Unit 4 - Waves

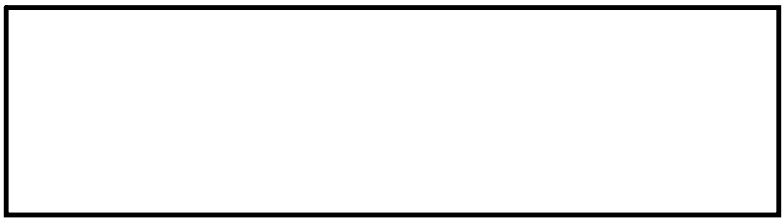
[Chapter 8
Chapter 9]

1. Types of Waves.
2. Measures / quantities
3. Wave Behaviors

Waves

A wave is a disturbance that transfers energy from one point to another. A wave is produced by a source that vibrates or oscillates.

A wave pulse is a single vibration whereas a continuous or periodic wave repeats over time.



Types of Waves

Mechanical Waves

require a medium (substance) in order to propagate or move

- transverse waves
- longitudinal waves

Electromagnetic Waves

do not require a medium in order to propagate or move

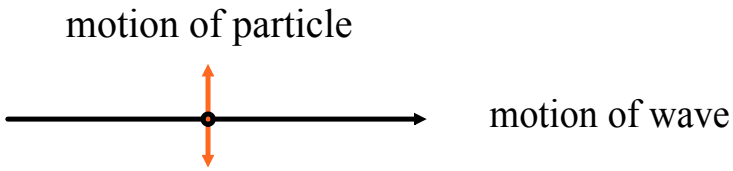
- electromagnetic spectrum

Mechanical Waves

Each type of mechanical wave is defined in terms of the direction of the wave's motion as compared to the direction of the medium's motion.

1. **Transverse Waves**

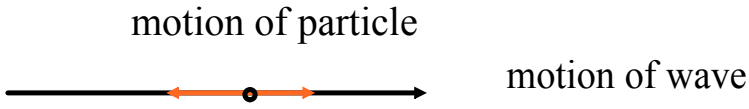
The particles of the medium vibrate perpendicular to the direction of the wave's motion.



http://www.mta.ca/faculty/science/physics/suren/Twave/Twave01.html

2. **Longitudinal Waves**

The particles of the medium vibrate parallel to the direction of the wave's motion.



http://www.mta.ca/faculty/science/physics/suren/Lwave/Lwave01.html

Electromagnetic Waves

There is a spectrum of electromagnetic waves. See below.

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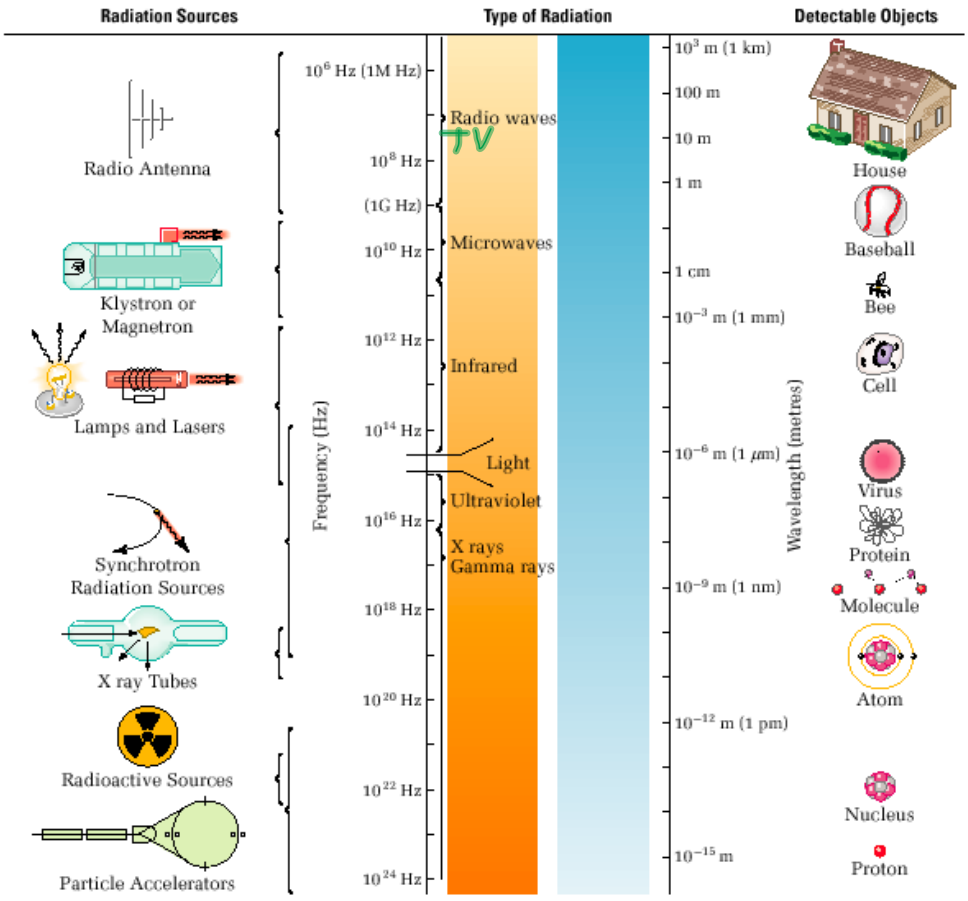
Figure 9.7 The electromagnetic spectrum includes a range of frequencies that covers more than 18 orders of magnitude. The subdivisions are artificial and, to some extent, determined by the mechanism that is used to produce them.



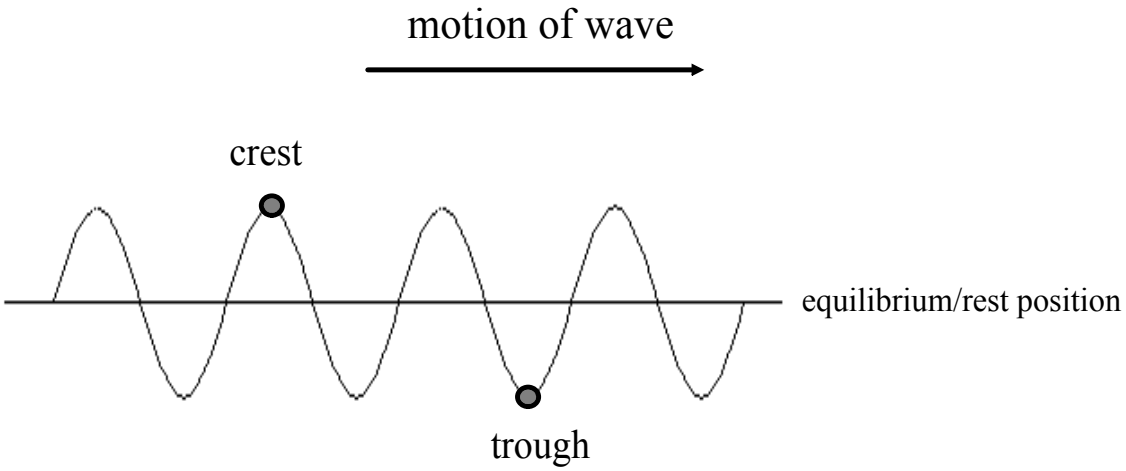
All electromagnetic waves travel at the speed of light in a vacuum.

$$v = 3.00 \times 10^8 \text{ m/s}$$

$$c = 3.00 \times 10^8 \text{ m/s}$$

c -> speed of light in a vacuum

Anatomy of a Transverse Wave



Anatomy of a Longitudinal Wave

A region where the coils are pressed together in a small amount of space is known as a ***compression***.

Compressions

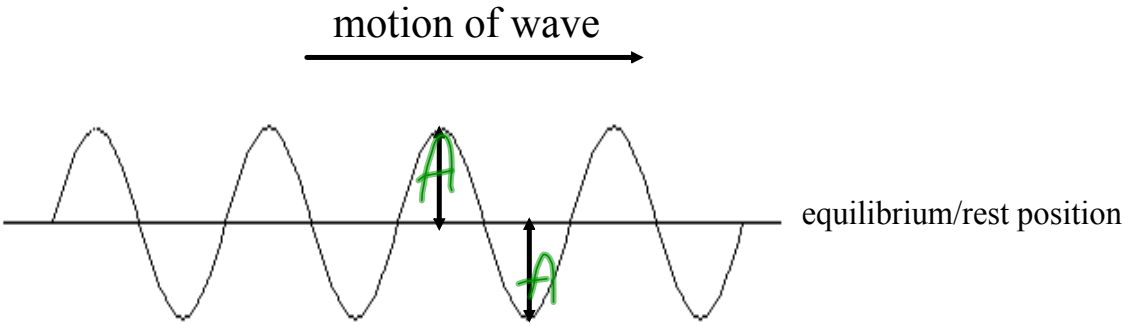
Rarefactions / Expansions

A region where the coils are spread apart, thus maximizing the distance between coils, is known as a ***rarefaction*** or ***expansion***.

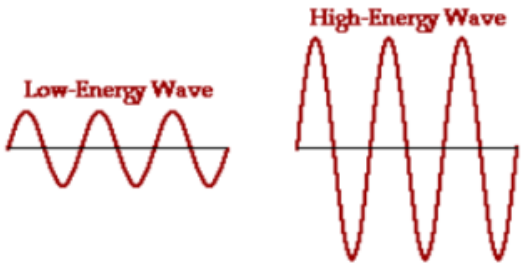
Measures of a Wave

Amplitude (A) units: cm, m

The maximum displacement of the wave from its equilibrium position is called the ***amplitude*** of the wave.



Waves transport energy and the amplitude of a wave is a measure of how much energy the wave is transporting.



To be precise, the energy transported by a wave is directly proportional to the square of the amplitude.

Mathematically,

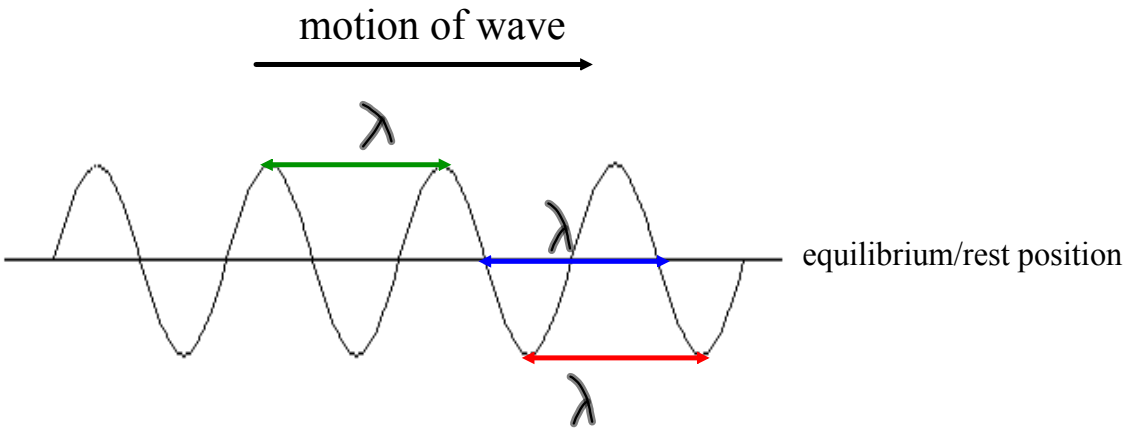
$$E \propto A^2$$

Wavelength

The ***wavelength*** of a wave is often defined as the distance between two successive crests.

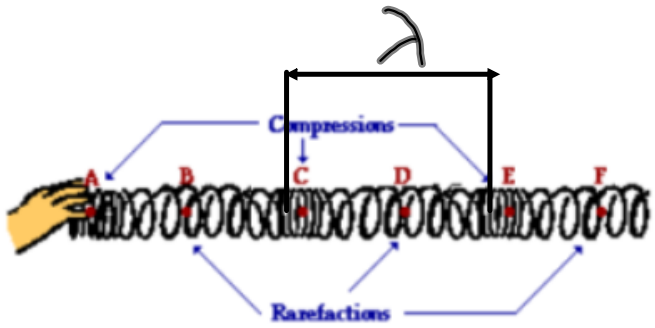
Wavelength is given the symbol λ (called *lambda*)

Transverse Wave



Longitudinal Wave

A **wavelength**, λ, is defined as the distance between the centers of successive compressions/rarefactions.



Frequency

The ***frequency*** is the number of complete wave cycles that pass a given point per unit time. Frequency is given the symbol ***f*** and is measured in ***hertz***.

$$f = \frac{\#\,waves}{time}$$

hertz

$$1\ \text{Hz} = 1\text{s}^{-1}$$

Simulation

Period

Closely related to frequency is the measurement called ***period***. The period of a wave is the time needed for the wave motion to repeat. The symbol *T* represents period, which is measured in seconds.

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

Speed

The wave speed is the speed at which any part of the wave moves. It is not the speed of the particles of the medium.

$$\text{wave speed} = \frac{\text{distance}}{\text{time}} = \frac{\text{wavelength}}{\text{period}} = \frac{\lambda}{T}$$

If we replace the period with $1/f$, we get a new formula for wave speed.

$$v = f\lambda$$

Universal Wave Equation

f	frequency	Hz
λ	wavelength	m
v	speed	m/s

$$v = \frac{d}{t} \qquad v = \frac{\lambda}{T} \qquad v = f\lambda$$

Summary

Quantity	Symbol	Unit

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Chapter 8 – Waves Transferring Energy
Problems – Wave Equation and More

1. A 0.5 Hz wave moves along a rope with a wavelength of 40 cm. What is its speed? (0.2 m/s)

2. The distance between successive crests in a series of water waves is 5.0 m, and the crests travel 8.6 m in 5.0 s. Calculate the frequency of a block of wood bobbing up and down in the water. (0.34 Hz)

3. The wavelength of a water wave is 3.7 m and its period is 1.5 s. Calculate
   a) the speed of the wave (2.5 m/s)
   b) the time required for the wave to travel 100 m (40 s)
   c) the distance travelled by the wave in 1.00 minute (1.5×10^2 m)

4. A water wave travels 60 cm in 2.0 s. If the wavelength of the wave is 5.0 cm, what is the frequency of the wave? (6.0 Hz)

5. A boat at anchor is rocked by waves whose crests are 30 m apart and whose speed is 8.0 m/s. What is the interval of time between crests striking the boat? (3.8 s)

6. A television station broadcasts with a frequency of 90 MHz. What is the wavelength of the waves? (3.3 m)

Attachments

- P112 - Superposition.notebook
- P111-112 Lab Resonance.notebook