## Outline Chapter 7 Waves

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### 7-1. Water Waves

Water waves are really circular. They are an example of Mechanical waves.

- Crest
- Trough
- Orbital motion of water particles
- Wave direction

*Surfing Taylor Knox, Todos Santos, 2/16/98. Photo: Les Walker.*
Transverse waves are mechanical waves in which the particles of the matter through which they pass move perpendicular to the wave direction; transverse waves can travel only through solids. Longitudinal waves are mechanical waves in which the particles of the matter through which they pass move parallel to the wave direction in a series of compressions and rarefactions. Longitudinal waves can travel through fluids as well as solids. Water waves are a combination of both transverse and longitudinal waves.

How Earthquake Waves Travel
- Shadow Zone (no P or S waves) shows evidence for a core
  - S waves cannot travel through liquid and are like transverse waves
  - Refraction of P or longitudinal waves shows the changes in composition of the interior

S-Wave Shadow Zone

P-Wave Shadow Zone

7-3. Describing Waves

Wavelength ($\lambda$) is the distance from crest to crest. Amplitude ($A$) is the maximum displacement from a normal position.
7-3. Describing Waves

Frequency ($f$) is the number of crests that pass a given point each second; the unit of frequency (cycles per second) is the hertz (Hz).

Speed ($v$) is the rate at which each crest moves; wave speed is equal to wavelength times frequency:

$$v = \lambda f$$

Period ($T$) is the time needed for a wave to pass a given point.

7-4. Standing Waves

Standing waves occur when reflected waves interact with forward-moving waves in such a way that some points in the medium have amplitudes twice that of the normal amplitude and at other points the amplitude is zero. Such waves appear to be stationary or standing still.

7-5. Sound

Sound waves are longitudinal waves. Speed of sound is about 343 m/s (767 mi/h) in sea-level air at ordinary temperatures. Sound travels faster in liquids and solids than in gases.

Echo Sounding

By measuring the time a sound echo takes to return to the ship the sea depth can be measured.
7-5. Sound

The **decibel** (dB) is the unit of sound intensity. Sounds with frequencies below about 20 Hz are called **infrasound**; those above about 20,000 Hz are called **ultrasound**. The human ear is most sensitive to sound frequencies between 3000 and 4000 Hz.

7-6. The **Doppler Effect**

The **doppler effect** is the apparent change in frequency of a wave due to the relative motion of the listener and the source of the sound. The doppler effect also occurs in light waves and is used by astronomers to calculate the speed at which stars are approaching or receding.

7-7. Musical Sounds

**Fundamental tone** is the tone produced when an object vibrates as a whole; this is always the lowest frequency. **Overtones** are higher frequencies that are produced when an object vibrates in segments; they add richness and quality, or timbre, to the fundamental tone.

**Resonance** is the ability of an object to be set in vibration by a source whose frequency is equal to one of its natural frequencies of vibration. The fundamental frequencies in ordinary human speech are mostly below 1000 Hz, averaging about 145 Hz in men and about 230 Hz in women.

**Line Spectra in Stars and the red shift indicating movement away or towards us.**

**Tacoma Narrows Bridge Collapse in 1940**
7-8. Electromagnetic Waves

Electromagnetic (em) waves consist of linked electric and magnetic fields traveling at the speed of light.

James Maxwell (1831-1879)

7-9. Types of EM Waves

Radio communication uses amplitude modulation (AM) or frequency modulation (FM).

Heinrich Hertz (1857-1894)

7-9. Types of EM Waves

The electromagnetic spectrum is the range of frequencies of em waves.

Heinrich Hertz (1857-1894)

Guglielmo Marconi at his laboratory in Newfoundland with the instruments that detected the first radio transmission across the Atlantic Ocean. The Waves were reflected by the ionosphere.

Fig. 7.22

Radio waves reflected by ionized layer

Ionized layer in upper atmosphere

Radio transmitter

The image in a mirror appears to originate from behind the mirror.

Reflected light is polarized and can be filtered out by using sunglasses made from polarizer material.
7-12. Refraction

**Refraction** is the change in direction of a train of waves when they enter a medium in which their speed changes. Light is refracted when it goes from one medium into another medium in which the speed of light is different.

The amount of deflection when light is refracted depends on the speeds of light in the two mediums.

7-13. Lenses

A **converging** lens is thicker in the middle than at its rim and brings parallel light to a single point at a distance called the **focal length** of the lens. A **diverging** lens is thinner in the middle than at its rim and spreads out parallel light so that it seems to come from a point behind the lens.

**How a Camera Works**

A camera uses a converging lens to focus light rays from an object onto the film.
7-14. The Eye

The human eye operates much like a camera.

Blind spot—Close your left eye and look directly at the X. When the X is about 20 cm from your eye, the spot on the right will disappear. (page 223 in book)

Refraction at the cornea gives rise to most of the focusing power of the human eye. Water in direct contact with the cornea reduces the refraction and thus we cannot focus and need goggles to keep the water away from the cornea. Beavers have transparent eyelids that act as goggles and fish use eyes with thick lens to counteract this effect.

Farsightedness occurs when the eyeball is too short, focusing the object behind the retina and making it difficult to focus on nearby objects.

Nearsightedness occurs when the eyeball is too long, focusing the object in front of the retina and making it difficult to focus on distant objects.

Astigmatism occurs when the cornea or lens has different curvatures in different planes. Below (a) how a cross looks normally and (b) how it looks if a person has an astigmatic eye.

White light is a mixture of light waves of different frequencies. Each frequency of light produces the visual sensation of a particular color.
7-15. Color

Dispersion is the separation of a beam of white light into its various colors or frequencies; rainbows are caused by the dispersion of sunlight by water droplets.

7-15. Color

What makes the evening sky red? How do colors affect each other? Take a look at the sky from the planet Mars!

http://www.panoramas.dk/fullscreen3/372_mars.html

7-16. Interference

Interference refers to the adding together of two or more waves of the same kind that pass by the same point at the same time.

1. In constructive interference, the original waves are in step and combine to give a wave of greater amplitude.

2. In destructive interference, the original waves are out of step and combine to give a wave of smaller amplitude.

7-16. Interference

When light of only one color (one wavelength) strikes a thin film, the film appears dark where the light waves reflected from its upper and lower surfaces undergo destructive interference; the film appears bright where constructive interference takes place. When white light strikes a thin film, the reflected waves of only one color will be in step at a particular place while waves of other colors will not; this interference results in a series of brilliant colors.

The Blue Sky

All colors are scattered, but blue and violet are scattered strongly, so the blue and violet light becomes more intense, and that is what we see.

The result: You look up and see a beautiful blue sky!
7-17. Diffraction

**Diffraction** is the ability of waves to bend around the edge of an obstacle.

Because of diffraction, the images of microscopes and telescopes are blurred at high magnification. The larger the diameter of a lens or mirror used in an optical instrument, the less significant the diffraction and the sharper the image. The resolving power of a telescope depends upon the wavelength of the light that enters it divided by the diameter of the lens or mirror; the smaller the resolving power, the sharper the image.

Very small lens
Small lens

Lecture Quiz 7

1. Why do ocean waves curl?
2. What effect do Police use to measure your speed?
3. What is the difference between red and blue light besides color?
4. Give an example of resonance?
5. Why is the sky blue?

Fig. 7.68

Antenna arrays are used together to produce super reception and resolving power in one direction.

Lecture Quiz 7

1. What are 3 characteristics of a wave?
2. Sound is what type of wave?
3. What effect do Police use to measure your speed?
4. Give some 3 examples of electromagnetic waves?
5. What are the two types of interferences?