DOPPLER EFFECT : WAVES

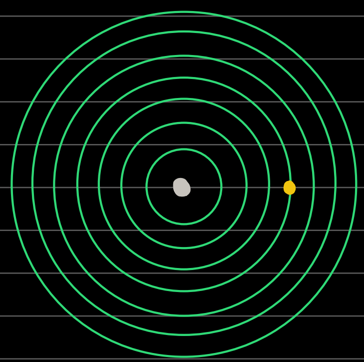
- Doppler effect is defined as the apparent change in the frequency caused by the relative motion between the source of the wave and the observer

- A common example is that of an ambulance with its siren blasting. You may recall that as the ambulance travels towards you, the pitch / frequency of the siren appears to be high and then after the ambulance passes by and moves away from the observer, the pitch / frequency appears to be low.

- The shift in the apparent frequency for a wave produced by a moving source is the doppler effect

Example 1. Source is stationary → In this case, the observed frequency is the actual frequency

$f_o = f_s$ where f_o = observed frequency
f_s = frequency of source

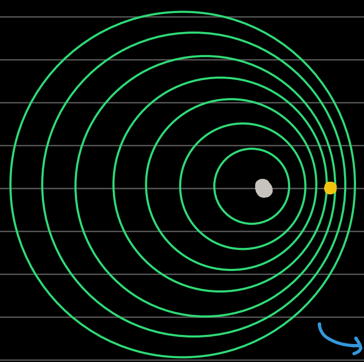


• = observer
• = Source

Example 2: The source is moving towards the observer

↳ In this case, the observed frequency is higher than the actual frequency

$f_o > f_s$



• = observer
• = Source

↳ waves seem "compressed" or "squashed" near the observer
Hence, the λ decreases and this causes the f to increase

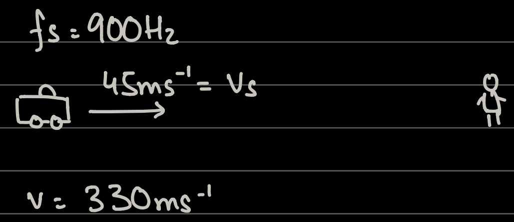
Calculating the observed frequency:

$$\boxed{f_o = \frac{f_s \times v}{v - v_s}}$$

where f_o = observed frequency
f_s = actual frequency
v = speed of sound
v_s = speed of the source

Example

Q. Calculate the observed frequency



$$f_o = \frac{900 \times 300}{330 - 45}$$

$= 1042\,Hz$

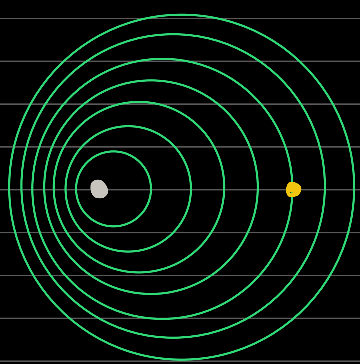
$f_o \approx 1040\,Hz$

↳ Note how the observed frequency is greater than the source frequency (900 Hz)

Example 3: The source is moving away from the observer

↳ In this case, the observed frequency is lower than the actual frequency

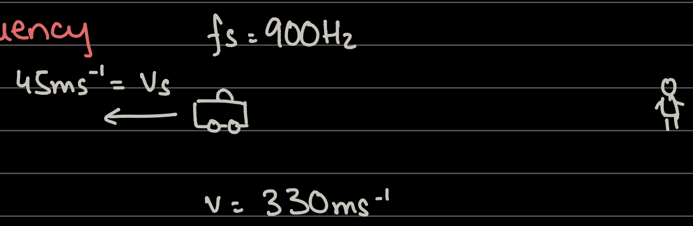
$f_o < f_s$



• = observer
• = Source

Example

Q. Calculate the observed frequency



$$f_o = \frac{900 \times 300}{330 - (-45)}$$

$= 792$

$f_o \approx 790\,Hz$

↳ Note how the observed frequency is lower than the frequency of the source (900 Hz)

LIGHT WAVES : same principle applies

- If an observer is loooking at a star which is emitting light
- If the star recedes away from the observer, the f_o (of light waves) will be less than the actual frequency of the light emitted by the star
- Since lower frequency of light is towards the red end of the spectrum, this effect is known as the red shift.

- However, if the star moves towards the observer, the observed frequency is greater than the actual frequency of the light emitted by the star
- Since higher frequencies are closer towards the blue/violent end of the spectrum, this effect is known as the blue shift