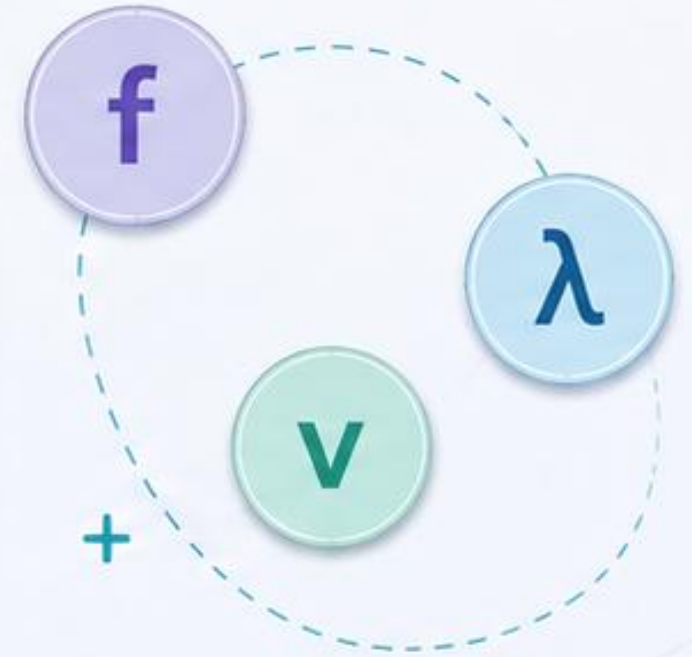
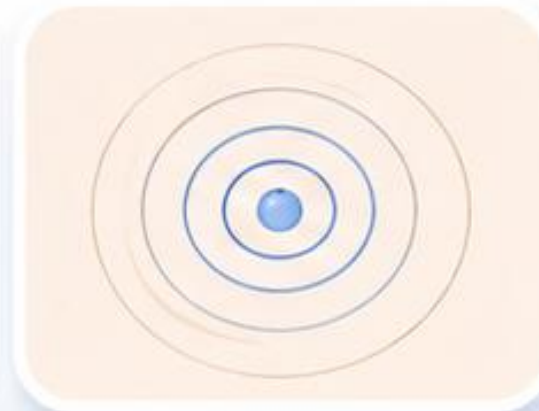
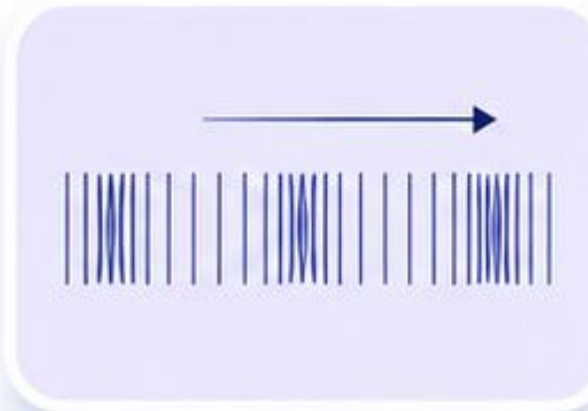
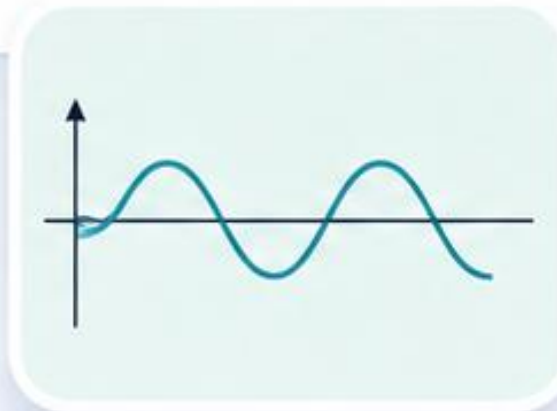
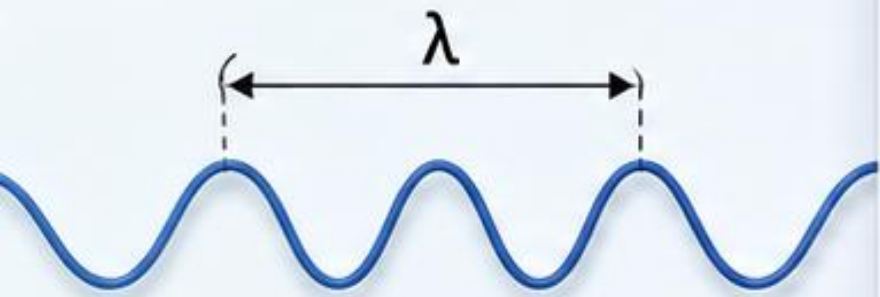
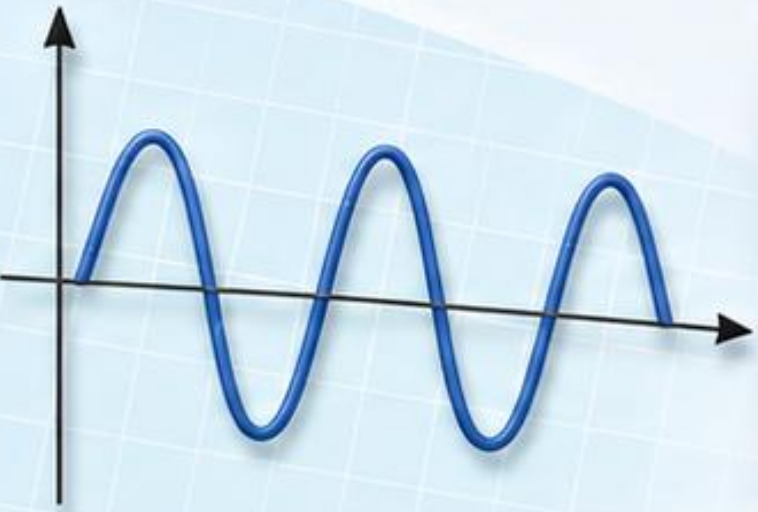


Chapter 14

Waves

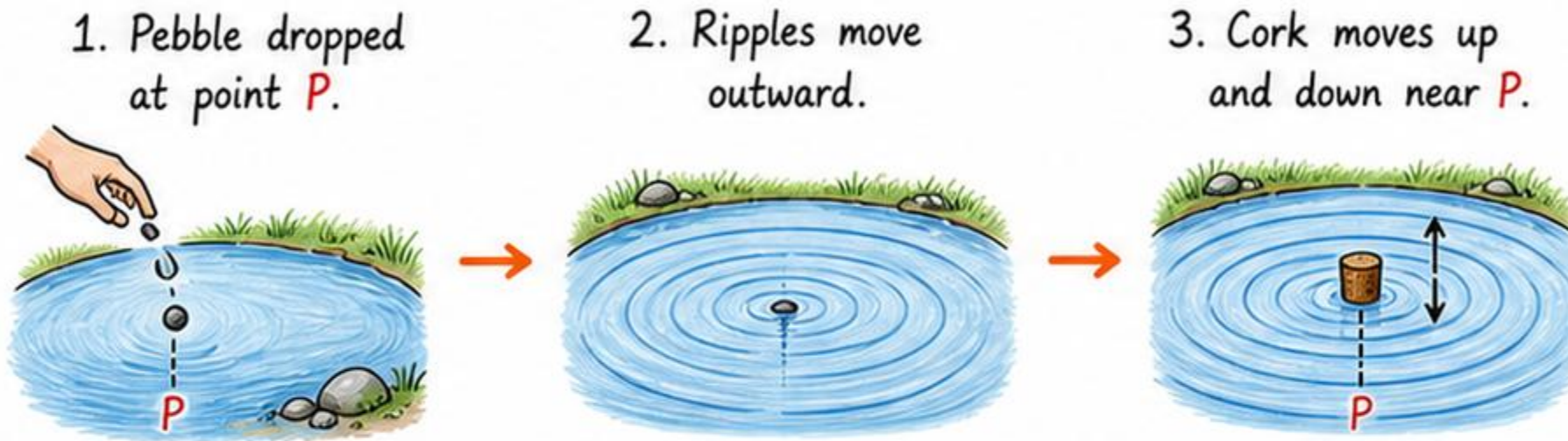
Frequency • Wavelength • Speed



WAVES — MOVING DISTURBANCES

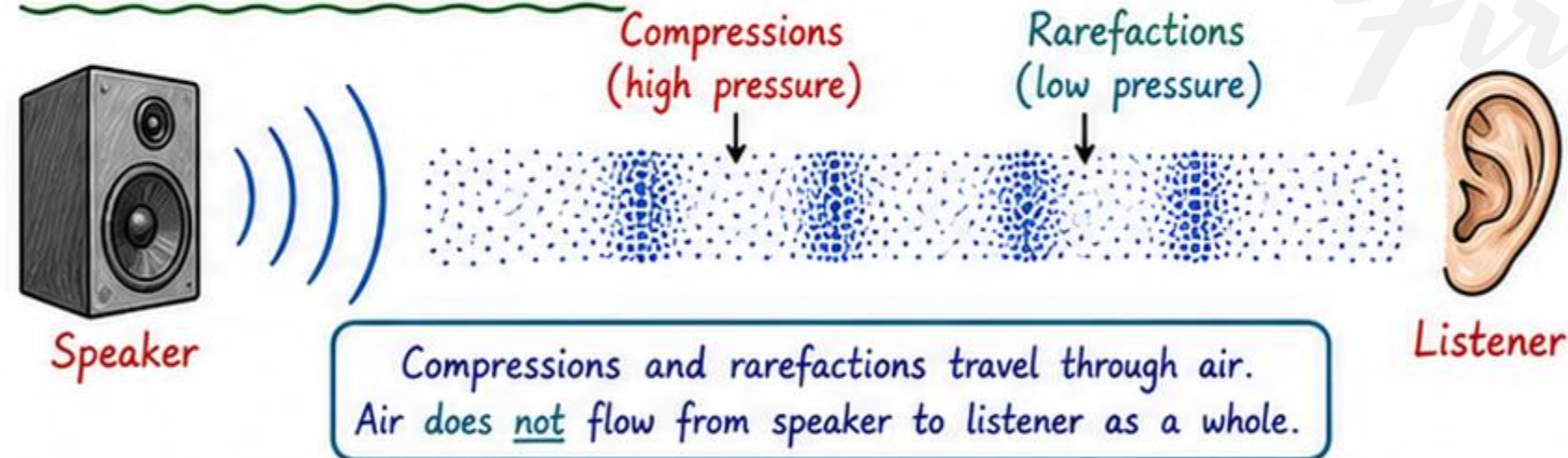
- A wave is a **disturbance** that travels from one place to another.
- The material medium as a whole does not travel with the wave; particles only oscillate about their mean positions.
- Waves carry **energy** and **information**, not bulk matter.

EXAMPLE: POND RIPPLES

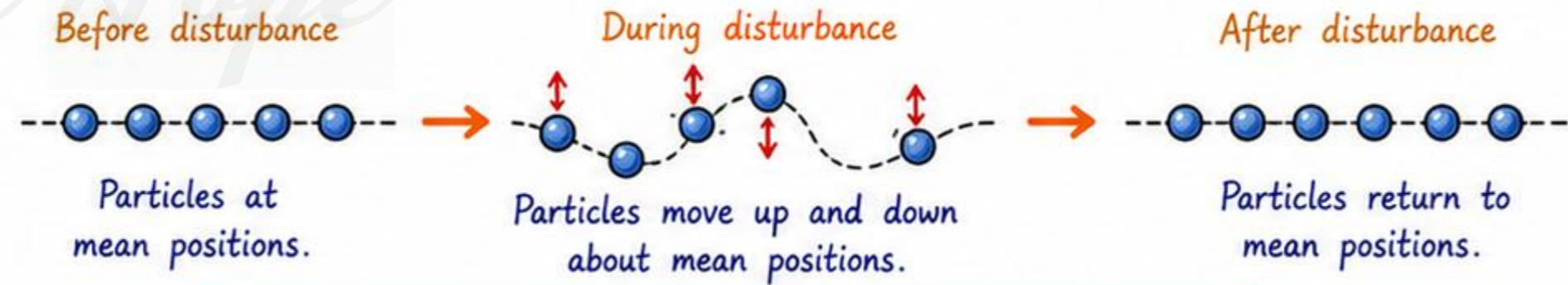


Disturbance moves outward as ripples; cork (matter) oscillates up and down at the same place.

EXAMPLE: SOUND IN AIR

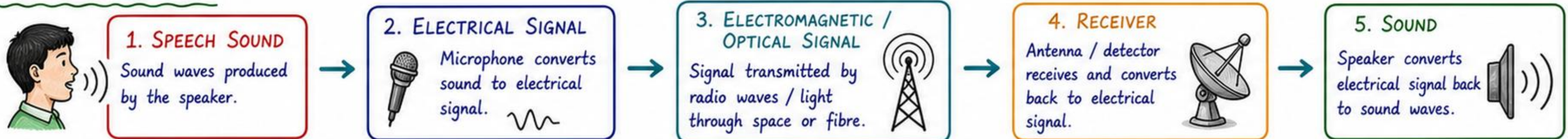


HOW PARTICLES OSCILLATE (EXAMPLE)



Disturbance moves; matter oscillates locally.

COMMUNICATION CHAIN



Waves transport **energy** and **information** from one place to another without transporting matter.

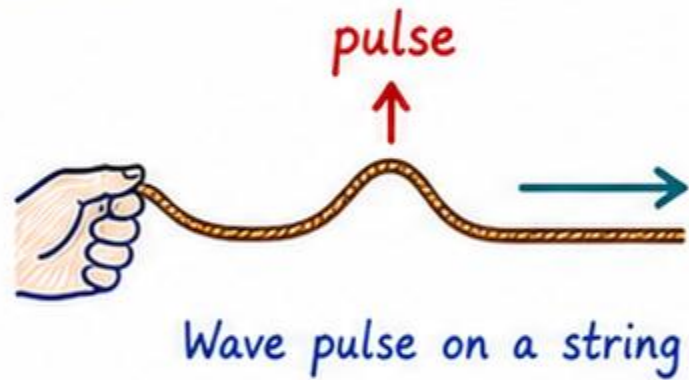
THREE KINDS OF WAVES

① MECHANICAL WAVES

- Require a material medium.
- Cannot travel through vacuum.
- Depend on elasticity and inertia of the medium.

EXAMPLES

- String waves
- Water waves
- Sound
- Seismic waves

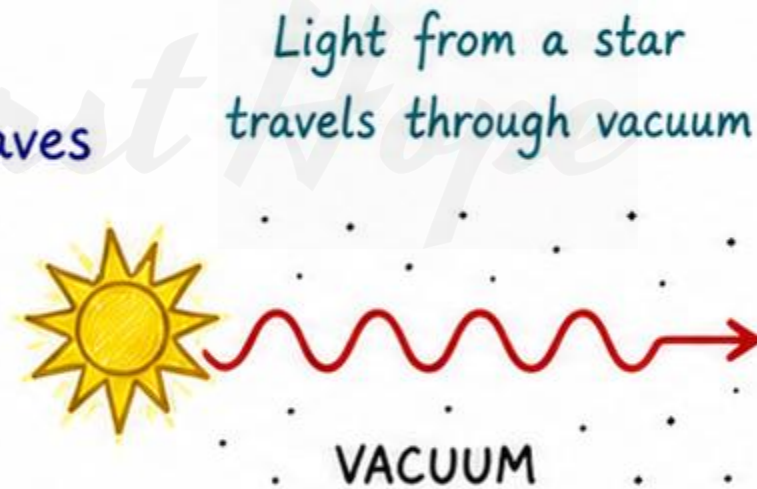


② ELECTROMAGNETIC WAVES

- Do not require a medium.
- Travel through vacuum.

EXAMPLES

- Light
- Radio waves
- X-rays

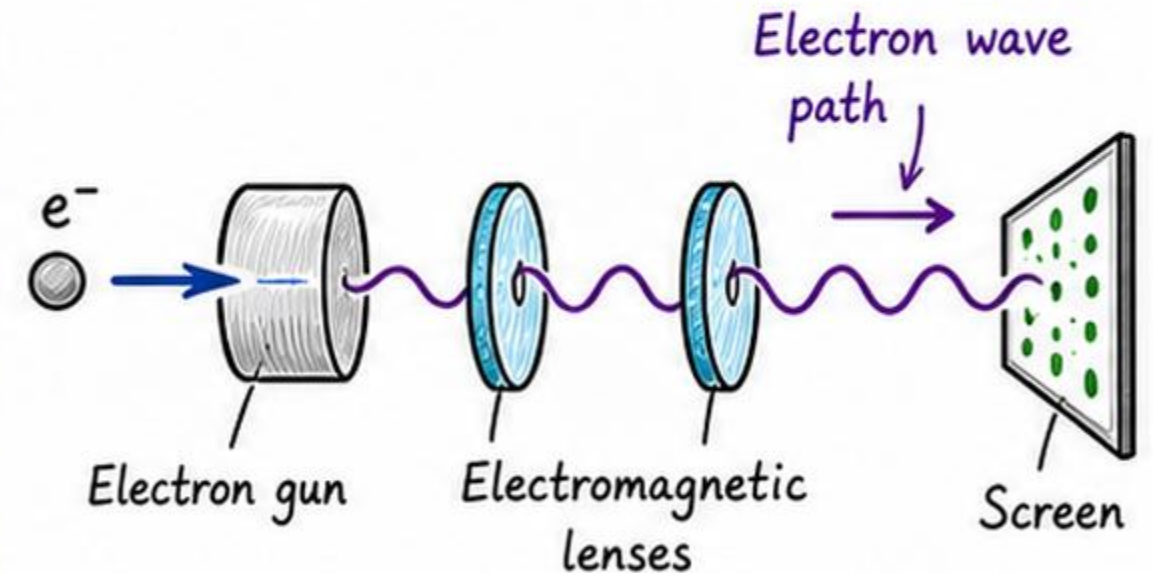


In vacuum:

$$c = 299,792,458 \text{ m s}^{-1}$$
$$\approx 3.00 \times 10^8 \text{ m s}^{-1}$$

③ MATTER WAVES

- Associated with particles such as electrons, protons, neutrons, atoms and molecules.
- Quantum idea studied later.
- Electron waves are used in electron microscopes.

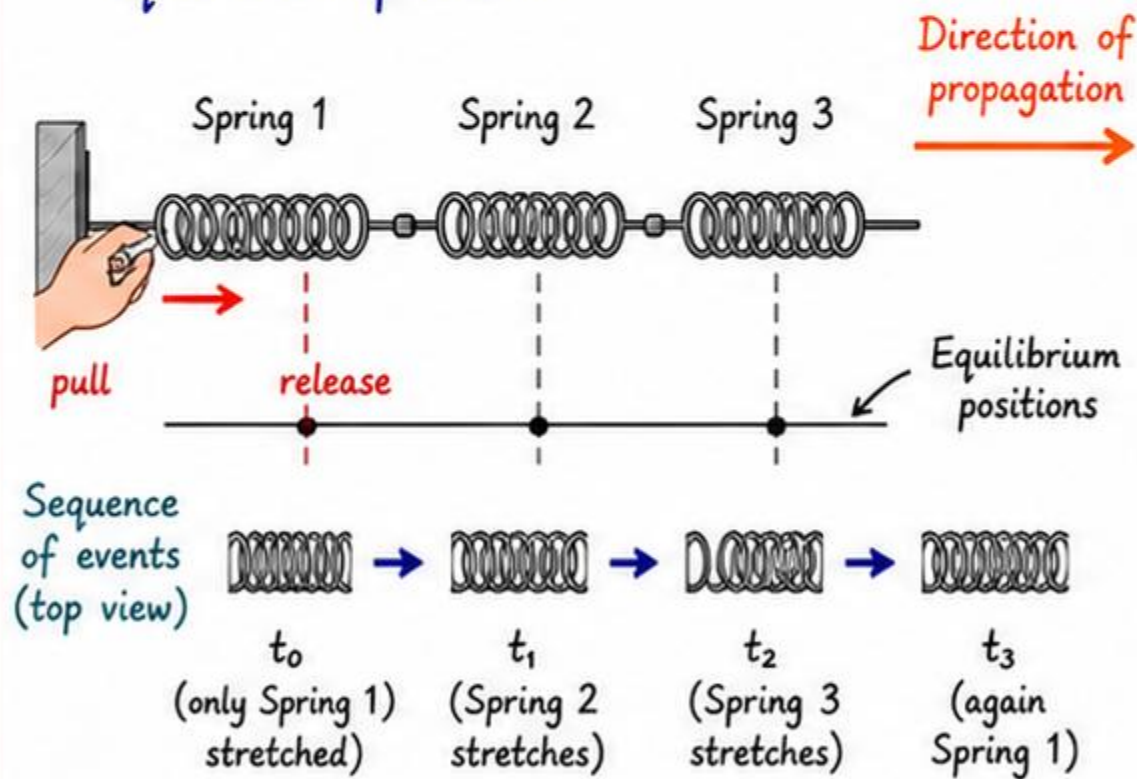


This chapter studies mechanical waves.

HOW MECHANICAL WAVES PROPAGATE

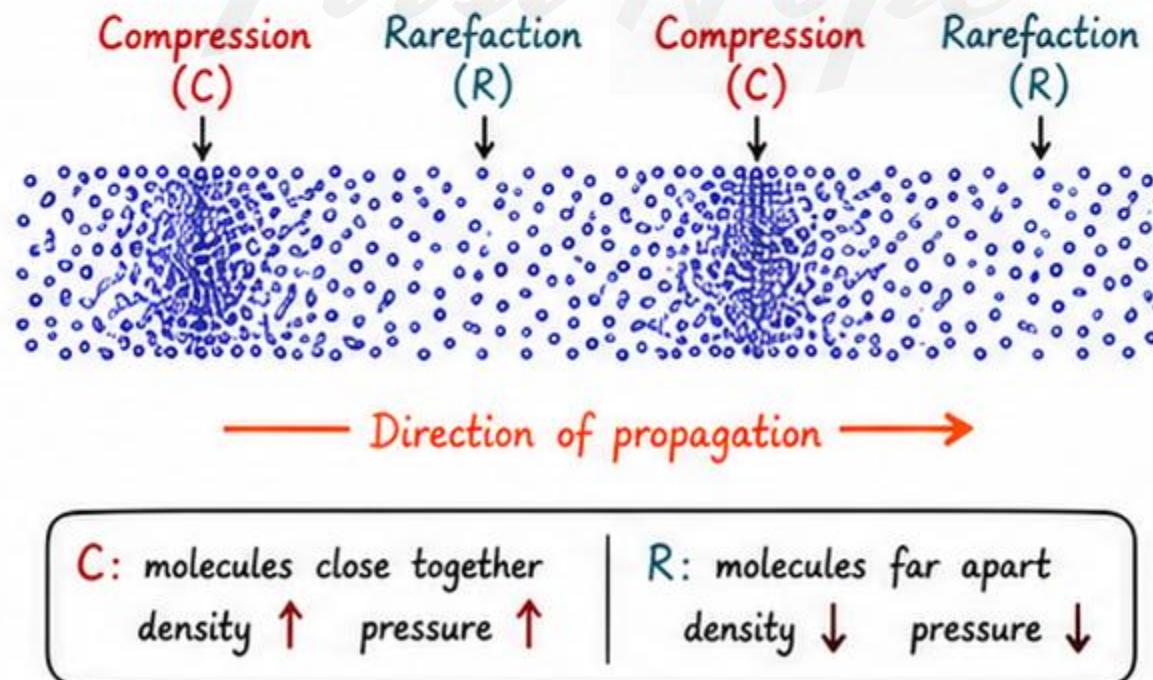
A CONNECTED SPRINGS

- Pull the first spring to the right and release.
- It pushes the next spring; the stretching or compression passes along,
- The disturbance travels rightward, but each spring oscillates about its own equilibrium position.



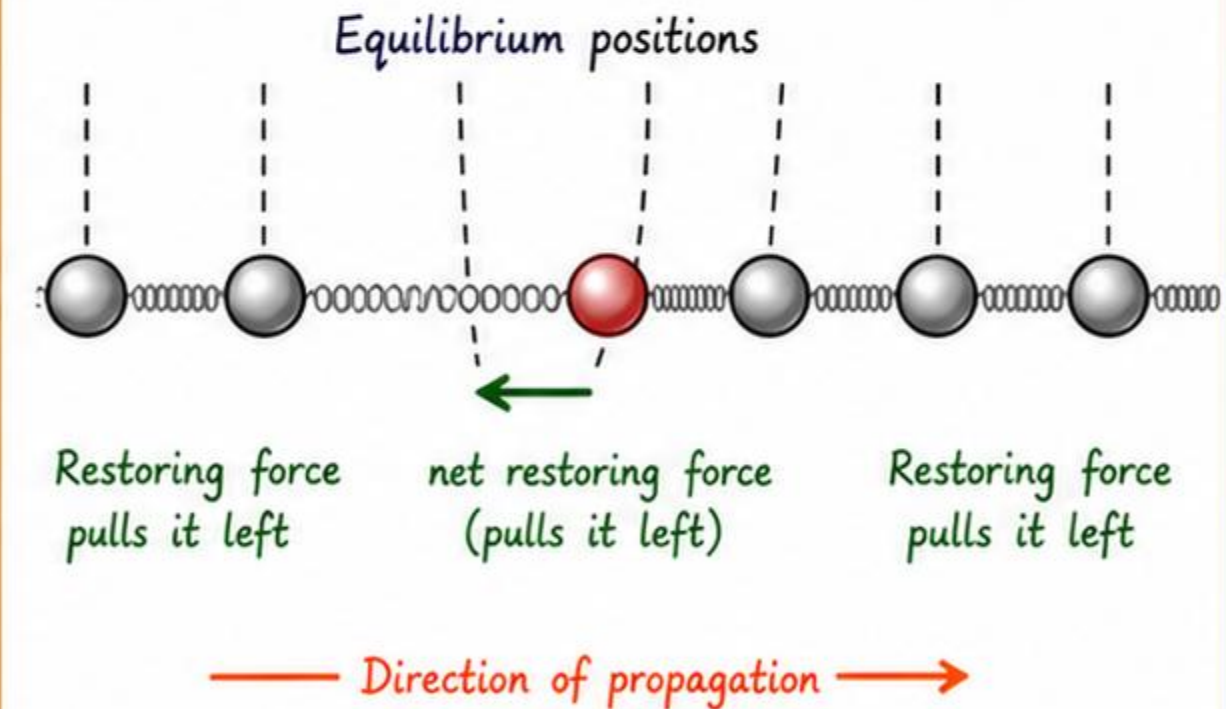
B SOUND IN AIR

- Sound is a longitudinal wave of **compressions (C)** and **rarefactions (R)**.
- In a compression, molecules are closer together; density and pressure are **higher**.
- In a rarefaction, molecules are farther apart; density and pressure are **lower**.
- Each region pushes or pulls the next, so C and R move forward.



C CRYSTALLINE SOLID

- Atoms in a crystal sit at equilibrium positions and are linked by interatomic forces.
- Displace one atom to the right.
- Restoring forces pull it back and push its neighbours.
- This effect spreads from atom to atom, allowing the disturbance to propagate.

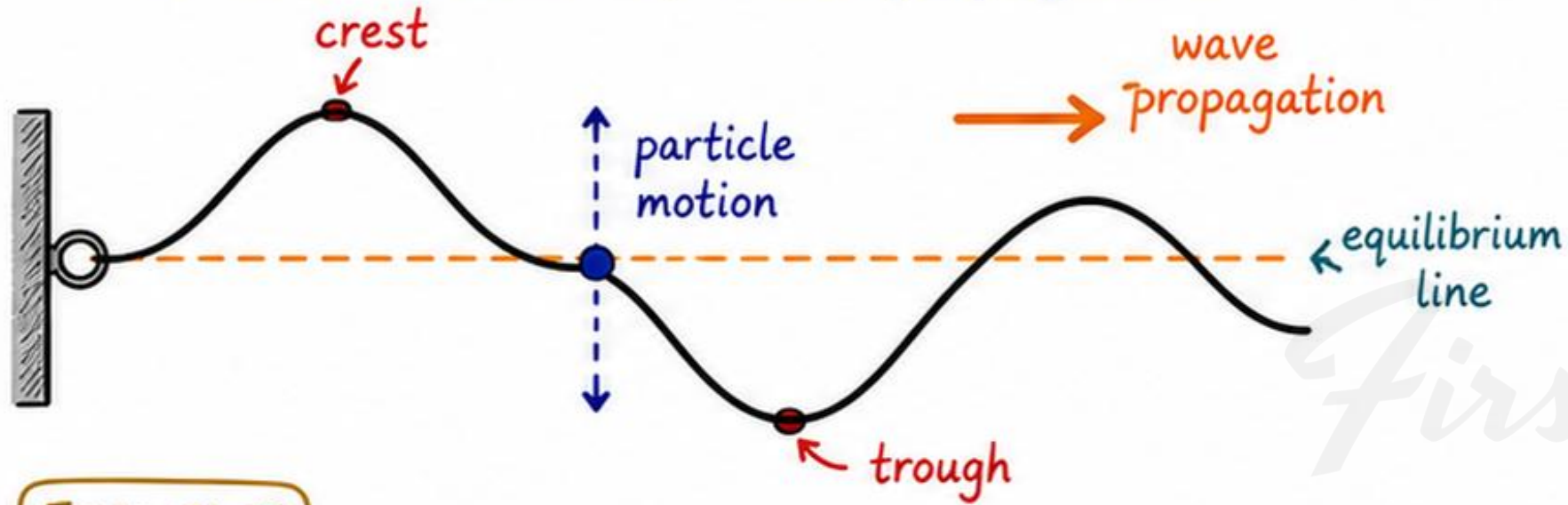


Elastic coupling + inertia allow a mechanical disturbance to travel.

TRANSVERSE & LONGITUDINAL WAVES

① TRANSVERSE WAVES

- Particles of the medium oscillate perpendicular to the direction of wave propagation.

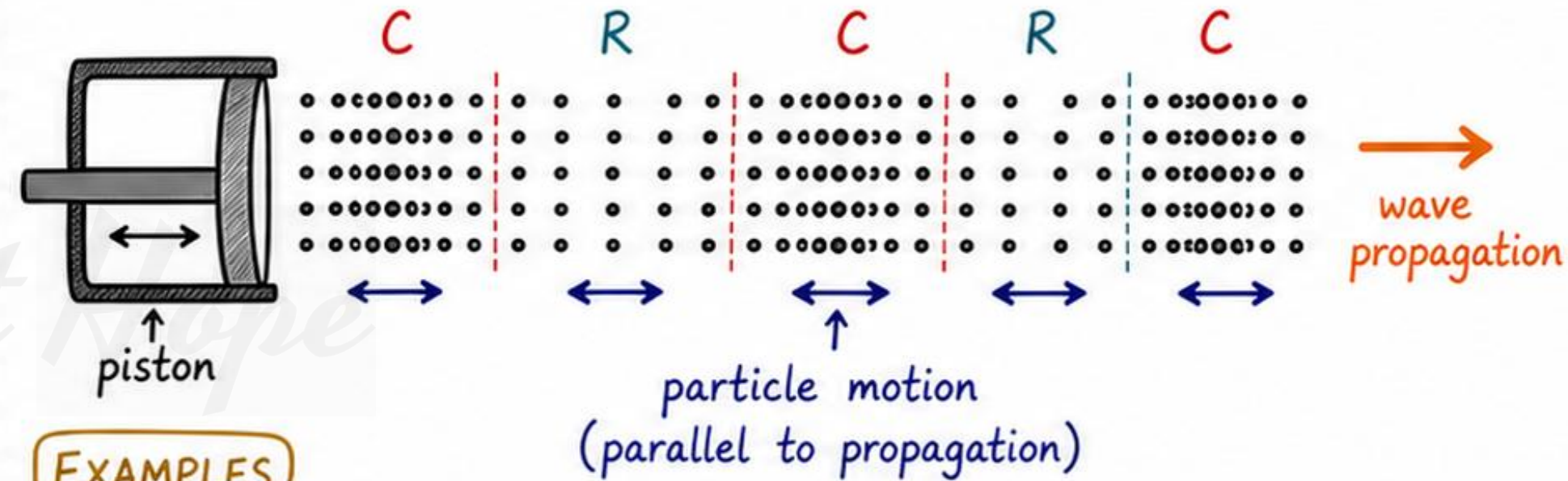


EXAMPLES

- Wave on a stretched string
- Seismic S-wave

② LONGITUDINAL WAVES

- Particles of the medium oscillate parallel to the direction of wave propagation.



EXAMPLES

- Sound in air
- Compression pulse in a spring (slinky)

PARTICLE DIRECTION	Perpendicular to the direction of propagation.	Parallel to the direction of propagation.
DISTURBANCE PATTERN	Crests and troughs about an equilibrium line.	Compressions (C) and rarefactions (R) along the medium.
COMMON EXAMPLE	Wave on a string.	Sound in air.

Both are **progressive** or **travelling** waves when the disturbance **moves through the medium** with time.



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