1. Simple Harmonic Motion: Recall that the displacement vs. time graph for any object in simple harmonic motion can be written as **$y = A \sin(\omega t)$**, where "A" represents the amplitude of the motion, "t" represents the time, and "ω" represents "angular frequency" in radians per second. (Angular frequency is just a proportionality constant which is equal to the regular frequency multiplied by __, because there are ___ radians in a complete cycle.)
   a. Use differentiation (#14 on RS XII) to create equations describing the velocity-time graph and the acceleration-time graph in terms of the same variables: v = ________; a = ___________
   b. Notice how the acceleration must be related to the displacement. With this and Newton's second law you can make a conclusion about how the restoring force must be related to the displacement:

      F = _____
   c. With that relationship and the definition of "spring constant" you can show how the frequency must be related to the spring constant ("k") and the mass of the object: f = ___ *Do the units balance?* __
   d. Does this formula agree with what you wrote on RS VIII?_____
   e. Is the derivation above simpler than the ones used previously, or is it more complicated? __

2. The Capacitive Reactance Formula: Consider a capacitor connected to a sine generator.
   a. Write an equation describing the capacitor voltage vs. time graph, using $\|V_C\|$ to represent the *amplitude* of the capacitor voltage: $V_C = \|V_C\|$ (_________)
   b. Use the capacitor law to determine the equation of the charge vs. time graph: Q = _______
   c. Use the definition of current to write the equation of the current vs. time graph: I = _______
   d. Express $\|I\|$ in terms of $\|V\|$ and other constants: $\|I\|$ = ______
   e. Use the definition of capacitive reactance to discover a formula for calculating it from capacitance and angular frequency: X_C = ______
   f. Does this agree with earlier theories and with experimental data? ____

3. Impedance of a Series R-C Combination: *(This is new!)*
   The "Impedance" of *any* AC circuit component is defined as a ratio of the amplitude of the voltage across the component to the amplitude of the current through it: **$Z = \|V\| \div \|I\|$**
   Suppose that the component in question is the series combination of a resistor and a capacitor, and that the current is **$I = \|I\| \cos \omega t$**, where $\|I\|$ represents the current amplitude, and "omega" represents the angular frequency, as in #1.
   a. Write an equation describing the resistor's voltage vs. time graph in terms of $\|I\|$, R, ω, and t:

      V_r = __________
   b. Use #2d to write an equation describing the capacitor's voltage vs. time graph in terms of $\|I\|$, X_C, ω, and t: V_c = _________
   c. The expression for Vr can be given a neat geometric interpretation: Imagine a vector with magnitude $R \cdot \|I\|$ which is rotating at "ω" radians per second clockwise, with its tail tacked to the origin of a coordinate system. Notice that the x-component of that vector is equal at all times to Vr. Draw a diagram to illustrate this. Label it clearly.
   d. A similar interpretation can be given to the expression for V_c. At all times, the angle between these rotating vectors must be ___ degrees. Illustrate that with a new diagram. Label each part clearly.
   e. The sum of V_r and V_c must therefore be equal at all times to the __-component of the ___ of the two vectors described above.
   f. Notice that the diagram for that vector sum forms a ____ triangle which also rotates clockwise as time goes on. The x-component of the sum is equal at all times to the voltage across the ______.
   g. Now you can use simple geometry to express the *amplitude of the combination voltage* in terms of *current amplitude, R, and Xc:* Combination Voltage Amplitude = $\|I\|$ (_________)
   h. Notice that the blank which you just filled in fits the definition of "impedance". Therefore the formula for the impedance of a series R-C combination must be: Z = _______
   i. Will the voltage vs. time graph for the combination be in phase with the current vs. time graph? ___ If not, how can their phase difference be predicted from R and Xc? Phase diff. = _________
      The "Phase Diagram" that you made for 3f can help.

* 4. The reciprocal of impedance is called "admittance". Using #3 as a model, show how the admittance of a *parallel* R-C combination can be predicted.

1. Turn the calculator on and hit the **Y=** key. (For TI-85 or 86 hit **GRAPH**, then **F1**.) Delete or switch off any equations already stored there. Then put in the equation of a sine curve: **y = sin x**

2. To avoid having stray data points on your graph, hit the **STATPLOT** key and select choice 4.

3. To choose appropriate scales for the axes of your graph, hit **ZOOM**, and select 7 (TRIG).

4. When you enter that selection (or whenever you hit the **GRAPH** key) your graph should appear. Sketch it and show it to your teacher.

5. Now let's zoom in to examine the region near the origin on that graph:
   a. Hit the **ZOOM** key and select ZOOM IN by hitting **2**. (On a TI-85 hit **Z IN** or **F2**.)
   b. Hit **ENTER** to see an enlarged picture of the central region on the screen.
      -Is the curvature still visible? ___
   c. Repeat 5a-b several times to see a greatly magnified picture of the region near the origin.
   d. In the region *very* close to the origin a sine curve *strongly* resembles a ________ line.

6. Hit the **TRACE** key. (On a TI-85 hit **GRAPH**, then **F4**.) Move the cursor along the line. Notice that the coordinates of points on the line are displayed on the screen.
   a. Record the coordinates of one of those points (not the origin) keeping many digits:
      X = ______________, Y = ______________
   b. Use those coordinates to calculate the slope of your line without rounding off:
      Slope = _____________ when x is in __________s. (degrees, radians, grads)

7. Hit the **Y=** key. (On a TI-85 hit **GRAPH**, then **F1**.) Below the original equation enter a new equation in "y = mx" form to describe the straight line that you saw on the screen in #6 & 7. (Use the slope recorded in 6b.) Leave the original equation (y = sin x) above the new one. Then hit **ZOOM** and select 7 again. (On a TI-85 use **F2**, **ENTER**.) Sketch what you see after entering that choice, and show it to your teacher.

8. Turn on the **TRACE**. Move the cursor along the straight line until its x-value is 180 degrees or the equivalent. Record the *special y-value* that you find there: Y = ____________

9. Repeat # 1-8 using y = 2*sin x or y = sin(2*x) or y = sin(x/2).
   Share the results with your classmates and make some observations:
   a. Doubling the amplitude of a sine curve causes the slope near the origin to be multiplied by ___.
   b. Doubling the amplitude causes the "special y value" in #8 to __________________________.
   c. Doubling the "argument" of a sine function (i.e. changing the equation from "y = sin x" to "y = sin 2x") causes the "period" (width of one cycle) to be __________ed by 2 and causes the steepest slope to be _________ed by 2. The "special" Y value is _______ed.
   d. Cutting the argument in half causes the period to _______ and the steepest slope to ___________.

10. Let "A" represent the amplitude of a sine curve, and let "P" represent its period:
    For example the period of the original curve that you saw in #4 was P = _____ _____.
    In 9a the amplitude was A = _____ units.
    a. The special Y value found in #8 depends only on the ___________ of the sine curve.
    b. In **every** case we find that the special Y-value is roughly _____ times the value of that _________.
    c. In **every** case we find that the steepest slope is approximately ________ times the value of A/P.