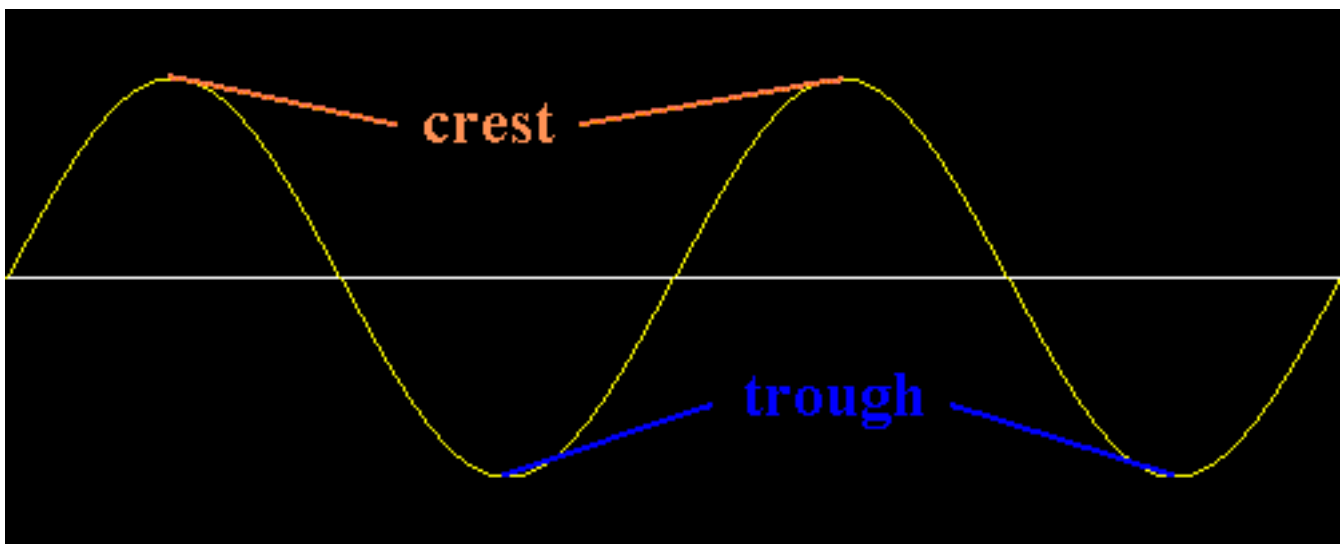
Chapter 13

Vibrations and waves

A wave is a travelling disturbance



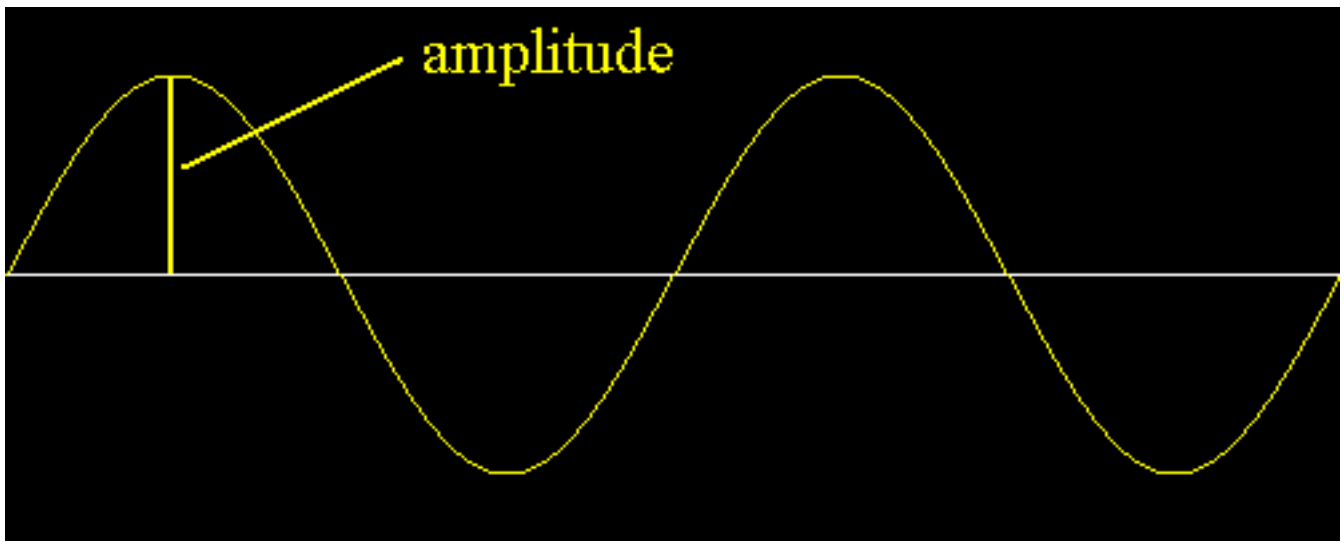
Wave parameters:

(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 height of the wave above its rest position

(T) Period – the amount of time required to generate one cycle


amplitude

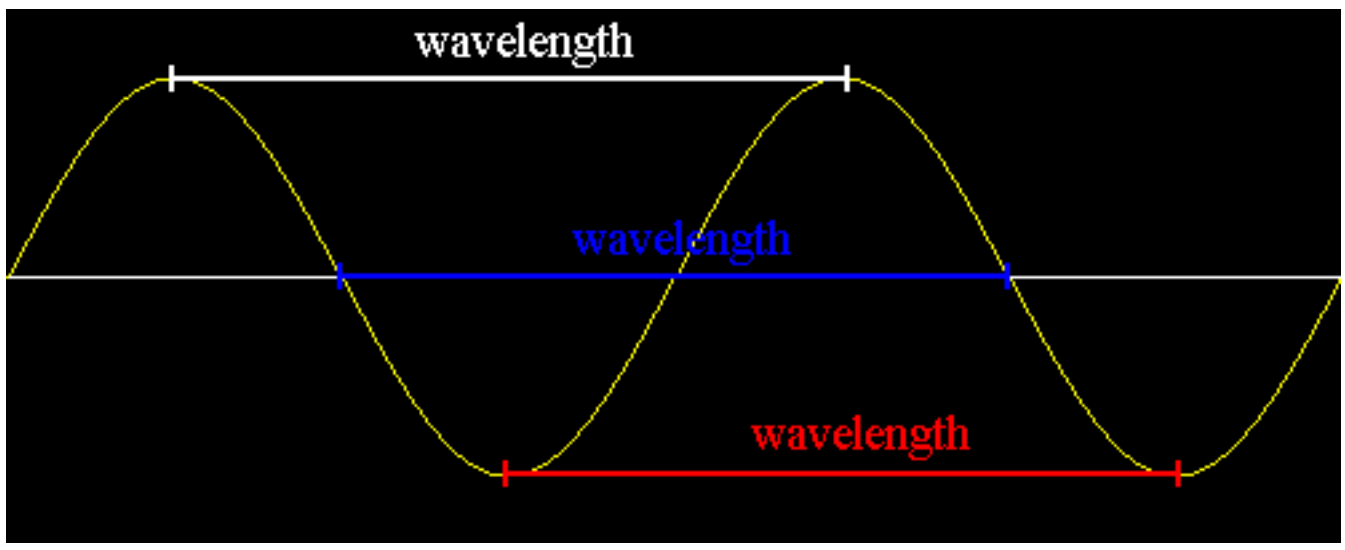

wavelength
wavelength
wavelength

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

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

https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html

$$T = 2\pi \sqrt{(L/g)}$$

T = Period
L = length
g= accel. of gravity

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

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

http://en.wikipedia.org/wikiSimple_harmonic_motion

Another periodic motion is a mass on a spring

For a mass on a spring

T = period
m = mass
k = spring constant

$T=2\pi$ √(m/k)

https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_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.

Longitudinal wave:
The medium moves parallel to the direction of propagation of the wave.

The following video demonstrates both longitudinal and transverse mechanical waves

https://www.youtube.com/watch?v=7cDAYFTXq3E

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 and possibly other variables, like the temperature. (The material in which the wave is moving is called the
medium.)

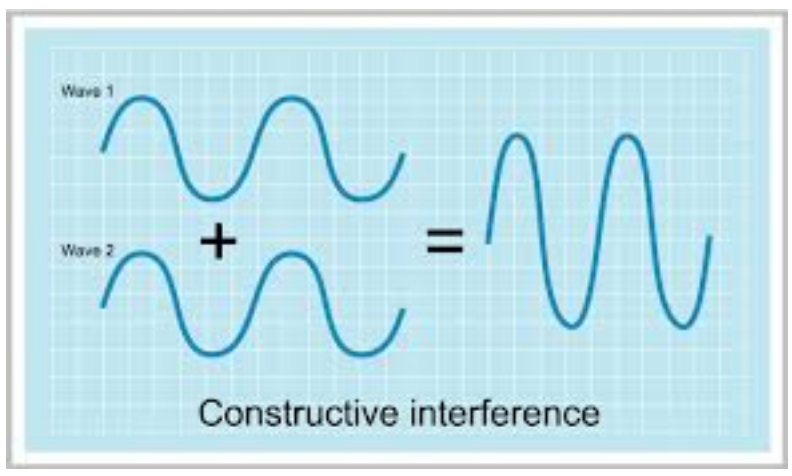
This appears on your radio. What are the frequency and period of the broadcasting station?

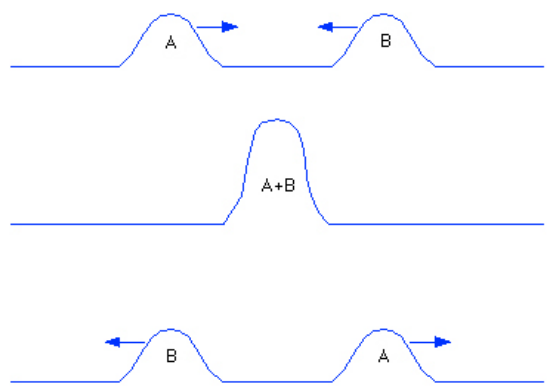
Vocabulary review:
Amplitude
Frequency
Hertz
Longitudinal Wave
Medium
Period
Periodic Motion
Pulse
Resonance
Transverse Wave
Wave
Wavelength

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

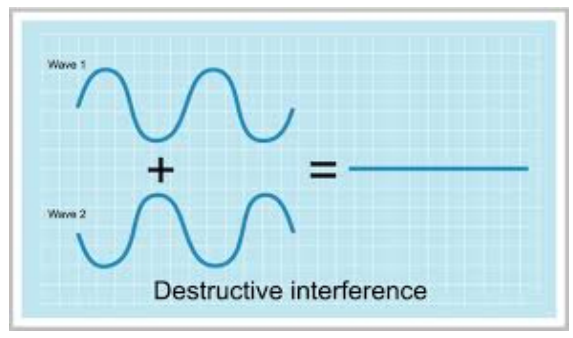
That means that they may reinforce each other or cancel each other.

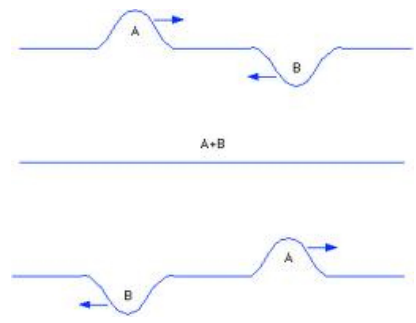
Constructive Interference:
The waves meet in phase (in step) and combine to form a wave with increased amplitude.

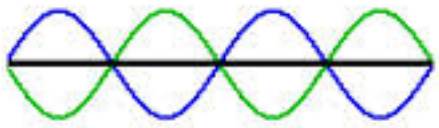




Destructive interference - when two waves meet out of phase (out of step) with each other and combine to form a wave of decreased amplitude.







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
Destructive Interference
Frequency
Hertz
Interference
Longitudinal Wave
Medium
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?

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