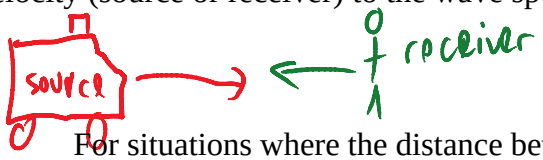
Doppler Effect

Wednesday, May 19, 2010
12:34 PM

Amplitude = volume

frequency = pitch

The Doppler Effect is a shift in frequency caused by either a moving source or moving receiver. The frequency shift is approximately equal to the ratio of the velocity (source or receiver) to the wave speed.



For situations where the distance between the source and receiver is decreasing, the shift decreases λ and increases f. The reverse is true when distance between source and receiver is increased.

The reason this occurs is because of the change in location of the source/ receiver after it emits / receives one pulse and then emits / receives the next pulse.

See here: http://lectureonline.cl.msu.edu/~mmp/applist/doppler/d.htm
Image: D:\My Documents\strachan\Physics 11AP\sonicboomplane.jpg

The actual formulas regarding what is called the Doppler Effect are:

$$f' = f \frac{\left(1 \pm \frac{V_r}{V_w}\right)}{\left(1 \mp \frac{V_s}{}\right)}$$

f' = ? f = emitted

V_r = velocity of receiver

V_w = velocity of wave (sound in air 343 m/s)

V_s = velocity of source

detected frequency

emitted frequency

$\left(1 \pm \frac{V_s}{V_w}\right)$ — V_s: velocity of source; V_w: velocity of wave (sound in air 343 m/s)

when the source & receiver are getting closer

when the source & receiver are separating

A cat of mass 10 kg is travelling at 15 m/s making a yowl at 200 Hz toward a car of mass 1500 kg approaching the cat at 30 m/s. What frequency is detected by the driver and will the cat live if the driver will run it over at any frequency greater than 212 Hz?

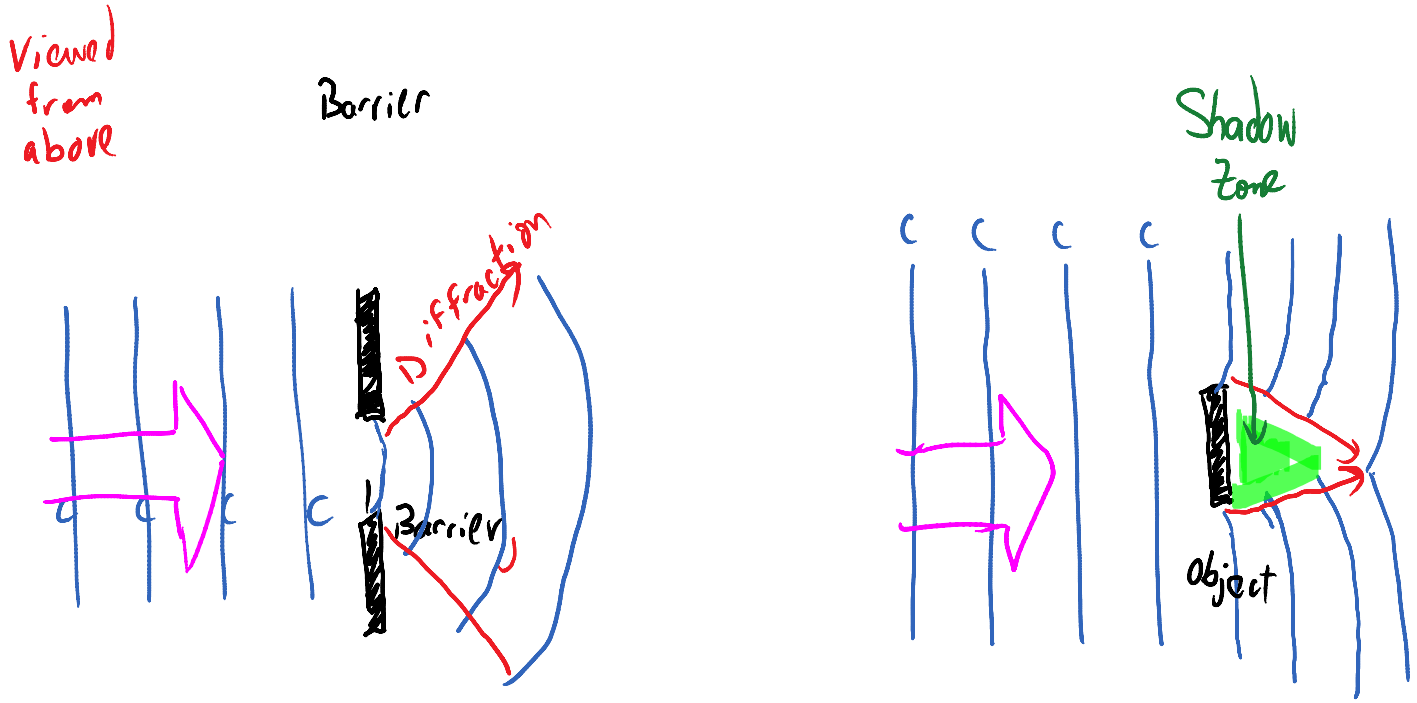
$$f' = f \frac{\left(1 \pm \frac{V_r}{V_w}\right)}{\left(1 \mp \frac{V_s}{V_w}\right)}$$

$$200 \frac{\left(1 + \frac{30}{343}\right)}{\left(1 - \frac{15}{343}\right)} = 200 \frac{(1.087)}{(.956)} = 227 \text{ Hz}$$

Application of the Doppler Effect:
Obvious applications include moving sound sources like sirens on vehicles. Sonic booms and shock waves are produced due to motion at or faster than the speed of sound due to constructive interference of the wave. Others include Doppler Radar for weather forecasting. Here radar signals (an EM wave) are beamed toward a target, as the beam is reflected the object then acts as a source, by comparing the shift in frequency from the original beam the velocity of the object is determined, used for detecting rotation in clouds. This is used in: radar guns for speeding, air traffic control, rain tracking, bomber flight speed control.

Other places the Doppler effect is seen is in light from distant stars and galaxies. As they approach us the frequency of light is increased creating a shift toward the blue side of the visible spectrum (called blue shift) and the reverse is true for objects moving away from Earth (red shifted).

Diffraction: The bending of waves around an object or through an opening. It works best when the Object or opening is approximately equal to the wavelength.



Polarizing removes one of the components (vertical or horizontal) of a transverse wave.

Polarizing filters stacked perpendicularly will block transmission of transverse wave.

you can NOT polarize sound wave

Polarizing filters stacked perpendicularly will block transmission of transverse wave.

This projector uses specially polarized light by colour.

A car horn has frequency 800 Hz, and is travelling toward a jogger at 36 m/s if the jogger is running at the car at 10 m/s find the frequency detected by a) the jogger, b) the driver!!!!

Examples:
Two sources, both moving at 25 m/s produces sound waves at 1600 Hz, find the shifted frequencies received if one source is moving toward and the other away from the receiver.

1. f' = f / (1 – Vs/Vw) = 1600 / (1 – 25 / 343) = 1726Hz
2. f' = f / (1 + Vs/Vw) = 1600 / (1 + 25 / 343) = 1491Hz

What beat frequency would be detected by the receiver?

$f_{beat} = \Delta f = 1726 - 1491 = 235$ Hz

Polarization

This is a filtering of transverse waves. It only works with transverse waves.