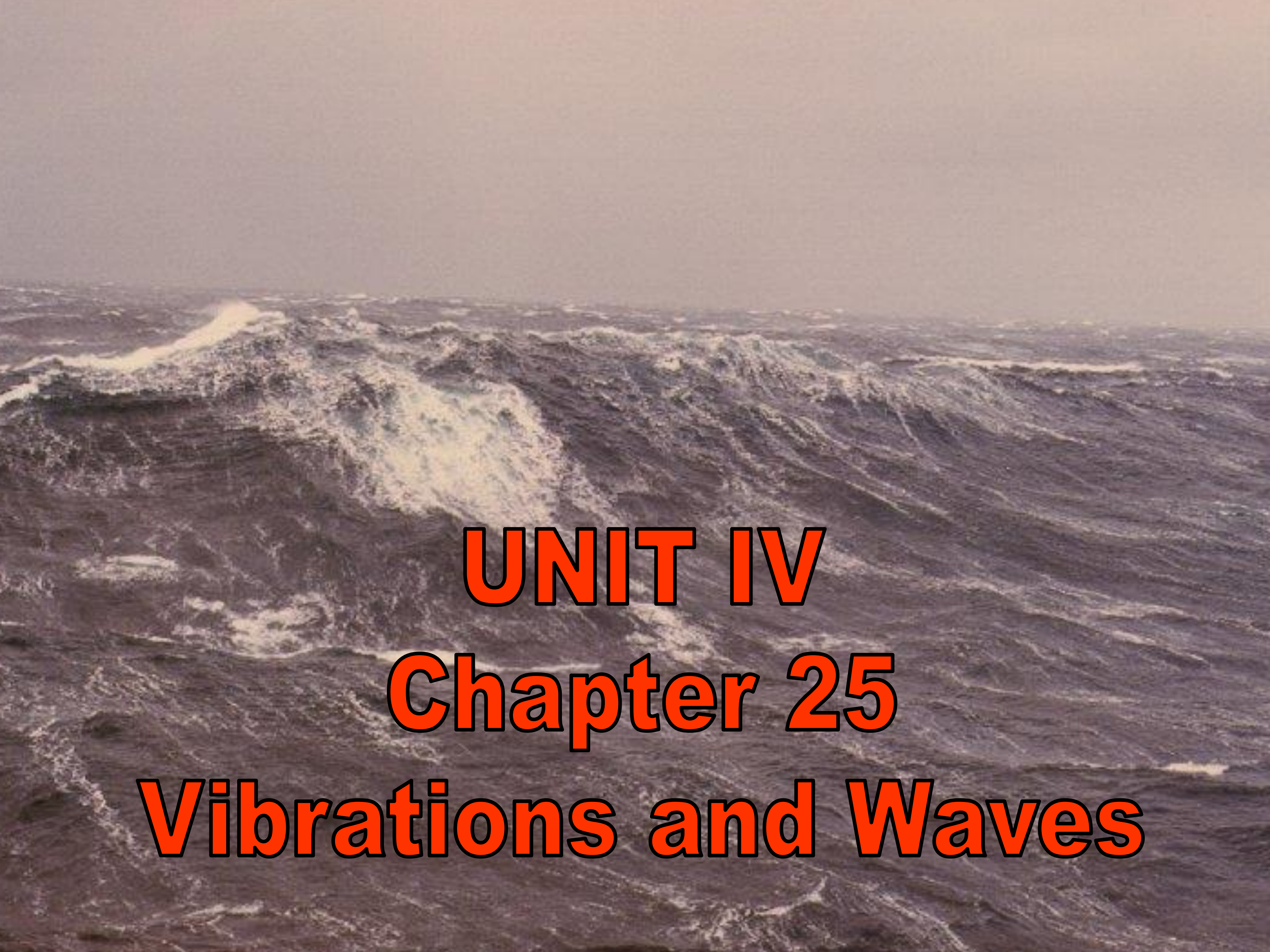


UNIT IV
Chapter 25
Vibrations and Waves

State Standards Addressed

Waves: *Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:*

- *Students know* waves carry energy from one place to another.
- *Students know* how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
- *Students know* how to solve problems involving wavelength, frequency, and wave speed.
- *Students know* sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
- *Students know* radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).
- *Students know* how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

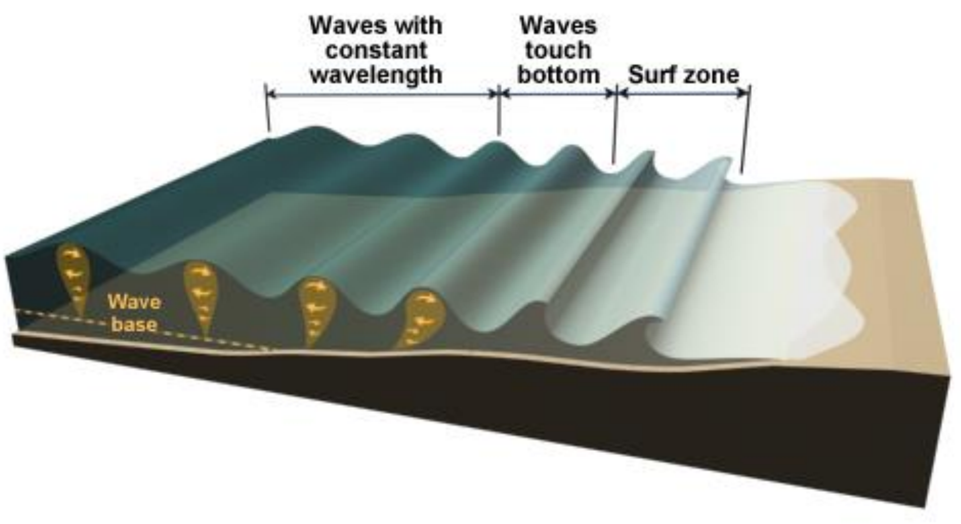
UNIT IV: SOUND AND LIGHT
Chapter 25: Vibrations and Waves

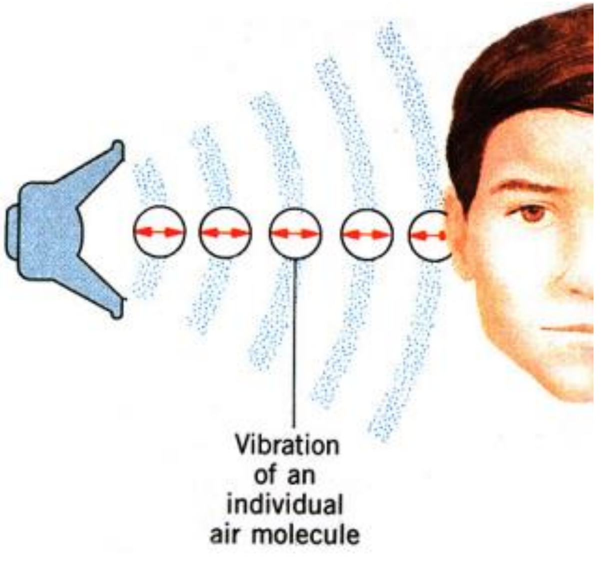
I. Vibrations and Waves

A. **Vibration-** a “wiggle in time”

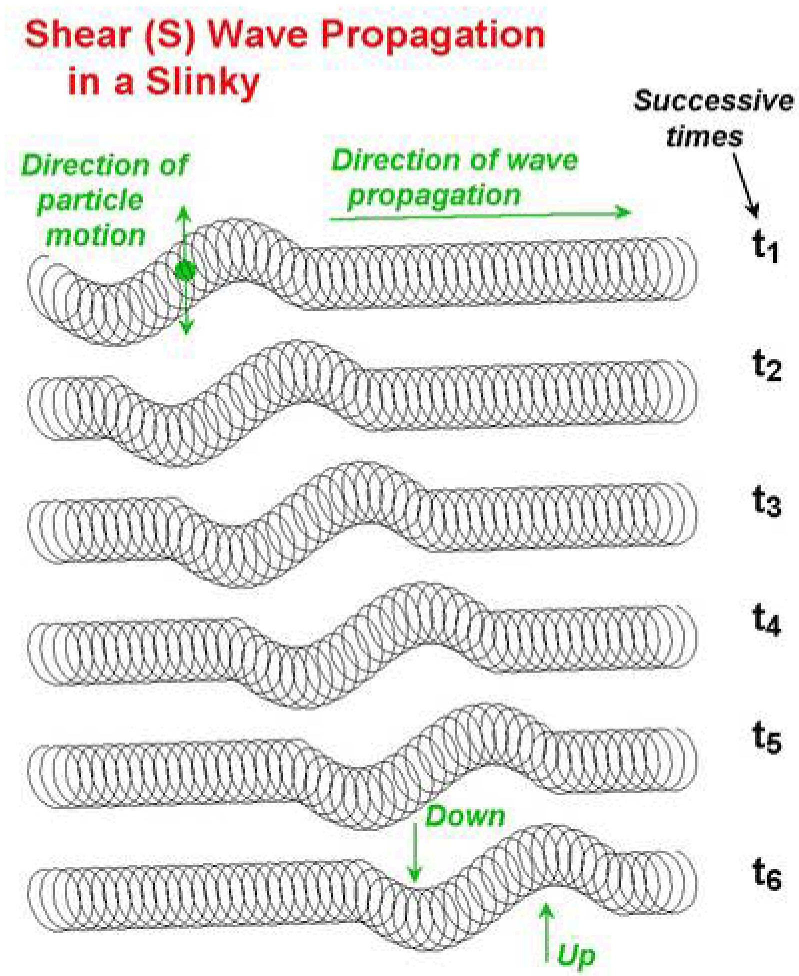
1. All things around us “wiggle” and “jiggle”.

2. <u>Cannot</u> exist in **one instant**, but needs **time** to move back and forth.





B. **Wave**- a wiggle in space and time



1. Cannot exist in one place, but must extend from one place to another

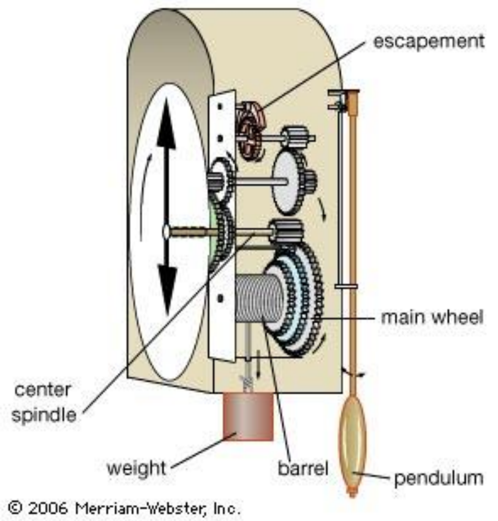
2. **Light** and **sound** are both forms of energy that move through space as waves

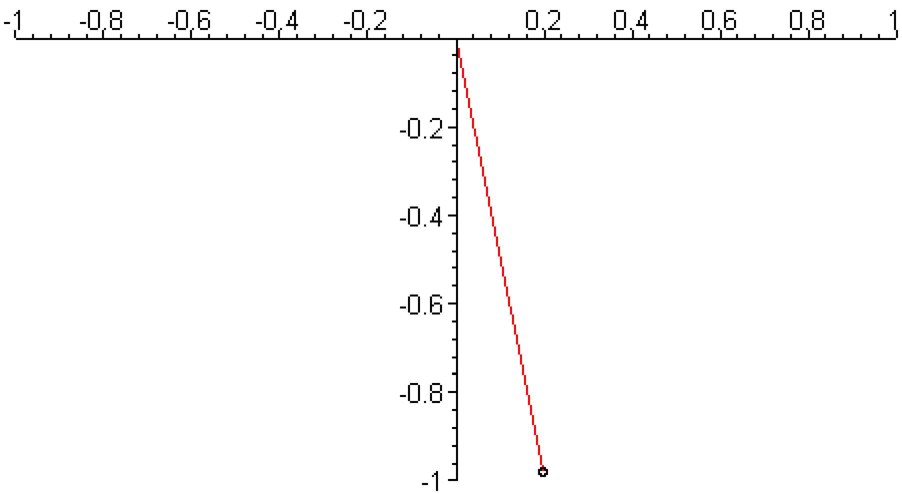
II. Vibration of a Pendulum (25.1)

A. **Pendulum**- swing back and forth with regularity

1. Galileo discovered time a pendulum takes to swing back and forth does <u>not</u> depend on **mass** of pendulum

2. Does <u>not</u> depend on **distance** through which it swings

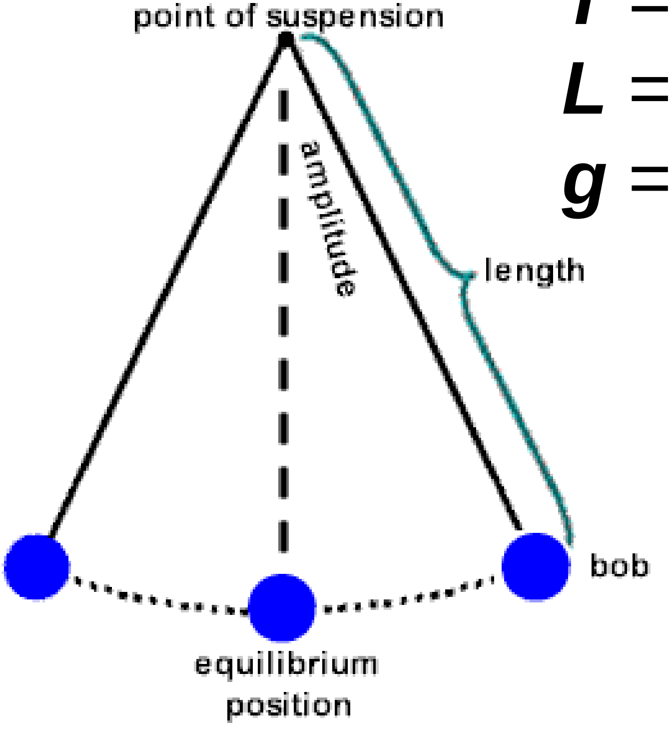


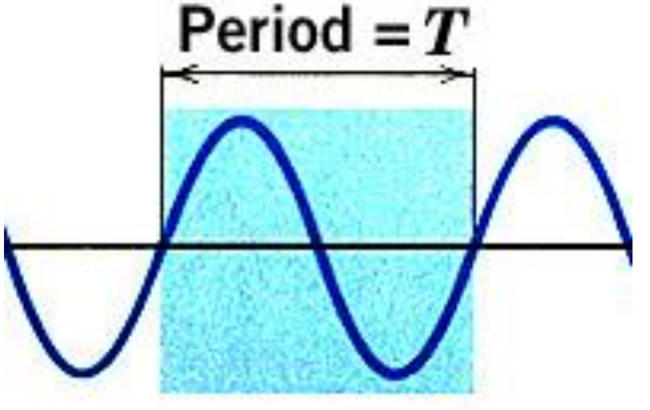


B. **Period**- time it takes to swing back and forth one time

$$T = 2\Pi\sqrt{\frac{L}{g}}$$

T = Period of pendulum
L = length of pendulum
g = acceleration due to gravity



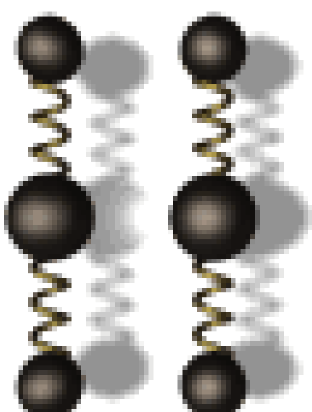


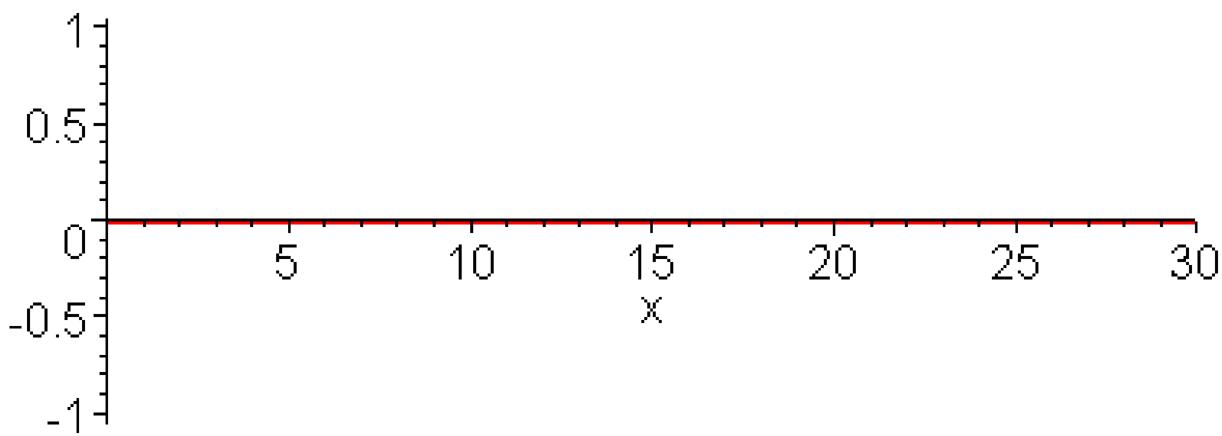
III. Wave Description (25.2)

A. **Simple harmonic motion**- often called **oscillatory motion**, is the back-and-forth vibratory motion of a swinging pendulum

1. Can be described by special curve (**sine curve**)

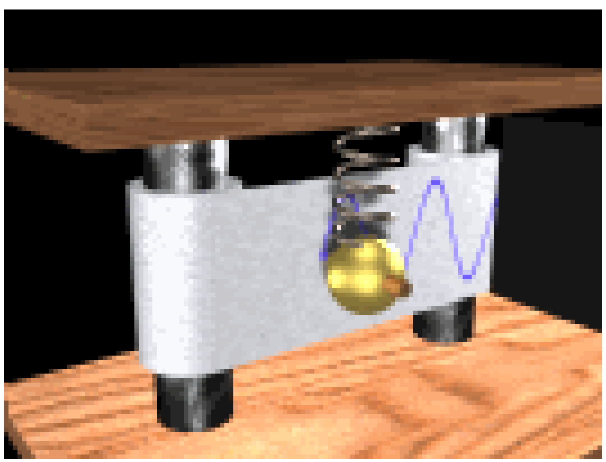
2. Sine curve is pictorial representation of a wave.

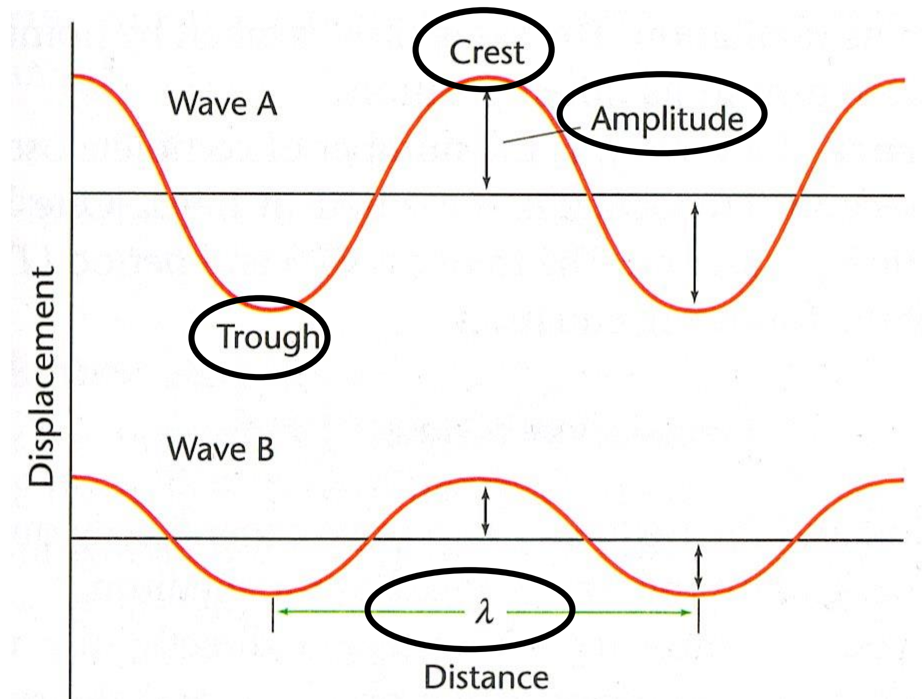




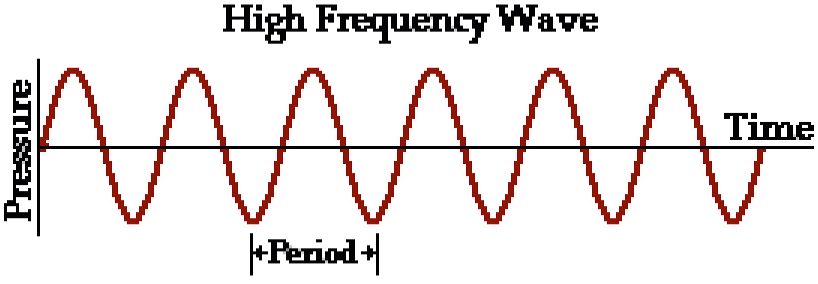
B. Wave terms

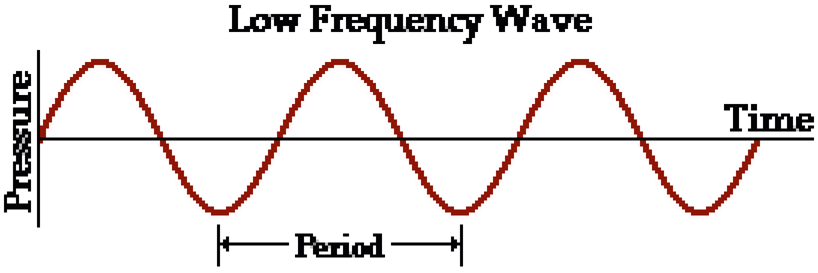
1. **Crests**- high points of wave
2. **Troughs**- low points of wave
3. **Amplitude**- distance from the midpoint to crest (or trough) of a wave.
4. **Wavelength**- distance from top of one crest to top of the next crest





5. **Frequency**- how often a vibration occurs (usually number/second. Measured in **Hertz** (cycles/second)



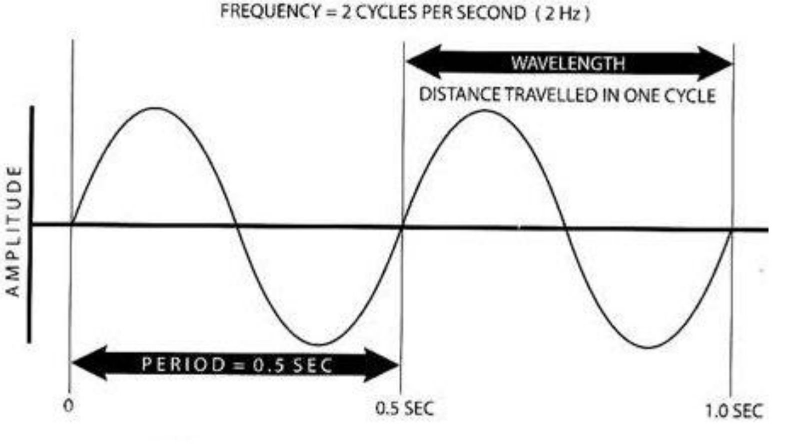


C. The <u>source</u> of all waves is a **vibrating object**

1. **Frequency** of vibrating object and frequency of wave it produces are the <u>same</u>
2. Can calculate the **period** of vibrating object if **frequency** is known (and vice versa)

$$frequency = \frac{1}{Period} \qquad f = \frac{1}{T}$$

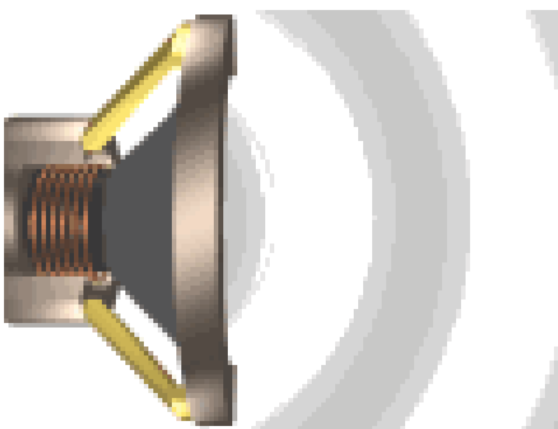
$$Period = \frac{1}{frequency} \qquad T = \frac{1}{f}$$

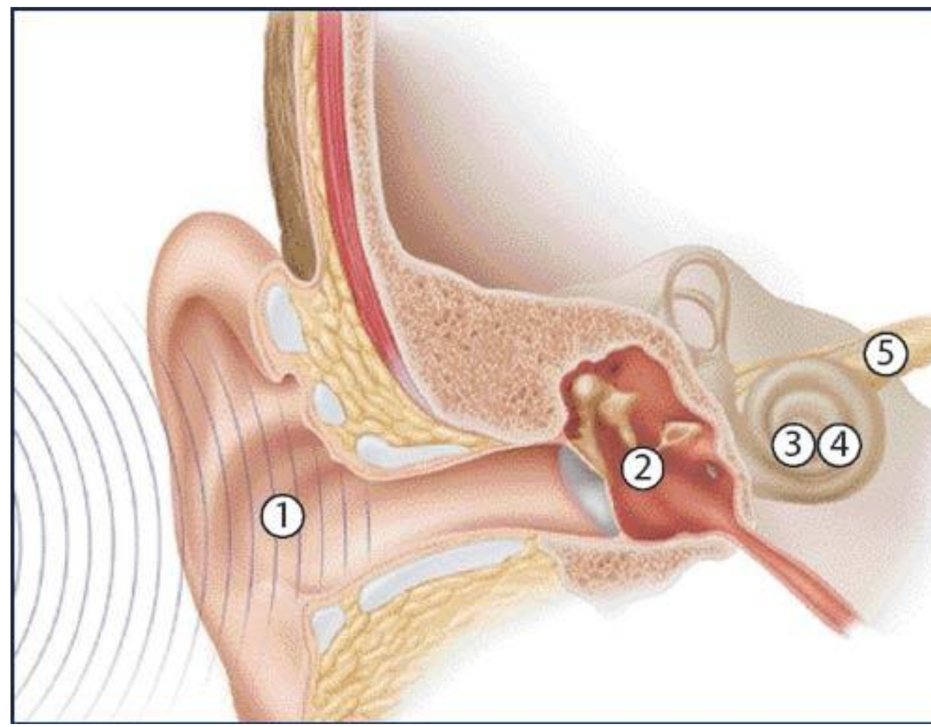


IV. Wave Motion (25.3)

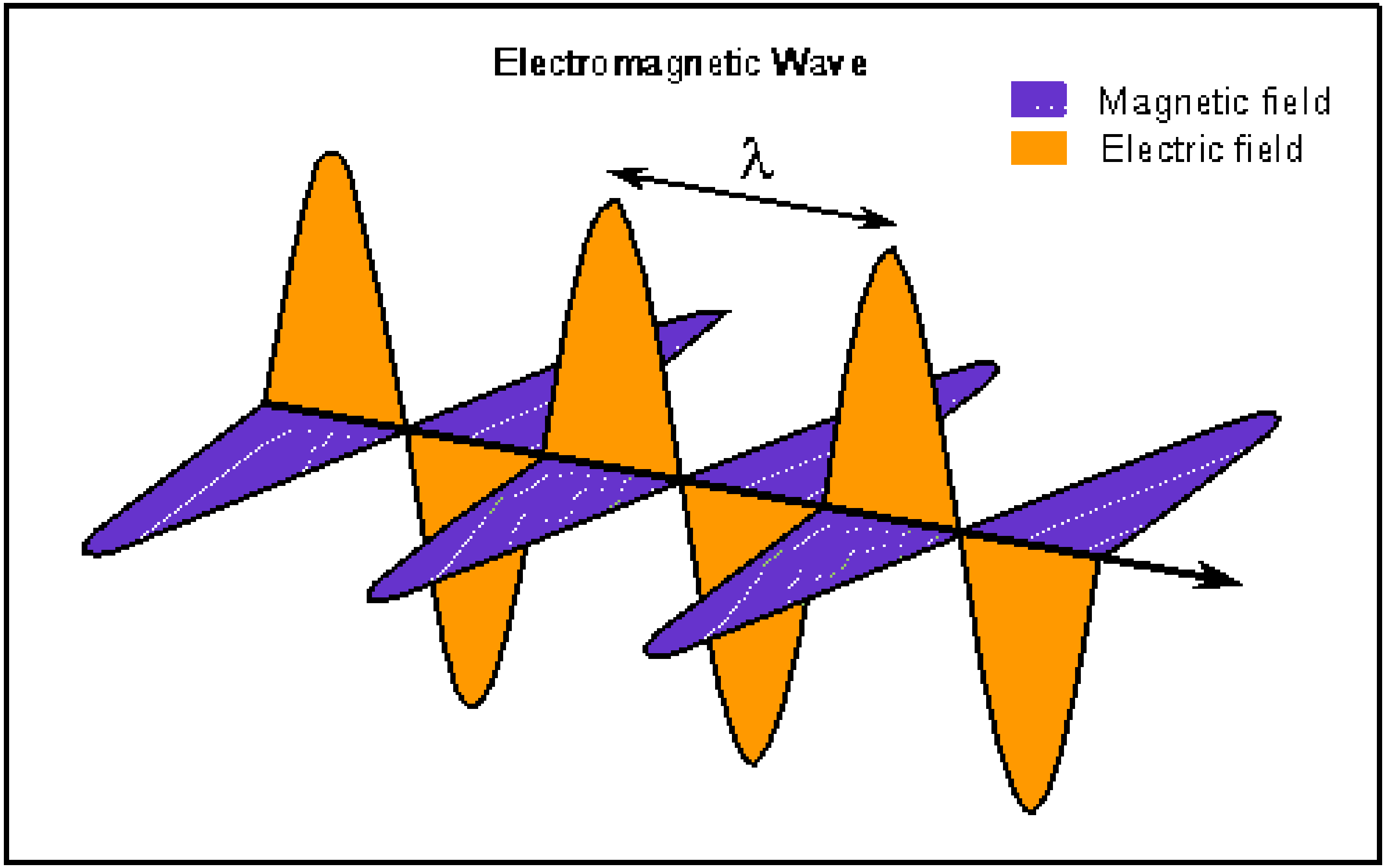
A. Most of the information around us gets to us in waves

1. **Sound** is energy that travels to our ears as a wave

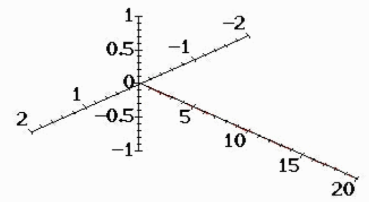


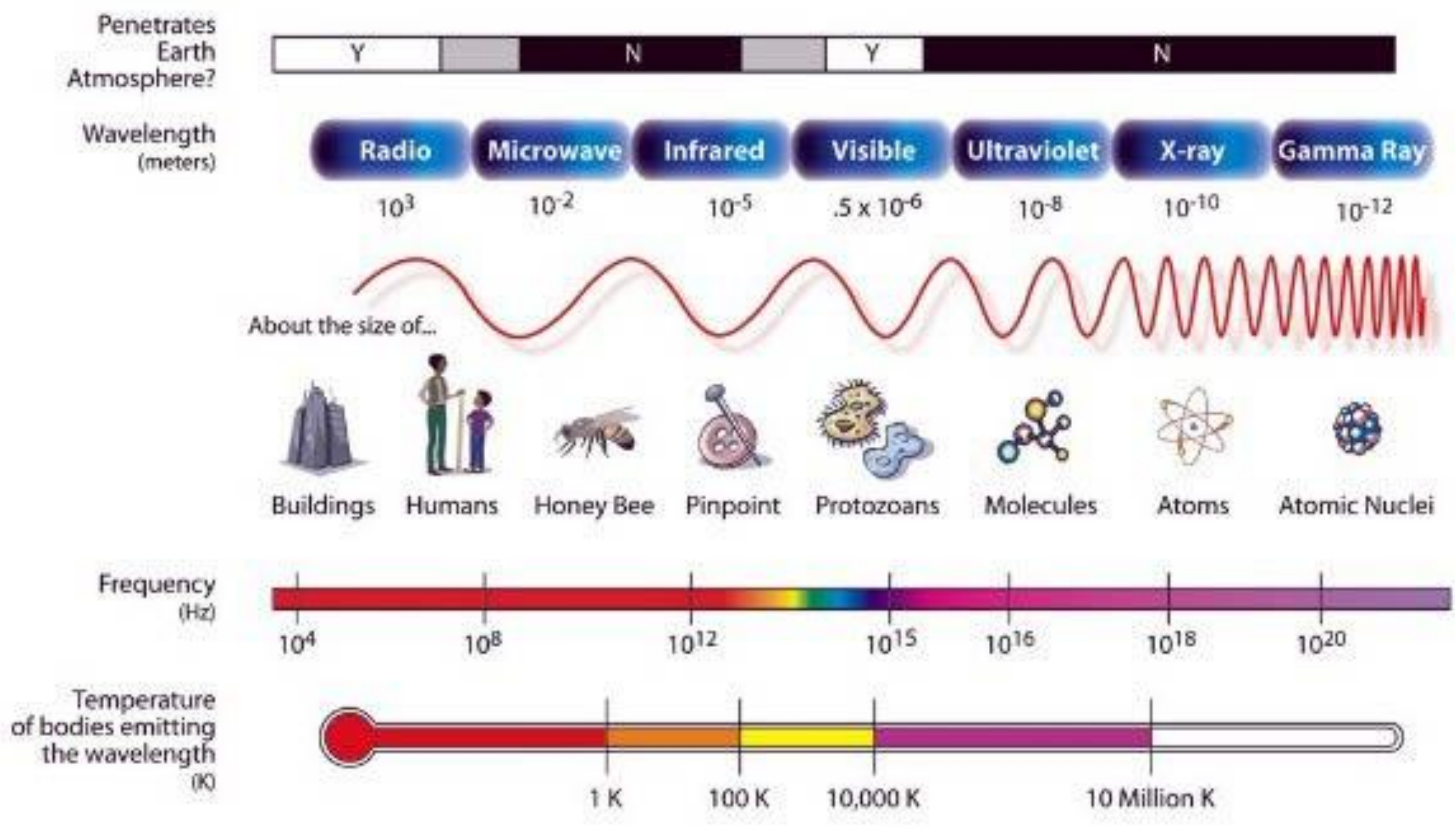


2. **Light** is energy that travels as electromagnetic waves

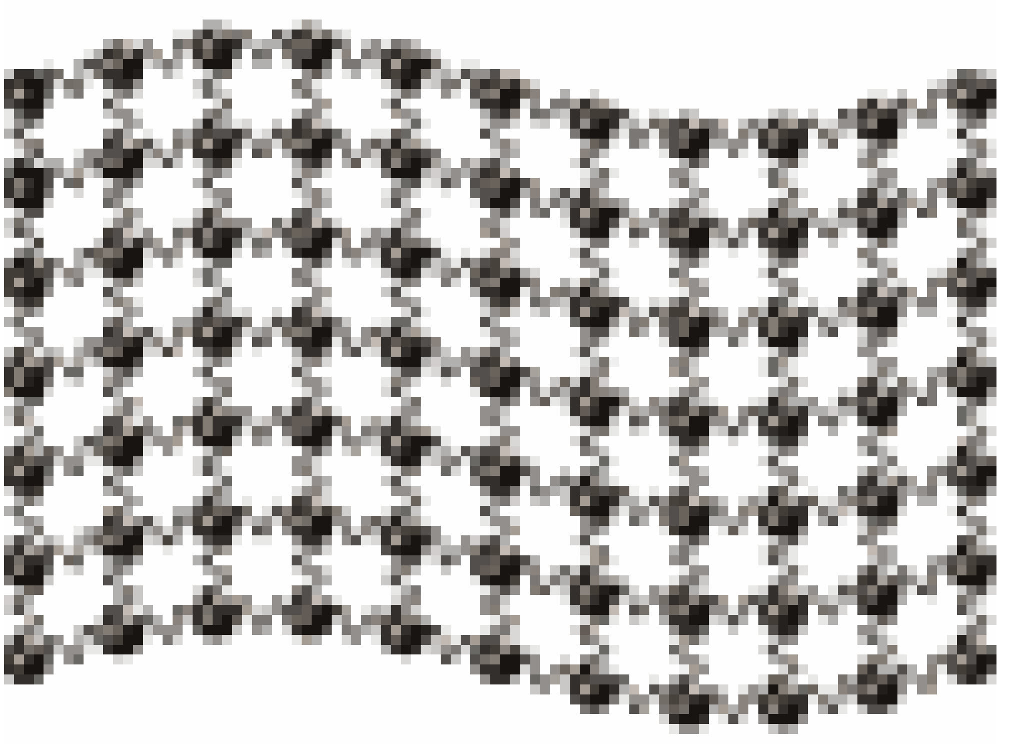


3. **Radio** and **television** travel in <u>electromagnetic waves</u>



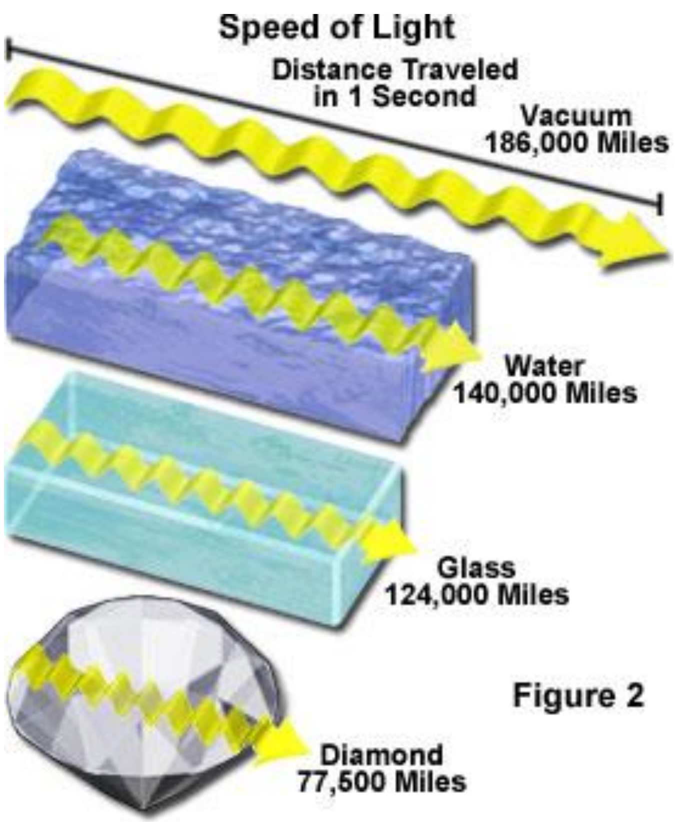


B. The **energy** transferred from a vibrating source is carried by a **disturbance** in a medium, not by the **matter** moving from one place to another within the medium



V. Wave Speed (25.4)

A. Speed of wave depends on medium it moves through



1. Whatever medium, **speed**, **wavelengths**, and **frequency** of wave are related.
2. Equation:

Wave speed = wavelength x frequency

$$v = \lambda f$$

V. Wave Speed (25.4)

A. Speed of wave depends on medium it moves through

1. Whatever medium, **speed**, **wavelengths**, and **frequency** of wave are related.

2. Equation:

$$v = \lambda f$$

Wave speed = wavelength x frequency

v = wave speed

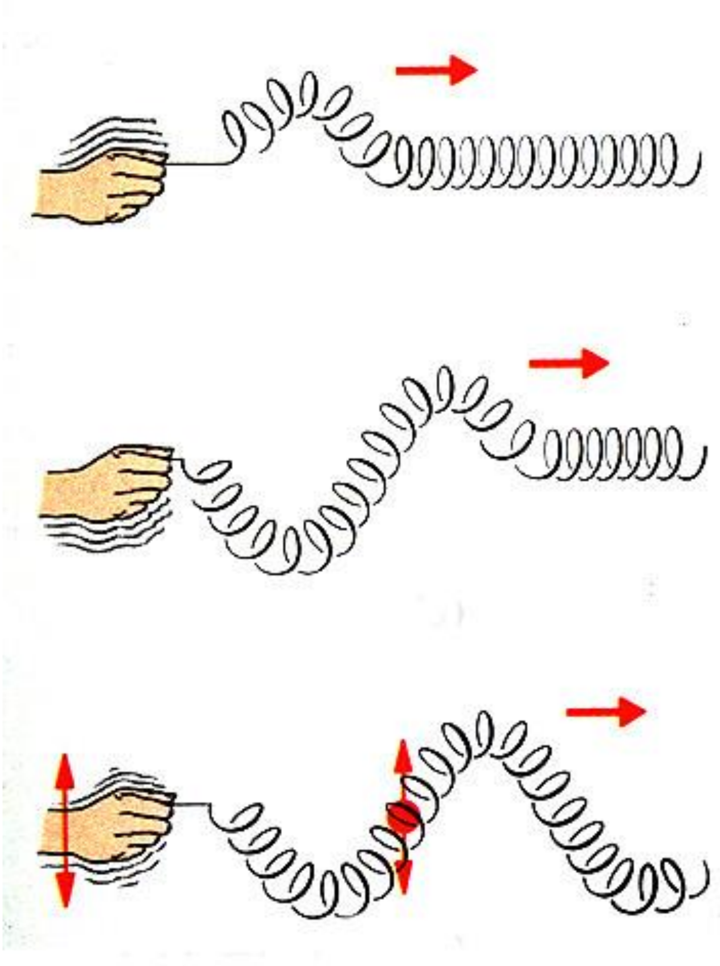
λ = wavelength (Greek letter lambda)

f = frequency

3. Wavelength and frequency vary inversely

VI. Transverse waves (25.5)

A. **Transverse wave**- motion of medium is at <u>right angles</u> to the direction in which the wave travels.

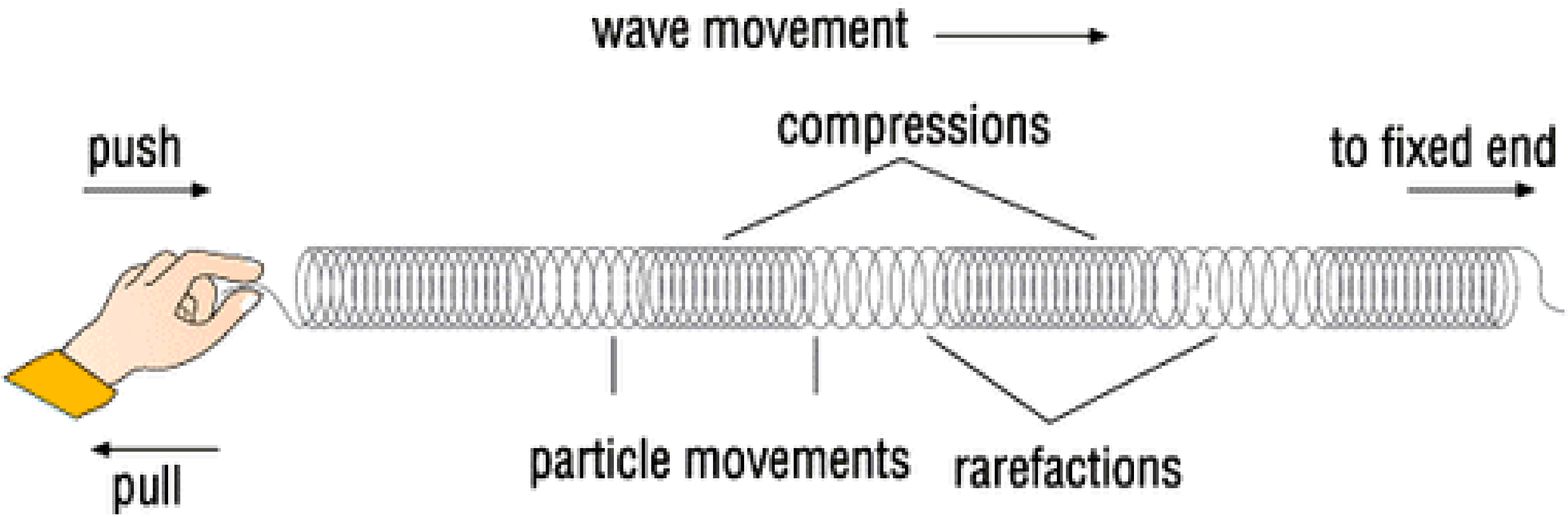


B. Examples: waves in strings of musical instruments, waves upon surface of liquids, electromagnetic waves (radio and light)

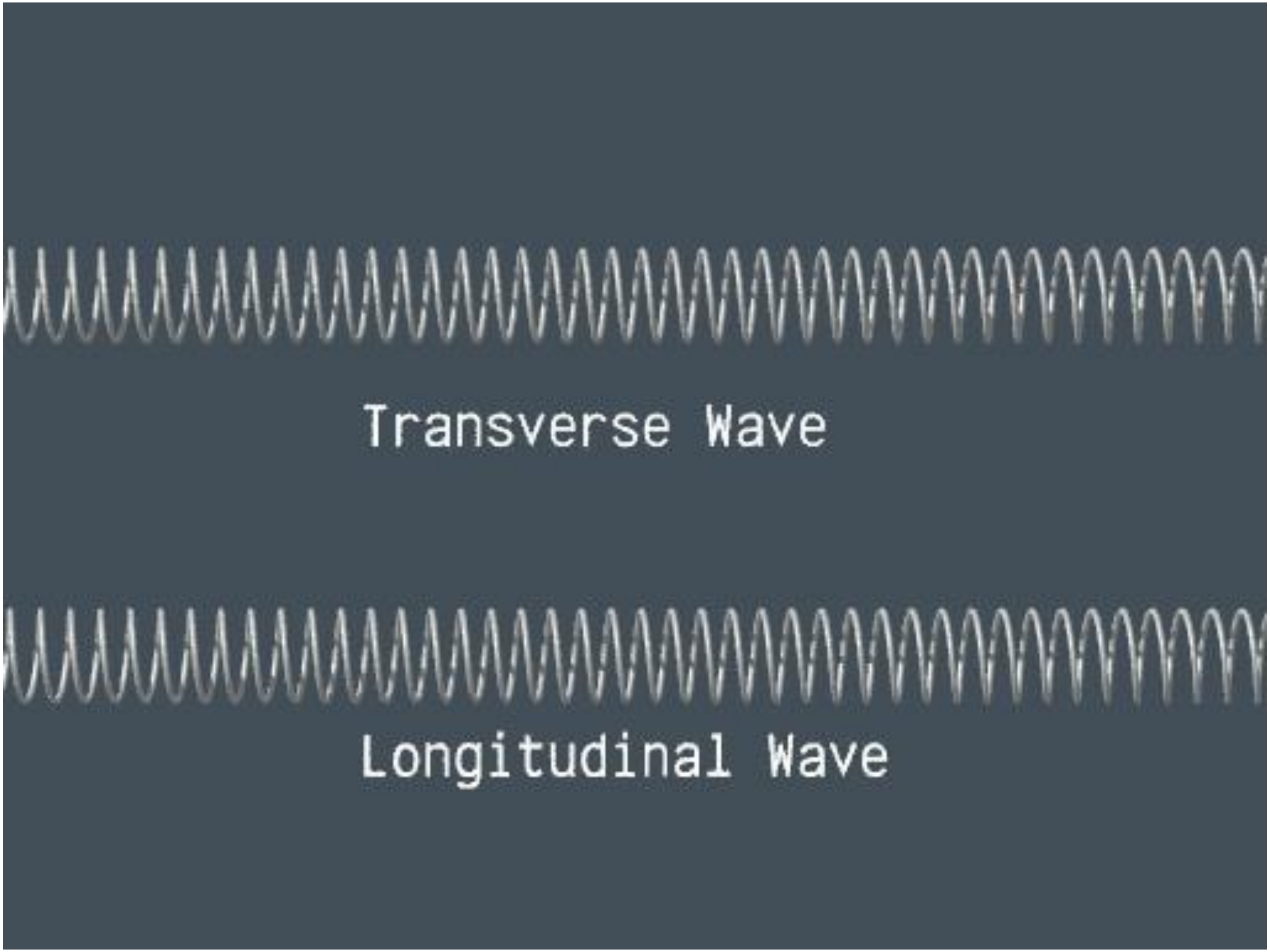
VII. Longitudinal waves (25.6)

A. **longitudinal waves**- particles move along the direction of the wave rather than at right angles to it.

B. both types of waves can be demonstrated with a slinky



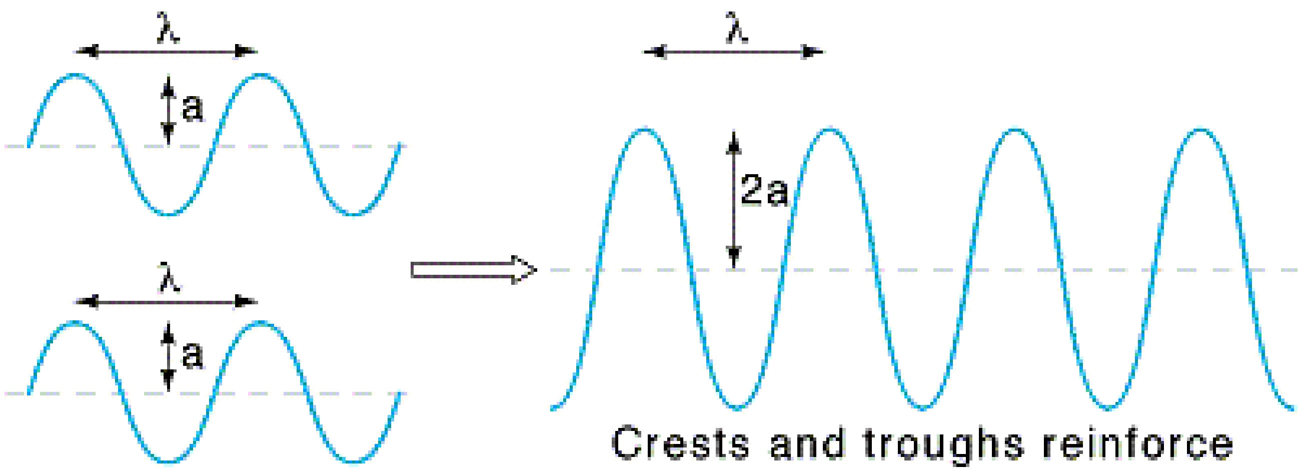
B. both types of waves can be demonstrated with a slinky



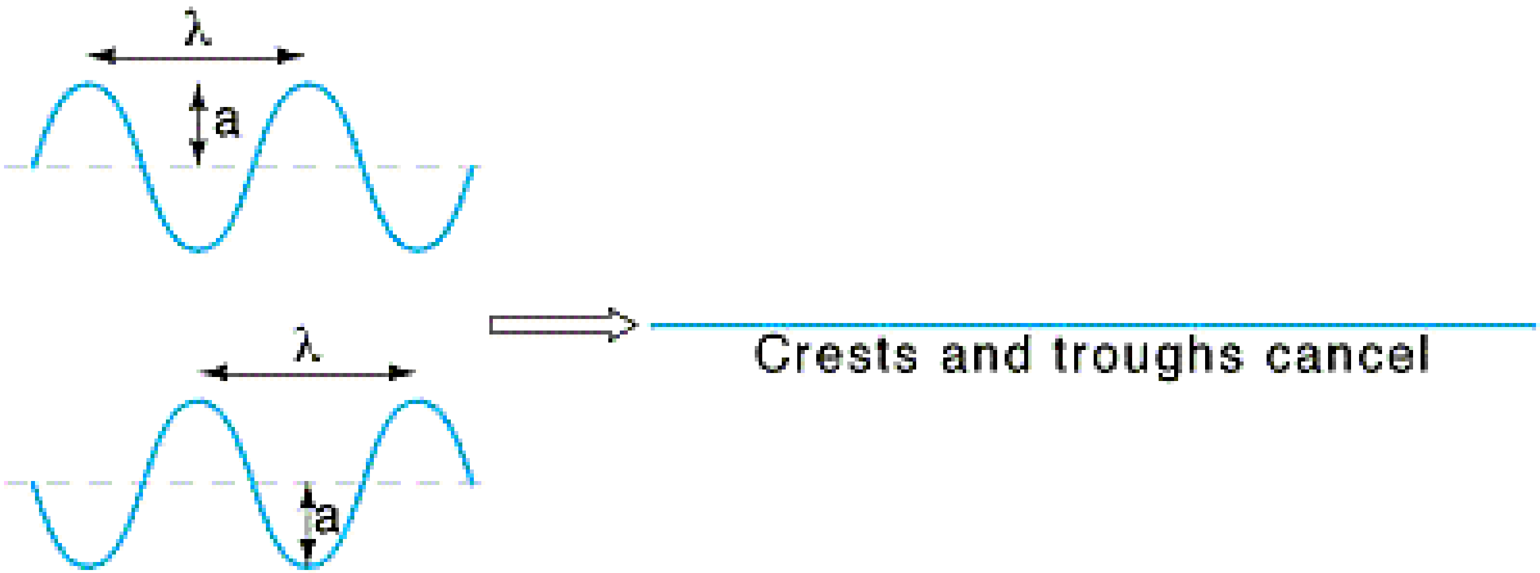
VIII. Interference (25.7)

A. **Wave interference**- when more than one vibration or wave exists at the same time in the same space- they effect each other (**increased, decreased, or neutralized**)

1. **Constructive interference**- when one crest of one wave overlaps the crest of another. Effects **add** together



2. **Destructive interference**- when crest of one wave and trough of another, individual effects are reduced.

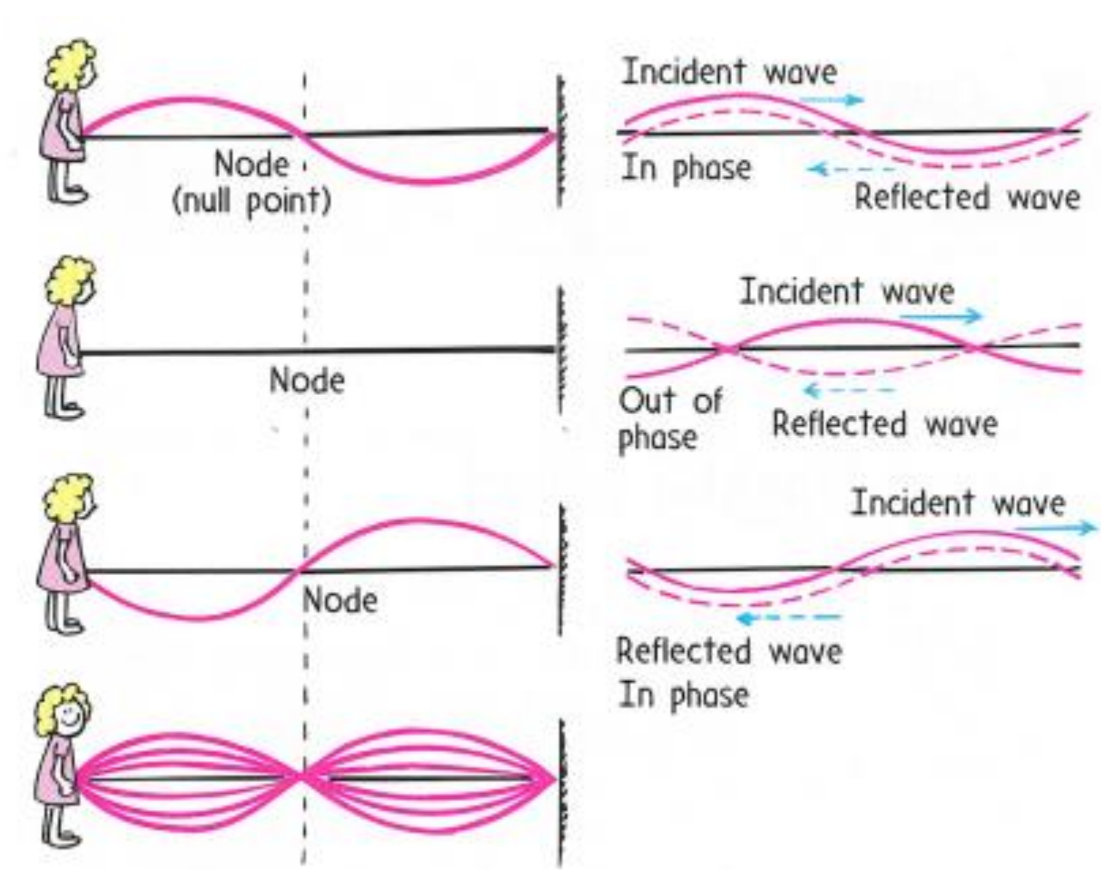


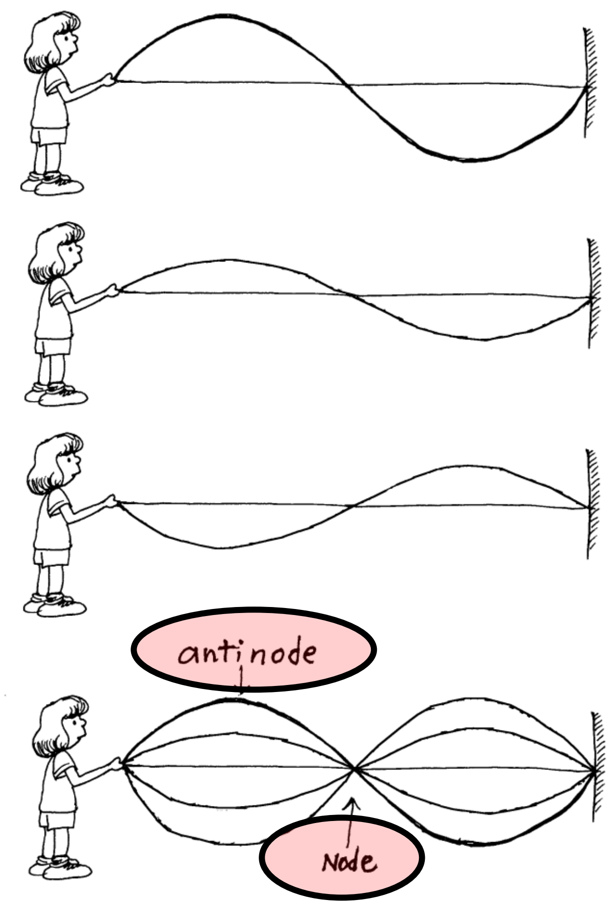
B. Interference is **characteristic** of all wave motion, whether they are water waves, sound waves, or light waves.

IX. Standing waves (25.8)

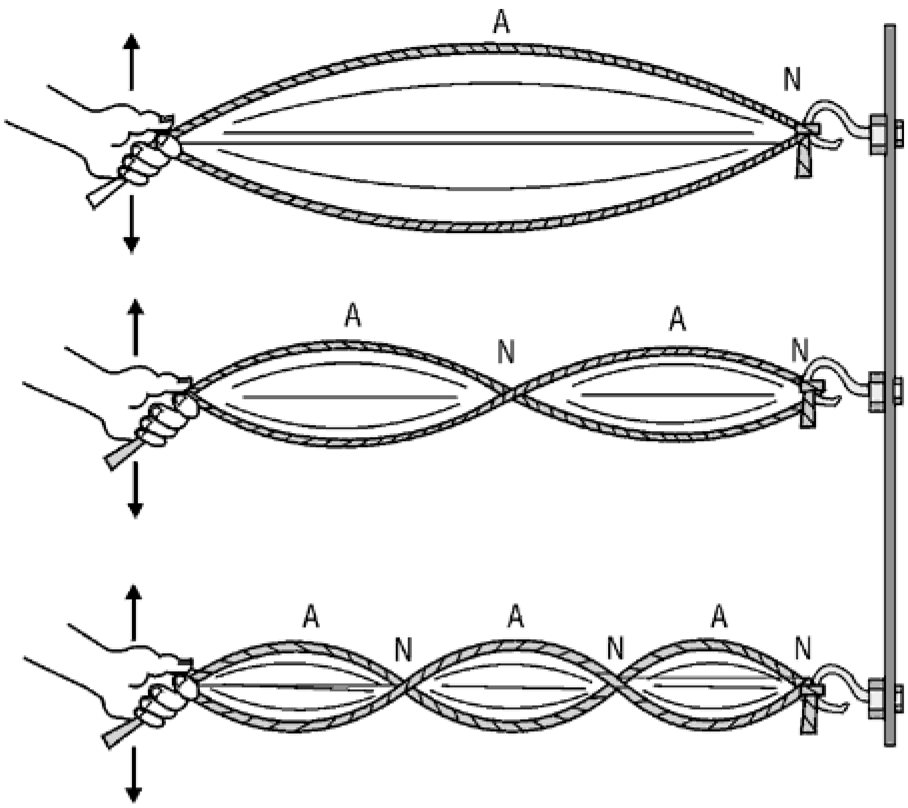
A. **standing waves** -certain parts of the wave, called **nodes**, remain stationary.

B. Standing waves are result of interference.

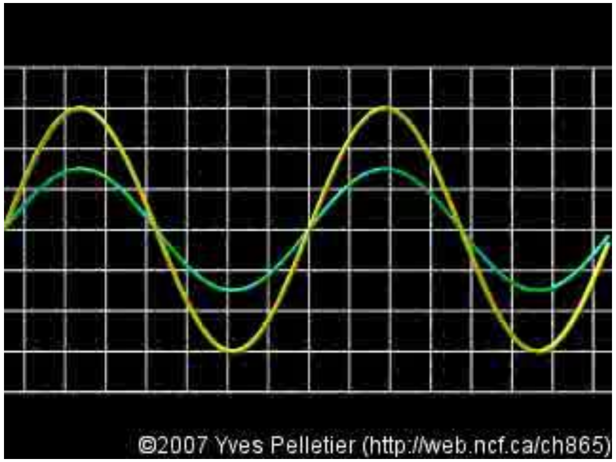




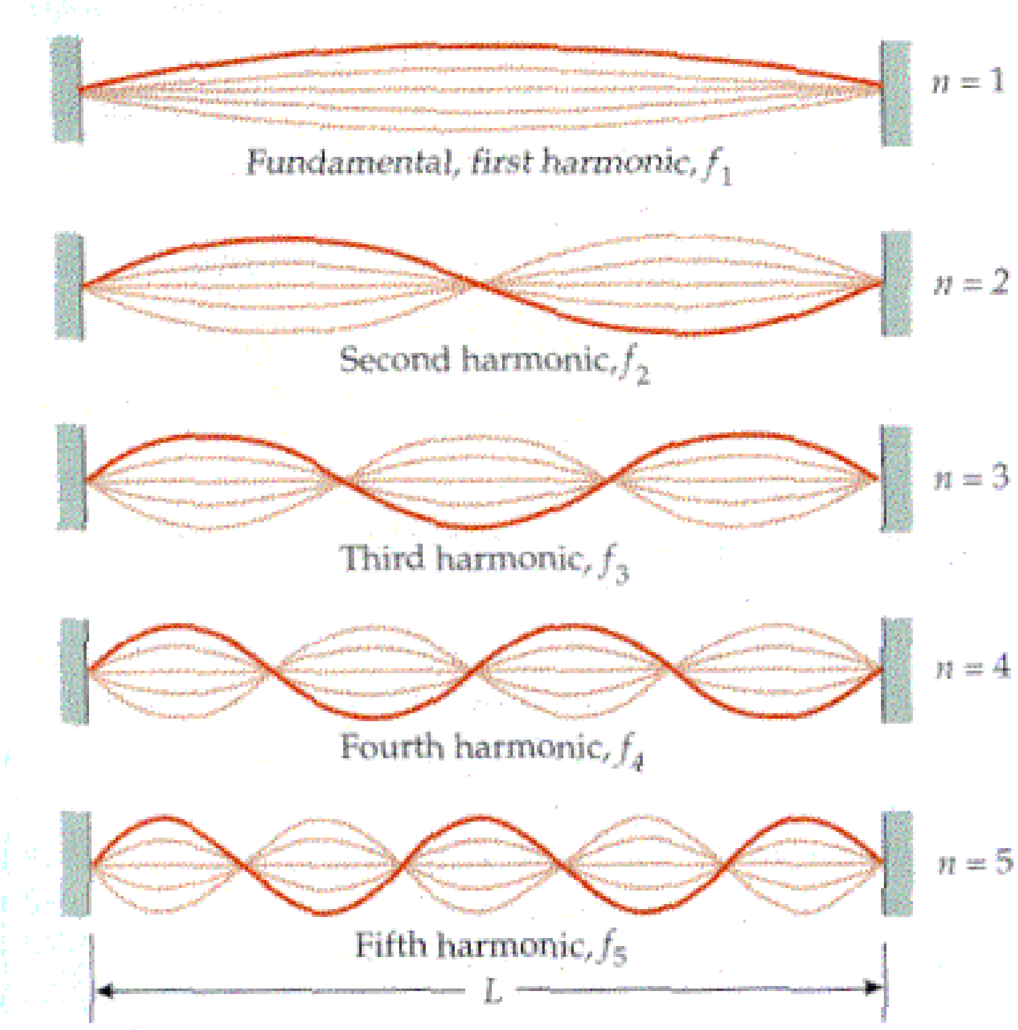
1. When two waves of <u>equal magnitude</u> and wavelength pass through each other in <u>opposite directions</u>, the waves are always **out of phase** at the nodes.



2. You can produce a variety of standing waves by shaking the rope at different frequencies.

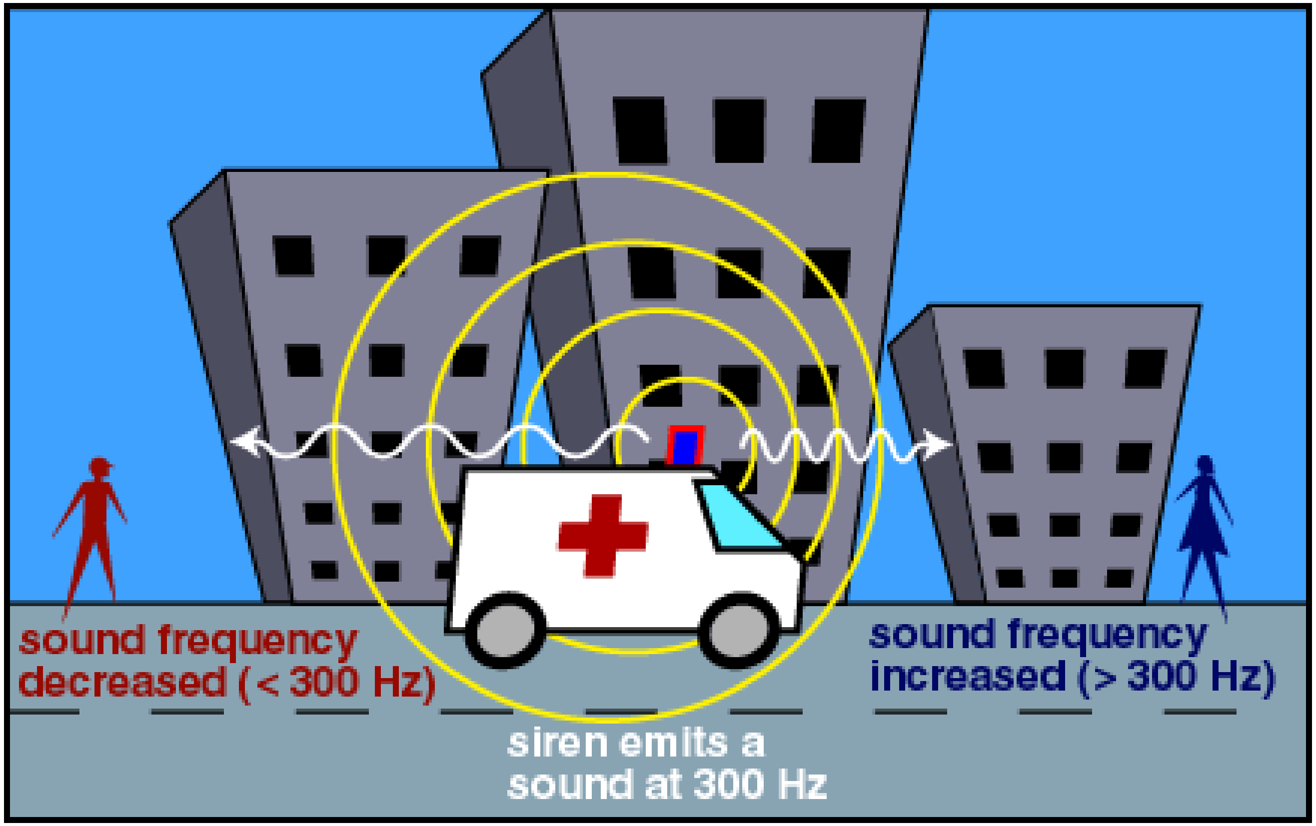


3. Standing waves are set up in the strings of musical instruments.



X. The Doppler Effect (25.9)

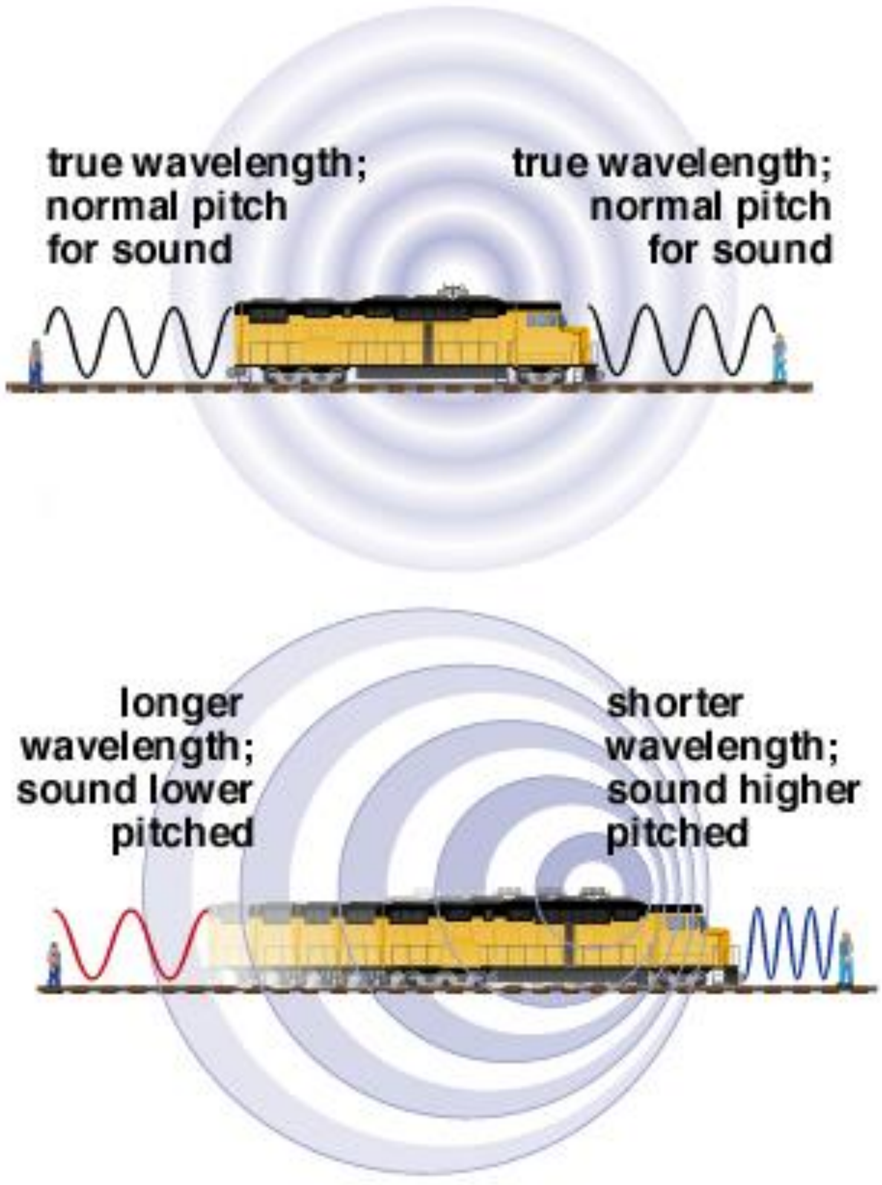
A. **Doppler effect**- the apparent change in frequency due to the motion of the source (or receiver)

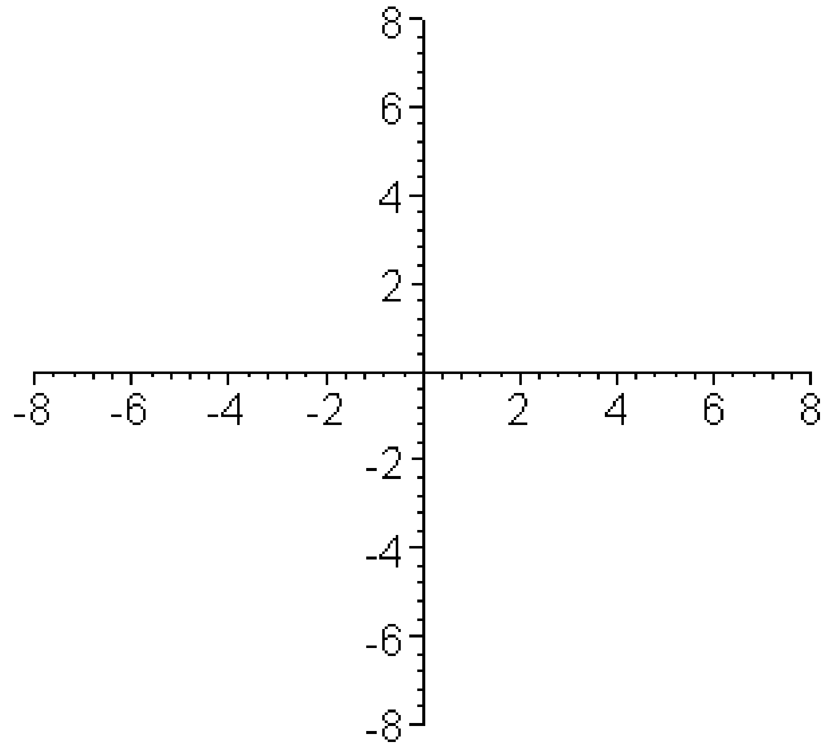


1. The **greater** the speed of the source, the **greater** will be the **Doppler effect**
2. when source is traveling **towards you** the waves <u>velocity</u> is **greater**, thus its <u>frequency</u> will be **greater**
3. When source is **traveling away** from you the <u>velocity</u> of the wave hitting your ear will be **less**, therefore the frequency will be smaller

$$v = \lambda f$$

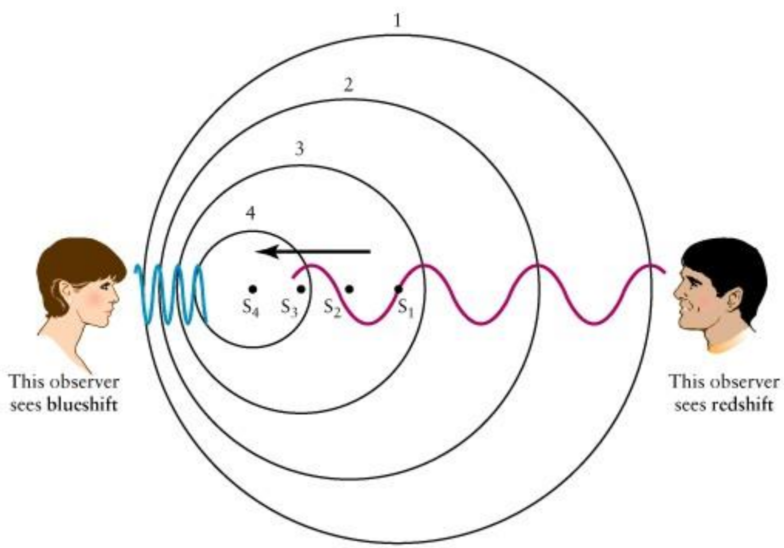
B. Doppler effect and sound-

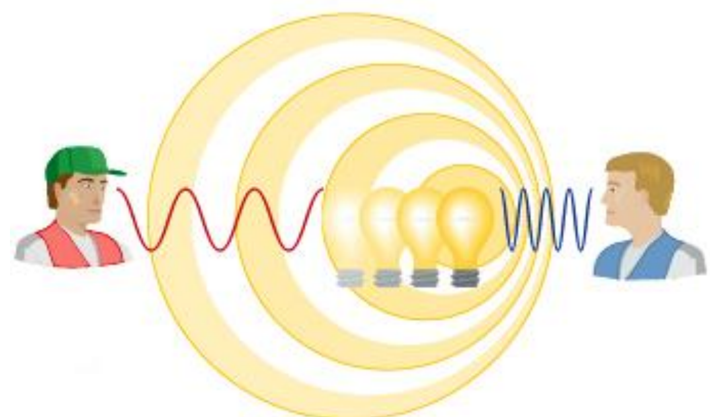




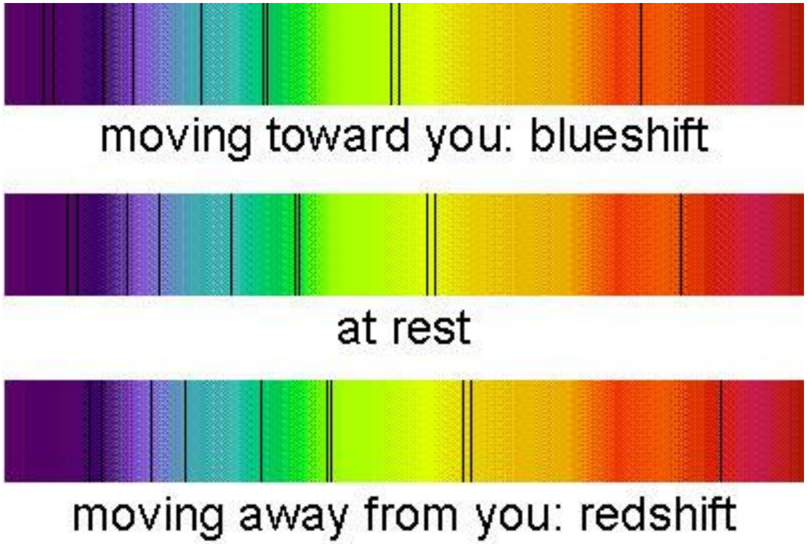
C. Doppler effect and light

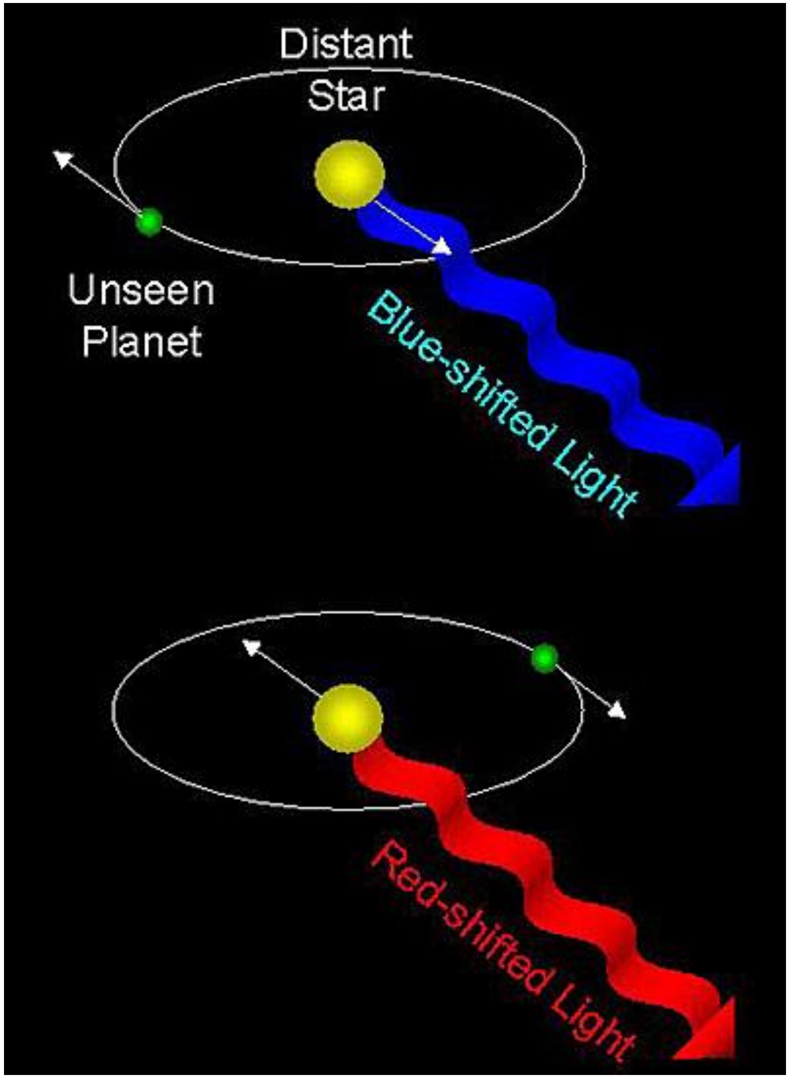
1. approaching light increases its measured frequency. An increase is called a **blue shift** (blue is toward high-frequency end of color spectrum
2. When it recedes, there is a decrease in frequency called **red-shift** (referring to the low-frequency, or red, end of the color spectrum





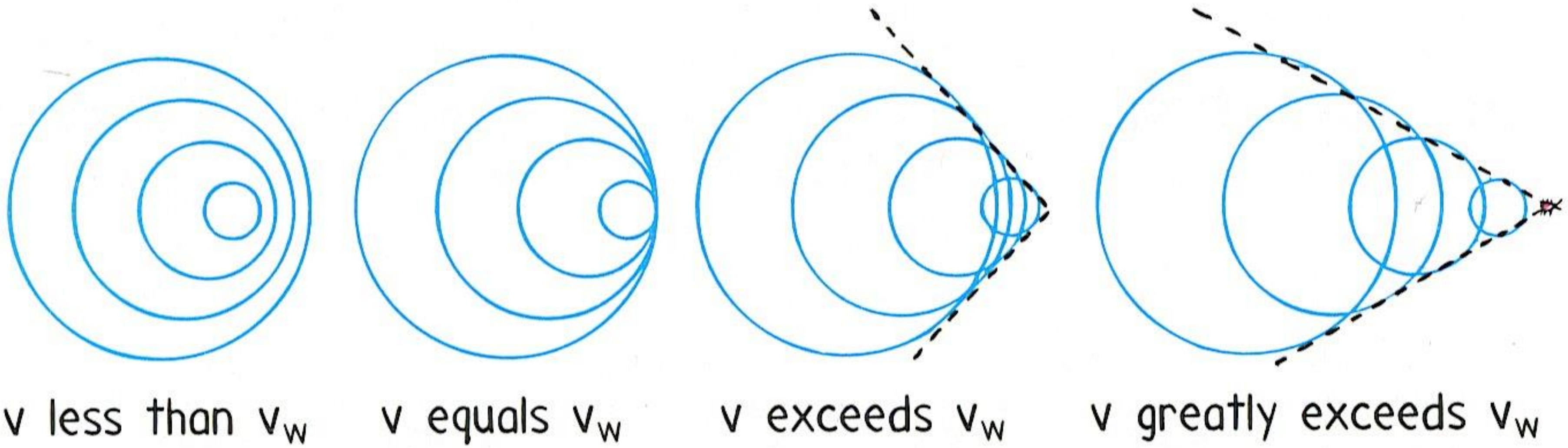
3. This is used to calculate star's spin rates and whether a star or galaxy is moving towards us or away.



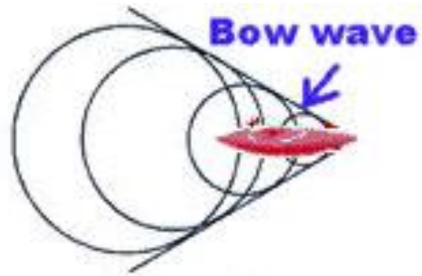


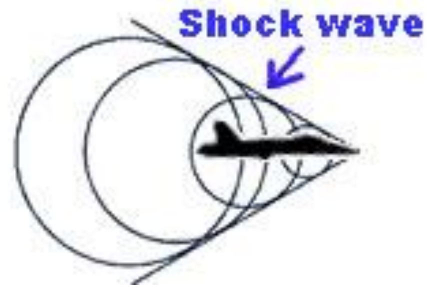
XI. Bow waves (25.10)

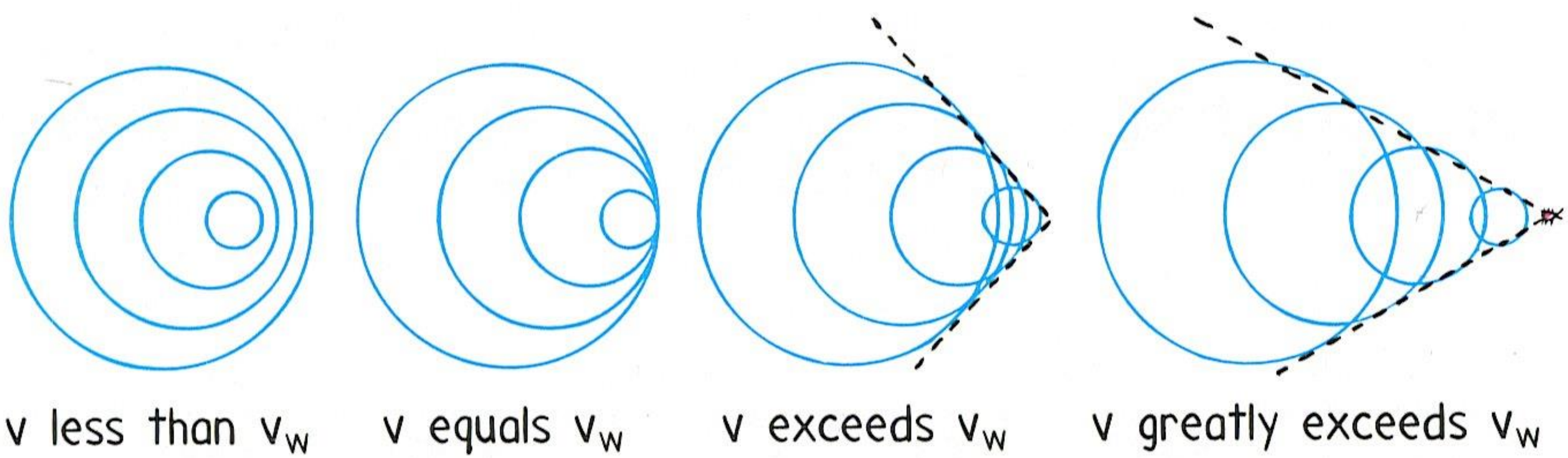
A. Sometimes the speed of source in medium is as great as the speed of the waves it produces and waves “pile up”



B. **Bow wave-** When wave source is greater than the wave speed. Produces a **V-shape**







XII. Shock Wave- a three dimensional bow wave.

Can produce a sonic boom (compressed air that sweeps behind a supersonic aircraft