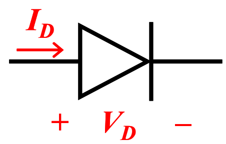
UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Dept. of Electrical Engineering and Computer Sciences

EECS 40 **Fall 2003**

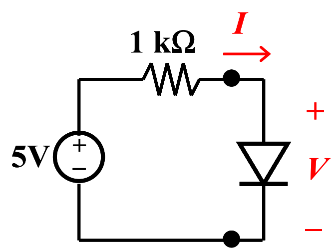
Homework Assignment #7
Due at 11:00 AM in 240 Cory on Friday, 10/24/03
* Be sure to put your name and **Discussion Section number** on your paper; **otherwise 5 pts will deducted from your score!**

Problem 1: pn-Junction Diode *I-V* characteristic

The *I-V* characteristic of a pn-junction diode is given by the equation $I_D = I_S(e^{qV_D/kT} - 1)$ where the **diode saturation current I_S is proportional to n_i^2.**



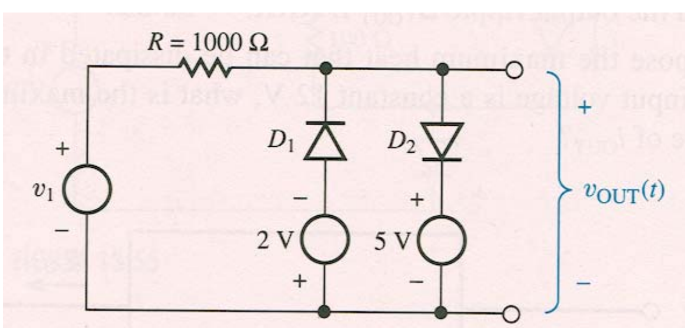
Suppose a diode is to be used in the following circuit, maintained at T = 300K:



a) Solve for I and V using the load line analysis method, assuming a Si diode with $I_S = 10^{-15}$ A.
b) Now solve for I and V using the large-signal model of the diode, with V_{Don} = 0.7V. Compare these values of I and V against the ones which you obtained in part (a).
c) Suppose the silicon diode is replaced with an AlGaAs light-emitting diode. (See Slide 11 of Lecture 20.) How would you expect I and V to change, qualitatively? Explain.
(Hint: Recall that the energy of the emitted photons $E = h\nu = hc/\lambda$ corresponds to the energy given up by a conduction electron when it recombines with a hole, and therefore corresponds to the energy required to generate an electron-hole pair. Recall from Slide 2 of Lecture 18 that the energy required to generate an electron-hole pair in Si is 1.1 eV, which corresponds to wavelength $\lambda \cong 1\mu$m.)

Problem 2: Diode Circuit

The circuit shown below is known as a "clipper", and can be used to protect the circuit that it is connected to it from excess voltages. Assume the diodes are perfect rectifiers and the input voltage $v_1(t) = 10 \sin(2\pi t)$. Sketch the output voltage $v_{OUT}(t)$.



<u>Problem 3</u>: MOSFET Fundamentals

a) Explain qualitatively (without using any equations) how a conductive path is formed between the n-type source and drain regions of an n-channel enhancement-mode MOSFET (with a p-type body), by applying a suitable voltage on the gate electrode. How does the resistance between the source and drain change with increasing gate voltage?

b) How does the resistance between the source and drain change with drain voltage increasing from 0 V up to the gate voltage, for a long n-channel MOSFET? (Again, explain qualitatively without resorting to any equations.) Assume that the source and the body are each biased at 0 Volts.

c) How does your answer to part (b) change if the channel length is very short (so that velocity saturation effects are evident)?

<u>Problem 4</u>: MOSFET *I-V* characteristics

A long-channel n-channel enhancement-mode MOSFET has threshold voltage $V_T = 0.5$ V, process transconductance parameter $k_n' = 0.2$ mA/V^2, channel length $L = 1$ μm and channel width $W = 10$ μm.

a) Sketch the drain current *vs.* gate voltage (I_{DS} *vs.* V_{GS}) characteristic for $0 \leq V_{GS} \leq 5$ V, $V_{DS} = 0.5$ V.

b) Sketch the drain current *vs.* drain voltage (I_{DS} *vs.* V_{DS}) characteristics for $0 \leq V_{DS} \leq 5$ V, for V_{GS} = 0 V, 1 V, 2, V, 3 V, 4 V, and 5 V.

c) For each set of voltages below, state the region of operation and compute the drain current:

   i) $V_{GS} = 1$ V and $V_{DS} = 5$ V

   ii) $V_{GS} = 1$ V and $V_{DS} = 0.5$ V

   iii) $V_{GS} = 0$ V and $V_{DS} = 5$ V