1. Definition: The slope of the capacitor's charge vs. voltage graph is called "capacitance" and is represented in equations by a "C". The standard unit of capacitance is the "farad", named after Michael Faraday. **One farad = one _________ per ______.** (Saved on RS ___)

2. A one-farad capacitor would be rather large. Most capacitors used in everyday electronics are rated in "microfarads", abbreviated "μF". "Micro" is the standard prefix meaning *one millionth, or* 10^{-6}. For example, 0.015 μF = _______ farad. *Scientific notation is appropriate here.*

* 3. You probably determined the capacitance of a capacitor twice on page 99. Copy the result here, using *RANGE FORM.* (Use #1.) Also explain briefly how it was determined. (The value printed on the capacitor is probably not very accurate.) Keep a copy of that range for future work.

* 4. **First Capacitor Law:** We use the letter "Q" to represent the charge on a capacitor plate, and "V_c" to represent capacitor voltage. Using those symbols, write an equation to describe your graph. Define each symbol in the equation and tell which ones represent variables and which are constants. If you need help, review #1 & #3 above. *Remember to keep a copy of this law for future reference.*

5. We have discussed "rates" many times in the past.
   a. For example, "acceleration" was defined in Ch. III as the *rate* at which __________ changes.
   b. If the path of a motion is linear, then that rate is the slope of a ___________ vs. ______ graph.
   c. The process used in finding such a rate is called "_____________tion". (Copy from RS II.)

6. In discussing rocket propulsion in chapter IV we introduced a special *symbol* for rates: we put a *dot* over the symbol representing mass to mean the *rate* at which mass was ejected from the rocket.
   a. According to 5a, acceleration can be represented by "Δv/Δt" OR by the letter ___ *with a dot over it.*
   b. If "Q" represents the charge on a capacitor plate (in _______s) then a Q *with a dot over it* represents the ____ at which ________ accumulates on the plate, in _______s per _____.
   c. According to #3 on RS XI, that rate in 6b is equivalent to the ______ in the leads of the ________.
   d. The compound SI *unit* mentioned at the end of 6b is also known as an _______.

7. Is the expression on the left side of equation 4 *always* equal to the expression on the right side? ___
   a. If one of those expressions changes in value, must the other change at the same rate? ___
   * b. Using the symbols already defined on this page, write your answer to 7a as an equation. *Try not to confuse constants with variables, and remember to use what you learned in 6b and 6c.*
   * c. Define each symbol in equation 7b clearly. *Remember to use #1, 6b, and 6c.*

8. Equation 7b will be called the "Second Capacitor Law", although it is only a restatement of the first.
   a. Are both capacitor laws recorded for future reference? _____ --Where? _____
   b. Will you ever need to know what the symbols in those two equations represent? ____
   c. What are you doing about that need? ____________________________ --Where?____

9. Using a ruler, draw a tangent line at some point on a graph of capacitor voltage vs. time. Staple that graph with its computer-printed data table to this page. *Include the "current" and "time" columns.*
   a. Find the slope of that line in range form, *without* excessive roundoff. Make a dot on the curve at the point where it touches the tangent line. Use the graph to find the time coordinate of that dot.
   b. Use the second capacitor law to calculate the current in the capacitor leads at that time as a range and *also* as an MLV with uncertainty in percentage form.
   c. Find the current listed for that time in your data table and copy it here: ________ _____
   This value is __% ______er than the MLV of the current calculated in 9b.
   * d. Explain how closely you *expected* them to agree, again using percentage language. Remember that the current found in 9c has an uncertainty. Show how it is calculated.

10. Write the measured values *and uncertainties* of R and C on *both* of the voltage-time graphs that you made while the experiment was in progress. -Did you use those uncertainties in 9d? ____
    Keep one of the graphs for future work. The other should be stapled to this page, with its data table.

11. Suppose a steady 0.17-mA current charges a 0.015-μF capacitor for 0.0020 seconds. By how much will the capacitor voltage be changed? *Use SI units, round off properly, and explain your solution.*

* 1. Write the two capacitor laws. Define your symbols and classify them as constants or variables.

2. Draw a diagram showing a 50-ohm resistor connected to a battery in series with a capacitor. When the resistor current is 0.170A the capacitor's voltage *increases* at the rate of 3.0 x 10^4 volts per second.
   a. Can the capacitor voltage be determined from this information? ___ *If so, please show how.*
   b. Is the capacitor voltage equal to the resistor voltage in this circuit?__ Is it charging, or discharging? __
   c. The current in this circuit must be ___creasing. The capacitor charge must be ___creasing.
   d. Calculate the capacitance in microfarads. *Show how you do it, using #1.*

3. A 5100-ohm resistor is connected across a charged capacitor. Is the capacitor charging, or discharging? -How much current do you expect when the capacitor voltage is 4.8 volts? -Did you round off properly?

4. A capacitor's voltage decreases from 4.8 to 4.6 V during a certain time interval. What percentage of the capacitor's charge was transferred during that same interval? *Explain*, using 17f & 24 on RS II.

5. The capacitor voltage in #3 has dropped to half of its original value:
   * a. What fraction of its original charge is left? *Explain, using #7 on RS I.*
   * b. By how much has its discharging rate changed, and how do you know?
   * c. Write a conclusion about how current is related to charge for *this* circuit. *Illustrate with a diagram.*
   * d. Is that conclusion valid if a light bulb is used instead of a resistor? *Explain, using #1 on RS X.*
   * e. Diagram the three capacitor circuits that we have studied. (Copy them from 2, 3, and 5d.)
   * f. For each diagram state clearly whether or not conclusion 5c is correct. *Try not to contradict 2c or 5d.*

6. Review pages 87 and 88. Use the improved definition of "voltage" on RS IX to figure out how the energy carried by a small amount of charge entering or leaving a capacitor can be calculated. (See #14 on RS IX.) Remember to check units and to define your symbols clearly. For example, do you use the initial capacitor voltage, the final capacitor voltage, the average voltage, or what?

7. Imagine a 5.0 K resistor connected across a capacitor. ("K" means kilo-ohm.) The capacitor voltage decreases from 4.8 to 4.6 volts in 0.20 second, just as in #3 & 4. Use the given data with #6 to:
   a. Show how you calculate the energy delivered to the resistor during that period of time.
   b. Suppose the discharge process is allowed to continue until another batch of charge equal to the first one has passed through the resistor. Calculate the final and average voltages for the second batch.
      final voltage = ______ __ ; *average voltage* = ________ __
   c. Is the energy delivered by the second batch equal to that delivered by the first? ____ If not, which is greater?____ *Please explain how you know.* -Does it take more time, less time, or the same? ___
   d. Use #6 & 7b to show how the energy delivered by the second batch is calculated.

8. How can the energy delivered from or to a capacitor be determined geometrically from a graph of capacitor voltage vs. charge? _____ What shape does this graph always have? ____
   a. How can the total energy stored in a capacitor be calculated from Q and V? _____
   b. Do the units balance in equation 8a?___ -Does 8a contradict the previous two sentences?___
   c. Equation 8a is being recorded for future reference in #___ on RS__.

* 9. Suppose a capacitor's voltage vs time graph is a sine curve: The voltage amplitude is 1 volt, the period is 1 second, and C = 1 Farad. Sketch the graph and label it clearly. (See p. 74, 76, or #9 on RS VIII.)
   a. Draw a tangent line at the origin and a vertical line at the next zero point, half a cycle later. Estimate the coordinates of the point where those two straight lines intersect. *Don't forget the units.*
   b. Use those coordinates to estimate the slope of the tangent line.
   c. Then use #9 or #11 on RS VIII to *improve* that estimate. *Don't forget the units.*
   d. Use the second capacitor law to predict the shape of the current vs. time graph. (Sketch it.)
   e. Use the second capacitor law *with 9c* to calculate the current amplitude. Don't forget the units.

* 10. Review the logic that you used on page 91 to figure out the equivalent resistance formulas for combinations of resistors. Use similar logic with the capacitor law to derive the equivalent capacitance formulas for series and parallel combinations of capacitors. *Explain your reasoning.*