Two general types of surface gravity waves

- **Deep water waves**
  - Depth >> wavelength (> ~½ L)
    - Waves don’t feel bottom
      - Orbits remain circular
      - Speed: \( V = \frac{L}{T} = 1.56 \times T \) (m/s)

- **Shallow water waves**
  - Depth << wavelength (1/20 of L)
    - Waves feel bottom
      - Orbits flatten into ellipses
      - Speed = \( V = \sqrt{gZ} \), or \( V = 3.13 \times \sqrt{Z} \)
Death of a wave

Forces that end waves

- Capillary waves
  - Surface tension
- Gravity waves
  - Internal friction (viscosity)
  - External source of friction
    - Seafloor
Approaching Shore (‘shoaling’)

• V decreases
  – Bottom friction
  – Following waves “catch up” & pile up
  – Waves get steeper

• When z = 1.3 * H
  – Surfs up! Waves break

Deep water waves become shallow water waves as they approach shore
Types of break

1. Spilling
   - Gentle beach slope allows waves to disperse energy gradually

2. Plunging
   - Moderately steep beach slope gives waves a curling shape that propels surfers

3. Surging
   - Abrupt beach slope makes waves build up and break rapidly at the shore. No curl.
Spilling breakers
Gentle beach slope

Plunging breaker
Steep beach slope
Surf

When water depth is \( \frac{4}{3} \times H \), get surf:

http://www.isracam.co.il/swell.htm

What’s the water depth here?
Wave processes in the surf zone

• Reflection
  – Waves bounce off density differential back towards source

• Refraction
  – Waves bend towards slower speeds
    • Shallower depth

• Diffraction
  – Waves can “bend” around solid objects
Refraction, Diffraction, Reflection

- **Refraction**: waves “feel bottom” and will turn (or get dragged) towards headlands

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Wave Reflection
Wave Refraction

Refraction

Incoming wave direction
Wave Refraction

Refraction by a submarine ridge

Refraction by a submarine canyon

Increasing depth

H = high wave set-up
L = low wave set-up
→ = longshore current

Wave Diffraction
Put all together: waves can be so different only short distances apart

“The Wedge” in Newport Beach
Where does the sand go?

• On west coast, it mostly goes SOUTH.
• Form littoral cells—connected region where sand/sediment is transported down the coast, not across the shelf
• Littoral cells are “broken up” by canyons and rocky headlands… Goes across the shelf-break and to deep ocean at these locations

Storm Surge

• Not really a wave (we can’t apply our mathematical descriptions to it)
• Hurricanes “pile up” water in the right front quadrant
Tsunamis: "Harbor Wave"

- Caused by a **seismic** disturbance
- Most common in the Pacific
- Harmless until they hit the coast
Tsunamis will keep traveling until the energy is dissipated.