Physics 20

Unit D: Oscillations and mechanical waves

Wave interference and the Doppler effect

One clamp flips the pulse

- A 4.0 cm upward pulse runs along a rope toward a clamp screwed to the lab bench.
- The pulse returns upside down, while a second rope with a free ring sends an upright pulse back.

Wave behaviour

- Reflection returns a pulse inverted from a fixed end and upright from a free end.
- Interference is what you see or hear when two waves overlap. A pipe rings loudly when the note matches the air inside.
- You stand still. A moving horn reaches your ear at a different pitch than the pitch the horn makes.

Key terms

reflection

Reflection is the return of a mechanical wave after the pulse meets an end or another boundary.

interference

Interference is the overlap of two waves at one place, giving a resultant amplitude.

acoustic resonance

Acoustic resonance is a large amplitude vibration of an air column when the driving frequency matches a resonant frequency of that column.

Doppler effect

The Doppler effect is the change in heard frequency when a sound source moves toward or away from a stationary observer. (f prime)

Crests that stack and crests that flatten

- Constructive interference happens when crests meet and the amplitudes add.
- Destructive interference happens when a crest meets a trough and the resultant amplitude drops.
- With two sources, count how many wavelengths each path is. That difference tells you whether the waves add or flatten.

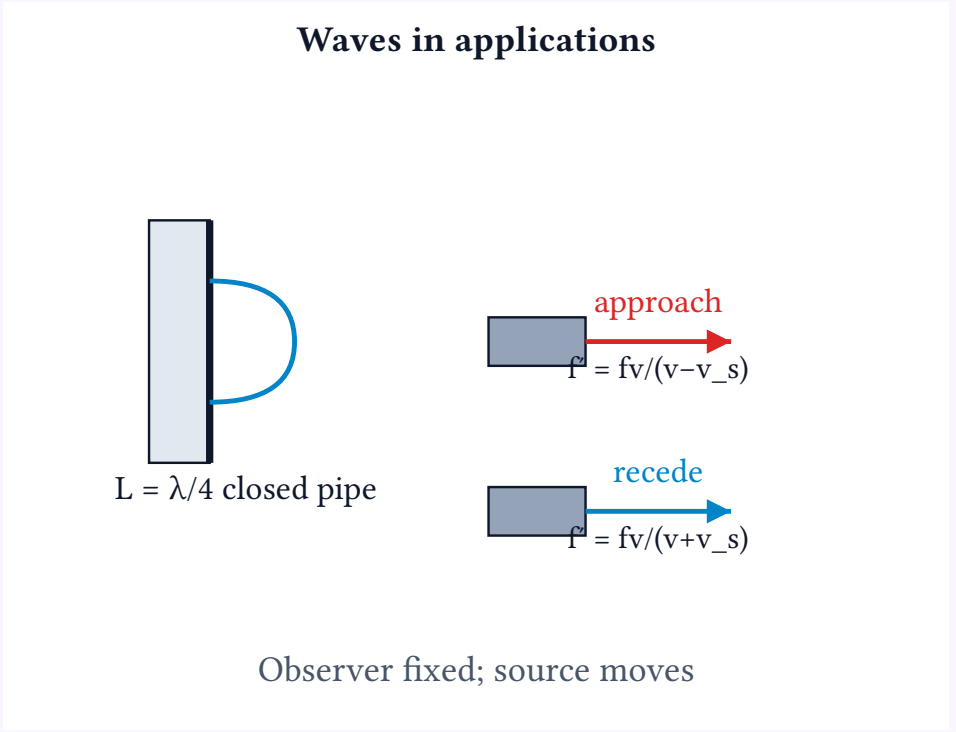


Path differences of 0.80 m and 0.20 m

- Two sources send waves of wavelength 0.40 m.
- Point A differs by 0.80 m, which is 2 wavelengths, so the waves add.
- Point B differs by 0.20 m, half a wavelength, so the waves flatten.

Applications of waves

- A closed pipe first resonates when its length is one quarter of the wavelength.
- You stand still. As the horn approaches, divide f times v by v minus the horn speed.
- As the horn leaves, divide f times v by v plus the horn speed.
- Sonography, sonar, organs, brass, noise tools, and a canoe all use wavelength and wave speed.



Resonance in a 0.180 m pipe

- Find the first resonant frequency of a closed pipe 0.180 m long when v = 343 m/s.
- Check the wave speed with 4 L f.
- Two sources of wavelength 0.40 m meet where the path difference is 0.20 m. Predict the interference.

An ambulance horn

- An ambulance siren has frequency 620 Hz and moves at 22.0 m/s in air where v = 343 m/s.
- Find the frequency heard by a stationary observer as the ambulance approaches.
- Find the frequency heard as the ambulance recedes.

Image credits

Markus Pössel, Interfering surface waves on a lake, CC BY 4.0