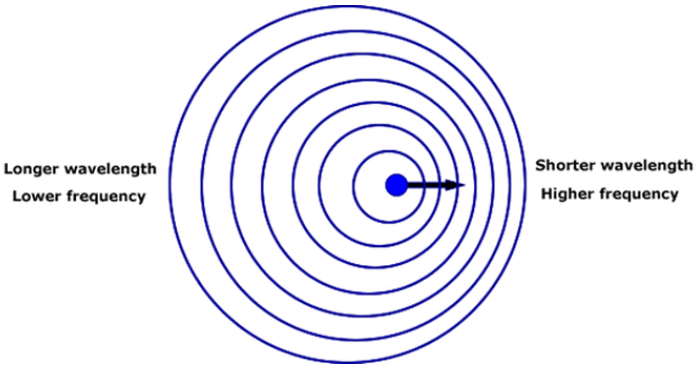
Doppler Effect

Doppler equations for sound waves

The Doppler effect refers to the change in observed frequency of a wave due to the movement of the observer and/or that of the wave source.



For a source moving towards a stationary observer, the detected frequency appears is higher. A higher pitched sound is heard.

For a source moving away from a stationary observer, the detected frequency is lower. A lower pitched sound is heard.

Imagine a race car driving past you with the frequency (pitch) higher but constant while it approaches, and the frequency (pitch) goes lower but constant as it passes by – this is assuming the source of the sound is going at a constant speed.

There are four Doppler effect equations for observed frequency depending on different cases:

Source moving towards observer at rest:

$$f' = \frac{v}{v - v_s} f$$

Source moving away from observer at rest:

$$f' = \frac{v}{v + v_s} f$$

Observer moving towards stationary source:

$$f' = \frac{(v + v_o)}{v} f$$

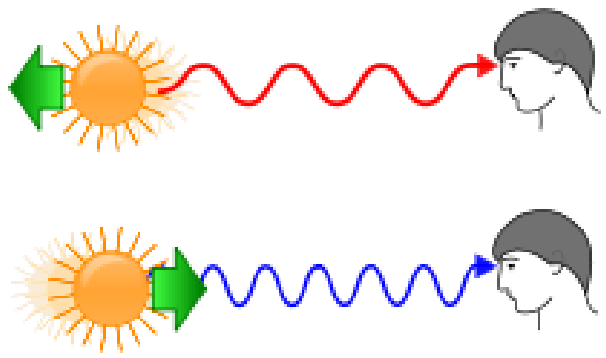
Observer moving away from stationary source:

$$f' = \frac{(v - v_o)}{v} f$$

where f' is the observed frequency received by the observer, f is the original frequency of the wave, v is the velocity of the wave, and v_0 is the velocity of the observer.

	Velocity of the wave	Wavelength of the wave	Frequency of the wave
Moving source	Constant	Changes	Changes
Moving observer	Changes	Constant	Changes

Doppler effect for electromagnetic waves



Doppler equation for EM waves

$$\Delta f = \frac{v}{c} f$$

where Δf is the change in frequency of the wave received by the observer as compared to the original frequency emitted by the source, v is the velocity of the observer, c is the speed of light, and f is the original frequency of the wave.

This equation should only be used when the velocity of the observer is much smaller than the speed of light ($v \ll c$).

Add Δf to f to obtain the observed frequency (f’) when the wave source and the observer are moving towards each other.

Subtract Δf from f to obtain the observed frequency (f’) when the wave source and the observer are moving away from each other.