Phys 100 2023

Lecture 29

Friday: Read 9.2 Mon: HW by 5pm

Waves:

A stretched string or slinky can be disturbed in such a way that a pattern propagates along its length. This is an example of a wave

DEMO: Stretched slinky wave.

DEMO: PhET - Waves Intro
* Water waves
* Sound waves

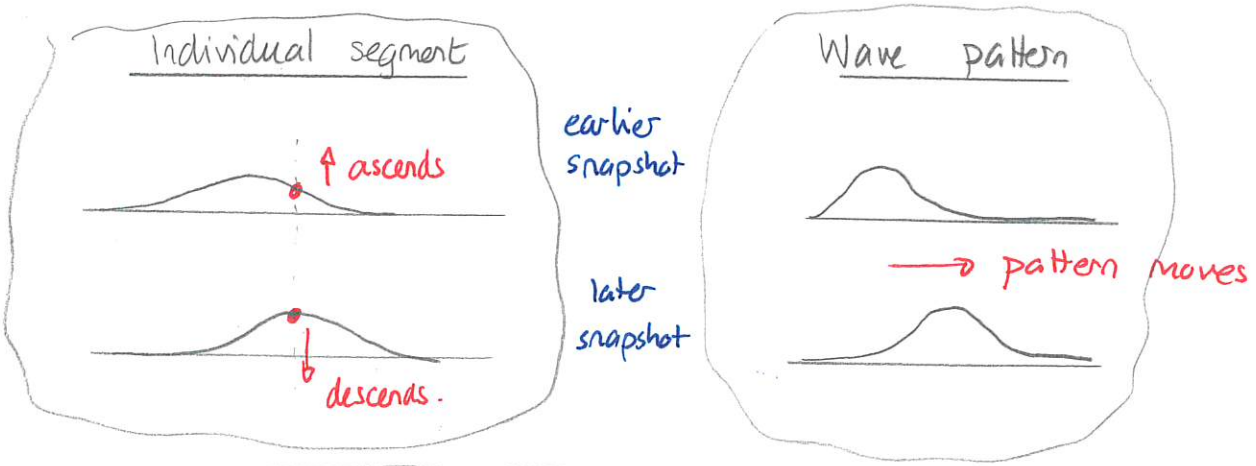
In these situations, the entity that hosts the disturbance has a continuous, extended nature. We refer to it as a "medium." As the wave propagates, there is an organized pattern of disturbances of parts of the medium. We aim to describe such waves or wave disturbances.

DEMO: PhET W.o.a.S.
* no end
* no damping
* produce pulse.

Quiz 1 95%

We observe that for certain types of waves on a string:
* the individual pieces of the string move vertically
* the pattern propagates horizontally

We have two aspects to the motion



Knowing how the pattern propagates allows us to predict the motion of any segment of the medium.

We can adapt basic physics (Newton's mechanics, electromagnetism) to provide a language that describes

* how the pattern propagates
* how the pattern transmits energy

This applies to:

1) water waves
2) sound waves
3) waves on strings
4) waves in bulk material
5) light and other electromagnetic waves.

Continuous waves

The waves that are easiest to describe consist of a continuous series of peaks and troughs.

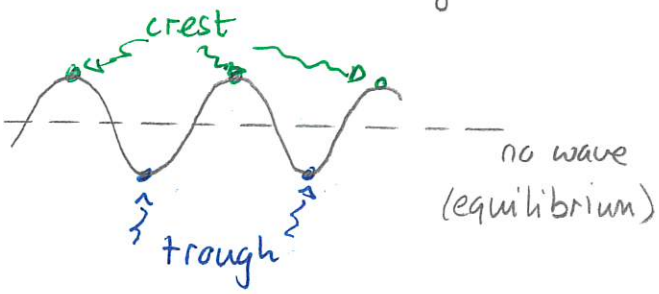
DEMO: PhET W.o.a.S.

* continuous waves

Mathematically these can be described using sinusoidal/cosinusoidal functions. However, most of their features can be described using a few simple quantities

We first consider a snapshot at one instant in time. We identify

1) crests ~ highest points
2) troughs ~ lowest points



We separately describe vertical and horizontal aspects of the snapshot. Note that as time passes the entire snapshot shifts horizontally, so these descriptions will not change with time

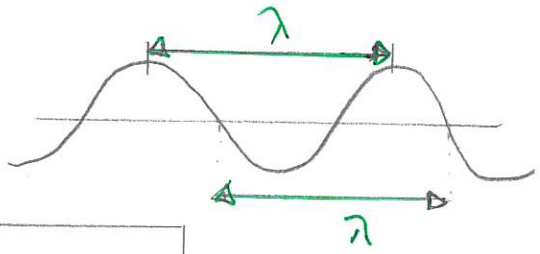
1) Amplitude (vertical aspect) = maximum vertical displacement from equilibrium
   * symbol, A

DEMO: Slide 1

A more sophisticated treatment shows that amplitude is related to the energy transported by the wave. Examples are:

a) light: amplitude ≈ intensity of light
b) sound amplitude ≈ loudness of sound

2) Wavelength (horizontal aspect)
   * describes horizontal "stretch" of pattern.
   * symbol: λ ("lambda")



The definition is

wavelength, λ = distance from one crest to next crest

units: meters

DEMO: Slide 2

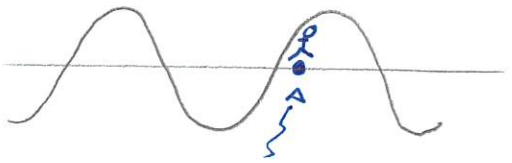
DEMO: PhET W.o.a.S → continuous
→ lower tension, see λ vary

Quiz 2 80%

We now need to consider temporal aspects of the wave - these describe how the pattern evolves as time passes.

3) Period (temporal aspect)

* describes "repetition time" for pattern.
* fix one horizontal location and observe crests passing this location.
* then



period of wave = time taken between arrival of one crest and the next crest at this location

units: seconds

4) Frequency (temporal aspect)

* describes the repetition rate of pattern.
* roughly count the number of crests that pass the observation location each second
* defined as:

$$\text{frequency} = \frac{1}{\text{period}}$$

units: Hertz (Hz)

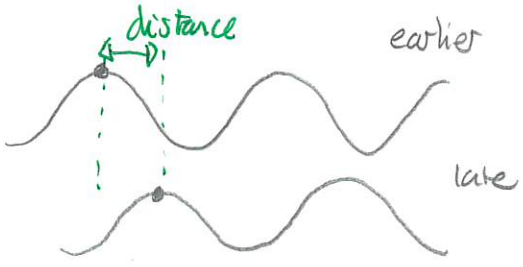
$Hz = \frac{1}{sec.}$

DEMO: W.o.a.S

* no end
* no damping
* tension low + adjust frequency.

5) Wave speed (spatial and temporal)

* describes speed with which pattern moves
* observe distance traveled by crest in some time interval



$$\text{wave speed} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

units: m/s

1 Wavelength, frequency and speed for continuous waves

The PhET animation "Waves on a String" allows you to visualize transverse waves on a string. Find the animation at

`https://phet.colorado.edu/en/simulation/wave-on-a-string`

and open it. Adjust the settings as follows:

- Check the button "No end" at the upper right.
- In the control panel at the bottom, adjust "Damping" to none.
- In the control panel at the bottom, adjust "Tension" to medium.
- In the control panel at the bottom, check the "Rulers" and "Timer" buttons.
- Leave the frequency on its default setting 1.50 Hz.
- Check the button "Oscillate" at the upper left.

a) Pause the wave and use the ruler to determine the wavelength of the wave.

b) Play the animation and use the timer to determine the period of the wave. Determine its frequency. *You can use the "Slow Motion" option. This does not affect the timing.*

c) Use the rulers and timer to determine the speed of the wave

A general rule for any continuous wave of this type is

$$\text{speed} = \text{wavelength} \times \text{frequency}.$$

d) Using your data verify whether this general rule is correct.

Answer: a) Appears to be 2,5cm

b) 5 crests pass in 3.36s

Time between successive crests is

$\frac{3.36s}{5} = 0.672s$ period = 0.672s

Frequency $= \frac{1}{\text{period}} = \frac{1}{0.672s} = 1.49\,Hz$

c) One crest travels 5cm in 1.34s

speed $= \frac{5cm}{1.34s} \approx 3.7\ cm/s$

d) wavelength × freq = $2.5cm \times 1.49Hz = 3.7\ cm/s$