

Resonance & Doppler Effect

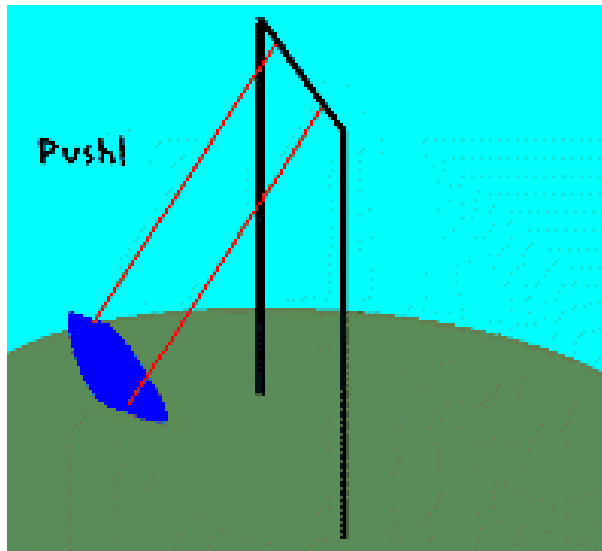


National Science Foundation
WHERE DISCOVERIES BEGIN

Resonance

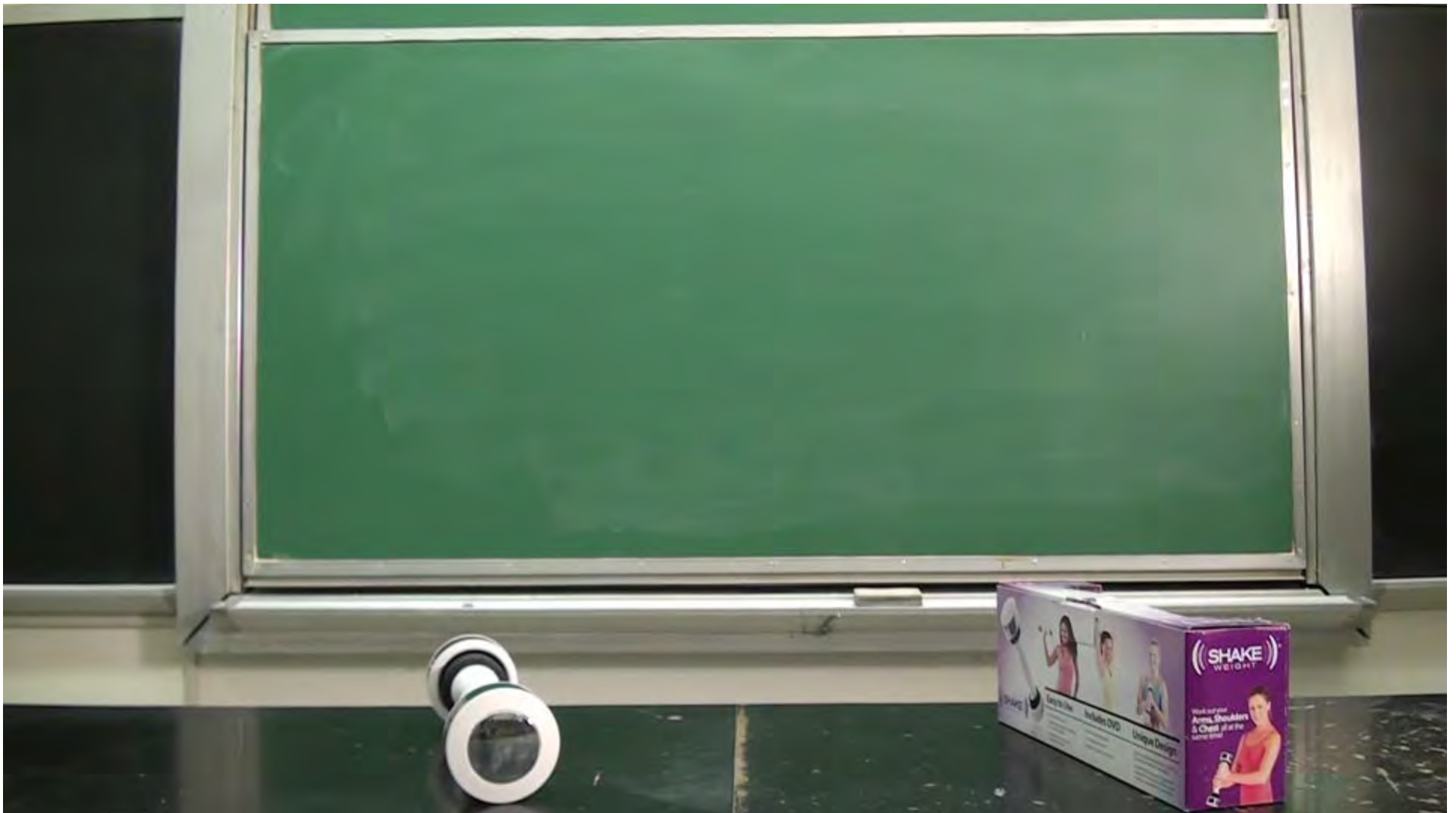
Resonance occurs when forced vibrations match an object's natural frequency.

Oscillations grow in amplitude due to synchronized transfer of energy into the vibrating object.



Resonance

If you shake too slow or too fast
then very little energy goes into
the Shake Weight®



Acoustic Resonance

If the amplitude of the sound is sufficiently large, resonant vibrations can shatter a wine glass.

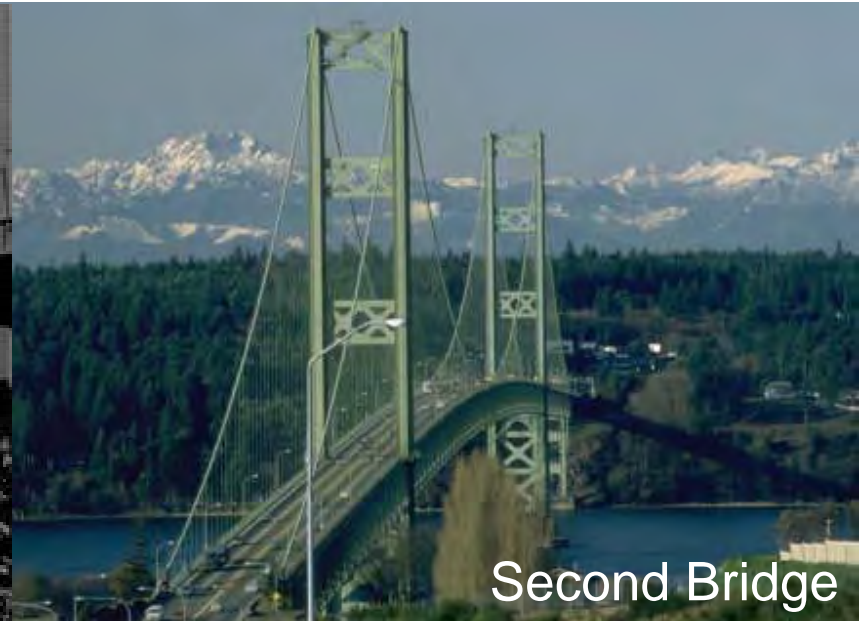


<http://www.youtube.com/watch?v=BE827gwnnk4>

This may be achieved by exceptionally powerful singers (and by average singers using electronic amplifiers).

Tacoma Narrows Bridge

In 1940, the first Tacoma Narrows bridge was destroyed by resonance.



Wind-forced oscillations that happened to match one of the bridge's natural frequencies.

Tacoma Narrows Bridge



<http://www.youtube.com/watch?v=j-zczJXSxnw>

Doppler Effect

Sound coming from a moving object has a different wavelength and frequency than if it were stationary.

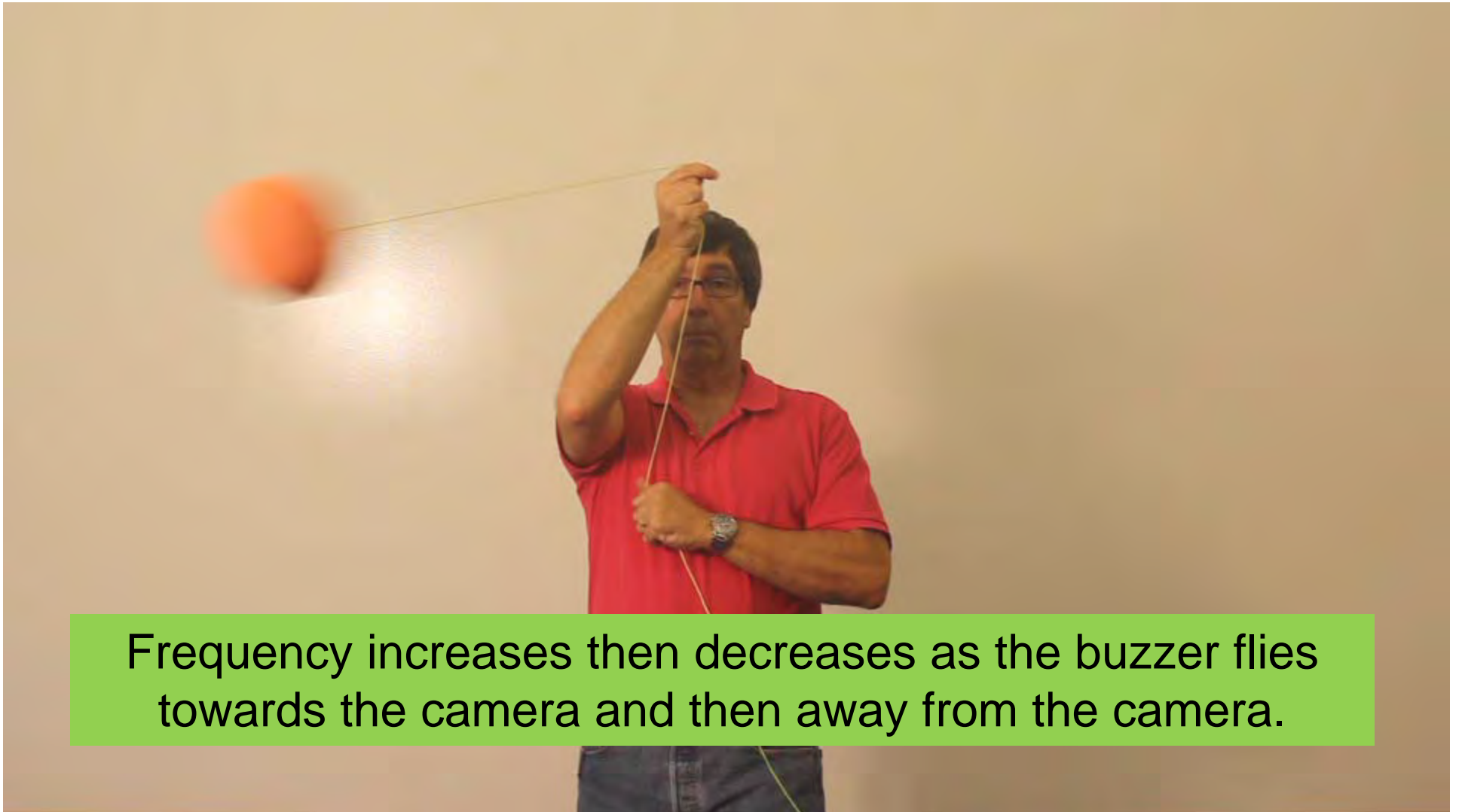
If moving towards you, wavelength shorter and frequency higher.

If moving away, wavelength longer and frequency lower.

Video



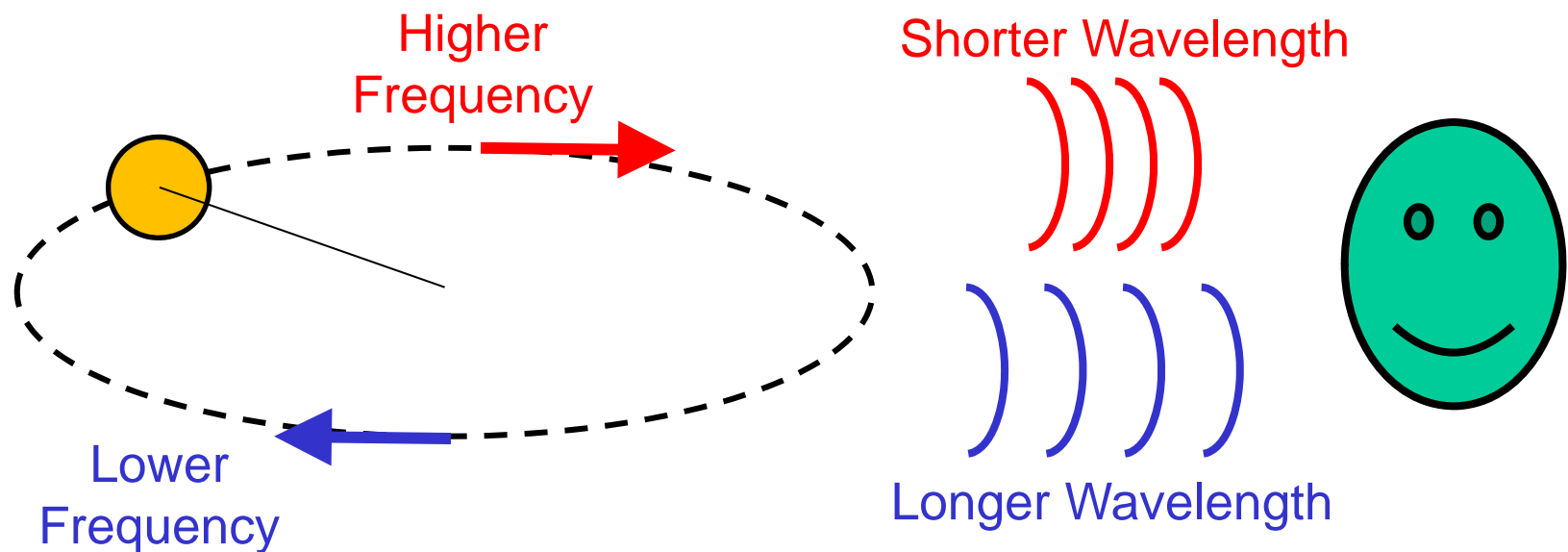
Doppler Effect



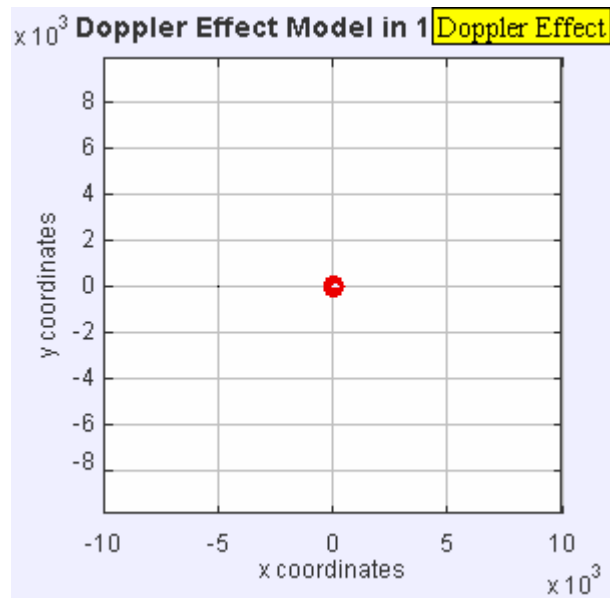
Frequency increases then decreases as the buzzer flies towards the camera and then away from the camera.

Doppler Effect

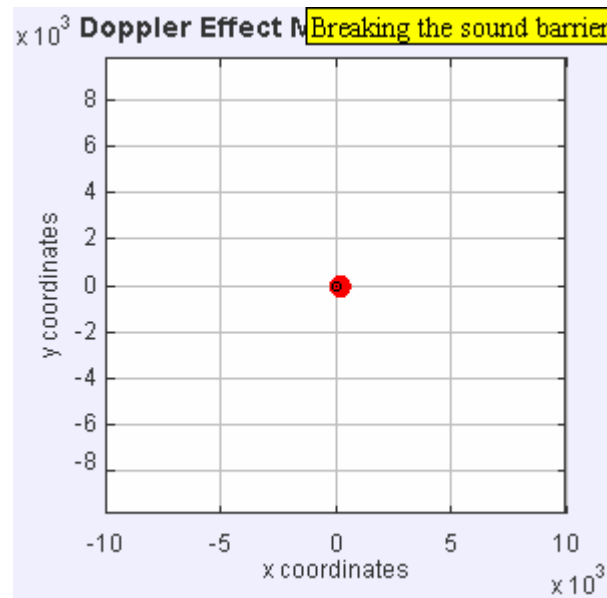
Frequency increases as buzzer flies towards you.
Frequency decreases as it flies away from you.



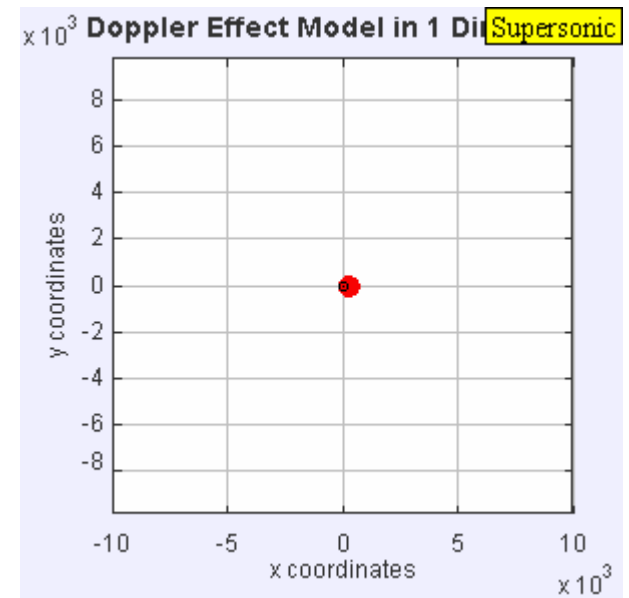
Doppler Effect and Shocks



Below wave speed



Source speed = wave speed

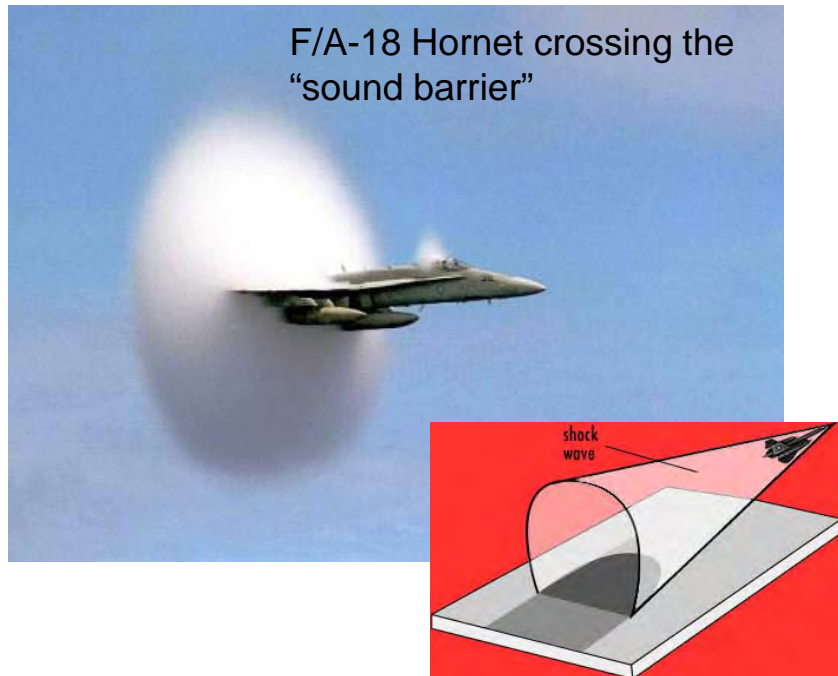


Above wave speed

When the source travels at or above the speed of sound (Mach 1 or more), the wavelength goes to zero and a shock wave is formed.

Sonic Boom

A intense shock wave is formed when a plane travels faster than the speed of sound (765 mph).



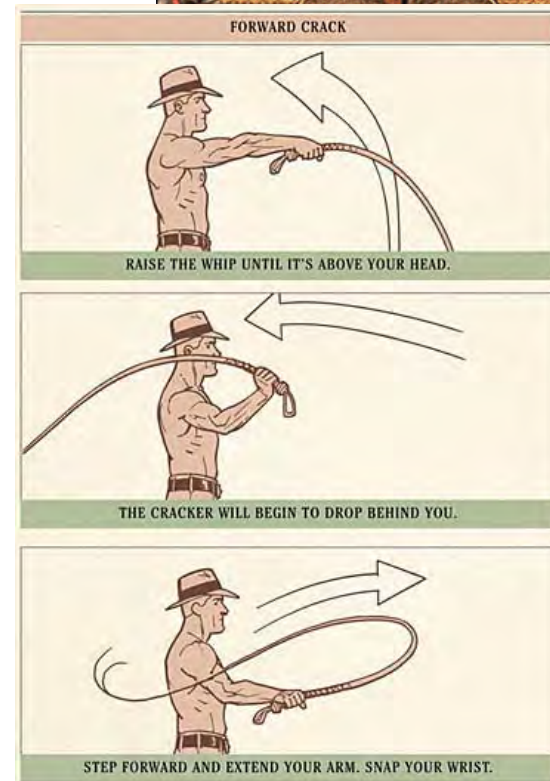
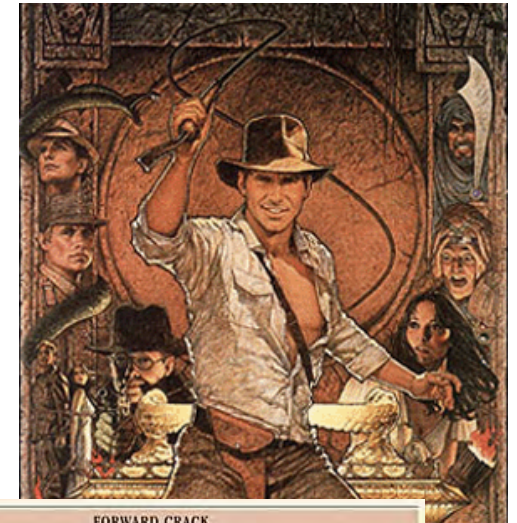
<http://www.youtube.com/watch?v=QX04ySm4TTk>

Loudness of a sonic boom is about 130-135 decibels.

Cracking the Whip

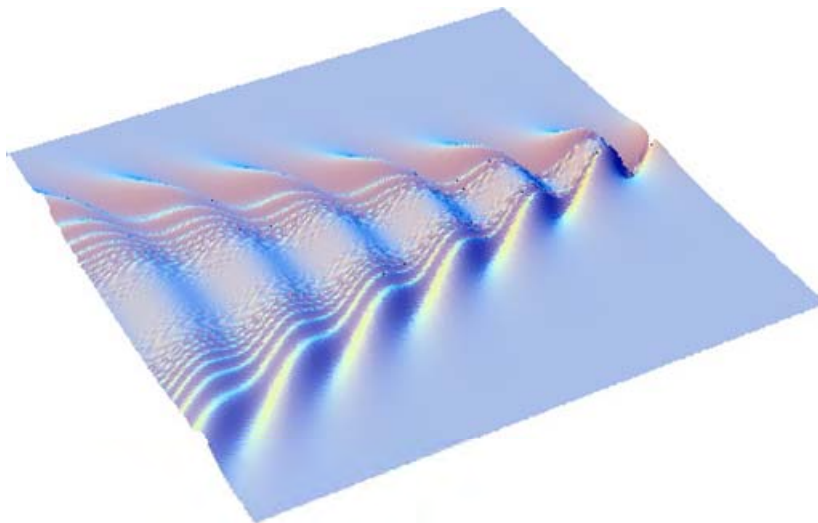
The whip goes faster and faster as the length unfurls. The tip of the whip can reach supersonic speed, creating a sonic boom at the snap.

<http://www.youtube.com/watch?v=Od7JBEIQi7M>



Water Wakes

Water wakes are similar to sonic cones. Water waves are slow so wakes are common but more complex in shape.



Summary

- Resonance occurs when forced vibrations match an object's natural frequency.
- Resonant oscillations may grow exponentially due to the steady, synchronized transfer of energy into the vibrating object.
- By the Doppler Effect, waves coming from a moving object have a different wavelength and frequency than if the object were stationary.
- If moving towards you, wavelength is shorter and frequency higher. If moving away, wavelength is longer and frequency lower.