Waves

- What are Waves
- Wave Motion
- Wave Energy
- Description of Wavefield
- Waves Approaching Shore
- Coastal Waves

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What is a Wave?

- Transfers a disturbance from one point of a material to another
- No net overall motion to the material >> Energy is transported through the water without any transport of the water itself
- Constant speed and period. But in the ocean since waves interact with the bottom, their speed does change.

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Wave Characteristics

In Space:
- **Amplitude (a)**
- **Height (H)**
- **Wavelength (L)**
- **Wavenumber (*k*)**
- **Steepness (H/L)**

In Time:
- **Period (T)**
- **Frequency (ω)**

Speed (c) = L / T

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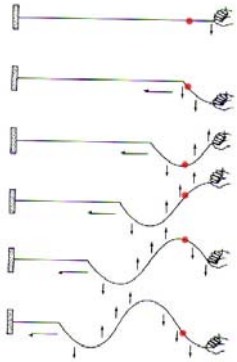
- 2 separate motions:
- Motion of the wave
- Motion of the material



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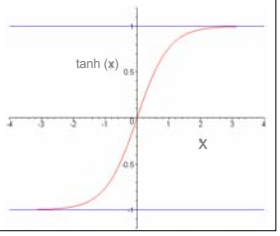
$c^2 = \frac{g}{k} \tanh(kd)$

- $kd << 1$ or $d/L << 1$ or $d << L$
- $L > 20\ d$
- $c^2 = \frac{g}{k} kd$
- $c^2 = gd$
- $c = \sqrt{gd}$
- Shallow Water Waves



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$c^2 = \frac{g}{k} \tanh(kd)$

- $kd >> 1$ or $d/L >> 1$ or $d >> L$
- $L < 2\ d$
- $c^2 = \frac{g}{k}$
- $c^2 = \frac{g\ L}{2\pi}$
- $c = \sqrt{\frac{g\ L}{2\pi}}$ Deep Water Waves

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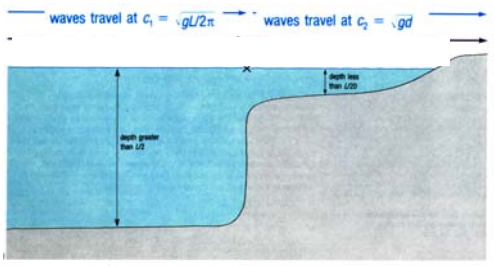

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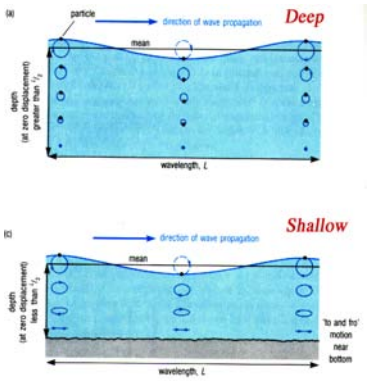
- Motion of the material
- $r = a e^{kz}$
- z is negative



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Wave Energy

- Energy = $\frac{1}{8} \rho g H^2$ (per unit area)
- Energy Flux = Amount of Energy *x* Speed of Energy
- What is the energy flux for a shallow water wave?

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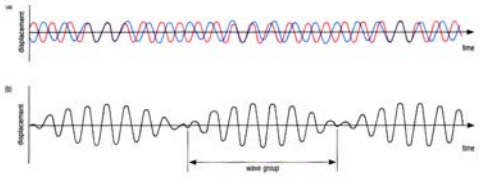
Wave Interaction

- Waves often travel in groups or packets
- Individual waves move with a certain phase speed (c)
- Groups move with a group velocity (c_g)



- Animation

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Wave Interaction: Groups

- Shallow water waves:
- Cg = c
- Deep Water waves:
- $Cg = \frac{1}{2}(c_1 + c_2)$ / 2

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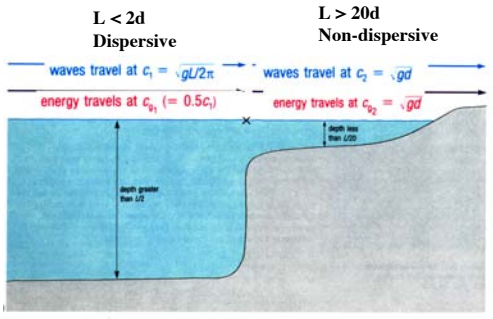

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Making Waves

Energy In >> Wind

1. Capillary Waves (L < 1.7cm)
2. Gravity Waves (L > 1.7cm)
3. Waves grow in size dependent on
   a) Wind Speed
   b) Duration
   c) Fetch

4. If fetch & duration large enough, equilibrium is reached where Energy In = Energy Out. The waves are at the maximum height for that wind speed and we have a Fully Developed Sea

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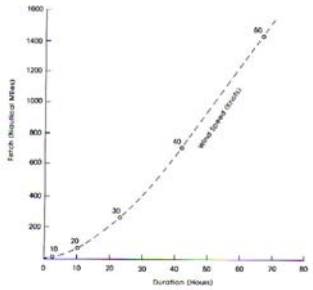
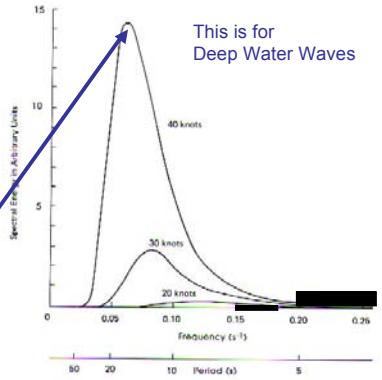
Fully Developed Sea



$H = .031 \times W^2$

H (m)

W (m/s)



- Shows the Dominant Wave period (T_d)

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- Ocean surface consists of complex Wavefield described by Significant Wave Height $H_{1/3}$ = average height of highest 1/3 of the waves
- Waves leave generation site, disperse, travel far from origin as Swell.
- Swell has diminished wave height due to
  - Attenuation
  - Spreading Loss

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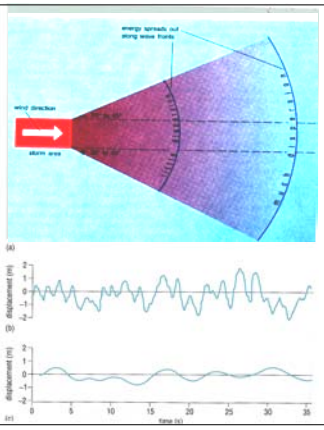

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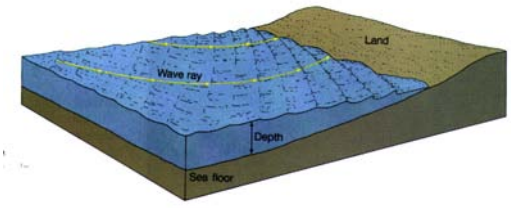

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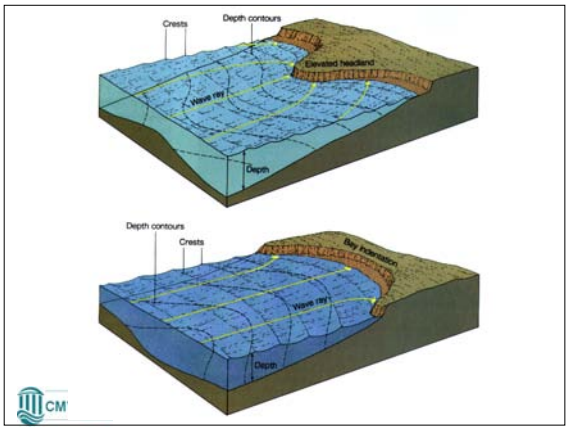
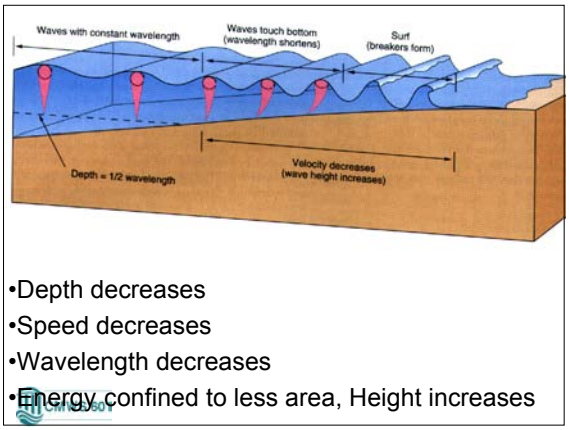
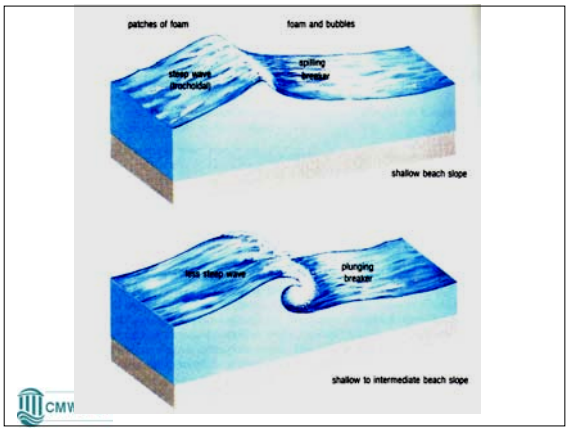
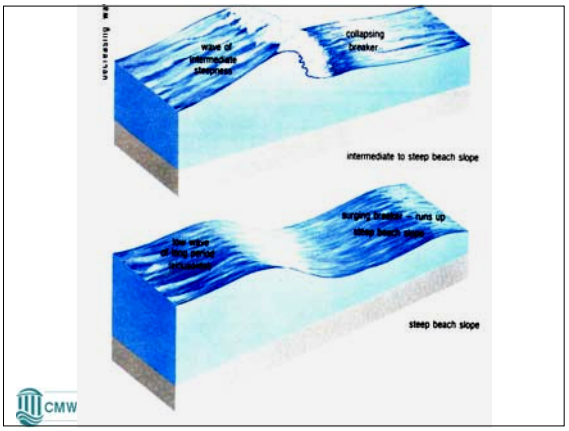
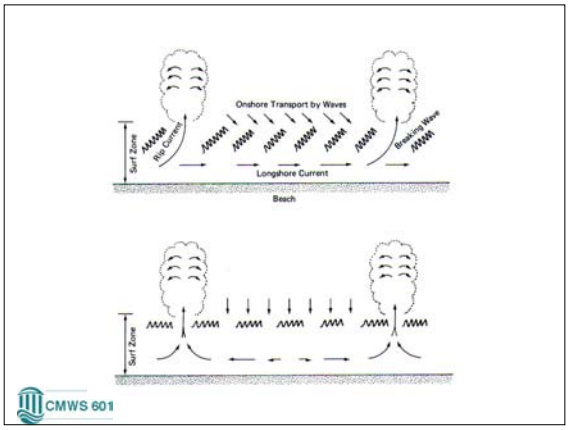


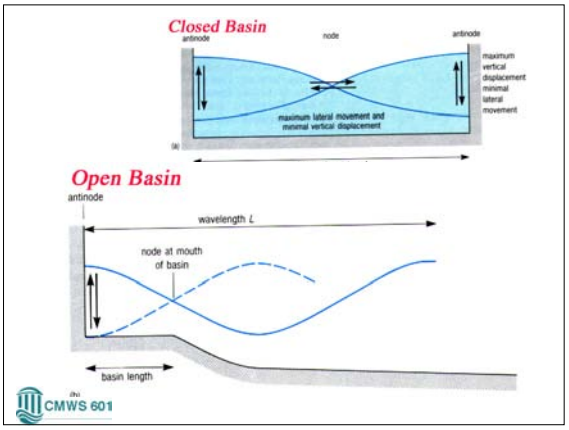


- Depth decreases
- Speed decreases
- Wavelength decreases
- Energy confined to less area, Height increases

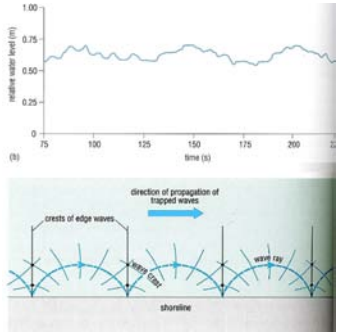








Edge Waves



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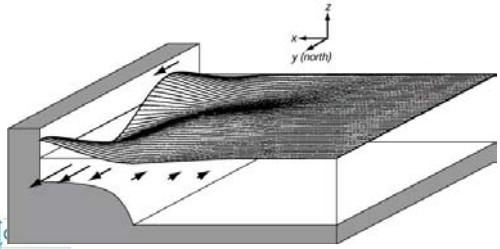
- Edge waves are low-frequency waves attached to the beach.
- T =few minutes, long-shore L = around a kilometer, a – decays exponentially offshore



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Tsunami Formation

- In open ocean:
- L = 100's of km
- $C = (gd)^{1/2} = (10 m/s^2 \cdot 4000m)^{1/2} = 200 m/s$
- H ~ 1 m

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Tsunamis Reaching Shore

- Energy flux is conserved
- Speed of the energy • Amount of energy
- $(gd)^{1/2} \cdot 1/8\ \rho\ g\ H^2$ is constant.
- When d quickly decreases, H quickly increases

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Waves & Coasts

•Input of energy via waves is one of the main driving forces of coastal physical processes

•Grand Strand beaches are wave dominated beaches

Ability of waves to erode a coast depends on:

1) Wave Environment
   - Fetch direction
   - Significant Wave Height
   - Frequency of Storms
   - Types of Storms

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Depends on

2) Geology
   - Rock/sand/sediment type
   - Geological structure

3) Coastline Morphology
   - Configuration
   - Topography
   - Bathymetry/Slopes

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