Piano Science

Connect Music and Science

Age: Elementary, Middle School

www.ptg.org

The piano is one of the most interesting musical instruments you can learn to play. It is also one of the most versatile of all keyboard instruments because of its large range of notes, capability of playing loud and soft, and its unique ability to blend well with other instruments. Learn more about your piano and how the different parts work together to create sounds. Use the exercises and experiments below to see how your piano uses the science of sound to make beautiful music.

What is sound?

Sound is a type of energy made by vibrations. When any object vibrates, it causes movement in the air particles. These particles bump into other particles nearby and they vibrate, too. This movement, called sound waves, keeps going until the particles run out of energy. If your ear is within range of the vibrations, you hear the sound.

How does a piano create sound?

When you push down on a key, the mechanism inside (the action) makes a hammer go up (in a grand) or forward (in an upright) to strike the strings. The hammer is a round stick with a head on it (it looks something like a real hammer), and the head is covered with very dense wool felt. When the string vibrates it makes a musical sound; the string is connected to a large soundboard that amplifies the sound much louder than the string could do by itself. When you let go of the key, a felt pad, called a damper, drops back onto the string and stops the sound again. When you press down the right pedal with your foot it raises all the dampers so that the strings can keep sounding. The strings vibrate across the soundboard to the bridge. The soundboard, cast iron frame and the case hold the sound as it flows through and then out of the piano. With the top up, the sound coming out of the piano has not only high tone quality, but also great resonance. The wood used to create the piano affects the resonance. If the wood is of high quality, the resonance is great; if the piano is poorly constructed with a weak wood, the resonance of the sound will also be of poor quality. If the top of the piano is down, the music is certainly quieter but also has more resonance.

Try it out!

Put your index and middle finger on your neck. Say the word "Aah" as loud as you can. Then try it as soft as you can. You not only hear a sound, but you can feel a movement inside your throat. When you say, "Aah", your vocal cords vibrate. That means they move quickly back and forth. As your vocal cords vibrate they produce sound.

Piano Parts Glossary

String – when struck by a hammer, a string vibrates to create a soundwave. There are over 200 strings on a piano. Treble notes are each made up of three thin wire strings and bass notes are one thick wire string. The middle notes usually have two medium size wire strings that are struck at the same time to make a sound. The thicker the wire, the slower the vibration and the lower the tone we hear. The longer the string, the more it vibrates and the louder the sound you hear.

Soundboard – the heavy wooden base of the piano; it acts like a diaphragm to make the sound you produce resonate; amplifies the sound made by vibrating strings

Pedal - play these metal levers with your feet. They can deaden, soften or increase the vibration of the sound depending on which lever you press.

Damper - wood and felt pieces that cover strings to stop any unwanted vibrations. When you press a key, you raise the damper so that the string can vibrate. The damper falls back onto the string when you release the key.

Frame, or Plate – made of cast iron; holds the tension of the strings

Key – weighted wooden levers that pivot like a seesaw; pressing a key causes the hammer to hit the strings and the vibration creates a sound.

Hammer – felt-covered wooden mallet; when a hammer strikes a string, or set of strings, it causes the string to vibrate.

Case/Cabinet – made of wood, the case of the piano acts like a soundbox that helps swell the piano's tone.

Lid – open the lid on the top of the case to increase the volume of sound.

Pins – hitch pins anchor the strings and tuning pins can be turned to allow a piano technician to adjust the pitch of the note by tightening or loosening the string

Bridge – strings pass over two bridges that define their speaking length (the portion of the string that is free to vibrate when struck by a hammer), conducts the energy of the vibrating strings to the soundboard

Action – how the keys lift the hammers to strike the strings is included in the mechanics, or action, of the piano. The action may be made up of hundreds of moving parts.

Try it out!

Piano parts can be divided into three categories based on how they help create the sound a piano makes. Sort the piano parts listed above into the three categories listed below.

Sound Generators parts that make the sound directly	**Amplifiers** parts that take the energy of the vibrating strings and magnify them	**Mechanism** parts that turn an action of the piano player in the desired vibration of the string

Visit the Piano Learning Center of the Piano Technicians Guild at www.ptg.org for more fun ways to learn about the piano.

Learning About Pitch

Introduction: *In music if we say a note is high or low, we are not talking about how loud it is. We are talking about its pitch. A sound with a higher pitch is caused by vibrations that are fast. A sound with a lower pitch is caused by vibrations that are slow. The size of an object helps to determine if it will vibrate fast or slow and affects its pitch. You can lower the pitch of a vibrating string by making it long, making it thicker, decreasing the tension applied to it or making it of a material with a greater density.*

Pitch Experiment #1
Supplies: two 16-20 oz. plastic soda bottles, water

Do this:
1. Fill one bottle about one-fourth full of water and one bottle half way with water
2. Gently blow across the top of each bottle until you can make a sound. Hint: your lower lip and your chin must both touch the bottle.

Ask yourself:
Which bottle had the highest note, or pitch? Which had the lowest?
What do you think would happen if you add more water to the bottle that is half full? Test your prediction by adding more water. Were you right?
Why do you think the water level in each bottle changed the pitch?

Pitch Experiment #2
Supplies: 1 skinny rubber band, 1 fat rubber band, 2 pencils, a box (like a milk carton)

Do this:
1. Put both the rubber bands around the milk carton the long way.
2. Put one pencil under the rubber bands near each end of the carton. (Like the bridge on a piano or guitar.)
3. Pluck the skinny rubber band and listen.
4. Now pluck the fat rubber band and listen.
5. Pluck the rubber bands again and watch them vibrate.
6. Try making the length between the pencils shorter. First, pluck the skinny rubber band again and remember its sound. Move one of the pencils to the middle of the carton. Pluck the skinny rubber band again.

Ask yourself:
Does the skinny rubber band have a higher or lower pitch than the fat one?
Does the whole rubber band vibrate or just the part between the pencils?
When you moved one of the pencils to the middle, was the new sound higher or lower in pitch?
What did you learn about how the length and size of the rubber bands affected the pitch?
What did you learn from this experiment that tells you why piano strings are different sizes and lengths?

Learning About Tuning Forks

What is a tuning fork?

A metal device for establishing pitch. When struck, its two prongs (or tines) vibrate and produce a note that becomes louder if its stem is pressed on a wooden surface. You can purchase tuning forks from music and scientific supply companies. It was invented by John Shore, an English musician, in 1711. Standard Pitch, or Concert Pitch, is a universal frequency or note that most musical instruments are tuned to. Today's standard pitch is A440 or C523.3 and this enables musicians to play instruments together in harmony, without clashing pitches. A tuning fork is normally used to set the pitch. Tuning forks are also used in health care, electronics, science, etc.

How does a tuning fork work?

Sound waves are produced by vibrating objects. Whether it be the sound of a person's voice, the sound of a piano, or the sound of a dropped object, the source of the sound is always a vibrating object.

A tuning fork shows how a vibrating object can produce sound. A tuning fork is a metal object consisting of two tines capable of vibrating if struck by a rubber hammer or mallet. The back and forth vibration of the tines produce disturbances of in the air molecules around it. As a tine stretches *outward* from its usual position, it squeezes the air molecules around it into a smaller space; this high pressure area is called a compression. As the tine moves inward from its usual position, air surrounding the tine expands; this produces a low pressure called a rarefaction. As the tines continue to vibrate, an alternating pattern of high and low pressure areas are created. As these patterns move through the air, they move sound signal from one place to another. Visit www.onlinetuningfork.com to see a visual demonstration of how a tuning fork works.

We know that a tuning fork is vibrating because we hear the sound produced by its vibration, but we don't actually see the vibrations of the tines. This is because the tines are vibrating at a very high frequency. If the tuning fork corresponds to middle C on the piano keyboard, then the tines are vibrating at a frequency of 256 Hertz (or 256 vibrations per second). We are unable to visibly detect vibrations of such high frequency. The pitch (or frequency) of the sound wave is determined by the length of the prongs.

A piano technician may use a tuning fork when tuning a piano to compare a note played on the piano compares to the pitch of the tuning fork. The technician then will adjust the tension of the strings so that they are in harmony with each other.

Try it out!

Supplies: tuning fork, ping pong ball glued to piece of string

Do this:

Hold your fork by the "stem" (handle) and tap sharply on your shoe. Place the fork stem on various surfaces and listen for differences in the sound. Touch your elbow with the stem of the vibrating fork and place your index finger of the same hand in your ear. You will hear the sound because it is being conducted through your bones. (This explains why our voice on a tape recorder doesn't sound right to us. We can hear our own voices through our bones and ears.)

Next, dangle the ping pong the ball next to the vibrating fork so that it is gently tapped and you'll be able to see the "wiggle" of the vibrating fork transmitted to the ping pong ball.

Fun Ways To Learn About Sound

Sound Scavenger Hunt

Go on a scavenger hunt at home, at school or outdoors to see how well you hear what is around you.
Try to find a different sound for each answer.

1. Find a musical sound.
2. Find the loudest sound you can.
3. Find a sound that makes you feel relaxed and calm and sleepy.
4. Find a sound that it is irritating or annoying.
5. Find a sound that makes you feel like moving a lot.
6. Find a sound that makes you feel happy (or sad, scared, excited, etc.).

Now, think of some more things to add to this list of sounds and send your friends on a scavenger hunt, too. Or, find different songs or types of music that fit each of the items above.

Hot Waves

Supplies: a round bowl about half full of water, ground black pepper, dishwashing soap.

Do this:

Spread the pepper into the bowl of water until it is evenly coating the surface. Carefully allow one drop of the soap to fall into the middle of the bowl. The pepper moves out away from the drop much like a sound wave emanates out from where the sound was produced. When you play the piano, the sound spreads out in all directions just like the pepper moved away.

Making Waves

Supplies: A Slinky™, 1 piece of thin rope (6 -8 ft.)

Do this:

Tie one end of the rope around a door handle and hold the other end tightly. Shake your hand up and down to make a wave in the rope. The wave you made is called a transverse wave (like a water wave or a light wave). Try shaking your hand faster to see how the wave changes.

Stretch the Slinky™ out on a smooth floor and have a partner hold one end. Holding the other end, give the Slinky™ a sharp push. Notice the wave of coils move along the Slinky™. This is called a longitudinal wave (like a sound wave). What can you do to change the way the wave moves along the Slinky™? How are the strings on a piano like a Slinky™?

Echo Music

Supplies: A hard wall outside such as the flat side of a building.

Do this:

Stand a few hundred feet away from and facing the wall. Make a sharp sound such as clapping your hands or hitting a drum sharply. Listen for the sound to come back to you a little later in the form of an echo. Try shouting and listen for the echo. The sound waves bounce, or reflect off the wall and come back as an echo. What parts of a piano act like the wall as it bounced your sound back to you?