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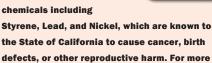
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# **4-18061 Vertical Resonance Tube Apparatus**

#### **Warning:**

California Proposition
65 Warning: This product
can expose you to
chemicals including



information go to www.P65Warnings.ca.gov.



The Vertical Resonance Tube Apparatus is a device to help understand the principle of waves and resonance, in particular, the study of sound waves. Sound waves, light waves, radio or electromagnetic waves and even water waves all have similar characteristics. They all have a wave form and wave length. They can be reflected, amplified, and all can be measured and altered.

# **Terms You Should Know**

# Types of Waves

**Transverse Wave:** A wave that travels at right angles to the energy source that produced the wave. For example, if you have a long rope laid out across the floor and you give one end a quick flip, you will see the wave traveling down the length of the rope. The force that propagated the wave was the up and down motion of your hand. The wave travels all the way down the rope, which is perpendicular to the force that started everything.

Longitudinal Wave: A wave that travels parallel to the force that propagated it. A good example of this would be a long coiled spring stretched out across the floor. If you were to squeeze several coils of the spring together and then release them, you would note a wave traveling down the length of the coil. Now this wave is traveling parallel to the force that caused it. It would be an incorrect notion to believe the wave is traveling in the same direction because once the wave reaches the end of the spring, the wave could return to the source.

# Properties of a Wave

**Amplitude:** The amplitude of the wave is the height that the wave reached before it begins to recede. In sound waves, this would characterize the volume of the sound. In light, it would be the intensity of its brightness.

**Frequency:** This is the number of times the wave occurs within a given time, usually within one second. The number measured would relate to the pitch in sound waves and the color in light waves.

Wave Length: The actual distance between the crest of the troughs of consecutive waves. The change can be measured in either meters or feet. The symbol for wave length is  $\lambda$ .

#### **Additional Information**

Sound waves are caused by the air being vibrated longitudinally by some sort of oscillating source. The wave strikes our eardrum thus setting up vibrations in our ear that are the same frequency and intensity. It allows us to distinguish between different pitches and volume. Humans can normally hear sounds that vibrate between 20 and 20,000 Hz (**Hertz**-- unit used to measure frequency. One cycle per second would be called one hertz). The speed of sound at sea level and at a temperature of zero degrees centigrade is 331.4 m/s (meters per second). The speed increases by about 0.61 m/s for every one degree of centigrade rise in temperature.

## **Formula**

v = 331.4 + 0.61T

v=Speed of sound in the air, measured in meters per second T=Air temperature in Celsius

When waves travel through a medium, they will quite often be reflected back toward their original source. If these reflected waves are in time (in phase) with the source of the vibration they will amplify the waves. For example, when you are pushing a person in a swing and your pushes are in time with the person in the swing, the person will continue to swing at a constant height, with very little effort. If the waves are out of phase they will degrade or even cancel each other out. Again, using our example of the swing, by pushing forward on the swinging person as the person swings back toward you; you will stop the swing or worse, send the person flying out of the seat.

# **How to Set Up and Use**

Set up the unit as shown in the picture to the right. Please note the bottom of the resonance tube lies just slightly over the edge of the table. If you want to use the unit on the floor, place a book or board under the base so that the bottom of the tube can rest just below the base. The unit will work with either set up, but we suggest using a book or other weight source across the back to prevent tipping.

You will need a 512 Hz tuning fork and right angle clamp as your sound source. The tuning fork is placed in the right angle clamp, just above the top of the resonance tube.

Raise the can all the way to the top and tighten the clamp. Now pour the water into the can, pausing periodically to allow the water to fill up the tube. You will need approximately 3/4 of a liter of water. Allow the water to level up to about the 80cm mark. You will have very little water left in the can. Next, lower the can to a point where the top of the can rests at about the 35 cm mark. The water level should drop in the tube to about the 35 cm mark. Now strike the tuning fork with a mallet or something hard in order to set the tuning fork into vibration. Once the tuning fork is emanating a steady tone, quickly slide the can upwards and clamp it at about the midpoint of the rod. Listen to the tone that is set up in the unit as the water in the tube rises. There will be a point where you will hear the volume dramatically increase and then begin to decrease again. Strike the fork again and lower the can, listening for the increase in volume again. Repeat this procedure until you can accurately pinpoint the level at which the tone is at its loudest. Mark this point on the tube with a marker. Next raise the can all the way to the top, tighten the clamp and strike the tuning fork again. As the level of water climbs, listen for a second point where the volume increases drastically. You may have to strike the tuning fork again if the sound completely falls off before the water reaches its highest point in the tube.



### How to Set up and Use, Continued

Once you hear the increased volume, move the column up and down while striking the tuning fork until you can pinpoint the second point. If everything has been done correctly, you should have found the two points of increased volume somewhere near the 40 and 75 cm marks.

So what does this mean? As the sound waves from the tuning fork travel downward, it pushes a column of air with it, sending a sound wave down into the tube. The wave will strike the surface of the water in the column, and some of the wave will be absorbed, but some will be reflected back up toward the tuning fork. If the If the level of the water is in the wrong position, the wave will strike the fork or another wave head, thus reducing or canceling out the sound. On the other hand, if the level is just right, the wave will arrive at the tuning fork at the precise moment that it is traveling upward and will actually help to amplify the sound, (remember the example of the swinging person). You should find two points on the tube where this will occur. If the tube was long enough, there would actually be many points where the sound would resonate.

# Your figures should be close to what is listed below:

Example: V=331.4m/s T=240 X=165mm Y=490mm Wave Length 490—165 = 325x2=600 Speed of sound is m/s 331.4 + (.061x24) = 332.86 (332.86 meters = 332,860mm) 332,860/650=512Hz To determine the actual wave length, take the length of the bottom mark on the tube as measured from the tuning fork and from this subtract the distance of the highest mark as measured from the tuning fork. Next, multiply this by two to get the wave length of this sound wave. Once you have the wave length, it is just a simple matter of calculating the actual frequency of the sound wave. Remember, the speed of sound through the air is determined by the temperature of the air. So, you must first measure the temperature of the room in centigrade. Next, multiply the temperature by 0.61 (the increase of traveling sound for every one degree increase in air temperature). The number is then added to the speed of sound constant of 331.4 (the speed of sound at sea level and at one degree centigrade). The total gives you the actual speed of sound in meters per second at the current room temperature.

You now know that sound will be traveling this calculated distance in one second. Also known is the length of the wave, so just divide the total distance that the sound will travel in one second by the wave length to get the number of waves (cycles) in one second. The number will be the frequency of the tuning fork used.