

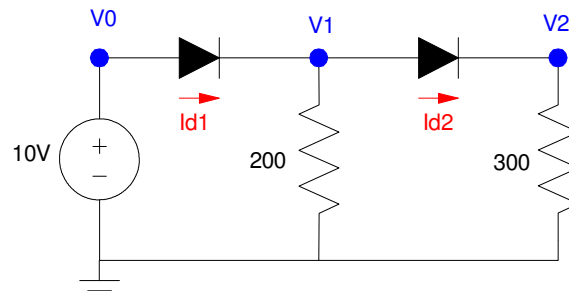
ECE 111 - Homework #13

Week #13 - ECE 320 Electronics I. Due Tuesday, April 18th

Assume the VI characteristics for 1N4004 diodes are:

$$V_d = 0.038 \cdot \ln\left(\frac{I_d}{7.7 \cdot 10^{-11}} + 1\right) \quad I_d = 7.7 \cdot 10^{-11} \left(\exp\left(\frac{V_d}{0.038}\right) - 1\right)$$

1) Write the voltage node equations for the following circuit.



Problem 1-3

Write the diode equations (V_d is the voltage from anode to cathode)

$$I_{d1} = 7.7E-11 \left(\exp\left(\frac{V_0 - V_1}{0.038}\right) - 1\right)$$

$$I_{d2} = 7.7E-11 \left(\exp\left(\frac{V_1 - V_2}{0.038}\right) - 1\right)$$

Now write the node equations

$$V_0 = 10$$

$$-I_{d1} + I_{d2} + \left(\frac{V_1}{200}\right) = 0$$

$$-I_{d2} + \left(\frac{V_2}{300}\right) = 0$$

2) Solve using fminsearch and MATLAB

Create an m-file to compute the sum-squared error in the currents:

```
function [ J ] = Diode2( z )
V0 = 10;
V1 = z(1);
V2 = z(2);

Idss = 7.7e-11;
nVt = 0.038;

Id1 = Idss* exp( (V0 - V1)/nVt - 1 );
Id2 = Idss* exp( (V1 - V2)/nVt - 1 );

e1 = -Id1 -Id2 + (V1)/200;
e2 = -Id2 + (V2)/300;

J = (e1)^2 + (e2)^2;

disp([V0, V1, V2, log10(J)])
pause(0.1)

end
```

Optimize using fminsearch()

Guess the voltages are (5V, 4V)

```
>> Diode2([5,4])
    10.0000    5.0000    4.0000    93.1924

ans = 1.5574e+093
```

The sum-squared error is 1.55e93 (a really bad guess). Let fminsearch() try to do better:

```
>> [V,e] = fminsearch('Diode2',[5,4])
    10.0000    5.0000    4.0000    93.1924
    10.0000    5.2500    4.0000    87.4780
    10.0000    5.0000    4.2000    93.1924
    10.0000    5.2500    3.8000    87.4780
(time passes)
    10.0000    9.2299    8.4426   -8.6853
    10.0000    9.2298    8.4425   -9.4219
    10.0000    9.2298    8.4426   -8.2336
    10.0000    9.2297    8.4425   -9.6629

V =     9.2297     8.4425

e = 2.1734e-010
```

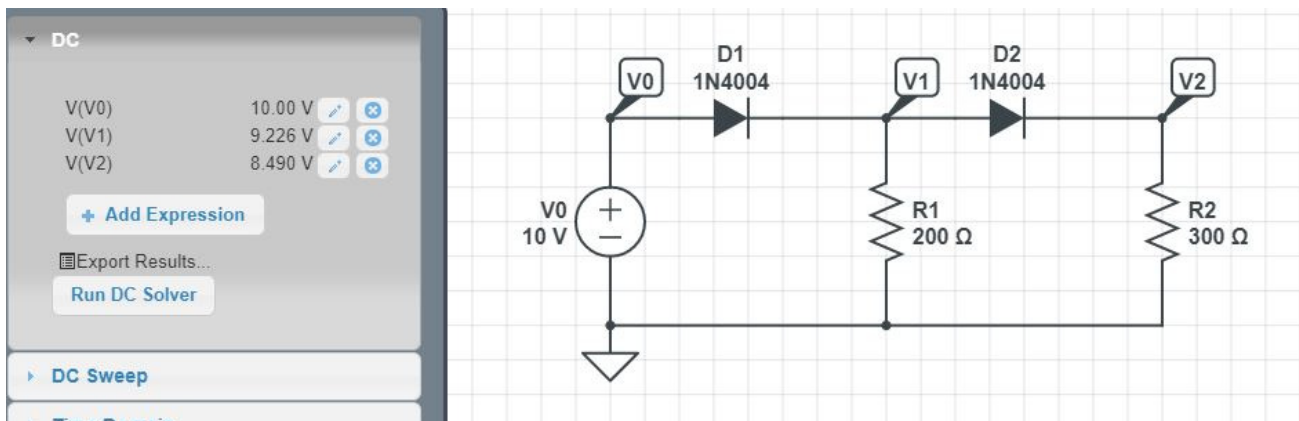
The error is almost zero, so this is the solution

- **V0 = 10V**
- **V1 = 9.2297V**
- **V2 = 8.4425V**

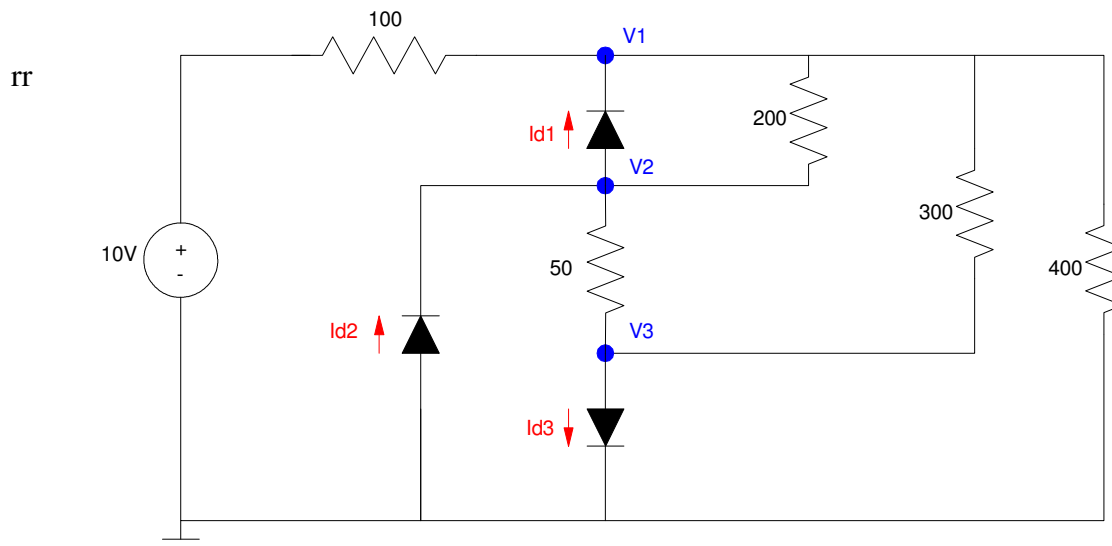
3) Check your results using CircuitLab and 1N4004 diodes

Method	V0	V1	V2
Matlab	10V	9.2297V	8.4425V
CircuitLab	10V	9.226V	8.490V
Lab done in ECE 320	-	-	-

If you built the circuit and measured the voltages, you'll get a third answer (which is close but slightly different)



4) Write the voltage node equations for the following circuit.



Problem 4-6

Start with the diode equations

$$I_{d1} = 7.7E - 11 \left(\exp \left(\frac{V_2 - V_1}{0.038} \right) - 1 \right)$$

$$I_{d2} = 7.7E - 11 \left(\exp \left(\frac{0 - V_2}{0.038} \right) - 1 \right)$$

$$I_{d3} = 7.7E - 11 \left(\exp \left(\frac{V_3 - 0}{0.038} \right) - 1 \right)$$

Now write the voltage node equations

$$V_0 = 10$$

$$\left(\frac{V_1 - V_0}{100} \right) - I_{d1} + \left(\frac{V_1 - V_2}{200} \right) + \left(\frac{V_1 - V_3}{300} \right) + \left(\frac{V_1 - 0}{400} \right) = 0$$

$$I_{d1} - I_{d2} + \left(\frac{V_2 - V_1}{200} \right) + \left(\frac{V_2 - V_3}{50} \right) = 0$$

$$\left(\frac{V_3 - V_2}{50} \right) + I_{d3} + \left(\frac{V_3 - V_1}{300} \right) = 0$$

5) Solve using fminsearch and MATLAB

Start with an m-file where you

- pass your guess for V1, V2, V3, and
- Return the sum-squared error in the currents

```
function [ J ] = Diode3( z )
    V0 = 10;
    V1 = z(1);
    V2 = z(2);
    V3 = z(3);

    Idss = 7.7e-11;
    nVt = 0.038;

    Id1 = Idss* exp( (V2 - V1)/nVt - 1 );
    Id2 = Idss* exp( ( 0 - V2)/nVt - 1 );
    Id3 = Idss* exp( (V3 - 0)/nVt - 1 );

    e1 = (V1-V0)/100 -Id1 + (V1-V2)/200 + (V1-V3)/300 + (V1)/400;
    e2 = Id1 - Id2 + (V2-V1)/200 + (V2-V3)/50;
    e3 = (V3-V2)/50 + Id2 + (V3-V1)/300;

    J = (e1)^2 + (e2)^2 + (e3)^2;

    disp([V0, V1, V2, V3, log10(J)])
    pause(0.1)

end
```

Wild Guess (3V, 2V, 1V)

```
>> Diode3([3,2,1])
    10.0000    3.0000    2.0000    1.0000    1.7590

ans =    57.4072
```

Use fminsearch to improve the result

```
>> [V,e] = fminsearch('Diode3', [3,2,1])
    10.0000    3.0000    2.0000    1.0000    1.7590
    10.0000    3.1500    2.0000    1.0000    1.7589
    10.0000    3.0000    2.1000    1.0000    1.7587
    10.0000    3.0000    2.0000    1.0500    2.9041
    10.0000    3.1000    2.0667    0.9500    0.6068
(time passes)
    10.0000    5.3355    1.7019    0.7936   -11.6927
    10.0000    5.3353    1.7020    0.7936   -11.0322
    10.0000    5.3355    1.7020    0.7936   -11.8372

V =      V1      V2      V3
    5.3355    1.7020    0.7936

e = 1.4548e-012
```

The error is almost zero, so this is the answer

6) Check your results using CircuitLab and 1N4004 diodes

Method	V0	V1	V2	V3
Matlab	10V	5.3355V	1.7020V	0.7936V
CircuitLab	10V	5.317V	1.657V	0.7425V
Lab done in ECE 320	-	-	-	-

Again, the answers are close but slightly different

CircuitLab uses a slightly different nonlinear model for the diodes

If you build this circuit, you would get a third answer that is close but slightly different

Both Matlab's and CircuitLab's models for diodes are not exact

