Waves

What is a wave?

- Waves transmit a disturbance / energy from one part of a material to another.
- The energy is transmitted without substantial movement of the material.
- Waves occur in lots of places, not just the ocean.

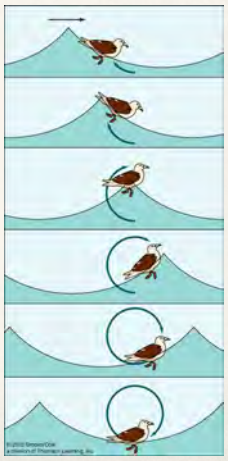
Wave in stadium

YouTube

Even here the wave more or less keeps it's shape and travelled at a constant speed.

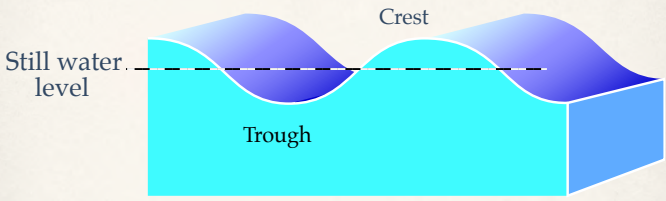
Water particle motion

The bird, like a surfer on sitting on a board, only moves a little as the wave travels through.



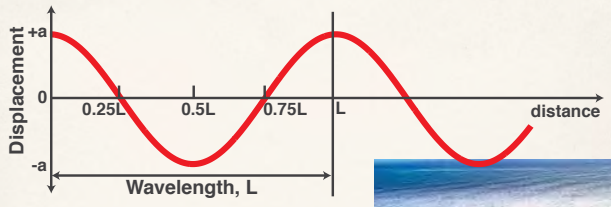
Brooks/Cole

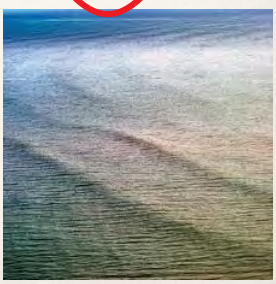
Crests and Troughs



Wave amplitude	Vertical distance between the still water level and the crest.
Wave height	Vertical distance between crest and trough.

Wavelength

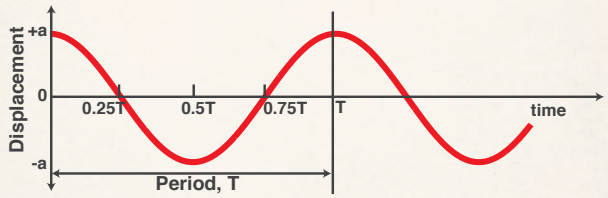




Wavelength is the horizontal distance between two consecutive wave crests.

Period and Frequency

Period is the time taken for one wave to pass a fixed point in space.



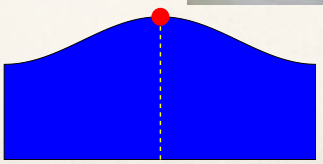
Frequency is the number of waves passing a fixed point in a set time interval, usually a second.

What causes waves

Something displaces the wave surface

e.g.,
- Wind
- Earthquake
- Landslide
- Raindrops
- Gravity from moon

Wikimedia Commons

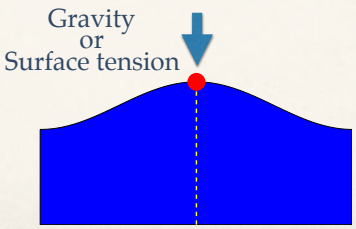


What causes waves

Restoring Force acts to flatten out wave surface

but

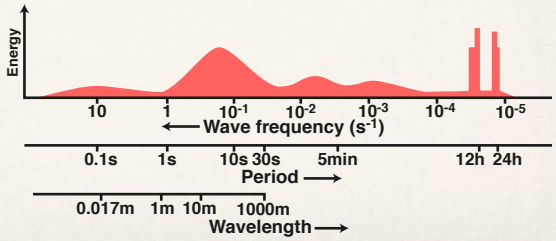
overshoots, setting up an oscillation.



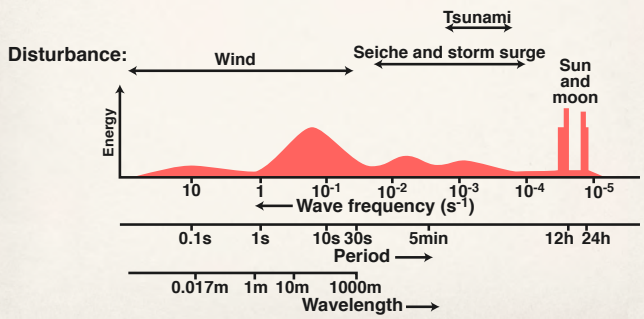
Classifying Waves

- By frequency and/or wavelength.
- By disturbance.
- By restoring force.
- Water depth relative to wavelength
- Propagating or standing

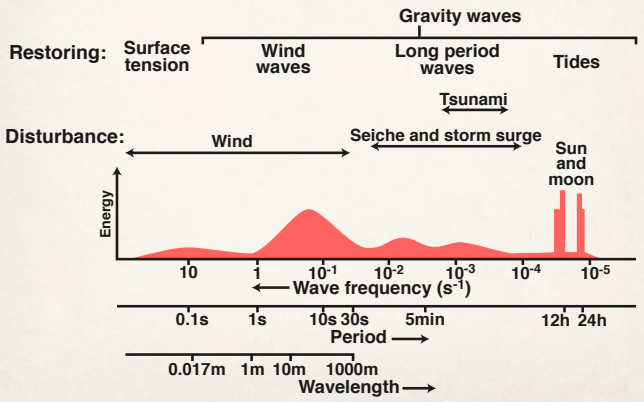
By wavelength, period



By disturbance



By restoring force



By water depth relative to wavelength

Deep water waves

Shallow water waves [long waves]

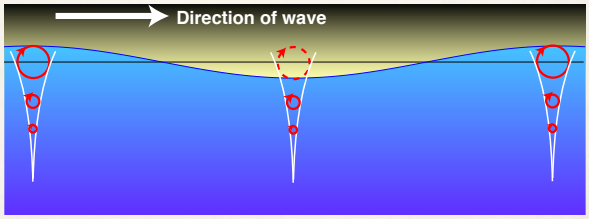
(and the ones that don't fit in either category)

Deep water Wave

Fluid particle move in nearly circular paths.

Orbit diameter decreases rapidly with depth.

Orbital motions nearly zero at a depth of L/2.

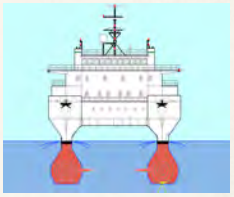


UH Vessel Kilo Moana

UH Vessel Kilo Moana

Submerged pontoons provide buoyancy.

Consequently, the ship 'feels' the orbits about 10 feet below the surface.



Depth < L/2?

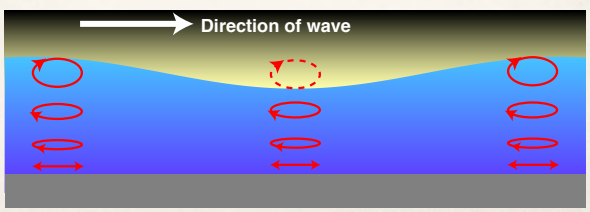
When the depth is shallower than half the wavelength, the wave 'feels' the bottom. In that there is non-zero orbital velocities at the seabed.

Two cases:

1) Shallow water waves (depth < L/20)
2) Transitional waves (L/20 < depth < L/2)

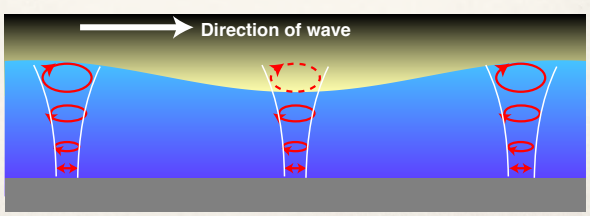
Shallow water waves

- Depth < Wavelength/20
- Orbitals are elliptical, which get progressively flatter with depth.
- Orbital size does not decrease with depth.

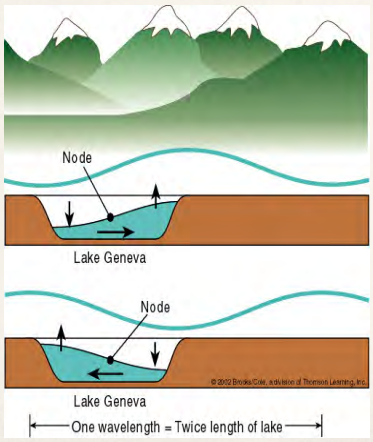


Transition waves

- Wavelength/20 < Depth < Wavelength/2
- Orbitals are elliptical, which get progressively flatter with depth.
- Orbital size still decreases with depth.

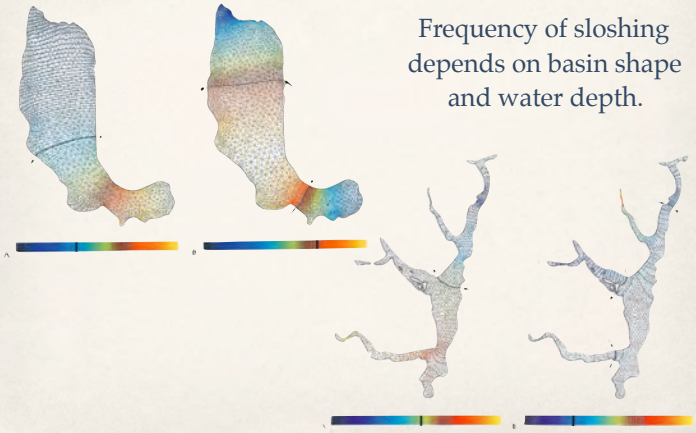


Standing waves



Seiches are a wave sloshing back and forth in an confined basin.

Standing waves



Frequency of sloshing depends on basin shape and water depth.

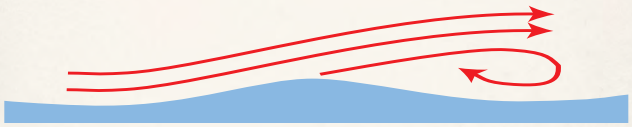
Wind wave formation

Wind friction 'stretches' the ocean surface, surface tension resists which results in capillary waves.

Capillary waves have very short wavelength (less than 1.7 cm or 0.7 inches)

Wind wave formation

Wind gets deflected upward, which adds energy to the wave pushing it forward. Low pressure region behind the wave contributes to forward motion.



Gravity becomes restoring force.

With continuing wind, the wave period and height grow.

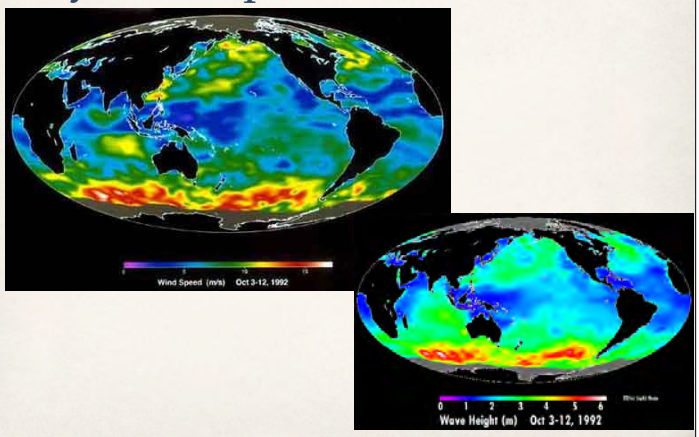
Wind wave formation

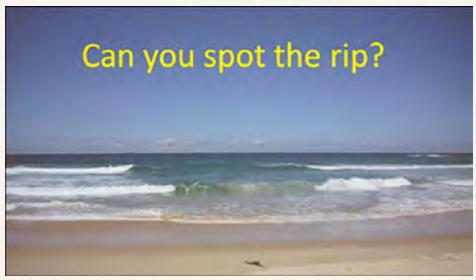
- Factors affecting wind wave development:
  - Wind strength - wind speed exceeds wave speed.
  - Wind duration
  - Fetch - the uninterrupted distance over which the wind blows without changing direction

Fully developed sea

Direction	Fetch	Duration	Height	Wavelength	Period
19 kph	19 km	2 hr	0.3 m	9 m	3.0 sec
37 kph	139 km	10 hr	1.5 m	34 m	5.7 sec
56 kph	518 km	23 hr	4.1 m	77 m	8.6 sec
74 kph	1,313 km	42 hr	8.5 m	136 m	11.4 sec
92 kph	2,627 km	69 hr	14.8 m	212 m	14.3 sec

Fully developed sea





Rip currents

When waves break at the shore, water moves towards the beach. This water returns in rip currents,

Rip current under normal waves

Big rip current during a Hurricane

Rip currents

Rip currents account for over 80% of rescues performed by life guards. About 100 people die each year in the US because of rip currents.

www.ripcurrents.noaa.gov

Some key ideas

- Waves propagate a disturbance without much movement in the material itself.
- Wavelength (L), period (T), frequency (f), amplitude, height
- Something displaces the surface, and the restoring forces overshoots.
- Deep water waves (D>L/2) don't feel the bottom.
- Shallow water waves (D<L/20) do feel the bottom.
- Seiches are standing waves in lakes or harbors.