Name:_____ Period:_____ Date:_____

CHEMISTRY: LAB ON WAVES

Purpose: Most of us have very little visual contact with waves in our lives. That is, except for water waves, we cannot see the many waves that are around us. As a result, we fail to realize that light, radio and television signals, cosmic rays, sound, and neutrinos are passing all around and through us. We have a very limited understanding of the special, almost unbelievable properties of waves. In the final analysis, even the things we claim to be solid and standing still have hidden wave motions attached to them. Because all subatomic particles are mostly wave motion and little else (such as electrons!!), we are actually made of standing probability waves and the whole concept of "solid" is but an illusion.

This is hard to believe even though it was proven by 1920 by Neils Bohr, Schroedinger, and Heisenberg. Thus, the purpose of this lab is to let you see waves and some of their common properties, including the relationship between wavelength, frequency, and energy. Hopefully this will help you understand what an electron or proton is when you are asked to believe that they are both a wave and a particle!

Materials: Each pair of partners needs access to two types of steel springs; a narrow, long one (snakey) and the shorter, fat one (slinky).

CAUTIONS:

- PLEASE DO NOT TRY THESE EXERCISES IN THE AIR. THIS CAN DAMAGE THE SPRINGS AND YOURSELVES. KEEP THE SPRINGS ON THE FLOOR.
- DO NOT STRETCH THE SPRINGS BEYOND THEIR ELASTIC LIMITS.
- DO NOT EVER LET GO OF THE SPRINGS WHEN YOU ARE WORKING WITH YOUR PARTNER.
- KEEP YOUR LAB GLASSES ON!

<u>COMPRESSIONAL & TORSIONAL WAVES</u>: We will look at these waves as a class demonstration—they don't have quite so much to do with atoms as transverse waves.

<u>TRANSVERSE WAVES</u>: These are chemist's favorite waves because electromagnetic radiation travels in this way…and electrons too!

Procedure: Get the narrow long snakey and be sure to hold on to it for dear life while you use it (if you let go, it *does* hurt and you *will* get in trouble if you do it purposefully). This time the wave propagation will be done by pulling a "flick" of the wrist or by shaking it to one side very, very quickly.

Step #1 - Start off by creating a smooth shaped pulse (see below). The trick is to snap fast, and don't move back past your starting point. Any movement past center gives a whole wave which we will use next.

1. Can you measure the wavelength of this wave? Why or why not?

Step # 2 – Now try both you and your partner making transverse waves at the same time but on opposite sides of the spring. Start off trying to make long wavelengths (shaking the spring from side to side relatively slowly). Find a point where you and your partner are creating "harmonics" or a "standing wave."

Example of a first harmonic (transverse wave):

Step #3 – Now try shaking the snakey back and forth a little faster to create a second harmonic:

Example of second harmonic :

Step #4 – Now play around a little bit with creating multiple harmonics and make some observations of standing waves by answering the following questions.

2. Sketch the 4^{th} harmonic of a transverse wave. Label the crests and troughs of the wave.

3. Why do you think what you are demonstrating here is known as a "standing wave"?

4. How would you describe what the frequency of the waves you are making?

5. **<u>**What do you notice about the frequency of the waves as you make the wavelength shorter and shorter?</u>**

6. ****What do you notice about how much energy you have to put into the wave as you make the wavelength shorter and shorter?**

Now some application questions about waves…

7. Does the spring material (i.e. the metal coil) travel all the way to your partner's hand and back? In other words, does the water in Hawaii have to move with the wave to get a wave all the way to our coastline?

8. What is a wave if it is not the medium that it moves through?

9. If you are on a beach and there is a ship in front of you at sea, but close to the beach, do the waves coming at the ship from the open sea stop when they hit the ship or move through it?

10. Based on your answers above, what do you think would happen to a compressional wave meeting a transverse wave in the same medium? (Hint: you can actually do this with your slinky or snakey)

11. List some examples of transverse waves (remember, they may not be visible).