

## EXPERIMENTAL GOAL

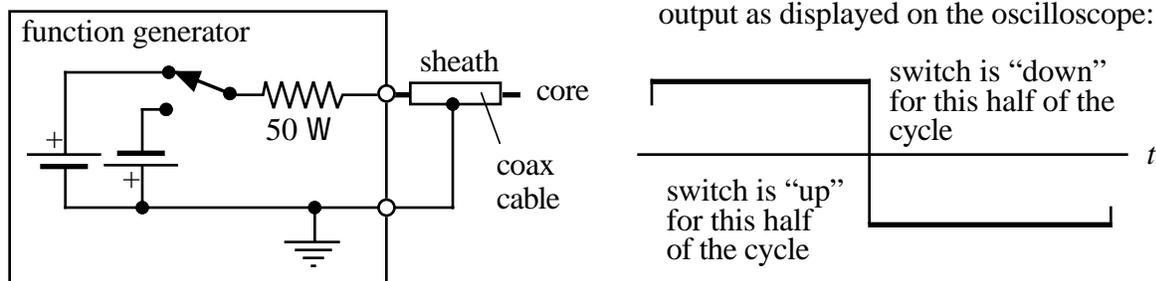
Your goal in this laboratory is to deduce empirically the equations for the total capacitance of two capacitors connected in series and in parallel.

## LABORATORY SKILLS you will be developing

1. Further familiarity with the function generator and the oscilloscope.
2. More practice using the rules for propagating uncertainties.

## SOME PROCEDURAL SUGGESTIONS AND NOTES

You will have at your station a function generator, an oscilloscope, a variable resistor (whose maximum resistance is  $10k\Omega$ ), and a few capacitors with capacitances of a few tenths of a microfarad. When your function generator is set to produce a square wave, it acts essentially as if one has connected a battery across its terminals in series with an internal resistance of  $50\ \Omega \pm 20\ \Omega$  for one half of the cycle, then a battery in the reverse orientation in series with the resistor during the second half cycle.



You should be able to create a circuit using this equipment that essentially charges a capacitor during one half cycle of the wave and discharges it during the other half cycle. You can also arrange the oscilloscope so that it displays the exponential decay part of the cycle (see section E5.6 of the text). You should be able to design a procedure that uses this exponential decay curve to *measure* the capacitor's capacitance. Design your procedure so that you are pretty sure that you can determine  $C$  to within 5 to 10 percent accuracy. When you think you have a procedure that will work, request a procedure interview from your helper (do this *before* you take lots of measurements). Note that if the total resistance in your circuit is not much greater than  $50\ \Omega$ , then you will have to include the function generator's  $50\ \Omega$  internal resistance in your calculations. This will add uncertainty, since we do not really know what this internal resistance is very accurately.

Test your procedure by measuring the capacitance of a single capacitor and comparing your result with the labeled value of the capacitor. (These labels, by the way, are often quite inaccurate: the actual capacitance of a capacitor may be as low as half or as much as double the labeled value.) When you have succeeded in measuring the capacitance of each of the three small capacitors at your station, try measuring the capacitance of *sets* of capacitors. See if you can find a simple rule for adding capacitances in parallel and series analogous to the rules for resistors in chapter E6. (You may want to study the parallel case first.) When you think you have such a rule, make *certain* that your rule correctly predicts the capacitance of the set to *within your uncertainties* (this means that you will have to calculate the uncertainty range of the *predicted* capacitance of the set using the uncertainties of the individual capacitors and compare it to the uncertainty range of the *measured* capacitance of the set. You should check your formulas for more than just one series set and one parallel set.

In your checkout interview, your grader will ask you questions about the theory behind your experimental design and exactly how you are determining the capacitances and their uncertainties. Your grader will also ask you to describe the rules for adding capacitances in parallel and in series, and about the empirical evidence supporting those rules.