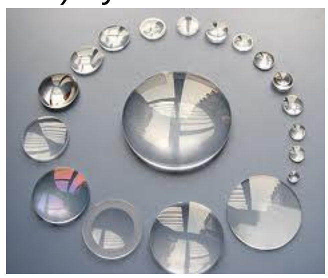
PHY132H1F Introduction to Physics II

You recognize these guys?

- Hello and welcome!
- This is the second course of a 1-year sequence: PHY131/132.
- We will study waves, sound, light, electricity, magnetism and special relativity.
- Required Text: **“Physics for Scientists and Engineers”** 3rd Edition (Copyright 2011) by Randall Knight.



Course Overview

First half, now until Feb. 14:

- **Jason Harlow**

- Waves
- Optics
- Electric Charges
- Electric Field

Second half, February 24 to April 2:

- **Andrew Meyertholen**
  - Electric Circuits
  - Magnetism
  - Electromagnetic Induction
  - Einstein’s Theory of Relativity

My contact information

- **Jason Harlow**
- jharlow@physics.utoronto.ca
- **Office: MP121B** – right beside the Practicals rooms
- www.facebook.com/harlowphysics
- Twitter @jasonjbharlow
- Voice line (no texts): 416-946-4071

- Winter/Spring 2014 office hours: Mondays: 3-4PM, Thursdays and Fridays: 11AM-12 noon.
- In addition to these hours, you have are invited to call or email for an appointment, or just drop by my office.

Other important contacts

- **Dr. Pierre Savaria**, Course Coordinator
- phy132@physics.utoronto.ca
- Office: MP129E
- Voice line (no texts): 416-978-4135

- **Ms. April Seeley**, Course Administrator
- seeley@physics.utoronto.ca
- Office: MP129
- Voice line (no texts): 416-946-0531
- Office hours: Monday,Tuesday, Thursday, Friday 9:30am to 5:00pm, and Wednesdays from 9:30am to 4:30pm

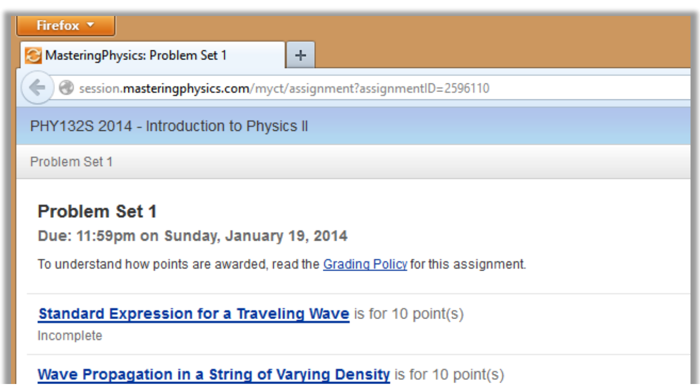
Clickers…

- Beginning Wednesday, we will be asking in-class clicker questions every class.

- You will receive marks participation only; there is no penalty for getting the wrong answer.
- Clicker Participation is worth 2% of your course mark.
- In this course you have the option of using an i>clicker, i>clicker+, or i>clicker2 remote, or using i>clicker GO, which enables you to vote via a web-enabled device like a laptop or smart phone.
- You do ***not*** need to re-register your remote if you're using the same one as last semester (fall 2013)

Online Homework: MasteringPhysics®

- Hopefully you still have your MasteringPhysics account from PHY131.
- Enrol in this course: **MPPHY132S14**
- **Problem Sets** (worth 9% of course mark) are quite long – make take between 1 and 3 hours per week



Pre-Class Reading Quizzes: MasteringPhysics®

- In order to get the best out of our classes (which will include lots of clicker questions and discussion) you must read the chapters ***before*** coming to class
- If you hate reading, I have also posted pre-class videos, which go over the main points from each day's reading
- Beginning this Wednesday, there will be a short online multiple choice quiz on MasteringPhysics due by 8:00am before class.
- The quiz will be based on your reading **or** watching of the pre-class video.
- The questions are not too tricky – if you've read the material, you should find them quite straightforward.
- These quizzes are worth 2% of your course mark

Tests and Exam

- **Test 1** is **Tuesday February 4, 6:00-7:30PM** in room(s) to be announced
- An alternate sitting will be scheduled just before the main sitting of the test for students who demonstrate a conflict with another academic activity at U of T – you must visit April in MP129
- **Test 1** is worth 15% of the course mark, and covers Chapters 20, 21, 23, 24 and 25
- **Test 2**, also worth 15%, is Tue. March 11, 6:00PM
- The **Final Exam** is worth 40% of the course mark, covers the entire course, and will be held some time TBA between April 9-30.

Practicals

- Note that Practicals begin this week, starting ***today***. This week is a short Practical.
- All Practicals are either in MP125A or MP125B, which are right beside each other – lists will be posted so you know which room to go to
- You will be assigned to sit with 3 other people from this course, and the 4 of you will form a team for the next five practical sessions.
- You will be working on Practicals activities together and sharing a mark on the notebooks.

Pre- and Post-course quiz

- 1% of your mark is reserved for the pre and post course quizzes
- We use these tests as one way to measure how the course is going
- The first you will take in practicals this week
- The second you will take at the end of the semester

Piazza

- Online discussion board (invites go out today)
- https://piazza.com/utoronto.ca/winter2014/phy132/home
- Fastest way to get help
- We will check this as often as we do e-mail
- Please be nice!

How to get more information

- The main way of keeping up with what's going on in the course is the web-site at:

https://portal.utoronto.ca

- The Course Information page on the portal page for this course has all the rules for the course – PLEASE READ IT!
- Also, we will email you from time to time at your utoronto.ca email address
- The above forms of electronic communication are mandatory – please use them!

LEARNING PORTAL
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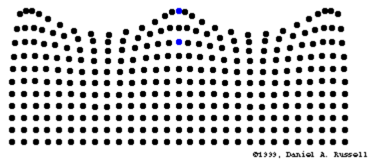
Chapter 20. Traveling Waves

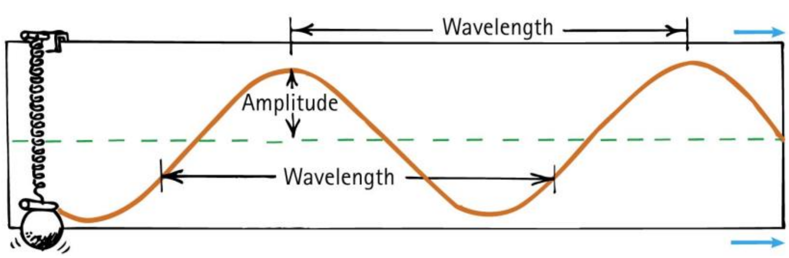
- A *vibration* is a periodic linear motion of a particle about an equilibrium position.
- When many particles vibrate and carry energy through space, this is a *wave.* A wave extends from one place to another.
- Examples are:
  – water waves
  – light, which is an electromagnetic wave
  – sound



[image from https://webspace.utexas.edu/cokerwr/www/index.html/waves.html ©1999 by Daniel A. Russell]

Amplitude and Wavelength

- Amplitude = A   units are those of the wave
  – distance from the midpoint to the crest or to the trough
- Wavelength = λ "lambda"   units = [m]
  – distance from the top of one crest to the top of the next crest, or distance between successive identical parts of the wave



Wave speed

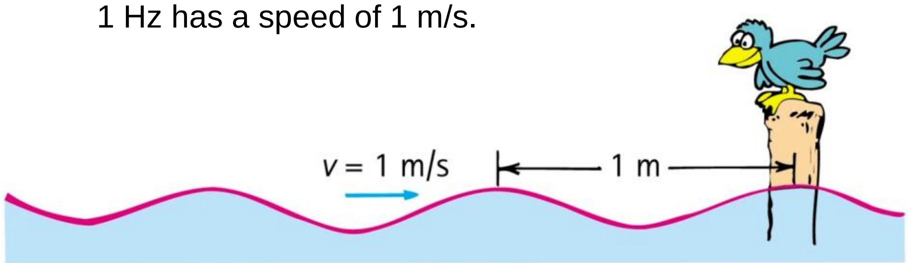
- Describes how fast a disturbance moves through a medium
- Related to frequency and wavelength of a wave

Wave speed = frequency × wavelength

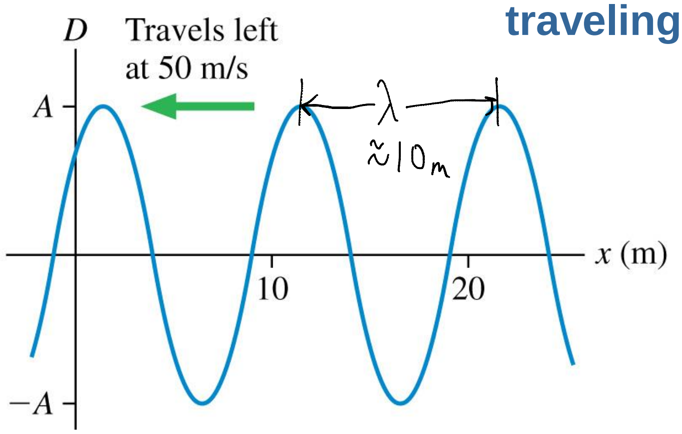
$v = f\lambda$ $\left[\frac{m}{s}\right] = [Hz]\cdot[m]$

Example:

- A wave with wavelength 1 meter and frequency of 1 Hz has a speed of 1 m/s.



What is the frequency of this traveling wave?

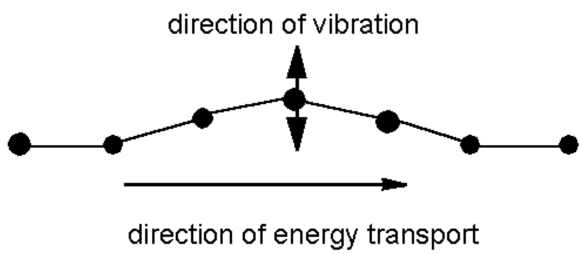


A. 0.1 Hz
B. 0.2 Hz
C. 2 Hz
D. 5 Hz
E. 10 Hz

Transverse waves

- Medium vibrates perpendicularly to direction of energy transfer
- Side-to-side movement

  Example:
  - Vibrations in stretched strings of musical instruments

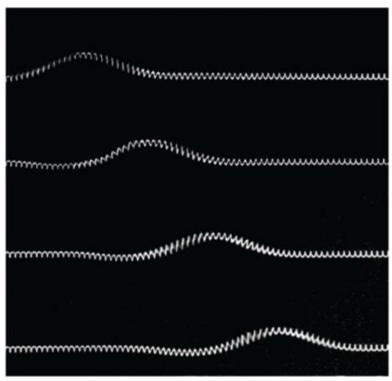


[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

Transverse waves

The speed of transverse waves on a string stretched with tension T_s is:

$$v_{\text{string}} = \sqrt{\frac{T_s}{\mu}}$$



Where μ is the string's mass-to-length ratio, also called the **linear density**:

units check:

$$\sqrt{\frac{T_s}{\mu}} : \sqrt{\frac{N}{kg/m}} = \sqrt{\frac{kg \cdot m\, s^{-2} \cdot m}{kg}} = \sqrt{\frac{m^2}{s^2}} = [m/s]$$

$$\mu = \frac{m}{L}$$

Units: [kg/m]

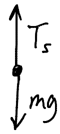
Example.
An 80 kg climber hangs from a rope, 20 m below a rocky overhang. The rope has a linear density of 37 g/m. $= \frac{37}{1000}$ kg/m Approximately how long would it take a transverse pulse to travel the length of the rope from the climber to the overhang?

← Neglect mass of rope....

$m \approx 20\ m \times 0.037\ \frac{kg}{m}$

$\lesssim 1\ kg$

fbd of climber:



$F_{net} = 0$

$T_s - mg = 0$

$T_s = mg = 80 \times 9.8$

$T_s = 784\ N$

$v = \sqrt{\frac{T_s}{\mu}} = \sqrt{\frac{784}{0.037}} = 145.6\ m/s$

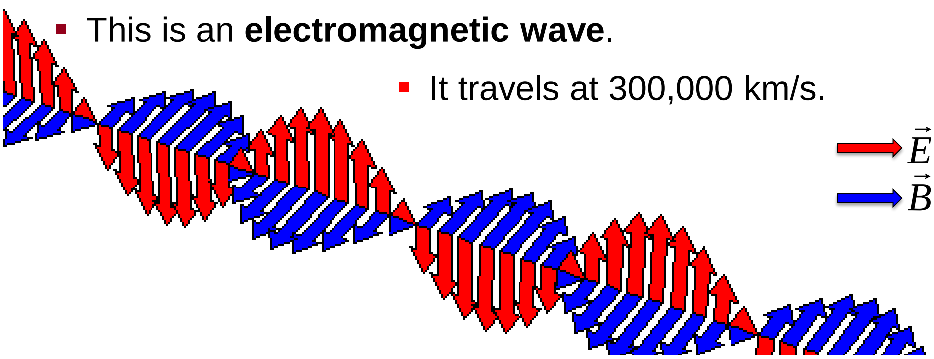
constant speed:

$v = \frac{d}{t}$, $t = \frac{d}{v} = \frac{20\ m}{145.6\ m/s}$

$t = 0.14\ s$

Transverse Waves
Maxwell's Theory of Electromagnetic Waves

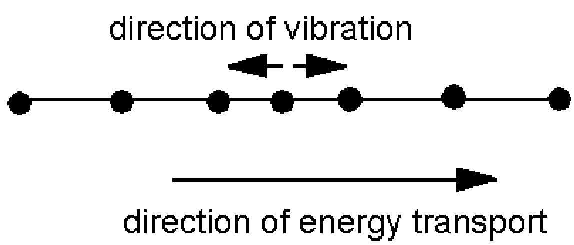
- A changing electric field creates a magnetic field, which then changes in just the right way to recreate the electric field, which then changes in just the right way to again recreate the magnetic field, and so on.
- This is an **electromagnetic wave**.
  - It travels at 300,000 km/s.



Longitudinal waves

- Medium vibrates parallel to direction of energy transfer
- Backward and forward movement consists of
  - compressions (wave compressed)
  - rarefactions (stretched region between compressions)

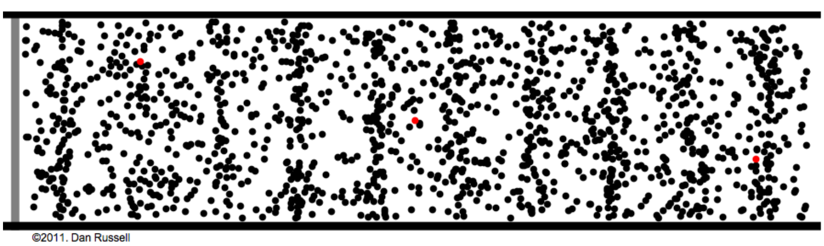
  Example: sound waves in solid, liquid, gas



[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

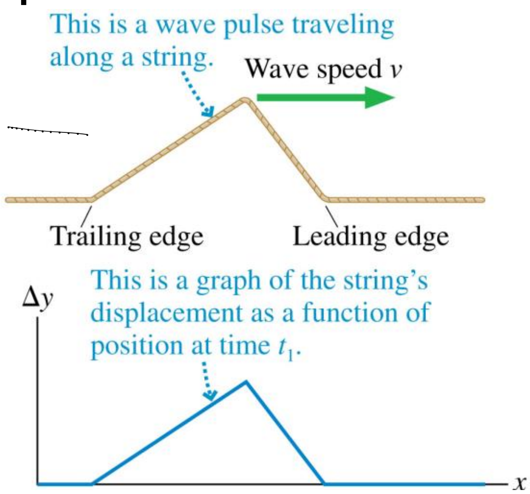
Longitudinal Waves

- Sound is a longitudinal wave.
- Compression regions travel at the speed of sound.
- In a compression region, the density and pressure of the air is higher than the average density and pressure.



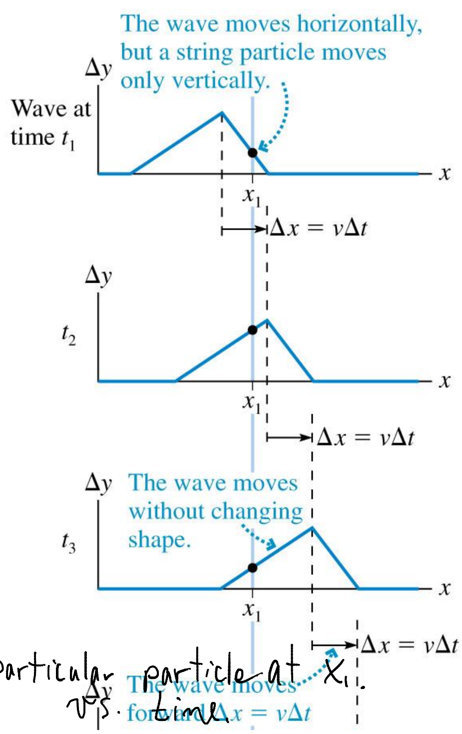
Snapshot Graph

- A graph that shows the wave's displacement as a function of position at a single instant of time is called a **snapshot graph**.
- For a wave on a string, a snapshot graph is literally a picture of the wave at this instant.



One-Dimensional Waves

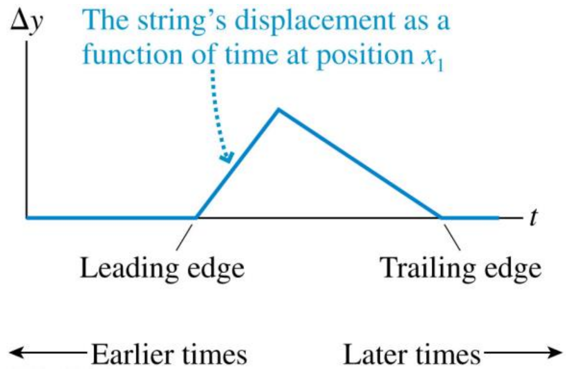
- The figure shows a sequence of snapshot graphs as a wave pulse moves.
- These are like successive frames from a movie.
- Notice that the wave pulse moves forward distance $\Delta x = v\Delta t$ during the time interval Δt.
- That is, the wave moves with *constant speed.*



Let's plot Δy for a particular particle at x_1 vs. time

History Graph

- A graph that shows the wave's displacement as a function of time at a single **position** in space is called a **history graph.**
- This graph tells the history of that particular point in the medium.
- Note that for a wave moving from left to right, the shape of the history graph is *reversed* compared to the snapshot graph.



The Mathematics of Sinusoidal Waves

$$D(x, t) = A \sin(kx - \omega t + \phi_0)$$

(sinusoidal wave traveling in the positive x-direction)

ϕ_0 = phase constant [rad]

- The *angular frequency* of the wave is omega:

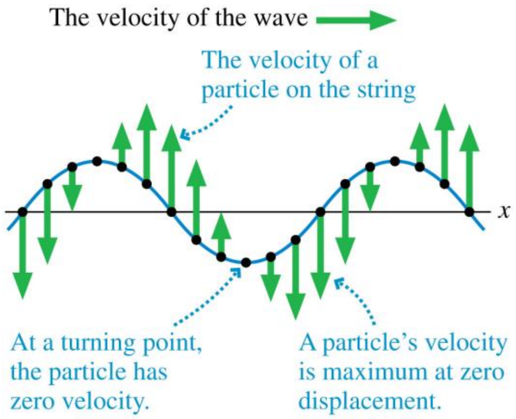
$$\omega = 2\pi f = \frac{2\pi}{T}$$ units $\left[\frac{rad}{s}\right]$

- The *wave number* of the wave is k:

$$k = \frac{2\pi}{\lambda}$$ units $\left[\frac{rad}{m}\right]$

This wave travels at a speed: $v = \dfrac{\omega}{k}$. $= \dfrac{2\pi f}{2\pi/\lambda} = f\lambda$ ✓

- Shown is a snapshot graph of a wave on a string with vectors showing the velocity of the string at various points.
- As the wave moves along x, the velocity of a particle on the string is in the y-direction.



$$v_y = \frac{dy}{dt} = -\omega A \cos(kx - \omega t + \phi_0)$$

Before Class 2 on Wednesday

- Please read all of Chapter 20: pages 560-583 in Knight.
- Please do the short pre-class quiz on MasteringPhysics by tomorrow evening.
- Problem Set 1 on MasteringPhysics is due Jan.19: take a look at it. Don't leave problem sets until the last minute!
- Don't forget to bring your clicker!
- Something to think about: As a police siren is approaching you, does its frequency get higher and higher as it approaches?