PHYSICS CONNECTIONS

Lesson 2: Intensity And The Human Voice

Prior Knowledge:

During our first lesson on music and physics we investigated how sound waves work in relationship to the human body. We explored how to raise and lower pitch to identify vibration frequency and looked at how that affects the sound made in the chest and head voice for singers. But why don't all sounds sound exactly the same? As molecules move faster, they go up in pitch.

Vocabulary:

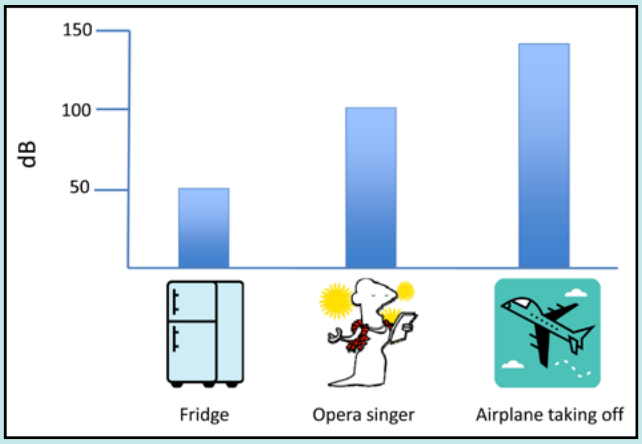
Intensity: a way to measure loudness or quietness of sound over a period of time.

Decibel (dB): is a unit of measuring loudness. 0 dB is the smallest audible sound possible, 10 dB is ten times louder. 20 dB is 100 times more powerful than 0 dB, 30 dB is 1,000 times more powerful than 0 dB. For context a refrigerator's dB level is about 50, an opera singer usually is around 100 dB. An airplane taking off is about 140dB.

Hertz: measurement of frequency vibration. 1 hertz is one cycle per second (cps).

Frequency: the rate of energy that makes things vibrate. Remember everything has a frequency.

Pitch: the effect of raising or lowering the speed of vibration. Remember, the closer the waves the higher the pitch, the lower the waves the longer the pitch.

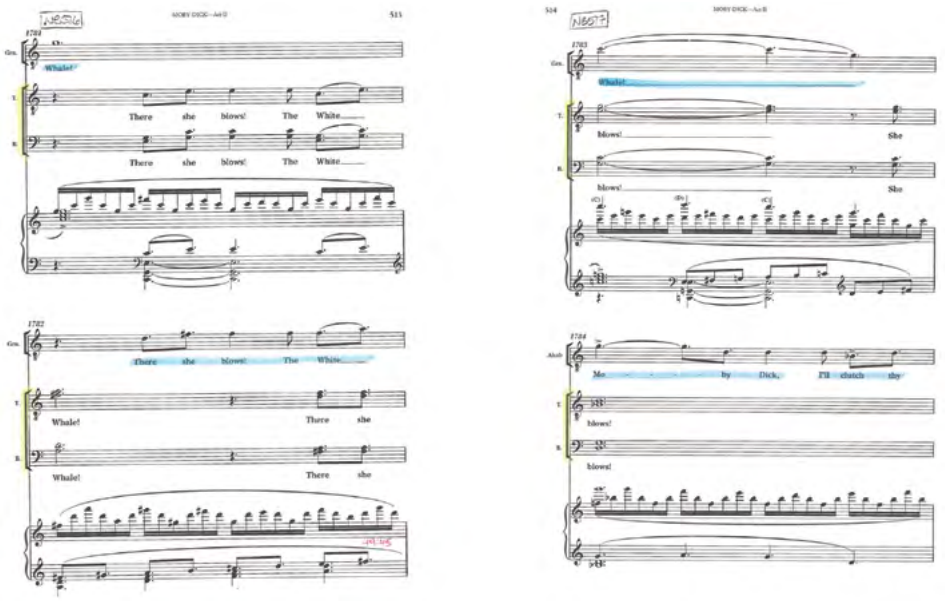


Principal singer: a named character in an opera.

Sound Waves: the length of vibrations that occur when sound passes through something.

Big Idea:

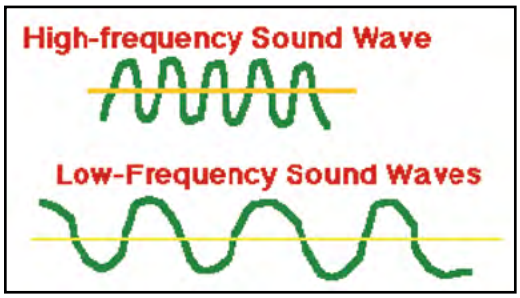
Opera singers know how to project their voices over an entire orchestra and chorus. One of the ways they can do this is through the **intensity** of their voices.



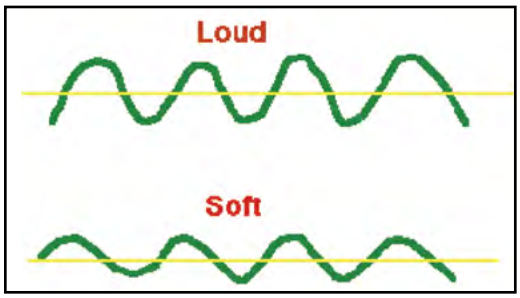
Lesson:

Opera singers are trained to sing over an orchestra and a chorus without any electronic amplification. Their training helps them combine pitch and intensity to cut through the other sounds of an orchestra and a chorus. Generally the **principal singers** in an opera are singing at a higher or lower **pitch** than the other instruments and chorus. This keeps the frequency open for their voices which are trained to be incredibly strong. When you go to the opera or listen to a recording of an opera, draw your attention to where the principal singers are standing, or if they are singing higher or lower than everyone else?

Pitch:
This is how high or low a sound seems.



Intensity:
Sounds also are different in how loud and how soft they are. The more energy the sound wave has the louder the sound seems. The intensity of a sound is the amount of energy it has. We hear intensity as loudness.



Don't try this:

Can a singer shatter a wine glass with the pitch and intensity in their voice? The answer is yes and modern physics prove it. This takes a combination of pitch and intensity. To find the frequency of the glass, run your fingers around the rim and listen for the sound it creates. Chances are good that this is a High C flat. Now the singer must be able to match that pitch, which is about 105 dB and 556 hertz, and hold that pitch and intensity for at least 3 seconds. If the pitch and intensity are correct, *and* constant *and* if the wine glass has any type of microscopic flaw in it, the glass will shatter.

Two basic physics equations that describe waves:

1) $E = hf$

Where:
E = energy
h = planck's constant (6.62606957x10-34 Joule-seconds;
represents the constant proportionality between energy of a photon and the frequency of its wave.)
f = frequency

2) $\lambda = v/f$

Where:
λ = wavelength
v = velocity (of wave)
f = frequency

The reason it shatters is this! All objects have a resonant frequency! If you match the frequency of the object, it will absorb the energy instead of reflecting it. The object, in this case the wine glass, can't accommodate the vibration and so it bursts when it absorbs too much energy!

Wrap up:

We now know about how singers can make their voices heard over a full orchestra and we've proved a myth about the intensity of a powerful human voice. Next, let's look at how each human voice is unique.