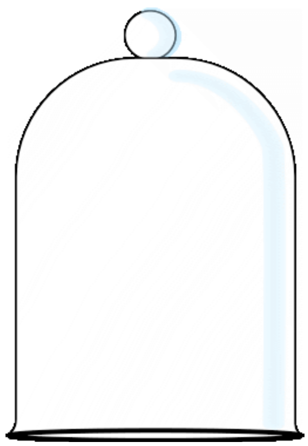
Sound Notes

I. What is sound? (the science of sound is called _acoustics_)

A. **Sound** is a form of **energy** consisting of **pressure variations** that travel through **matter** and can be heard when they reach a person's or animal's **ears**.

1. Bell Jar Sound Demonstration: Sound producing object placed in bell jar with air and then has the air removed.



bell jar with air

Observation:______________________

Conclusion:______________________

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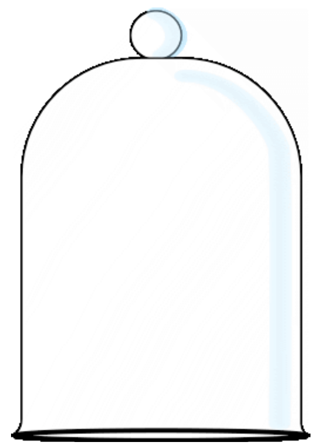

bell jar with air removed (vacuum)

Observation:______________________

Conclusion:______________________

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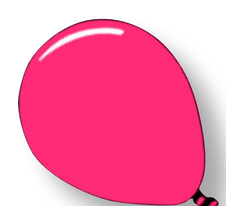
II. How can sound be produced?

A. Demonstration #1: A tuning fork is struck producing a clear sound. What does the tuning fork do to a piece of paper it touches?

It repeatedly hits against the paper. When the paper is hit it makes a sound as well.

1. To produce sound, solids can **vibrate** back and forth. (remember that it's a compressional wave)



B. Demonstration #2: An inflated balloon is **popped**.

1. Rapid expansion or compression (explosions,implosions)

C. Demonstration #3: A wood dowel is **whipped** around.

1. Air flow vortices (whistles,flutes,fast moving objects)

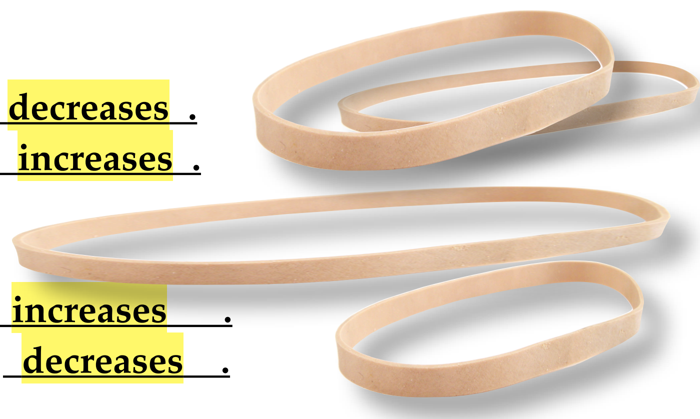
III. Pitch is the degree of highness or lowness of a sound and depends on a sounds frequency.

A. Observe simple demonstrations of vibrating objects and identify some of the factors that affect pitch, specifically **music**.

1. Object **length** (meter stick)

   a. As the **length** of a vibrating object increases its pitch becomes **lower**.

   b. As the **length** of a vibrating object decreases its pitch becomes **higher**.



2. Object **mass** (rubber bands)

   a. As **mass** increases, pitch **decreases**.

   b. As **mass** decreases, pitch **increases**.

3. Object **tension** (rubber bands)

   a. As **tension** increases, pitch **increases**.

   b. As **tension** decreases, pitch **decreases**.

B. Observe a demonstration of sound of varying pitch.

1. The normal range of human hearing is from **20** Hz to **20,000** Hz.
2. The human voice ranges from **250** to **2,500** in normal **speech**.
3. **Infrasonic** : Sound frequencies below the range of human hearing.
4. **Ultrasonic** : Sound frequencies above the range of human hearing.
5. **Infrasound examples from natural causes**:(sounds you often feel) avalanches,meteors,ocean waves,severe weather,tornadoes,air turbulence, earthquakes,volcanoes.
6. Elephants, whales, hippos, rhinoceros, giraffe, okapi, and alligator are just a few examples of animals that create infrasound.
7. Some migratory birds are able to hear the infrasonic sounds produced when ocean waves break. This allows them to orient themselves with coastlines.
8. An elephant is capable of hearing sound waves well below the human hearing limitation (approximately 30 Hertz). Typically, an elephant's numerous different rumbles will span between 14 and 35 Hertz.
9. **Ultrasound examples:**

   a. Animal echolocation

      (1) microchiropterans a.k.a. microbats: carnivorous bats (not fruit bats or flying foxes)

(2) cetaceans: dolphins, porpoises, orcas, whales

(3) two bird species: swiftlets and oilbirds

(4) some visually impaired humans have learned this technique

b. Medical ultrasonography (the images generated are called sonograms).

Frequency Hearing Ranges for Selected Animals (60 dB) (from "The Physics Hypertextbook" – http://physics.info/sound/)	
fish – *actinopterygii*	frequency range (Hz)
american shad – *Alosa sapidissima*	200 – 180,000
goldfish – *Carassius auratus*	5 – 2,000
atlantic cod – *Gadus morhua*	2 – 500
tuna – *Thunnus …*	50 – 1,100
catfish – *… …*	50 – 4,000
amphibians – *amphibia*	frequency range (Hz)
tree frog – *… …*	50 – 4,000
bullfrog – *Lithobates catesbeianus*	100 – 2,500
cave salamander – *Proteus anguinus*	10 – 10,000
reptiles – *reptilia, sauropsida*	frequency range (Hz)
red-eared slider – *Trachemys scripta elegans*	68 – 840
spectacled caiman – *Caiman crocodilus*	20 – 6,000
birds – *aves*	frequency range (Hz)
mallard duck – *Anus platyrhynchus*	300 – 8,000
pigeon – *Columba livia*	? – 5,800
chicken – *Gallus gallus*	125 – 2,000
canary – *Serinus canaria*	250 – 8,000
cockatiel – *Nymphicus hollandicus*	250 – 8,000
parakeet – *Melopsittacus undulatus*	200 – 8,500
penguin – *Spheniscus demersus*	100 – 15,000
owl – *… …*	200 – 12,000
mammals – *mammalia*	frequency range (Hz)
cattle – *Bos taurus*	23 – 35,000
sheep – *Ovis aries*	100 – 30,000
pig – *Sus scrofa domestica*	45 – 45,000
dog – *Canis lupus familiaris*	67 – 45,000
cat – *Felis silvestris catus*	45 – 64,000
ferret – *Mustela putorius furo*	16 – 44,000
raccoon – *Procyon lotor*	100 – 40,000
blue whale – *Balaenoptera musculus*	5 – 12,000
humpback whale – *Megaptera novaeangliae*	30 – 28,000
risso's dolphin – *Grampus griseus*	8,000 – 100,000
beluga whale – *Delphinapterus leucas*	1,000 – 123,000
atlantic bottlenose dolphin – *Tursiops truncatus*	75 – 150,000

greater horseshoe bat – *Rhinolophus ferrumequinum*	2,000 – 110,000
jamaican fruit bat – *Artibeus jamaicensis*	2,800 – 131,000
northern quoll – *Dasyurus hallucatus*	500 – 40,000
opossum – *… …*	500 – 64,000
hedgehog – *… …*	250 – 45,000
rabbit – *… …*	360 – 42,000
horse – *Equus caballus*	55 – 33,500
japanese macaque – *Macaca fuscata*	28 – 34,500
old world monkeys – *… …*	60 – 40,000
human – *Homo sapiens*	31 – 17,600
asian elephant – *Elephas maximus*	16 – 12,000
guinea pig – *Cavia porcellus*	54 – 50,000
chinchilla – *Chinchilla lanigera*	90 – 22,800
hamster – *Mesocricetus auratus*	80 – 45,000
rat – *Rattus …*	500 – 64,000
mouse – *Mus …*	2,300 – 85,500
gerbil – *Meriones unguiculatus*	100 – 60,000
manatee – *Trichechus manatus latirostris*	400 – 46,000

insects - *insecta*	frequency range (Hz)
noctuid moth – *… …*	1,000 – 240,000
grasshopper – *… …*	100 – 50,000

Frequency of Selected Sounds

(from “The Physics Hypertextbook” – http://physics.info/sound/)

f (MHz)	device, event, phenomena, process
1–20	medical ultrasound

f (kHz)	device, event, phenomena, process
25–80	bat sonar clicks
40–50	ultrasonic cleaning
32.768	quartz timing crystal
18–20	upper limit of human hearing
4–5	field cricket (Teleogryllus oceanicus)
2–5	maximum sensitivity of the human hear

f (Hz)	device, event, phenomena, process
300–3000	voice frequency (VF), important for understanding speech
2048	C_7 scientific scale, highest note of a soprano singer (approximate)
440	A_4 american standard pitch, tv test pattern tone
435	A_4 international pitch
426.67	A_4 scientific scale
261.63	C_4 american standard pitch
258.65	C_4 international pitch
256	C_4 scientific scale, typical fundamental frequency for female vocal cords

128	C_3 scientific scale, typical fundamental frequency for male vocal cords
64	C_2 scientific scale, lowest note of a bass singer (approximate)
90	ruby-throated hummingbird in flight
60	alternating current hum (US and Japan)
50	alternating current hum (Europe)
8–20	lower limit of human hearing
17–30	blue and fin wales are the loudest marine sound in this range
1–5	tornadoes

IV. Loudness and The ________Decibel(db)______ Scale (see chart page 510)

A. The greater the __**amplitude**__ of a sound wave the __**louder**__ it is.

B. The lowest sound humans can hear is _**0**_ db.

C. Sounds above 85 db can _**damage**_ your hearing.

D. Sounds of 140 db or more cause __**instant damage**__.

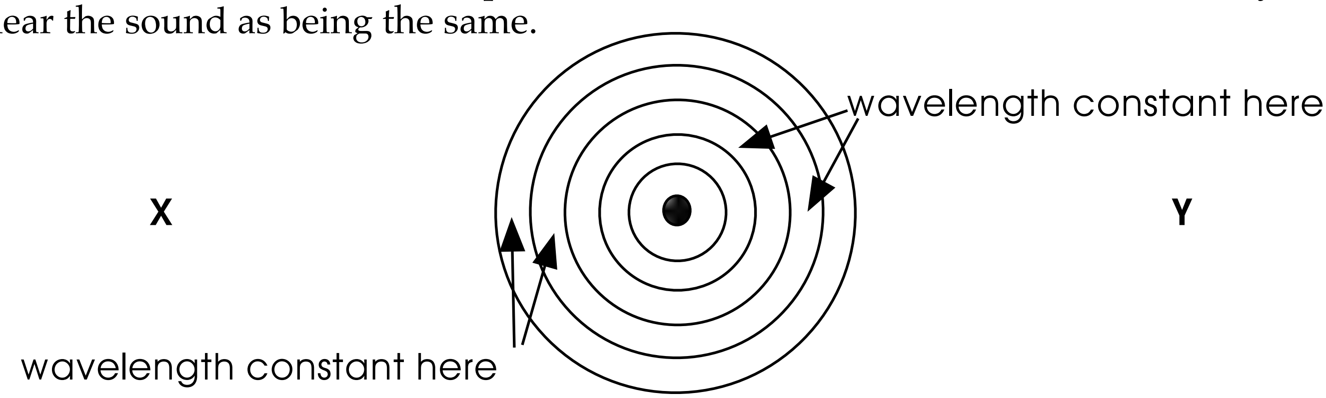
E. For every increase of _**10**_ units on the decibel scale, the sound intensity increases by a factor of _**10**__.

1. For example, a sound of 10 db is **10** times more intense than a sound of 0 db.
2. A sound of 20 db is **100** times more intense than a sound of 0 db, and a sound of 30 db is **1,000** times more intense than a sound of 0 db.
3. A sound of 70 db is **10** times more intense than a sound of 60 db.

V. The Doppler Effect (Teacher Demo)

A. This occurs if there is relative _**motion**_ between the sound source and the listener. (either the listener or the source is moving) As the distance between the source and listener changes, the pitch of the sound will also change .

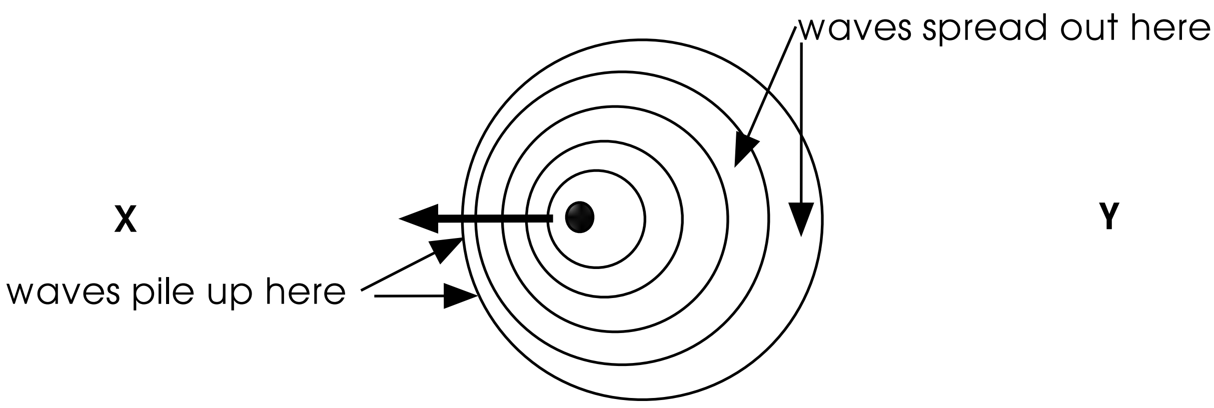
B. The group of circles below, represents sound waves emanating from a _**stationary** source. Each sound wave is an equal distance from the other waves , producing a constant wavelength and frequency. This sound appears to have a constant pitch as we hear it. The "X" and "Y" represent two observers that hear the sound. They both hear the sound as being the same.



Stationary Sound Source

C. In this second example, we see what happens when the source of the sound is __**moving**__ relative to an observer.

1. The sound source is getting closer to the observer "X" at the left. As a result, the source of the sound is catching up with the sound waves just made. This causes the waves to 'pile up' on top of each other, and decreases the distance between waves, making the wavelength shorter in front of the moving source. This increases the pitch and the frequency of the sound for observer "X".



Moving Sound Source

2. However, the sound waves behind the source, 'lag behind' the moving source. This lengthens the distance between waves, making the wavelength longer as the source moves away from previously created sound waves and from observer "Y". This lowers both the pitch and frequency for observer "Y".

3. Radar guns used by police and baseball coaches determine speed by doppler effect frequency changes of moving objects.

VI. How fast is the Speed of Sound?

Use the information in the chart that follows to answer questions 1 and 2 .

1. How could you increase the speed of sound in a substance? Explain your answer. Look at the different speeds of air for a clue!

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2. Generally, the speed of sound increases as you go from a gas, to a liquid, and then to a solid . Based on what you know of the structure of matter, come up with a logical explanation for why this is so.

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Speed of Sound in Various Materials
(from "The Physics Hypertextbook" – http://physics.info/sound/)

solids	v (m/s)
aluminum	6420
beryllium	12,890
brass	4700
brick	3650
copper	4760
cork	500
glass, crown	5100
glass, flint	3980
glass, pyrex	5640
gold	3240
granite	5950
iron	5950
lead	2160
lucite	2680
marble	3810
rubber, butyl	1830
rubber, vulcanized	54
silver	3650
steel, mild	5960
steel, stainless	5790
titanium	6070
wood, ash	4670
wood, elm	4120
wood, maple	4110
wood, oak	3850

liquids	v (m/s)
alcohol, ethyl	1207
alcohol, methyl	1103
mercury	1450
water, distilled	1497
water, sea	1531

gases (STP)	v (m/s)
air, 0 ℃	331
air, 20 ℃	343
argon	319
carbon dioxide	259
helium	965
hydrogen (H_2)	1284
neon	435
nitrogen	334
nitrous oxide	263
oxygen (O_2)	316
water vapor, 134 ℃	494

biological materials	v (m/s)
soft tissues	1540

VII. Music versus Noise

A. _**Music**_ : sounds created using specific pitches and sound quality in a regular pattern.

B. _**Noise**_: sound with no regular pattern or definite pitch.

C. _**White noise**_: sound consisting of very many frequencies, capable of interfering with other noises.

D. _**Natural frequency**_ **:** The frequency that all materials, objects and musical instruments vibrate at that is natural for it.

E. _**Resonance**_: When the vibrations of one object cause another object/material to also vibrate, when the vibrations are the same as its natural frequency.

1. Teacher Demonstration: Music box and blackboard/bucket.

F. _**Sound quality**_: When musical instruments produce other frequencies unique to that instrument even when the same note is being played. This is why a violin and a guitar playing the same note sound different.

G. _**Overtones**_: Frequencies of musical instruments that are numerical multiples of some fundamental frequency.

H. ___**Tuning a musical instrument**___: Whenever a second sound source is vibrating at a slightly different frequency than another, a warbling variation in sound intensity is heard called a beat. When the beat disappears, the instruments are now at the same frequency.

1. Teacher Demonstration: Two tuning forks differing slightly in frequency.

I. __**Reverberation**___ : Effect produced by many reflections of sound. To reduce this effect, the shapes of rooms, ceilings, walls and the materials on them are designed to absorb these unwanted reflections. Examples: Pitted ceiling tiles, overhangs between adjoining rooms, drapes or other soft materials on walls, carpeted floors.

VIII. Echo ,Sonar and Echolocation

A. An __**Echo**__ is a reflected sound wave.

B. __**Sonar**__ (So̲und N̲avigation and R̲anging) is a way of determining distance based on how much time it takes a sound wave to travel from its source to its target and back again. The total time taken is multiplied times the speed of sound in the medium to get the distance to the target. A type of sonar is used in fish finders.

C. __**Echolocation**___is a way for some animals to navigate and/or hunt using reflected sound waves. (see previous information)