NO PREP

Waves

Formation, Characteristics, and Energy Transfer

Includes: Student reading, case study, differentiated questions, teacher key

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Name: Period: Date:

Waves: Formation, Characteristics, and Energy Transfer

The Nature of Ocean Waves

When most people think of the ocean, they picture rolling waves breaking along the shoreline. While waves can be beautiful, they are also powerful forces of energy transfer across the ocean. An ocean wave is not water moving forward in a block, but rather the transmission of energy through the water. The water molecules move in circular orbits, rising and falling as the wave passes, but returning almost to their original position. This orbital motion means the ocean itself doesn't travel across entire basins with the wave, but the energy does. Waves are most commonly generated by wind, and their size depends on three main factors: wind speed, wind duration, and fetch (the distance over which the wind blows across open water). Strong winds blowing over a large fetch for a long period produce massive waves. In contrast, small local winds

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Wave Behavior and Types

Ocean waves behave differently depending on water depth and the conditions they encounter. Deep-water waves occur when the depth is greater than half the wavelength, meaning the wave's orbital motion does not interact with the seafloor. These waves travel quickly and efficiently across vast distances, forming the swells that surfers and sailors rely on. As waves move into shallower water, they become shallow-water waves. Here, the orbital motion touches the seafloor, causing the

wave to slow down, increase in height, and eventually break. This is why waves build as they approach shorelines and why coastal erosion is often intensified during storms. Not all waves are generated by local winds. Tsunamis, for example, are caused by undersea earthquakes, volcanic eruptions, or landslides. Unlike typical wind waves, tsunamis have extremely long wavelengths—sometimes hundreds of kilometers—and can cross entire oceans with devastating impacts when they reach shallow coasts. Another type, seiches, occur in enclosed or partially enclosed basins such as lakes, harbors, or bays, caused by sudden changes in atmospheric pressure or wind shifts.

Waves and Coastal Impact

Waves are not only fascinating physical phenomena but also critical to shaping coastlines. Large storm waves erode beaches, while calmer conditions deposit sand back onto the shore. Over time, this balance maintains barrier islands, spits, and estuaries. However, stronger storms fueled by climate change are altering these natural cycles, threatening coastal infrastructure and ecosystems. Understanding wave behavior is essential for engineers designing seawalls, for coastal managers planning development, and for communities preparing for hazards like tsunamis. Marine science helps transform waves from unpredictable threats into manageable forces, giving humans the knowledge needed to live alongside the ever-changing ocean.

Key Information: Key Concepts Table

Wave Type	Cause	Characteristics	Example
Wind Waves	Wind speed, fetch, duration	Short to long wavelengths, vary in height	Local storm waves
Swells	Distant storms	Long, rolling, regular waves	Surf on Hawaii's North Shore
Shallow-Water Waves	Interaction with seafloor	Slows, increases height, breaks near shore	Shoreline breakers

Wave Type	Cause	Characteristics	Example
Tsunamis	Earthquakes, volcanic activity	Very long wavelengths, cross basins	2004 Indian Ocean tsunami
Seiches	Pressure or wind in enclosed basins	Standing wave motion	Lake Geneva, Switzerland

Case Study: The 2004 Indian Ocean Tsunami

On December 26, 2004, a massive earthquake struck off the coast of Sumatra, Indonesia, triggering one of the deadliest natural disasters in recorded history. The quake displaced enormous volumes of water, generating a tsunami with waves traveling more than 500 miles per hour across the Indian Ocean. Within hours, towering walls of water struck coastlines in Indonesia, Sri Lanka, India, and Thailand, eventually reaching as far as East Africa. Entire villages were swept away, and more than 230,000 people lost their lives. Scientists later noted that many coastal areas lacked early warning systems, leaving communities vulnerable. In the aftermath, international cooperation led to the creation of the Indian Ocean Tsunami Warning System, which now uses seismic data, ocean buoys, and satellites to detect potential tsunamis and alert populations at risk.

1. What physical process triggered the 2004 Indian Ocean tsunami?

2. Why was the absence of an early warning system so significant during this disaster?

Multiple Choice

1. Which factor does NOT directly influence the size of a wind-generated wave?

    a) Length of time the wind blows

    b) Wind speed

    c) Fetch

    d) Water temperature

2. What happens when a deep-water wave moves into shallow water?

    a) It slows down and grows taller

    b) It disappears entirely

    c) It speeds up and loses wave height

    d) It forms seiches

3. What makes a tsunami different from regular wind waves?

    a) Shorter wavelength

    b) Extremely long wavelength and seismic origin

    c) Caused only by wind storms

    d) Occurs only in lakes and enclosed water basins

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ Swell	A) Generated by earthquakes or volcanic eruptions
2. ___ Tsunami	B) Orbital motion touches the seafloor near shore
3. ___ Seiche	C) Caused by local storms and wind duration
4. ___ Shallow-water wave	D) Long, rolling waves formed far from shore
5. ___ Wind wave	E) Standing waves in enclosed basins

Fill-in-the-Blank

1. The _____ of a wave is the distance between two crests.

2. A wave slows down and grows taller as it enters _____ water.

3. The three main factors controlling wind waves are wind speed, wind duration, and _____.

Short Answer

Answer each question in 2-4 complete sentences.

1. Why are long-wavelength swells important for surfers and sailors?

_____

_____

_____

2. How do tsunamis demonstrate the difference between energy transfer and water movement?

_____

_____

_____

3. Why is understanding wave behavior important for coastal engineering and safety?

_____

_____

_____