SPH3U UNIVERSITY PHYSICS

WAVES & SOUND

- Vibrations (P.378-380)

Waves & Vibrations

Waves *are disturbances that transfer energy over a distance. Water waves, sound waves, waves in a rope, and earthquake waves all originate from objects that are vibrating.*

Waves & Vibrations

For example, a water wave can result from the vibration caused by a boat rocking on the water while sound waves could originate from a vibrating tuning fork or a vibrating guitar string. In each case, the vibrating source supplies the energy that is transferred through the medium as a wave.

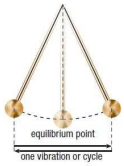
Waves

WAVE (MECHANICAL)

- disturbance that transfers energy through a medium
- caused by a vibration

Vibrations

*The cyclical motion about an equilibrium point is called a **vibration** and one complete vibration or oscillation is called a **cycle**. For example, windshield wipers and the pendulum in a clock repeatedly move back and forth along a fixed path, resulting in a cyclical motion.*



VIBRATION

- cyclical motion about an equilibrium point

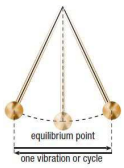
CYCLE

- one complete vibration/oscillation

Vibrations

NOTE!

Oscillating waves (vibrations) caused by wind or earthquakes can threaten the structure of bridges if they are not properly designed. Engineers have developed different designs of bridges, depending on local conditions, but no single design can take all possible wave frequencies into account.



Vibrations

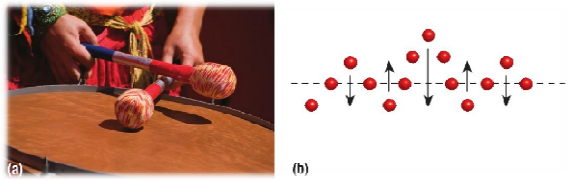
PRACTICE

1. A child is swinging on a swing with a constant amplitude of 1.2 m. What total distance does the child move through horizontally in 3 cycles? (Hint: amplitude is the maximum displacement of a vibrating particle from its equilibrium point.)

   14.4 m

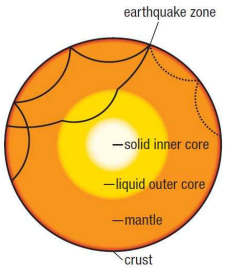
Medium

*All vibrations need a **medium** to transfer waves and when vibrating, the medium tends to gain or lose very little energy. Thus, a vibration can continue for a long time – in some media. It depends on the medium's molecular and mechanical structure, its density, and even its temperature.*



Medium

For example, in a solid medium, the atoms are held securely in a crystal formation by strong intermolecular forces. Therefore, they can only vibrate slightly as the disturbance passes through. As a result, mechanical waves in rigid materials last longer, go faster, and go farther than they do in less rigid media. During an earthquake, for example, vibrations through rigid media like rock can be transmitted thousands of kilometres from the source.



Medium

Conversely, the less rigid a medium, the less efficient it is at transferring a vibration. In liquids, molecules are not in a crystal formation but are still very much in contact. So liquids are also very effective transmitters of vibrations. The individual molecules in a gas are much farther apart than they are in liquids and solids. Consequently, gases are less effective than solids or liquids at transmitting vibrations.

State	Medium	Speed of Sound (m/s)
solid	glass (Pyrex)	5170
	steel	5000
	wood (maple)	4110
liquid	water (fresh)	1493
	water (salt)	1470
	alcohol	1241
gas	helium	970
	air (20° C)	344
	air (-20° C)	319

Medium

MEDIUM

- material (solid, liquid, or gas) through which a vibration travels
- the more rigid it is the more efficient it is at transferring a vibration (i.e. solids > liquids > gases)

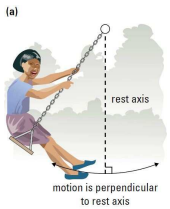
NOTE!

A medium's ability to transmit vibrations also depends on other factors such as temperature, density, tension, …

Types of Vibrations

There are three basic types of vibration.

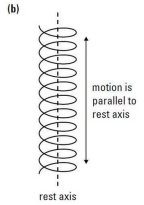
- *A **transverse vibration** occurs when an object vibrates perpendicular to its rest axis (a).*



Types of Vibrations

There are three basic types of vibration.

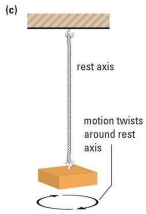
- *A **longitudinal vibration** occurs when an object vibrates parallel to its rest axis (b).*



Types of Vibrations

There are three basic types of vibration.

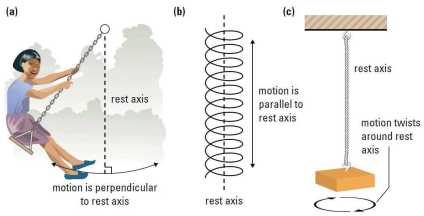
- *A **torsional vibration** occurs when an object twists around its rest axis (c).*



Types of Vibrations

VIBRATIONS

- 3 categories:
  - ① transverse ☞ object vibrates perpendicular to its axis
  - ② longitudinal ☞ object vibrates parallel to its axis
  - ③ torsional ☞ object twists around its axis



Types of Vibrations

PRACTICE

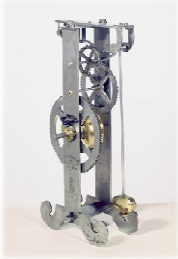
2. State the type of vibration in each of the following:
   (a) a diving board vibrates momentarily after a diver jumps off
   (b) a woodpecker's beak pecks a tree trunk
   (c) the shock absorbers on a mountain bike vibrates as it travels over a rough trail
   (d) a car motor turns at 2450 rpm (revolutions per minute)

   (a) transverse
   (b) longitudinal
   (c) longitudinal
   (d) torsional

Galileo's Pendulum – DYK?

NOTE!

A pendulum swings with a regular period (time), so it is a useful device for measuring time. In fact, early drawings of a pendulum clock were developed by Galileo Galilei in 1641. His ideas for a pendulum clock were based on his observations of the regular period of vibration of a lamp hanging in a church in Pisa, Italy. He then postulated laboratory experiments to determine the factors that affected the period and frequency of a swinging pendulum.



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TEXTBOOK

P.380 Q.1,3