

SECTION 2.3 Remote Sensing

### Objectives

- **Compare** and **contrast** the different forms of radiation in the electromagnetic spectrum.
- **Discuss** how satellites and sonar are used to map Earth's surface and its oceans.
- **Describe** the Global Positioning System.

### Vocabulary

- remote sensing
- electromagnetic spectrum
- frequency
- Landsat satellite
- *Topex/Poseidon* satellite
- Global Positioning System
- sonar

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### Remote Sensing

- Until recently, mapmakers had to go on-site to collect the data needed to make maps.
- Today, advanced technology has changed the way maps are made.
- **Remote sensing** is the process of collecting data about Earth from far above Earth's surface.

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### The Electromagnetic Spectrum

- Satellites detect different wavelengths of energy reflected or emitted from Earth's surface.
- This energy has both electric and magnetic properties and is referred to as electromagnetic radiation.
- Electromagnetic radiation includes visible light, gamma rays, X rays, ultraviolet waves, infrared waves, radio waves, and microwaves.

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### The Electromagnetic Spectrum

#### Wave Characteristics

- All electromagnetic waves travel at the speed of 300 000 km/s in a vacuum, a value commonly referred to as the speed of light.
- Electromagnetic waves have distinct wavelengths and frequencies.
- The **electromagnetic spectrum** is the arrangement of electromagnetic radiation according to wavelengths.
- **Frequency** is the number of waves that pass a particular point each second.
- These unique characteristics help determine how the energy is used by different satellites to map Earth.

- $\lambda = c/f$
- Or
- $C = \lambda f$  ...where
- Lambda ( $\lambda$ ) = wavelength in any unit of length (generally meter)
- C = velocity of light = (m/s)  
300,000km/s or  $3 \times 10^8$  m/s
- f = frequency in Hz (cycles per second)

In this diagram, the distance (d) indicated represents the distance the waves travel in 1 second.

Wave #1 has 5 complete waves passing by in one second, while Wave #2 has 10 waves passing by in the same time. If you were to watch Wave #1 pass a point, the frequency would be 5 waves per second – 5 Hz. Wave #2 would have a frequency of 10 hertz. Wave #1 has half the frequency of Wave #2 and two times the wavelength. For both waves, the product of the wavelength and frequency are the same.

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## The Electromagnetic Spectrum

### Wave Characteristics

Note: Wave not to scale

The diagram illustrates the electromagnetic spectrum with two axes: Frequency (Hertz) and Wavelength (meters). The spectrum is divided into several regions: Radio waves, Microwaves, Infrared radiation, Visible light, Ultraviolet radiation, X rays, and Gamma rays. The wavelength axis ranges from  $10^5$  meters to  $10^{-5}$  meters, and the frequency axis ranges from  $10^4$  Hertz to  $10^{23}$  Hertz.

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## Landsat Satellites

- A **Landsat satellite** receives reflected wavelengths of energy emitted by Earth's surface, including some wavelengths of visible light and infrared radiation.
- Since the features on Earth's surface radiate warmth at slightly different frequencies, they show up as different colors in images

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## Topex/Poseidon Satellite

- The **Topex/Poseidon satellite** uses radar to map features on the ocean floor.
- Radar uses high-frequency signals that are transmitted from the satellite to the surface of the ocean.
- A receiving device then picks up the returning echo as it is reflected off the water.

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## Topex/Poseidon Satellite

- The distance to the water's surface is calculated using the known speed of light and the time it takes for the signal to be reflected.
- Variations in time indicate the presence of certain features on the ocean floor.

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## The Global Positioning System

- The **Global Positioning System**, or **GPS**, is a radio-navigation system of at least 24 satellites that allows its users to determine their exact position on Earth.
- Each satellite orbits Earth and transmits high-frequency microwaves that contain information about the satellite's position and the time of transmission.
- A GPS receiver calculates the user's precise latitude and longitude by processing the signals emitted by multiple satellites.

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## Sea Beam

- Sea Beam technology is similar to the *Topex/Poseidon* satellite in that it is used to map the ocean floor.
- Sea Beam is located on a ship and relies on sonar to map ocean-floor features.
- Sonar** is the use of sound waves to detect and measure objects underwater.

### Sea Beam

- First, a sound wave is sent from a ship toward the ocean floor.
- A receiving device then picks up the returning echo when it bounces off the seafloor.
- Computers on the ship can then calculate the distance to the ocean bottom based on the time it takes the signal to be reflected.

