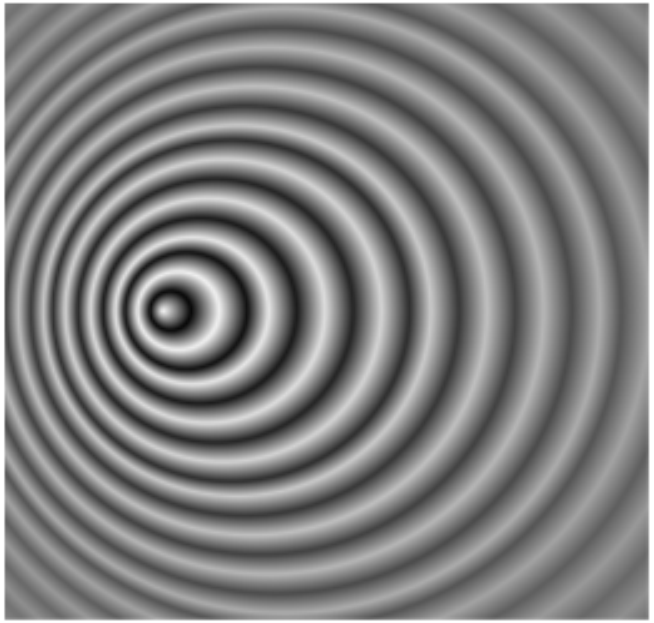
Echoes and The Doppler Effect

- **Echoes are what we here when sound waves reflect off of a dense surface (ie: wall) and reflect back to our ears.**
- **It is important to remember that the sound waves have travelled TWICE the distance to reach your ear!**



ex) What is the speed of sound waves if an observer standing on one side of the Grand Canyon yells "GET YOUR LOTTO TICKET!" and has to wait 8.0s to hear the echo? Assume the distance across the canyon is 1.4km.

Speed of Sound

- The speed of sound can change, depending on the temperature of the surrounding air.
- As air temperatures rise, the speed of sound waves also goes up (directly proportional).
- The speed of sound at 0℃ is 331m/s.
- The formula to determine the speed of sound is:

$$v = (331 + 0.6T)$$

- where v = velocity of sound waves
  T = temperature of the air

ex) What is the temperature of the air of the speed of sound is 349 m/s?

The Doppler Effect

- **The Doppler Effect refers to the phenomenon where sound waves sound differently to an observer, based on whether the source of the sound is coming closer or moving farther away to the observer.**
- **If the sound source is moving closer (or the observer is moving toward the sound), the sound *appears* to have a higher frequency.**
- **If the source is moving away (or the observer is moving away), the sound appears to have a lower frequency.**

Doppler Effect Formula

- **Because the Doppler effect depends on the motion of both the observer and the sound source, the formula must reflect that.**
- **Formula:**

$$f' = f_o \frac{(v \pm v_o)}{(v \pm v_s)}$$

where:

f' = apparent frequency (Hz)

f_o = original frequency (Hz)

v = speed of sound

v_o = speed of observer

v_s = speed of source

ex) What is the speed of an observer if an ambulance is blaring its siren (f = 500Hz) while travelling toward a student at 65km/h. The student was out for a walk on a beautiful 30℃ day and heard the sound as he walked towards the ambulance at 505Hz.