Unit 3. Waves

Y12

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1 Wave Basics

What is a wave? How many types of waves are there? Why are they useful?

→ **Wave:** transfer of energy without matter (by transmission of oscillations):

- Mechanical: oscillations of the medium.
- Electromagnetic: oscillations of fields (electrical or magnetic).

1.1 Analysis of a Wave

- Displacement x (m): distance to the equilibrium (average) position.
- Amplitude A (m): maximum displacement of a wave.
- Frequency f (Hertz Hz): number of cycles through a point per second.
- Wavelength λ (m): distance between 2 equal waypoints (eg 2 peaks). Figure 1
- Period T (s): time for 1 full oscillation or wavelength. Figure 2
- Phase θ (rad): stage of wave at a point (~ angle around a circle, we will see it…).
- Wave speed v (m/s): $v = \frac{d}{t}$ and also $v = f\lambda$ (Wave equation)
- Pulse-echo measurements (like bat and dolphin echolocation): emit a pulse of ultrasound (50-100kHz) and calculate $d = vt/2$ (rebound).

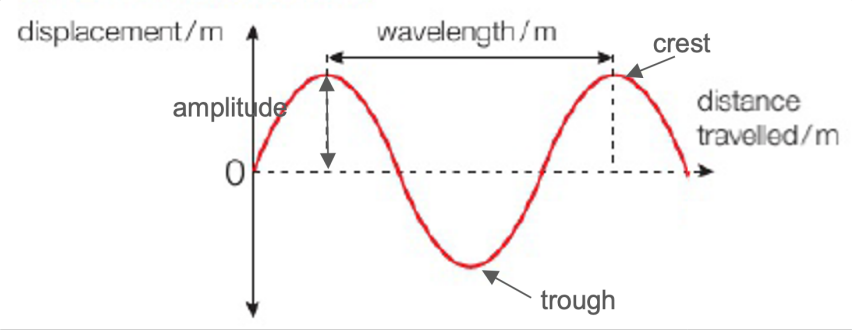

Figure 1: wave components 1

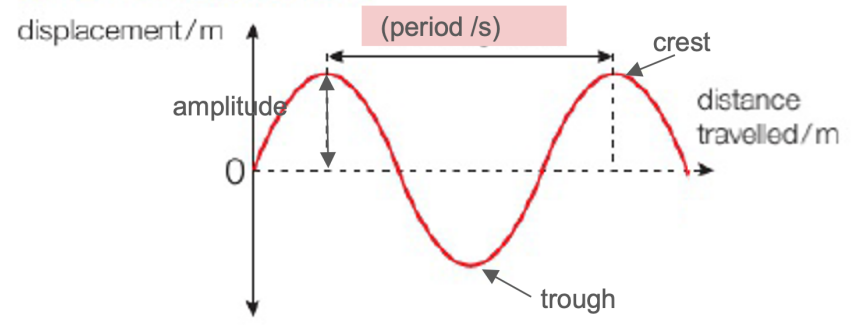

Figure 2: wave components 2

Checkpoint questions. (Extra: Read the experiment p.91, draw the wave diagram).

Answers

1. Graph from top to bottom: $0.2m$, $80m$, $5.5m$.
2. $1240m$ ($d = v \cdot t$)
3. $8.5 \cdot 10^{14} Hz$ ($f = c/\lambda$, wave equation)
4. As frequency is defined as waves per second, multipliying frequency by wavelenght is equivalent as dividing distance by time (velocity)
5. Student's own answers using $v = f \cdot \lambda$. Eg. estimated wavelenght is $5m$, estimated frequency is 1 wave every 3 seconds, so $f = 0.33Hz$. $v = f \cdot \lambda = 0.33 \times 5 = 1.7m\ s^{-1}$

2 Wave types

2.1 By oscillation plane

According to the oscillation plane, compared with wave displacement, we find transverse and longitudinal waves.

Do you know what transverse and longitudinal means?

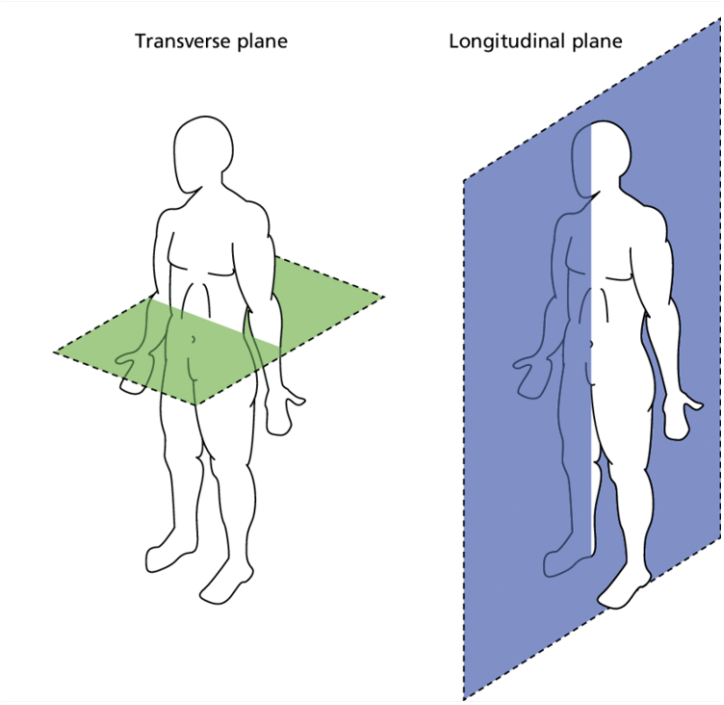

Figure 3: Transverse and longitudinal planes

→ Transverse wave: motion is perpendicular to displacement (up/down). Eg ropes, electromagnetic waves (light), earthquake S-waves.

→ Longitudinal wave: motion is parallel to displacement (front-back). Eg sound waves (compressions vs rarefactions), earthquake P-waves.

Both kinds of waves are represented in the same graphs.

- Compression: area at higher pressure (molecules closer together).
- Rarefaction: area at lower pressure (molecules further apart).

Watch this video

Minipractical: flick a string on top of the table and let it stop. Waves should remain visible. Measure the time for 10 "flicks" (oscillations) to calculate the frequency ($\frac{1}{T}$), and with a ruler the amplitude and wavelength. From this calculate the speed.