From Diddley Bow to Bo Diddly: Science & Sound

Sound is Vibration: The source of a sound is always a vibration of some sort. You can place your hand over your throat and hum, sing, or speak and feel the vibrations of your vocal cords. You can touch a musical instrument while is it being played and feel the physical vibration of the body of the instrument. If you look closely, you can see the strings of an instrument vibrate when they are physically plucked or set off in sympathetic vibration by a sound wave passing by in the air around it.

Sound waves: Sound waves are created as the mechanical energy from a vibrating source is transferred to the air around it. The physical vibration of the source disturbs air molecules next to it, causing them to bump into the air molecules next to them. In this way the mechanical energy of the vibration is transferred from one molecule to the next until it is dissipated.

The pitch of a sound wave is determined by how fast the vibrations are. Faster vibrations yield higher pitches; slower vibrations, lower pitches. Some pitches are too fast and high for humans to hear, some are too low. Dogs hear high notes that we do not hear; elephants hear low notes that we do not hear.

A scientific note on wave action: It is good to realize that air molecules are not fired like bullets through the air out of a musical instrument or sound source, but remain essentially where they are. The energy of the vibrations is transferred through them, while they remain basically in the same place. Waves in water and air behave in similar ways: The water and air transfer the energy from one molecule to its neighbor. The water or air are set in motion when the energy they are transferring encounters an obstacle, like water hitting the shore in the ocean, or a sound wave hitting your eardrum in the air.

How Loud Is It?

The loudness or strength of a sound wave is determined by how much air is moved. This, in turn, is determined by two interdependent things: 1) the vibrational properties of the resonator/amplifier, and 2) the mass, hardness, and surface area of the resonator/amplifier.

Tuning Forks:

A vibrating string or a tuning fork is a marvelous source of vibrations. But by themselves, they are nearly inaudible. They are able to vibrate easily and hold the vibrations for a long period of time, but they have almost no surface area and so, they don't move much air.

If you take a tuning fork around a room, strike it gently on a block of wood or your knee (watch out, I've been bruised doing this for a couple of class periods), you will notice that you have to be within inches of the tuning fork to hear anything at all. Tons of vibrations: No sound wave to speak of.

If you strike that tuning fork and get it vibrating and then apply the single end/handle to the top of a desk, a glass window pane, a hollow core door, a metal shelf, the black or white board, something different happens. You'll clearly hear the pitch amplified.

You've created a stronger sound wave by setting those materials vibrating. The surface area of these things is touching a lot more air molecules than the string or tuning fork itself. As it is set in motion at a specific frequency of vibrations, it moves the air next to it at that same rate of vibration. The air molecules next to the surface of the desk, for instance, transfer the vibrational energy to the air molecules next to them and a mechanical chain reaction starts to take place as the energy, the sound wave spreads out from the desk surface.

When one of those air molecules hits your eardrum, it causes your eardrum to move. If those three little bones in your inner ear are all in place and undamaged, if the nerves and filia in your cochlea are all in tact, and if your brain is undamaged: you hear a sound.

This is a very mechanical process.

You can see sound wave energy absorbed in water by immersing the vibrating tines of a tuning fork into a small dish of water. You will see the water splash as the energy of the vibrations transfers into the water. You can also allow the vibrating tuning fork tines to lightly touch a desk top: when the tines are parallel to the desktop you'll hear a little buzz and see them jump a little; when the tines are held at a right angle to the desktop and the lower one touches the fork will jump considerably more.

Experimenting with a Tuning Fork

Take the tuning fork around the room, try the poured concrete floor, the cinderblock walls, the windows, the file cabinets, desk tops – whatever is at hand. You and your students can mark and make a list of the better and worse amplifiers. Then ask yourselves, "Why is a one better than the other? What properties make a better amplifier?"

In this way, through these experiments, you can build a pretty good collection of observations about the suitability of different materials for sound wave generation/amplification.

You will find that hardness, mass (how easy something is to move, to get vibrating), and surface area are the main determinants. And you can solicit predictions on untested materials in the room and test each one: Will it be a good amplifier or a bad amplifier? You will all hear when you and the students are on the right track.

This done, you can send the students home to rummage around in their basements, garages, back yards, and trash piles in search of a resonating body for their diddley bows, something that using their experience in class, they predict would be a good amplifier. They can test the various objects that are brought in with the tuning fork. Some may refine their choices.

Math & Measuring – Proportions & Ratios

A vibrating string is delightfully physical. If you are close enough, you can see the vibrating waves that get set up in a string. The mechanical energy of plucking the string remains visible along its length after the plucking hand is pulled away, until it is dissipated in the air or stopped by touching something else.

If we are working with a vibrating length of 26 inches, and pluck the string at its full length, then depending on the tightness of the string, we get the starting note of a key we'll be working it. It is known as the keynote [Musicians call this the "tonic," but the note, whatever it is, names the key]. All the other notes in the musical scale will get their identities from their relationship to this beginning note.

If we divide that 26” string in half, shortening its vibrating length and pluck it, we will have doubled the number of vibrations per second: this plays a pitch that will be an octave above the open string pitch.

If the string at full length is tuned to what is known as Concert A 440 khz/second, then halving the vibrating length will double the number of vibrations to 880 khz/second: an octave above the original open-string A.

Dividing a vibrating string length in half, in thirds, and in quarters will allow you to mark the Octave or eighth note of the scale, the fifth and the fourth notes of the scale, respectively.

26” cut in half to 13” = An Octave/8th note of scale
26” cut in thirds to 8.66” = A Fifth/5th note of the scale
26” cut in fourths to 6.5” = A Fourth/4th note of the scale

These physical relationships and proportions hold true regardless of what note is the fundamental starting note.