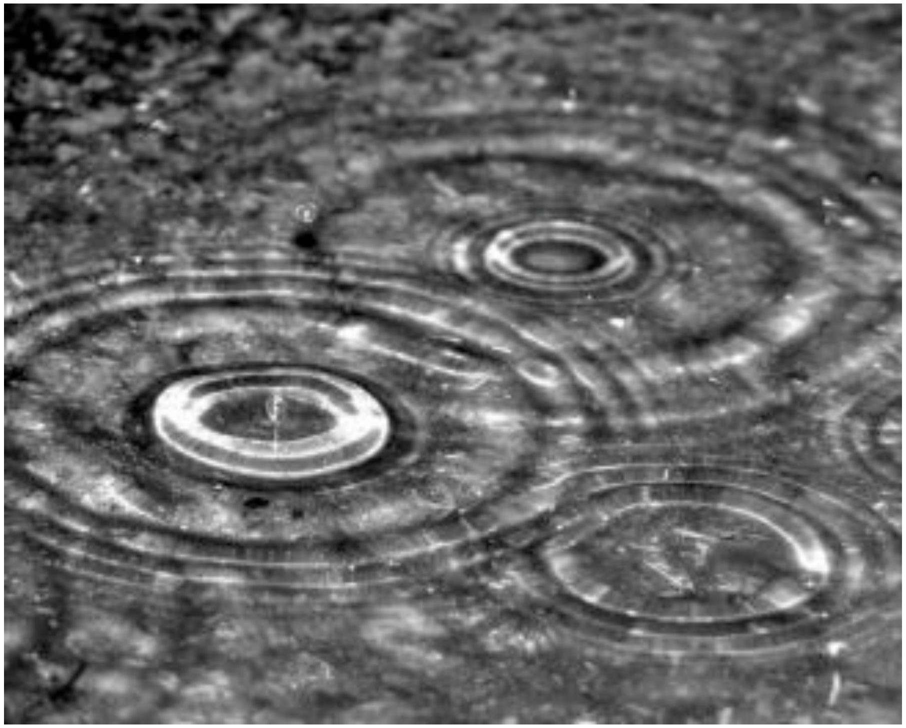
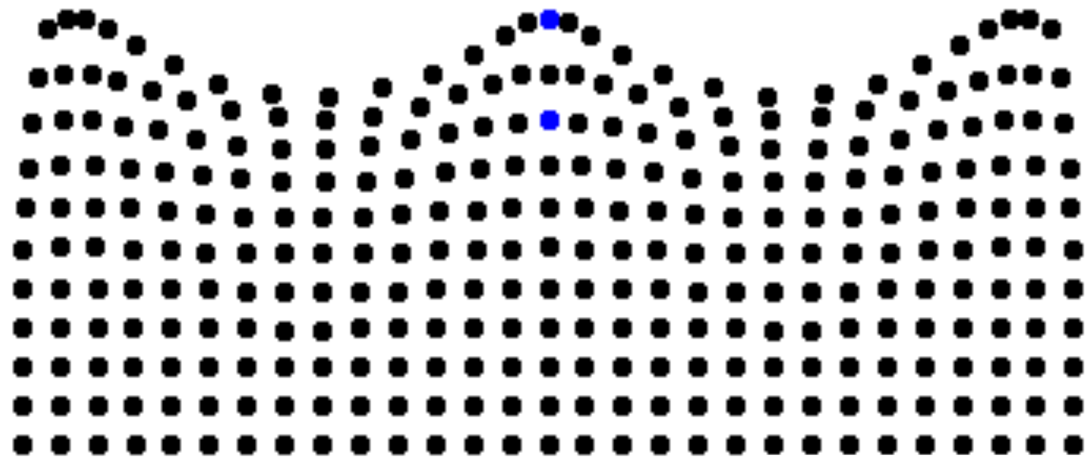
Musical Acoustics

Lecture 6

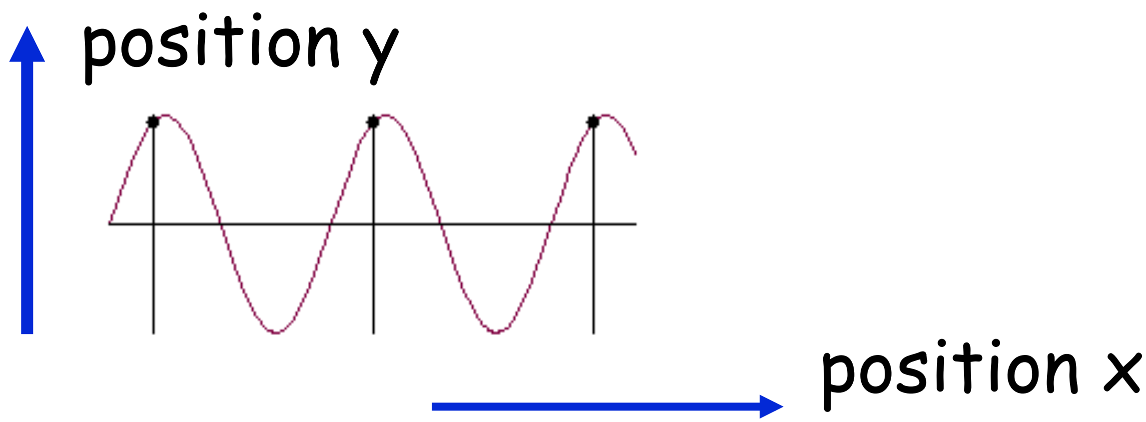
Waves - 1

Waves



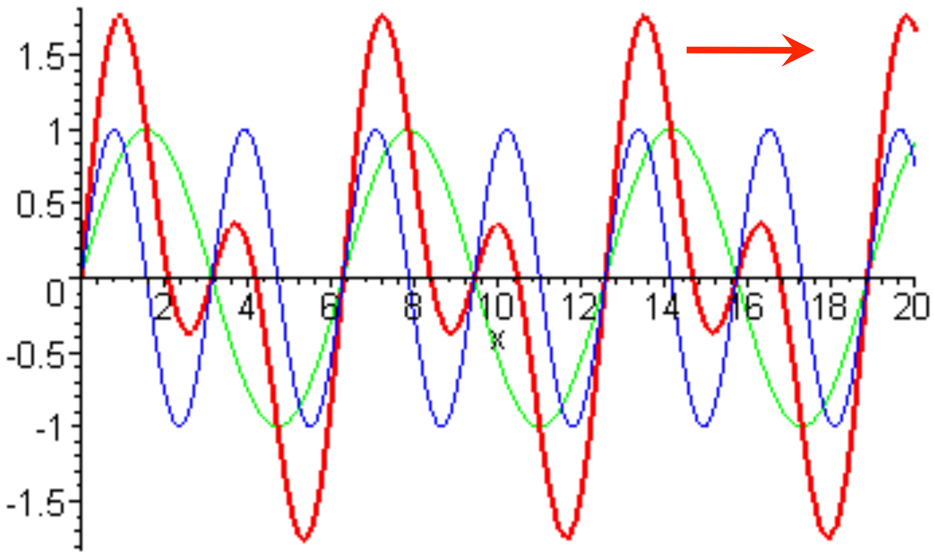


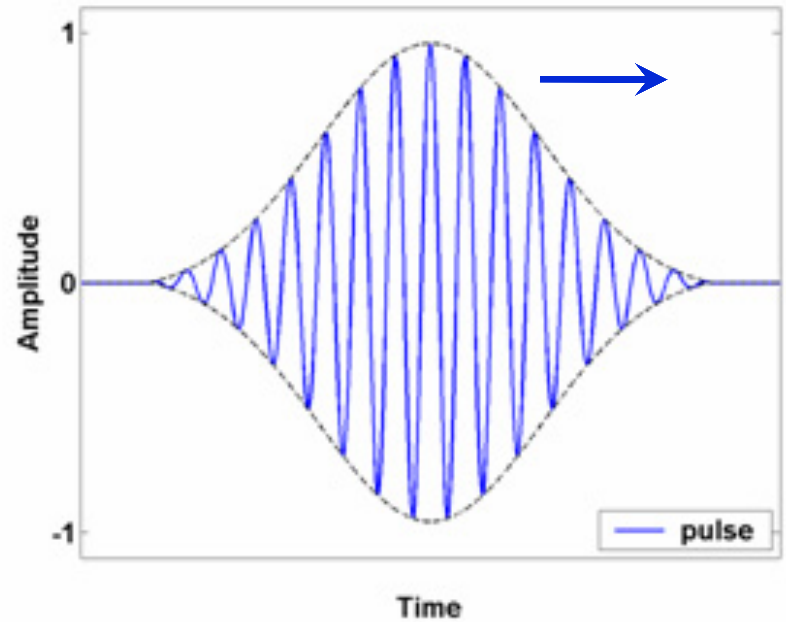
The wave carries the disturbance, but not the water



Each point makes a simple harmonic vertical oscillation

- **Periodic wave** – is regular frequency continuing for may cycles





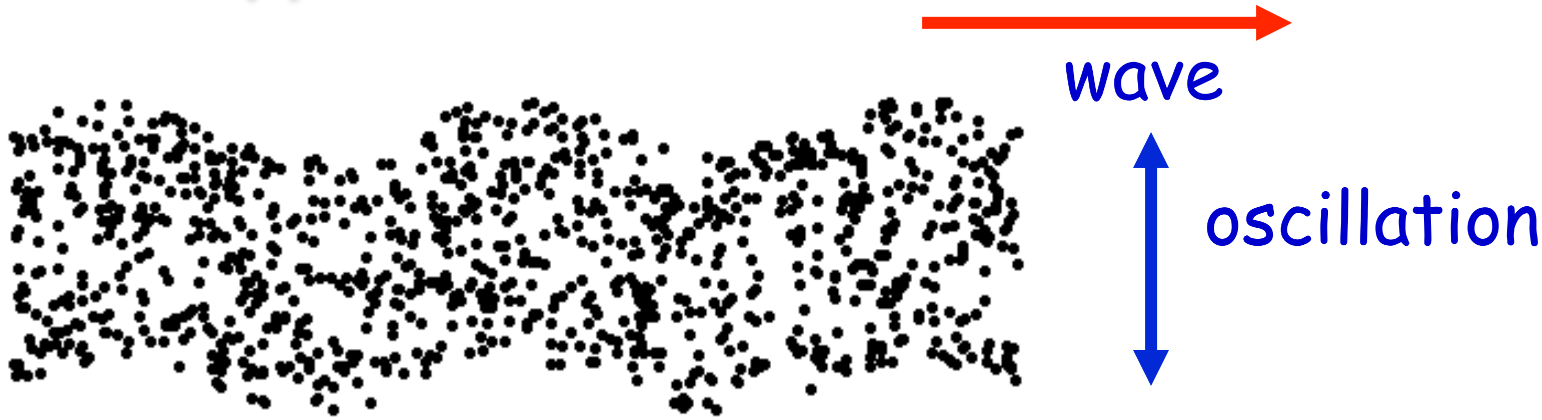
- **Wave pulse** - is a disturbance of short duration

Mechanical waves

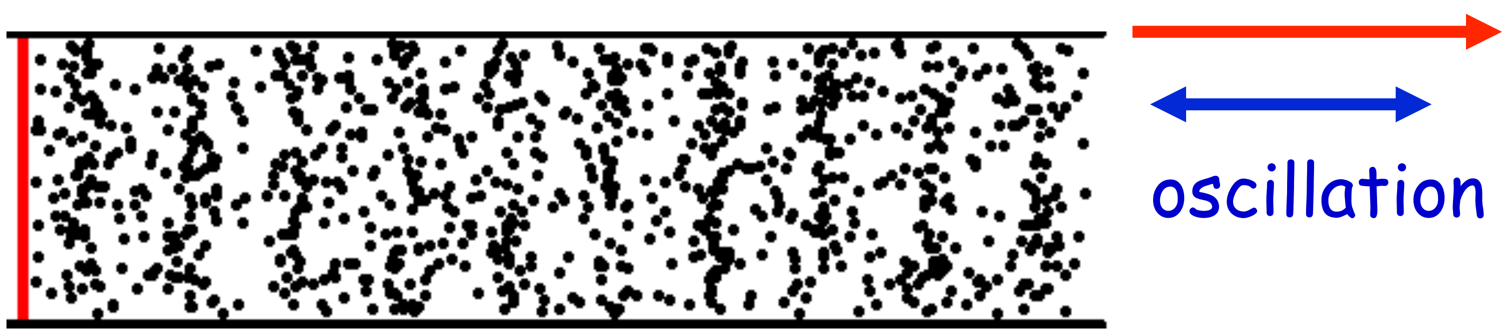
- Require medium for propagation
- Waves move through medium
- Medium remains in place

Electromagnetic waves (light) do not require medium

Types of waves

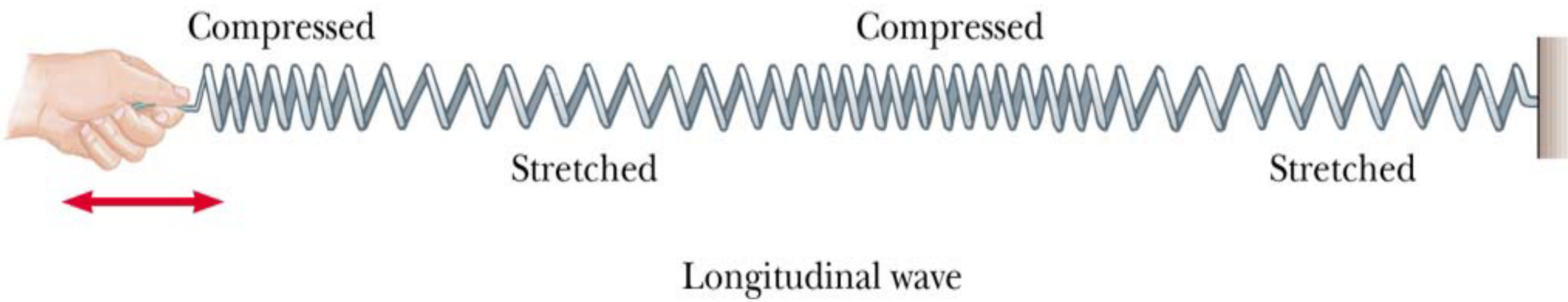


Transversal: movement is perpendicular to the wave motion



Longitudinal: movement is in the direction of the wave motion

Longitudinal (Compression) Waves

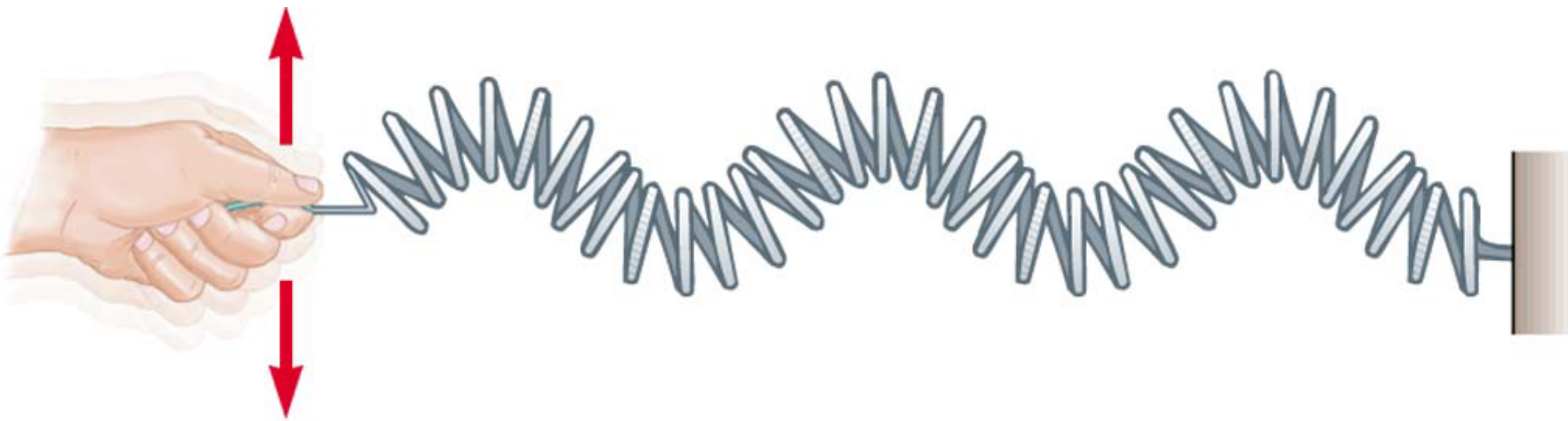


Sound waves are longitudinal waves

Elements move parallel to wave motion

Transverse Waves

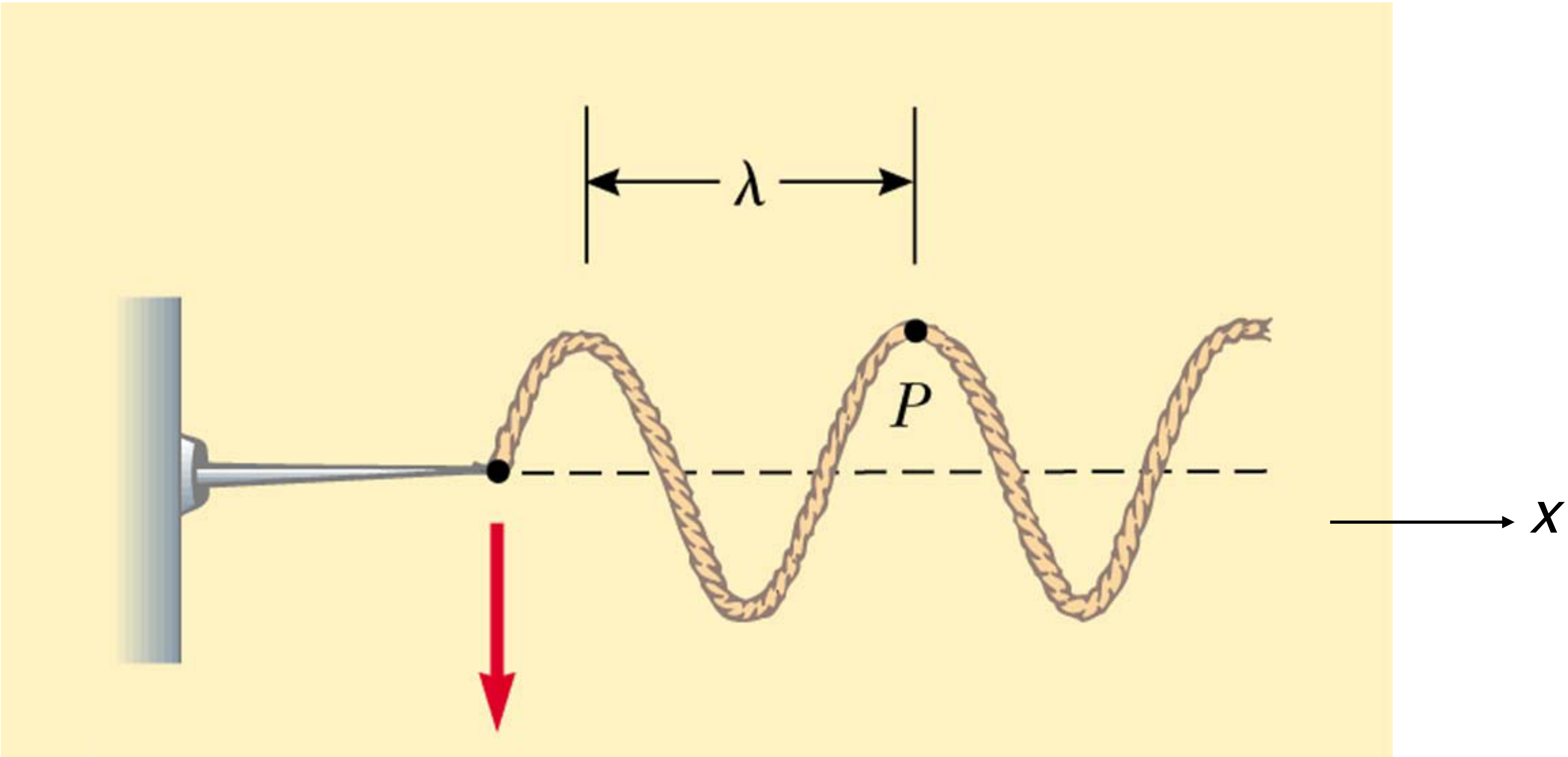
Elements move perpendicular to wave motion



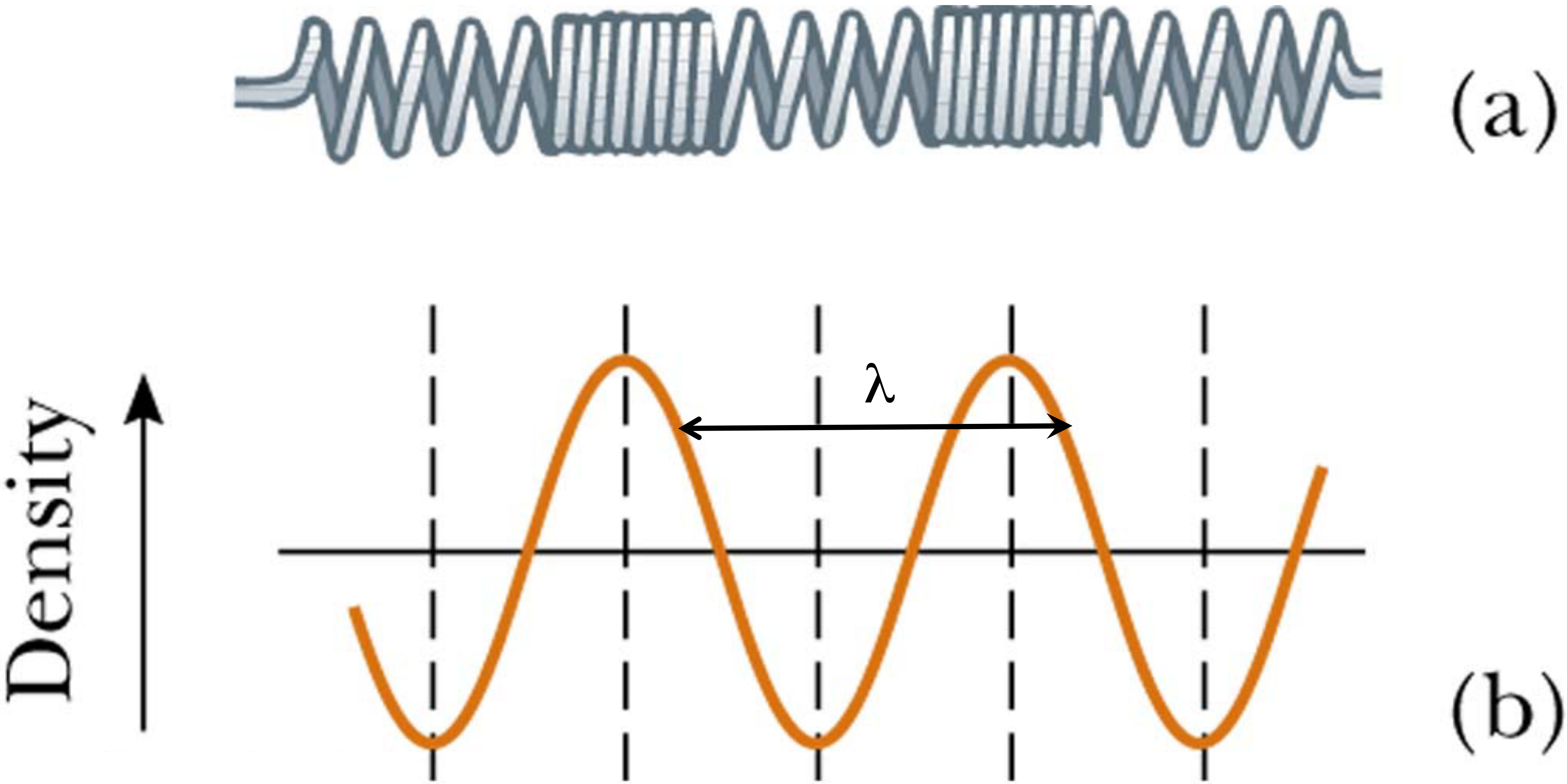
Transverse wave

Snapshot of a Transverse Wave

wavelength



Snapshot of Longitudinal Wave



y could refer to pressure or density

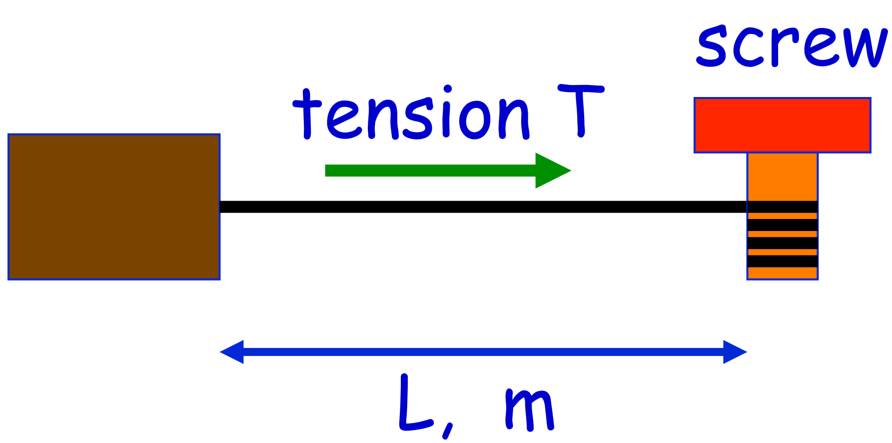
Describing a traveling wave

λ: wavelength distance between two maxima.
f: frequency of oscillations

While the wave has traveled **one wavelength**, each point on the rope has made one period of oscillation.

$$v_{wave} = \frac{\lambda}{T} = \lambda f$$

Speed of a Wave in a Vibrating String



$$v = \sqrt{\frac{T}{\mu}} \quad \text{where} \quad \mu = \frac{m}{L}$$

For different kinds of waves: (e.g. sound)

- Always a square root
- Numerator related to restoring force
- Denominator is some sort of mass density

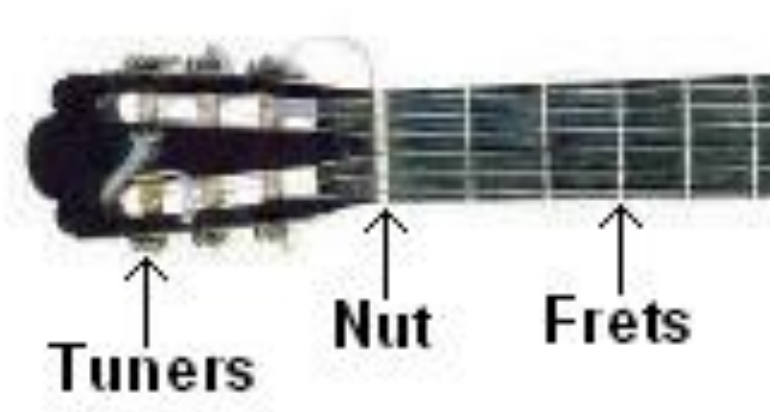
Why does it matter?

$$\lambda f = v \quad \text{or} \quad f = \frac{v}{\lambda}$$

Higher tension T → higher frequency, because $v = \sqrt{\frac{T}{\mu}}$
(for the same wavelength and same string)

- Reverse is true (smaller T, lower f)

Higher density μ → lower frequency



change T or change μ

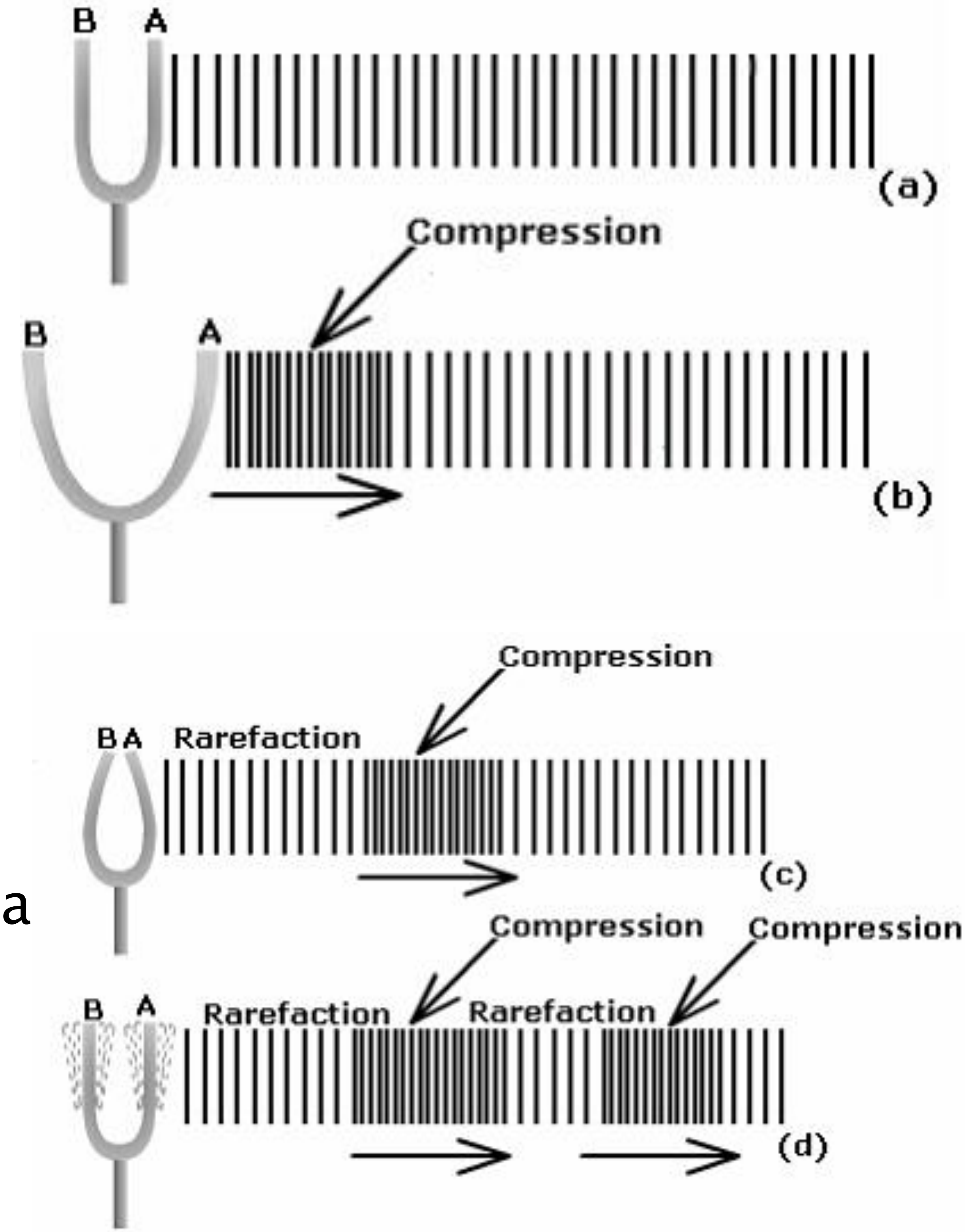
Sound wave speed

$$v = \sqrt{\gamma \frac{p}{\rho}}$$

γ = adiabatic index
p = pressure
ρ = density

Air: $\gamma \sim 1.4$,
$p \sim$ 1 atm ~ 100 Pa
$\rho \sim$ 1.2 kg/m^3

→ $v_{air} \sim 331$ m/s



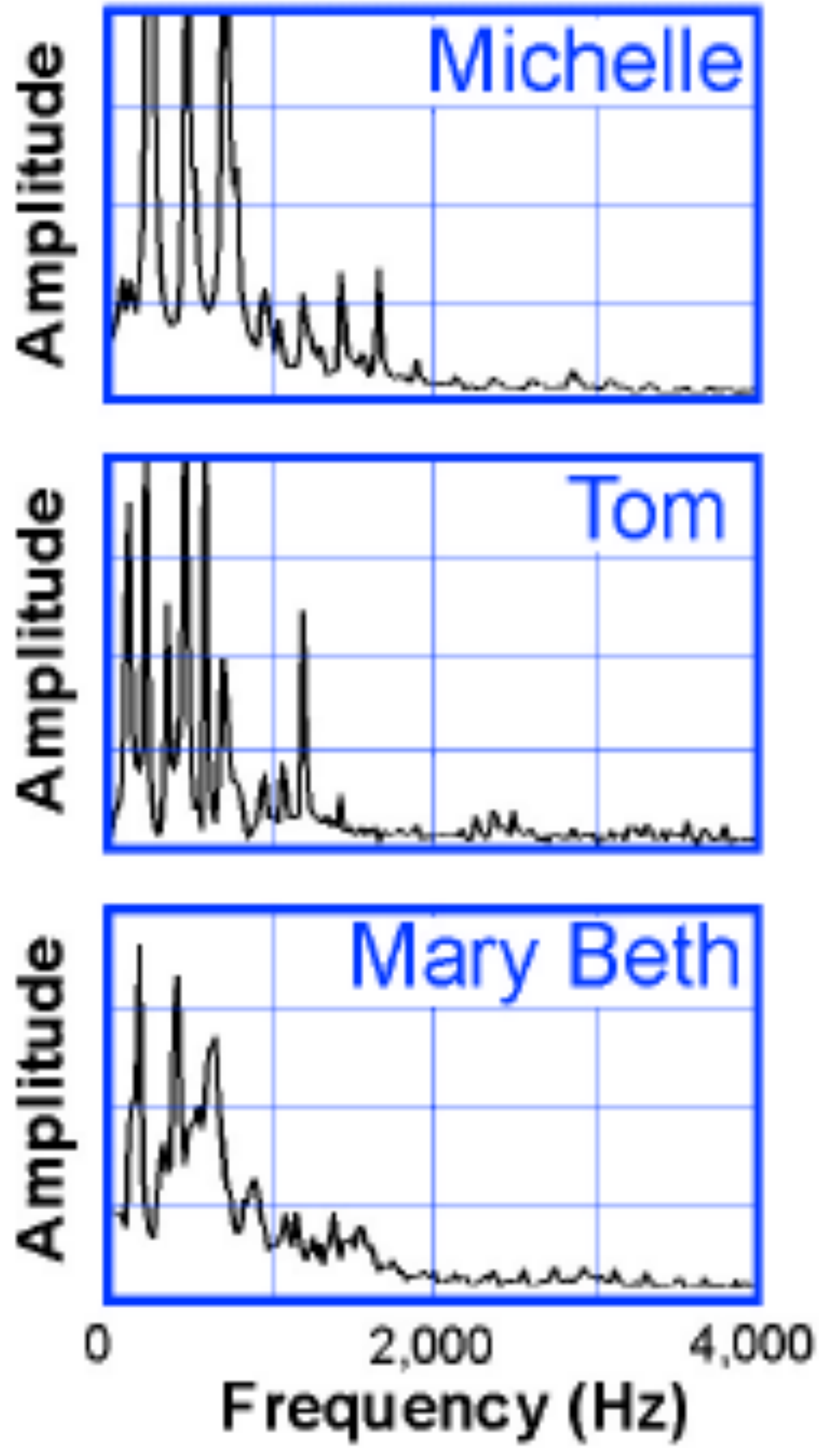
Speed of sound in several materials

Medium	m/s	ft/s
Carbon dioxide (0°C)	259	850
Dry air (0°C)	331	1,087
Helium (0°C)	965	3,166
Hydrogen (0°C)	1,284	4,213
Water (25°C)	1,497	4,911
Seawater (25°C)	1,530	5,023
Lead	1,960	6,430
Glass	5,100	16,732
Steel	5,940	19,488

The lone Ranger put his ear to the ground

The frequency of sound

- We hear frequencies of sound as having different pitch.
- A low frequency sound has a low pitch, like the rumble of a big truck.
- A high-frequency sound has a high pitch, like a whistle or siren.
- In speech, women have higher fundamental frequencies than men.



The wavelength of sound

Frequency (Hz)	Wavelength	Typical Source
20	17 meters	rumble of thunder
100	3.4 meters	bass guitar
500	70 cm (27”)	average male voice
1,000	34 cm (13”)	female soprano singer
2,000	17 cm (6.7”)	fire truck siren
5,000	7 cm (2.7”)	highest note on a piano
10,000	3.4 cm (1.3”)	whine of a jet turbine
20,000	1.7 cm (2/3”)	highest pitched sound you can hear