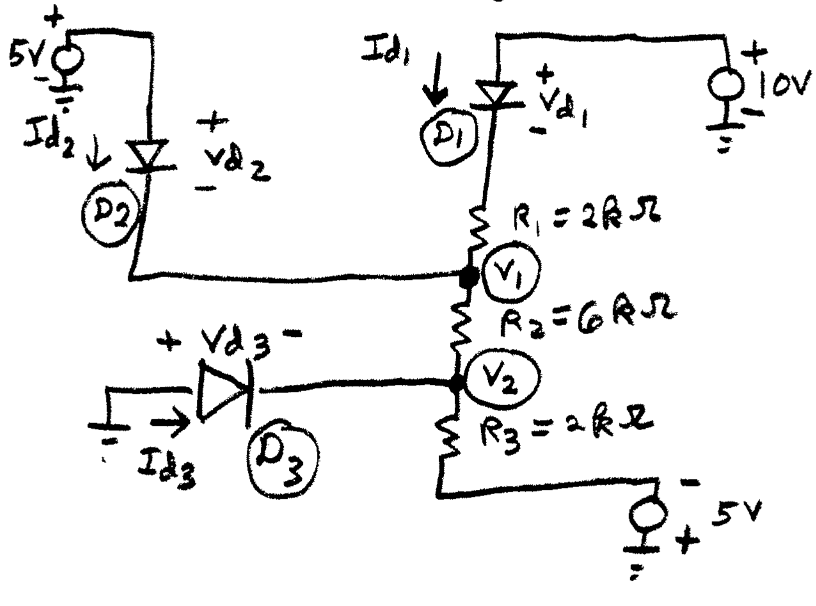
ECE250 Multiple-Diode Circuit Analysis Using the "0.7 V Battery Model"

In a dc circuit containing one or more diodes, the 0.7 V battery model may be used to analyze the circuit using the following steps:

1. Define reference voltages across each diode which are referenced (+) at the anode and (-) at the cathode. Define reference currents through each diode which are referenced to enter the anode side of each diode.
2. Begin by making an "intelligent guess" as to which diodes are most likely ON and which diodes are most likely OFF. For the diodes that you guessed were off, replace them by OPEN CIRCUITS. For the diodes that you guessed were ON, replace them by 0.7 V batteries, which have their positive terminal on the anode side of the diode.
3. Next, analyze the resulting simplified circuit, where each diode is acting either as a 0.7 V battery or an open circuit, finding the current through each ON diode (0.7 V battery) and finding the voltage across each OFF diode (open circuit).
4. Now check the results of your analysis:
   a. For each diode assumed ON, the anode-to-cathode diode current MUST be POSITIVE.
   b. For each diode assumed OFF, the anode-to-cathode voltage must be < 0.7 V.
   c. If even one of these checks FAILS, you must loop back to Step 2 and make a new guess. However, you are guided by which check fails.
      i. If a diode had been assumed to be ON, but its anode-to-cathode current came out negative, then you should assume that diode is OFF in your next iteration.
      ii. Likewise, if a diode has been assumed to be OFF, and its anode-to-cathode voltage came out above 0.7 V, you should assume that diode is ON in your next iteration.
5. Once all of the consistency checks of Part 4 are passed, you have determined the proper state of each of the diodes in your circuit, and your calculated diode voltages and currents are correct.

Example of Applying this Method to a Multiple Diode Circuit

1. Consider the following 3-diode circuit. We are asked to find the node voltages V1 & V2.



Assumption #1: D1 ON; D2 & D3 OFF

Note from our assumptions, we may replace diode D1 by a 0.7 V battery, and diodes D2 and D3 by open circuits. Then we can make a table of diode voltages and currents and fill in THREE of the entries immediately.

	D1	D2	D3
Diode anode-to cathode voltages:	0.7V	?	?
Diode anode-to-cathode currents:	?	0A	0A

Now we may analyze the resulting circuit to calculate the 3 unknown entries in the table above:
(Remember D1 is a 0.7 V battery and D2 and D3 are OPEN CIRCUITS.)

Id1 = (10-0.7-(-5))/(2k + 6k + 2k) = 1.43 ma
Vd2 = 5 – (10 – 0.7 – Id1*2k) = -1.44 V
Vd3 = 0 – (10 – 0.7 – Id1*(2k + 6k)) = 2.14 V

The completed table follows:

	D1	D2	D3
Diode anode-to cathode voltages:	0.7V	-1.44V	2.14 V
Diode anode-to-cathode currents:	1.43mA	0A	0A

Note that ON diode D1 has a positive diode current, so it meets the requirements!
The OFF diode D2 has a voltage that is < 0.7 V, so it meets the requirements!
But the OFF diode D3 has a voltage that is > 0.7 V, so it FAILS the requirements.

Therefore we are guided into making a SECOND assumption, where diode D3 is now assumed to be ON. We will leave the other diodes alone.

Assumption #2: D1 ON; D2 OFF; D3 ON

Once again, we can immediately fill in three of the six entries in the diode voltage/current table:

	D1	D2	D3
Diode anode-to cathode voltages:	0.7V	?	0.7V
Diode anode-to-cathode currents:	?	0A	?

(Remember Diodes D1 and D3 are 0.7 V batteries, and Diode D2 is an OPEN CIRCUIT.)

Because D3 is ON, node voltage V2 is now held at 0 – 0.7 = -0.7 V
Id1 = (10 – 0.7 – (-0.7V))/(2k + 6k) = 1.25 mA
Vd2 = 5 – (10 – Id1*2k) = -2.5 V
To find Id3, write KCL equation at "V2 node": Id3 + Id1 = IR3,
where IR3 = (V2 – (-5))/R3 =(-0.7+5)/2k = 2.15 mA
Therefore Id3 = IR3 – Id1 = 2.15 – 1.25 = 0.9 mA

The finished table appears below:

	D1	D2	D3
Diode anode-to cathode voltages:	0.7V	-2.5V	0.7V
Diode anode-to-cathode currents:	1.25 mA	0A	0.9 mA

Note that now each ON diode (D1 and D3) has a POSITIVE anode-to-cathode current, and the OFF diode (D2) has an anode-to-cathode voltage that is < 0.7 V. Therefore, ALL CONSISTENCY CHECKS ARE SATISIFIED. OUR ASSUMPTIONS ARE CORRECT THIS TIME!

Now that the diode voltages and currents are consistent, the two node voltages can be found very easily:

V1 = 10 – Id1*R1 = 10 – 1.43 mA * 2k = 6.80 V
V2 = 0 – 0.7 V = -0.7 V