Doppler Effect

10.1.1 Describe and explain the Doppler effect

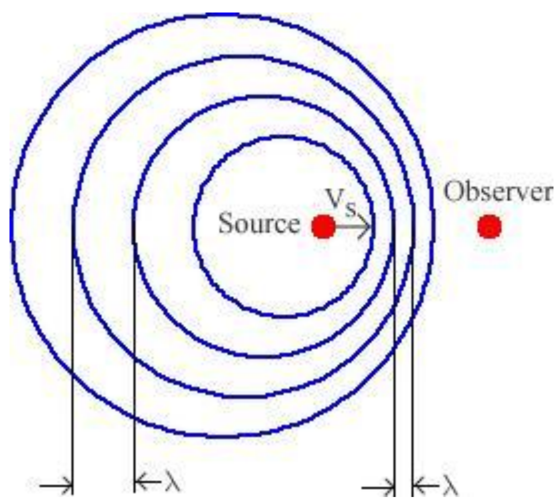
The Doppler effect is an apparent change in frequency of a source of sound (or other waves) when there is relative motion of the source and the listener. A Doppler effect is observed in all types of waves, however the Doppler effect with regards to light is fundamentally different than for sound or other types of waves that require a medium to propagate. To explain and/or derive the Doppler effect for light we must use Special Relativity. So we'll skip that for now.

Let's look at the Doppler effect for the case of sound waves:

10.1.2 Construct wavefront diagrams for moving-detector and moving source situations

10.1.3 Derive the equations for the Doppler effect for sound in the cases of a moving detector and a moving source.

First lets look at the case of a moving source and stationary observer.



The wavelength due to a stationary source is:

(1)
$\lambda = v / fs$

Where v is the velocity of sound in the medium and fs is the frequency of the sound. If the source is moving to the right at a speed of vs, then the distance between the peaks (the wavelength) is shortened and can be described by:

(2)
$\lambda' = v / fs - vs / fs = v - vs / fs$

Now the frequency measured by the observer is:

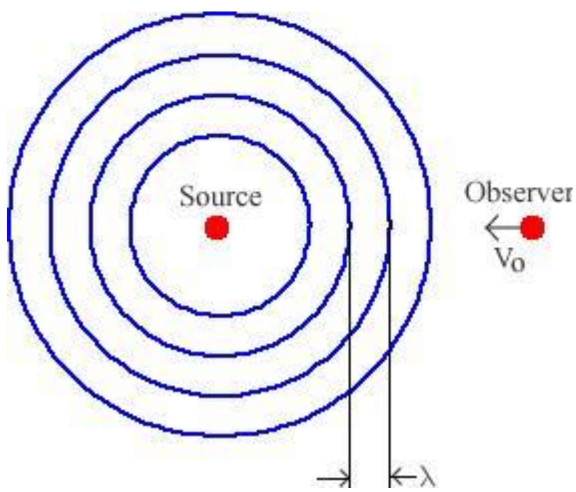
(3)
$fo = v / \lambda' = [vv - vs] * fs$

Do a little algebra and we get the formula given in the IB formula booklet:

(4)
$fo = [1 / 1 \pm vsv] fs$

The plus/minus has been added to compensate for the direct of the source. The sign should be negative if the source is approaching the observer and positive if the source is moving away from the observer.

Now for a stationary source and a moving observer:



You may ask why would it be different if the observer or the source moves? After all motion is relative, and it is, but the speed of sound is fixed relative to the medium (air) that it is traveling in, this causes differences…

In the case of the moving observer the wavelength of the sound does not change, but the frequency as measured by the observer does change. This happens because the observer encounters a wavefront more frequently… The frequency as measured by the observer is:

(5)
$fo=v+vo / \lambda$

Where v0 is the velocity of the observer.

The wavelength is speed of sound divided by the frequency, we can then rewrite the equation as:

(6)
$fo=[v+vov] / fs$

(7)
$fo=[1 \pm vo / v] / fs$

This last equation is given in the IB formula booklet. The plus or minus is added to compensate for the direction of the observer. The sign should be negative if the observer is approaching the source and positive if the observer is moving away from the source.

Source: http://ibphysicsstuff.wikidot.com/doppler-effect