SPH3U UNIVERSITY PHYSICS

WAVES & SOUND

☞ Doppler Effect
(P.433-435)

Doppler Effect

Have you ever noticed how the sound of an emergency vehicle's siren changes as it comes toward you and then passes by? The change is caused by changes in the frequency of the sound waves as the vehicle passes by. As the siren approaches observer A, the waves are compressed. As a result, the frequency of the sound detected by observer A is higher than the frequency of the sound originally emitted by the siren.

Doppler Effect

As the vehicle passes observer B, the source is now moving away so the effect is the opposite: the frequency of the sound detected by observer B is less than the frequency originally emitted by the siren. A similar effect occurs when the source of sound is stationary and the observer is moving toward or away from it.

Doppler Effect

*This apparent changing frequency of sound in relation to an observer's motion is called the **Doppler effect**, named after Christian Doppler, an Austrian physicist and mathematician who first analyzed the phenomenon. However, not all moving sources of sound will generate a Doppler effect. For example:*

- *The speed of the moving source must be a reasonable fraction of the speed of sound. If the speed of sound is 330 m/s and the speed of the siren on an emergency vehicle is 30 m/s, then the speed of the siren is ~ 10% of the speed of sound. This is a reasonable fraction.*

Doppler Effect

*This apparent changing frequency of sound in relation to an observer's motion is called the **Doppler effect**, named after Christian Doppler, an Austrian physicist and mathematician who first analyzed the phenomenon. However, not all moving sources of sound will generate a Doppler effect. For example:*

- *In addition, the moving source of sound has to have a component of its velocity vector moving parallel to the detector. So a sound source moving in a circular orbit around a detector, for instance, would not generate a Doppler effect.*

Doppler Effect

DOPPLER EFFECT

- apparent changing frequency of sound in relation to an observer
- since v is constant, as a sound:
  - approaches ☞ $\lambda \downarrow$ so $f \uparrow$
  - moves away ☞ $\lambda \uparrow$ so $f \downarrow$

NOTE!

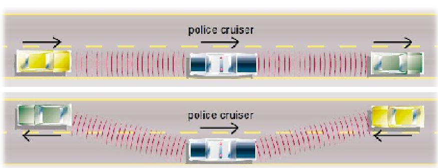
Speed and direction of travel are determining factors.

Doppler Shift – DYK?

Although the Doppler effect was first explained in relation to sound waves, it may be observed in any moving object that emits waves. The change in frequency and wavelength is called the ***Doppler shift****. Astronomers use the Doppler effect of light waves to estimate the speed of distant stars and galaxies relative to us (recall the term* ***redshift****).*

Doppler Shift – DYK?

Short-range radar devices, such as those used by the police, also work on the Doppler shift principle to determine the speed of a car (regardless of its direction of travel).



Doppler Effect

PRACTICE

1. State what happens to the apparent frequency of a sound source in each of the following situations:
   (a) The listener is stationary and the source is approaching.
   (b) The listener is stationary and the source is receding.
   (c) The source is stationary and the listener is approaching.
   (d) The source is stationary and the listener is receding.

   (a) $\lambda \downarrow$ so f $\uparrow$
   (b) $\lambda \uparrow$ so f $\downarrow$
   (c) $\lambda \downarrow$ so f $\uparrow$
   (d) $\lambda \uparrow$ so f $\downarrow$

✔ Check Your Learning

TEXTBOOK
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