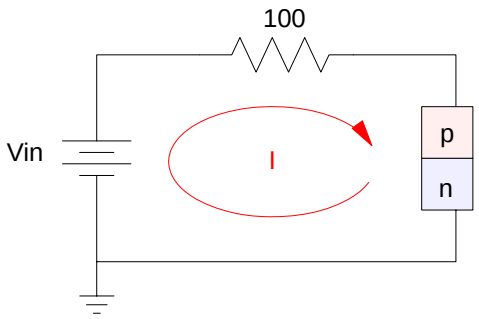
ECE 320 - Solution to Homework #2

PN Junctions, Diodes, Ideal Diodes. Due Wednesday, September 7th

1) A 100 Ohm resistor and a pn junction are in a circuit:



1a) Will current flow if Vin = +10V? Explain why or why not.

Yes - curent will flow

You are using majority carriers so the resistance is small from p to n

10V is enough to overcome the potential energy barrier and allow current to flow

10V is enough to reduce the depletion zone to zero, allowing current to flow

1b) Will current flow if Vin = +10mV? Explain why or why not.

Yes - current will flow

It will be very small since 10mV is not enough to overcome the potential energy barrier. Still, a few electrons will have enough energy to overcome this barrier

No - current will not flow

10mV is not enough to overcome the potential energy barrier

10mV is not enough to remove the depletion zone - which is blocking current flow

1a) Will current flow if Vin = -10V? Explain why or why not.

Yes - current will flow, but it will be very small. You are using minority carriers, which are very few but non-zero.

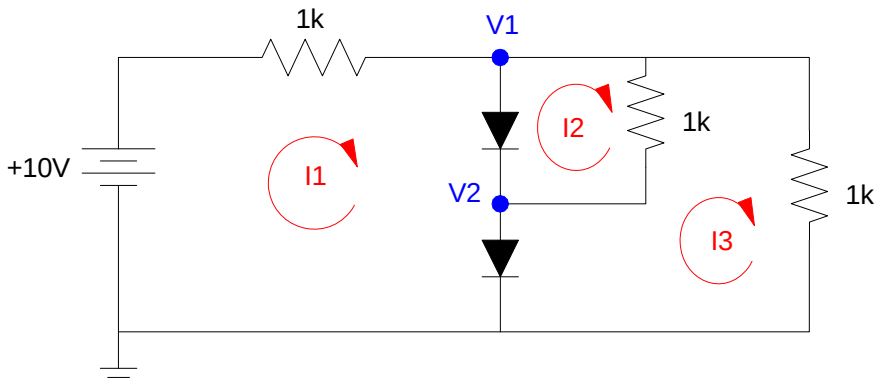
No - current will not flow.

You are using minority carriers so the current is very small (10^{-12} Amps - essentially zero)

-10V just makes the potential energy barrier even larger, blocking current

-10V just makes the depletion zone larger, blocking current

Problem 2 - 7) Use the following circuit:



$$V_d = 0.052 \ln(10^7 \cdot I_d + 1) \qquad I_d = 10^{-7} \cdot \left(\exp\left(\frac{V_d}{0.052}\right) - 1\right)$$

2) Write the voltage node equations for the above circuit (don't solve)

$$\left(\frac{V_1 - 10}{1k}\right) + \left(\frac{V_1 - V_2}{1k}\right) + \left(\frac{V_1}{1k}\right) + 10^{-7} \cdot \left(\exp\left(\frac{V_1 - V_2}{0.052}\right) - 1\right) = 0$$

$$\left(\frac{V_2 - V_1}{1k}\right) + 10^{-7} \cdot \left(\exp\left(\frac{V_1 - V_2}{0.052}\right) - 1\right) = 10^{-7} \cdot \left(\exp\left(\frac{V_2}{0.052}\right) - 1\right)$$

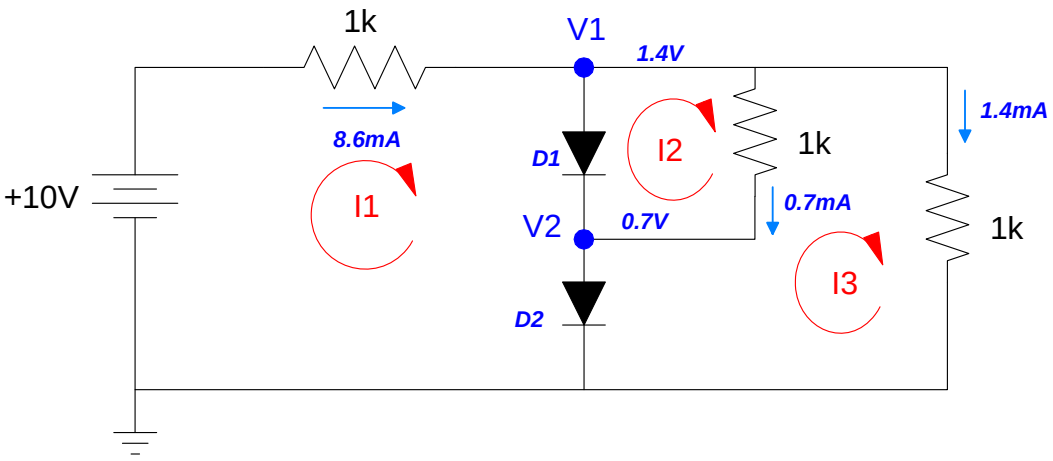
3) Write the current loop equations for the above circuit (don't solve)

$$-10 + 1000I_1 + 0.052 \ln(10^7(I_1 - I_2) + 1) + 0.052 \ln(10^7(I_1 - I_3) + 1) = 0$$

$$-0.052 \ln(10^7(I_1 - I_2) + 1) + 1000(I_2 - I_3) = 0$$

$$-0.052 \ln(10^7(I_1 - I_3) + 1) + 1000(I_3 - I_2) + 1000(I_3) = 0$$

4) Determine the voltages and currents assuming ideal silicon diodes.



Assume both diodes are on. The voltage drop across each is 0.7V

This results in the currents being as shown above. The current through D1 is then from conservation of current:

$$8.6mA = I_{d1} + 0.7mA + 1.4mA$$

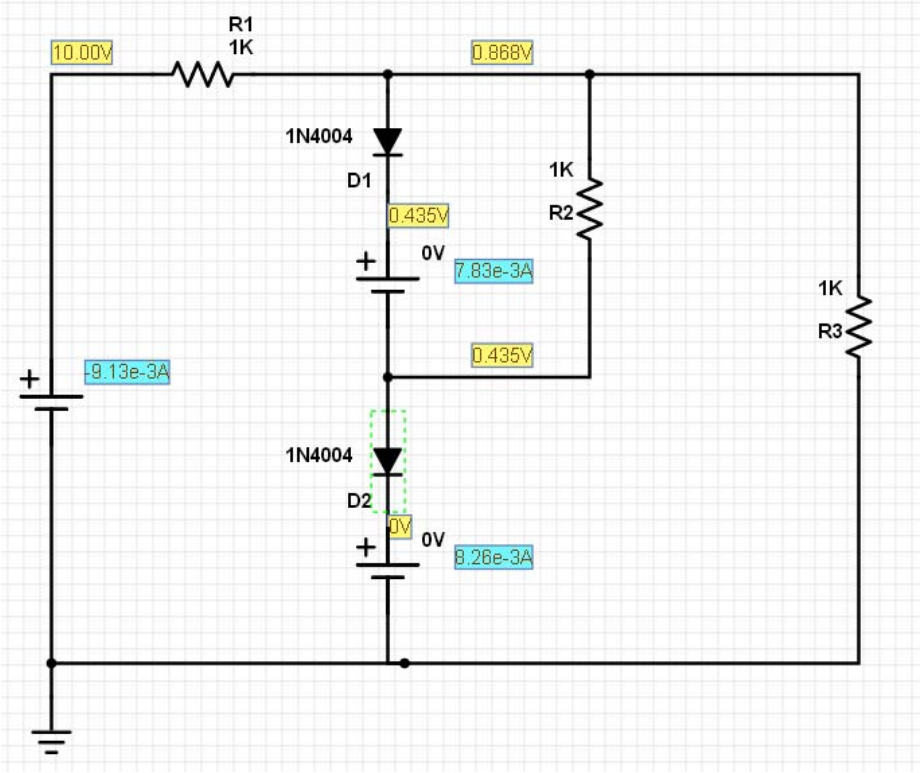
$$I_{d1} = 6.5mA$$

Id2 is then

$$I_{d2} = 6.5mA + 0.7mA$$

$$I_{d2} = 7.2mA$$

5) Determine the voltages and currents using PartSim (or other simulation software)



Lab

6) Determine the voltages and currents using real silicon diodes.

Parameter	Computed	Simulated	Measured
V1	1.4V	0.868V	-
V2	0.7V	0.437V	-
Id1	6.5mA	7.83mA	-
Id2	7.2mA	8.26mA	-