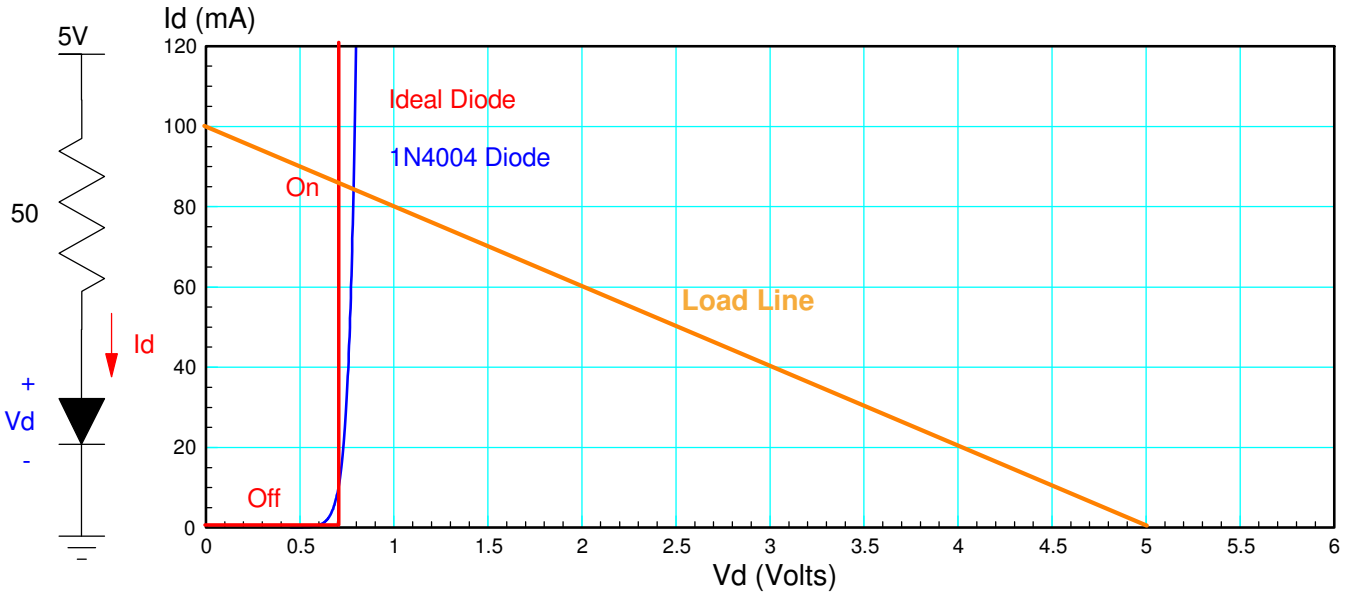
ECE 320 - Homework #3

Ideal Diodes, LEDs, AC to DC Converters. Due Monday, January 31st

Ideal Diodes:

1) Assume ideal sililcon diodes (Vf = 0.7V). Determine the voltages and currents for the following circuit



The diode is probably on (more than 0.7V is applied), meaning

$$V_d = 0.7V$$

$$I_d = \left(\frac{5V - 0.7V}{50\Omega}\right) = 86.0mA$$

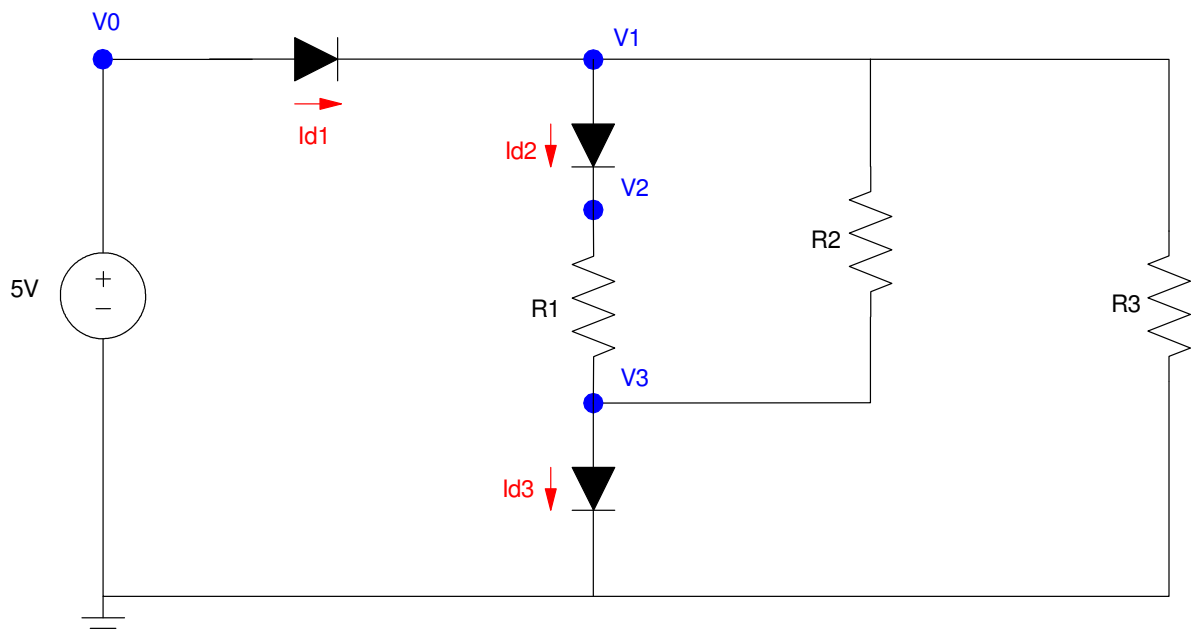
Note

- The results are close to what we found in homework #2, but
- Ideal diode model is *much* easier to use

	Vd	Id
HW3: Ideal Diode	700mV	86.00mA
HW2) Graphical solution	800mV	85mA
HW2) Numeric Solution	821.1mV	83.58mA
HW2) Simulation (CircuitLab)	779.1mV	84.42mA
HW2) Lab (experimental)	757mV	83.20mA

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

- R1, R2, R3 are the same that you used in homework #2



There are eight permutations of on & off. Assume

- D1, D3 are on
- D2 is off

this gives

$$V_0 = 5V$$

$$V_1 = V_0 - 0.7V = 4.3V$$

$$V_2 = V_1 - 0.7V = 3.6V$$

$$V_3 = 0.7V$$

Comparing to homework #1

- The ideal diode model is close but a little off

	V0	V1	V2	V3
Ideal Diode	5.00V	4.30V	3.60V	700mV
Numeric Solution	5.00V	4.1955V	3.4172V	801.8mV
Simulation (CircuitLab)	5.00V	4.229V	3.494V	758.5mV
Lab (experimental)	4.92V	4.14V	3.40V	755mV

LEDs

The specifications for a Piranah RGB LED are

Color	Vf @ 20mA	mcd @ 20mA
red	2.0V	10,000
green	3.2V	10,000
blue	3.2V	10,000

3) Design a circuit to drive these LEDs with a 5V source to produce olive green:

- Red = 6901 mcd (176/255)
- Green = 7686 mcd (196/255)
- Blue = 2313 mcd (59/255)

Current is proportional to brightness

$$I_r = \left(\frac{6901mcd}{10{,}000mcd}\right) 20mA = 13.802mA$$

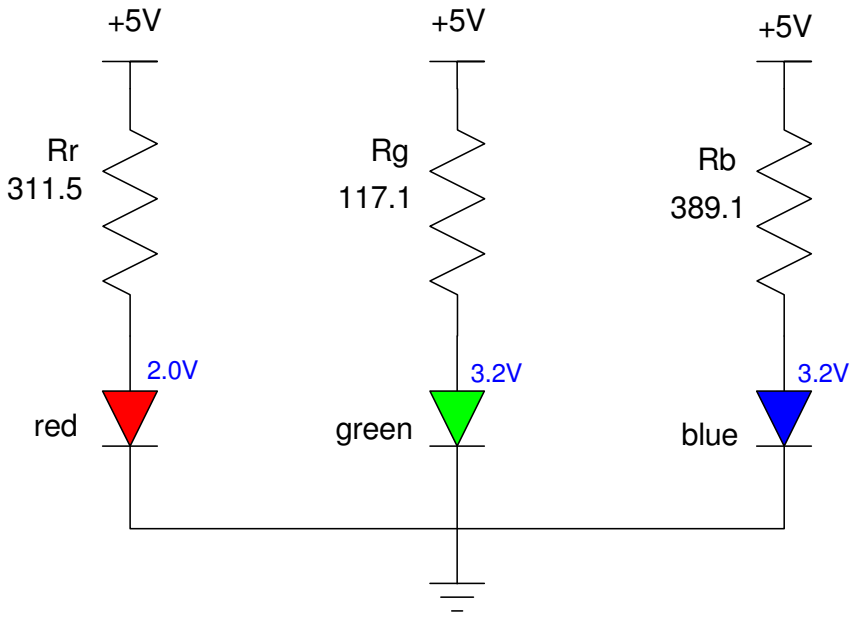
$$R_r = \left(\frac{5V - 2.0V}{13.802mA}\right) = 311.5\Omega$$

$$I_g = \left(\frac{7686mcd}{10{,}000mcd}\right) 20mA = 15.372mA$$

$$R_g = \left(\frac{5V - 3.2V}{15.372mA}\right) = 117.1\Omega$$

$$I_b = \left(\frac{2313mcd}{10{,}000mcd}\right) 20mA = 4.626mA$$

$$R_b = \left(\frac{5V - 3.2V}{4.626mA}\right) = 389.1\Omega$$



4) Design a circuit to drive these LEDs with a 5V source producing salmon pink:

- Red = 6666 mcd (170/255)
- Green = 3333 mcd (85/255)
- Blue = 5490 mcd (140/255)

$$I_r = \left(\frac{6666mcd}{10{,}000mcd}\right) 20mA = 13.333mA$$

$$R_r = \left(\frac{5V - 2.0V}{13.333mA}\right) = 225.0\Omega$$

$$I_g = \left(\frac{3333mcd}{10{,}000mcd}\right) 20mA = 6.667mA$$

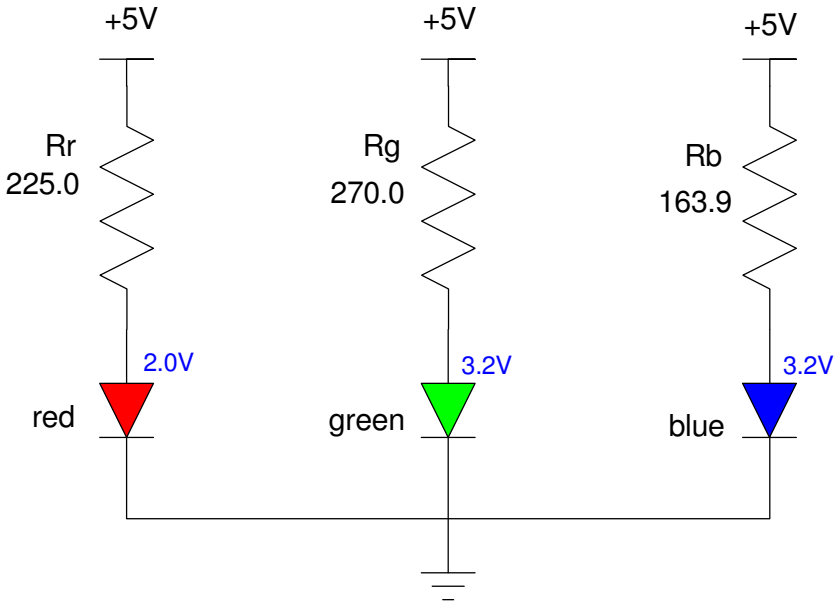
$$R_g = \left(\frac{5V - 3.2V}{6.667mA}\right) = 270.0\Omega$$

$$I_b = \left(\frac{5490mcd}{10{,}000mcd}\right) 20mA = 10.98mA$$

$$R_b = \left(\frac{5V - 3.2V}{10.980mA}\right) = 163.9\Omega$$

Other colors can be obtained from

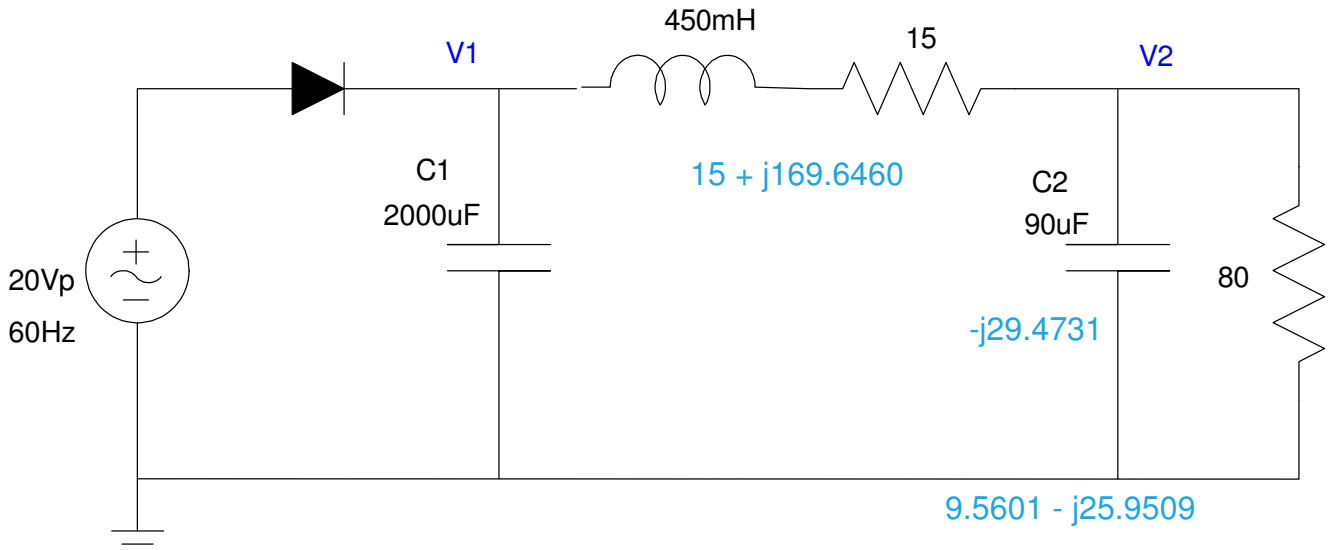
https://www.rapidtables.com/web/color/color-wheel.html



AC to DC Converters

For the circuit below:

5) Determine the votlages at V1 and V2 (DC and AC)



V1:

max(V1) = 19.3V

$$I \approx \left(\frac{19.3V}{80\Omega+15\Omega}\right) = 203.2mA \qquad \textit{worst case}$$

$$I = C\frac{dV}{dt}$$

$$203.2mA = 2000\mu F \cdot \left(\frac{dV}{1/60s}\right)$$

$$dV = 1.6930V$$

$$V_1(AC) = 1.6930V_{pp}$$

$$V_1(DC) = 19.3V - \frac{1}{2}V_{1pp} = 18.45V$$

V2:

$$V_2(DC) = \left(\frac{80\Omega}{80\Omega+15\Omega}\right) \cdot V_1(DC)$$

$$V_2(DC) = 15.5398V$$

$$V_2(AC) = \left(\frac{(9.5607-j25.9509)}{(9.5607-j25.9509)+(15+j169.6460)}\right) \cdot V_1(AC)$$

$$|V_2(AC)| = 0.3232V_{pp}$$

Circuit for problems 5 - 8

6) Build the circuit in CircuitLab (or similar program) and verify your calculations for problem #5

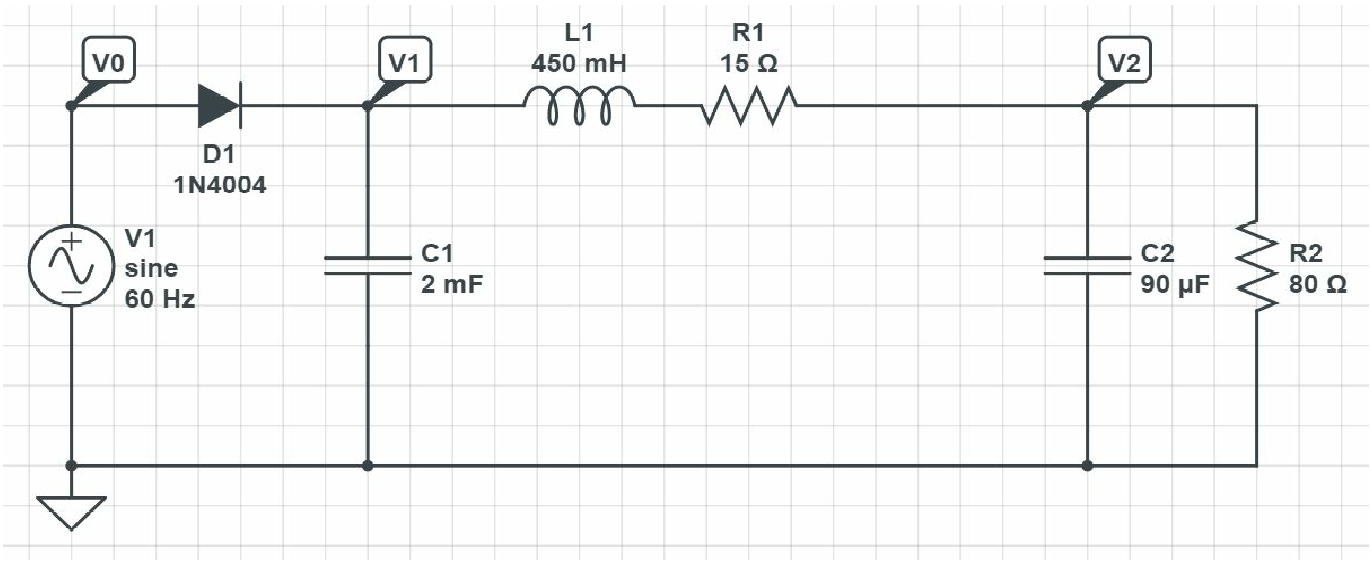
From CiruitLab

- max(V1) = 19.11V
- min(V1) = 17.62V
- max(V2) = 15.56V
- min(V2) = 15.37V

DC = (max + min)/2

AC = (max - min) Vpp

	V1		V2	
	DC	AC	DC	AC
Calculated	18.45V	1.693Vpp	15.5398V	0.3232Vpp
Simulated	18.365V	1.490Vpp	15,465V	0.190Vpp



Problem 6: CircuitLab Simulation

7) Determine C1 and C2 so that AC voltages are: V1 = 2Vpp and V2 = 250mVpp.

$$V_1(AC) = 2V_{pp}$$

max(V1) = 19.3V

$$V_1(DC) = 19.3V - \tfrac{1}{2}V_1(AC)$$

$$V_1(DC) = 18.3V$$

$$I = \left(\frac{18.3V}{80\Omega+15\Omega}\right) = 192.6mA$$

$$I = C\frac{dV}{dt}$$

$$192.6mA = C_1\left(\frac{2V_{pp}}{1/60s}\right)$$

$$C_1 = 1605\mu F$$

Assume C2 = 0

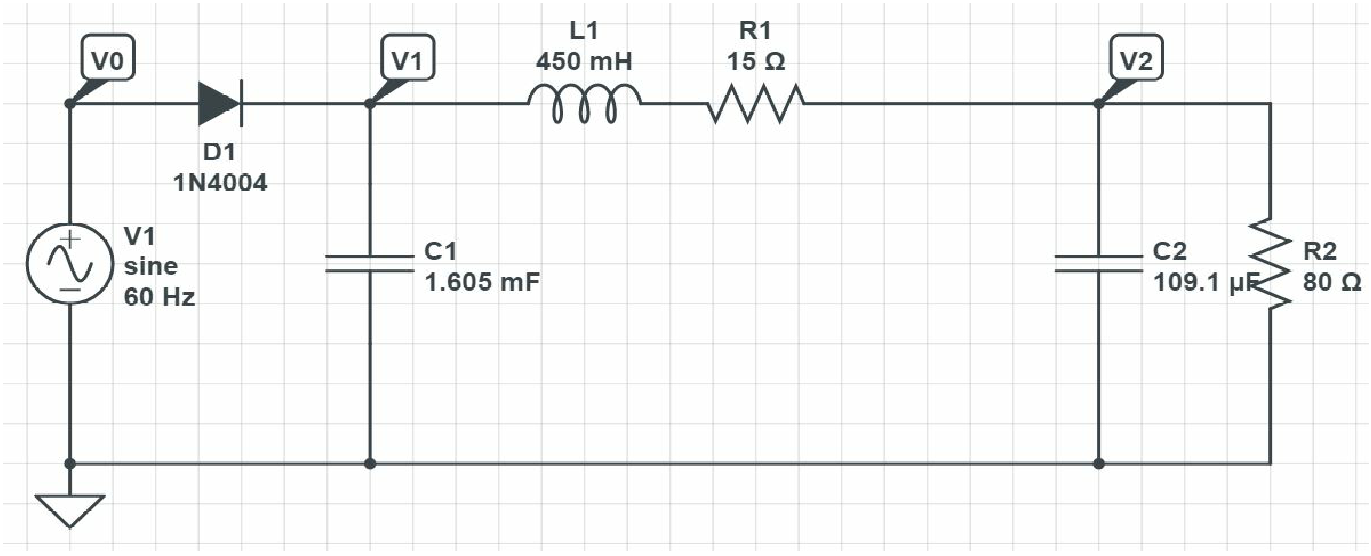
$$V_2(AC) = \left(\frac{80\Omega}{(80\Omega)+(15+j169.64)}\right)(2V_{pp})$$

$$|V_2(AC)| = 822.9mV_{pp}$$

For the ripple to be 250mVpp

$$\left|\frac{1}{j\omega C_2}\right| \approx \left(\frac{250mV}{822.9mV}\right)\cdot 80\Omega = 24.3037\Omega$$

$$C_2 = 109.1\mu F$$



8) Build this circuit in CircuitLab (or similar program) and verify your calculations for problem #7

From CircuitLab

- max(V1) = 19.12V
- min(V1) = 17.30V
- max(V2) = 15.44V
- min(V2) = 15.24V

	V1		V2	
	DC	AC	DC	AC
Calculated	18.30V	2.000Vpp	15.41V	250mVpp
Simulated	18.21V	1.820Vpp	15.34V	200mVpp