

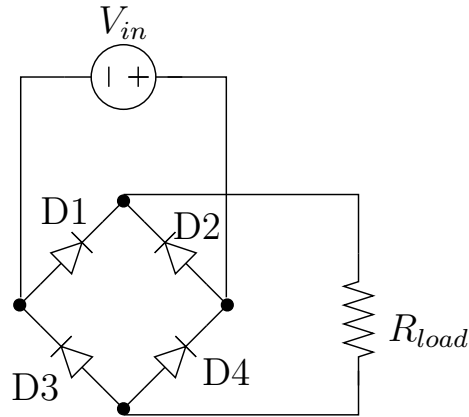
Physics 261

Homework # 6

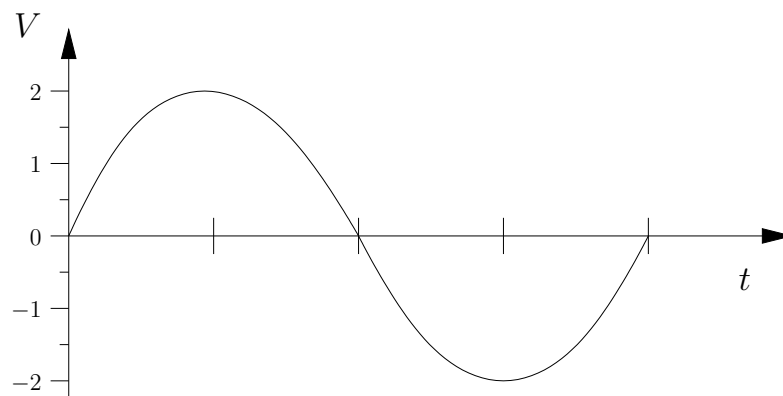
Remember to show your work.

1. You have been using small ( $1/4\text{ W} - 1\text{ W}$ ) resistors in lab. Resistors and other electrical components lose heat mainly by conduction and convection to their surroundings. Heat loss is proportional to the difference in temperature between the device and its surroundings, and to device surface area. Therefore, the larger the device, the more heat it can dissipate without reaching a temperature high enough to cause failure.
  - (a) Let us suppose that a diode of similar size to a  $1/2\text{ W}$  resistor can also safely dissipate  $1/2\text{ W}$  when forward-biased. (This is roughly equivalent to assuming that the maximum operating temperatures of the two devices are about the same.) Under this assumption, how much current can a typical silicon diode ( $V_T = 0.6\text{ V}$ ) handle?
  - (b) Now look up the data sheet for the popular 1N400x series of diodes: [http://www.onsemi.com/pub\\_link/Collateral/1N4001-D.PDF](http://www.onsemi.com/pub_link/Collateral/1N4001-D.PDF). You will see from the drawing on the last page that the size is indeed similar to that of a  $1/2\text{ W}$  resistor. What is the maximum rated continuous (average, not surge) current for this device? According to the plot, what is the voltage at this maximum current (hint: since you must choose one of the curves, assume the diode is getting hot)? Hence, what is the actual maximum power dissipation of the 1N400x series?
  - (c) Now look at the curves of reverse current *vs.* reverse voltage. Now what do you think: is the maximum (repetitive) reverse voltage probably due to destructive heating of the device? Why or why not?

2. A **diode bridge rectifier** is constructed from four diodes, as shown.



- Which diodes may have nonzero currents for sufficiently large, positive  $V_{in}$ ? Which diodes may have nonzero currents for sufficiently large, negative  $V_{in}$ ?
- Assume the turn-on voltage is 0.6 V. Over what range of  $V_{in}$ , both positive and negative, is the load current nonzero?
- Plot the voltage across the load resistor ( $V_{load}$ ) as a function of  $V_{in}$  for  $-3 < V_{in} < 3V$ .
- Below I have plotted a time-varying  $V_{in}(t)$ . On the same axes, sketch  $V_{load}(t)$ .



3. In the example used in class, we had a common-emitter amplifier using an npn transistor. Let  $R_b = 10\text{k}\Omega$ ,  $R_c = 100\Omega$ ,  $V_s = 10\text{V}$ , and  $\beta = 1000$ . Over what range of  $V_{in}$  does the transistor work in active mode? What is  $V_{out}$  when  $V_{in}$  goes outside that range?
4. Below is a **pnp common-emitter amplifier**. In terms of the variables in the circuit diagram and the transistor  $\beta$ ,
- Label the parts of the pnp transistor (e, b, c) and label the associated currents with the correct signs.
  - find the expression for output voltage in active mode. Much like the npn version of the circuit, it has the form:

$$V_{out} = V_{offset} + G V_{in}.$$

What is the gain,  $G$ , and how does its sign and magnitude compare to the gain of the npn circuit?

- What value(s) of  $V_{in}$  put the transistor in cutoff mode?
- What value(s) of  $V_{in}$  cause saturation?

