Phys 111 2023

Lecture 39

Weds: Warm Up 15

Thurs: Diagnostic Test 2nd Round

Up to 5pts extra credit: take test ≥ 3pts
improve ≥ 4pts
improve by more than ≥ 40% ≥ 5pts

Details in email.

Thurs: Discussion

Ex 351, 352, 353, 354, 356, 357, 358

Fri: Final Review.

Waves

Waves are a co-ordinate disturbance that propagates along a medium. These often have an oscillatory nature

DEMO: 1) slinky waves

2) PhET W.o.a.S - no end
- no damping
- tension; low
- oscillate.

The general language of waves in the physical world applies to

1) water waves
2) sound waves
3) light
4) vibrations in solids
5) quantum physics

Traveling waves

Typically waves propagate through a medium (object, matter, any other "host" for the waves). The animation illustrates a particular type of wave:

1) portions of the medium are disturbed (pieces of string move) vertically.

2) the pattern propagates horizontally through the medium

When the pattern propagates in a direction perpendicular to the displacement of the medium, we say that the waves are transverse. This is not always the case. We can follow the progress of the pattern as time passes

DEMO: PhET W.o.a.S

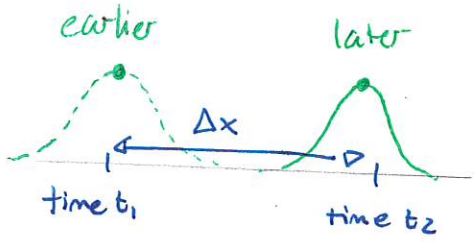
- create pulse and observe progress.

Then

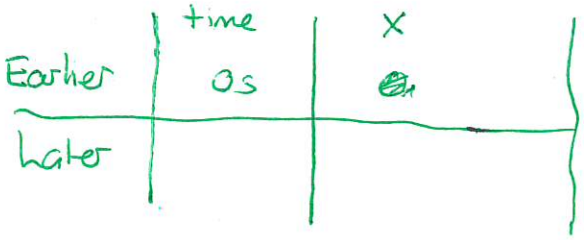
> wave speed = speed with which any single portion of the pattern progresses

We consider the pattern at two instants. Then

$$\text{wavespeed} = \frac{\Delta x}{\Delta t} = \frac{\Delta x}{t_2 - t_1}$$



observe peak at two instants



$$\Rightarrow v = \frac{\Delta x}{\Delta t}$$

=

The wavespeed generally depends on the medium (and sometimes on the nature of the wave). We can establish rules for the wavespeed by mathematical manipulations involving Newton's laws and other basic physics

For waves on a string

$$v = \sqrt{\frac{T}{\mu}}$$

where T = tension in the string

μ = mass per meter of the string

Quiz! 70% - 80%

Example: A 0.80m long string has mass 0.010kg. Determine the tension required so that waves travel with speed 450m/s.

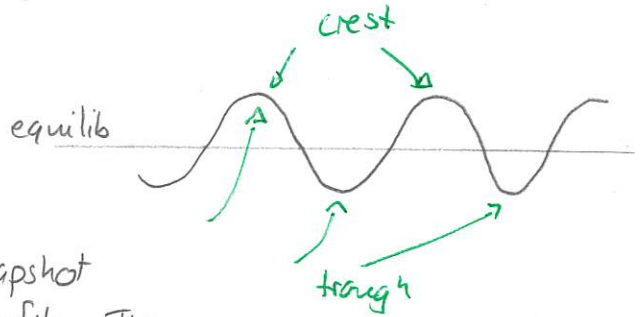
Answer: $v = \sqrt{\frac{T}{\mu}} \Rightarrow v^2 = \frac{T}{\mu} \Rightarrow T = v^2\mu$

$$\mu = \frac{0.010\,kg}{0.80m} = 0.0125\,kg/m \Rightarrow T = (450m/s)^2 \times 0.0125\,kg/m$$

$$= 2500N$$

Sinusoidal waves

One can produce a wave that consists of a stream of crests and troughs

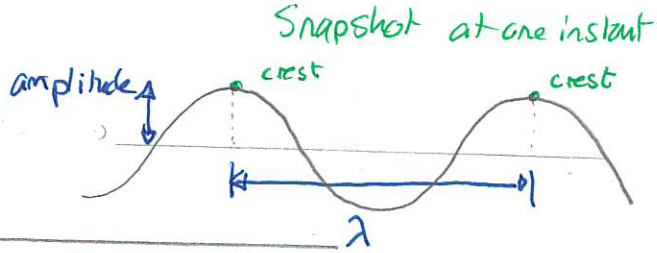


DEMO: PhET W.o.a.S

Oscillate

The simplest case is that where a snapshot at any instant reveals a sinusoidal profile. This is a sinusoidal wave. The spatial aspects are described by two quantities refering to a snapshot of the wave

1) The amplitude of the wave is the maximum displacement from equilibrium ~~hori~~ vertical



2) The wavelength is horizontal

λ = horizontal distance between successive crests

= distance between successive points in same "state"

units: m

Quiz 2

As time passes the pattern moves and there are two quantities that describe the temporal evolution.

1) the period of the wave, T, is the time between the arrival of successive crests at one location

units: s

DEMO: PhET W.o.a.S

- no end, no damping, tension low
- freq = 0.33 Hz

→ time for successive crests to reach left edge of window = 3.06s

2) the frequency of the wave is

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

units: $Hz = 1/s$

This also corresponds to the number of crests that passes any location in 1.0s

- for the demo $f = \frac{1}{0.306} = 0.33\,Hz$

In general, for any sinusoidal wave:

$$v = \lambda f$$

wavespeed, wavelength, frequency

355 Guitar string

A guitar string has length 0.80 m and mass 0.0028 kg and vibrates with frequency 440 Hz. The wavelength of the waves on the string is 1.60 m. Determine the tension in the string. *(111F2023)*

Answer: Tension related to speed $v = \sqrt{\frac{T}{\mu}}$

Speed related to wavelength / freq: $v = \lambda f$

Then $v = \lambda f$

$\Rightarrow v = 440\,\text{Hz} \times 1.60\,\text{m}$

$= 704\,\text{m/s}$

$v = \sqrt{\frac{T}{\mu}}$

$v^2 = \frac{T}{\mu} \Rightarrow T = v^2\mu$

and $\mu = \frac{0.0028\,\text{kg}}{0.80\,\text{m}} = 0.0035\,\text{kg/m}$

$\Rightarrow T = (704\,\text{m/s})^2 \times 0.0035\,\text{kg/m}$

$= 1.73 \times 10^3\,\text{N}$

$= 1730\,\text{N}$