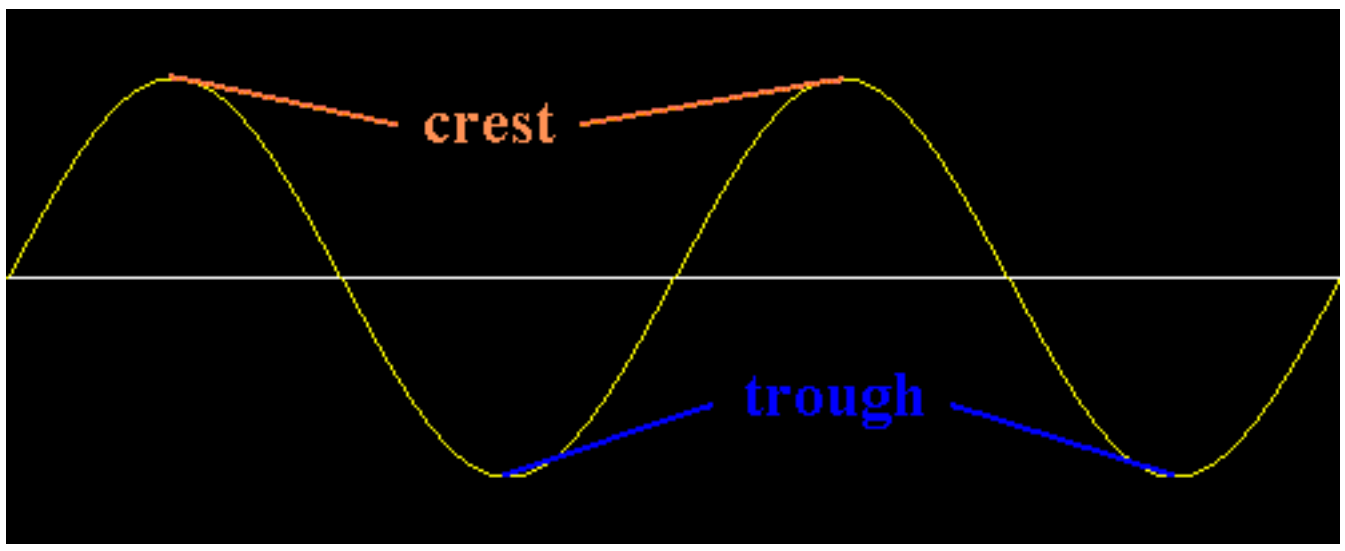
Chapter 13

Oscillations and waves

A pulse is a single travelling disturbance.

A wave is periodic disturbances

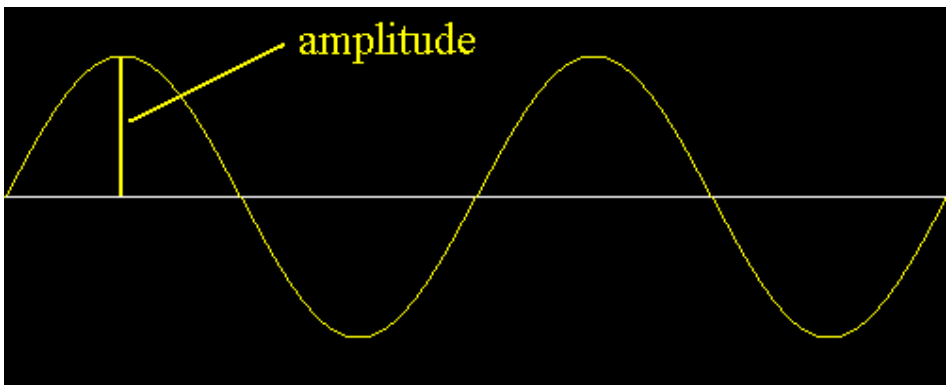


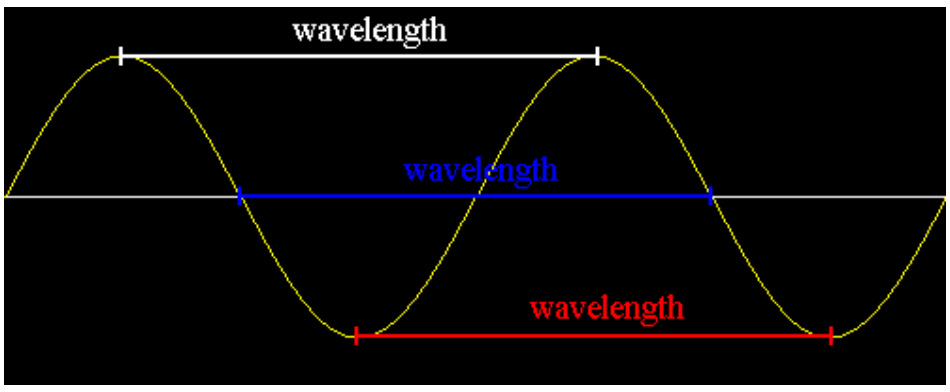
Let’s take a look at waves in a ripple tank.

https://www.falstad.com/ripple/

Revised 1.27.2022 Some diagrams from Pearson Physics by Walker. Used with permission

Wave parameters:
(λ) Wavelength – the distance between two consecutive points which are in phase
(f) Frequency – the number of cycles leaving the source each second
Amplitude – the maximum displacement of the wave from its rest position
(T) Period – the amount of time required to generate one cycle





Simple Harmonic Motion
The restoring force is proportional to the displacement from the equilibrium position.

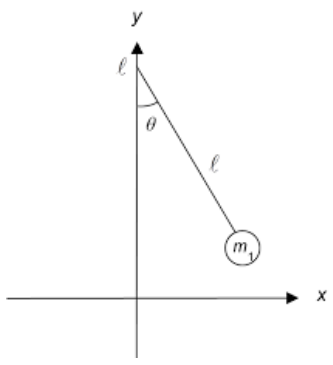
Examples:

Spring/Mass Combination
https://www.walter-fendt.de/html5/phen/springpendulum_en.htm

Simple Pendulum
https://www.walter-fendt.de/html5/phen/pendulum_en.htm

Periodic motion is motion that repeats regularly. An example of periodic motion is the simple pendulum.

http://www.ionaphysics.org/lab/Pend%20ALT%20Approach/TenSecOneSwing.html



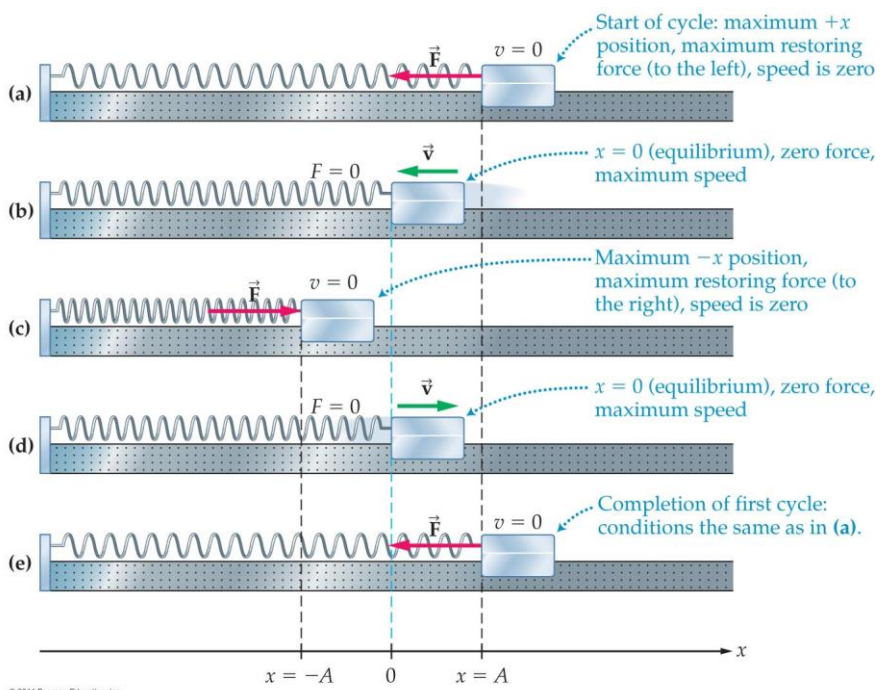
T = period
L = Length
g = Acceleration due to gravity

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

Definition:
Period: The amount of time it takes for 1 complete cycle

http://en.wikipedia.org/wiki/Simple_harmonic_motion

For a Mass/Spring



$$T = 2\pi\sqrt{\frac{m}{k}}$$

T = period
m = mass
k = spring constant

Here is a link you can play with

https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html

Resonance:
Large amplitude of motion when a system is driven at its natural frequency.

Tacoma Narrows Bridge Video (Copy the link and paste it into your browser)

https://www.youtube.com/watch?v=j-zczJXSxnw

https://www.youtube.com/watch?feature=player_detailpage&v=j-zczJXSxnw

A pulse is a single traveling disturbance
A wave is periodic traveling disturbances

Direction of propagation:
the direction the wave is moving.

Transverse wave:
The medium moves perpendicular to the direction of propagation of the wave.
Examples: The entire electromagnetic spectrum (Light, Radio, Radar, TV, Microwaves, Infrared, Ultraviolet, X-rays, etc)
Here is an animation
If that does not work, copy/paste this URL
http://physics.bu.edu/~duffy/HTML5/wave.html

Longitudinal wave:
The medium moves parallel to the direction of propagation of the wave.
Example: Sound
Here is an animation
If that does not work, copy/paste this URL.
http://physics.bu.edu/~duffy/HTML5/longitudinal_wave.html

You can compare the two with this link
If that does not work, copy/paste this URL.
http://physics.bu.edu/~duffy/semester1/c20_trans_long.html

Wave Parameters:

Wavelength λ
Amplitude A
Frequency f
Period T

Frequency is the number of cycles completed each second. It is measured in cy/sec or Hertz (Hz)

Prefixes:
kilo
mega

Table 13.1 Common Periods and Frequencies

System	Period (s)	Frequency (Hz)
Hour hand of a clock	43,200 (1 cycle per 12 hours)	2.3×10^{-5}
Minute hand of a clock	3600 (1 cycle per hour)	2.8×10^{-4}
Second hand of a clock	60 (1 cycle per minute)	0.017
Pendulum in a grandfather clock	2.0	0.50
Human heartbeat	1.0	1.0
Sound at lower range of human hearing	5.0×10^{-2}	20
Wing beat of a housefly	5.0×10^{-3}	200
Sound at upper range of human hearing	5.0×10^{-5}	20,000
Computer processor	3.1×10^{-10}	3.2×10^{9}

Period = 1/frequency
frequency = 1/period

Vocabulary review:
Amplitude
Frequency
Hertz
Longitudinal Wave
Period
Periodic Motion
Pulse
Resonance
Transverse Wave
Wave
Wavelength

Important Reminders:

Period = 1/frequency

$$T = 1/f$$

Frequency = 1/period

$$f = 1/T$$

Questions:
1. If the frequency is doubled, what happens to the period?
2. Suppose a tennis ball is hit back and forth between two players. If it takes 2.3 seconds for the ball to go from one player to the other, what are the period and frequency of the ball's motion?

Wave speed
(how fast it moves from the source to the observer.)
v= distance/time
v= wavelength/period
period = 1/frequency

$v=f\lambda$

The speed of the wave depends upon the material in which the wave is moving. (The material in which the wave is moving is called the medium.)

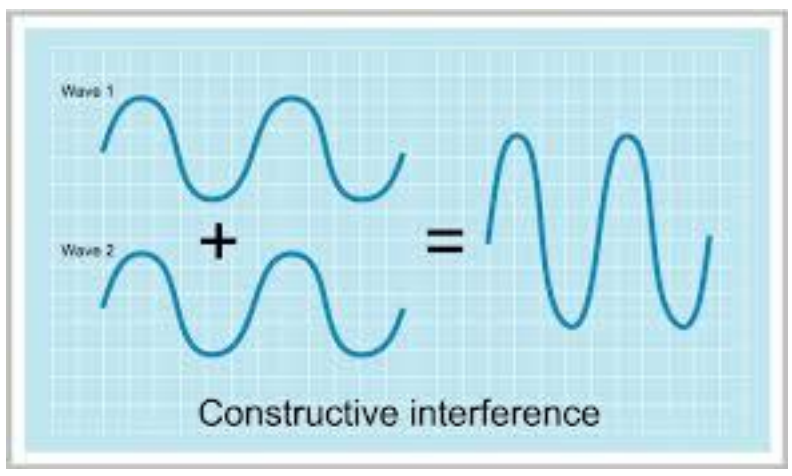
This appears on your radio. What are the frequency and period of the broadcasting station?

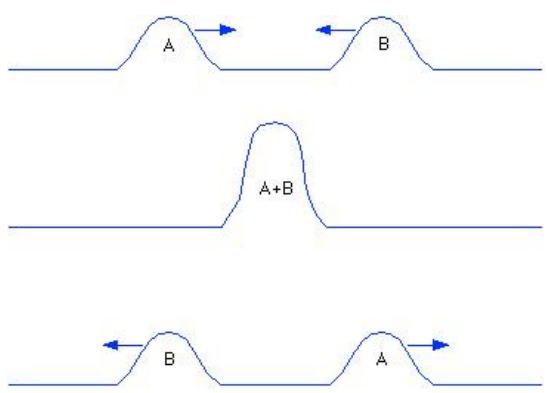
Vocabulary review:
Amplitude
Frequency
Hertz
Longitudinal Wave
Mediuim
Period
Periodic Motion
Pulse
Resonance
Transverse Wave
Wave
Wavelength

Superposition and interference - when two [SEP]or more waves pass through the same [SEP]space they simply add up (as vectors).

That means that they may reinforce each [SEP]other or cancel each other.

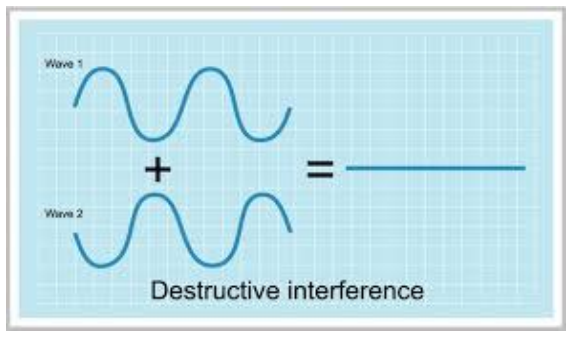
Constructive Interference:
The waves meet in phase (in step) and combine to form a wave with increased amplitude.

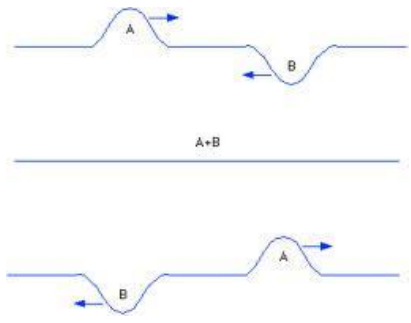




http://physics.bu.edu/~duffy/HTML5/interference.html

Destructive interference - when two waves meet out of phase (out of step) with each other and combine to form a wave of decreased amplitude.





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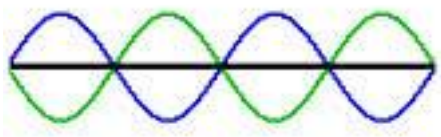

Standing waves:
A wave is reflected back on itself.
-nodes (minimum motion)
-antinodes (maximum motion)

Sound travels at about 340 m/s.
Light travels at 3.00 x10^8 m/s.

1. What is the wavelength of the wave transmitted by radio station 1010 WINS ? (f=1010 k Hz)

2. What is the wavelength of the musical note called concert A (frequency = 440 Hz)?

Vocabulary review:
Amplitude
Constructive Interference
Destrictove Interference
Frequency
Hertz
Interference
Longitudinal Wave
Mediuim
Period
Periodic Motion
Pulse
Resonance
Standing Wave
Superposition
Transverse Wave
Wave
Wavelength

3. What is the frequency of red light which has a wavelength of 6.00x10^-9 meters?

Sound travels at about 340 m/s.
Light travels at 3.00 x10^8 m/s.

4. How long does it take lightning to travel 1 mile (1 mile = 1609 meters)?

5. How long does it take thunder to travel 1 mile?

Important Formulae in this chapter

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

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 1/f$$

$$v = f\,\lambda$$

Problems: (Page 486)

60. A person in a rocking chair completes 12 cycles in 21 seconds. What is the period and the frequency of the motion?

63. If you dribble a basketball with a frequency of 1.8 Hz, (A) how long does it take for you to complete 12 dribbles? (B) How long does it take for the ball to go from the floor to your hand?

64. If you take your pulse and observe 74 heartbeats in a minute, what are the period and frequency of the heartbeat?

66. Suppose a 0.46 kilogram mass is attached to a spring and undergoes simple harmonic motion with a period of 0.77 s. (A) What is the frequency of the motion? (B) What is the spring constant of the spring?

69. A pendulum swings back and forth. How many times does it pass through the equilibrium position during one complete cycle of its motion, assuming the cycle begins when the pendulum is at maximum displacement from equilibrium?

87. You dip your finger into the water of a pond twice a second. The waves you produce have crests that are separated by 0.18 m. Determine the frequency, period, and speed of the waves.

ANSWERS to the mathematical problems:
P 19 #1 = 297 m; #2 = 0.77 m
P 20 # 23 = 5 x10^16 Hz
P. 22 #4 5.36 x10^-6 sec #5 =4.7 sec
P 23
#60 T= 1.75 sec; f=0.57 Hz
#63 T=0.55 sec; Time for 12 = 7.7 sec; time to floor = 0.275 sec
#64 1.2 Hz; 0.81 sec
#66 A=1.29 Hz B=OMIT
#69 TWICE
#87 f = 2 Hz; wavelength = 0.18 m; v = 0.36 m/s