INTRODUCTION TO WAVES

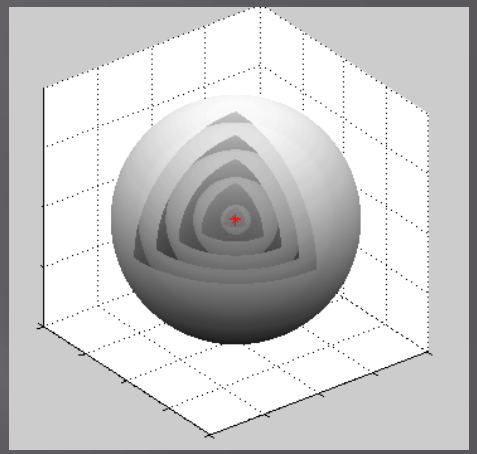
What is a wave?

A vibration that travels through space and transmits energy.

Waves can travel in 1, 2 or 3 dimensions!

Wave in a string- 1D

Wave in a pond- 2D



Sound waves spreading out from point source

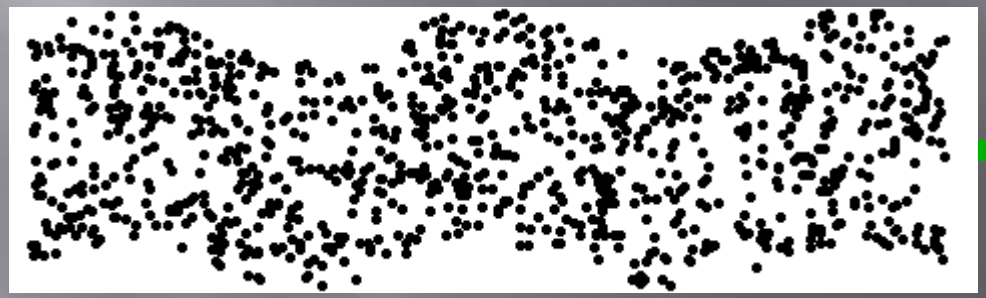
3D

Animation…

Types of 1D waves

Transverse Waves

particle motion is **perpendicular** to direction of wave motion

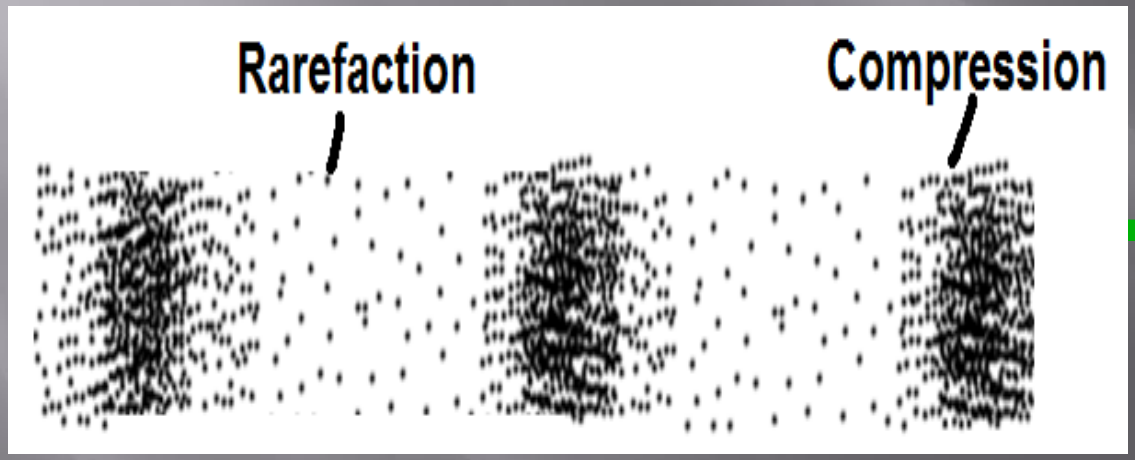


Particle Vibration

Wave propagation direction

Longitudinal Waves

particle motion is parallel to direction of wave motion

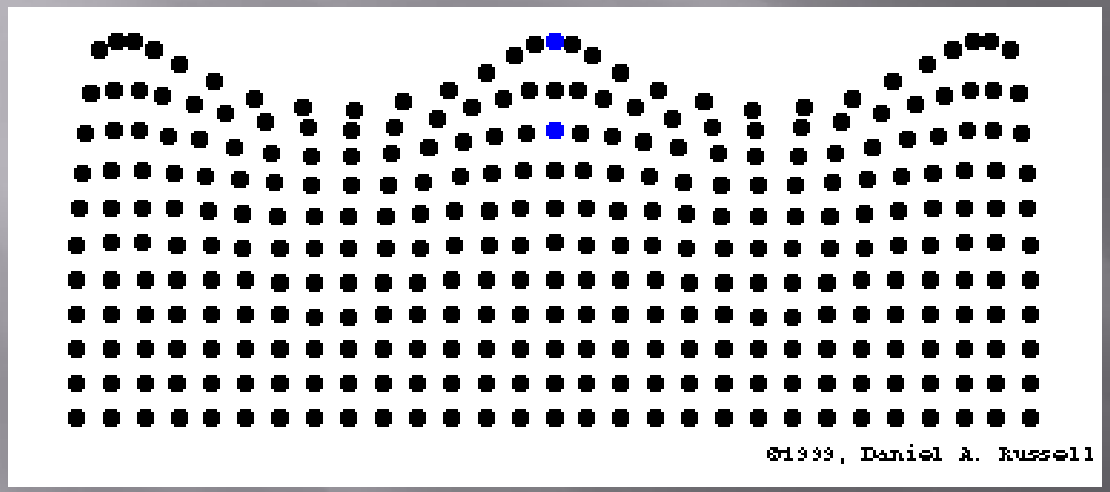


Particle Vibration

Wave propagation direction

Water Waves

A combination of longitudinal and transverse motion



Particle Vibration

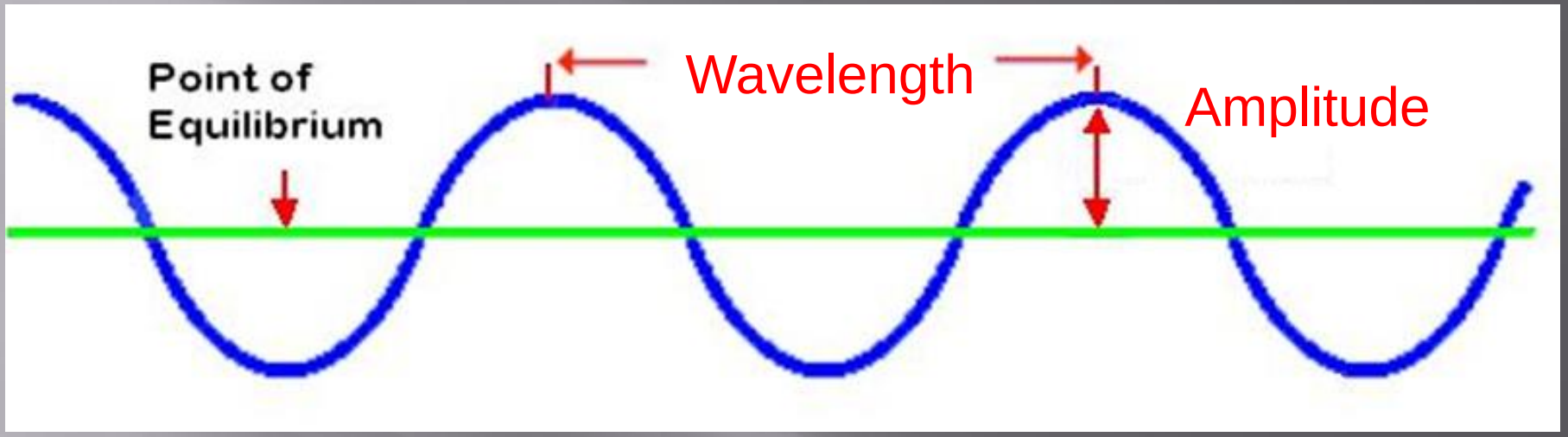
C

Wave propagation direction

Particles travel in clockwise circles!!

Wave animations….

Wave Properties



Wavelength (λ) **Units: m**

-distance between any two successive points in phase

Amplitude (A) **Units: m**

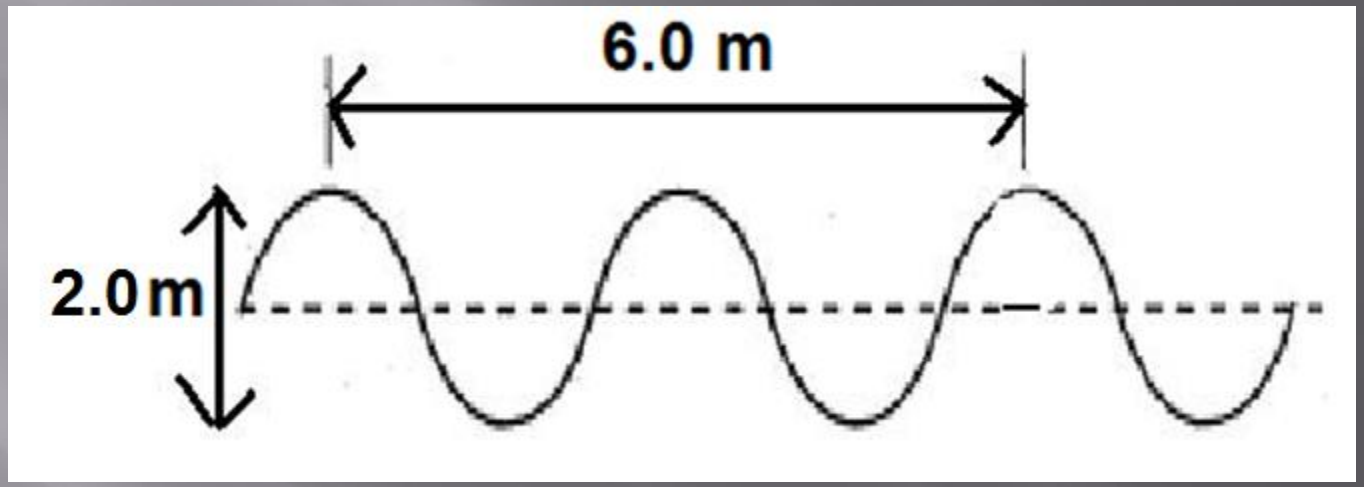
-maximum displacement of a particle from its rest position

Example 1: For the wave below

a) State the wave type

b) Determine the amplitude (A)

c) Determine the wavelength (λ)



Answer:

a) transverse

b) $2A = 2.0$ m

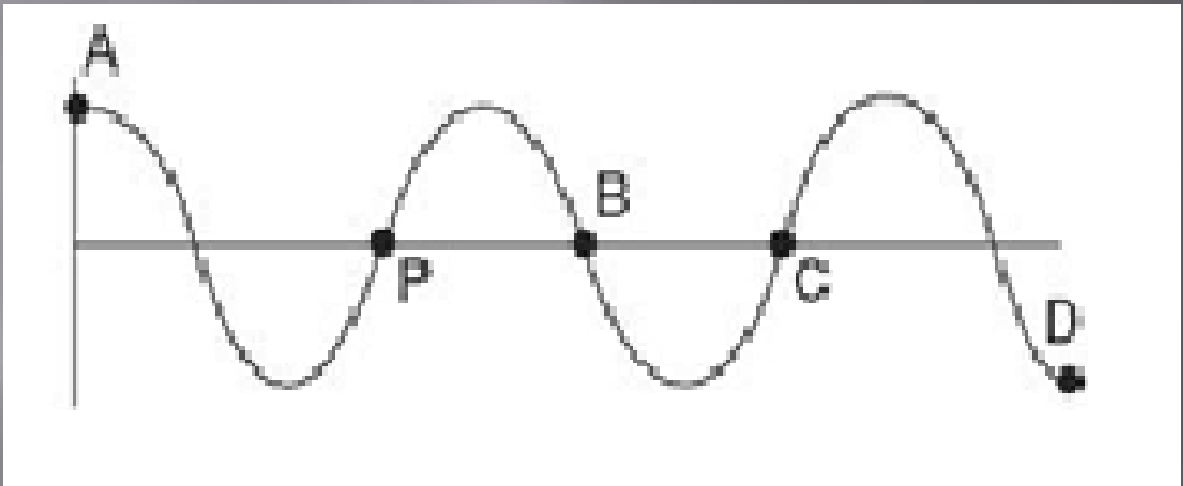
$A = 1.0$ m

c) $2\lambda = 6.0$ m

$\lambda = 3.0$ m

Phase: refers to a particular point in the cycle of a wave

Ex. 2: What point is in phase with point P?



Answer:

Only point C is in phase with point P!

Period (T): Units: s

- the time for one full vibration cycle

Frequency (f): Units: s^{-1} or Hertz

- inverse of period (f=1/T)
- the number of cycles per second

Calculating period and frequency:

Given N cycles counted over a time interval of Δt:

$$T = \frac{\Delta t}{N} \quad and \quad f = \frac{N}{\Delta t}$$

Ex. 3:

You are at the beach watching waves lap up against the shore. You count 5 waves lapping up every 2.0 seconds. What is the period and frequency?

Ans:

N= 5

t= 2.0 s

f=?

T=?

$f = \frac{N}{\Delta t}$

$= \frac{5}{2.0\ s}$

$= 2.5\ Hz$

$T = \frac{\Delta t}{N}$

$= \frac{2.0\ s}{5}$

$= 0.40\ s$

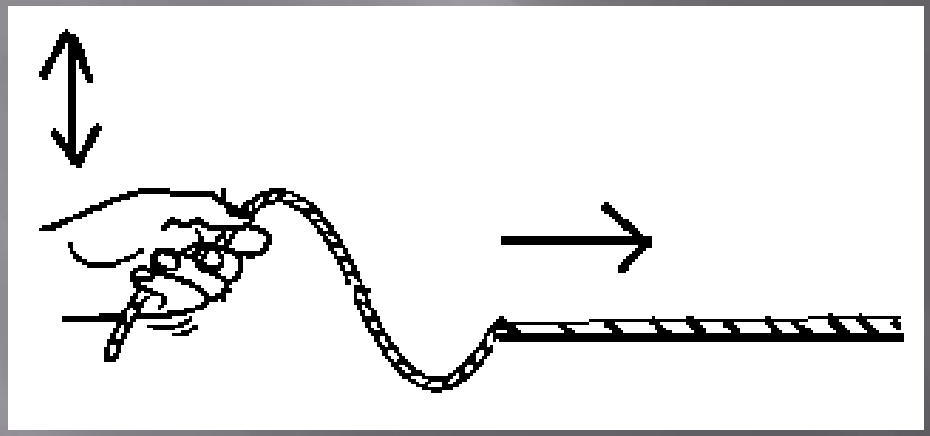
The Universal Wave Equation

Recall: Speed=$\frac{\text{distance}}{\text{time}}$ or $v=\frac{\Delta d}{\Delta t}$

For a wave:

distance = length of one cycle (wavelength-λ)

time= time of one cycle (period T)



Speed equation becomes:

$$v = \frac{\lambda\,(m)}{T\,(s)}$$

The Universal Wave Equation

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

$$v = \lambda f$$

Ex. 4:

a) You are at the beach watching waves lap up against the shore. You count 12 waves lapping up every 15.0 seconds. What is the wave frequency?

b) You also notice that there is 3.50 m between successive crests of the wave. What is the wave speed?

Ans: a) 0.800 Hz b) 2.80 m/s

What determines Wave Speed?

The speed of a wave is determined by the material it travels in.

Example: The speed of waves travelling in a string is controlled by tension.

High tension= high speed

Low tension=low speed

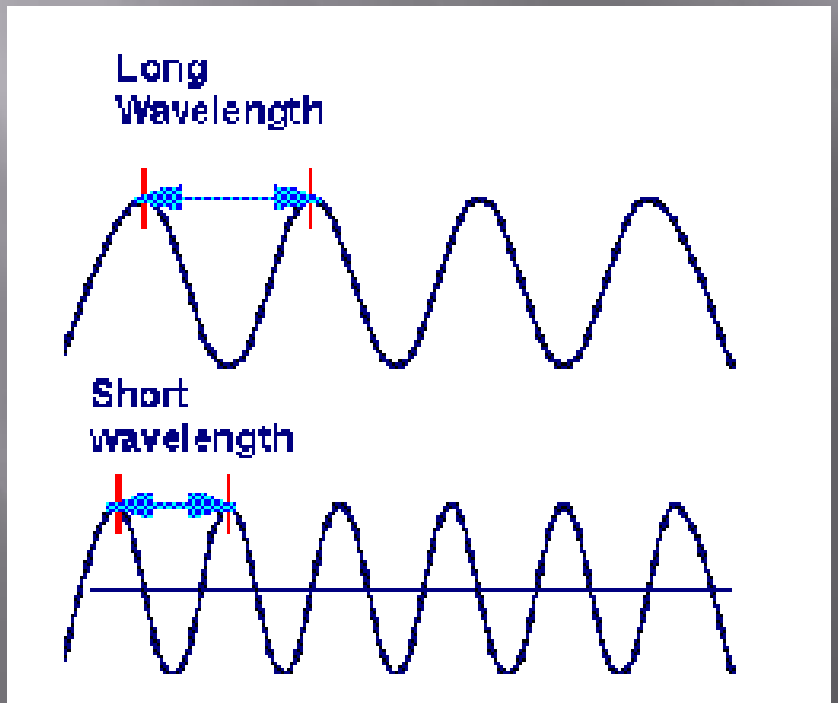
Relationship between wavelength and frequency:

For a given medium, wave speed, v, is constant!

Frequency and wavelength are inversely proportional!

$f \uparrow, \lambda \downarrow$

$f \downarrow, \lambda \uparrow$



Low frequency

High frequency