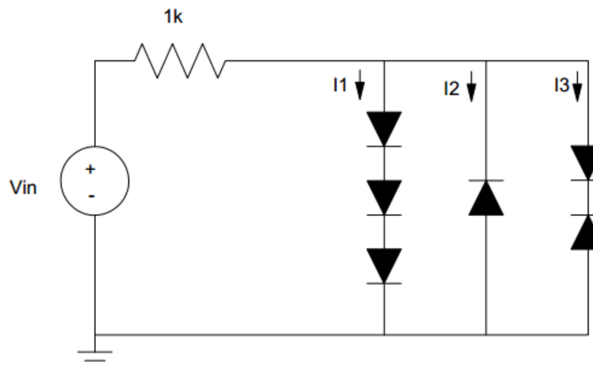
ECE 321 - Homework #2

Ideal diode, LEDs, Clippers - Due Monday, February 2nd

Assume ideal silicon diodes (Vf = 0.7V). Determine the currents for the following circuit

1) Vin = +10V



Since the current is trying to flow down, assume

- I1 > 0 (first three diodes are on)
- I2 = 0 (reverse biased diode is off)
- I3 = 0 (the lower diode is reverse biased)

Then

$$V_o = 2.1V$$

The currents have to balance

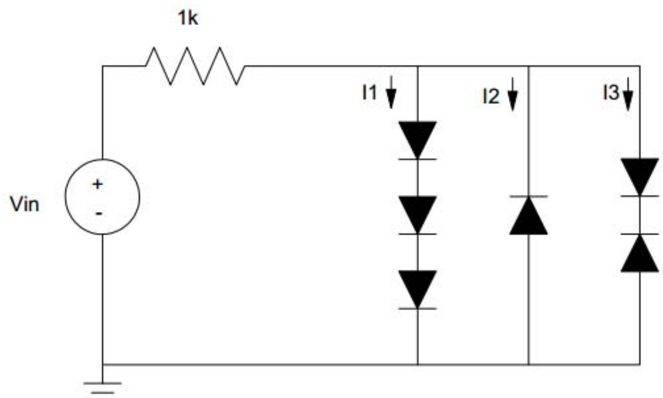
$$\left(\frac{10V-2.1V}{1k}\right) = I_1 + I_2 + I_3$$

$$\left(\frac{10V-2.1V}{1k}\right) = I_1$$

$$I_1 = 7.9mA$$

Check: For the diodes in I1 to be on, Id > 0. It is.

2) Vin = -10V



Since the input is trying to push current counter-clockwise (up through the diodes), assume

- I1 = 0 (current goes backwards)
- I2 > 0 (current goes the correct way through the diode)
- I3 = 0 (current goes backwards through the top diode)

Vo = -0.7V

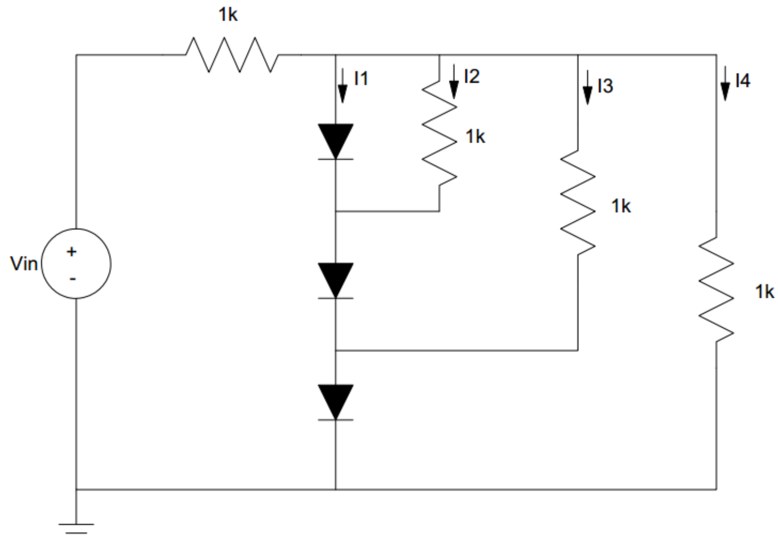
I2 is then

$$I_d = \left(\frac{10-0.7}{1k}\right) = 9.3mA$$

$$I_2 = -9.3mA$$

Assume ideal silicon diodes (Vf = 0.7V). Determine the currents for the following circuit

3) Vin = 1V



There are 3 diodes - meaning 8 permutations. One of the eight is correct (Vd < 0.7V for off diodes, Id > 0 for on diodes)

Assume the diodes are off - off - off.

Solving using voltage nodes

$$\left(\frac{1-Y}{1k}\right) = I_1 + I_2 + I_3 + I_4$$

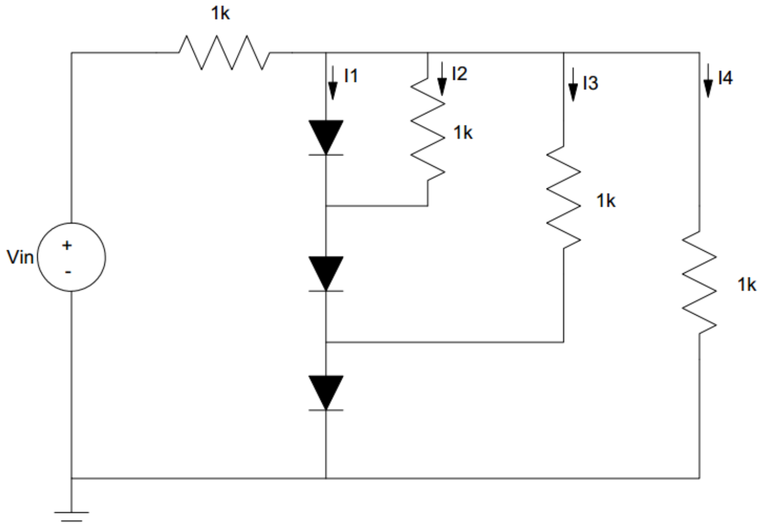
$$\left(\frac{1-Y}{1k}\right) = 0 + 0 + 0 + \left(\frac{Y}{1k}\right)$$

Y = 0.5V

resultig in

I1	I2	I3	I4
0	0	0	0.5 mA

4) Vin = 5V (same as homework #1)



Referring to homework #1, assume the diodes are off - on - on

$$\left(\frac{5-Y}{1k}\right) = I_1 + I_2 + I_3 + I_4$$

$$\left(\frac{5-Y}{1k}\right) = 0 + \left(\frac{Y-1.4V}{1k}\right) + \left(\frac{Y-0.7V}{1k}\right) + \left(\frac{Y}{1k}\right)$$

$$Y = 1.775V$$

Check: Is diode #1 off?

1.775V < 2.1V yes

Then

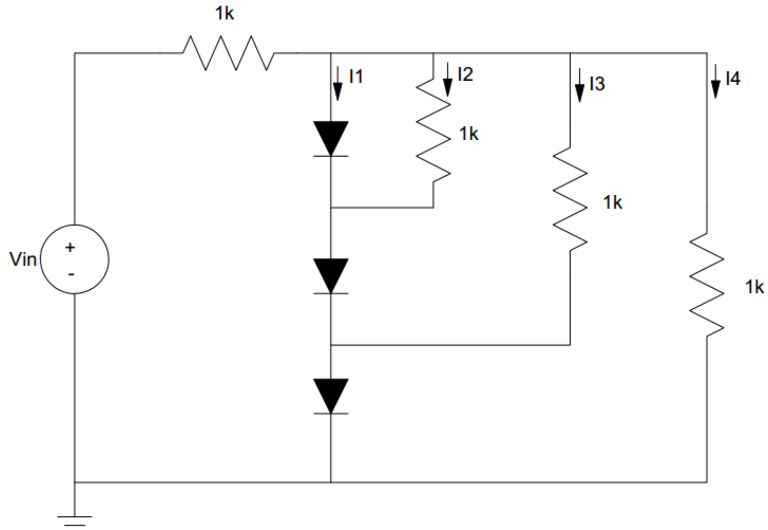
$$I_1 = 0$$

$$I_2 = \left(\frac{Y-1.4V}{1k}\right) = 0.375mA$$

$$I_3 = \left(\frac{Y-0.7V}{1k}\right) = 1.075mA$$

$$I_4 = \left(\frac{Y}{1k}\right) = 1.775mA$$

5) Vin = 10V



Assume all diodes are on

Y = 2.1V (from the three diodes in series)

$$I_2 = \left(\frac{Y-1.4V}{1k}\right) = 0.7mA$$

$$I_3 = \left(\frac{Y-0.7V}{1k}\right) = 1.4mA$$

$$I_4 = \left(\frac{Y-0V}{1k}\right) = 2.1mA$$

To find I1:

$$\left(\frac{10-Y}{1k}\right) = I_1 + I_2 + I_3 + I_4$$

$$7.9mA = I_1 + 0.7mA + 1.4mA + 2.1mA$$

$$I_1 = 2.8mA$$

Check:

Id > 0 if the diode is on

This checks for all three diodes

6) Design a circuit which produces the color pink for Valentine's day

	Color	Vf	mcd
Piranah RGB LED	Red	1.9V @ 20mA	8000 @ 20mA
	Green	3.0V @ 20mA	8000 @ 20mA
	Blue	3.0V @ 20mA	8000 @ 20mA
White 1W	White	3.3V @ 250mA	100 lumens @ 350mA

Pink:

- Red = 15mA
- Green = 0mA
- Blue = 5mA

LEDs are diodes - meaning the voltage drop is approximately constant as long as Id > 0

Assume a +5V source

To set the current, add a resistor:

Red:

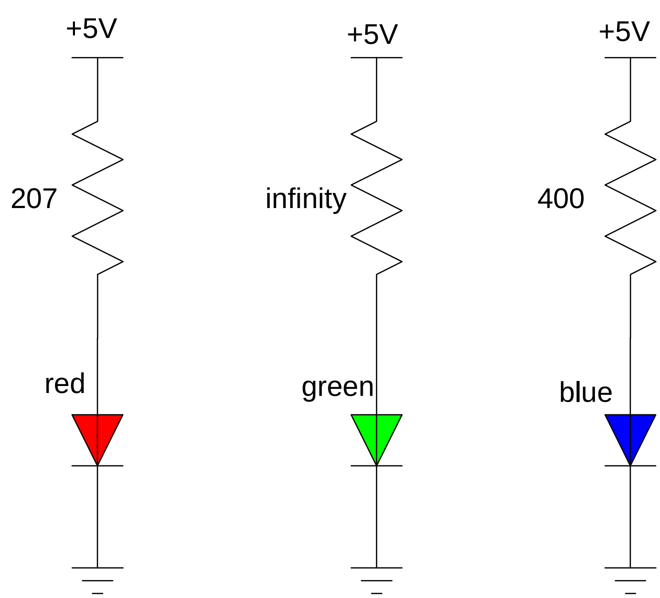
$$R_r = \left(\frac{5V - 1.9V}{15mA}\right) = 207\Omega$$

Green:

$$R_g = \left(\frac{5V - 3.0V}{0mA}\right) = \infty$$

Blue:

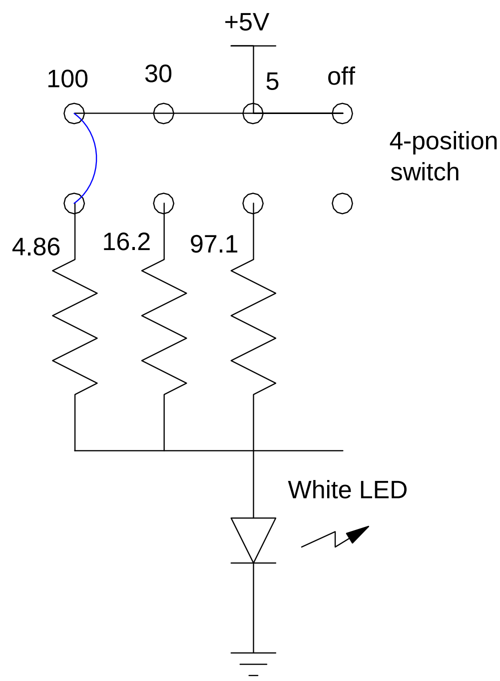
$$R_b = \left(\frac{5V - 3.0V}{5mA}\right) = 400\Omega$$



7) Design a circuit with a rotory switch which can power the 1W white LED as a flashlight with three brightness levels:

- 100 lumens
- 30 lumens
- 5 lumens
- Off

Assume a +5V source:



100 Lumens:

I = 350mA

$$R_{100} = \left(\frac{5V-3.3V}{350mA}\right) = 4.86\Omega$$

30 lumens

$$I = \left(\frac{30lumens}{100lumens}\right)350mA = 105mA$$

$$R_{30} = \left(\frac{5V-3.3V}{105A}\right) = 16.2\Omega$$

5 lumens

$$I = \left(\frac{5\ lumens}{100\ lumens}\right)350mA = 17.5mA$$

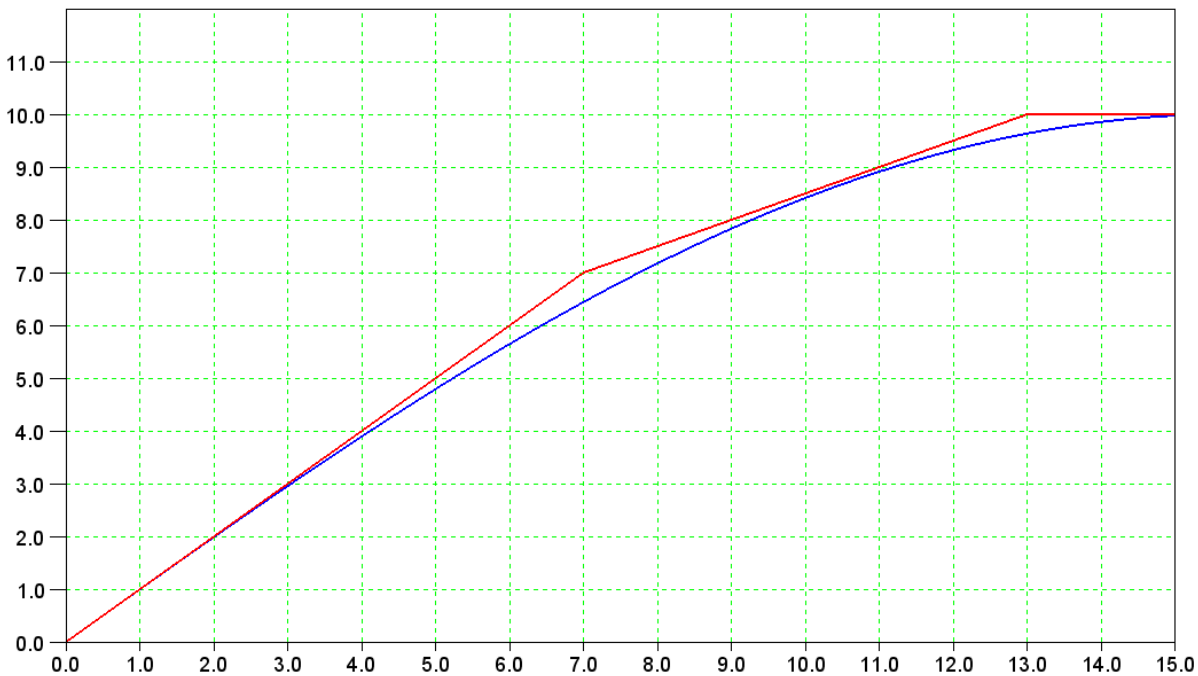
$$R_5 = \left(\frac{5V-3.3V}{17.5mA}\right) = 97.1\Omega$$

0 lumens

I = 0

R = infinity

8) Design a circuit which approximates the funtion: y ? 10 sin?x/10?

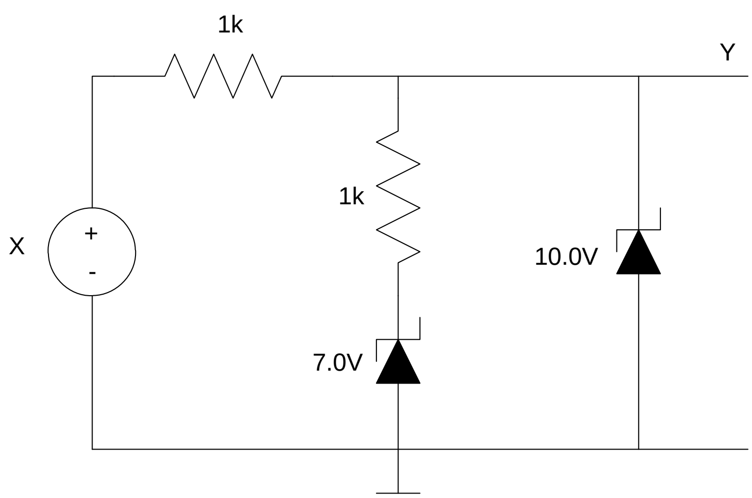


Draw in straight lines with slopes of 1, 1/2, 1/4, 1/8, etc. to approximate the curve (shown in red)

Each drop in slope from 1 to 1/2 to 1/4, etc is an additional stage.

The zener voltage is when that stage turns on (read on the Y axis)

As show, there are only two corners, meaning two stages



9) Measure the V/I characteristics for an LED in the lab from 0mA to 20mA.

Piranah Red LED						
1.14mA	4.18mA	7.10mA	10.54mA	13.97mA	16.38mA	19.86mA
1.77V	1.84V	1.87V	1.90V	1.93V	1.94V	1.96V

10) Approximate this curve with a function

```
-->Id = [1.14, 4.18,7.10,10.54,13.97,16.38,19.86]' ;
-->Vd = [1.77,1.84,1.87,1.90,1.93,1.94,1.96]' ;

-->X = [Vd, Vd.^0];
-->Y = log(Id);
-->A = inv(X'*X)*X'*Y

    14.897863
  - 26.071782
```

Meaning

$$\ln(I_d) \approx 14.89V_d - 26.07 \qquad \text{(mA)}$$

$$I_d \approx e^{-26.07} \cdot e^{14.89V_d}\ mA$$

$$\boxed{I_d \approx 4.76 \cdot 10^{-12} \cdot (e^{14.89V_d} + 1)\ mA}$$

```
-->V = [1.7:0.01:2]';
-->I = exp(A(1)*V + A(2));
-->plot(V,I,'-',Vd,Id,'.')
-->xlabel('Vd (Volts)');
-->ylabel('Id (mA)');
```