ECE 320 - Homework #1

MATLAB, Numerical Methods Due Monday, August 31st

For each of the following, solve

a) Using graphical methods, and

b) Using numerical methods.

Problem 1) Resistor - Diode circuit:

$$V = 10 - 1000I$$

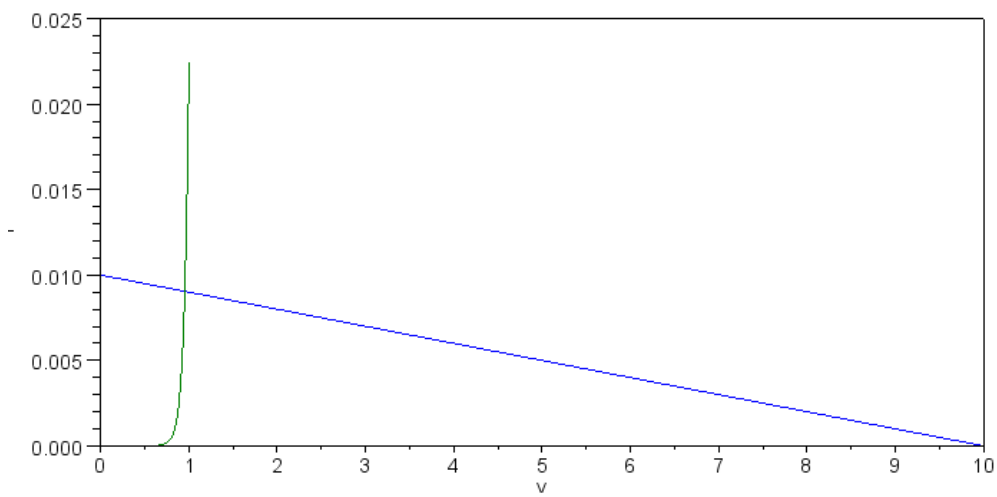
$$I = 10^{-10} \cdot \left(\exp\left(\frac{V}{0.052} \right) - 1 \right)$$

a) Graphical Method. Note from the first equation that when V=0, I = 10mA. Plot for 0 < I < 10mA

```
-->V1 = [0:0.01:10]';
-->I1 = (10 - V1) / 1000;

-->V2 = [0:0.001:1]';
-->I2 = 1e-10 * ( exp(V2 / 0.052) - 1 );

-->plot(V1,I1,V2,I2)
-->xlabel('V');
-->ylabel('I');
```



Answer: The two cross at about 1V, 9mA

Numerical Solution:

- Start with a guess (V = 1).
- Find the error
- Perturb V to find the slope at that point
- Determine the next guess

```
I1 = (10 - V) / 1000;
I2 = 1e-10 * ( exp(V / 0.052) - 1 );
e = I1 - I2;
dV = V + 1e-6;
dI1 = (10 - dV) / 1000;
dI2 = 1e-10 * ( exp(dV / 0.052) - 1 );
de = dI1 - dI2;
slope = (de - e) / (dV - V);
V = V - e/slope;
I1 = (10 - V) / 1000;
I2 = 1e-10 * ( exp(V / 0.052) - 1 );
e = I1 - I2
```

Iterating:

Guess 1:

- V = 1
- Error = - 0.0134811

Guess 2:

- V = 0.9688898
- Error = - 0.0033281

Guess 3:

- V = 0.9549460
- Error = - 0.0004072

Guess 4:

- V = 0.9527183
- E = - 0.0000086

Guess 5:

- V = 0.9526694
- E = - 4.076D-09

Call it good enough.

Answer:

- I = 0.0090473
- V = 0.9526694

2) Two diodes in series

$$V = 10 - 1000I$$

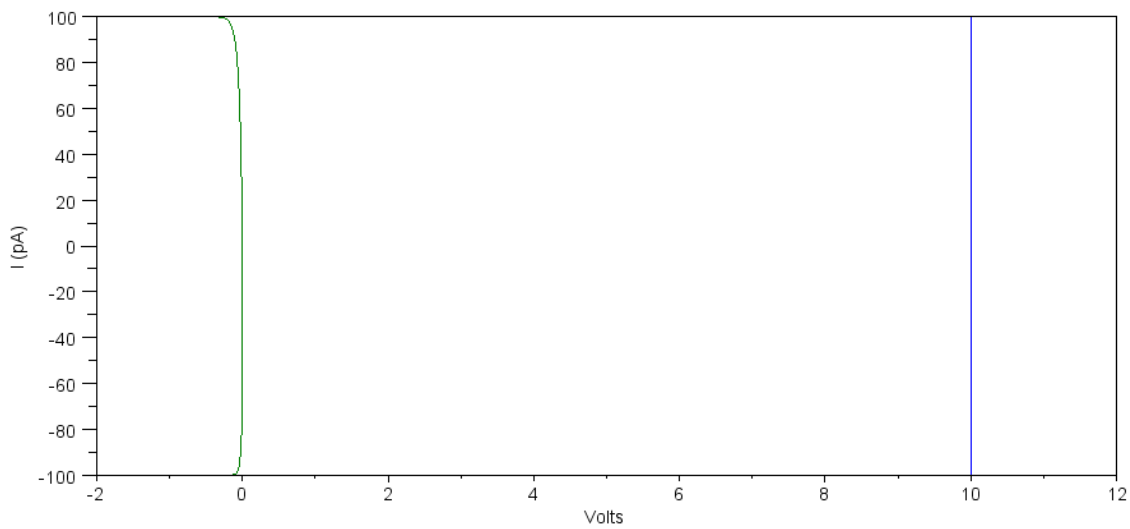
$$V = 0.052\ln(1 + 10^{10}I) + 0.052\ln(1 - 10^{10}I)$$

Note: The second equation has complex numbres for $-10^{-10} < I < +10^{-10}$

```
--> I = [-0.999:0.001:0.999]' * 1e-10;

-->V1 = 10 - 1000*I;
-->V2 = 0.025*log(1 + 1e10*I) + 0.052*log(1-1e10*I);

-->plot(V1,I*1e12,V2,I*1e12)
-->xlabel('Volts');
-->ylabel('I (pA)');
```



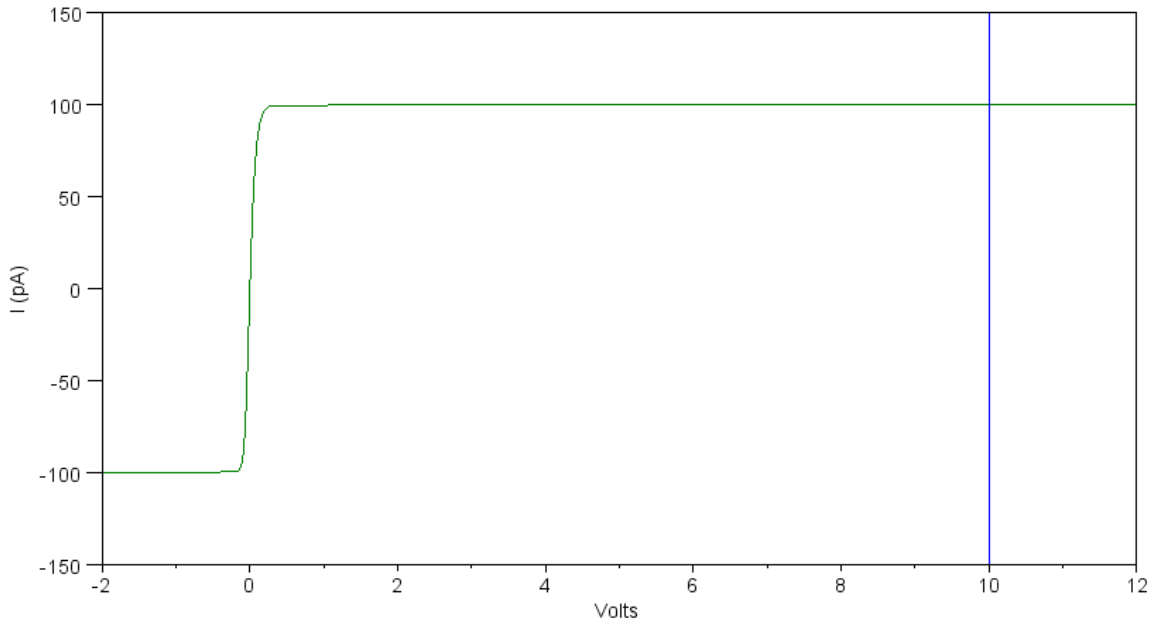
The two curves don't intersect. **No Solution**

Problem 2 (sidelight)

Note: This is the circuit for two diodes placed back to back (one forward biased, one reverse biased). If you build the circuit, the current will be *something*. The problem is a sign error in the above equations. They should be

$$V = 0.052 \ln(1 + 10^{10} I) - 0.052 \ln(1 - 10^{10} I)$$

This results in the following curve:



Answer:

I = 100pA

V = 9.999 999 9 V

or approximately (10V, 0mA)

You'll see this shortly - reverse biased diodes don't allow current flow (or almost no current)

Problem 3) MOSFET Amplifier

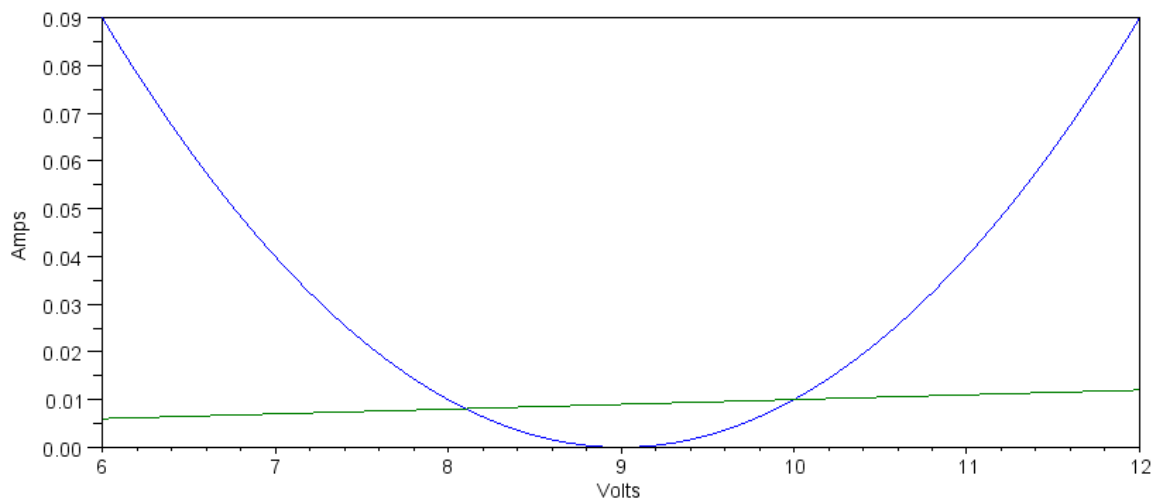
$$I_d = 0.01 \cdot (9 - V_d)^2$$

$$V_d = 1000 I_d$$

In SciLab (this took two tries: one to get a general idea, the second to zoom in on the portion which shows the interesection)

```
-->Vd = [-10:0.01:10]';
-->I1 = 0.01* (9 - Vd) .^ 2;
-->I2 = Vd / 1000;
-->plot(Vd,I1,Vd,I2)

-->Vd = [6:0.01:12]';
-->I1 = 0.01* (9 - Vd) .^ 2;
-->I2 = Vd / 1000;
-->plot(Vd,I1,Vd,I2)
-->xlabel('Volts');
-->ylabel('Amps');
```



Solutions:

(10V, 0.01A)

(8.10V, 0.0081A)

Numerical Soltion: Same answers

Problem 4) MOSFET Switch

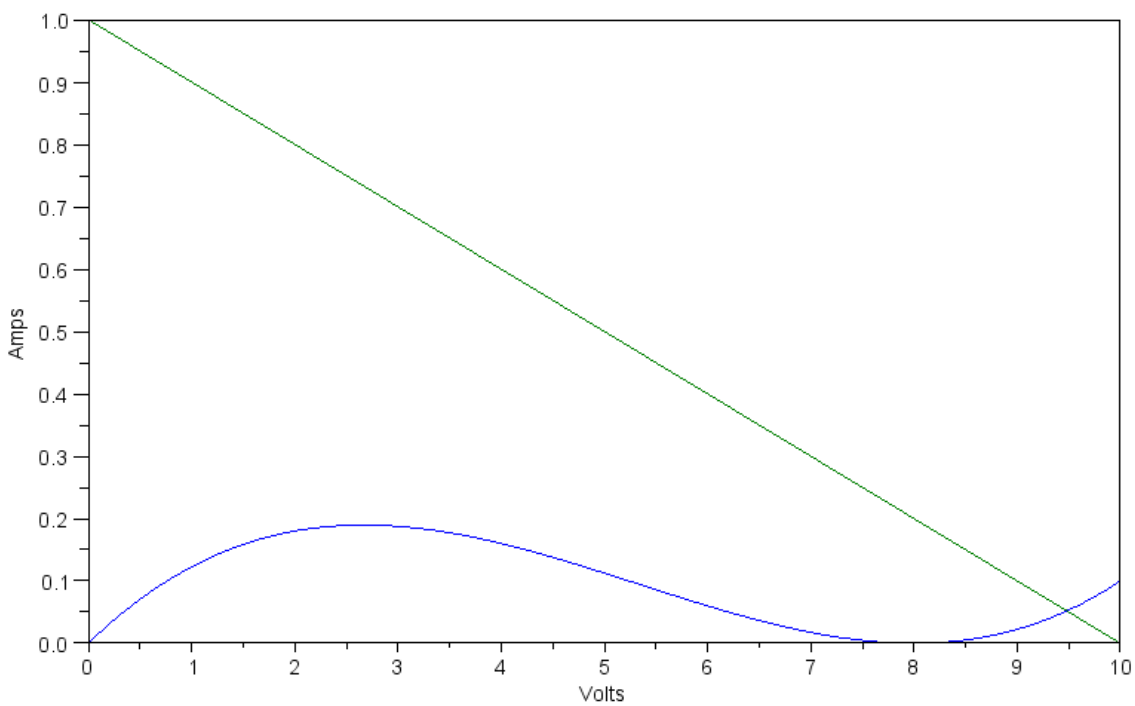
$$I_d = 0.01\left(4 - \tfrac{V_d}{2}\right)^2 V_d$$

$$V_d = 10 - 10 I_d$$

In SciLab

```
-->Vd = [0:0.001:10]';
-->I1 = 0.01* (4 - Vd/2) .^ 2 .* Vd;
-->I2 = (10 - Vd) / 10;

-->plot(Vd,I1,Vd,I2)
-->xlabel('Volts');
-->ylabel('Amps');
```



Solution:

(9.4805V, 0.0520 A)