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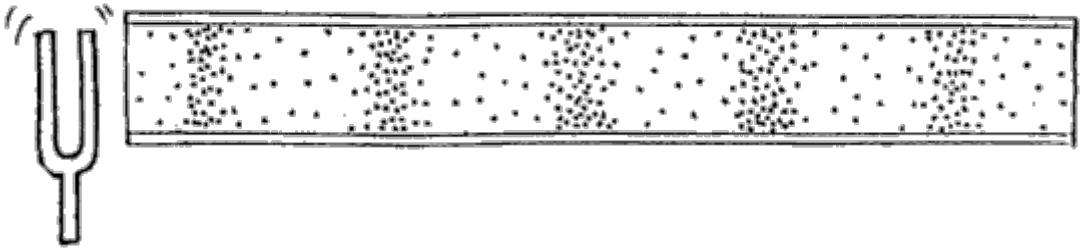
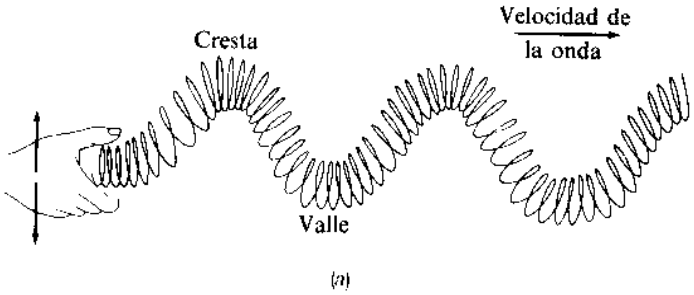
01.SOUND

DEFINITION

Sound is a sensation produced by an object vibrating. It is a complex process in which we can distinguish **THREE** phases:

1. A body is taken out of its resting situation (for example, by a blow, a knock on it...) and **begins to vibrate**, making small back-and-forth movements pushing particles to be first all next to each other and then all separated. When they are all close there is an increase of pressure and when they are separated there is a decrease of pressure. The vibrations in fact correspond to a local increase or decrease of the air pressure above or below normal atmospheric pressure.
2. These **vibrations travel** through a transmitting medium (usually air) in a similar way to the waves that form in a pond when a stone is thrown. Without a transmitting medium, there is no sound. Sound waves are "pressure waves" and cannot propagate in a vacuum because they need a material to make particles vibrate.
3. Finally, they reach our hearing organ (ear). There, pressure wave impacts our eardrum making it vibrate (like a drum!) and the mechanical energy is transformed, after a complex process, into electrical energy and sent to the brain where it is processed assigning it a meaning. This is what a sound wave would look like in a laboratory:





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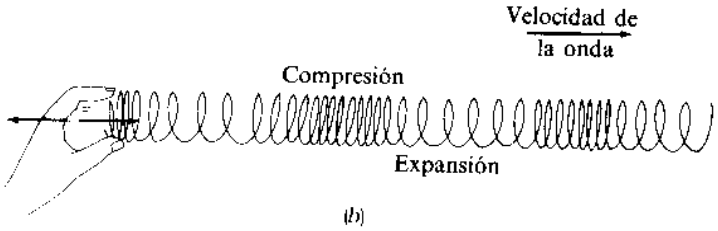


(b)

HOW SOUND IS TRANSMITTED

- It is important to understand that when sound waves travel through the air, **air DOES NOT move from place to place, it only oscillates around its position back and forth**. Energy, nevertheless, is “pushed forward” and moves from place to place.

  Experience_1. Muelle de colores. Sonido: ondas longitudinales

  - 2 personas sujetan el muelle desde ambos lados. Si una de ellas empuja ligeramente se puede ver cómo los aros se agolpan y se separan lentamente. Las vibraciones son paralelas a la dirección de la onda.

- The sound moves in all directions. If you speak, can those at your back hear you? With less intensity, but yes.

  Experience_2. Bolitas de Poliespan sobre superficie tensa
  Experience_3. Bola en superficie de agua

- **Speed of sound.** It depends, among other things, on the density of matter. **The denser** it is (solid body: the particles of that body are closer together), **the faster** sound is transmitted.

  Examples: Aire, a 20º: 340 m/s l Agua a 25º: 1593 m/s l Aluminio: 6.400 m/s

- VIDEOS on Youtube to consolidate these concepts:

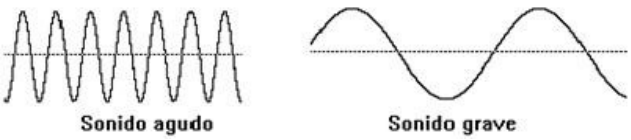
  Propagación del sonido
  CYT-13. Taller: Ondas, sonido y música
  Ciencia y sonido. Proyecto G

THE QUALITIES OF SOUND

All sounds are not equal because **FOUR** qualities can be distinguished in them that are directly related to certain characteristics of the wave that produces the sound.

1. **PITCH: quality of sound that allows us to distinguish between LOW from HIGH sounds**. It depends on the number of vibrations or oscillations per unit of time. It is measured in Hertz.

   More oscillations: higher. Fewer oscillations: lower.



   We can hear sounds that are between 20Hz (20 vibrations per second-very low) and 20,000Hz (20,000 vibrations per second-very high).

   Infrasound is a sound with such a low frequency (<20Hz) that our ear cannot appreciate it. **Ultrasound** is the sound we cannot perceive because its pitch exceeds 20,000 Hz, i.e. it is above our hearing limit.

   Some **insects and mammals** (dolphins and bats) use ultrasound as a radar for their orientation (echolocation). The sound waves emitted by them are reflected in the objects around, allowing them to create an image of where they are.

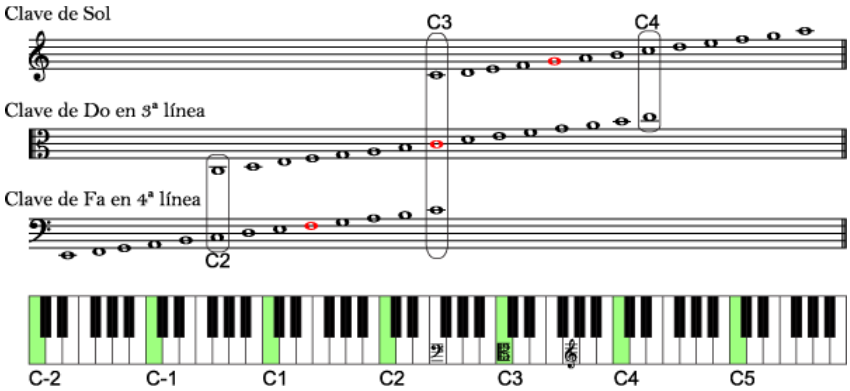
   Animals such as **elephants, whales and tigers** use infrasound to communicate. Therefore, natural disasters such as earthquakes, tornadoes and volcanic eruptions show themselves at first with infrasound.

   In **medicine**, ultrasound scans allow for ultrasound imaging.

Experience_4. Masa bailonguera hecha con maicena.
Experience_5. Teléfonos con vasos de yogur e hilo fino.
Experience_6. Instala en el móvil una app gratuita para jugar con las frecuencias. Puede ser Frequency Generator. Ponte unos buenos auriculares y comprueba tu umbral de audición: los sonidos más graves y agudos que eres capaz de oír. Fíjate al mismo tiempo en el tipo de onda que se genera según cambias la frecuencia.

MUSICAL LANGUAGE. Representation of pitch

We can represent different sounds by musical notes: la, si, do, re, mi, fa, sol, la (A, B, C, D, E, F, G, A). Musical notes are placed on the stave (the set of five lines and four spaces on which we write music) with different positions depending on the key used.



The string in the musical instrument changes its sound according to these **FOUR** factors:

Length: the longer a string is, the lower the sound is; the shorter the sound, the higher the pitch. There are instruments with strings of different length (harp) and others with the same length (guitar), but different thickness and tension.

Furthermore, the longer the tube of a wind instrument, the lower its sound. The shorter, the higher. See: trumpet/tuba; oboe/fagot.

With wood and metal plates in xylophones and metallophones happens the same thing.

Tension: the tighter a string is, the higher the sound is. The less tense, the lower.

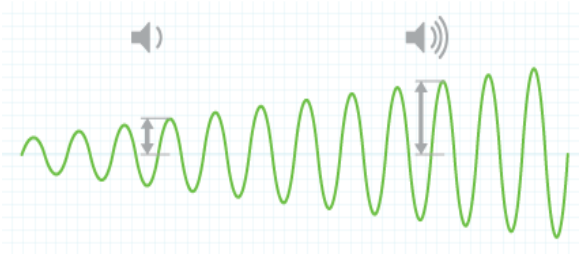
Pressure: the higher the air pressure, the higher the sound will be and vice versa.

Width or thickness: The thicker the string or sound tube, the lower the sound.

Experience_7. Boomwhackers. Tubos de diferentes longitudes y anchuras. Golpéalos y experimenta los cambios en la altura del sonido.

Experience_8. Instrumentos de placa del aula: xilófonos y metalófonos.

2. **DYNAMIC INTENSITY**: a quality of sound that distinguishes between **SOFT** and **LOUD** sounds. It depends on the energy of the waves, wich can be represented as the distance between the resting point and the highest part. The intensity is related to the “volume” that we perceive.



The sounds we perceive must exceed the **auditory limit** (0 dB) and not reach the pain tolerance (140 dB). We call **pain tolerance** to the maximum intensity of sound that produces a sensation of pain in the ear.

Decibel: Is the unit used to measure the sound intensity. It measures the pressure of the sound wave compared to atmospheric pressure. It the difference is just enough for a human ear to be perceived, the decible is 0. If the difference is so big that it hearts our ear, then it isa round 120 dB. All other “volumes” are in between.

130 dB	Pain tolerance. A plain flying
115 dB	Motorbike without silencer
110 dB	Inside nightclub
90 dB	Traffic
80 dB	Train
70 dB	Vacuum cleaner
50/60 dB	Dishwasher
50 dB	Normal conversation
20 dB	Leaves moving on the trees
10 dB	Birds singing
0 dB	Auditory limit

When someone is working for long periods of time in environments with levels above 85 dB, it is necessary to use special protection headphones. **Damage to hearing** caused by exposure to very loud noise is cumulative and irreversible, so it is important to take extreme precautions. Due to prolonged exposure to noise, anyone can suffer nervous, cardiac and mental disorders.

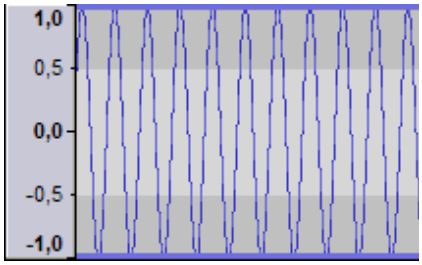
DYNAMIC MARKINGS. Representation of the intensity of sound.

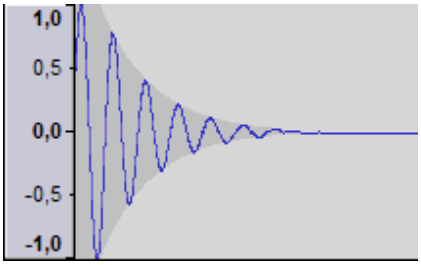
When you want to play a score with an instrument, you often use signs and words that indicate variations in intensity. Some of them are:

Términos	Abreviatura	Interpretación
Pianissimo	pp	very soft
Piano	p	soft
Mezzopiano	mp	medium soft
Mezzoforte	mf	medium loud
Forte	f	loud
Fortissimo	ff	very loud

Crescendo: increasingly loud Decrescendo: increasingly soft


3. **DURATION: sound quality that differentiates LONG** from **SHORT sounds**. It depends on the amount of time that sound remains playing. It is measured in units of time: seconds, minutes...



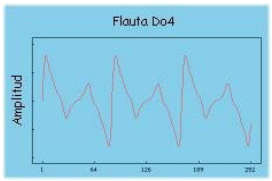


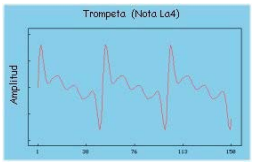
NOTE VALUES and rests represent the duration of sounds:

Redonda blanca negra corchea

4. **TIMBRE: is the quality of sound that indicates WHO or WHAT is producing it.** This quality does not have a measurement unit and depends on the materials or the way in which the sound object is made.

MUSICAL LANGUAGE. In music, the timbre is represented by writing the name of the musical instruments that appear.



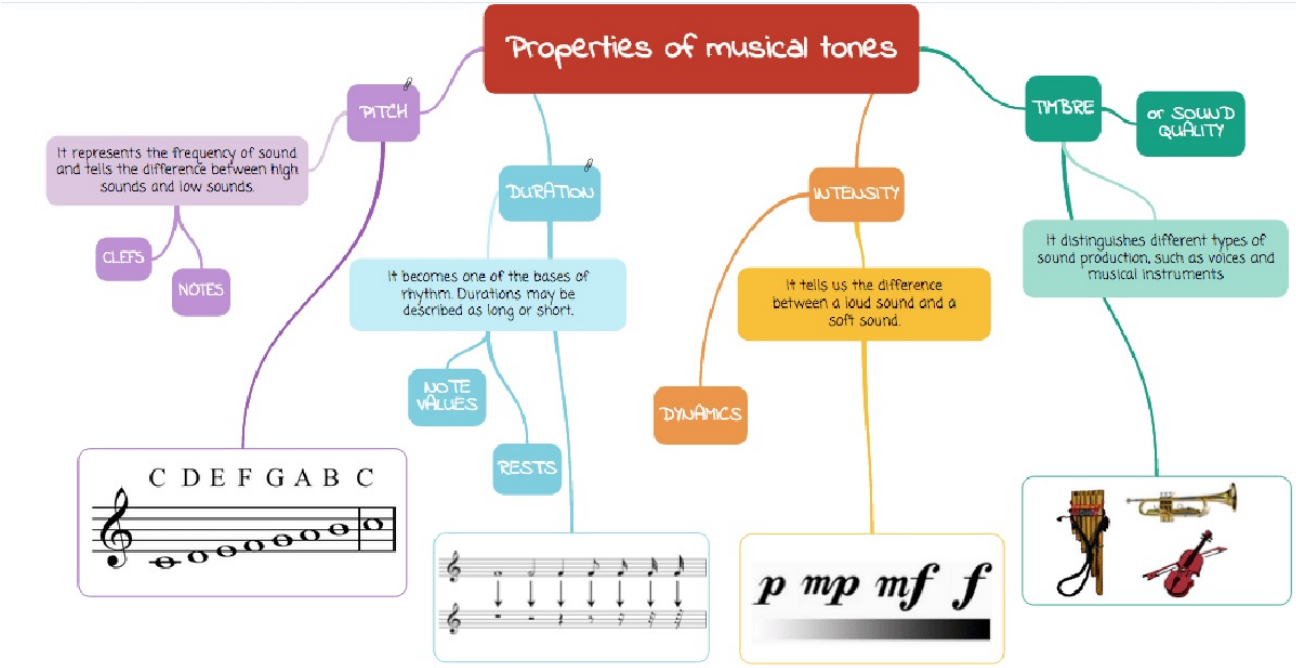


CONCEPTS:

- **Noise:** is produced by the same vibratory process described when speaking of sound, however it is not formed by regular vibrations but by irregular vibrations. It can also be defined as “unwanted sound”.

  That is why the noise is often unpleasant and annoying. It does not provide a clear feeling of height. Musical instruments such as tambourines, Chinese boxes, cymbals, etc. produce undetermined sounds.

- **Silence**: does not exist. You cannot hear the absolute silence. If we tried to create a situation of absolute silence, we would hear our own body (heartbeat or blood circulation).



- **Sound Level Meter**: device used to measure the intensity of sound, i.e., the amount of decibels in a place. It is used to check the noise outside discotheques, the noise that workers must endure in factories, etc.

  Nowadays, there are apps that work as sound level meters and make interesting measurements of our environment.

- **Tuning fork**: device used to tune musical instruments. It can be a fork, which always gives the A of 440 vib/s, or electronic, adapted to each instrument.

- **Metrónome**. Device use to measure the speed of the beat.

FENÓMENOS DEL SONIDO.

- **Eco**. Es el efecto del sonido que se produce cuando una onda sonora choca contra una superficie y se refleja con suficiente energía como para volver a su fuente de origen como un sonido repetido.

  Para que se produzca eco se tienen que dar unas **condiciones**: la superficie contra la que choca la onda debe estar al menos a 17m de distancia, y la onda sonora reflejada volver en **no menos de medio segundo**.

  Otra forma de explicarlo:

  Se suele tomar media décima de segundo (50 milisegundos= 50 *10 ^-3)

  Eco es la señal acústica percibida como dos o más señales desfasadas.
  Si el desfase temporal entre dos señales acústicas percibidas es inferior a 50ms, el receptor las percibe como una única señal. Si el desfase el superior a 50ms, las percibe como dos señales distintas (50ms = media décima de segundo).

  Dado que c ≈ 340 m/s, la diferencia de camino recorrida por el sonido directo y el reflejado debe ser de Δλ = c.t = 340. 50. 10^ -3 = 17 metros
  Límite no riguroso… depende del nivel de la segunda reflexión y del uso de la sala: palabra 30 ms; música 80 ms.

  El radar sónar que se puede ver en algunas películas antiguas de guerra se basa en la reflexión de las ondas sonoras en diferentes objetos.

- **Reverberación**.
  La reverberación es el efecto de permanecer el sonido en un espacio después de que la fuente haya cesado de emitir.

  Puede ser beneficioso y reforzar la sonoridad (si no se queda mucho tiempo), o ser nocivo (si se refleja con mucha intensidad y permanece mucho tiempo, lo cual ocurre en espacios grandes como los gimnasios o en las aulas vacías o que tienen muy pocos muebles y alumnos).

  En auditorios se busca un poco de reverberación, por ejemplo.

  Es importante no confundir del todo la absorción (que nos protege de la reverberación) y el aislamiento, que protege a los vecinos del ruido.

  Pueden ayudarse uno a otro, pero son conceptos diferentes y no siempre un buen aislamiento implica que no haya reverberación en tu aula y viceversa.

En nuestra aula de música las paredes y el techo tienen unos materiales especiales, absorbentes, que ayudan a que el ruido producido dentro de ella no sea atronador.

- **Efecto Doppler.** Es el cambio de frecuencia del sonido que se aprecia cuando el receptor está quieto y en cambio el objeto que produce el sonido se mueve.

  Si te paras cuando se acerca una ambulancia con la sirena funcionando, notarás que cuando se acerca a ti el sonido es agudo y cuando se aleja el sonido producido por la sirena se vuelve más grave.

Experience_9. Dale una bicicleta y un móvil a alguien que pueda pedalear con fuerza. Dile que pedalee en línea por delante de ti, desde 20 metros de distancia hasta otros 20 m más allá de donde te encuentres. Y que mientras pedalea esté sonando el móvil con un sonido fuerte y constante.