

Beats & The Doppler Effect

Interference and Beats

- When **constructive interference** occurs with sound waves, the listener hears a louder sound.
- When **destructive interference** occurs, the listener hears a fainter sound or no sound at all.
 - ▣ Noise-cancelling headphones
- When two tones of slightly different frequency are sounded together, a regular fluctuation in the loudness of the combined sounds is heard.
- The periodic variation in the loudness of sound is called **beats**.

Beats

- If two different frequencies sound simultaneously, the wavelengths will differ, and the crests and troughs of each wave will overlap in a way that causes variations in loudness.
- The resulting sound is a series of **beats**.

$$f_B = |f_2 - f_1|$$

The Doppler Effect

- **Doppler Effect** – The apparent change in frequency of a wave due to the motion of the source or the observer.
- As a wave source approaches, an observer encounters waves at a higher frequency. As the wave source moves away, an observer encounters waves with a lower frequency.
- Ex: Ambulance siren passing you.



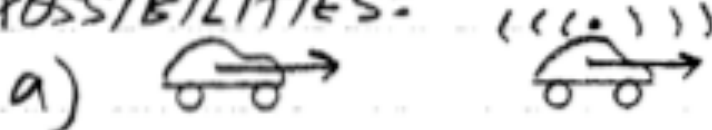
Doppler Effect Formula


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

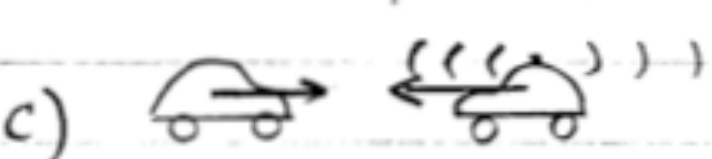
- f = actual frequency [Hz]
- f' = apparent frequency [Hz]
- v = wave speed [m/s] (for sound this is 340 m/s)
- v_o = observer speed [m/s]
- v_s = source speed

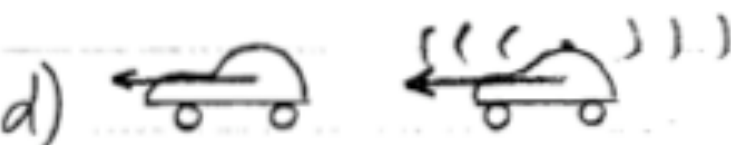
Doppler Possibilities

3. POSSIBILITIES:

a)  $f' = f \left(\frac{V + V_o}{V + V_s} \right)$

b)  $f' = f \left(\frac{V - V_o}{V + V_s} \right)$

c)  $f' = f \left(\frac{V + V_o}{V - V_s} \right)$

d)  $f' = f \left(\frac{V - V_o}{V - V_s} \right)$

****Source moving away from observer (+)**

Source moving toward observer (-)

****Observer moving towards source (+)**

Observer moving away from source (-)

Doppler Example 1

- A police car, whose siren has frequency 1080 Hz, is traveling at 30 m/s. We are traveling at 50 m/s away from the police as he chases us. Find the frequency which we hear.

Doppler Example 2

- Sitting on the beach at Coney Island one afternoon, Sunny finds herself beneath the flight path of the airplanes leaving JFK. What frequency will Sunny hear as a jet, whose engines emit sound at a frequency of 1000 Hz, flies toward her at a speed of 100 m/s?