Properties of Sound

Suppose that you and a friend are talking on a sidewalk and a noisy truck pulls up next to you and stops, leaving its motor running. What would you do? You might talk louder, almost shout, so your friend can hear you. You might lean closer and speak into your friend's ear so you don't have to raise your voice. Or you might walk away from the noisy truck so it's not as loud.

Loudness

Loudness is an important property of sound. **Loudness** describes your perception of the energy of a sound. In other words, loudness describes **what you hear**. You probably already know a lot about loudness. For example, you know that your voice is much louder when you shout than when you speak softly. The closer you are to a sound, the louder it is. Also, a whisper in your ear can be just as loud as a shout from a block away. **The loudness of a sound depends on two factors: the amount of energy it takes to make the sound and the distance from the source of the sound.**

Energy of a Sound Source

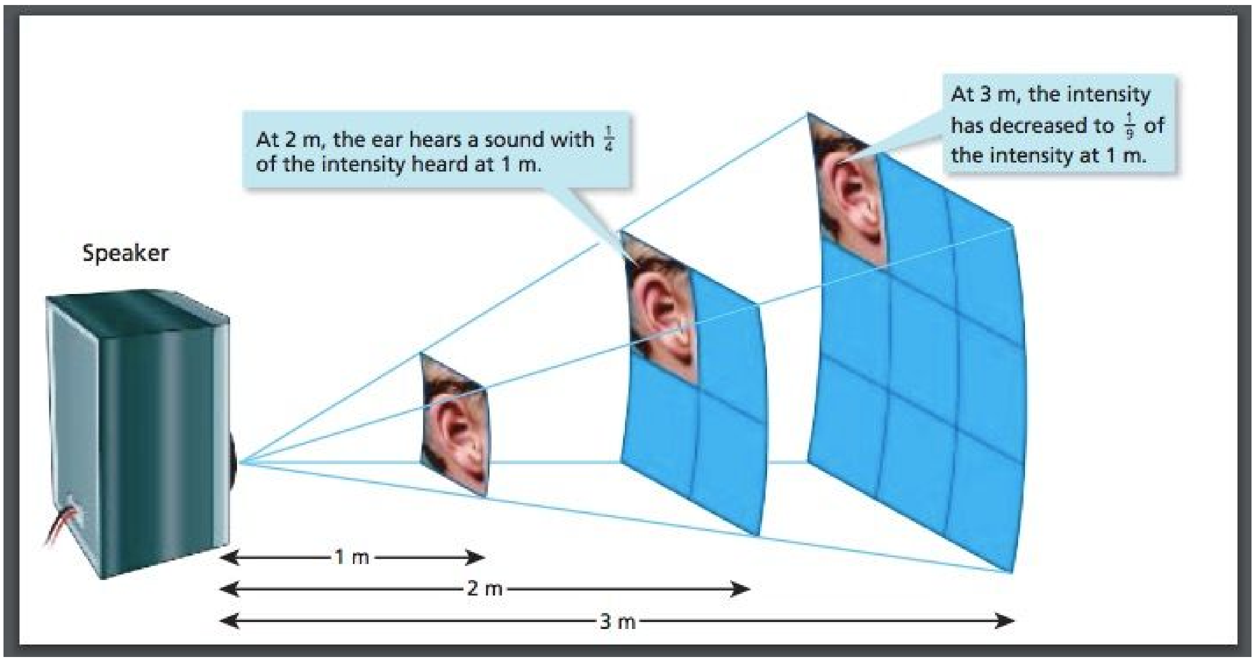
In general, the greater the energy used to make a sound, the louder the sound. The more energy you used to pull a guitar string back, the louder the sound is when you let the string go. This happens because the more energy you use to pull the string, the greater the **amplitude** of the string's vibration. (See, that word is back!) A string vibrating with a large amplitude produces a sound wave with a large amplitude. So, it will sound louder.

Recall that the greater the **amplitude** of a wave, the more **energy** the wave has. So, the larger the amplitude of the sound wave, the more energy it has and the louder it sounds.

Distance From a Sound Source

If your friend is speaking in a normal voice and you lean in closer, your friend's voice sounds louder. Loudness increases the closer you are to a sound source. But why?

Imagine ripples spreading out in circles after you toss a pebble into a pond. In a similar way, a sound wave spreads out from its source. Close to the sound source, the sound wave covers a small area, as you can see in the picture.



As the wave travels away from its source, it covers more area. The total energy of the wave, however, stays the same whether it is close to the source or far from it.

Measuring Loudness

The loudness of different sounds is compared using a unit called the **decibel (dB).** The next chart shows the loudness of some familiar sounds. The loudness of a sound you can barely hear is about 0 dB. Each 10 decibel (dB) increase in loudness represents a tenfold increase in the intensity of the sound. For example, soft music at 30 dB sounds ten times louder than a 20 dB whisper. The 30 dB music is 100 times louder than the 10 dB sound of rustling leaves. Sounds louder than 100 dB can cause damage to your ears, especially if you listen to those sounds for long periods of time. This is why it's important not to listen to music coming from a device too loudly. It can cause hearing damage.

Measuring Loudness

Sound	Loudness (dB)
Rustling leaves	10
Whisper	15–20
Very soft music	20–30
Normal conversation	40–50
Heavy street traffic	60–70
Loud music	90–100
Rock concert	110–120
Jackhammer	120
Jet plane at takeoff	120–160

YOUR TASK: Open up your Notability App, and create a new SUBJECT. Call it SOUND. From here on out, all the stuff we work on, regarding sound will be placed there.

TO DO - Number the problems as you go along:

1. 4 THINGS - Give the page a title, and call it LOUDNESS. Give the **meaning** of the word loudness - this means, write the definition, word for word from the text. Tell what loudness **describes**. Tell what loudness **depends on**.

2. **2 THINGS** - Draw 2 little pictures showing the amplitude of the guitar string described in the passage. The first picture should show high amplitude and the second should show low amplitude. Make sure you draw a wave at rest first, so you can show the distance from rest to crest.

3. **3 THINGS** - Write down what a **DECIBEL** is. Tell what decibels measure. At which decibel level would a person be at risk of some hearing damage?

4. **3 THINGS** - Pick 3 sounds from the chart above. Draw 3 separate pictures showing the amplitude of the sounds. You can choose to go lowest to highest, or highest to

lowest. Each picture of the wave must show your wave at rest, the name of the sound and wave representing the sound.

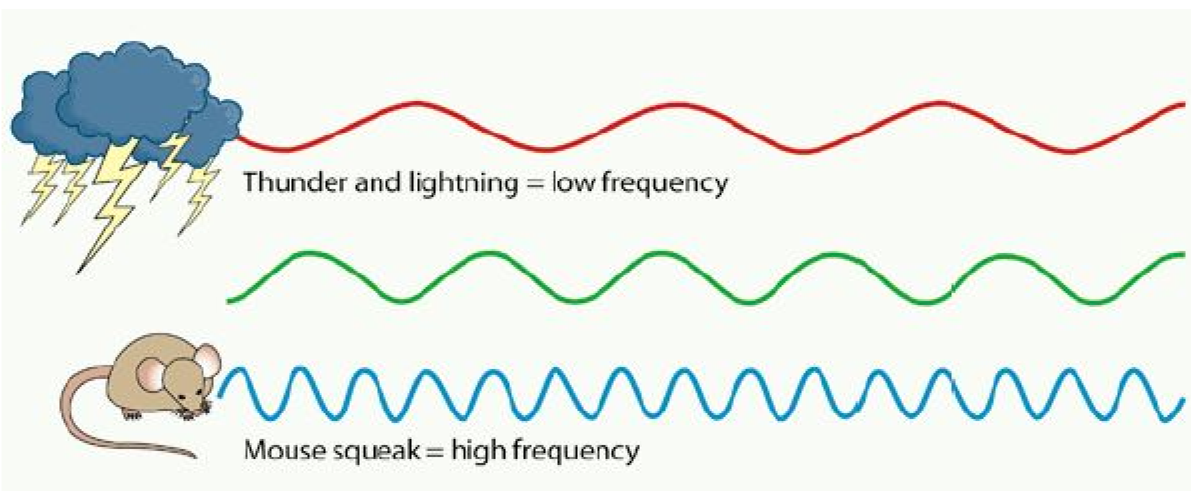
When you are finished with these tasks, show Mrs. Voris.

Pitch

Pitch is another **property of sound** you may already know a lot about. Have you ever described someone's voice as "high-pitched" or "low-pitched?" The **pitch** of a sound is a description of **how high or low** the sound seems to a person. **The pitch of a sound that you hear depends on the frequency of the sound wave.** (Oh lookie, that word is back, too!)

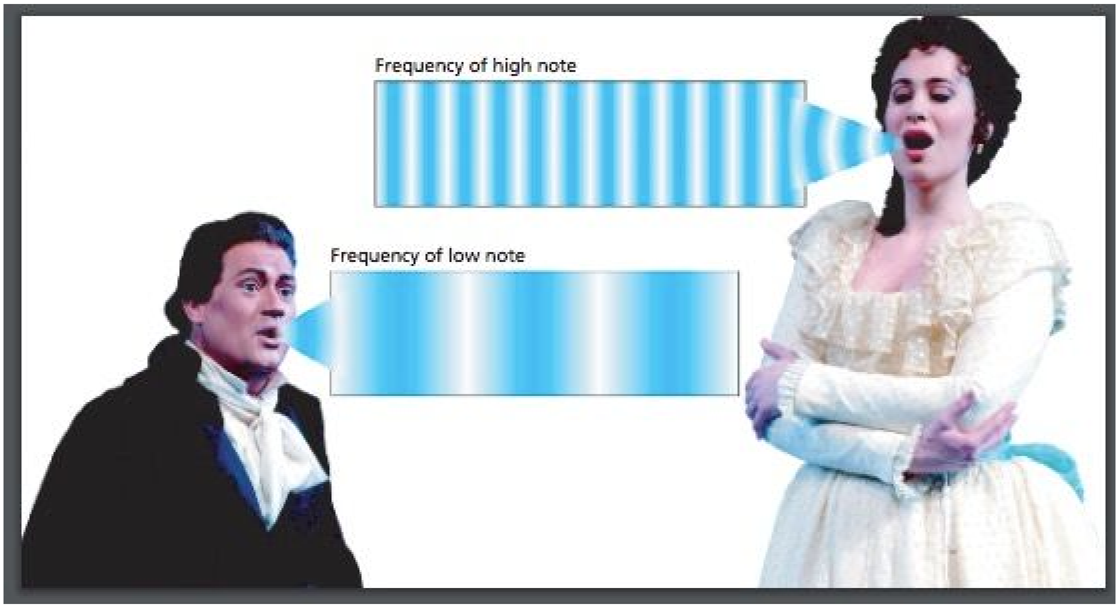
Pitch and Frequency

Sound waves with a high frequency have a high pitch. Sound waves with a low frequency have a low pitch.



Frequency is measured in **hertz (Hz)**. For example, a frequency of 50 Hz means 50 vibrations per second. Look at the picture below. A bass singer can produce frequencies lower than 80 Hz. A trained soprano voice can produce frequencies higher than 1,000 Hz. You can see in the picture that the wavelengths (oh, another repeat word) of the frequency of the high note from the soprano lady singer are much shorter compared to the wavelengths of the low note from the bass gentleman singer.

We actually performed a little hearing test using the Online Tone Generator. You can try it again. When you go to the website you will need to select Hearing Test. Click HERE to access the site. Be careful not to turn it up all the way.

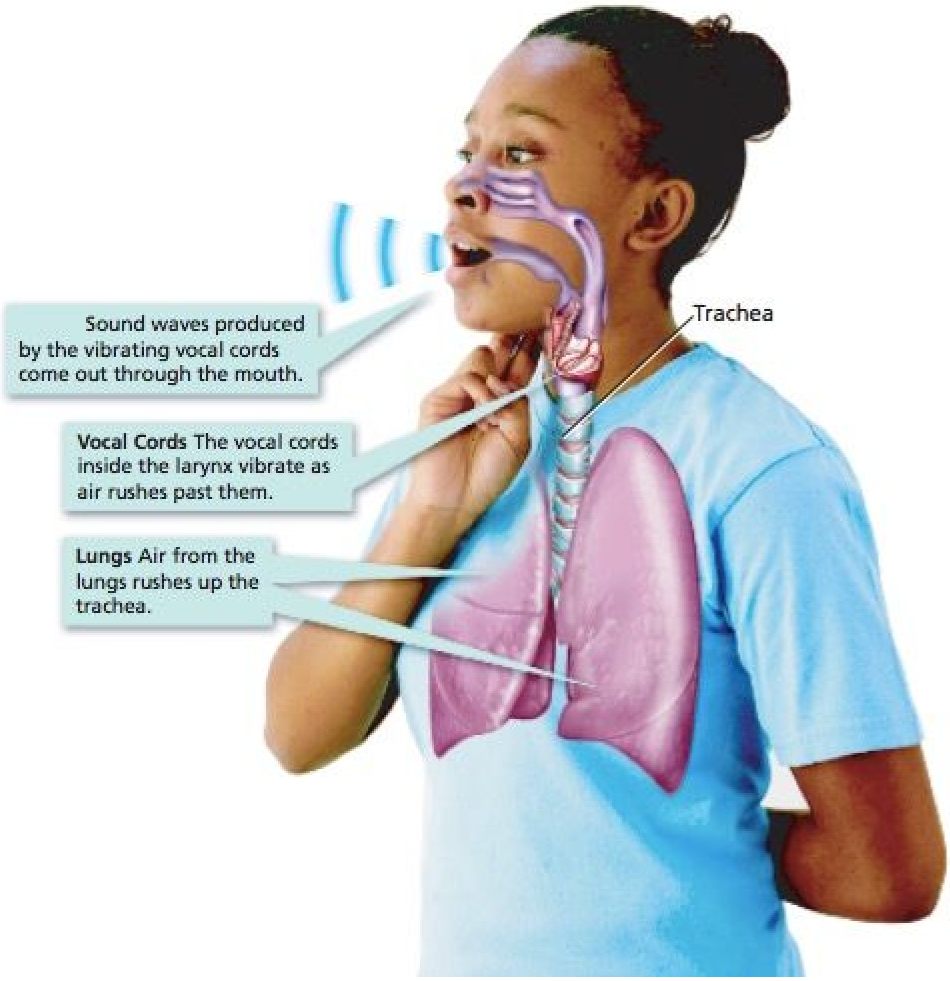


Most people can hear sounds with frequencies between 20 Hz and 20,000 Hz. Sound waves with frequencies above the normal human range of hearing are called **ultrasound.** The prefix *ultra*- means "beyond." Sounds with frequencies below the human range of hearing are called **infrasound.** The prefix *infra*-means "below." People cannot hear either ultrasound waves or infrasound waves.

Changing Pitch

Pitch is an important property of music because music usually uses specific pitches called notes. To sing or play a musical instrument, you must change pitch often.

When you sing, you change pitch using your vocal cords. Your vocal cords are located in your voice box, or **larynx,** as shown in the picture.



When you speak or sing, air from your lungs is forced up the trachea, or windpipe. Air then rushes past your vocal cords, making them vibrate. This produces sound waves. Your vocal cords are able to vibrate more than 1,000 times per second!

To sing different notes, you use muscles in your throat to stretch and relax your vocal cords. When your vocal cords stretch, they vibrate more quickly as the air rushes by them. This creates higher-frequency sound waves that have higher pitches. When your vocal cords relax, lower-frequency sound waves with lower pitches are produced.

With musical instruments, you change pitch in different ways depending on the instrument. For example, you can change the pitch of a guitar string by turning a knob to loosen or tighten the string. A tighter guitar string produces a higher frequency, which you hear as a note with higher pitch.

TO DO: Number the problems as you go along.

1. **2 THINGS** - Give the next section a new title and call it **PITCH**. Write the meaning of the word pitch. This means give the definition, word for word, from the text.

2. **3 THINGS** - We already know what frequency is. But, just to be sure, draw 2 little pictures (models) **showing a wave with HIGH frequency and one with LOW frequency**. Remember: frequency has to do with *wavelength*. The shorter the wavelength, the higher the frequency. Label with an arrow, which is high and which is low.

3. **3 THINGS** - Draw what a wave would look like showing 800 Hertz (Hz) compared to another wave showing 10,000 Hertz (Hz). Label to show which one is 800 Hz and which one is 10,000 Hz.

4. **3 THINGS** - Did you know that some very talented opera singers can shatter a crystal glass by matching the natural frequency of the glass and then singing loudly enough to where the glass vibrates to the point that it will shatter?

Check out this video showing this very same thing - it's actually a commercial, but it does the trick, nicely. Click **HERE**.

But, did you know that YOU, yes **YOU** might be able to do the same thing? It's not just opera singers who can shatter a glass with a high pitched tone. Check out this kid who did it at home. Click **HERE**.

Draw a model of what must happen, in order for the glass to shatter. Make sure I can tell the difference between your drawing in problem #3 versus problem #4.

5. **2 THINGS** - Pick a musical instrument and tell what you've picked.

Explain how you would increase the pitch to make a different sound.

When you are finished with these tasks, show Mrs. Voris.

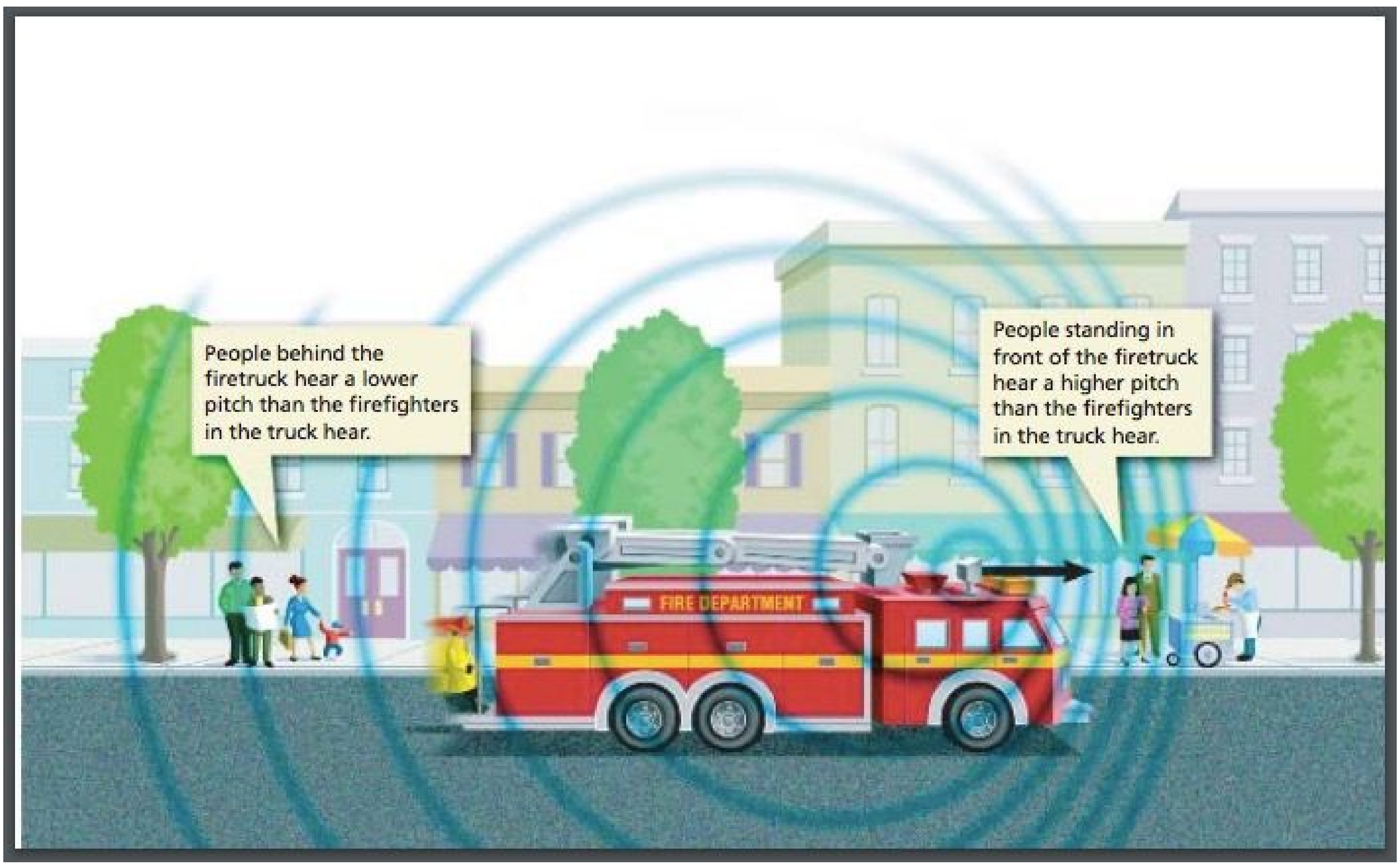
The Doppler Effect

If you listen carefully to the siren of a fire-truck on its way to a fire, you will notice something surprising. As the truck goes by you, the pitch of the siren drops. But the pitch of the siren stays constant for the firefighters in the truck. The siren's pitch changes only if it is **moving toward or away from a listener**.

The change in frequency of a wave as its source moves in relation to an observer is called the **Doppler effect.** If the waves are sound waves, the change in frequency is heard as a change in pitch. The Doppler effect is named after the Austrian scientist Christian Doppler (1803–1853).

What Causes the Doppler Effect?

The next picture shows how sound waves from a moving source behave.



When the source moves toward a listener, the frequency of the waves is higher than it would be if the source were stationary. **When a sound source moves, the frequency of the waves changes because the motion of the source adds to the motion of the waves.**

To understand why the frequency changes, imagine that you are standing still and throwing tennis balls at a wall in front of you. If you throw one ball each second the balls hit the wall at a rate of one per second. Now suppose you walk toward the wall while still throwing one ball per second. Because each ball has a shorter distance to travel than the one before, each takes less time to get there. The balls hit the wall more often than one per second, so the frequency is higher. On the other hand, if you throw balls at the wall as you back away, each ball has farther to travel and the frequency is lower.

The next video shows this phenomena called the Doppler Effect. Everything we've learned so far will make sense, but now we need to consider an object that is moving. Watch the video up to 1:54, after which it will talk about light. We will discuss Light in about another week or so. Click **HERE** to watch the short video.

TO DO: 3 THINGS

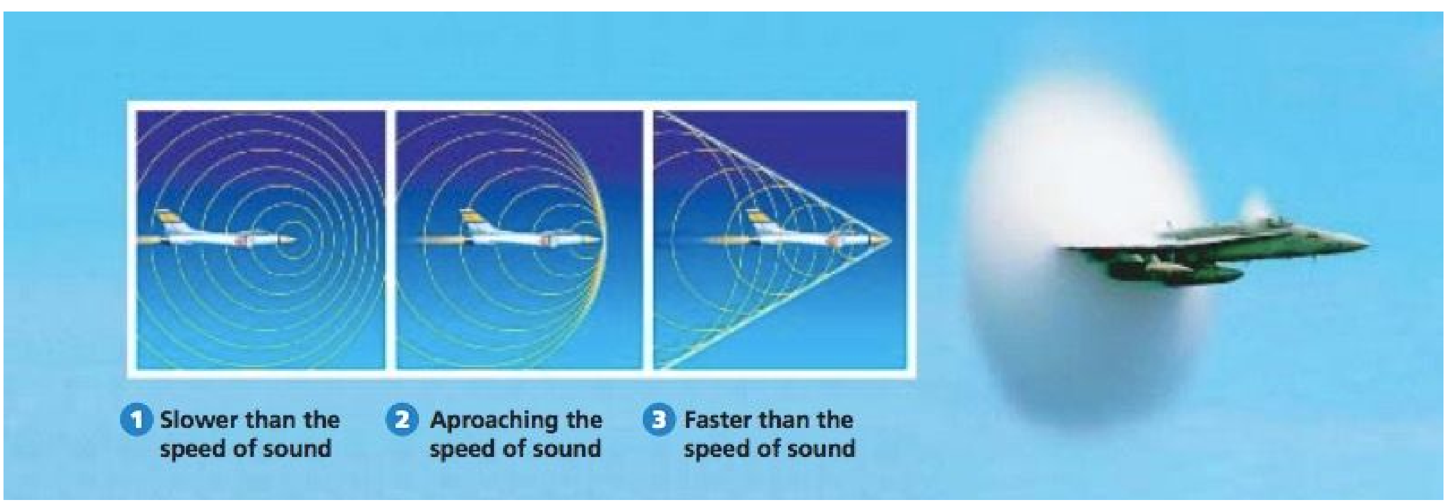
Create another title and call it **The Doppler Effect**.

After reading about it and watching a short video on it, explain it using your own words, and draw a model showing why we hear a siren first at a high pitch, and then at a low pitch.

When you are finished with this task, show Mrs. Voris.

Shock Waves and Sonic Booms

At high speed, the Doppler effect can be spectacular. Look at the picture.



When the plane travels almost as fast as the speed of sound, the sound waves pile up in front of the plane. This pile-up is the "sound barrier." As the plane flies faster than the speed of sound, it moves through the barrier. A shock wave forms as the sound waves overlap. The shock wave releases a huge amount of energy. People nearby hear a loud noise called a **sonic boom** when the shock wave passes by them.

You'll find the next video quite exciting, as it shows the Doppler Effect, very dramatically. You will see sonic booms, because the jets passed the speed of sound.

Click **HERE** to watch.

Make sure you have completed all of the tasks. We will be making pan flutes to show our understanding of loudness and pitch. As long as you have finished everything, you will get a chance to start on it.