PHYS*1070 Winter 2026

Physics for Life Sciences

lectures (sections 1, 2 & 3)

Prof. Liliana Caballero (weeks 1-4)

Prof. Stefan Kycia (weeks 5, 6, 11, 12)

Prof. Carl Svensson (weeks 7-10)

Weeks 1-4:

- Lecture notes will be posted at the end of the week
- Material which will NOT be posted is that which is written on the document camera

- Liliana’s office hours: **Thursdays 10:30-11:30 am in MacN 433D**

Content

Waves

Radiation

Electricity

Learning resources

Textbook / Learning Resource	Required / Recommended
Custom eBook - Physics for the Biological Sciences	Required
Study Guide for PHYS*1070	Required
Lab Kit for 1070/1080/1300	Required

Textbook: Physics for the Biological Sciences, 5th edition, Williams M.L, et al.

Available as online eBooks and Campus Bookstore

Course Evaluation

Activity	Purpose	Weighting
at-home Labs (5)	Apply physics concepts through guided activities; hands-on exploration • ~1 week to complete • help hours: check courselink	15%
online pretests (10)	low/mid-level self-test; provide feedback • Attempt after lectures and exploring study guide self-tests • Help hours will appear in courselink	10%
quizzes (5)	High-level assessment; 20 minutes, 3-4 worked problems • Attempt after completing textbook problems and online pretests	40%
final exam	Summative assessment, cumulative; 18-25 multiple choice questions (~2-3 questions per Study Guide) • Date: Apr 15 Time: Wed 2:30pm-4:30pm	35%

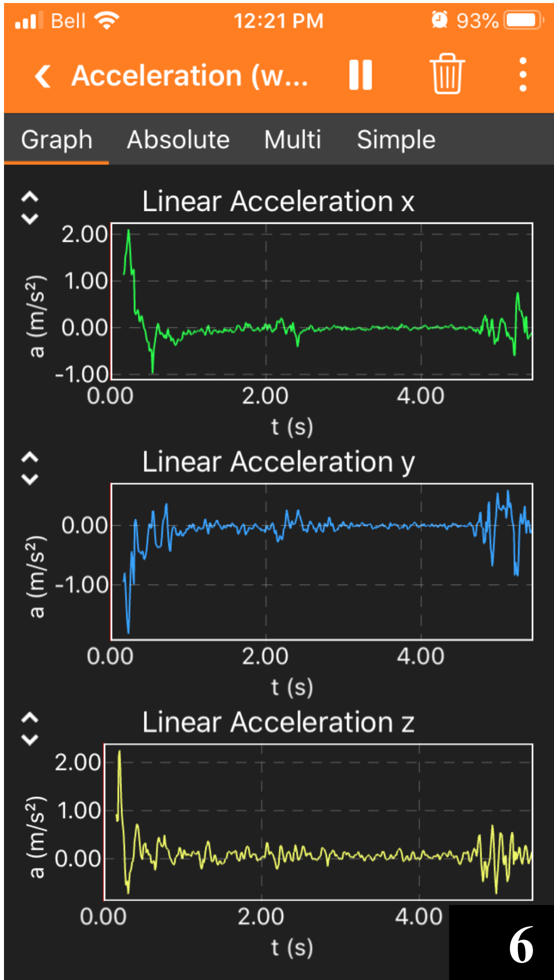
at-home labs: lab kit & PhyPhox

- Lab kit
  - Purchase at University Bookstore
  - The same kit is used for 1070 & 1080
  - A few additional materials will be needed (e.g. water, paper, a glass…)

- PhyPhox phone app
  - Free download, for iOS and Android:

    https://phyphox.org/download/

- Uses phone/tablet sensors to take measurements
  - Detailed instructions provided in the labs!



...I wish there was a place where I can find all the information the instructor is giving...

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Courselink: https://courselink.uoguelph.ca

Check the course outline for ALL the deadlines and work

CourseLink

Students in this course will need to use CourseLink

- to do the required pretests
- to book a quiz time
- to access lab instructions
- to check their term marks
- to see news about the course

As soon as possible, you should check that you can log into CourseLink at the website

https://courselink.uoguelph.ca

In course link you will find...

UNIVERSITY OF GUELPH

PHYS*1070 (01.02.03) W26 - Ph...

Course Home Content Pretests & Labs Grades CourseLink Help Groups Surveys

Announcements

Welcome to PHYS1070!

Posted Dec 23, 2025 12:01 AM

Welcome to PHYS1070!

This course examines how physics plays a role in every day life and teaches you how to solve physics problems related to the biological sciences, specifically the properties of waves, acoustics and hearing, optical systems and vision, electricity, radioactivity, quantum nature of radiation and its interaction with biomolecules.

For this course, you will require the items listed below:

course outline to find among other things…

- The pretest mark is awarded for scores of 3/5 or better on an attempt, scores less than 3/5 will receive a mark of zero.

Pretest	Content	Due Date
1	Study Guide 1	Tuesday Jan 20, 11:59 pm
2	Study Guide 2	Tuesday Jan 20, 11:59 pm
3	Study Guide 3 (Sections 1-3)	Tuesday Feb 3, 11:59 pm
4	Study Guide 3 (Sections 4-5)	Tuesday Feb 3, 11:59 pm
5	Study Guide 4 (Sections 1-2)	Tuesday Feb 24, 11:59 pm
6	Study Guide 4 (Sections 3-5)	Tuesday Feb 24, 11:59 pm
7	Study Guide 5	Tuesday Mar 10, 11:59 pm
8	Study Guide 6	Tuesday Mar 10, 11:59 pm
9	Study Guide 7	Tuesday Mar 24, 11:59 pm
10	Study Guide 8 (Sections 1-2)	Tuesday Mar 24, 11:59 pm

Quizzes: In the Quiz Room SCI 1101A

Quiz	Week	Content	Due Date
1	3	Study Guides 1 & 2	week ending Friday Jan 23
2	5	Study Guide 3	week ending Friday Feb 6
3	7	Study Guide 4	week ending Friday Feb 27
4	9	Study Guides 5 & 6	week ending Friday Mar 13
5	11	Study Guides 7 & 8 (sections 1 & 2)	week ending Friday Mar 27

- Study Guide 8 sections 3-5 will be tested on the final exam.

Quiz #1

Material will be covered in weeks 1 & 2 : In the Quiz Room SCI 1101A

1. **Study Guide 1 (Waves)**
   - Trig functions (sin, cos, tan) and inverse functions using both degrees and radians
   - The small angle approximation
   - Equation for a traveling wave and a standing wave
   - Wave quantities (period, frequency, wavelength, speed…)

2. **Study Guide 2 (Acoustics)**
   - Acoustic resonance
   - Beats
   - How to use logarithms
   - Decibels and Sound Levels
   - Acoustic energy, power and intensity
   - Structure and operation of the human ear

First thing to do after this lecture

Take a Questionnaire Course Introduction on courselink

1. Login to Courselink (https://courselink.uoguelph.ca/)

2. Questionnaire is under the section Pretests & Labs (Look for “Course Introduction – DO THIS FIRST!)”

3. You will have to complete this with a passing score before being able to access some content e.g., access to the Pretests and Labs is restricted.

PHYS*1070 Online Student Request Form
(accessible via Courselink)

Use the PHYS*1070 Online Student Request Form (OSRF) for all course inquiries/issues:

For example,
- Illness
- errors in your posted grades in your CourseLink record
- situations related to **course administration**

(i.e. not questions about physics)

Speak to me or the TA about physics

Let’s talk about Physics

Week 1:
Trigonometry
Oscillations, waves
Standing and traveling waves
Wave superposition

How are waves related to life sciences?
Can you think of an example or application of waves to your field of study?

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Can you think of an example or application of waves to your field of study?

Wave or oscillation?

- A. A girl playing in a swing
- B. The red color I see in a flower
- C. My dog’s wagging tail when I arrive at home
- D. Listening to Christmas Carols

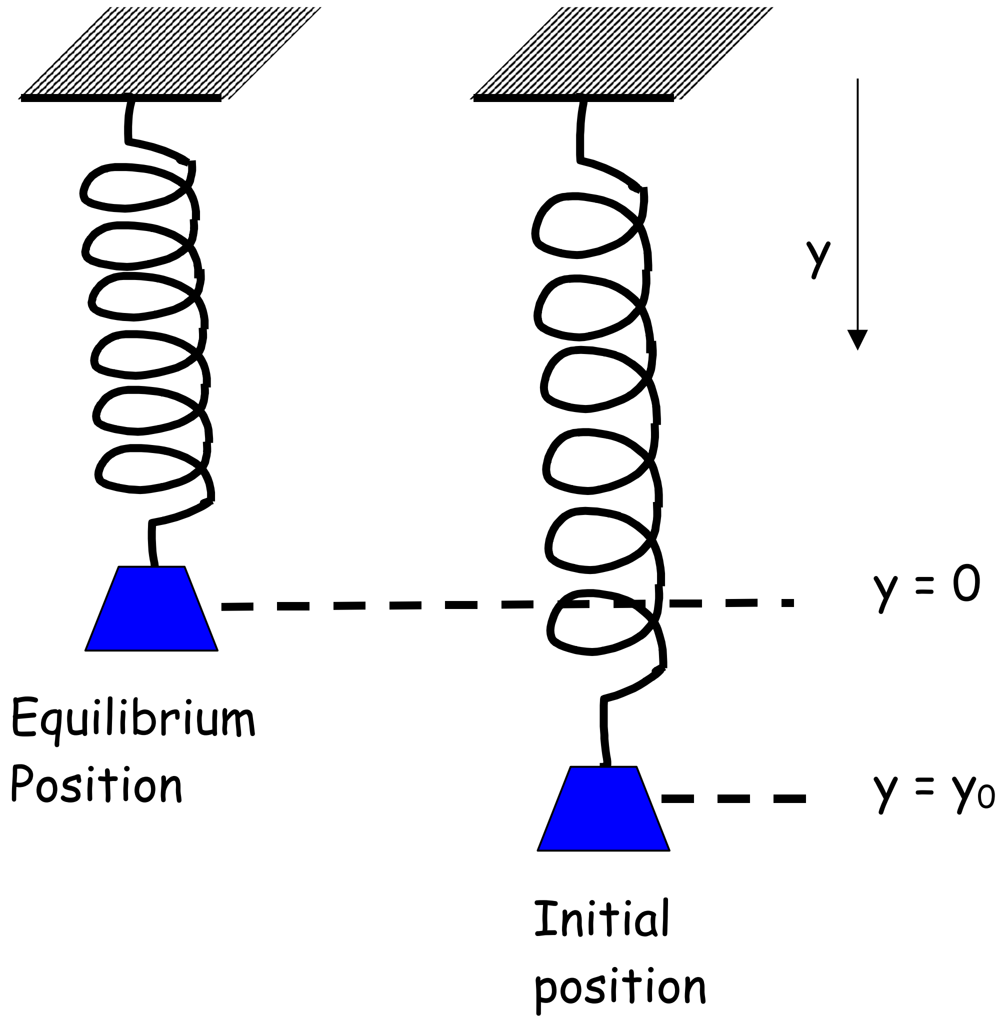
How are waves related to life sciences? Can you think of an example or application of waves to your field of study?

Wave or oscillation?

- A. A girl playing in a swing = oscillation
- B. The red color I see in a flower = wave
- C. My dog’s wagging tail when I arrive at home = oscillation
- D. Listening to Christmas Carols = wave

Oscillations and traveling waves

e.g. hanging weight on spring



Spring stretched to initial position, y_0, and released.

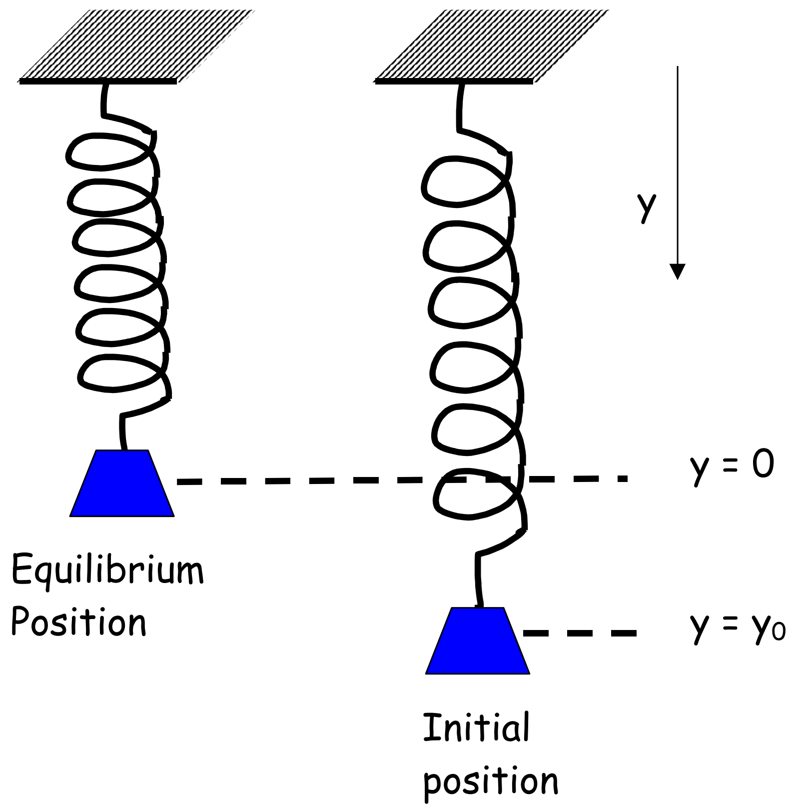
The mass oscillates between y_0 and $-y_0$ in

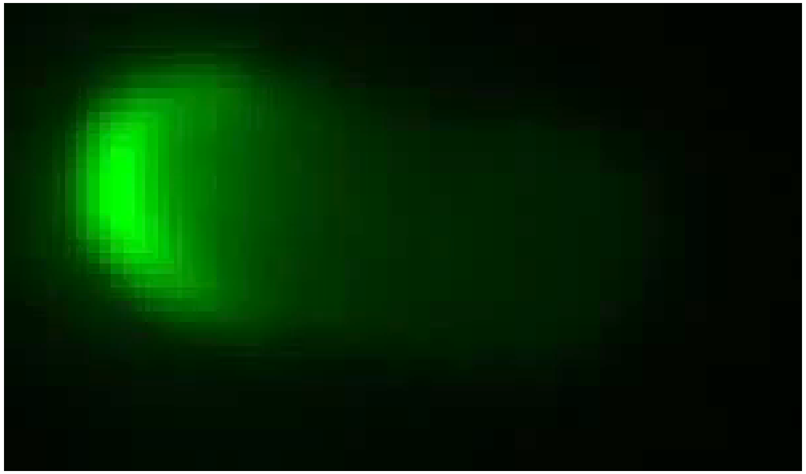
<u>"Simple Harmonic Motion"</u>

or **SHM**.

Oscillation

e.g. hanging weight on spring





Dutcher Lab, University of Guelph

There is a Restoring Force

Period and frequency

- Oscillations have a characteristic time associated with the motion

Period (T): The time taken to complete one full cycle

- Units: seconds (s)

Frequency (f): The number of cycles completed in 1 second

- Units: Hertz (Hz) [Hz = s^{-1}]

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

Angular frequency (ω): The number of **radians** completed in 1 second

- Units: (rad/s)

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

Using math to describe oscillations

Why using **trigonometry**?

A. Because oscillations are related to angles

B. Because oscillations are repetitive

C. Because motion on a circle can describe oscillations

D. All the above

Using math to describe oscillations

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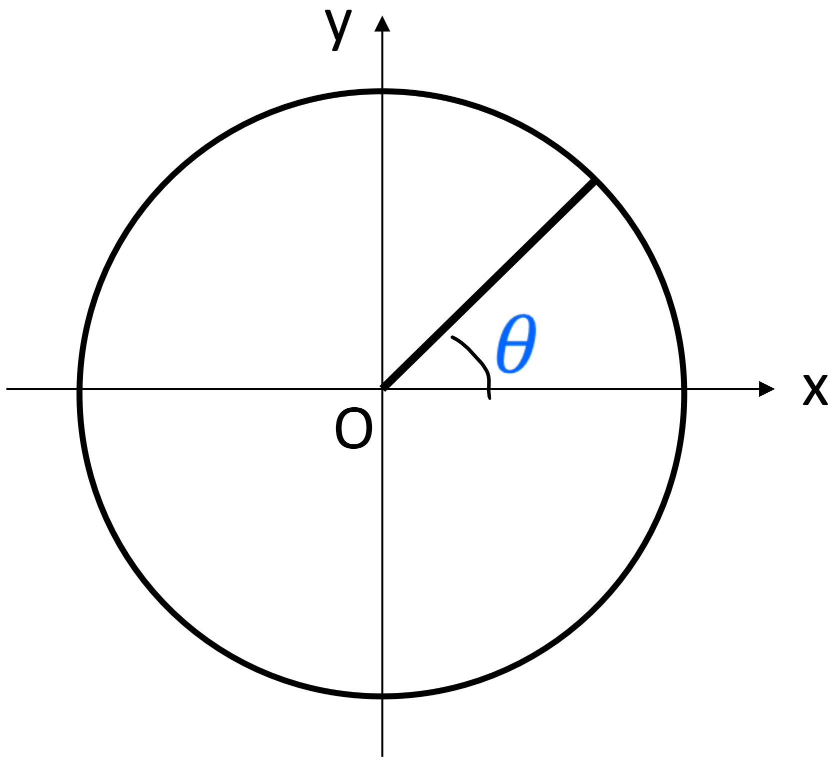
Trig – (Review??)

- Trig functions are defined on a circle



$$\sin\theta = \frac{opp}{hyp} = y/A$$

$$\cos\theta = \frac{adj}{hyp} = \mathrm{x/A}$$

$$\tan\theta = \frac{opp}{adj} = y/x$$

$$\theta = \frac{s}{r}$$

θ has units of radians

We often use "degrees"

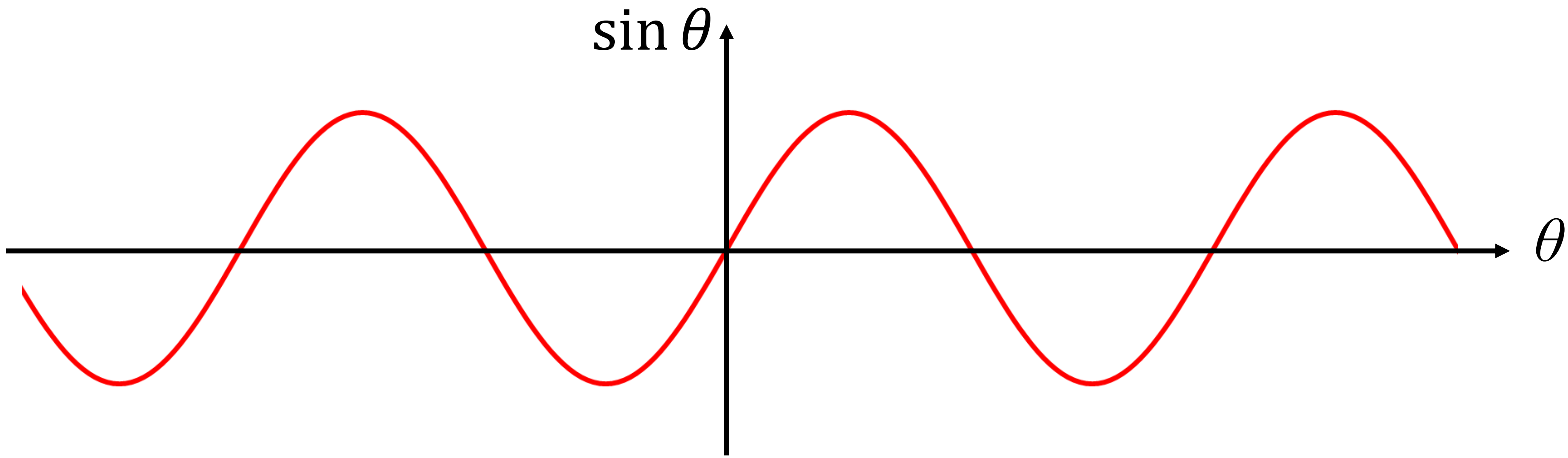
360^o = one full circle/cycle

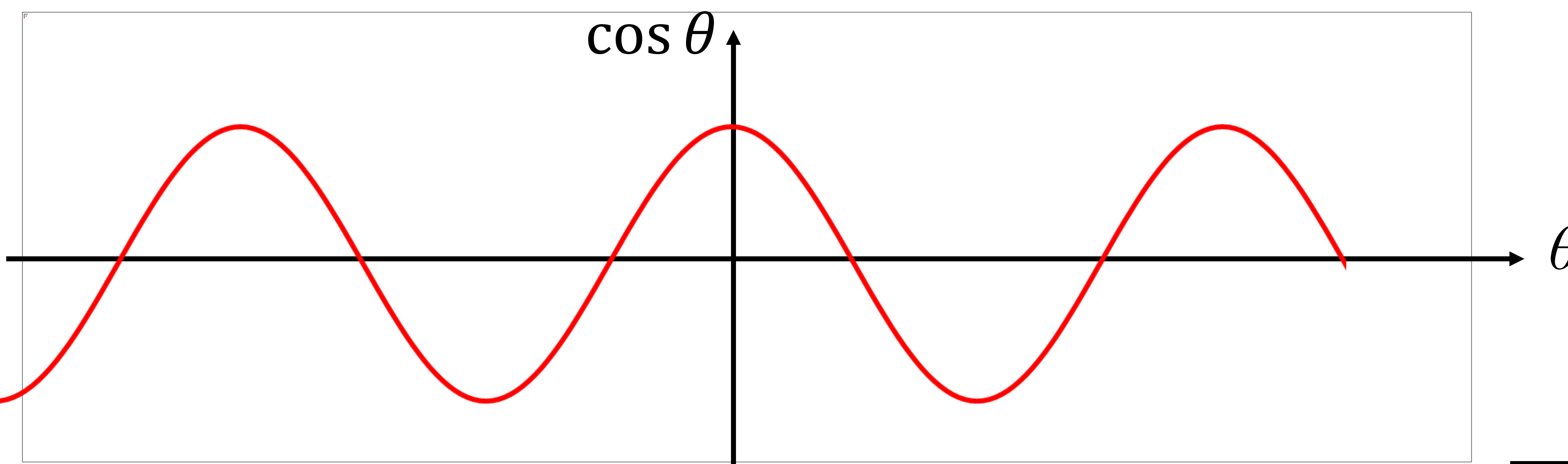
$57.3^o \approx 1$ radian

Use your calculator (in DEG) to find

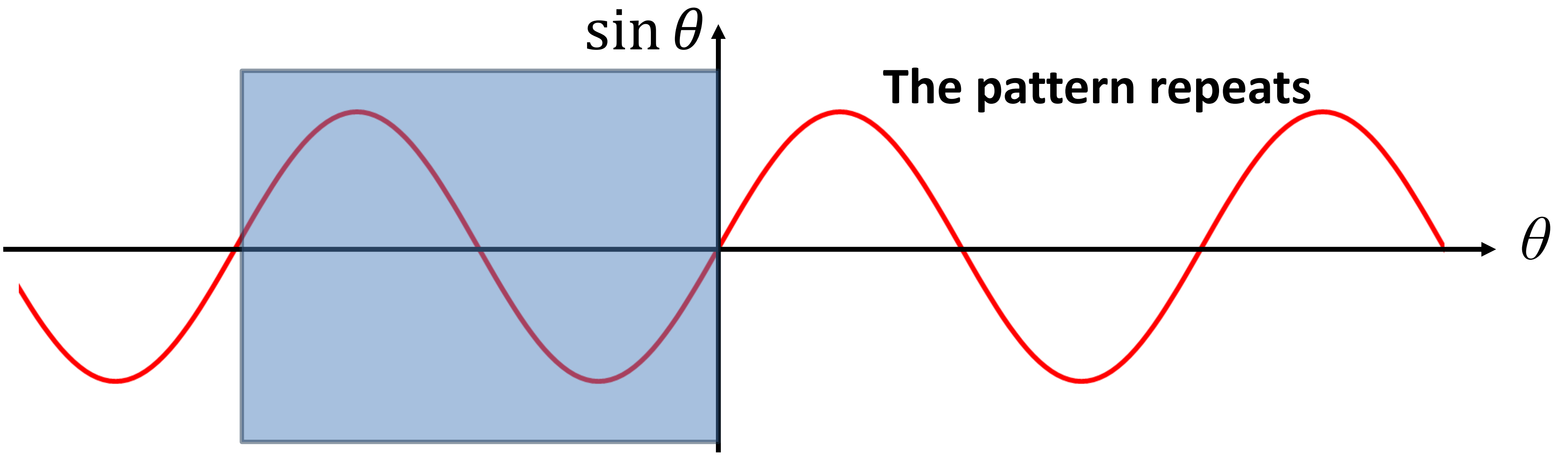
theta	Sin(theta)	Cos(theta)
0		
30		
60		
90		
120		
180		
210		
270		
300		
360		

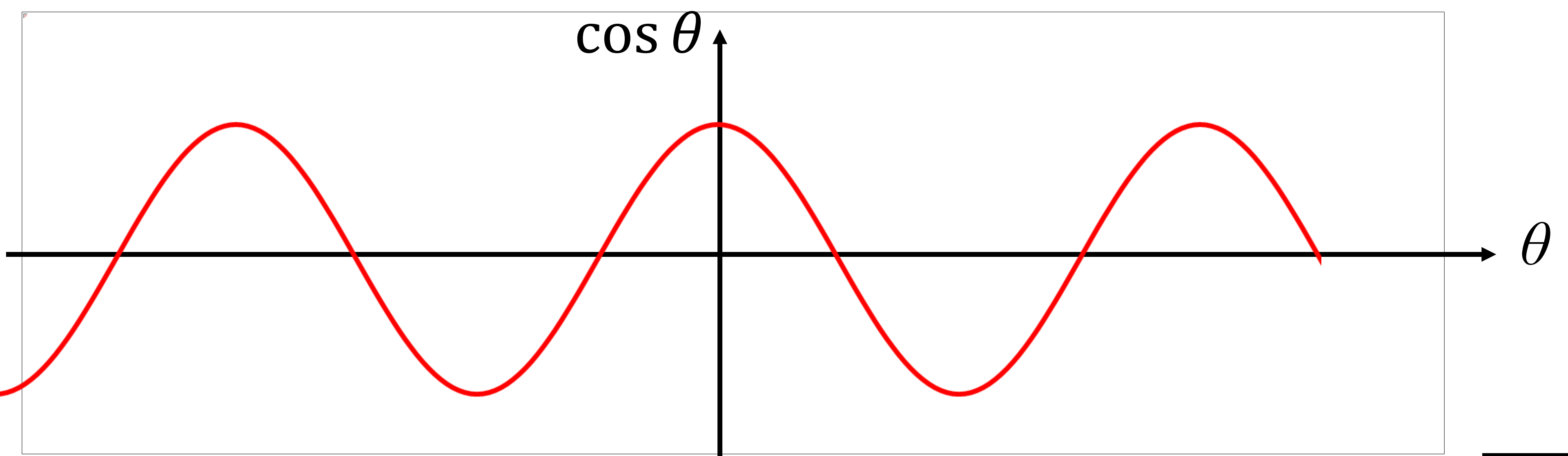
Graphing Trig functions





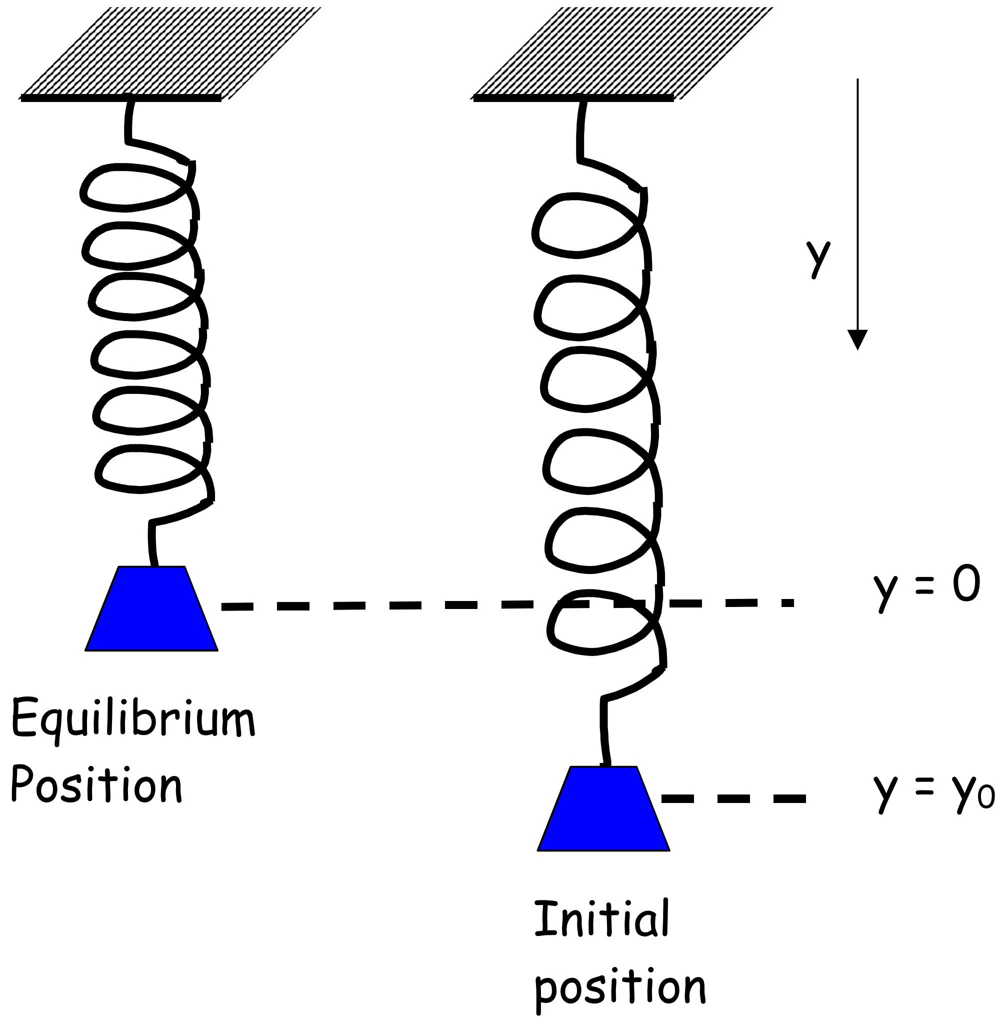
Graphing Trig functions





Oscillations and traveling waves

e.g. hanging weight on spring



Spring stretched to initial position, y_0, and released.

The mass oscillates between y_0 and $-y_0$ in

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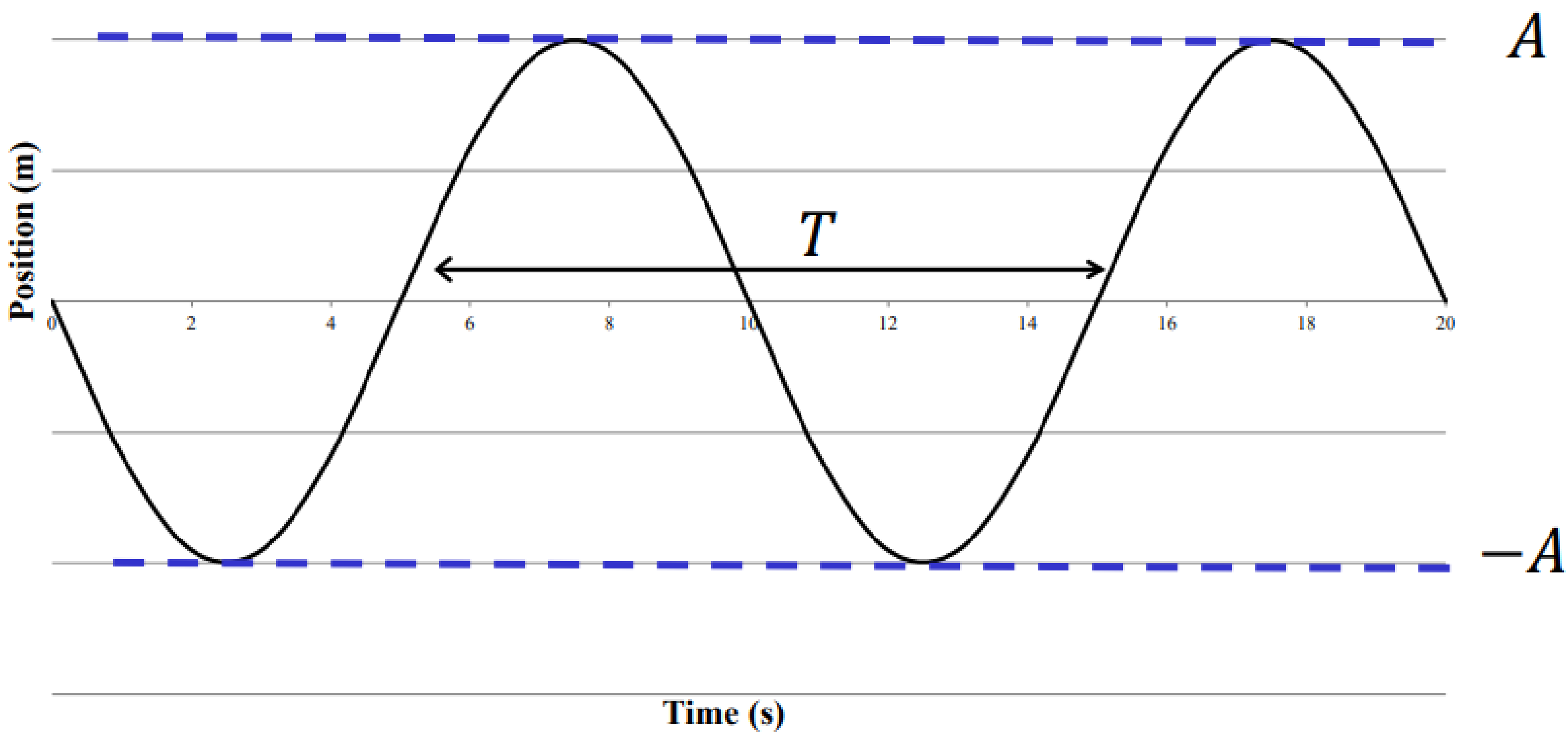
SHM Mathematically



$$x = -A\sin(\omega t) \quad \text{where} \quad \omega = 2\pi f$$

Where x is the position of the oscillating mass as a function of time, A is the maximum displacement from equilibrium, and ω or f describe the rate of repetition of the oscillation

Trig on your calculator

Be careful calculating these functions using calculator: “DEG” or “RAD” mode on calculator indicates units.

Examples: $\sin(40.0^o) =$

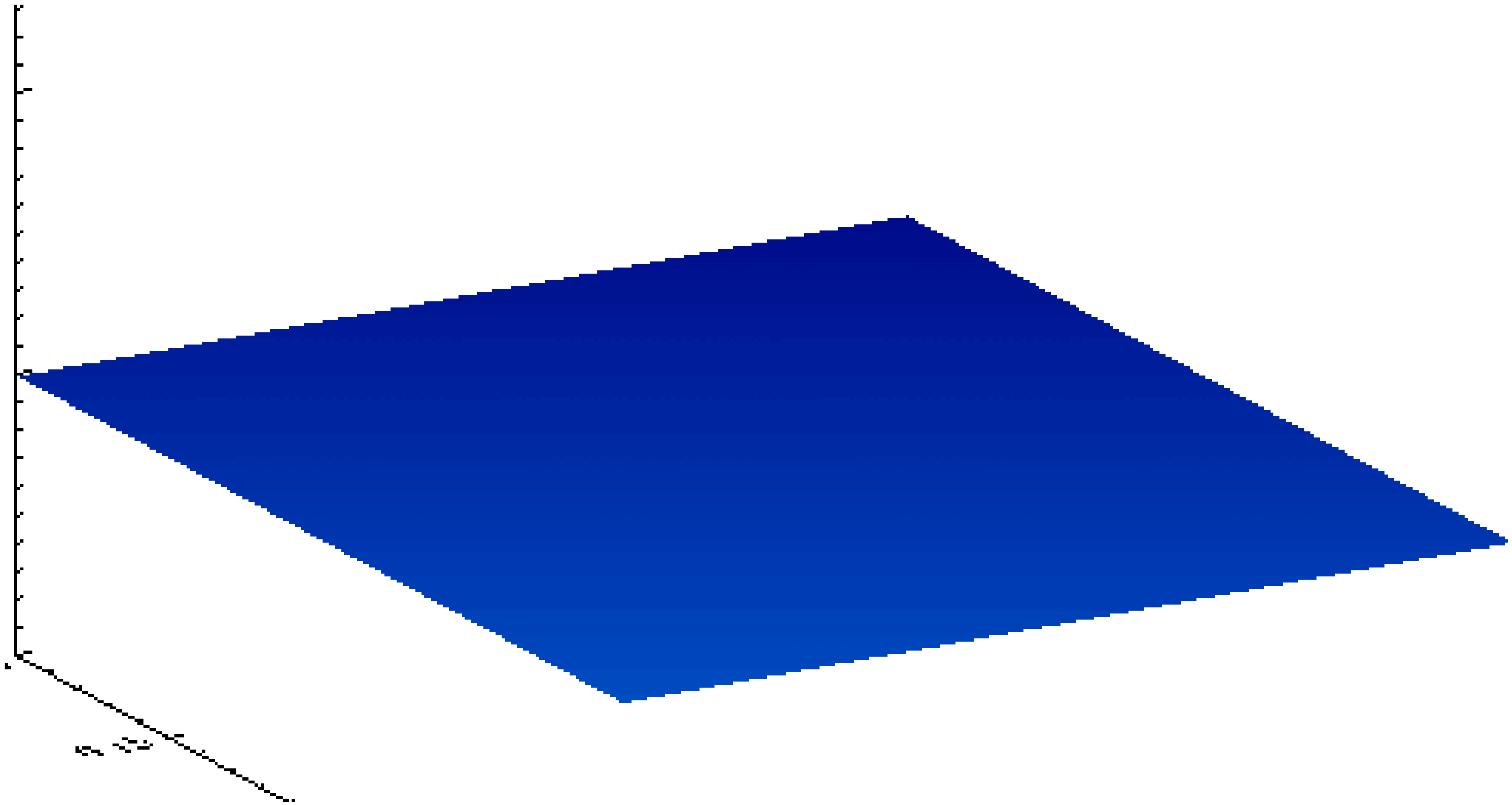
$\cos(2.5) =$

$\sin(140^o) =$

No degree symbol “ ^{o} ” → angle is in radians

Waves

- The propagation of a disturbance through a medium ***with a well-defined speed***.
- Matter is **not** transferred, but energy is transferred



Waves

- The propagation of a disturbance through a medium ***with a well-defined speed***.
- Matter is **not** transferred, but energy is transferred

- Produced by a disturbance of the medium
    - Period waves produced by oscillations or vibrations

- Waves have characteristic properties which can be discussed, such as wavelength, period, wave speed

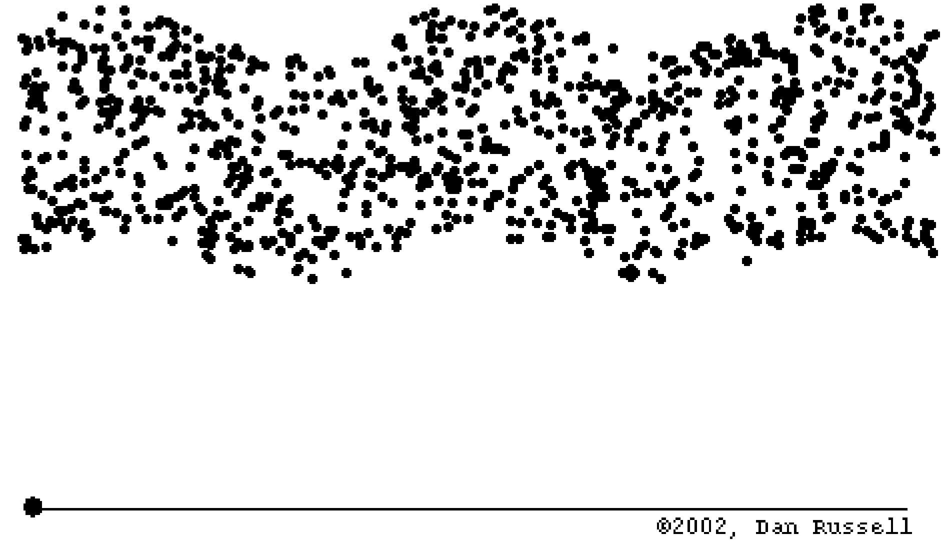
- Waves can be deflected and can interfere, either constructively or destructively

Mechanical waves

Waves will travel through a medium (solid, liquid, gas)

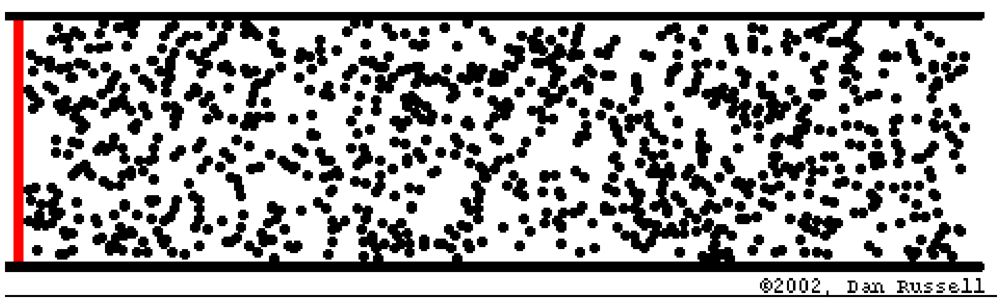
- Transverse waves

disturbance ⊥ travel



- Longitudinal waves (sound – Study Guide 2)

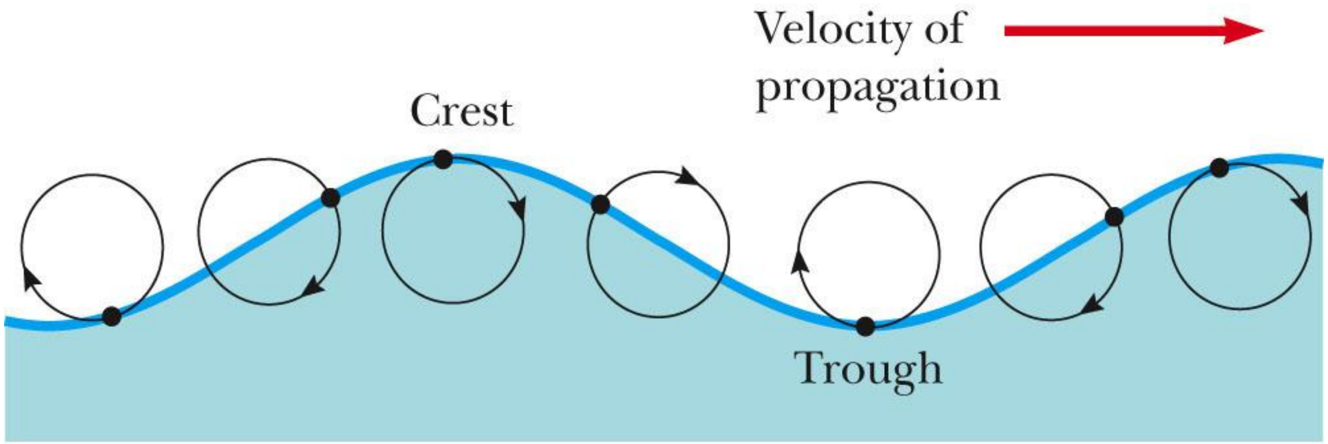
disturbance || travel

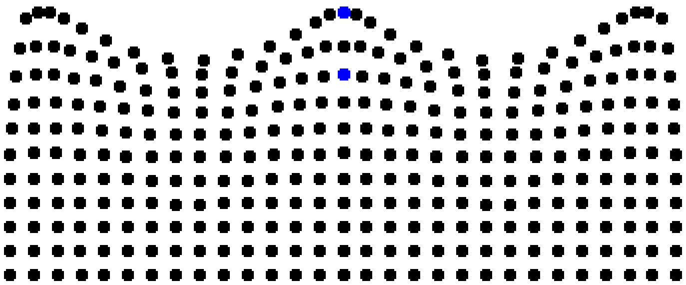


Mechanical waves

Complex waves

- Surface water waves exhibit a combination of transverse and longitudinal waves

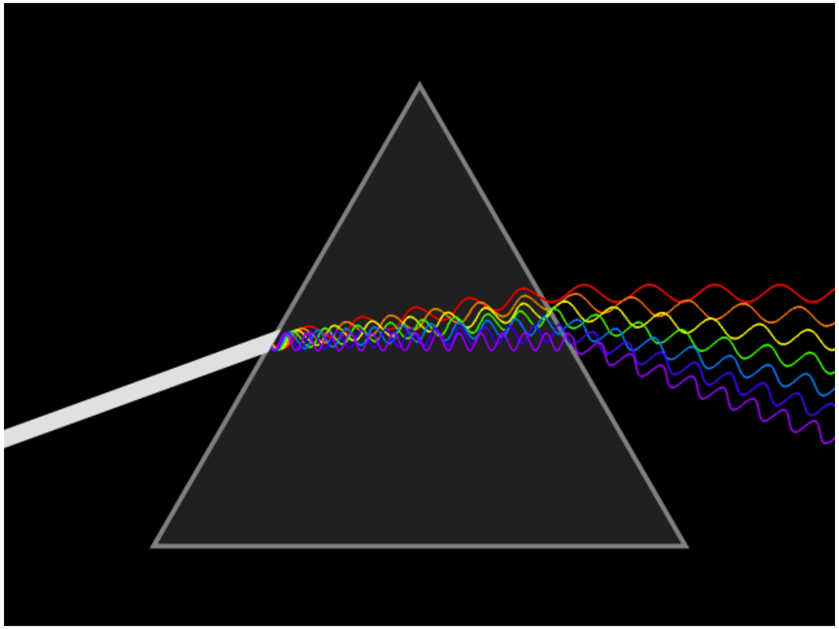


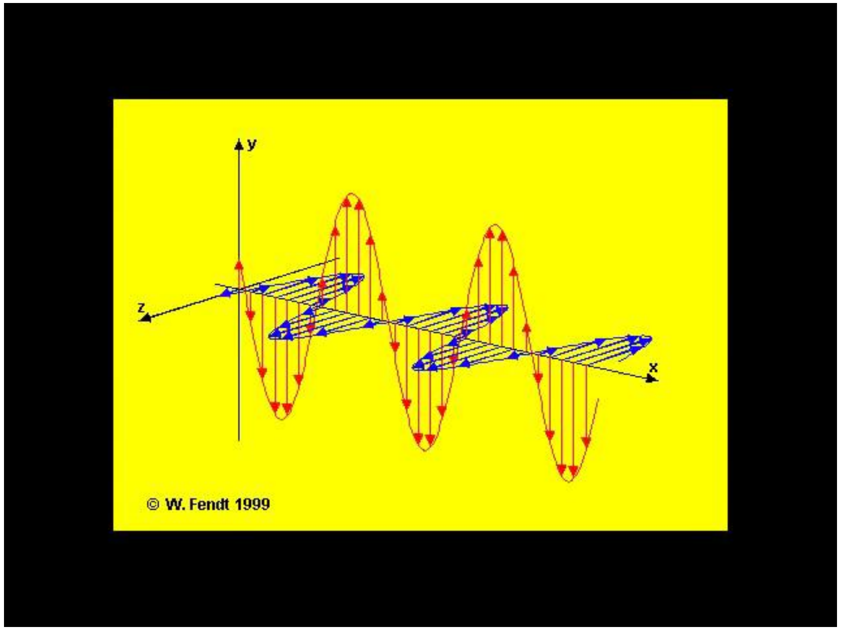


Electromagnetic waves (Study Guides 3 & 4)

These waves do not require a medium through which to travel

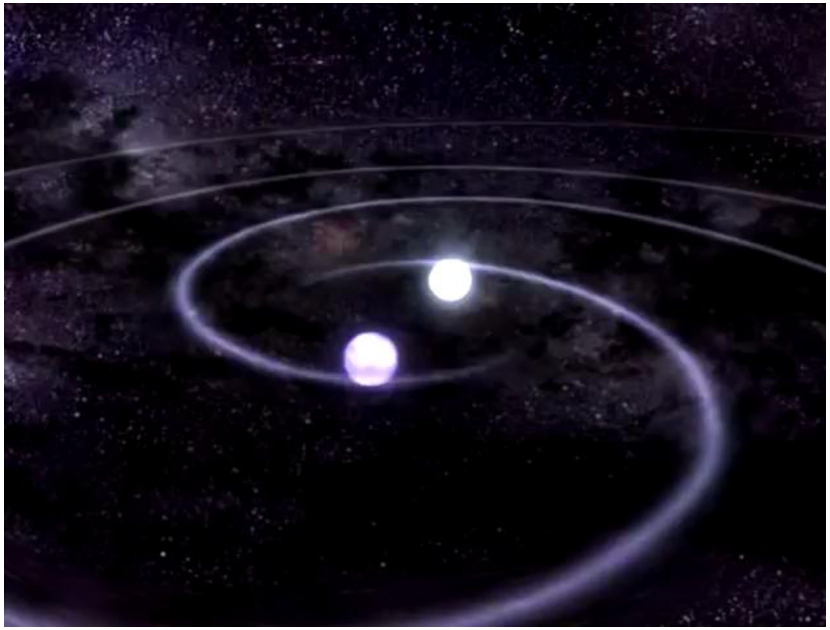
- They are disturbances of electric and magnetic fields which propagate each other!





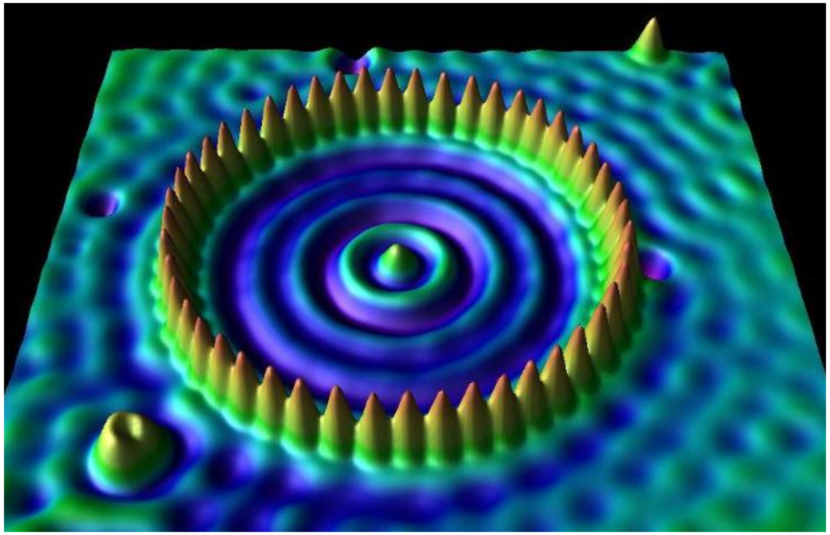
Exotic waves

- In **general relativity**, the motion of objects through space actually stretches/compresses the fabric of space-time, causing waves *of space* to propagate!



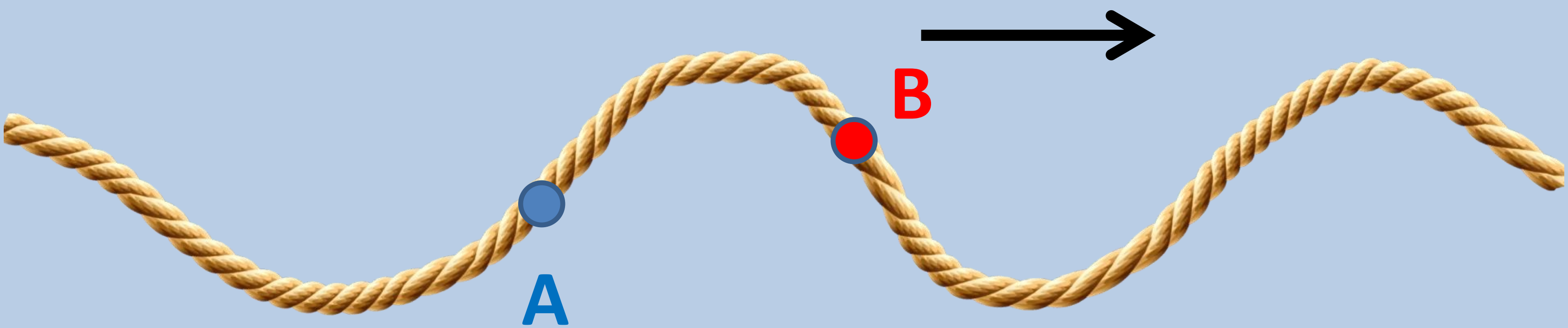
(Study Guides 4-6)

- In **quantum mechanics**, *even matter* can be interpreted as a wave (as opposed to a particle)
  - The amplitude of the wave relates to the probability that the matter can be found at position *x* in space



Clicker Quiz

A wave is traveling to the right on a long, stretched rope. Points A and B <u>are attached to the rope</u>, and are shown at some time *t*. When the wave moves slightly to the right, how do points A and B move?



A. **A** and **B** both move right

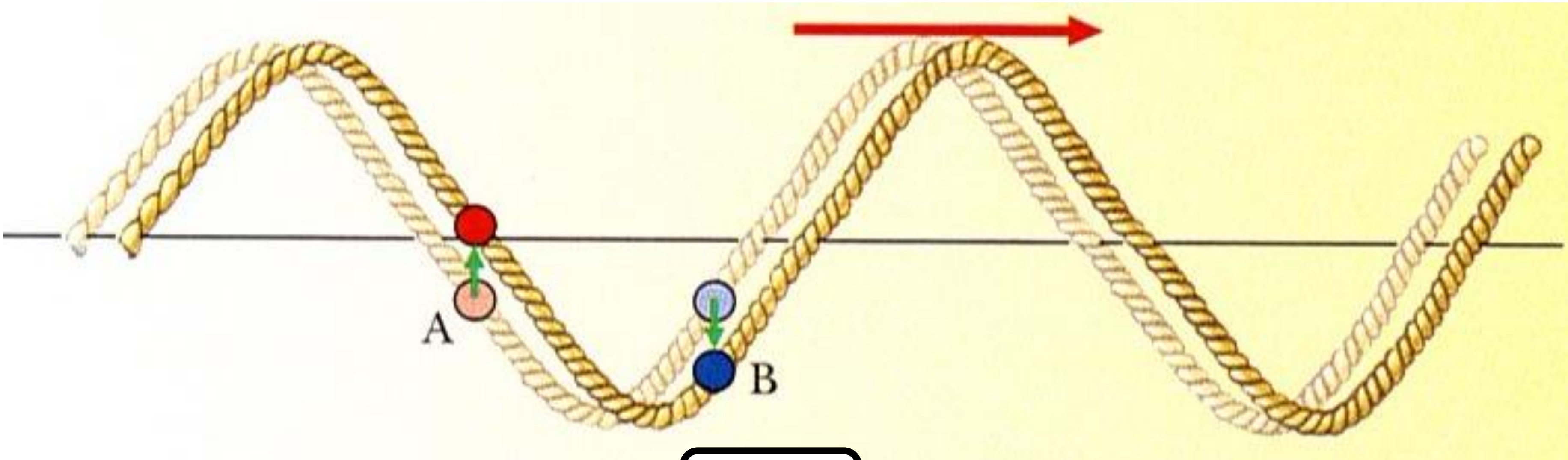
B. **A** and **B** both move left

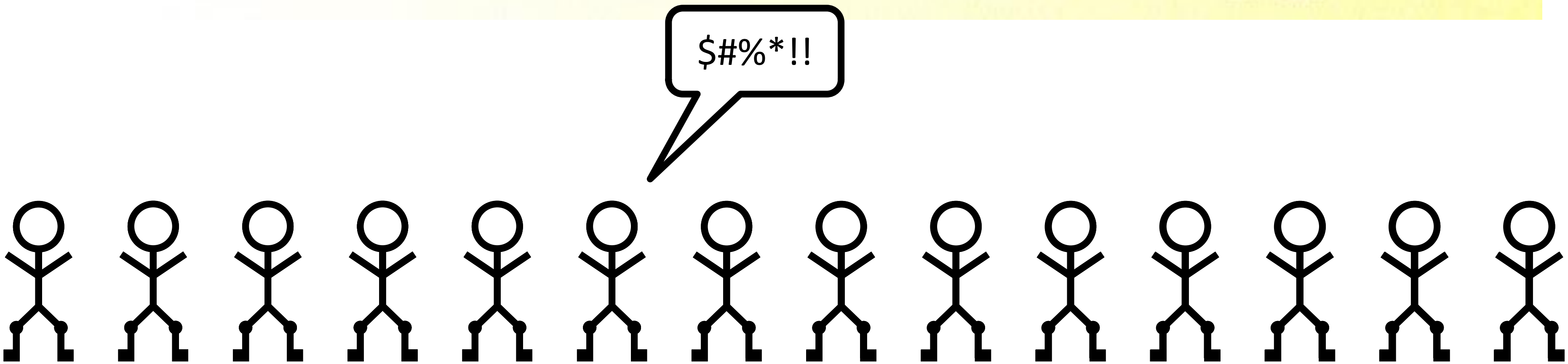
C. **A** moves down and **B** moves up

D. **A** moves up and **B** moves down

E. **A** and **B** both move up

Waves transport **energy**, not matter

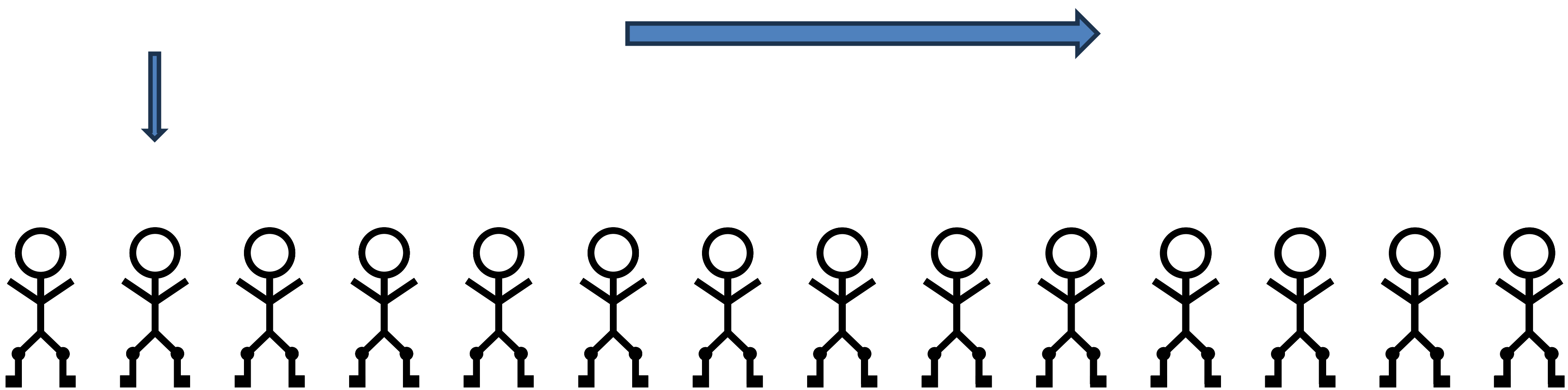




Waves travel in space and time

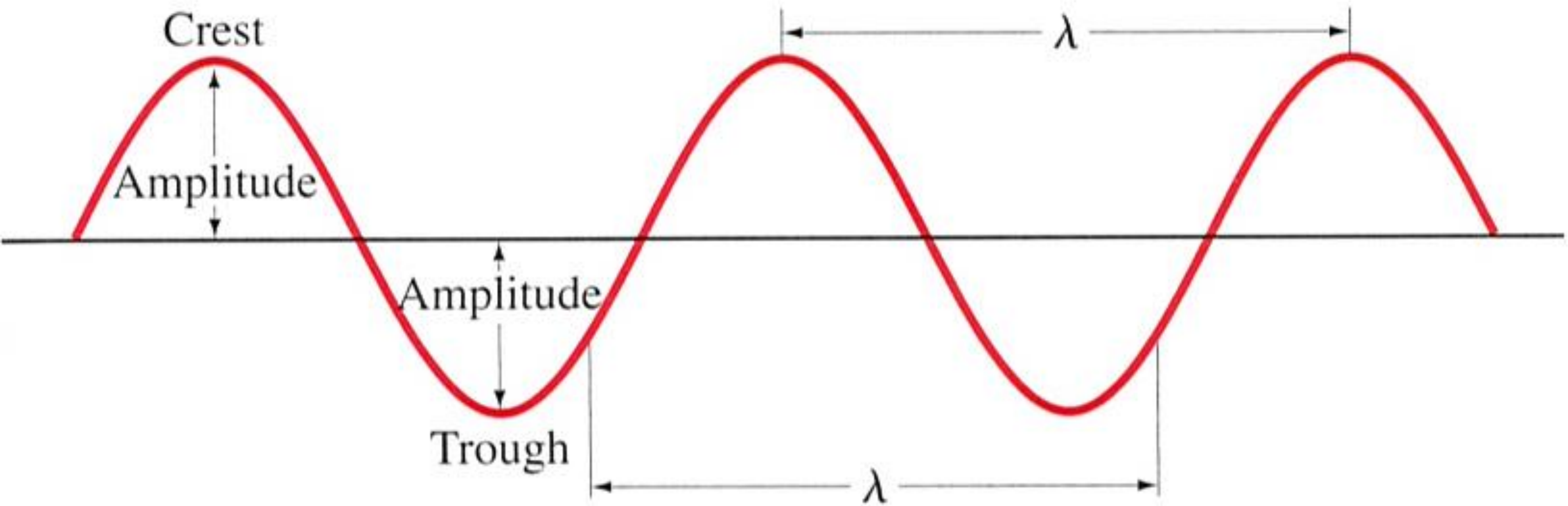
Fixed x

Traveling to the right



Periodic Waves

- ***Periodic waves*** are waves whose pattern repeats indefinitely along the direction of propagation with a fixed period of repetition:



- ***Amplitude (A):*** The maximum disturbance (y_{max}) caused by the wave
- ***Wavelength (λ):*** The size of the wave structure that is repeated

Anatomy of a traveling wave

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

- A – amplitude (units depend on type of wave)
- f – frequency (Hz or cycles/second)
- ω – angular frequency (radians/second)
- T – period (seconds)

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

- λ – wavelength (metres)
- k – wave number (radians/metre)

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

Wave speed

- It takes one full period for a wave to travel a distance of one wavelength

$$c = \frac{\lambda}{T} = f\lambda$$

- Also, since $\qquad \omega = \frac{2\pi}{T} \qquad k = \frac{2\pi}{\lambda}$

$$c = \frac{\omega}{k}$$

Waves travel forward in both TIME & SPACE; therefore we need a mathematical form of our wave which is dependent on both!

For a wave traveling along x direction:

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

- y = displacement from equilibrium
- A = maximum displacement
- ω = angular frequency (the change in the angle with respect to time)
- k = wave number or wave vector (the change in the angle with respect to space)
- "+" or "−" according to direction of travel
  - $+$ means it is traveling in the negative ($\longleftarrow$) x-direction
  - $-$ means it is traveling in the positive ($\longrightarrow$) x-direction

Example 1

A wave traveling along the x-axis is given as:

$$y(x, t) = (2.0 \text{ cm}) \sin[(1.0 \text{ rad/s})t - (1.5 \text{ rad/cm})x]$$

Where the displacement, y, is in cm.

Determine:

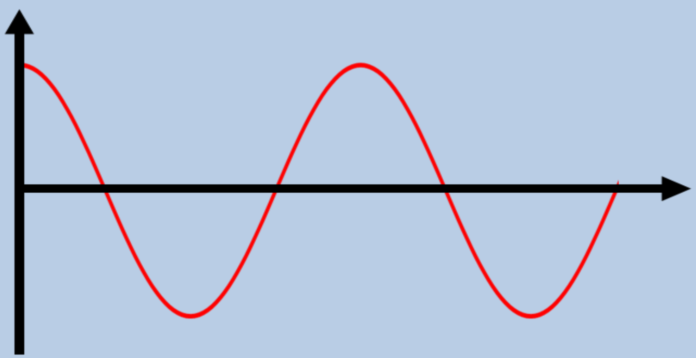
a) the amplitude
b) the wavelength
c) the angular frequency
d) the period
e) the frequency
f) the wave speed
g) Draw: $y(x, t = 0)$ and $y(x = 0, t)$

Clicker quiz

For the wave function given, which graph best represents a snapshot of the graph at time t = 0 s (i.e. the graph of y vs. x)?

$$f(x,t) = (2.0\ \text{cm})\,\sin[(1.0\ \text{rad/s})t - (1.5\ \text{rad/cm})x]$$

A



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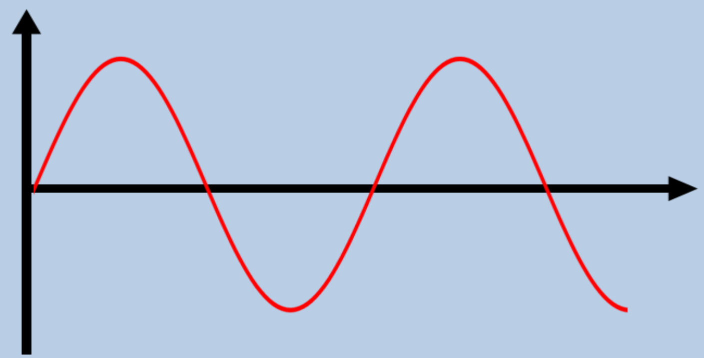

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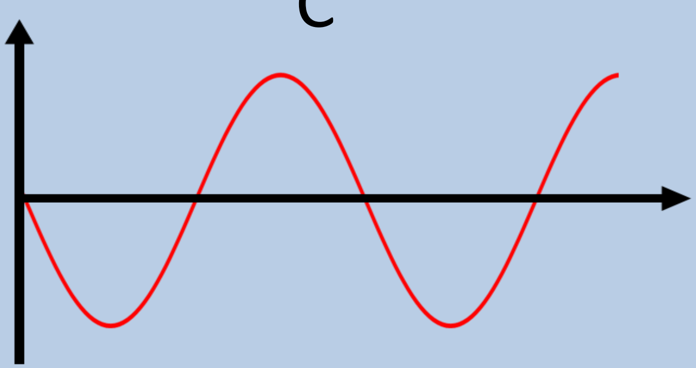

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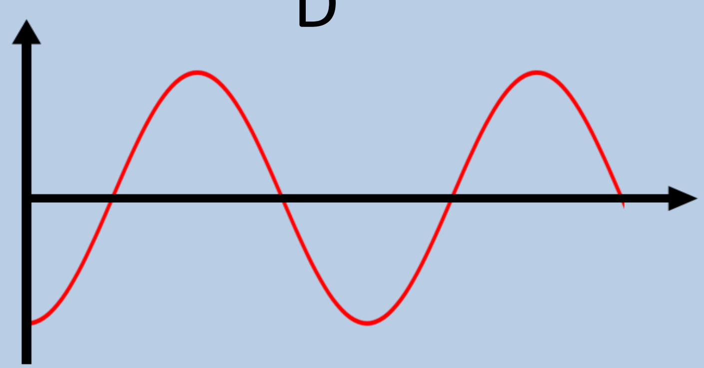
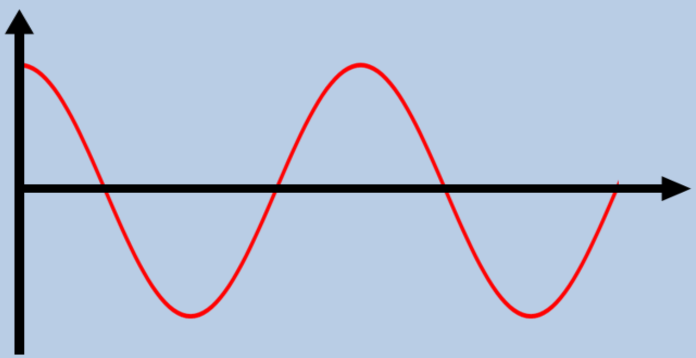


Clicker quiz

For the wave function given, which graph best represents the displacement of the medium at the origin (x = 0) as a function of time (i.e. the graph of y vs. t)?

$$f(x,t) = (2.0\ \mathrm{cm})\sin[(1.0\ \mathrm{rad/s})t - (1.5\ \mathrm{rad/cm})x]$$

A



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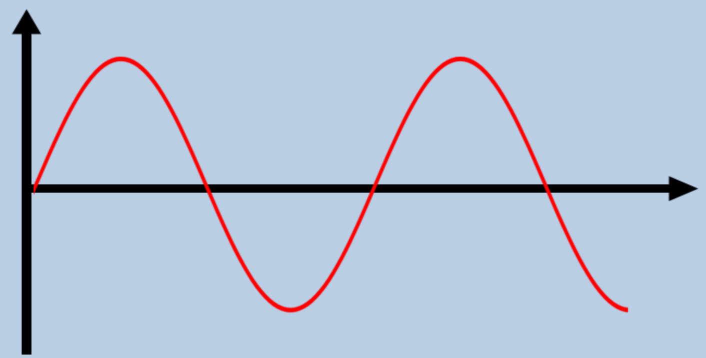

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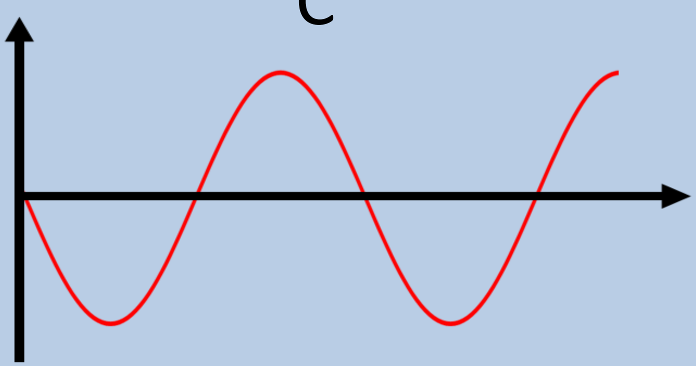
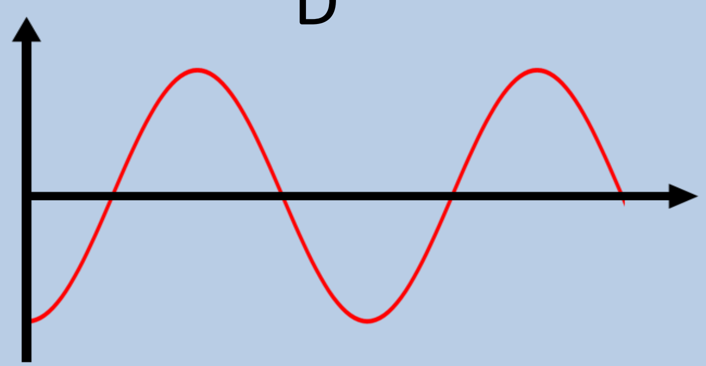


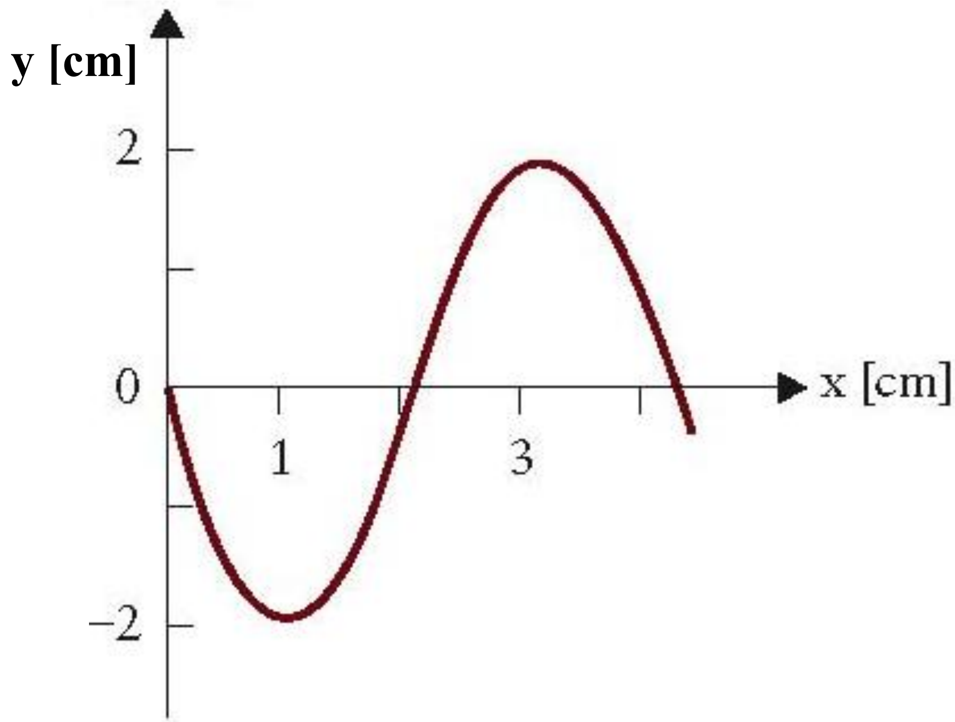
D



- (g) Draw at t=0:

$$y(x,t) = (2.0\,\text{cm})\sin\left[(1.0\,\text{rad/s})t - (1.5\,\text{rad/cm})x\right]$$

$$y(x,0) = -(2.0\,\text{cm})\sin\left[(1.5\,\text{rad/cm})x\right]$$



- (g) Draw at x=0:

$$y(x,t) = (2.0\,\text{cm})\sin\left[(1.0\,\text{rad/s})t - (1.5\,\text{rad/cm})x\right]$$

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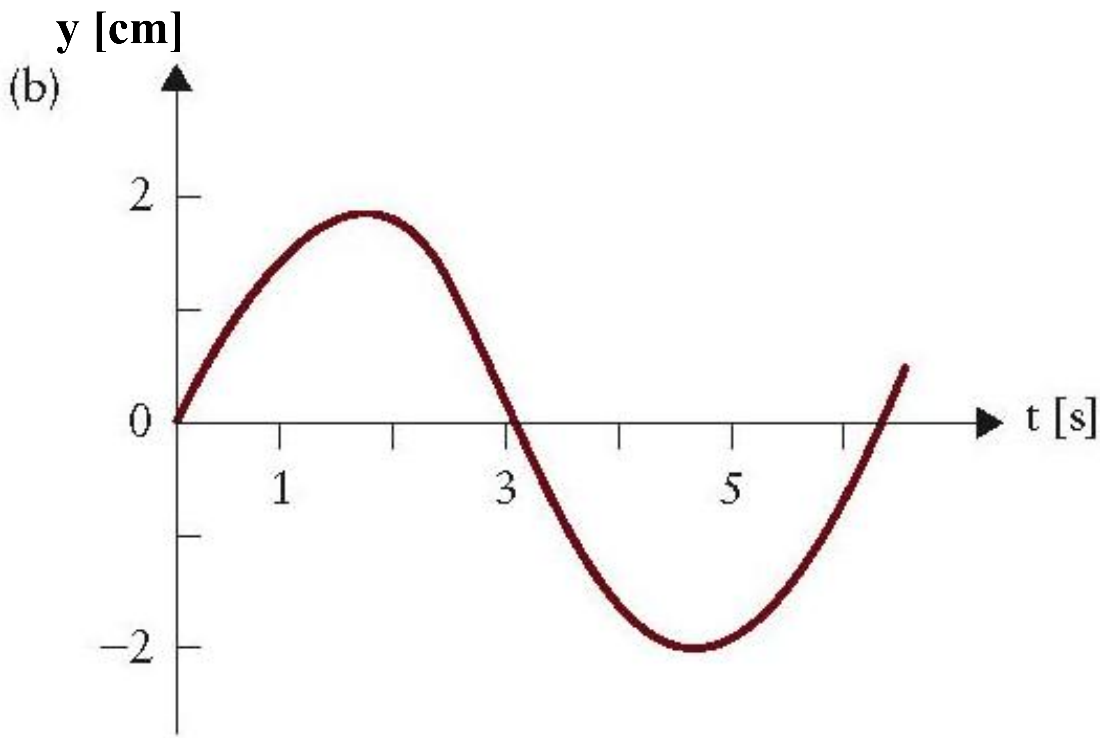


Example 2 – Try this on your own!

A wave moves along a string in the +x direction with a speed of 6.0 m/s, a frequency of 3.0 Hz and amplitude of 0.050 m. What are the…

(a) wavelength?

(b) wave number?

(c) period?

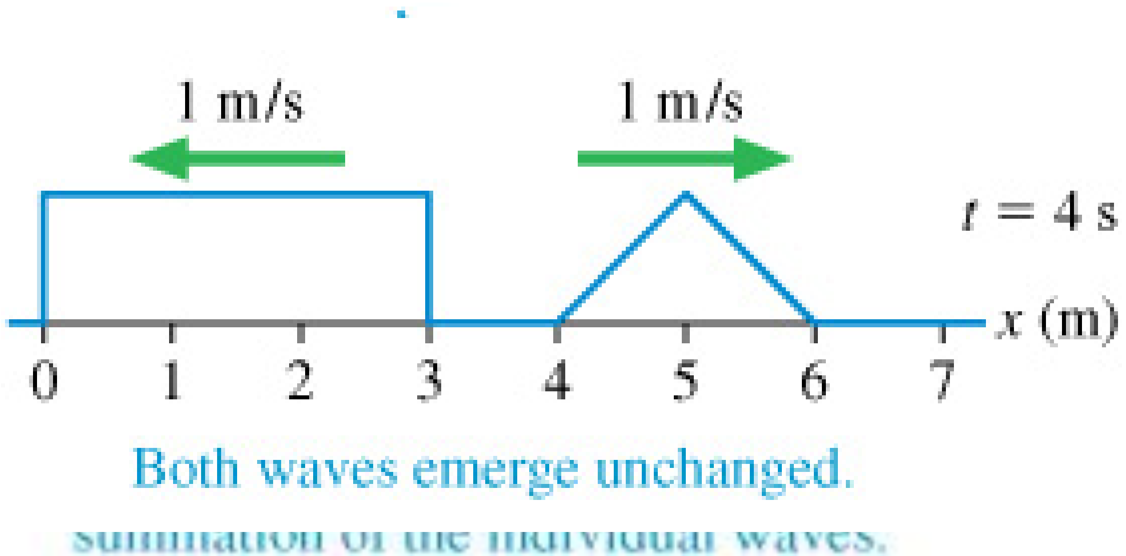
(d) Angular frequency?

(e) Determine an equation for this wave

(and sketch it for t = 0 and t= 0.1 s)

Superposition

- Two waves can pass through each other without altering either wave in any way



- The same cannot be said for you (or matter in general)
  - ~~Demo: Ask student to run at the wall, and try to end up in the hallway (tell them faster is better)~~

Superposition & Interference

Depending on the relative displacements caused by two wave pulses, the waves can interfere to produce a total displacement that could be larger or smaller than the individual waves

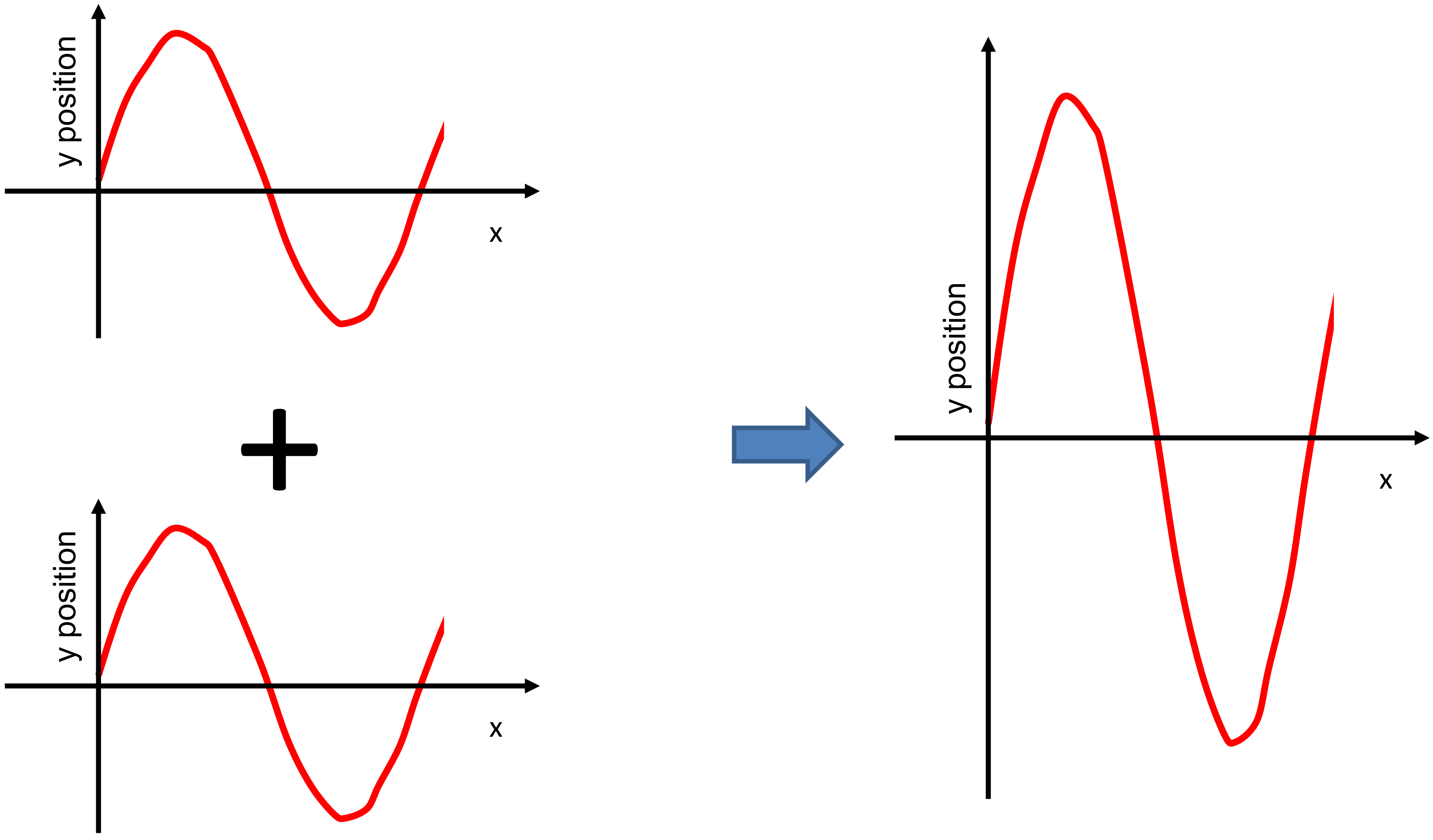
$$y_1(x,t) + y_2(x,t) = y_{TOT}(x,t)$$

Constructive Interference

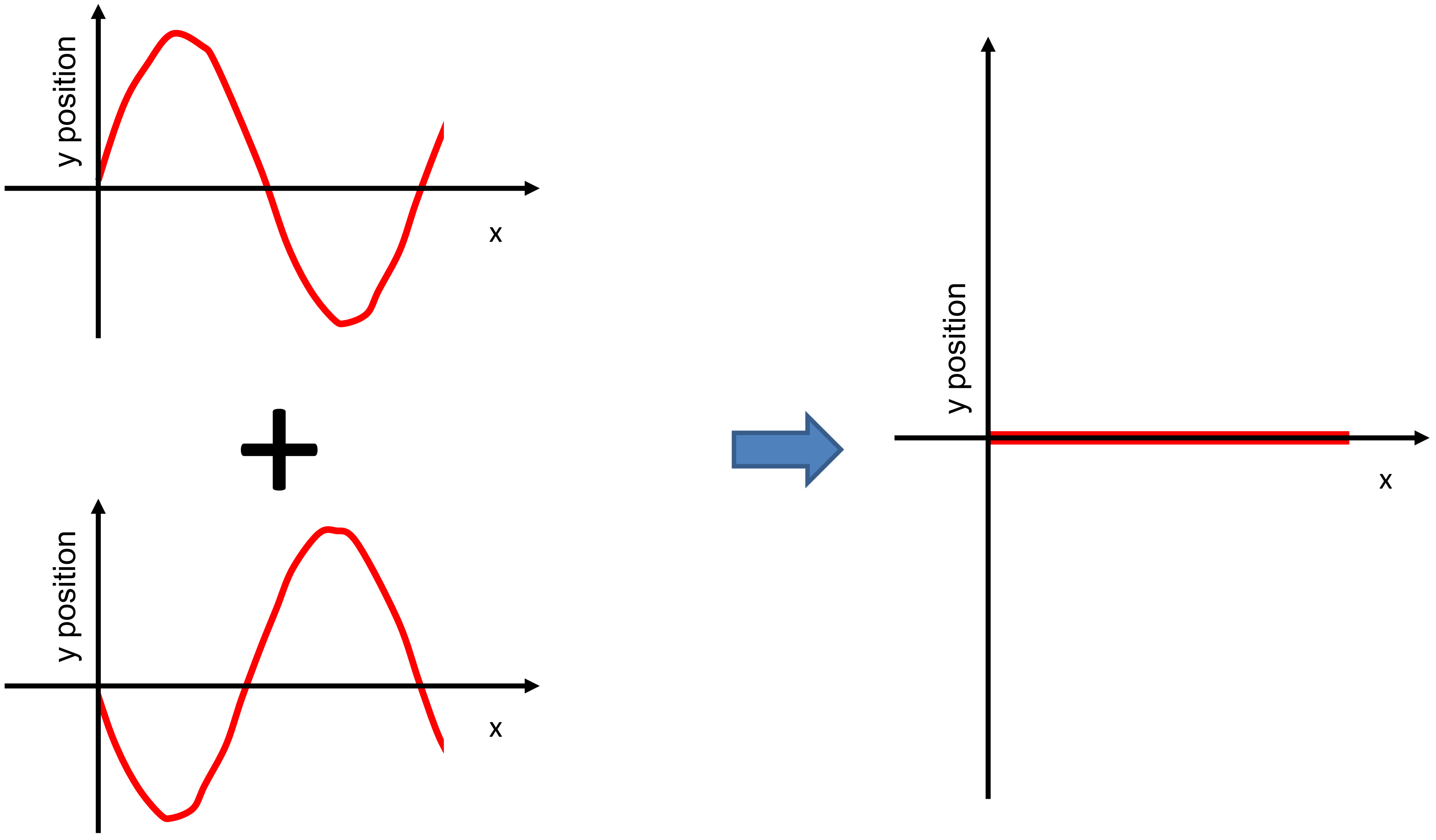
Destructive Interference

Completely Destructive Interference

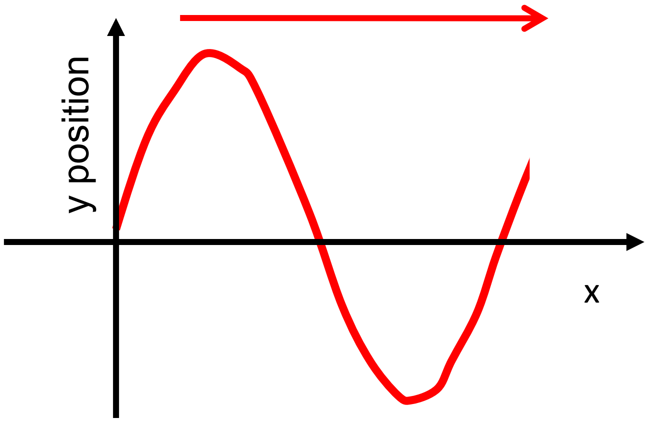
Constructive interference of a sine wave

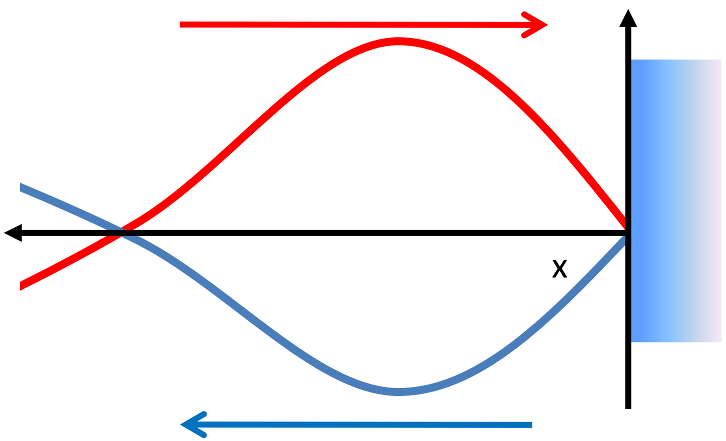


Completely destructive interference of a sine wave



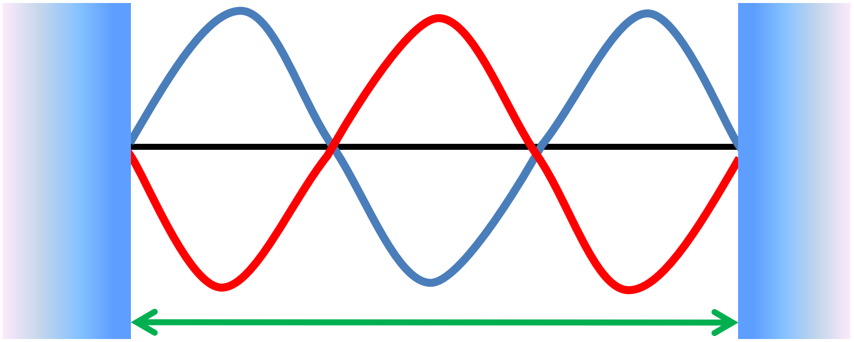
Standing Waves (stationary waves)





When it is reflected at a fixed barrier, the returning wave is inverted

If there are barriers AT both ends, there will be a reflection at both ends & the waves will be constantly travelling back & forth.



Clicker Quiz

A transverse wave on a string is described by

$$y(x,t) = Acos(\omega t - kx)$$

It arrives at the point *x* = 0 where the string is fixed in place. Which function describes the reflected wave?

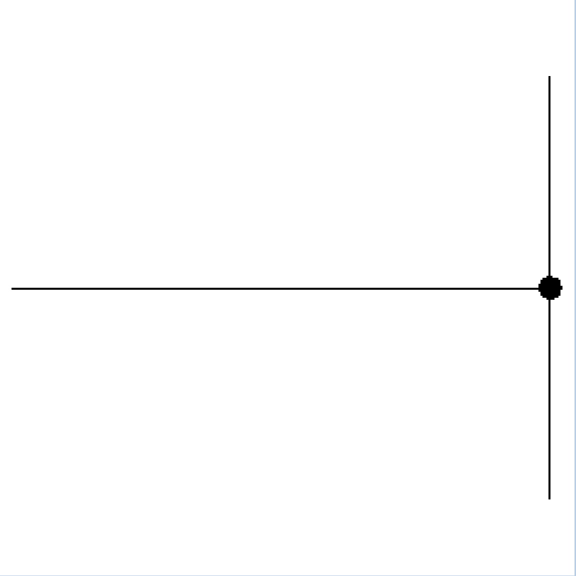
A. $y(x,t) = Acos(\omega t - kx)$

B. $y(x,t) = Acos(\omega t + kx)$

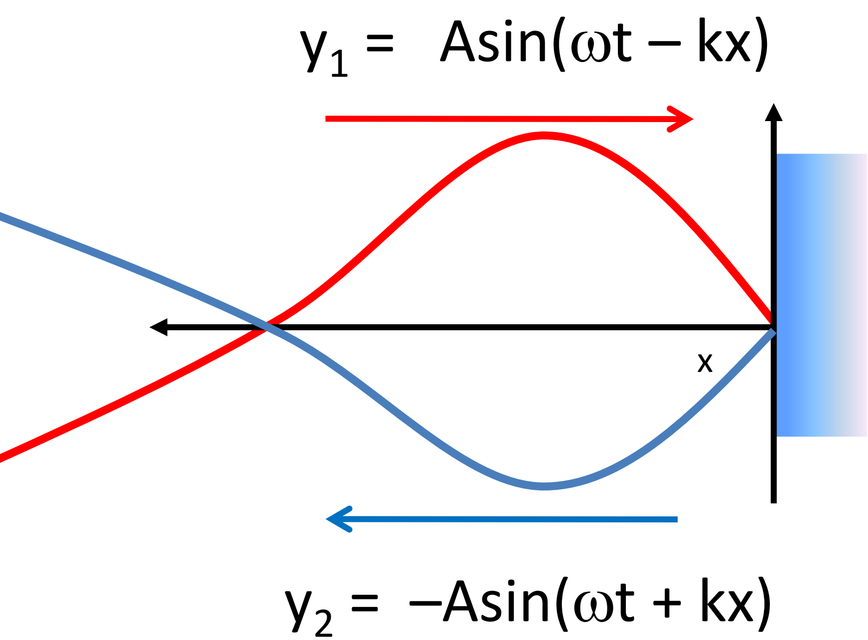
C. $y(x,t) = -Asin(\omega t - kx)$

D. $y(x,t) = -Acos(\omega t + kx)$

E. $y(x,t) = Asin(\omega t - kx)$



Standing waves



Add these two waves together – what's the result?

$$y_1(x,t) + y_2(x,t) = y_{TOT}(x,t)$$

A trig identity allows us to add these two

$$y(x,t) = -2A\cos(\omega t)\sin(kx)$$

Standing Waves

$$y = A\sin(\omega t - kx) - A\sin(\omega t + kx)$$

Recall:

$$\sin(A - B) - \sin(A + B) = -2\cos(A)\sin(B)$$

$$\boxed{y = -2A\cos(\omega t)\sin(kx)}$$

This is the equation for a standing wave!

It is the product of a:

TIME-dependent amplitude factor, $\underline{-2A\cos(\omega t)}$

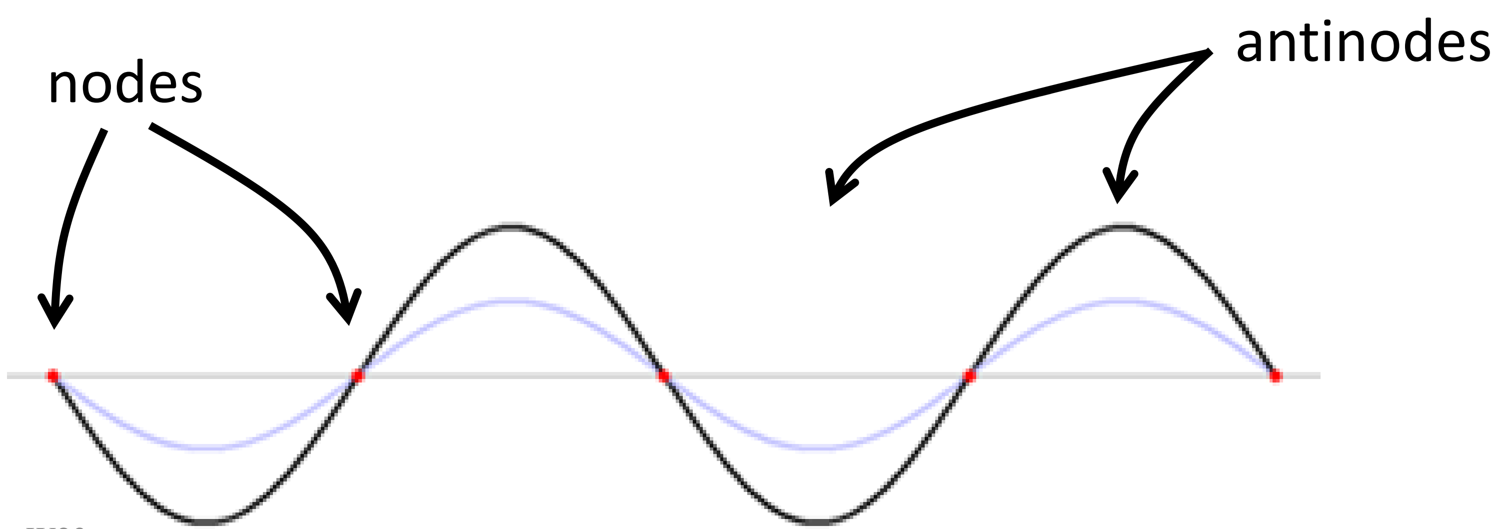
and a **POSITION**-dependent factor, $\underline{\sin(kx)}$

Standing Waves

- The superposition of two traveling waves (opposite directions) creates a standing wave. Mathematically, the standing wave is described by:

$$y_{TOT}(x,t) = -\underbrace{2A\cos(\omega t)}_{\text{amplitude changes with time}}\,\underbrace{\sin(kx)}_{\text{sinusoidal shape}}$$

- **What's important?**



Study Guide 1, Self Test III, Question 3

An incident wave

$$y_1 = -4\sin(3\pi t - 6\pi x)$$

and a reflected wave

$$y_2 = 4\sin(3\pi t + 6\pi x)$$

produce a standing wave. What is its equation? Use the traveling wave's amplitude in the standing wave equation

Study Guide 1, Self Test III, Question 3

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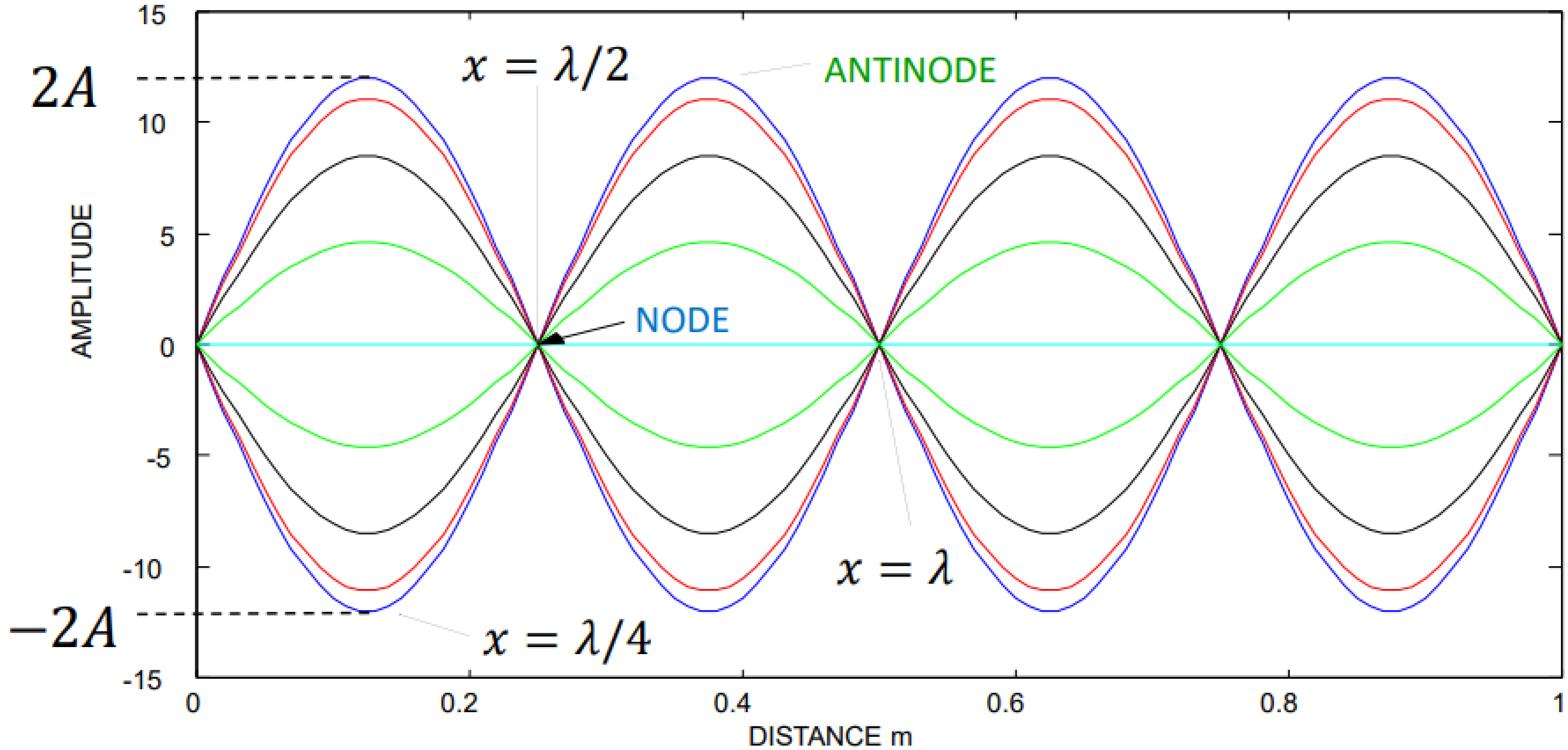
produce a standing wave. What is its equation? Use the traveling wave's amplitude in the standing wave equation:

$$y = -2A\cos(\omega t)\sin(kx)$$

$$y = 8\cos(3\pi t)\sin(6\pi x)$$

Snapshots of standing wave at different times

$$y = -2A\cos(\omega t)\sin(kx)$$

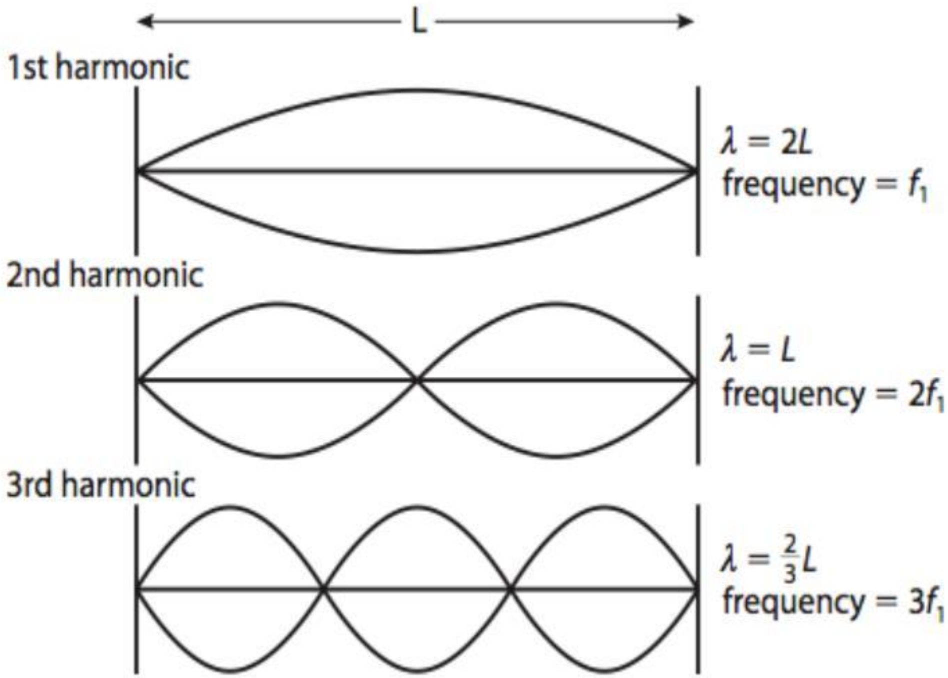


At all times, NODE positions ($y = 0$) are at same x

At all times, ANTINODE positions are at same x

Amplitude oscillates

Formation of Standing Waves



$$L = \frac{n\lambda_n}{2}$$

$$\lambda_n = \frac{2L}{n}$$

n=1,2,3,…

Example

The high “E” in a guitar is produced by a string of length 0.627 m

1) What are the three longest wavelengths of standing waves?
2) The frequency of the fundamental tone (first harmonic) of this high “E” is 329.6 Hz. What is the wave speed along this string?

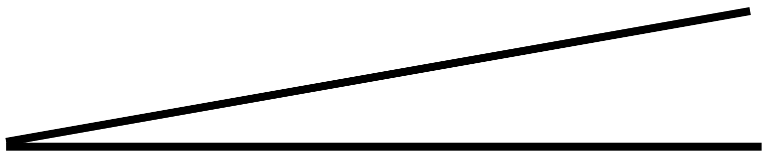
Small angle approximation

- For angles less than $\pi/20$ rad ($\approx 10^{o}$)

$$\sin\theta \cong \theta$$

$$\cos\theta \cong 1$$

$$\tan\theta = \frac{\sin(\theta)}{\cos(\theta)} \cong \theta$$



However, this only works when using **radians**!

- We will use this later in the course