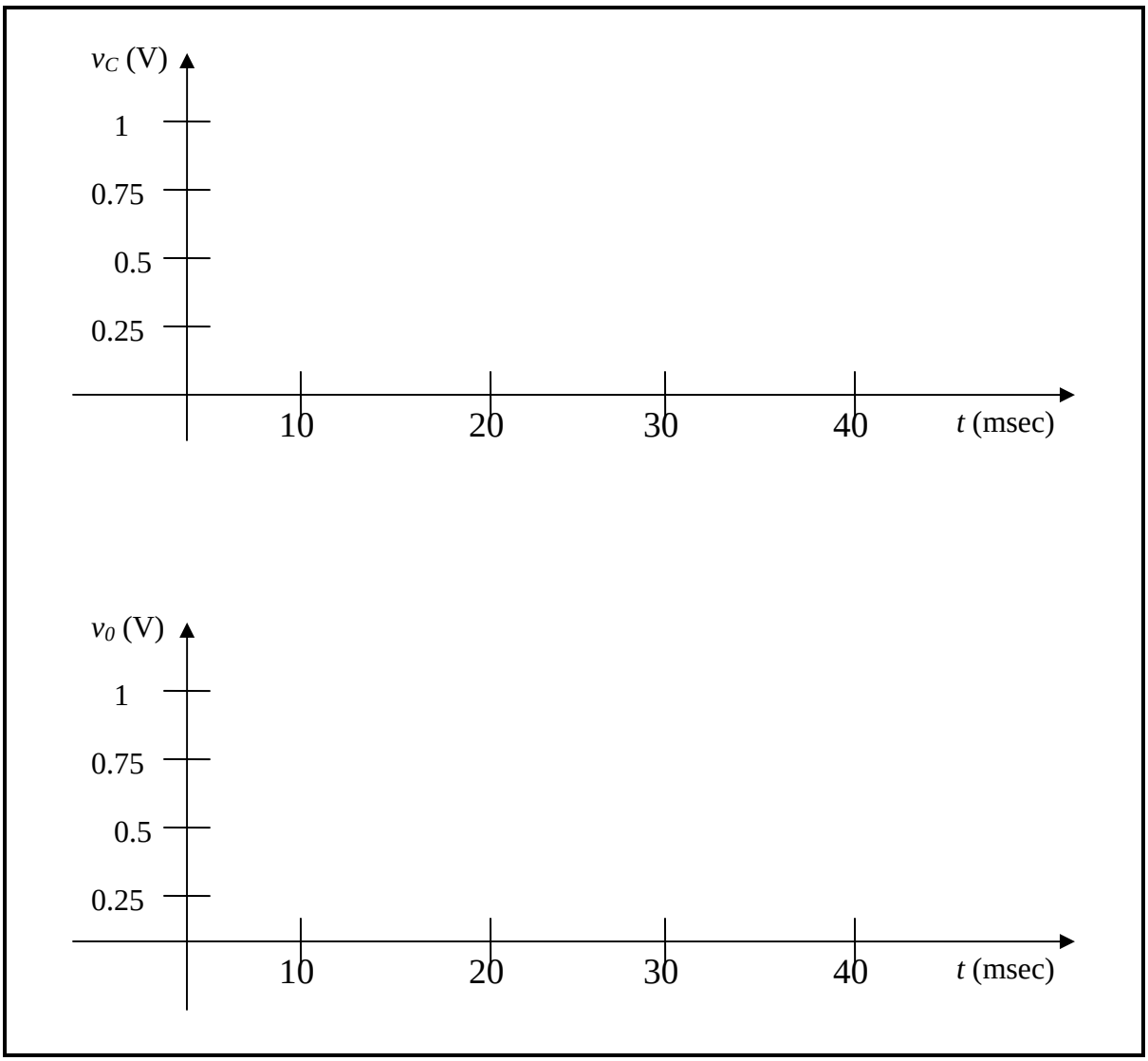
b.) Suppose we modify the circuit and apply a different input voltage.





On the axes below, plot for $v_C(t)$ and $v_o(t)$. Use the large signal model for the diode with a turn-on voltage, V_D=0.7 V. Label the following values: (1) the final voltage of v_C , (2) the time, t, when v_C reaches its final voltage, (3) the final voltage of v_o, and (4) the time, t, when v_o reaches its final voltage. **[10 points]**

Space for work:



Problem 4 [20 points]: Doping and Carrier Concentrations

Consider a Si sample maintained under thermal equilibrium conditions at T = 300K, doped with phosphorous at a concentration of 2×10^{16} cm^{-3}.

a.) Is this material n-type or p-type? What are the majority and minority carrier concentrations? **[4 pts]**

Write your answers here:

type:

majority concentration:

minority carrier concentration:

b.) Suppose this sample is additionally doped with boron at a concentration of 10^{16} cm^{-3}. How will the carrier concentrations change? **[3 pts]**

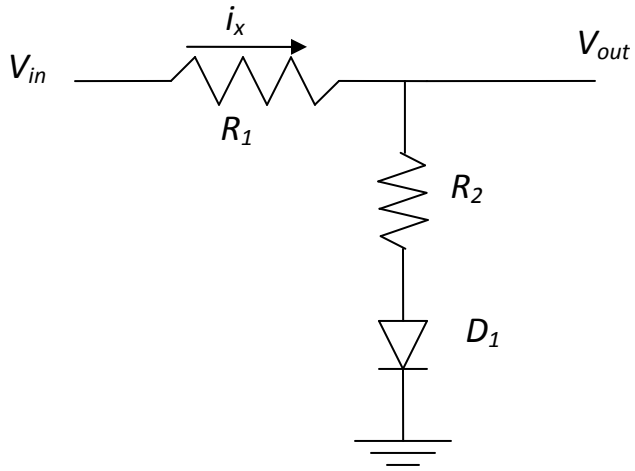
Write your answers here:

new majority concentration:

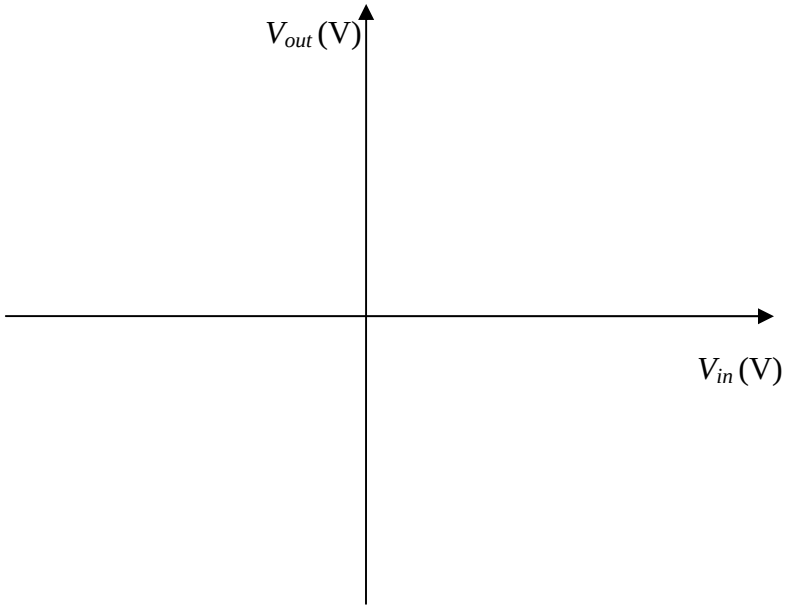
new minority carrier concentration:

c.) Find the resistivity of this sample (with the boron doping). **[4 pts]**

<u>Problem 5</u> [20 points]: Diode Circuits
Consider the following diode circuit:



a.) Using the large-signal model, plot V_{out} as function of V_{in} of the circuit below. Remember, a diode about to turn on carries zero current but sustains V_D. For full credit, you must label all important points on the graph (e.g. slope or cross-over points).



b.) Suppose R_1 = 2 kΩ, R_2 = 2 kΩ, and V_D=0.7 V and V_{in} is given by the waveform shown below. Plot V_{out} on the given axes.