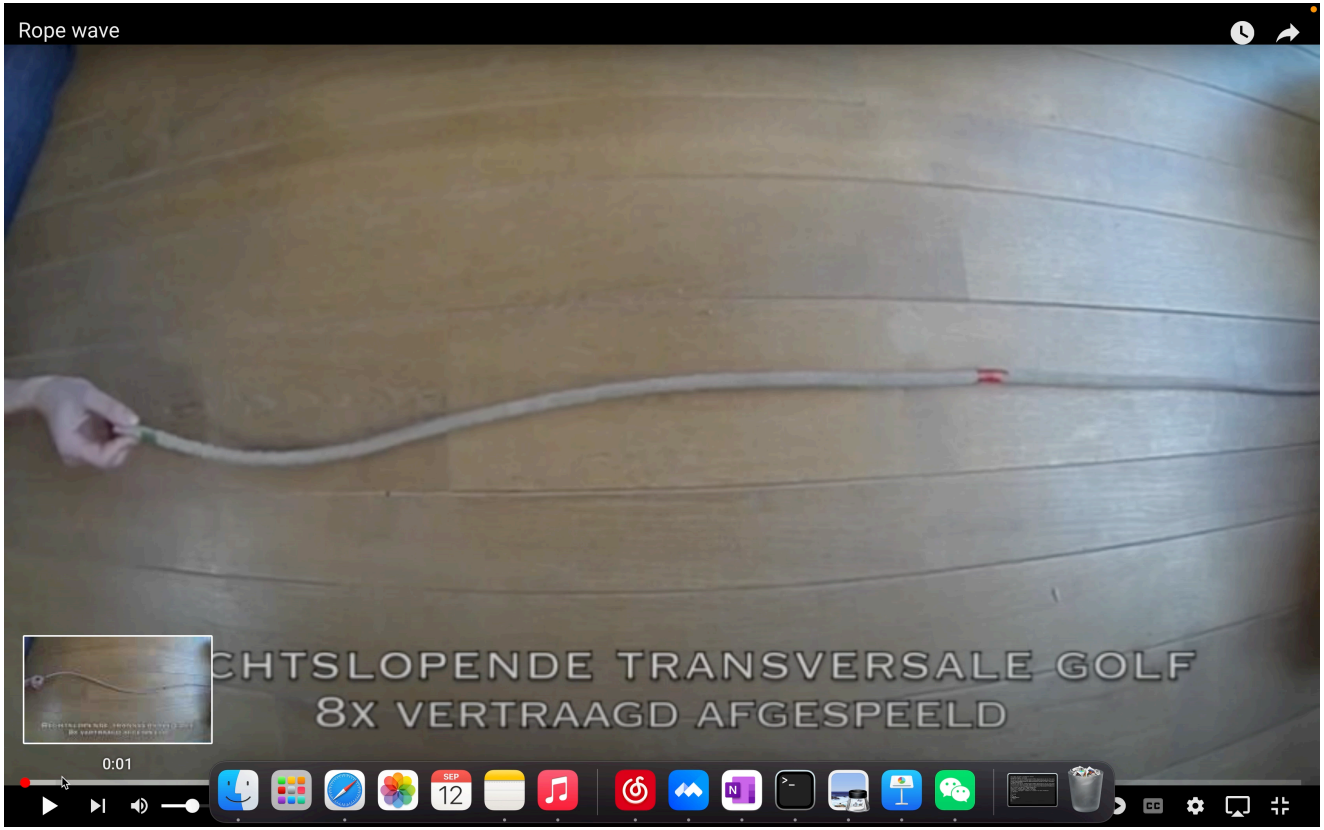
Properties of waves

Yutong 30/08/2022

Waves

Waves

Waves


Rope wave
CHTSLOPENDE TRANSVERSALE GOLF
8X VERTRAAGD AFGESPEELD
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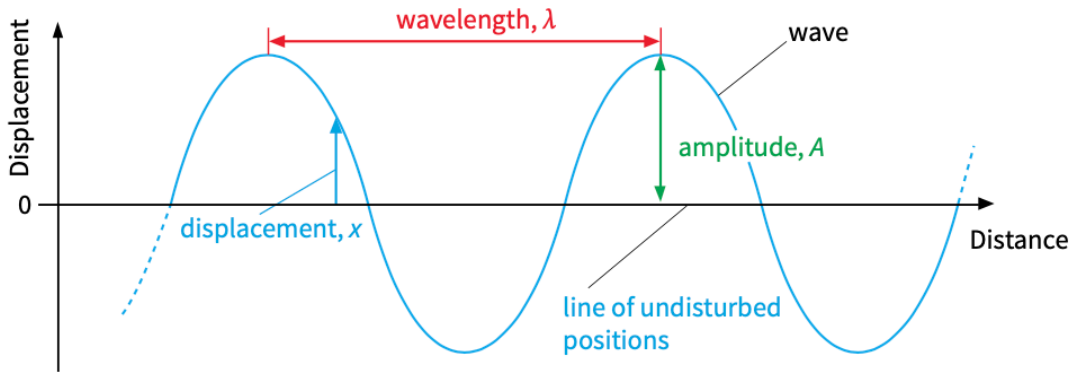
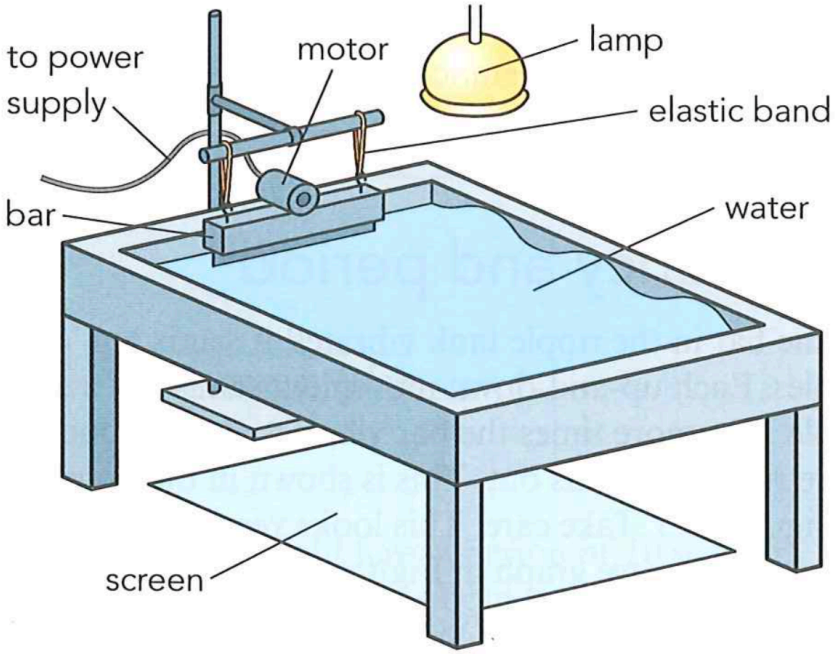
Waves

Wave model

In physics, we extend the idea of a wave to describe many other phenomena, including light, sound, etc. We do this by imagining an idealised wave.



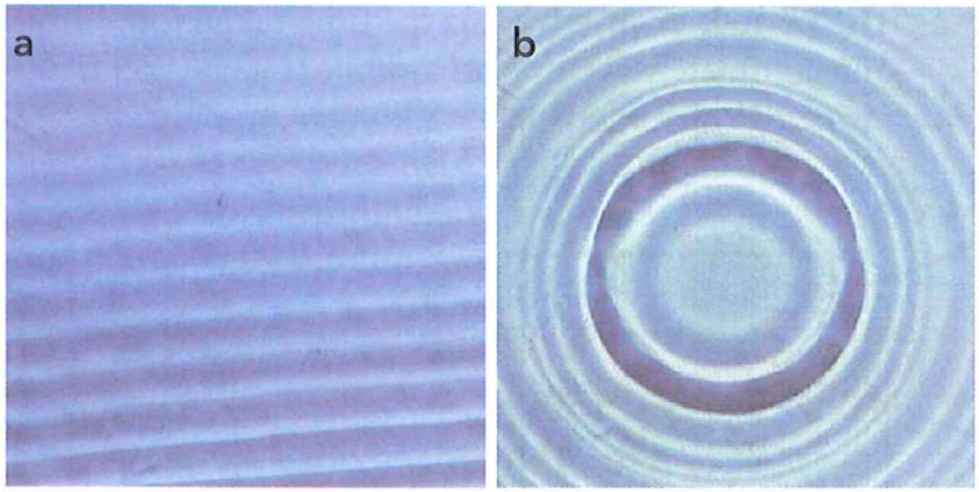
Ripple bank demonstation



a. Bar

b. Dipper

Vibrate up and down



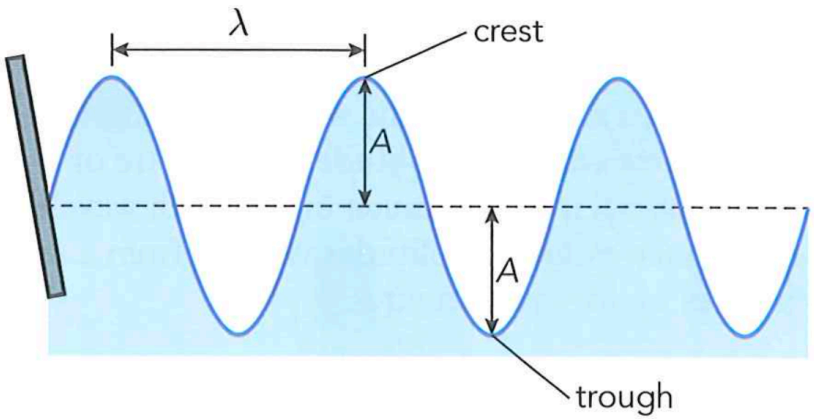
a. straight ripples: a broad beam of light

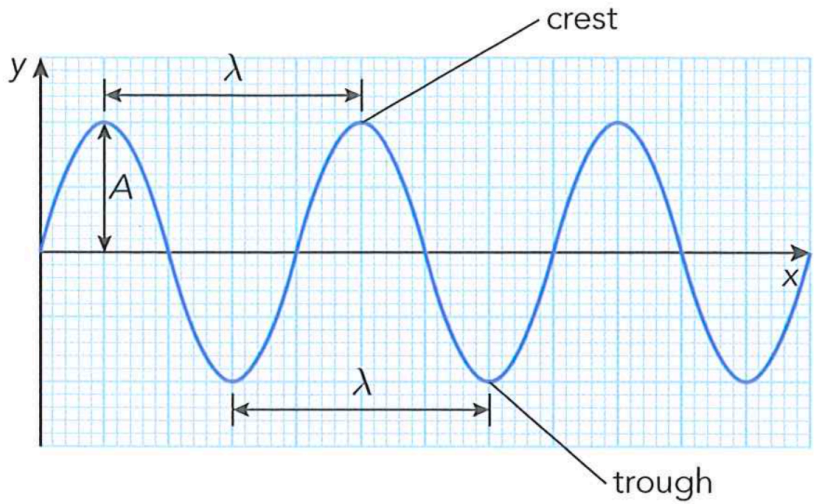
b. circular ripples: light spreading out from a lamp

Ripple bank demonstration

- Bar/dipper vibrates up and down vertically => ripplers move out horizontally
- Molecule moves up and down and drags its neighbors up and down
- **Wave transfers energy not matter/ wave is moving not matter**

Wave model: wavelength & amplitude





Mathematical representation:

$$y = \sin x$$

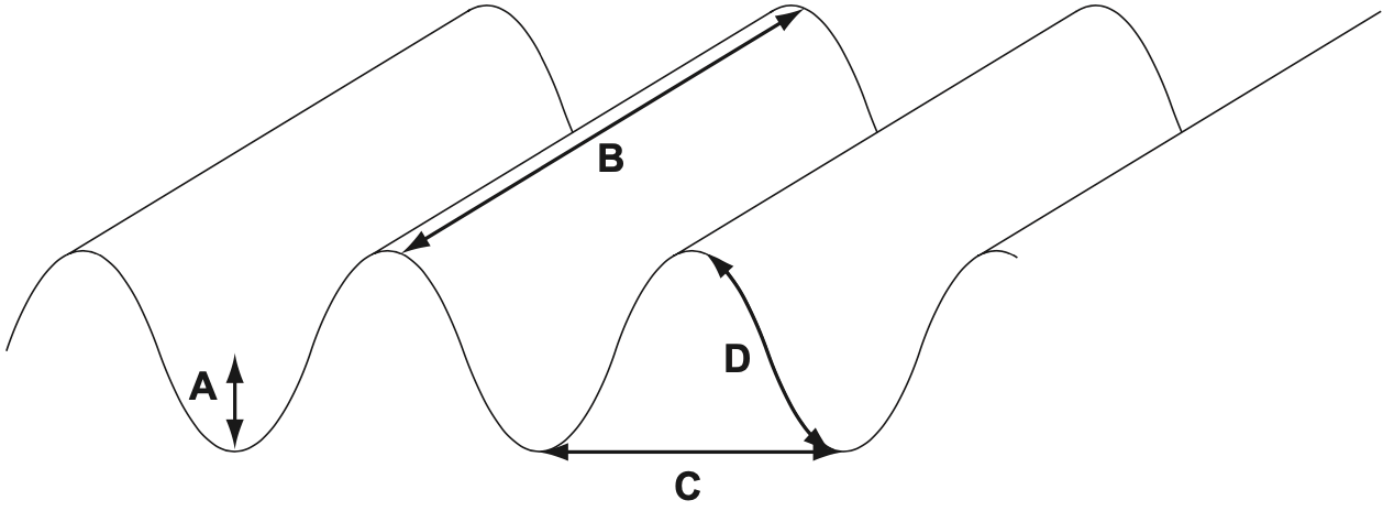
Wave model: wavelength & amplitude

- **Wavelength λ:** the distance from one **crest** to the next/ btw any two points which are in step; unit: m
- **Amplitude A:** the height of the crest/ the depth of a trough; unit: m
- **Wavefront:** the set of all points having the same *phase*
- What are the wavelength/ amplitude of ripples in the ripple bank?

Wave model: wavelength & amplitude

The diagram shows a water wave in a ripple tank.

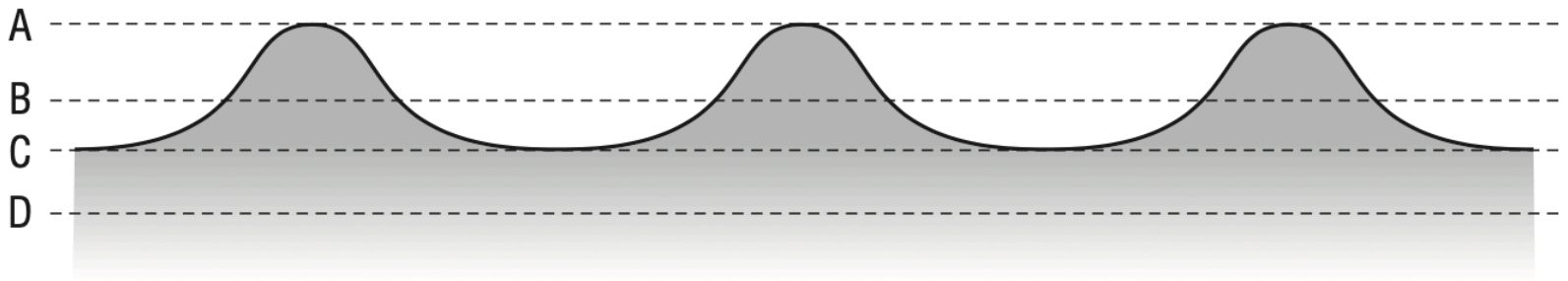
Which line represents a wavefront?



Wave model: wavelength & amplitude

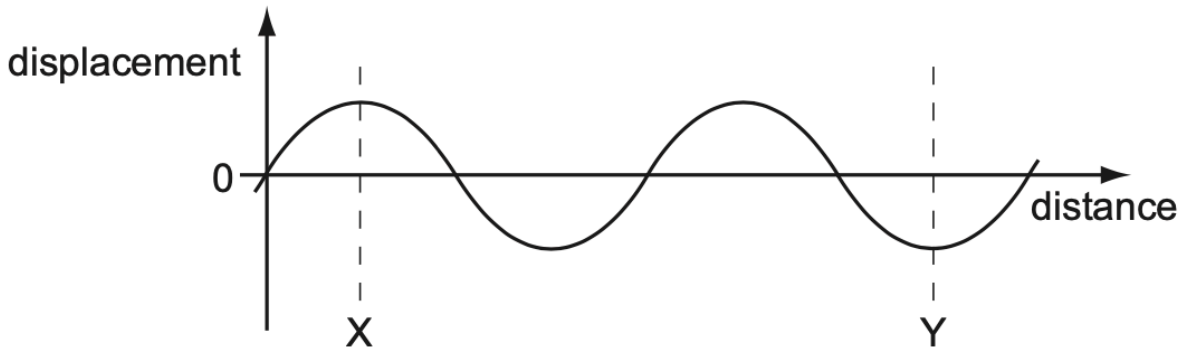
The diagram shows a section through a series of waves on water.

Which dotted line shows the position of the still water surface after the waves have passed?



Wave model: wavelength & amplitude

The diagram shows a wave.

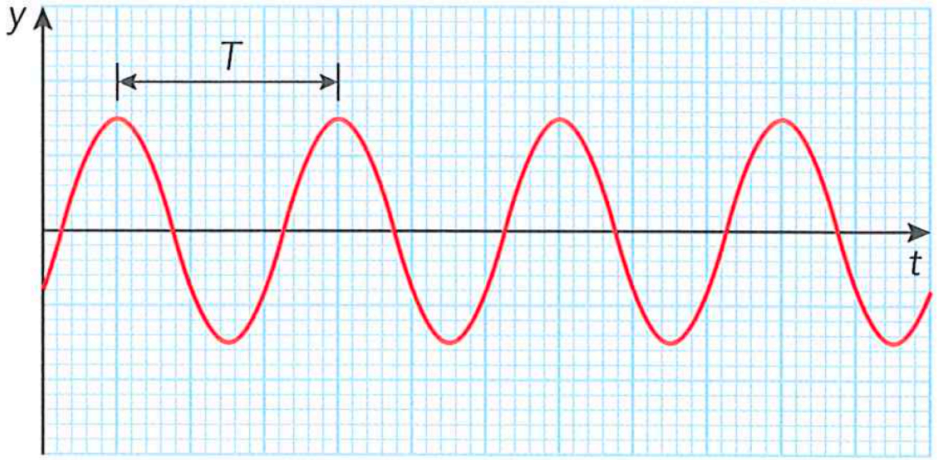


How many wavelengths are there between X and Y?

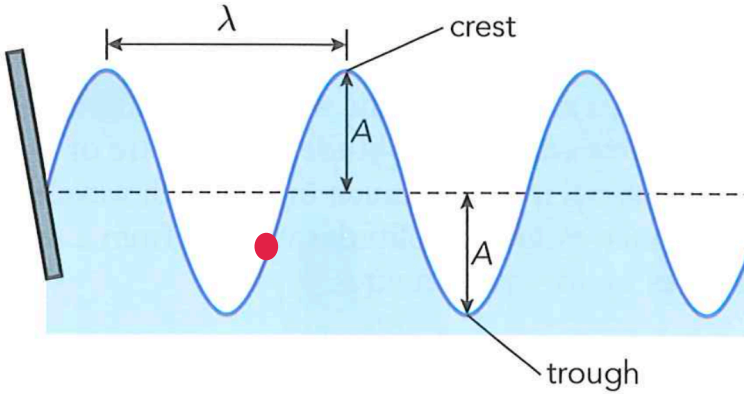
A $\frac{2}{3}$ **B** 1 **C** $1\frac{1}{2}$ **D** 3

Frequency and Period

- Each up-and -down movement (vibration) by bar/dipper sends out a single ripple
- More vibrations/second => more ripplers/second
- What are the frequency of ripples in the ripple bank?

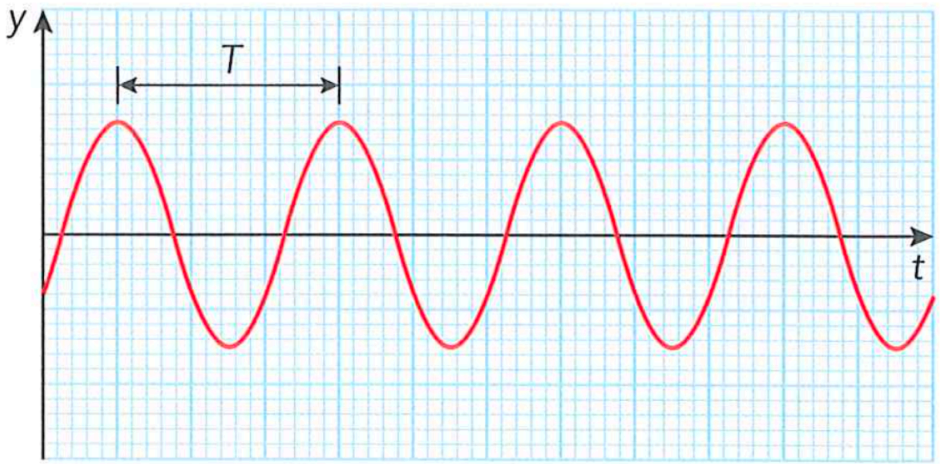


Wave at **a particular point** moves up and down as time passes



Frequency and Period

- X-axis: time **t**!!
- **Frequency f:** number of waves send out per second; unit: Hz
- **Period T:** the time taken for one complete wave to pass a point
- $T = \frac{1}{f}$



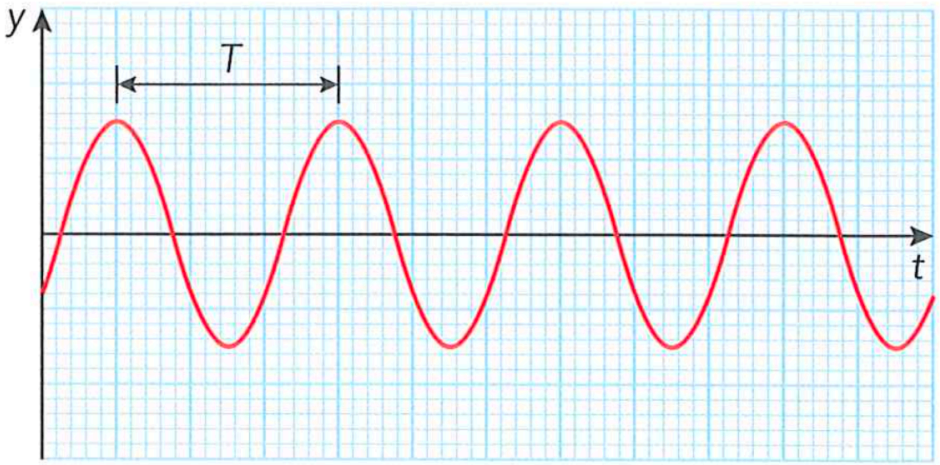
Wave at **a particular point** moves up and downs time passes

Frequency and Period

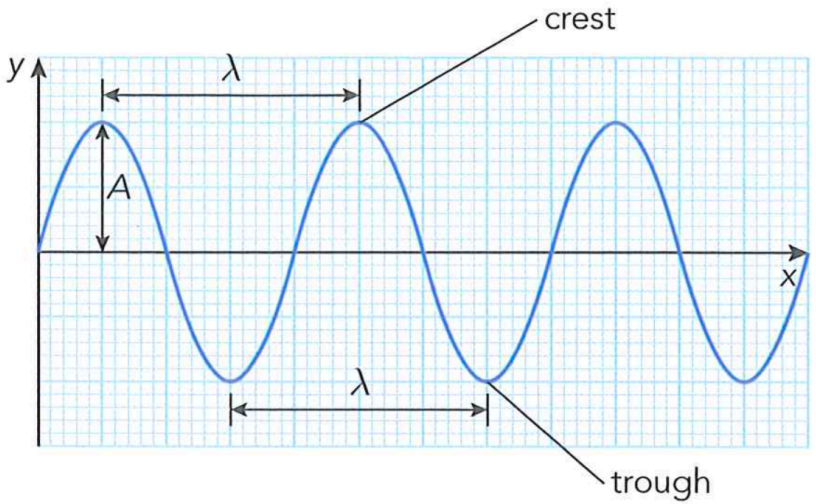
- $f = \frac{1}{T}$
- $T = \frac{1}{f}$

- Waves on the sea : T = 10s, f= 0.1Hz
- Sound wave: f = 0.001Hz, T = ?
- Electricity: f = 50Hz, T = ?

Frequency and Period



Wave at a particular **point** moves up and downs time passes



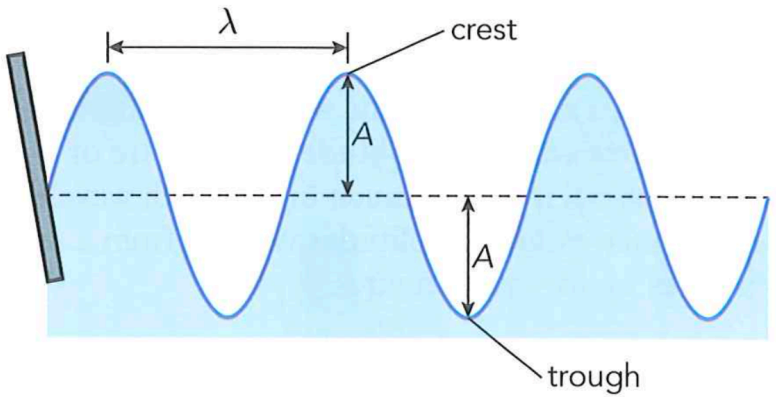
Wave at a particular **time** moves up and downs time passes

Wave speed

- **Wave speed:** the rate at which the crest of a wave travels

  E.g. the speed of the crest of a ripple traveling over the surface of the water

- Unit: m/s



Wave speed

Which is the best description of the speed of a water wave?

A the distance between one wave crest and the next

B the distance between the crest of a wave and a trough

C the distance that a particle of water moves up and down in one second

D the distance that a wavefront moves along the surface in one second

Wave speed

- **Wave speed:** the rate at which the crest of a wave travels

  E.g. the speed of the crest of a ripple traveling over the surface of the water

- Unit: m/s

$$v = \frac{\lambda}{T}$$

$$\lambda = vT = \frac{v}{f} \quad f = \frac{1}{T}$$

- Sound wave through air: $v = 330 m/s$
- Light wave through air: $v \approx 3 \times 10^8 m/s$

Wave speed

An FM radio station broadcasts signals of wavelength 1.5 meters and frequency 20MHz. What is their speed?

Wave speed

The highest note on a piano has a frequency of 4186Hz. What is the wavelength of the sound waves produces when this note is placed? Give your answers to two significant figures.

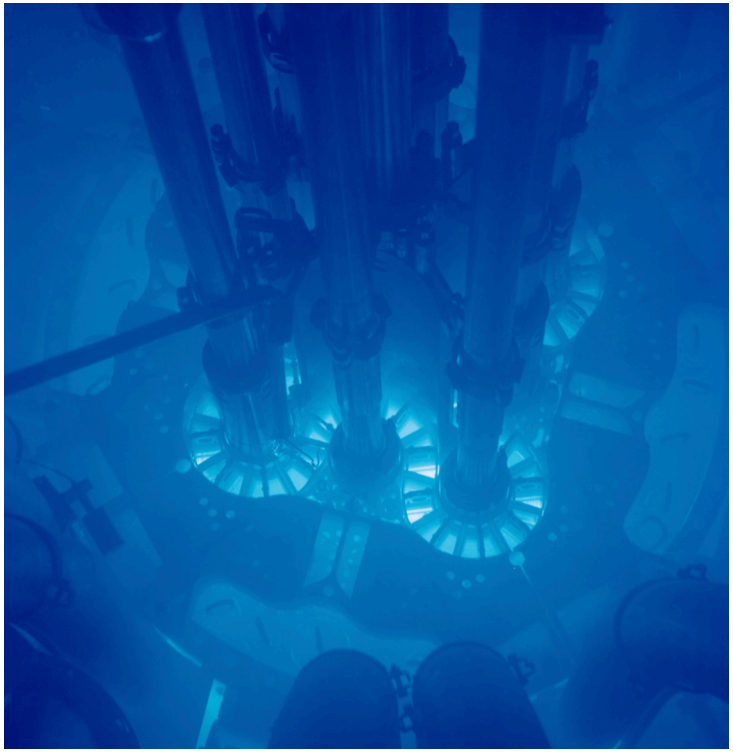
Changing material, changing speed

Faster than the speed of light?

Changing material, changing speed

Faster than the speed of light?

Cherenkov radiation

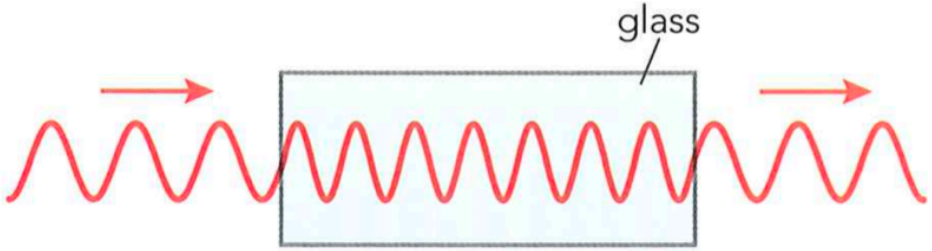


Changing material, changing speed

Waves travel in different materials will have different speed.

light in vacuum: c in water: 75%c in glass: 67%c

sound in air < sound in steel



Frequency unchanged; $v = \lambda f$

$(\lambda = \frac{v}{f})$

$v \uparrow \Rightarrow \lambda \uparrow$

Changing material, changing speed

A wave in air has a frequency of 1100Hz, an amplitude of 4cm and a wavelength of 30cm.

a. Calculate the speed of the wave

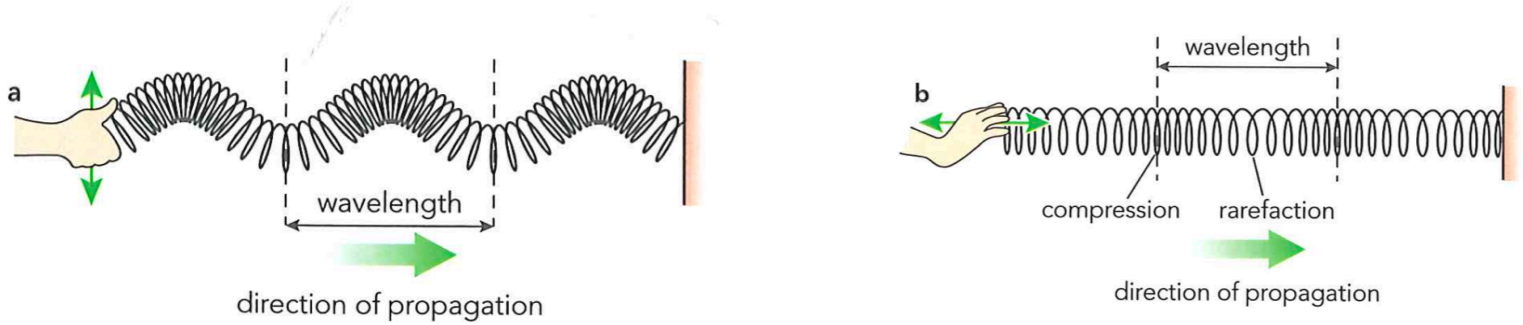
b. Calculate the period of the wave

Changing material, changing speed

Sound waves get faster when they go from air into water. What happens to their:

a. Speed?
b. Wavelength?
c. Frequency?
d. Period?

Transverse and longitudinal waves



Transverse waves: the particles carrying the wave move from **side to side**, at **right angle** to the direction of propagation of the wave.

Longitudinal wave: the particles carrying the wave move **back and forth**, **along** the direction of the propagation of the wave.

Transverse and longitudinal waves

Transverse waves	Longitudinal waves
ripples on water	sound
light and all other electromagnetic waves	primary seismic waves (P-waves)
secondary seismic waves (S-waves)	

Waves and energy

Alternatively, we can think of **wave speed** as the speed at which **energy** being transferred

Sun: light wave and infrared wave(radiation); sun -> earth

Loudspeaker: sound wave; source -> ear

Large **amplitude** (bright light/loud sound) -> more energy transferred

Waves and energy

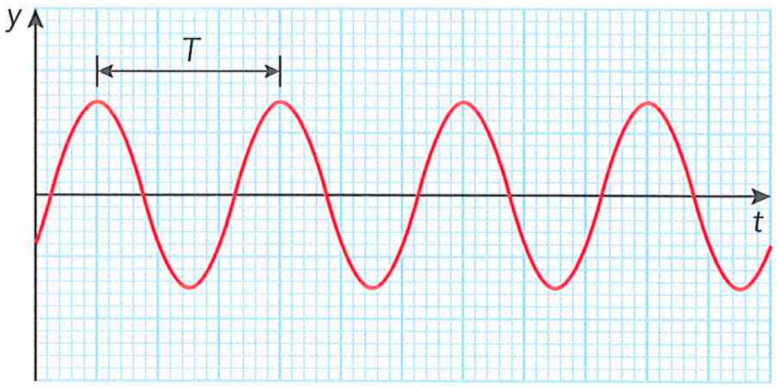
Waves and energy

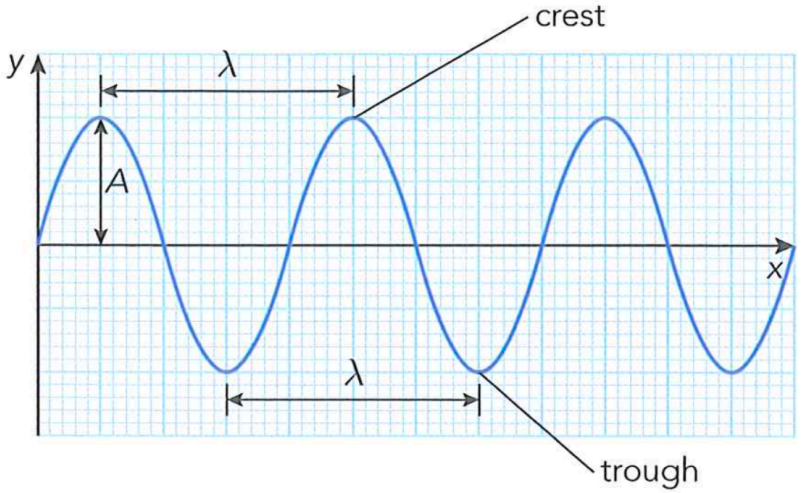
- A wave moves and transfers **energy** not matter

- Wave can travel through **medium or vacuum**

Summary

- Wave model: crest, trough, amplitude A, $\lambda = vT = \frac{v}{f}$ $f = \frac{1}{T}$
- y-t vs y-x graph
- Wave moves & transfers energy not matter



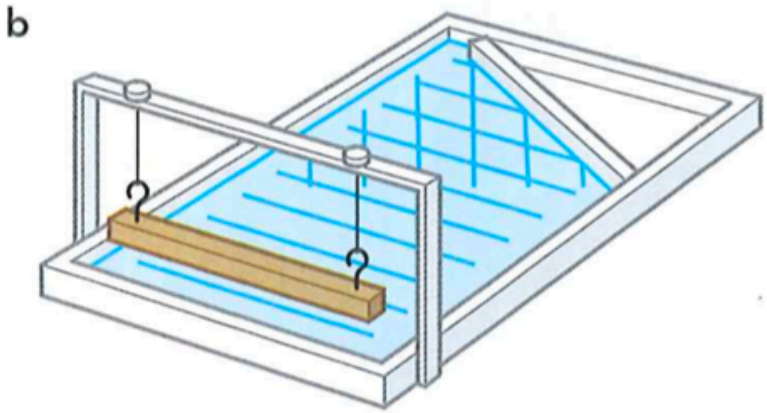


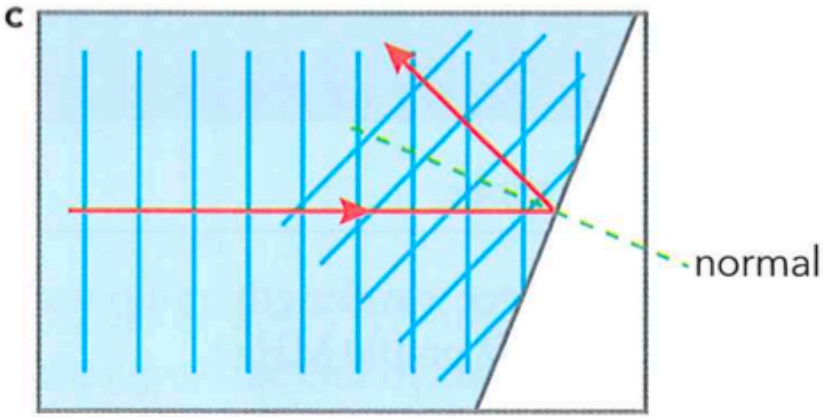
Explaining wave phenomena

Reflection:

Explaining wave phenomena

Reflection:

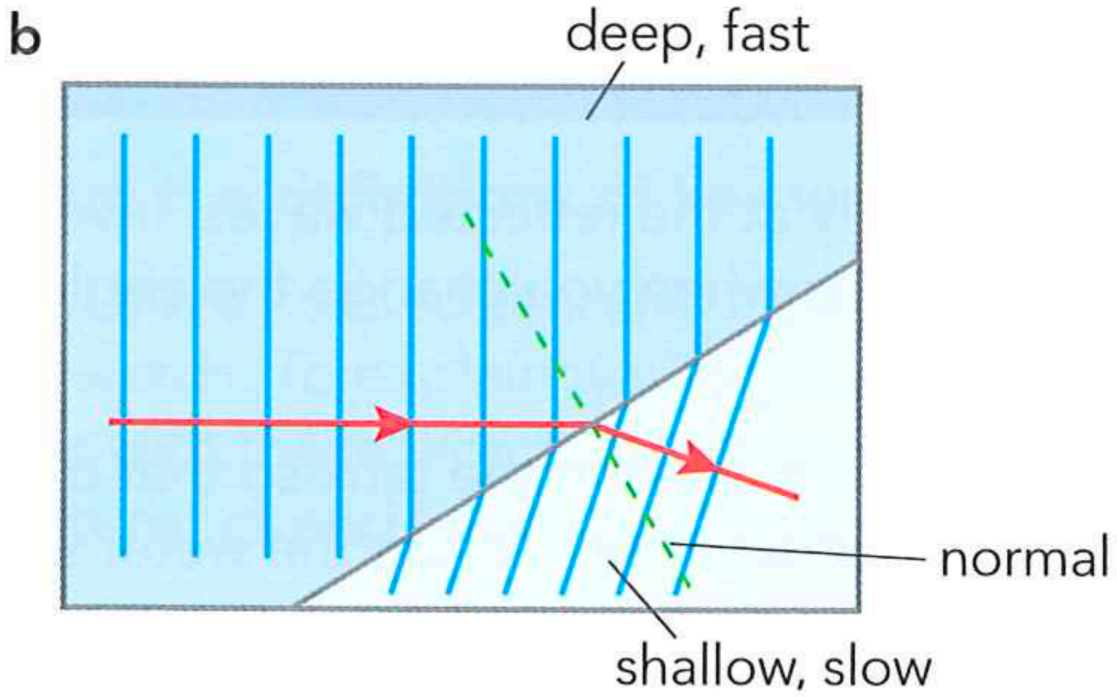




$$\theta_{incidence} = \theta_{reflection}$$

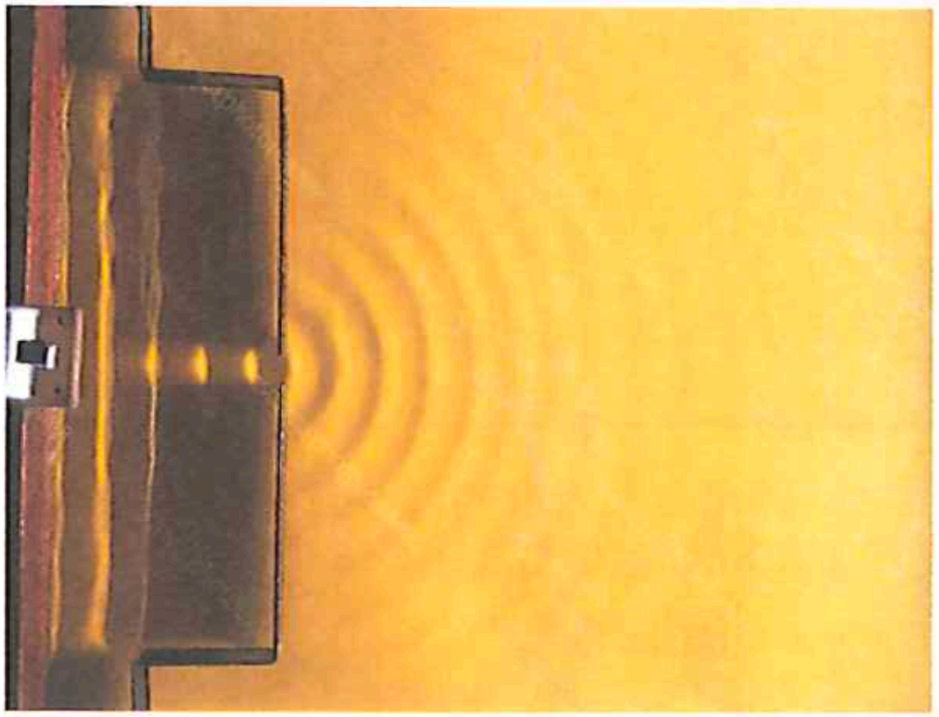
Explaining wave phenomena

Refraction:



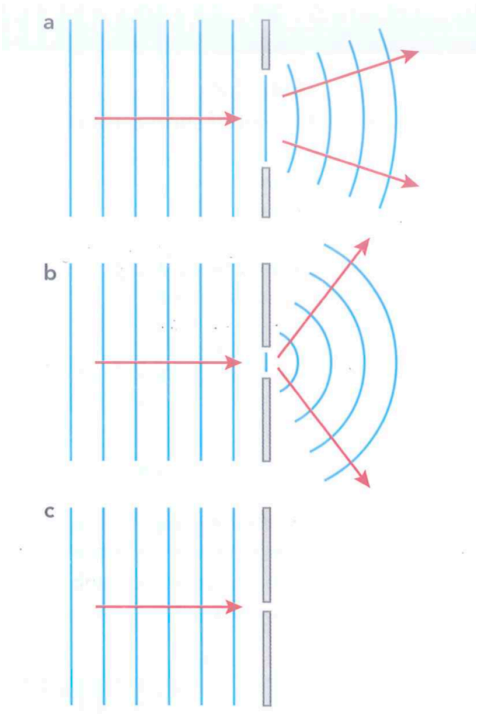
Explaining wave phenomena

Diffraction: a wave spreads out when it travels through a gap or a pst the edge of an object.



Diffraction

Diffraction effect is **greatest** when the **size of the gap or the object** equals to the **wavelength**.



Diffraction

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