Physics 313 assignment 4, Fall 2017:

New topics: diodes; diode clippers and clamps; voltage regulation
Problems: (assume any diodes are silicon)

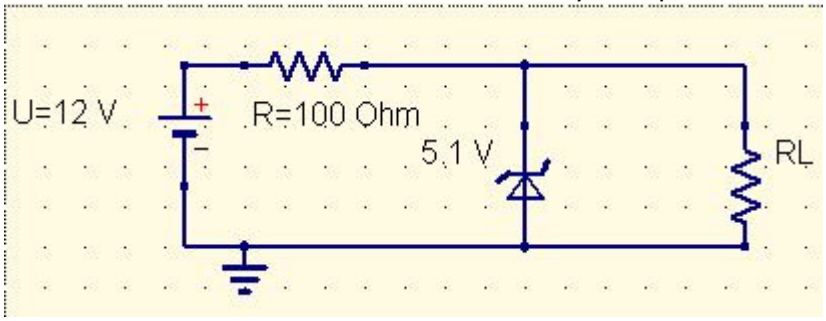
1) The input to an RC differentiator with R=100 Ω and C=0.1 uF is a triangle wave with amplitude 3.0 V and frequency 100 Hz. (The triangle wave goes between +3 V and –3V.) Carefully sketch one cycle of the input voltage and below it sketch one cycle of the output voltage. Label the time and voltage scales for **each** sketch (you'll have to quantitatively find V_{out} to do this).

2) Design a simple bandpass filter (a filter that attenuates low and high frequencies, while passing frequencies in between) by putting a low-pass filter in series with a high-pass filter (that is, make V_{out} from one filter serve as V_{in} for the other one). Sketch the circuit diagram. Design the filter to pass only signals around 20 kHz, so choose component values such that the 3dB points are at 15 kHz and 25 kHz. Also, choose component values such that the resistance of the second filter doesn't load down the first filter too much (remember the 10x rule). Choose reasonable component values (that is, ones you might hope to find in our lab).

3) Plot the I vs. V data you took for the 1N914 diode on a semilog scale (that is, log of I vs. V—you could also use semi-log graph paper or most reasonable (gnuplot) plotting programs let you set a scale logarithmically). What conclusion about the mathematical relationship between I and V can you draw from your plot?

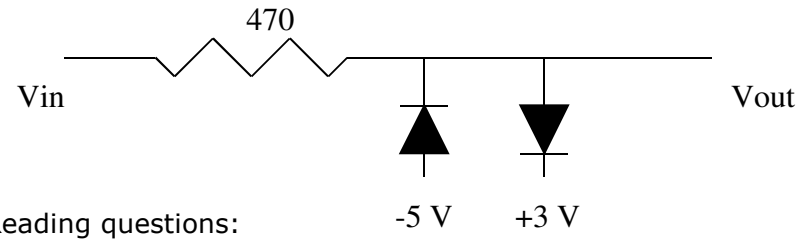
4) For the circuit below assume both the 100 ohm resistor and the Zener diode can safely dissipate ¼ watt.

a) What would happen if the load resistor R_L were shorted?
b) What would happen if the load resistor were removed?
Hint: think about the power ratings.



5) Design a full-wave bridge rectifier circuit that converts AC line voltage to 5 volts DC with less than 0.1 volt ripple into a 180 Ω resistive load. Sketch the circuit and give component values. Remember that transformer voltages are usually given as rms values. Ignore internal resistance of the transformer.
6) a) Consider the circuit below. For each of the following V_{in} values, find V_{out}. Explain each answer briefly.
V_{in}=+2V,+4V,+6V, -2 V, -4 V, -6 V

b) Now if the input is a 10 V amplitude triangle wave, sketch what the output looks like and explain briefly how you came up with your answer.
c) Indicate the path of the current in the circuit when V_{in}=-8V.
d) What would happen if the resistor weren't in the circuit? Explain your reasoning.



7) Reading questions:
a) What does the filter capacitor in a rectifier circuit do?
b) For voltages more negative than the breakdown voltage of a Zener diode, what is the relationship between the current through and the voltage across the diode?
c) Describe one possible application of a diode clipper circuit.