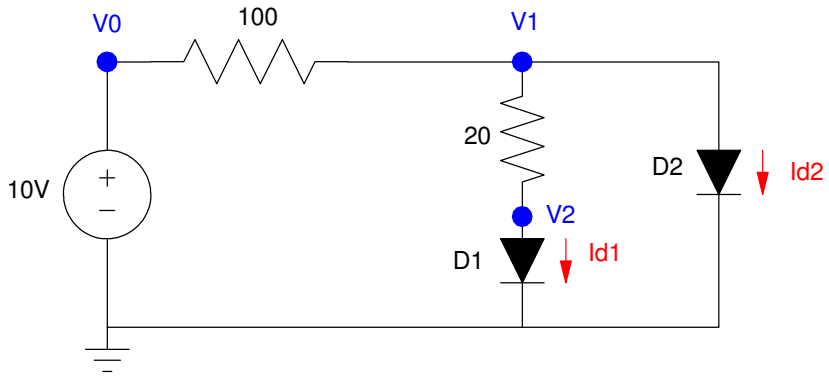
ECE 111 - Homework #13

Week #13 - ECE 320 Electronics I. Due 11am, Tuesday November 22nd

Assume the VI characteristics for 1N4004 diodes are:

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

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



Start with the diode equations

$$I_{d1} = 7.7 \cdot 10^{-11}\left(\exp\left(\frac{V_2}{0.038}\right) - 1\right)$$

$$I_{d2} = 7.7 \cdot 10^{-11}\left(\exp\left(\frac{V_1}{0.038}\right) - 1\right)$$

Add in the voltage node equations

$$V_0 = 10$$

$$\left(\frac{V_1 - V_0}{100}\right) + \left(\frac{V_1 - V_2}{20}\right) + I_{d2} = 0$$

$$\left(\frac{V_2 - V_1}{20}\right) + I_{d1} = 0$$

2) Solve using fminsearch and MATLAB

First, write a Matlab funciton:

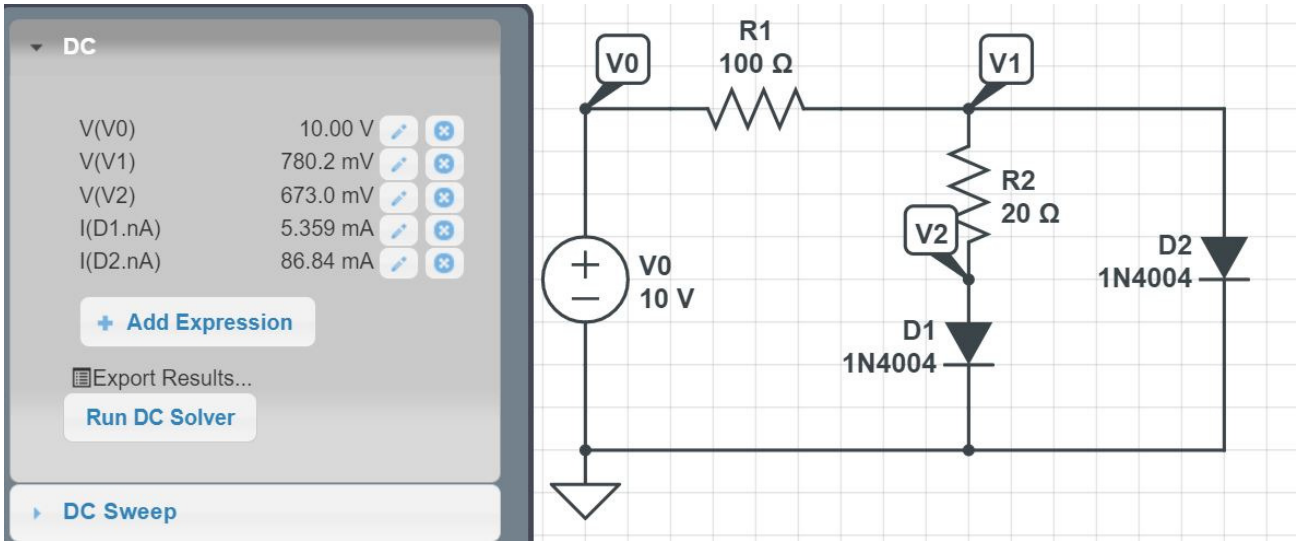
```
function [ J ] = diode2( X )

   V0 = 10;
   V1 = X(1);
   V2 = X(2);

   Id1 = 7.7e-11 * ( exp( V2 / 0.038 ) - 1);
   Id2 = 7.7e-11 * ( exp( V1 / 0.038 ) - 1);

   E1 = (V1 - V0)/100 + (V1 - V2)/20 + Id2;
   E2 = (V2 - V1)/20 + Id1;

   J = E1^2 + E2^2;

end
```

Solve using fminsearch()

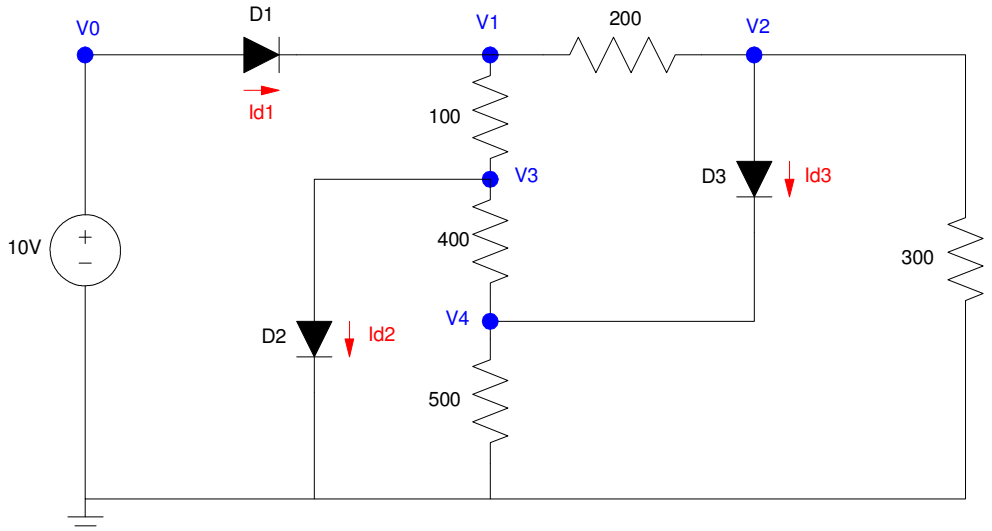
```
>> [V,e] = fminsearch('diode2',[1,2])

          V1          V2
V =    0.7920      0.6859

e =  1.6417e-011
```

3) Check your results using CircuitLab and 1N4004 diodes

- The results are almost the same
- Diodes in parallel don't share: one takes the brunt of the current



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



Problem 4-6

Start with the diode equations

$$I_{d1} = 7.7 \cdot 10^{-11}\left(\exp\left(\frac{V_0 - V_1}{0.038}\right) - 1\right)$$

$$I_{d2} = 7.7 \cdot 10^{-11}\left(\exp\left(\frac{V_3 - 0}{0.038}\right) - 1\right)$$

$$I_{d3} = 7.7 \cdot 10^{-11}\left(\exp\left(\frac{V_2 - V_4}{0.038}\right) - 1\right)$$

Now write the voltage node equations

$$V_0 = 10$$

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

$$\left(\frac{V_2 - V_1}{200}\right) + I_{d3} + \left(\frac{V_2}{300}\right) = 0$$

$$\left(\frac{V_3 - V_1}{100}\right) + I_{d2} + \left(\frac{V_3 - V_4}{400}\right) = 0$$

$$\left(\frac{V_4 - V_3}{400}\right) + \left(\frac{V_4}{500}\right) - I_{d3} = 0$$

5) Solve using fminsearch and MATLAB

Write a Matlab funciton

```
function [ J ] = diode3( X )

   V0 = 10;
   V1 = X(1);
   V2 = X(2);
   V3 = X(3);
   V4 = X(4);

   Id1 = 7.7e-11 * ( exp( (V0-V1) / 0.038 ) - 1);
   Id2 = 7.7e-11 * ( exp( (V3-0)  / 0.038 ) - 1);
   Id3 = 7.7e-11 * ( exp( (V2-V4) / 0.038 ) - 1);

   E1 = -Id1 + (V1 - V3)/100 + (V1 - V2)/200;
   E2 = (V2 - V1)/200 + Id3 + (V2/300);
   E3 = (V3-V1)/100 + Id2 + (V3-V4)/400;
   E4 = (V4-V3)/400 + (V4/500) - Id3;

   J = E1^2 + E2^2 + E3^2 + E4^2;

end
```

Solve using fminsearch...

It helps if you have a decent initial guess. A bad guess can wind up in la-la land

```
>> [V,e] = fminsearch('diode3',[1,2,3,4])

V =    9.1752  -15.0127    0.7654  -15.7831

e =    0.0297
```

(negative voltages are not possible with this circuit)

Try some better guesses

```
>> diode3([1,2,3,4])

ans =   3.1004e+185

>> diode3([9,8,7,6])

ans =  5.9733e+139

>> diode3([9,8,0.7,0.6])

ans =  1.6607e+149

>> diode3([9,0.8,0.7,0.6])

ans =  422.0521
```

Better, start from here

```
>> [V,e] = fminsearch('diode3',[9,0.8,0.7,0.6])

V =    9.1936    0.6789    0.7905    0.6243

e =    0.0016
```

e is still fairly large, so keep itterating

```
>> [V,e] = fminsearch('diode3',V)

          V1        V2        V3        V4
V =    9.1989    3.9907    0.7935    3.2716

e =  4.8881e-013
```

Pretty close to zero. This is a valid answer

6) Check your results using CircuitLab and 1N4004 diodes

- The results are almost the same