

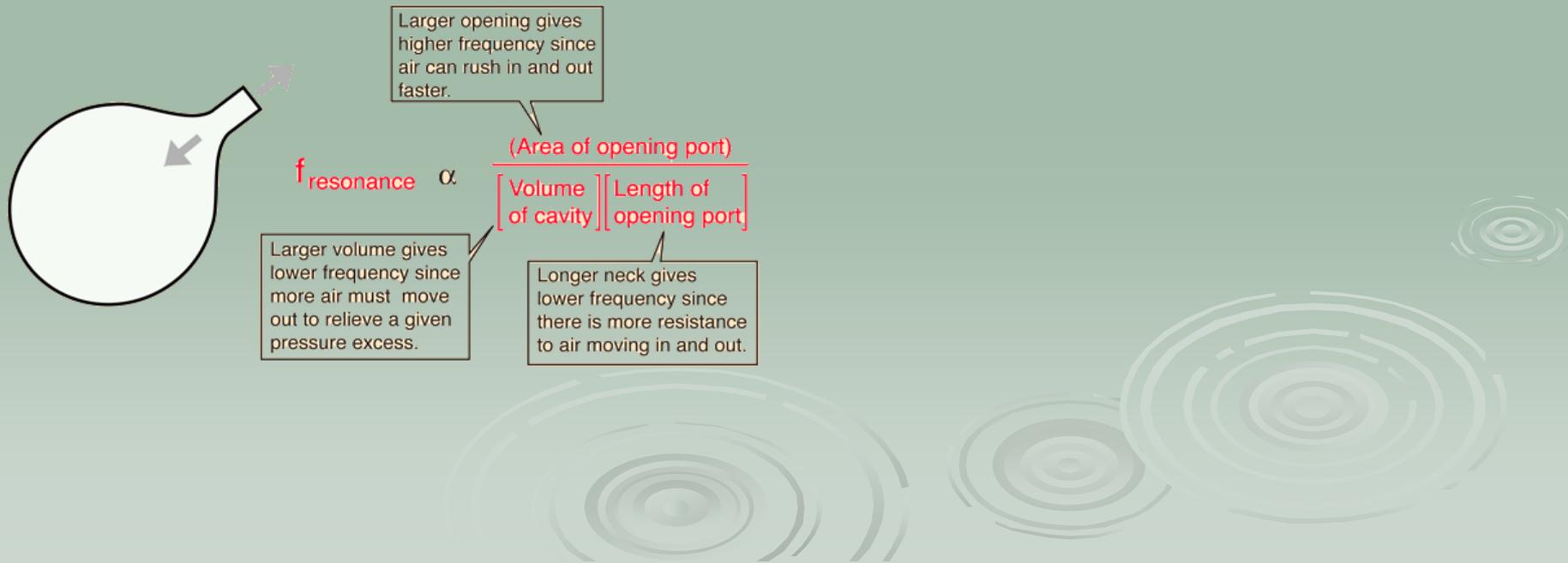
This is pages 17 – end 19.

Please EMAIL with any questions.



Resonance

- Natural Frequency – the frequency at which an object naturally vibrates due to its physical properties



- What would happen if the opera singer sang a note at the same natural frequency as the crystal wine glass?



- What would happen if the opera singer sang a note at the same natural frequency as the crystal wine glass?

The glass would shatter.





<https://www.youtube.com/watch?v=QGk8nXs6Aao>

Watch the video.

Resonance

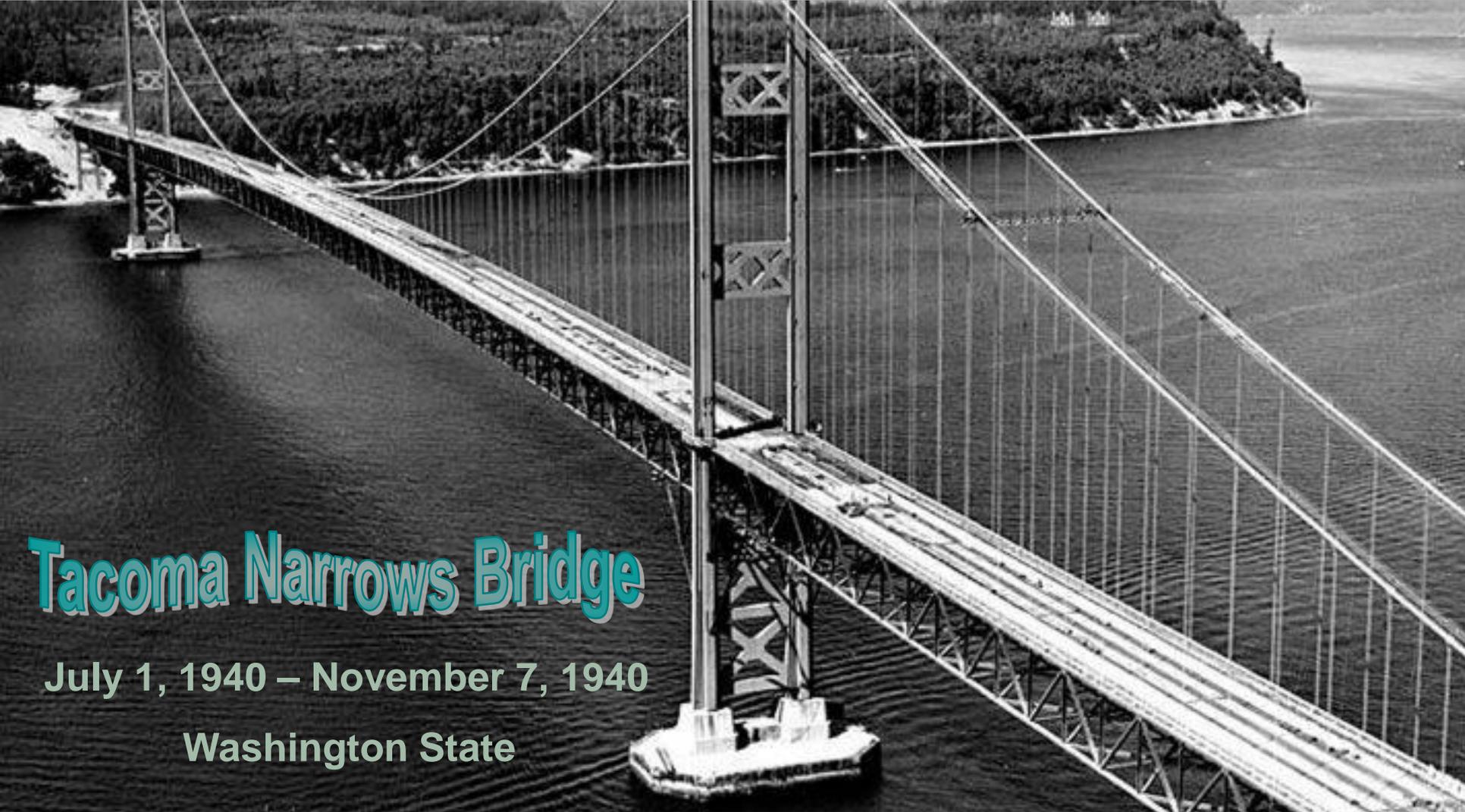
- Resonance – energy is transferred to a system by making it vibrate at its natural frequency resulting in large amplitude standing waves



Resonance

(You do not have to write down any of the following examples as long as you read them over and watch the video clips.)





Tacoma Narrows Bridge

July 1, 1940 – November 7, 1940

Washington State

Watch the video.

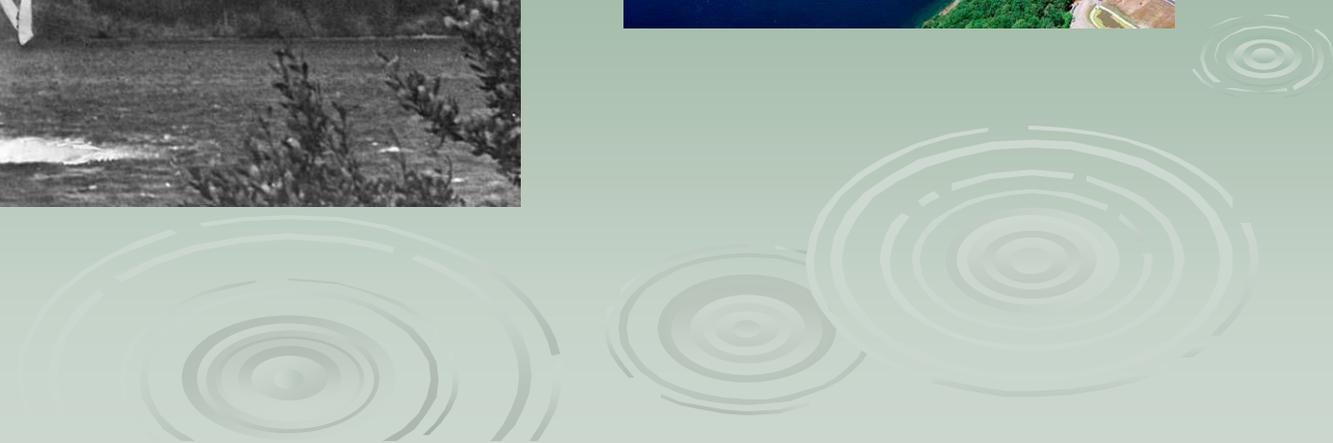
<https://www.youtube.com/watch?v=j-zczJXSxw>

Tacoma Narrows Bridge

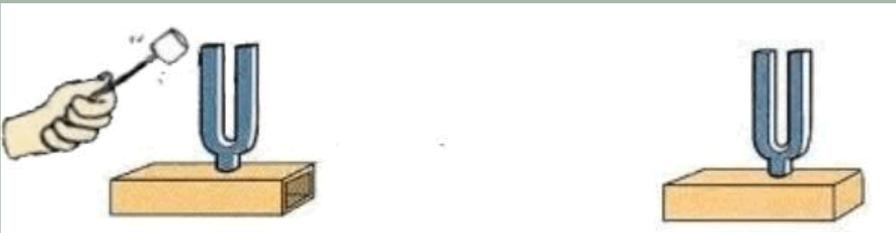
- Wind gusts at the natural frequency of the bridge.



Galloping Gertie



Tuning Forks on Resonance Boxes



<https://www.youtube.com/watch?v=4pEVI2Q86QM>



https://www.youtube.com/watch?v=E_Z

One tuning fork makes the other tuning fork vibrate, which you can hear inside the box.

Singing Wine Glasses



<https://www.youtube.com/watch?v=Il0DwYIfywk>

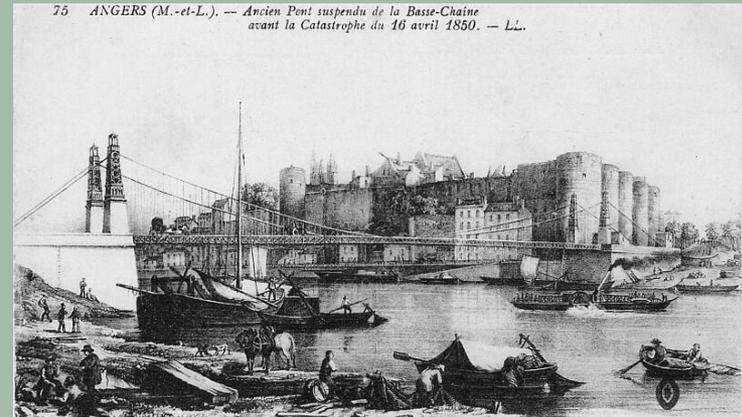
<https://www.youtube.com/watch?v=0JPJHYLEviA>

Watch the videos.

Broughton Suspension Bridge / Angers Bridge



In 1831, the Broughton suspension bridge in England collapsed when a column of soldiers crossed the bridge marching in step.

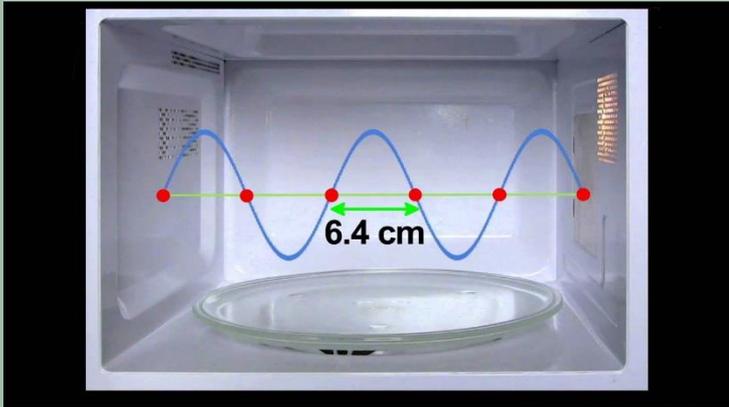


Angers Bridge, also called the **Basse-Chaine Bridge**, was a suspension bridge over the Maine River in Angers, France. The bridge collapsed on 16 April 1850, while a battalion of French soldiers was marching across it, killing over 200 of them.

Millennium Bridge

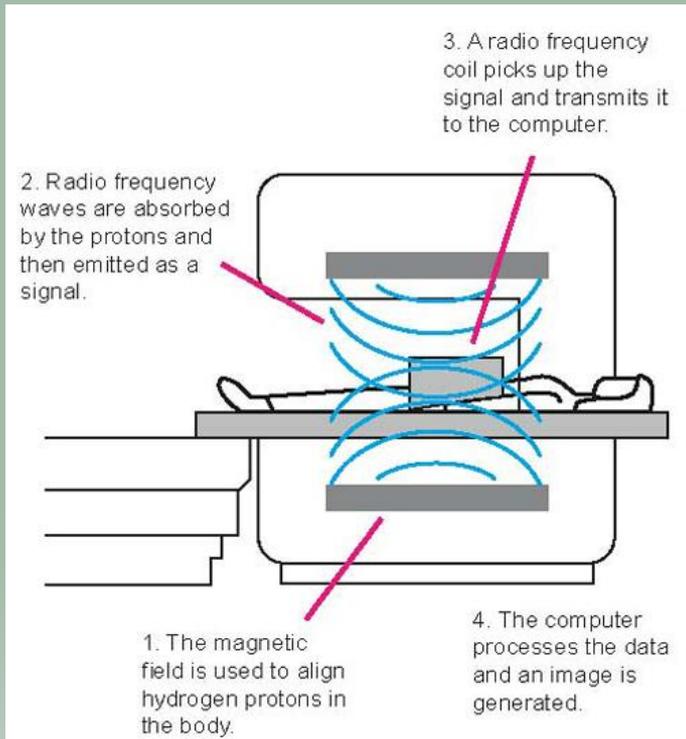
The Millennium Bridge in London was opened to the public on June 10, 2000. Due to excessive vibration caused by pedestrian traffic, it was shutdown after two days, retrofit with 37 fluid viscous dampers, and re-opened on February 22, 2002.

Microwave



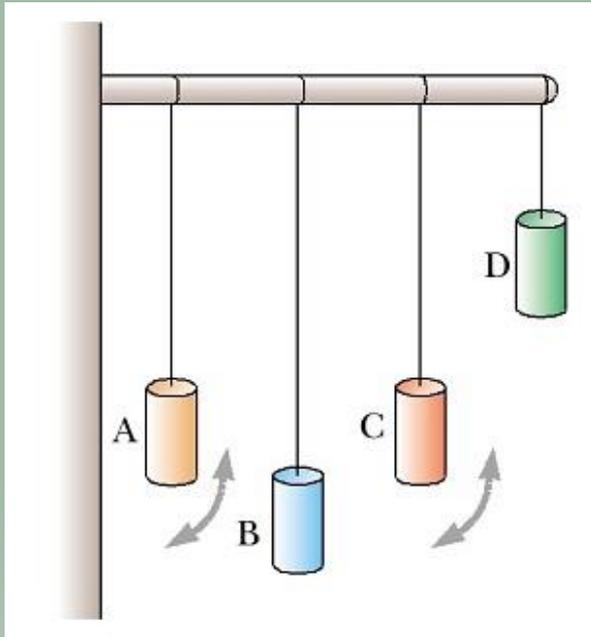
Microwave ovens match the natural frequency of water

MRI Scanner



MRI matches the frequency of hydrogen atom.

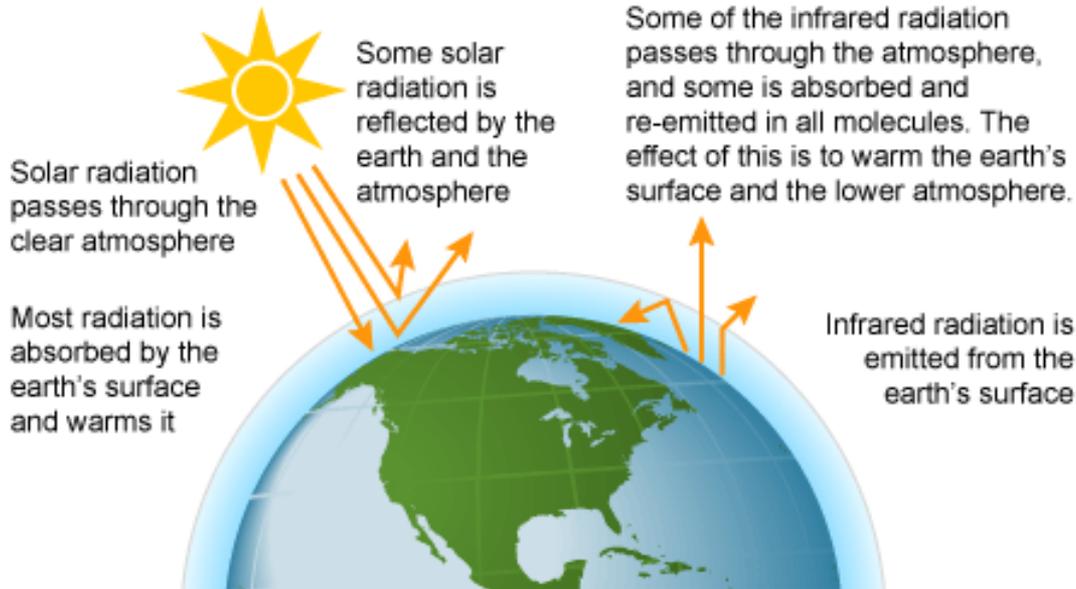
Pendulums & Swings



One pendulum causes another pendulum with the same length to swing. Push swings at natural frequency.

Greenhouse Gases

The greenhouse effect



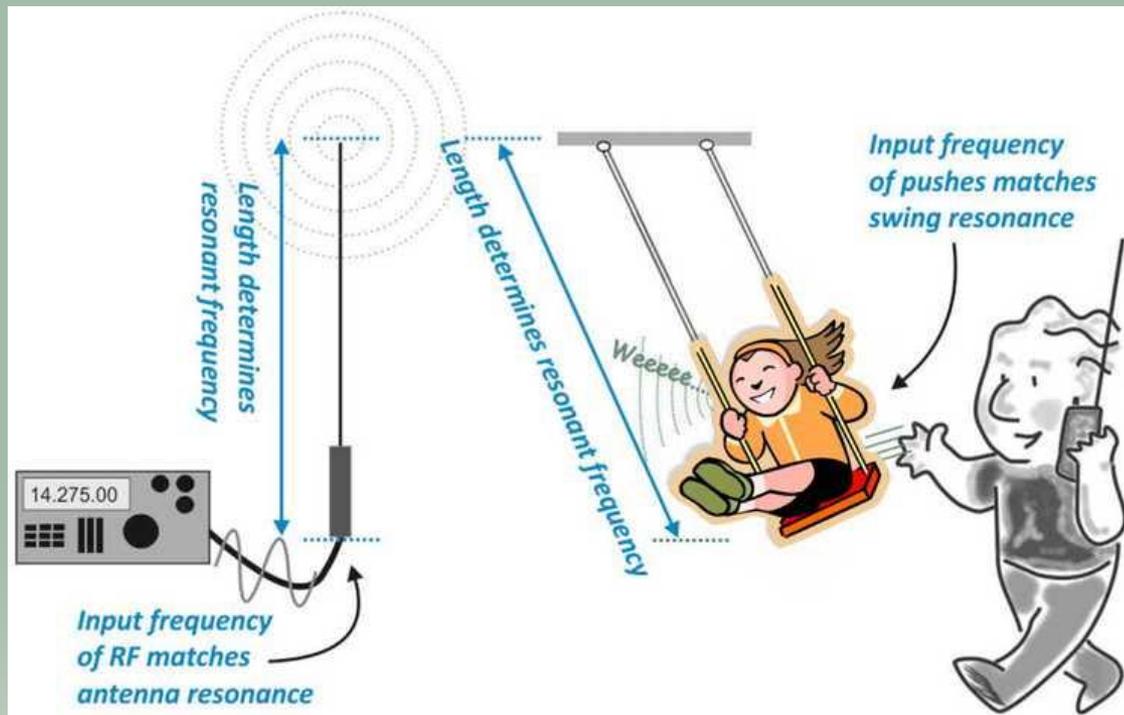
Natural frequency of CO_2 matches frequencies of infrared radiation

Skyscrapers



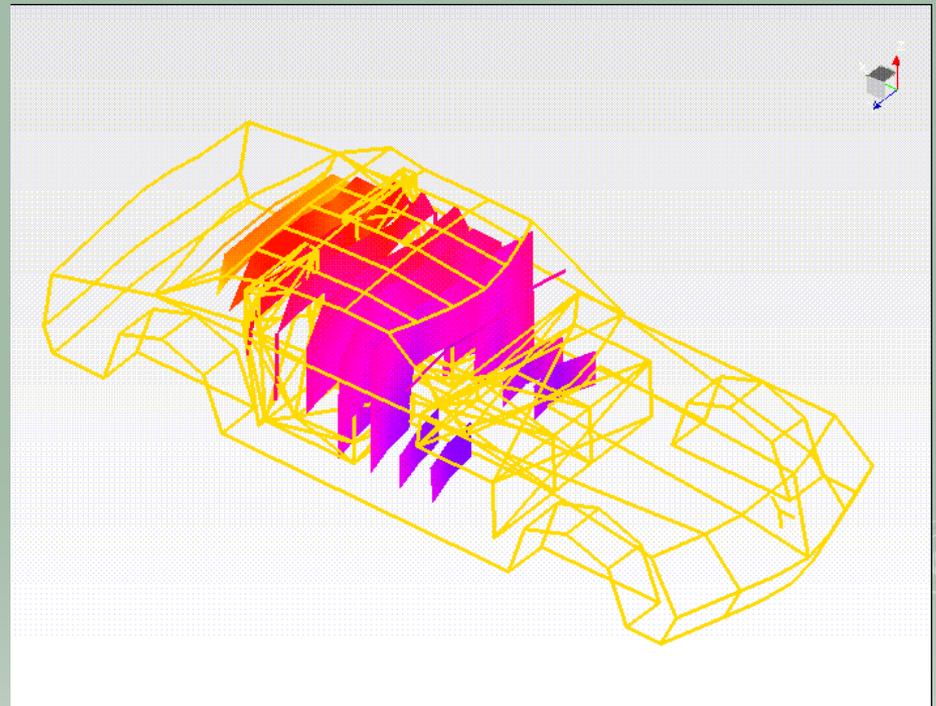
Tuned dynamic absorbers also are used to help reduce the swaying vibration in buildings. The Taipei 101 skyscraper contains the world's largest and heaviest tuned mass dampers, at 660 metric tons (730 short tons). The damper is tuned to the swaying mode of the building. The tuned absorber is viewable by the public on an indoor observation deck at the top of the skyscraper. It cost an estimated \$4 million to build.

Antennas



Air in Car

Rolled the rear windows down while driving and heard a beating sound? That beating sound (sometimes also called buffeting) is amplified by a resonance of the vehicle air cavity. Even air can have a resonance!



Pokemon

- This screenshot from the cartoon show Pokémon catches a critical moment in the episode "Electric Soldier Porygon." When the program first aired in Japan on Dec. 16, 1997, a scene in which the pocket monster Pikachu used his Thunderbolt attack caused hundreds of Japanese children to go into epilepsy-like seizures.

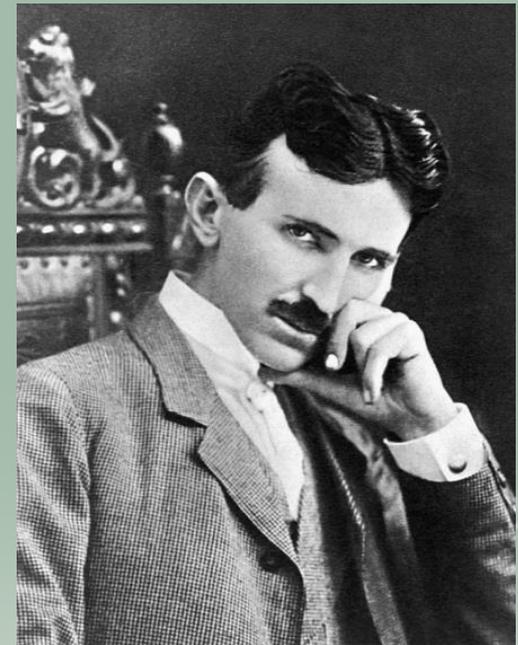
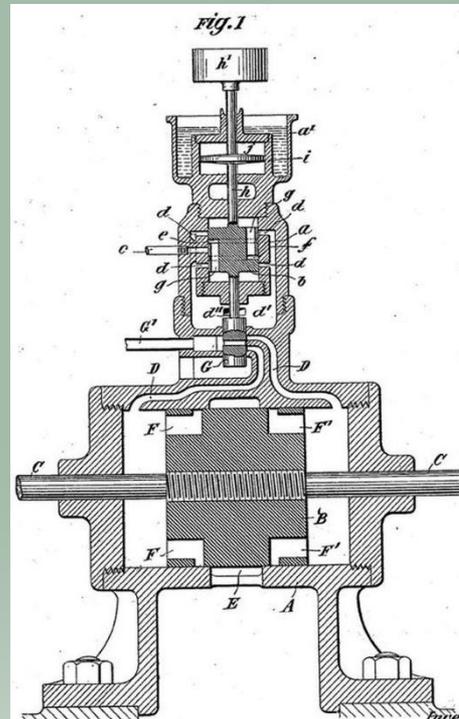


Resonance was one of Tesla's greatest passions.

In 1896 Tesla was working on oscillations to be used for energy transfer. The idea was to create a steam-powered oscillator, able to create various frequencies. If the frequency matched the resonance frequency, a receiving device should transform the mechanical oscillations back into an electric current.

In 1897 the device was ready and in 1898 he supposedly managed to oscillate his laboratory at 48 E. Houston St., New York, enough, that alarmed neighbors called the police and ambulance, fearing an earthquake happening.

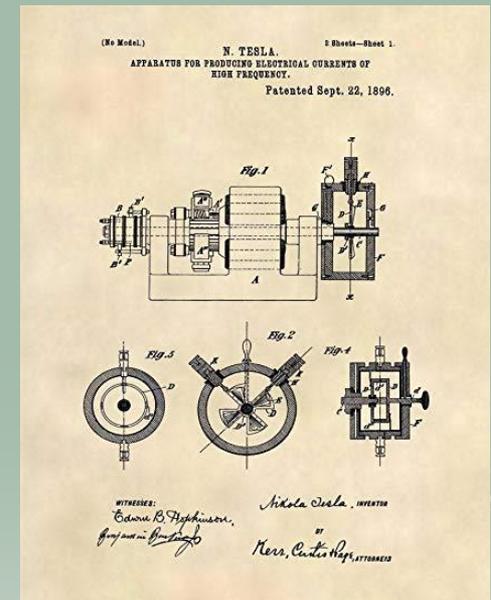
Nikola Tesla



Nikola Tesla

Resonance was one of Tesla's greatest passions.

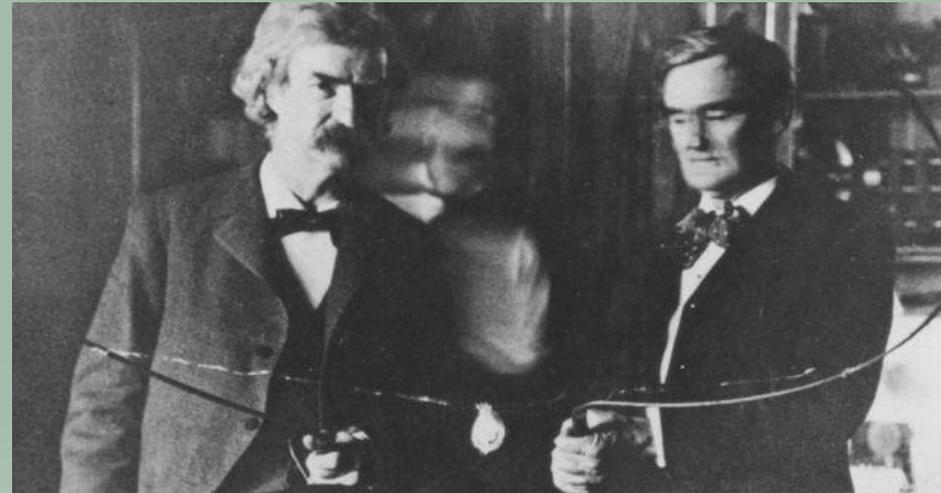
In 1943 the Supreme Court ruled that Tesla's radio patents had preceded all others including Marconi's .



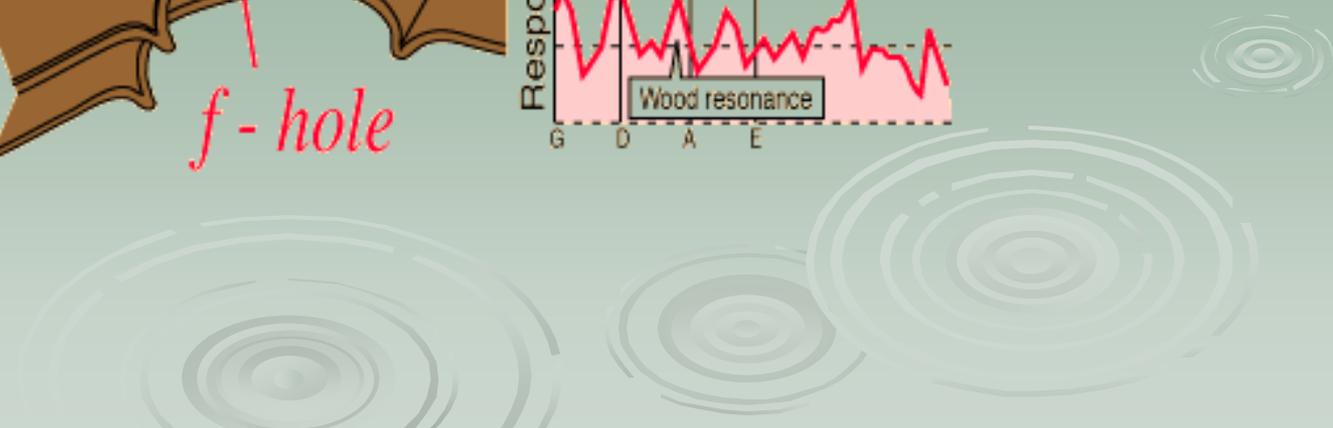
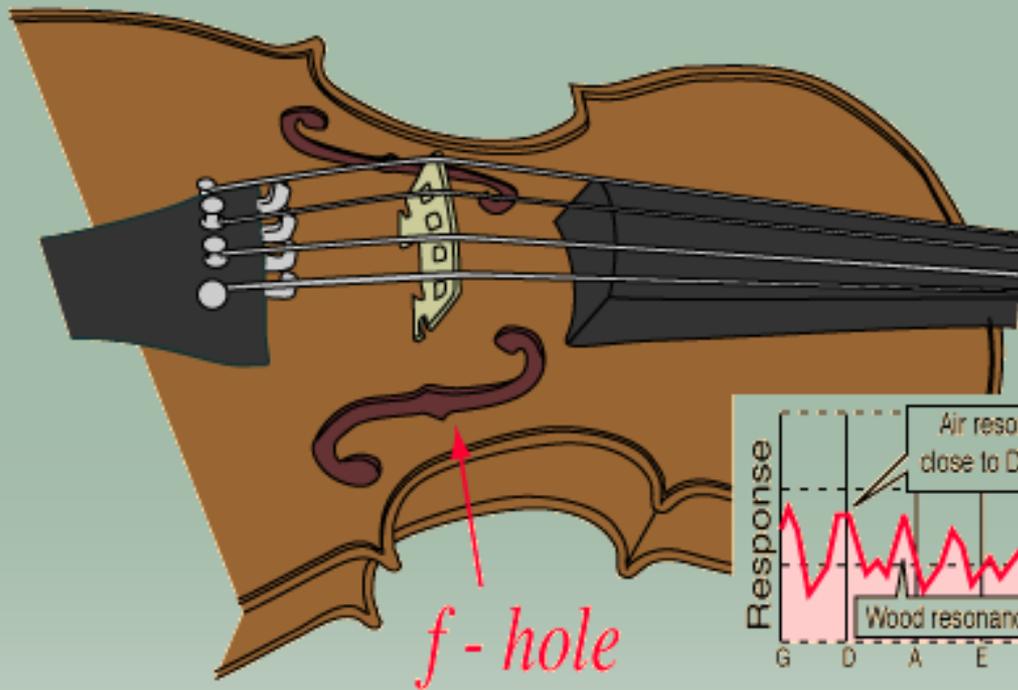
Nikola Tesla

Resonance was one of Tesla's greatest passions.

For entertainment, Tesla once convinced his good friend Mark Twain to test out a vibrating platform in his Manhattan lab. Twain took him up on the offer and found it to his liking. When Tesla commanded Twain to come down off the platform Twain refused because he was having a good time. A few minutes later Twain ran from the device. It seems that Tesla had deliberately neglected to tell Twain that the vibration tended to cause diarrhea.

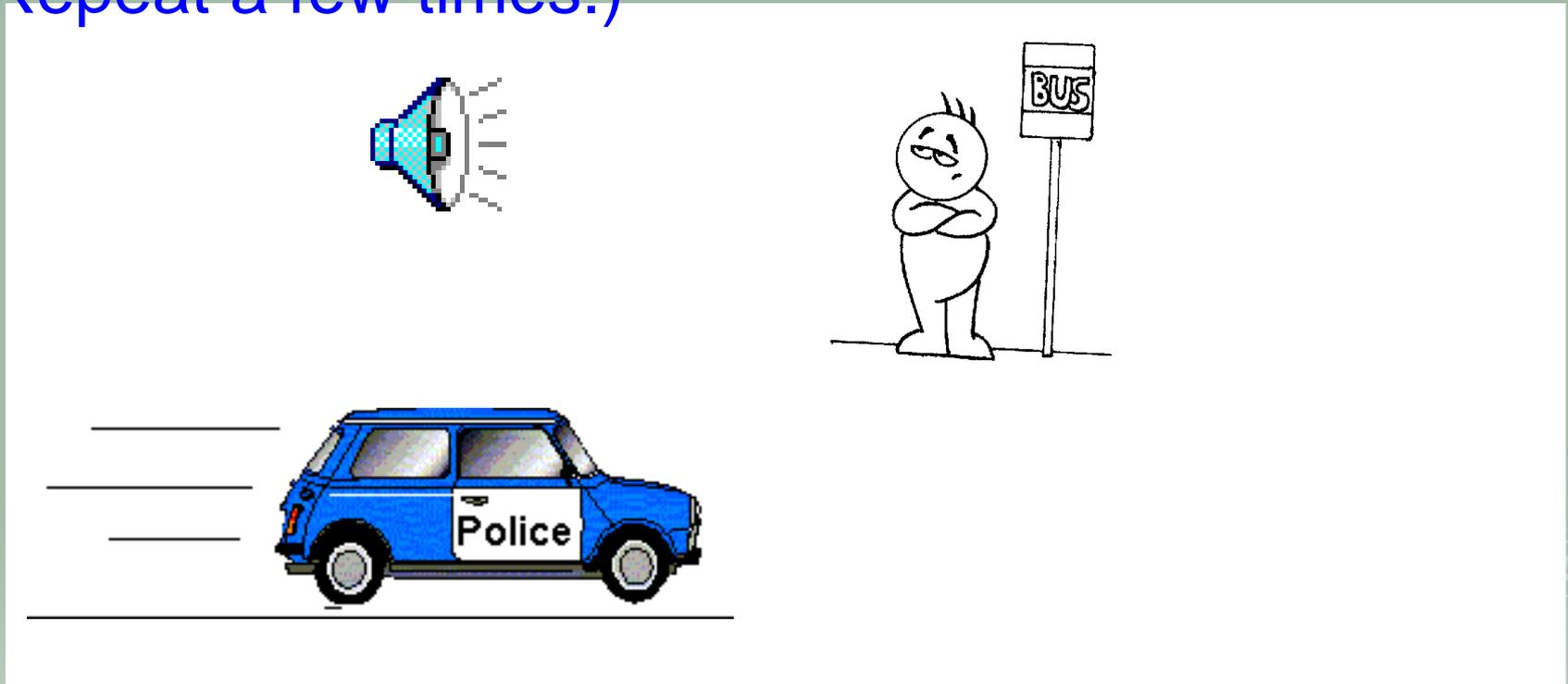


Other Examples of Resonance



Doppler Effect

(Click on speaker icon to hear sound effect.
Repeat a few times.)



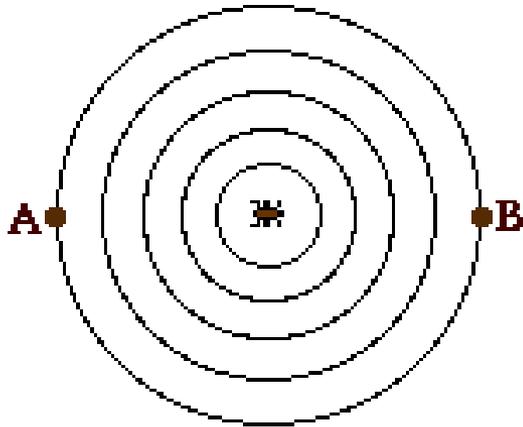
Doppler Effect

(What did you hear?)

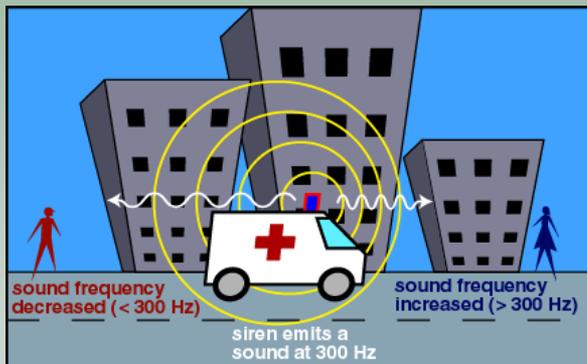
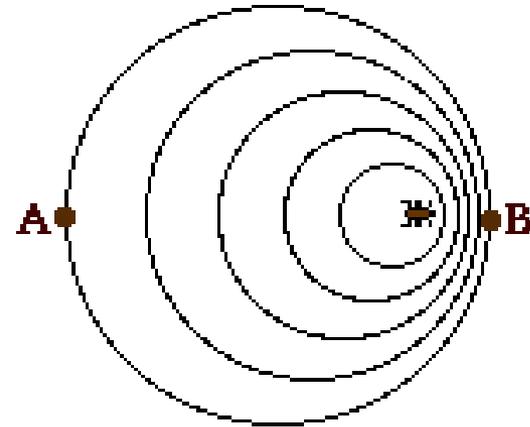


Doppler Effect

Stationary Source

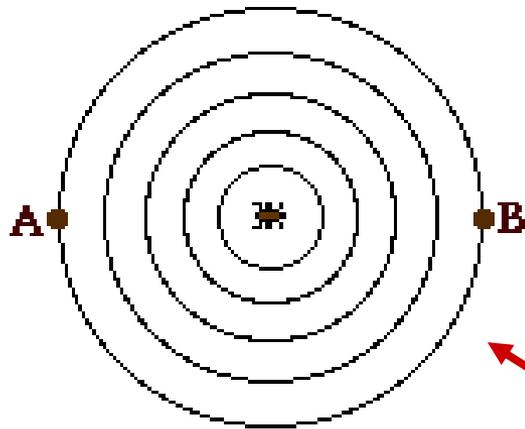


Moving Source

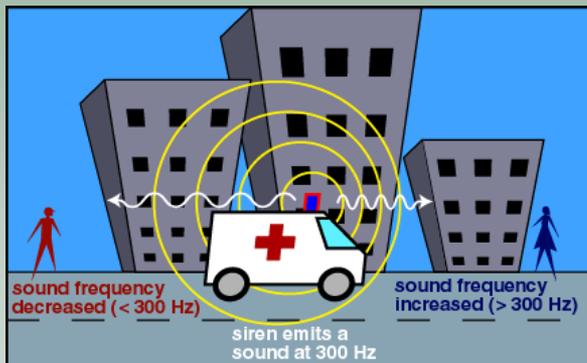
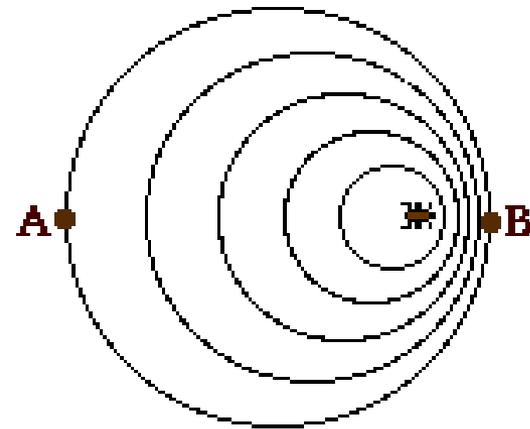


Doppler Effect

Stationary Source

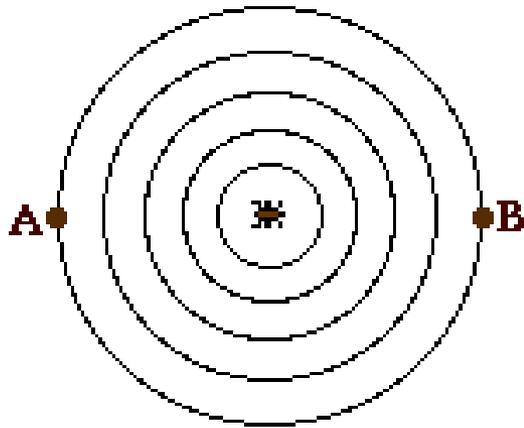


Moving Source

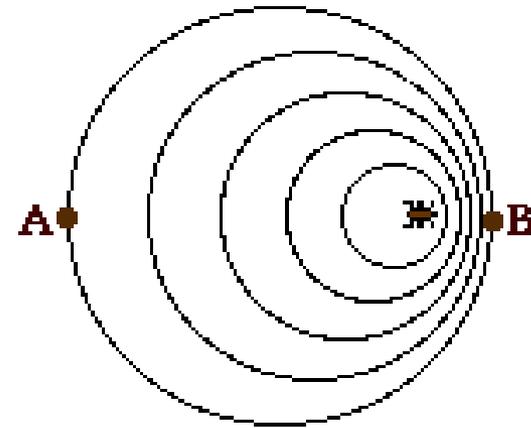


Stationary is regular sound because they just spread outwards.

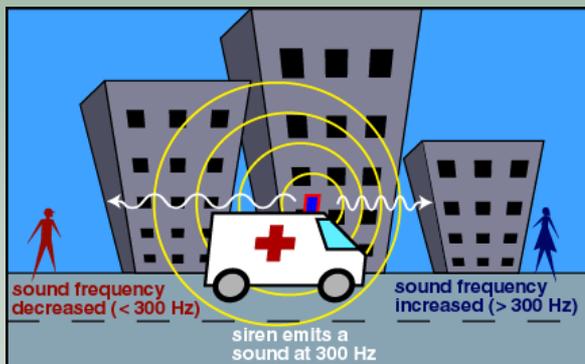
Stationary Source



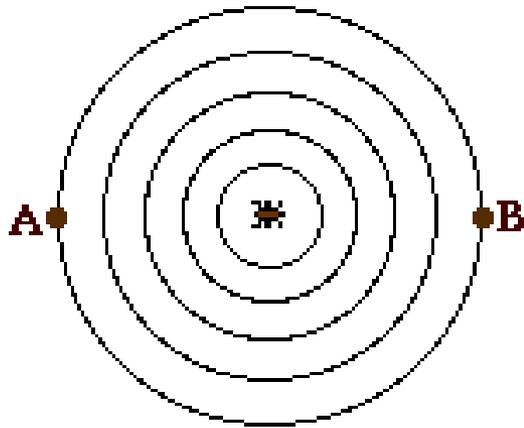
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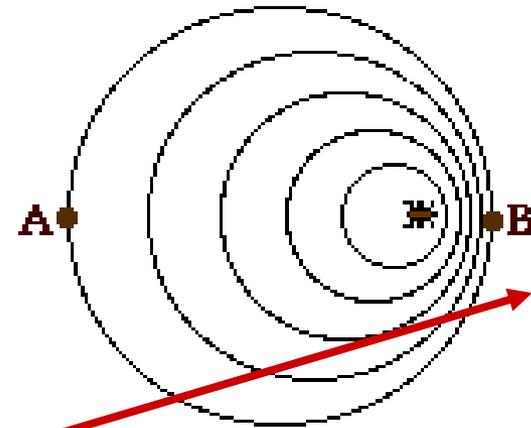
Side A: The sound waves get spread out, this increases wavelength, which decreases frequency. This produces low pitch sounds.



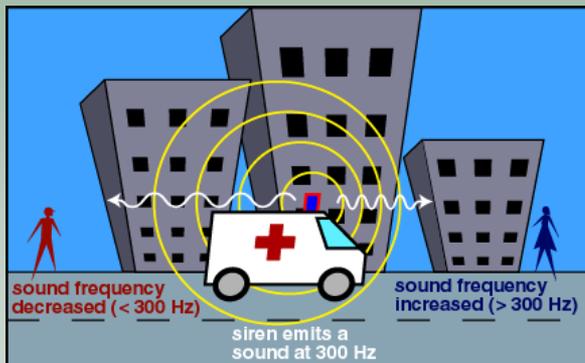
Stationary Source



Moving Source



Side B: The sound waves get compressed, this decreases wavelength, which increases frequency. This produces high pitch sounds.



Breaking the Sound Barrier



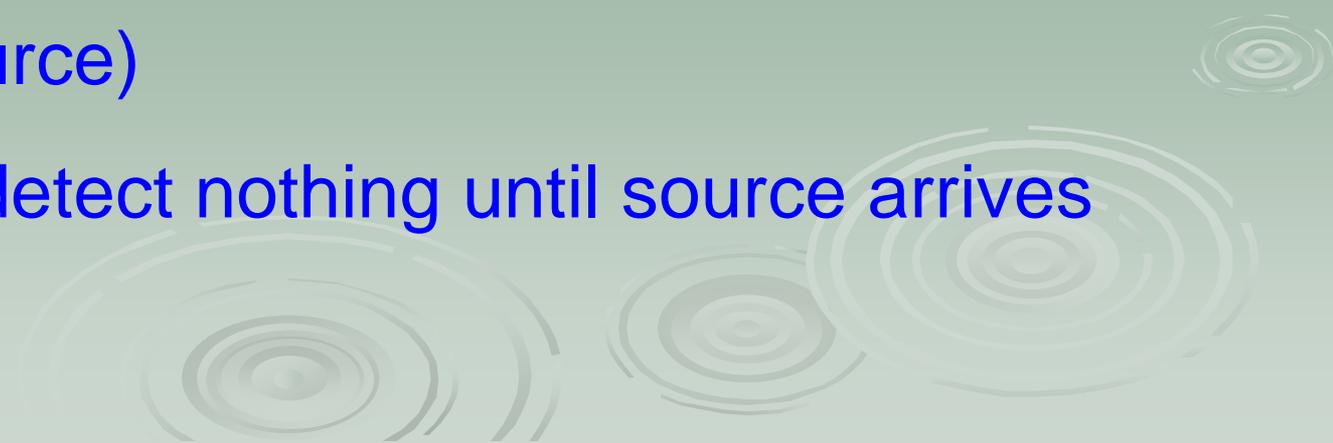
<https://www.youtube.com/watch?v=x6DUbxCpszU&t=11s>

(sonic boom)

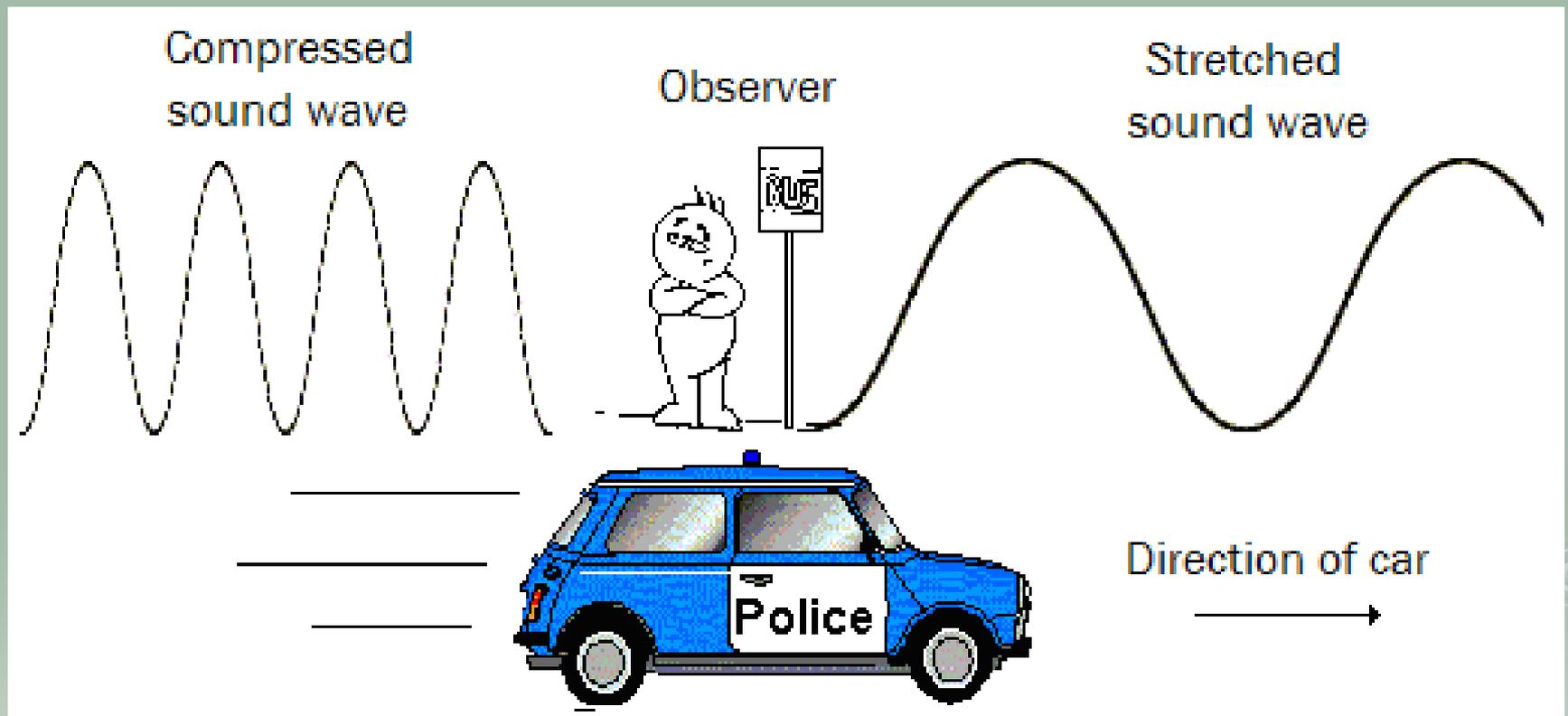
(You don't have to write this, just read it over.)

Breaking the Sound Barrier

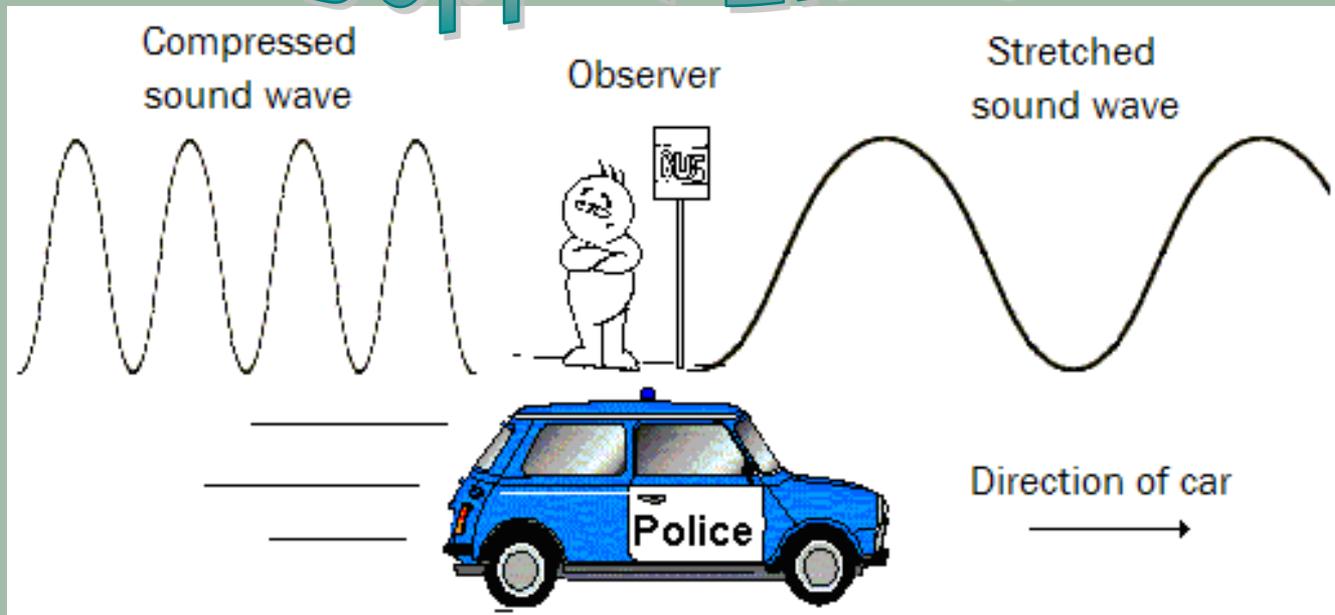
- The plane travels at same speed as sound.
- The white cloud is condensed water vapor caused by drop in air pressure.
- The wave fronts all bunch up at same point (moving source)
- Observers detect nothing until source arrives



Doppler Effect

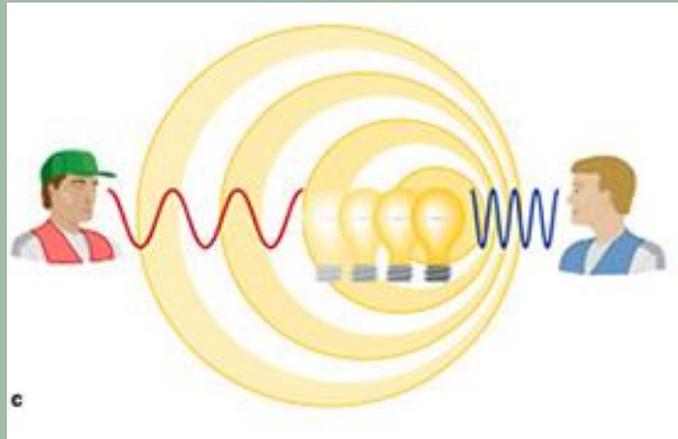


Doppler Effect



- Compressed sound waves produce a **higher** frequency and a **higher** pitch.
- Stretched sound waves produce a **lower** frequency and a **lower** pitch.

Doppler Effect on Light

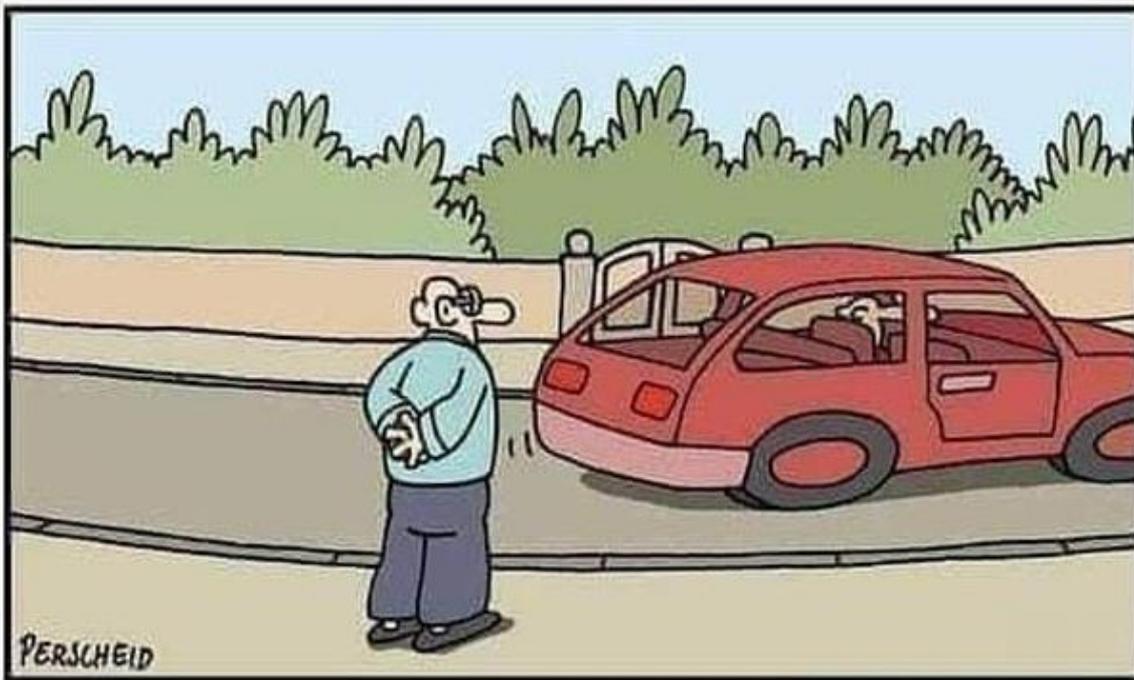
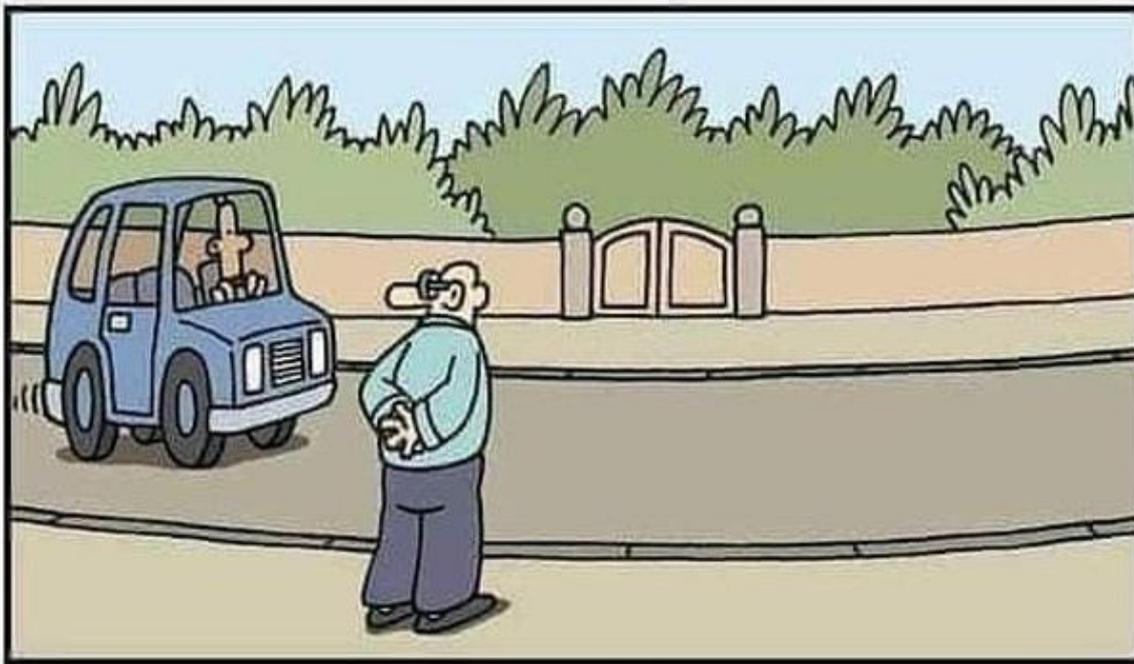


Redshift

Blueshift

The light of an object moving **AWAY** from an observer is shifted toward a **longer wavelength**, or toward the color **red**.

The light of an object moving **TOWARD** an observer is shifted toward a **shorter wavelength**, or toward the color **blue**.

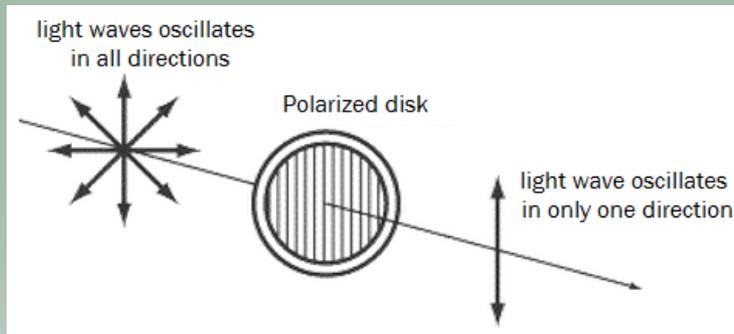


HA HA HA



Polarization

- Polarization – light that is transmitted through a certain medium so that all vibrations are restricted to a single plane
 - Provides proof that light is a wave



(Sound cannot be polarized because it is longitudinal)

