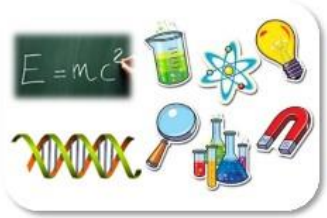
Unit 2: Waves

Part I

Why needs Physics? STEM?

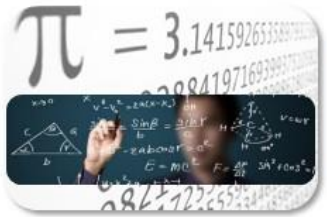


Science

Physics
Chemistry
Biology

Technology

Engineering



Mathematics

Computing
Signal Processing

The Need of Science Knowledge to implement a System Design

Automatic Car Collision Avoider

Virtual Drumming

Heart Beat Monitor

Infrared thermomete

Ultrasonic Meter ruler

Tsing Ma Bridge Vibration Monitor

Virtual drumming: https://www.youtube.com/watch?v=ExfU10vHTlU

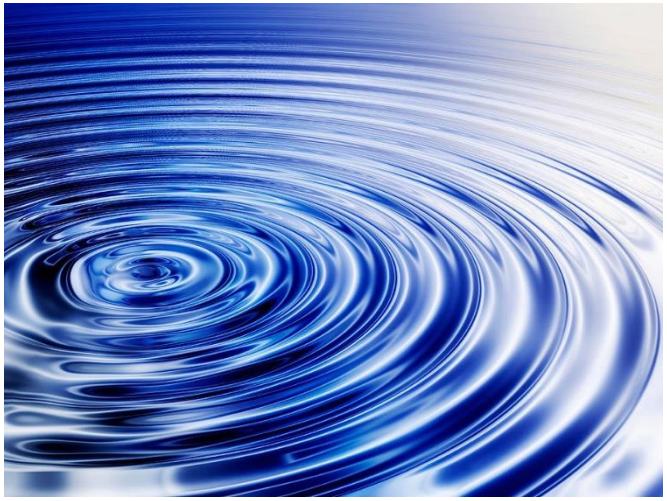
What Physics covers?

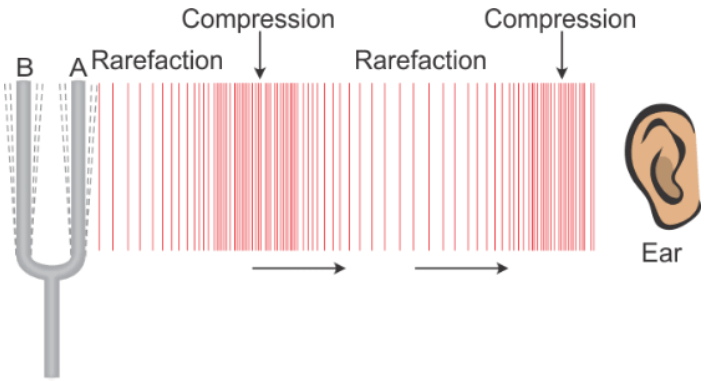
- **Classical physics** includes the traditional branches and topics that were recognised and well-developed before the beginning of the 20th century—classical mechanics, ***acoustics***, optics, thermodynamics, and electromagnetism.
- **Modern physics** is an effort to understand the underlying processes of the interactions with matter, utilizing the tools of science and engineering.

In this course, we will go through some basic physics related to “wave”. It is because we have labs and project related to “wave” and “optics”

https://en.wikipedia.org/wiki/Physics

Waves and Their Properties

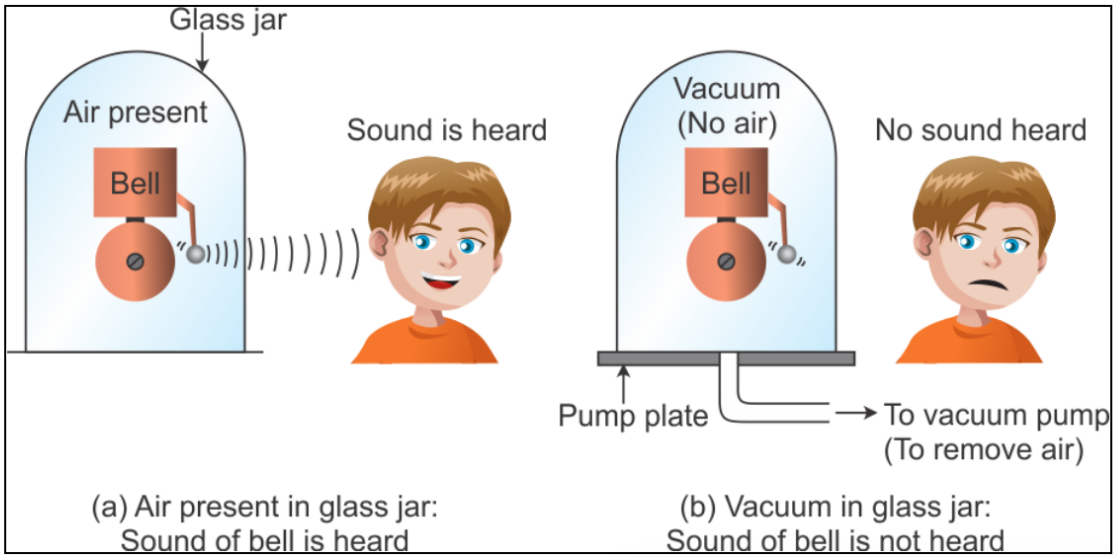




https://www.wallpaperup.com/65922/ocean_waves_surfing.html
https://fineartamerica.com/featured/3-water-ripples-pasieka.html
https://www.tuttee.co/blog/phys-sound-waves

Types of Waves - Mechanical Wave

- Example: sound and water waves, earthquakes
- It requires medium, e.g. solid, liquid, gas, to travel



https://www.topperlearning.com/answer/describe-an-activity-to-demonstrate-that-sound-cannot-travel-through-vacuum/fq0lsgorr

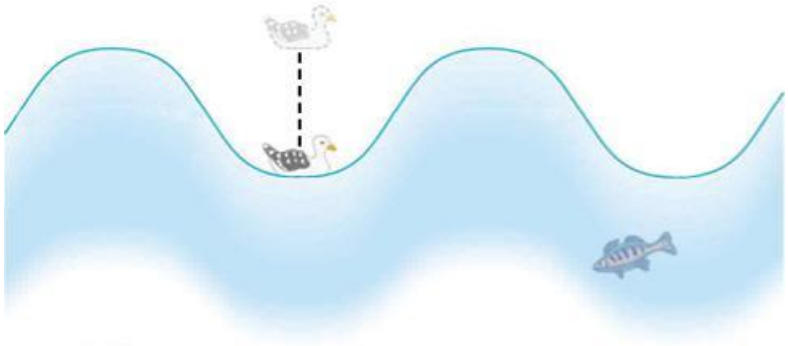
- Speed of wave in a medium depends on material properties
- Does “light” a mechanical wave?

https://openstax.org/books/physics/pages/13-1-types-of-waves#11015

Types of Waves – Pulse Waves and Periodic Waves

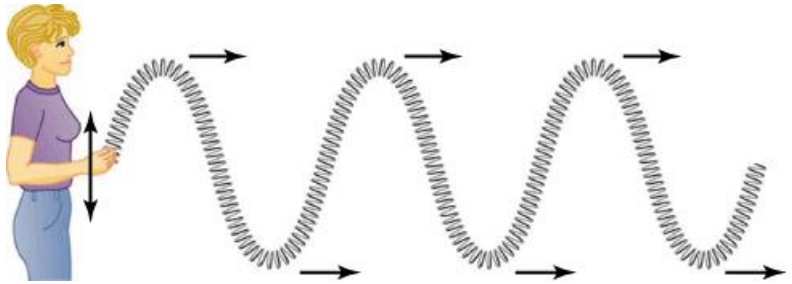
- A **pulse wave** is a single disturbance causing one wave or a few waves being generated, such as in the example of the pebble.

- A **periodic wave** repeats the same oscillation for several cycles, such as in the case of the wave pool, and is associated with simple harmonic motion.

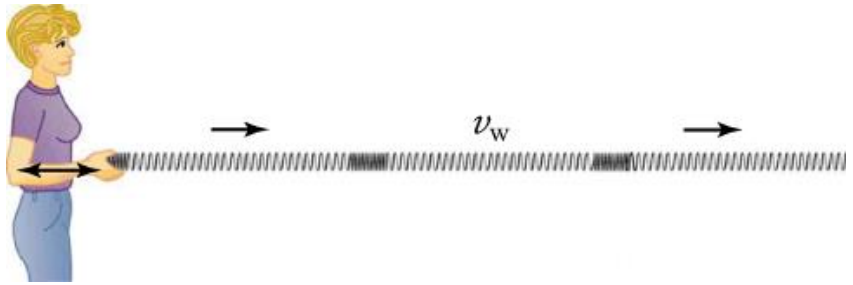


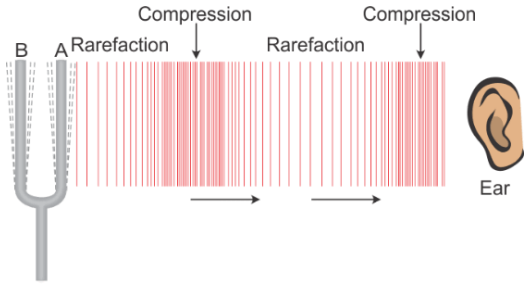
Types of Waves – Longitudinal Waves and Transverse Waves

- A **transverse wave** propagates so that the disturbance is perpendicular to the direction of propagation. Example: light



- A **longitudinal wave**, the disturbance is parallel to the direction of propagation. Example: fork, speaker

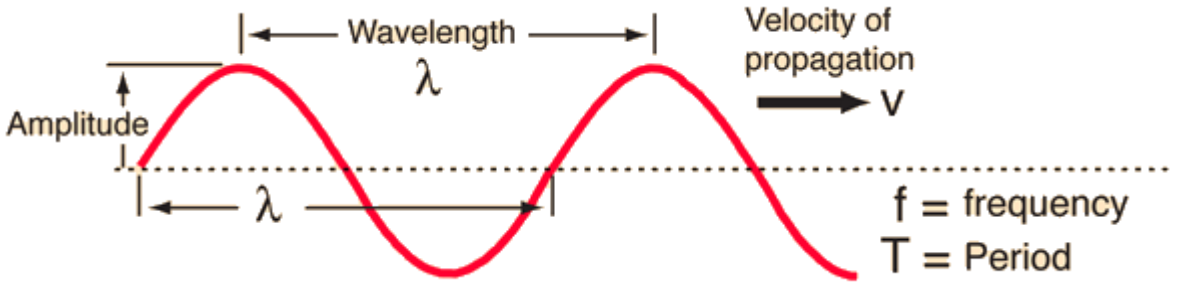




Youtube: https://www.youtube.com/watch?v=0Anh9HthWgQ

Wave Variables

- Amplitude is distance between the resting position and the maximum displacement of the wave
- Frequency f (Hz) is number of waves passing by a specific point per second. f = 1/T
- Period T (s) is time it takes for one wave cycle to complete
- The wavelength λ (m) is the distance between adjacent identical parts of a wave, parallel to the direction of propagation.
- The wave velocity ν (m/s) is the speed at which the disturbance moves. $v = f \lambda$



Speed of sound in different materials

Speed (v) = frequency (f) x wavelength (λ)

$$v = f\lambda$$

- Speed in solid > Speed in liquid > Speed in gas
- Speed depends on materials properties
  - ➢ It does not depends on frequency
- Speed depends on temperature
  - ➢ High temperature ➔ higher velocity

- Application:
  - ➢ The distance d between two points can be estimated by multiplying the time t of a sound wave and its speed

$$d = vt$$

Material	Speed (m / s)
Aluminum	6420
Granite	6000
Steel	5960
Pyrex glass	5640
Copper	5010
Plastic	2680
Fresh water (20 °C)	1482
Fresh water (0 °C)	1402
Hydrogen (0 °C)	1284
Helium (0 °C)	965
Air (20 °C)	343
Air (0 °C)	331

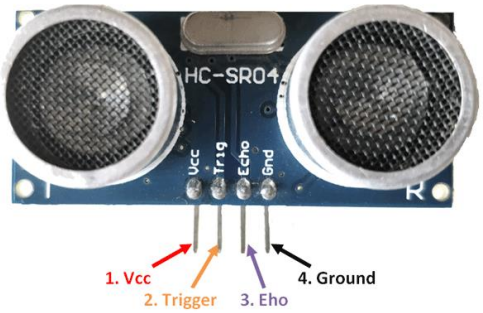
Remark: In one of our lab, we will make use of the above-mentioned principle to build an ultrasonic meter ruler.

Applications of ultrasonic waves

- It refers to the frequency above which our human ears can not hear
- Our human ears can normally hear up to 20KHz
- Ultrasonic sensors with frequency around 38KHz (beyond our human ear's response) will be used for distance / obstacle sensors
- Besides, we can use make use of ultrasonic wave to life up some weight

  ➔ultrasonic levitator

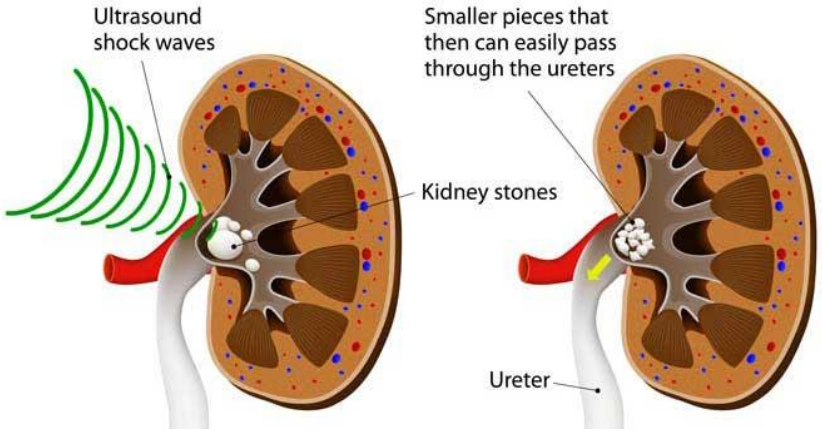
  https://www.youtube.com/watch?v=j3A267nsXgo



Applications of ultrasonic waves

- Medical diagnosis and treatment:

3D Ultrasonic Fetal Image



Applying Ultrasonic Shock Waves to break kidney stone

https://www.urologysanantonio.com/kidney-stones/lithotripsy