waves and sound

Equations

Frequency = # of cycles/time (in Hz ⟶ 1/s or s^-1)
Period = Time to complete 1 cycle ⟶ time/# of cycles
Universal wave equation (2 versions)

$$v=\lambda/T$$

wavelength / period

$$v = \lambda f$$

wavelength * 1/period
Speed of sound (elasticity + density)

$$c = \sqrt{\frac{K_s}{\rho}}$$

Speed of sound (temp)

$$v = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})\,T$$

Beat frequency = |wave 1 frequency - wave 2 frequency|
Doppler effect

$$f_2 = f_1 [(v \pm v_o) \div (v \pm v_s)]$$

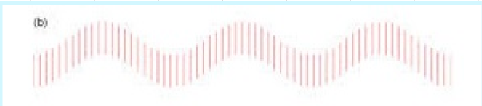
Sound intensity (dB) = 10 log((P/A)/(10^-12 W/m^2)) (power per unit area)
Look at this later

$$v = \sqrt{\frac{T}{\mu}}$$

General Definitions

Mechanical wave
- Transfer of energy thru disturbance in a medium
- Come from vibrating source

Transverse wave
- Movement perpendicular to rest pos. axis
- E.g: swing

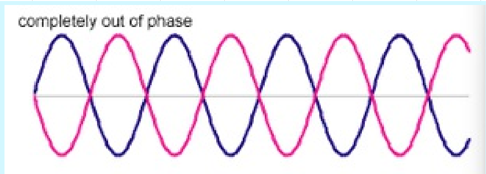


Longitudinal wave
- Movement parallel to rest pos. axis
- E.g: spring

Torsional wave

- Object twists around rest pos. axis

Cycle – 1 pattern of the motion
Frequency – # of cycles/time (in Hz ⟶ 1/s or s^-1)
Period – Time to complete 1 cycle ⟶ time/# of cycles
Amplitude – Max distance from rest pos.
Crest/Trough – Max/min pnt on transverse wave
Compression/Rarefaction – Most compressed/uncompressed point longitudinal wave
Wavelength – Distance btwn 2 consecutive pnts in phase (e.g: crest to crest, compression to compression)
Standing wave
Resonance
In phase – 2 waves same phase shift
Out of phase – different phase shifts
Completely out of phase – Half-wavelength difference in phase shift



Vibration – periodic motion abt a equilib pnt (basically smthing that goes back and forth periodically)

I n t e r f e r e n c e

Principle of superposition – Displacement of a particle = sum of separate displacements
Transmission
- Moving btwn mediums ⟶ speed of wave changes
- Partial reflection at pnt btwn mediums
- Less dense ⟶ more dense = inverted reflection, not inverted transmission
- More dense ⟶ less dense = reflection/transmission not inverted
- Speed of wave dependent on medium, elasticity, density, temperature

Standing wave
- 2 waves (same wavelength + amplitude) move thru each other ⟶ makes pattern of "stationary" areas
- **Node** – stationary pnts (areas of deconstructive interference)
  - Occur every 1/2 wavelength
- **Antinode** – crests/troughs (constructive interference)
- Fixed end
  - Nodes at ends
- 1 fixed end
  - Node at one end, antinode in the other
- No fixed ends
  - Antinode at ends, node in middle

Resonance
- When interfering wave matches natural frequency ⟶ forms standing wave ⟶ object oscillates with large amplitude

Damping
- Decrease in wave amplitude
- E.gs: noise cancellation earphones, shock absorbers (dampen car motion so less rebound on tire springs ⟶ car stays in contact with ground)

S o u n d

- Longitudinal wave
- Need medium for transmission

Characteristics
- **Pitch** – related to frequency of wave
  - > frequency = > pitch
  - Below 20 Hz = infrasonic, above 20 kHz = ultrasonic
- **Volume** – related to amplitude

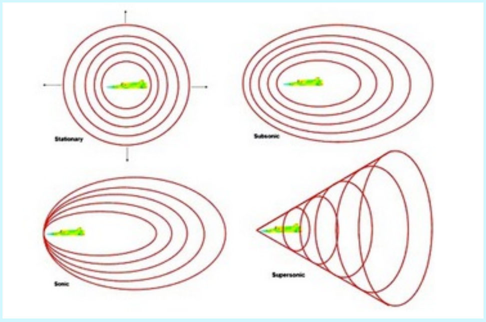
  - > amp = > sound
- **Quality/Timbre** – most sounds not single frequency, but many tgt

Sound speed

- Solid > liquid > gas
- Warm air > cold air
- Dependant on objects density (K) + elasticity ./(p)

$$c = \sqrt{\frac{K_s}{\rho}}$$

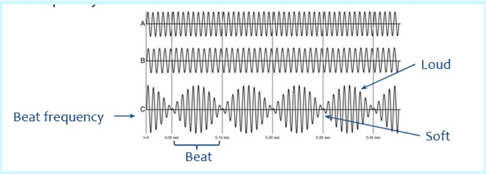
- Mach # = speed of object/speed of sound
  - > speed of sound = supersonic
  - < speed of sound = subsonic
- Sonic boom ⟶ basically just breaking sound barrier too lazy to write more here's a diagram tho



- Echo = reflection of sound
- Loudness (dB) vs sound intensity ⟶ loudness = ears response to sound intensity

Beats

- Sound alternating btwn loud/soft bc of interfering waves that r almost same wavelength + frequency



- Beat frequency = # of max intensity pts per second
  - beat frequency = |wave 1 frequency – wave 2 frequency|

Doppler effect

- Source generating waves approach observer ⟶ frequency sounds like it increases (opposite for moving away)

$f_2 = f_1 [(v \pm v_o) \div (v \pm v_s)]$

- Where:
  - v is the speed of sound in the medium
  - v_o is the speed of the observer (we will only consider stationary observer)
  - v_s is the speed of the sound source through the medium
  - f_1 is the actual frequency of the sound source (when it is stationary)
  - f_2 is the frequency of the sound source from the observer's perspective
  - – if source is moving towards the observer and
  - + if source is moving away from the observer