

4/2/08

GEOL 117 Class 28

WAVES IN THE OCEAN

Origin/Types

Parameters -- how we describe waves

Orbital motion

Wind-generated waves

Tsunami

Origins and Types

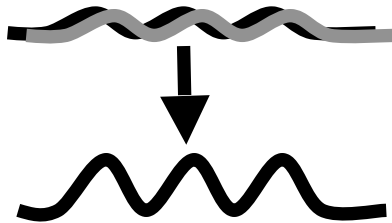
1. Wind-generated waves -- most common
2. Tsunamis -- earthquake-generated (Pacific)
3. Tides -- gravity of Moon, Sun; forces in Earth's rotation
4. Seiches -- standing waves, "bathtub"

Wave Parameters: How do we state the height, spacing, etc?

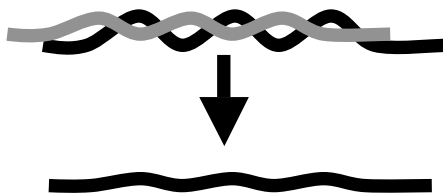
- Crest and Trough
- Height = H
- Wavelength = L
- Steepness = H/L
- Period (time between crest arrivals) = T
- Speed of an individual wave = $S = L/T$
- Speed of a wave group = V ($V < S$)
- Water Depth = D

Wave "interference"

Constructive -- in phase, increases height



Destructive -- out of phase, decreases height



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Orbital Motion of Water in Waves

- Circular motion of water as a wave passes
- Amount of motion (i.e., size of the orbit) decreases with depth
 - -- no motion at $D > 1/2 L$
- In deep water, waves are unaffected by the ocean bottom

Orbital Motion: Shallow Water Waves

In shallow water, the circular motion becomes “flattened” near the bottom
The wave “feels bottom”, and motion is impeded by the bottom

So we classify waves as follows:

- If $D < 1/20L$ --> Waves called “Shallow-water waves”
- If $D > 1/2L$ --> Deep-water waves
- In between $1/20L$ and $1/2L$: intermediate waves

Shallow and deep water waves behave very differently

WAVES IN THE OPEN OCEAN

Wind-generated

Deep-water waves -- $D \gg L$

$H = 1 - 15$ m

$L = 50 - 500$ m

$T = 5 - 20$ sec

$S = 30 - 100$ km/hr

Wave theory: Calculations of water motion in waves, using principles of physics and the tools of mathematics, give us the following:

For Deep Water Waves:

1. Wavelength, L , depends on period, T

$$L = (g/2\pi)T^2 \quad (g = 9.8 \text{ m/s}^2)$$

2. Velocity = $S = L/T$, so....

$$S = 1.56 \text{ m/s}^2 \times T \quad (T \text{ is in the units of seconds, } L \text{ is in meters, and } S \text{ is in meters/sec)}$$

The bottom line:

- a) Both S and L increase with increasing T
- b) If you measure T , you can calculate S and L

Size and speed of wind-generated waves

- Wind speed (most important)
- Wind duration
- Wind fetch (the distance over which wind blows in one direction)

Increase speed, duration, fetch --> increase H , T , L , S

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Dispersion: Longer L waves move faster and farther

Waves moving away from a stormy area:

- Waves with long L have highest speed
- Long and short L waves separated/sorted
- Long waves dissipate more slowly

This gives us "swell" at sea -- long-T waves are the ones that travel far from a stormy area, short-T ones die out

Tsunami: Very long wavelength waves caused by earthquakes, etc.

Example: Earthquake: Sea floor drops 6m

Resulting wave is not high, but is huge in a different way

- $T = 10 - 20$ min (600-1,200 s)
- $L = 100 - 200$ km (100,000 - 200,000 m)
- $H = 1 - 2$ m
- H/L very small -- not detectable in open ocean!

Tsunamis are **shallow-water waves because** $L \gg$ depth of ocean

- Thus, speed controlled by depth only (wave theory: next lecture)
- $S = \sqrt{gD} = 200$ m/s (400 mph)