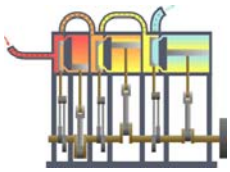
Physics 2C
Waves and Thermodynamics



Course Information

Course Syllabus on the web page http://physics.ucsd.edu/students/courses/spring2009/physics2c/

Instructor: Mel Okamura – mokamura@physics.ucsd.edu
Office: 1218 Mayer Hall
Office Hrs. Th 2-3 pm or by appointment

Teaching Assistant:Xiang Yang (betterfutureyx@gmail.com)
Office:
Office Hrs:TBA

Text. Physics for Scientists and Engineers, Wolfson and Pasacho
3rd edition. Volume III. UCSD custom edition.

Class Schedule

- **Lectures**
  - Mon. Wed. 3:00-3:50 pm WLH 2001
  - Tue. 8:00 – 8:50 pm Center 101
- **Quizzes**
  - Fri. 3:00-3:50 pm WLH 2001
- **Problem Session**
  - Thu. TBA

Grades

- Weekly quizzes (8) will be held on Friday. You are allowed to drop 2 quizzes. There will be no make-up quizzes.
- Final exam covering the whole course.
- The final grade will be based on

  Quizzes 60% (best 6 out of 8 quizzes)

  Final exam 40%

Homework

- Homework will be assigned each week.
- Homework will not be corrected but quiz questions will resemble the homework.
- Solutions to the homework problems will be posted on the web page.

Course Outline

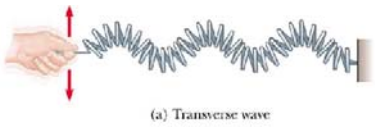
- Waves 6 weeks
  - Sound
  - Light
  - Optics
- Thermodynamics 4 weeks
  - Fluids
  - Heat
  - Energy and Entropy

Waves

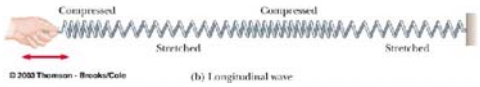
- A Wave is a disturbance that carries energy from one place to another but does not carry mass
- Wave propagation
  - Transverse waves
  - Longitudinal waves
- Wave form
  - Pulsed wave
  - Sinusoidal (continuous) waves
- Media
  - Mechanical waves (propagate through matter)
    - sound
    - vibration on a string
    - ocean waves
  - Electromagnetic waves (propagate through vacuum)
    - light
    - x-rays
    - microwaves
    - radio waves

Transverse and Longitudinal Waves

Transverse Wave - The displacement is perpendicular to the direction of propagation



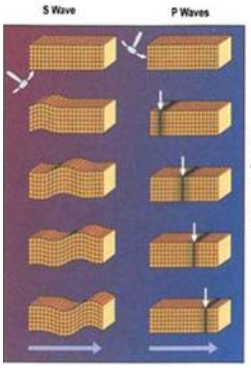
Longitudinal Wave- The displacement is parallel to the direction of propagation



Transverse and Longitudinal Waves

- The transverse and longitudinal waves depend on different mechanical properties of the material.
- The speed of the transverse and longitudinal waves are different.
- Example. earthquakes

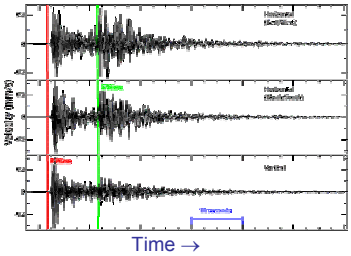
Seismic Waves



P waves- longitudinal faster
v~ 5000 m/s (granite)

S waves – transverse slower
v~ 3000 m/s (granite)

Seismograph record



Time →

Time difference Δt ~ 10 s.

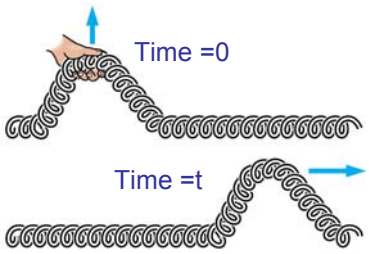
distance from earthquake = KΔt where K~8 km/s (derive this)

d ~ 80 km

Wave properties

- Mathematical description of waves
  - Wave pulse
  - Sinusoidal waves
    - Wave speed
    - Wavelength
    - Frequency

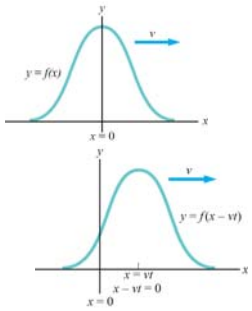
Wave Pulse



•The position of the wave along the direction of propagation changes linearly with time.

•The shape of the wave is not changed with time. (not always the case)

Wave pulse



At time =0

$$y = f(x)$$

At time = t

$$y = f(x - vt)$$

The displacement has the same shape but the origin is shifted by a distance vt.

v is the speed of the wave, phase velocity

Wave velocity

- The equation

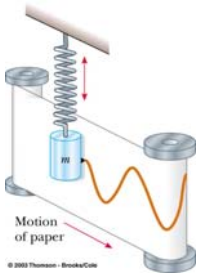
$$y = f(x - vt)$$

describes a wave traveling to the right (positive direction)

- A wave traveling to the left (negative direction) is described by the equation

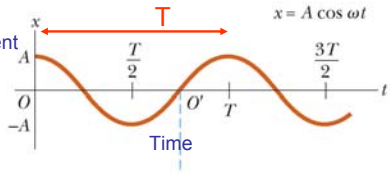
$$y = f(x + vt)$$

Simple Harmonic Waves



Generated by simple harmonic motion

Harmonic Motion



Key Concepts

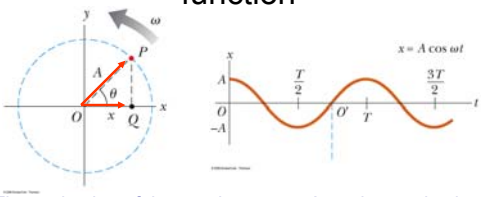
A -Amplitude

T=Period (s)

$f = \frac{1}{T}$ = Frequency , cycles/s (Hz)

ω = 2πf = Angular Frequency (radians /s)

The oscillation follows a sinusoidal function

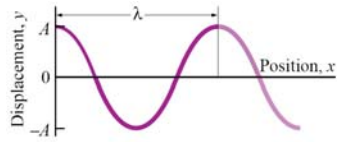


The projection of the rotating vector A on the x axis gives

$$x = A\cos(\frac{2\pi}{T}t) = A\cos(2\pi ft) = A\cos(\omega t)$$

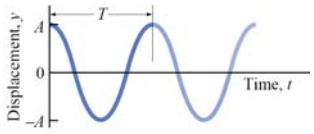
θ is the phase angle
f is the frequency (cycles/s)
ω is the angular frequency (radians/s)

Wavelength (Spatial period)

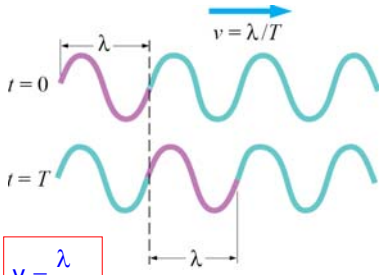


(a)

Period



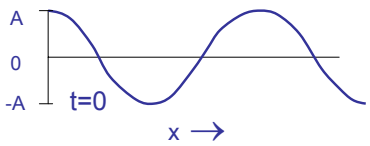
Wave velocity



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

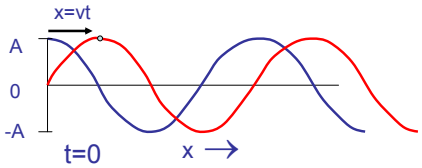
The wave moves on wavelength λ per period T.

Mathematical description of a harmonic wave



$$y = A\cos(\frac{2\pi}{\lambda}x)$$ At t=0

After some time t the wave has moved



$$y = A\cos(\frac{2\pi}{\lambda}(x - vt))$$ Since $v = \frac{\lambda}{T}$

$$y = A\cos(\frac{2\pi}{\lambda}x - \frac{2\pi}{T}t)$$

$$y = A\cos(kx - \omega t)$$

$k = \frac{2\pi}{\lambda}$

$\omega = \frac{2\pi}{T} = 2\pi f$

Other forms

For a wave with displacement =0 at t=0, x=0

$$y=A\sin(kx \pm \omega t)$$

General form including initial phase shift φ

$$y=A\cos(kx \pm \omega t + \phi)$$

Physlets

Some animations that can give some physical insight into wave motion.

http://www.surendranath.org/applets/waves/twave01a/twave01aapplet.html

Example 16.1

A surfer paddles out on the water to where the waves are sinusoidal with crests 14 m apart. She rises a vertical distance 3.6 m from trough to crest, a process that takes 1.5 s. Find the wave speed and write the equation for the wave. Take the wave crest to be at x=0 at t=0 with the positive x direction toward the open ocean.