Doppler Effect

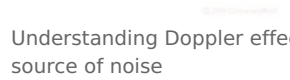
Doppler's effect can be defined as an observed change in frequency of a wave when an observer and source have a relative motion between them. In other words, it is an increase or decrease in the frequency of waves (for example - sound or light) as the source and observer move toward or away from each other.

This phenomenon was named after the Austrian physist, Christian Doppler, who proposed it in 1842 during his time at Prague Polytechnic University.

Understanding Doppler effect

The observed changes in frequency associated with Doppler Effect can be explained as follows:

- When the source is moving toward the observer, each consecutive wave is emitted from a position closer to the observer than the previous wave. So when travelling, the waves are seemingly grouped together, and the time between the arrival of successive wave crests to the observer is reduced (thus reducing the wave length), causing an increase in the frequency, as the velocity is constant.



Understanding Doppler effect - moving source of noise

- However when the source is moving away from the observer, each wave is emitted from a position further away from the observer than the previous wave, making the waves more spread, thereby increasing the wave length and reducing the frequency. It is interesting to note that in none of these instances, the frequency of the sound it is always a constant.

Equation

When a source moves and the observer is stationary, the following equation can be used.

$$f = \left(\frac{c}{c + v_s}\right) f_0$$, where

f is the observed frequency, f_0 is the actual frequency, C is the velocity of waves in the medium, Vs is the velocity of the source

It should be noted that Vs is positive when the source is moving away from the observer, and it is negative when the source is moving toward the observer.

In the same way, when a source is stationary and the observer is moving relative to it, the equation is as follows :

$$f = \left(\frac{c + V_0}{c}\right) f_0$$

The symbols stand for the same quantities as mentioned above and Vo is the velocity of the observer. Unlike before, Vo is positive when the observer is moving toward the source and negative when it is away from the source.

When both the source and observer are moving relative to one another, these equations can be combined to form the equation below.

$$f = \left(\frac{c + V_0}{c + V_s}\right) f_0$$

Uses of Doppler effect

Astronomy

Doppler effect is used to measure the speed at which stars and galaxies are approaching or receding from us, in a mechanism named red shift or blue shift. Redshift happens when light seen coming from an object that is moving away is proportionally increased in wavelength, or shifted to the red end of the spectrum. Vice versa occurs with blue shift. Since blue light has a higher frequency than red light, the spectral lines of an approaching astronomical light source exhibit a blue shift and those of a receding astronomical light source exhibits a redshift.

Medical imaging

In medicine, the Doppler Effect can be used to measure the direction and speed of blood flow in arteries and veins. This is used in echocardiograms and medical ultrasonography and is an effective tool in diagnosis of vascular problems.

Radar

The Doppler effect is used to measure the velocity detected objects where a radar beam is fired at a moving target. For example, the police use radar to detect a speeding vehicle. Radio waves are fired using a radar gun at the moving vehicle. The velocity is calculated using the difference between the emitted frequency and the reflected frequency. In a similar way, Doppler radar is used by weather stations to calculate factors like wind speed and intensity.

Links

Related articles

- Ultrasound
- Doppler Ultrasonography

External links

Bibliography