Waves Lecture B

4060 AdOc
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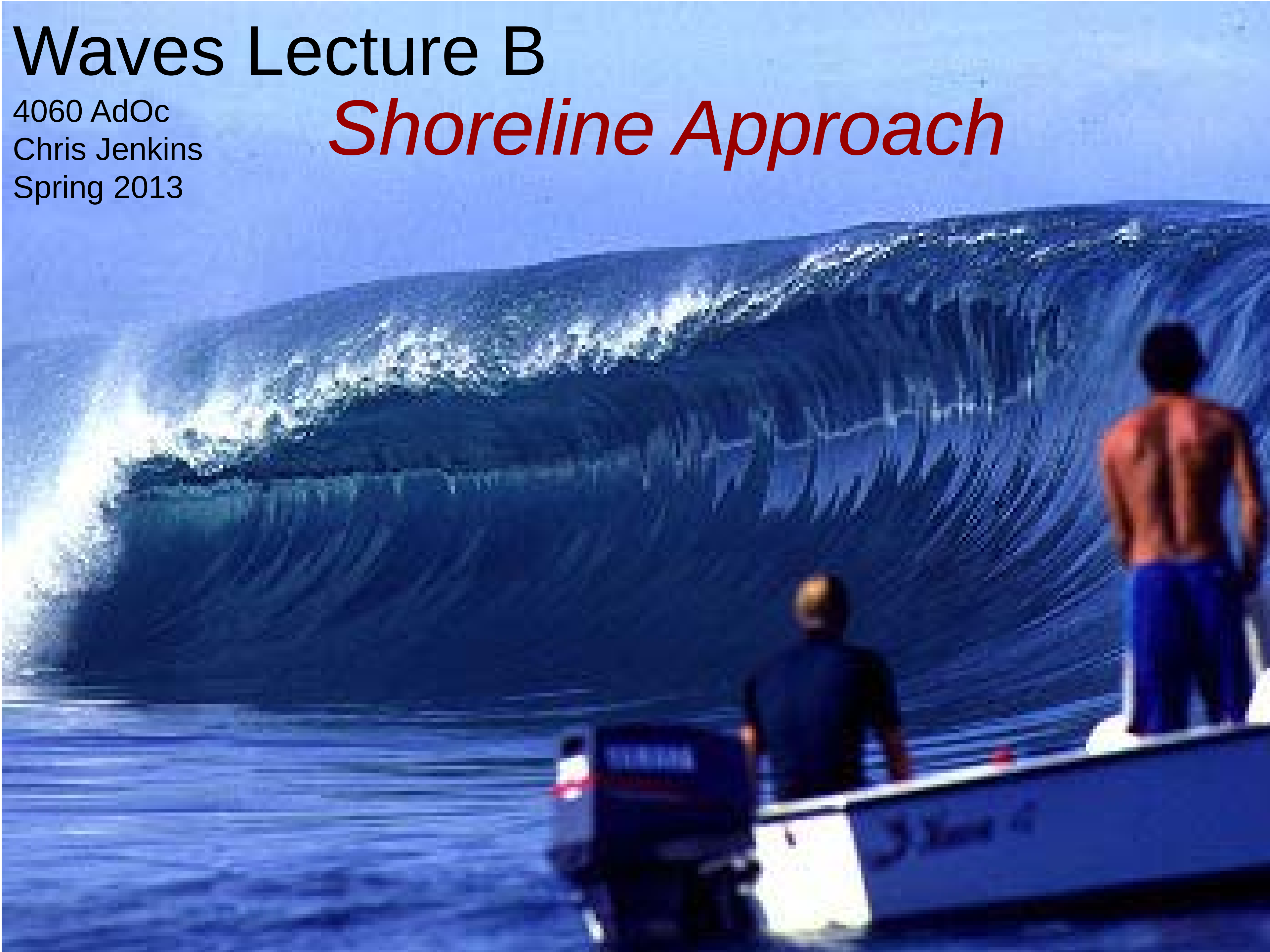
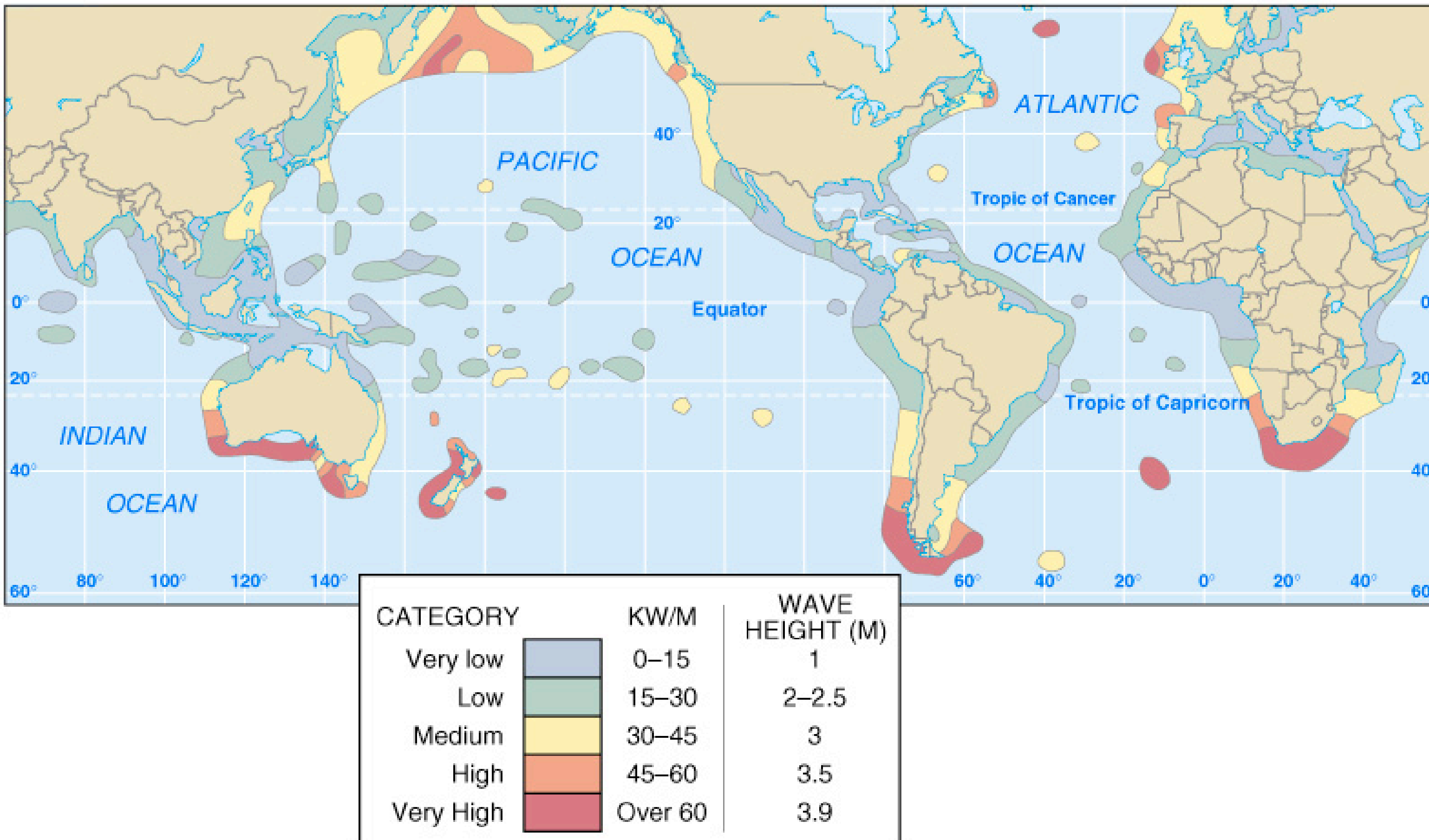
Spring 2013

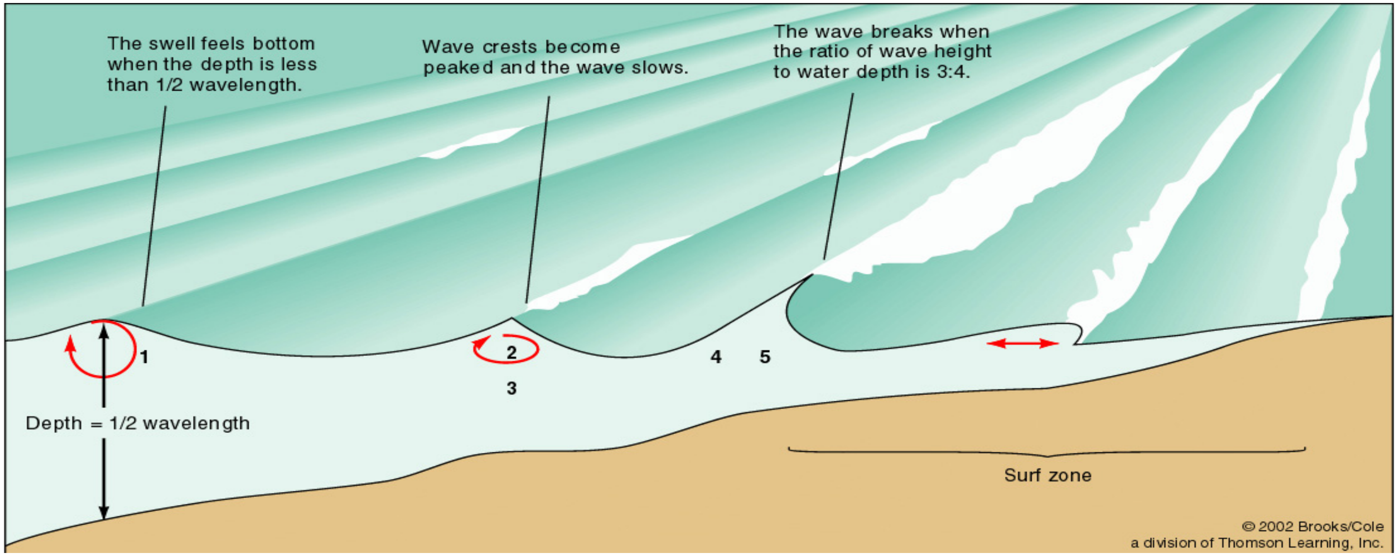
Shoreline Approach



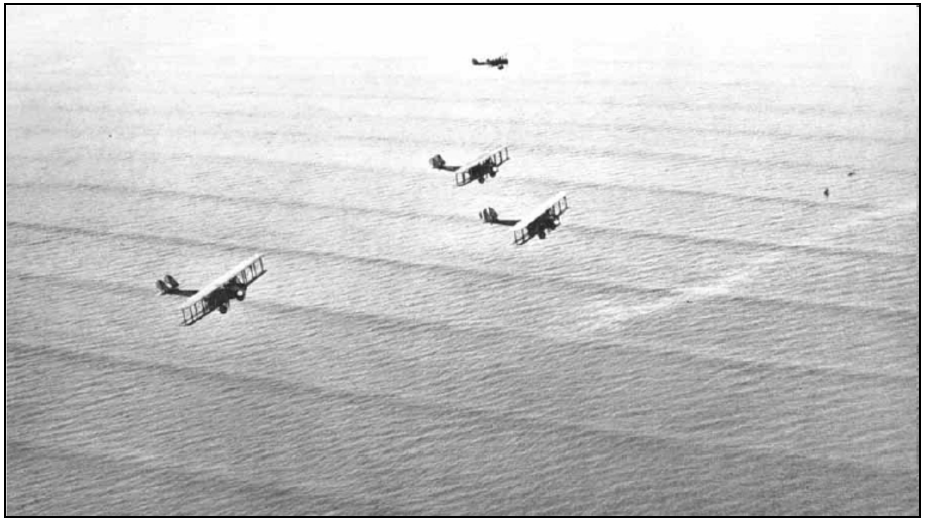
Coastal wave energy resources



Transformations



What happens when deep ocean waves come to the shore?

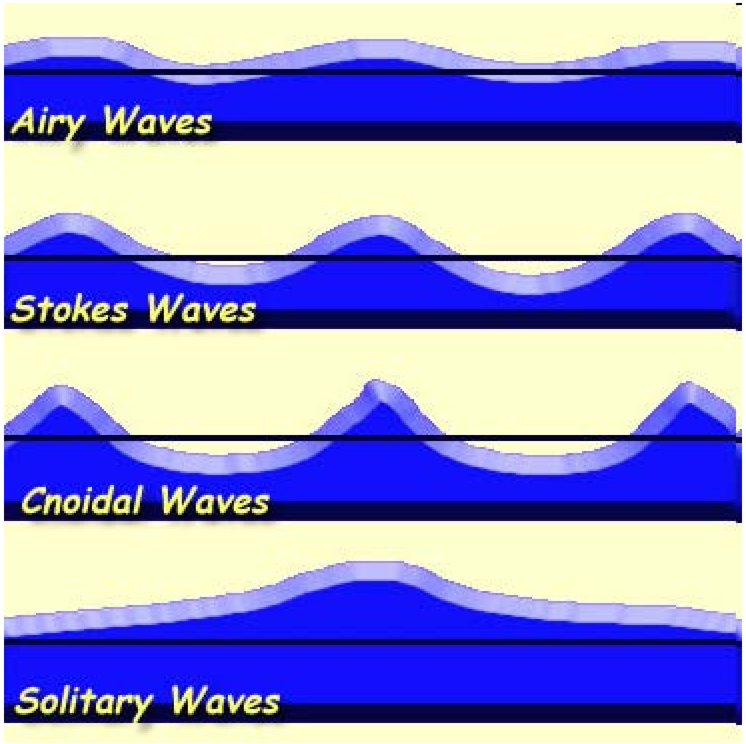


Theories of Waves

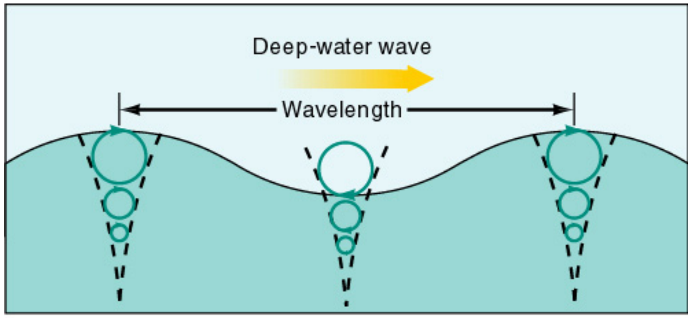
Airy Wave theory: sinusoidal waves
most accurate for low amplitude waves in deep water
less accurate for predicting wave behavior in shallow water; most commonly used wave theory because it is the least mathematically complex ("linear wave theory")

Stokes Wave theory: trochoidal waves
can be used for deep-, intermediate- and shallow-water waves; mathematically complex
Takes into account the effects of wave height on velocity
more accurately describes orbital velocity asymmetries

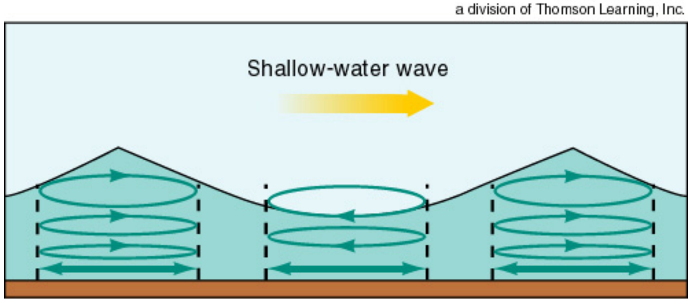
Cnoidal wave theory:
isolated crests moving in shallow water; flat trough areas; translatory, not oscillatory progressive waves; use only to describe shallow-water waves (breakers) or bores; isolated cases are **solitary waves (solitons)**



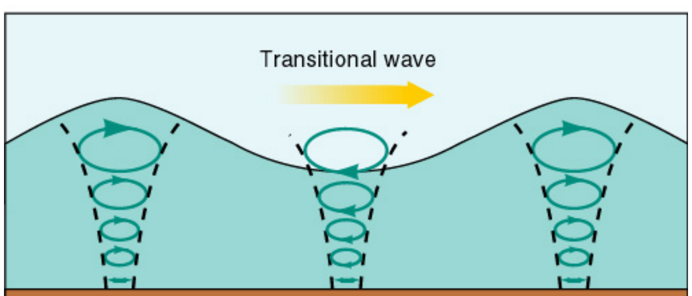
Deep, Shallow Water Airy Waves



a Depth ≥ $\frac{1}{2}$ wavelength



b Depth ≤ $\frac{1}{20}$ wavelength



c $\frac{1}{20}$ wavelength ≤ depth ≤ $\frac{1}{2}$ wavelength

Deep-water waves for $D > L/2$

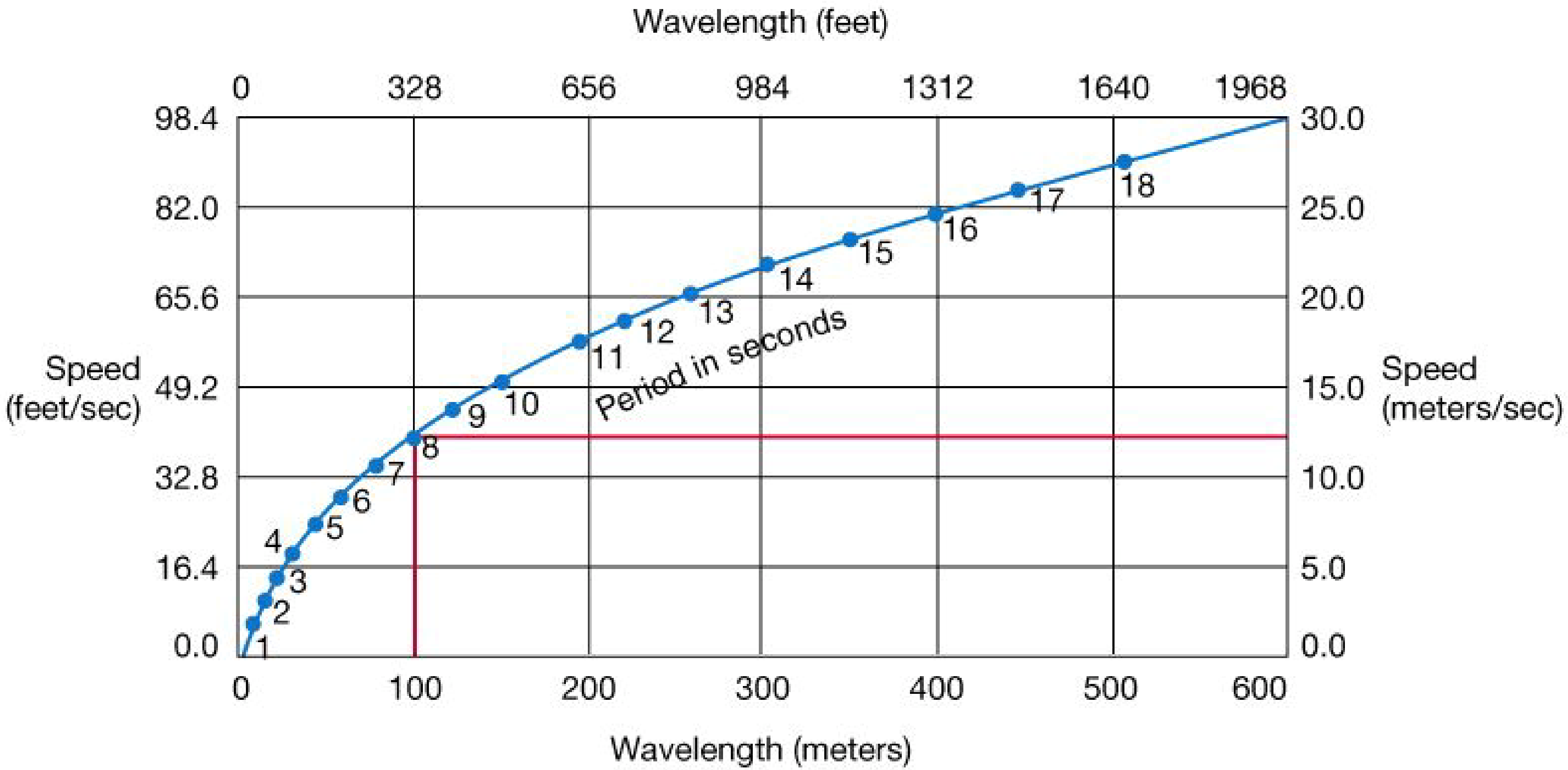
$$c = \sqrt{\frac{gL}{2\pi}} \qquad c_{m/s} = 1.56 T_{sec}$$

Shallow-water waves for $D < {}^{1}/_{20}\, L$

$$c = \sqrt{gD} \qquad c_{m/s} = 3.13 D_{m}^{0.5}$$

Transitional waves for $L/2 < \mathrm{D} > {}^{1}/_{20}\, L$

$$c = \sqrt{\frac{gL}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)}$$



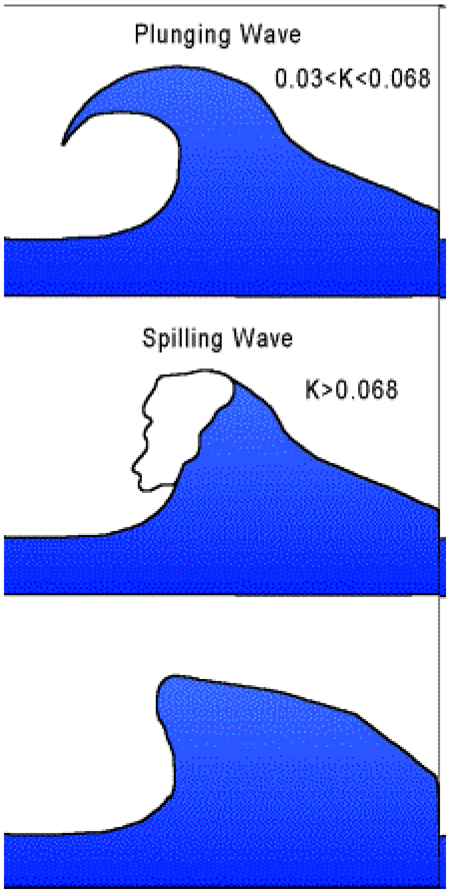
Wavelength (feet)
0
328
656
984
1312
1640
1968
98.4
82.0
65.6
49.2
32.8
16.4
0.0
Speed (feet/sec)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Speed (meters/sec)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Period in seconds
0
100
200
300
400
500
600
Wavelength (meters)

Different ways waves break against the shore

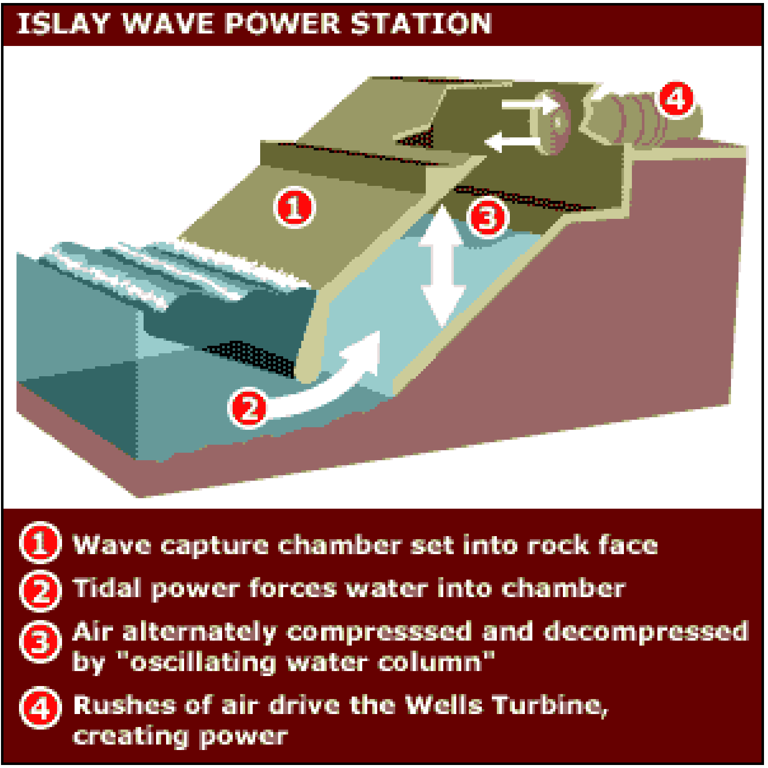
Plunging waves break violently against the shore, leaving an air-filled tube, or channel, between the crest and foot of the wave. Plunging waves are formed when waves approach a shore over a steeply sloped bottom.

Spilling waves occur on gradually sloping ocean bottoms. The crest of a spilling wave slides down the face of the wave as it breaks on shore.

Surging breakers abrupt beach slope makes waves build up and break rapidly at the shore



Energy and Power



Energy density (Total Energy per unit area of water; Joules/m2)

$$E_{density} = \frac{1}{8}\rho g H^2$$

{kg/m3*m/s2*m2 = kg m2/s2 per m2 = J per m2}

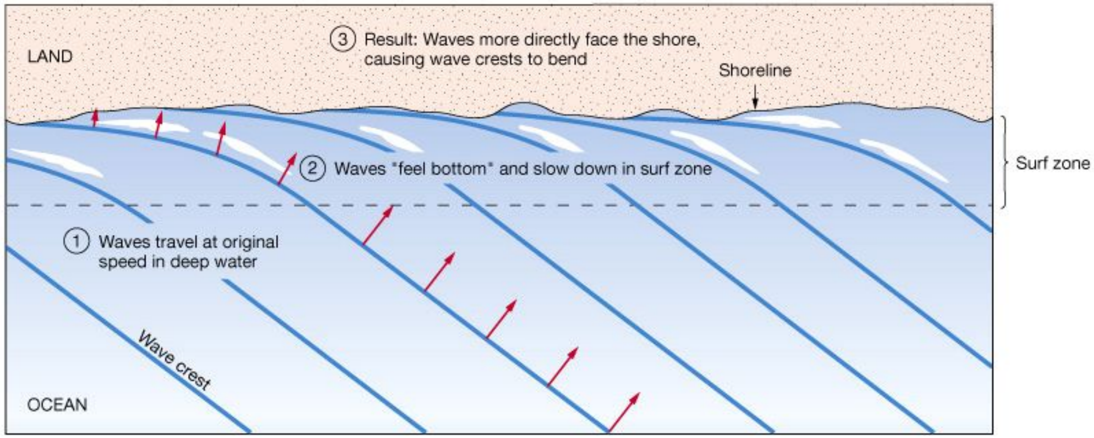
Wave Power (Joules/s per length of wave crest)

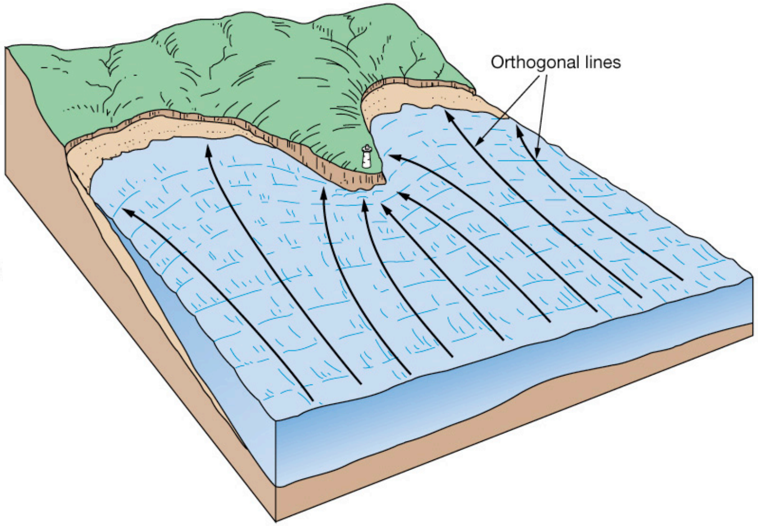
$$P_{density} = c_g E_{density}$$

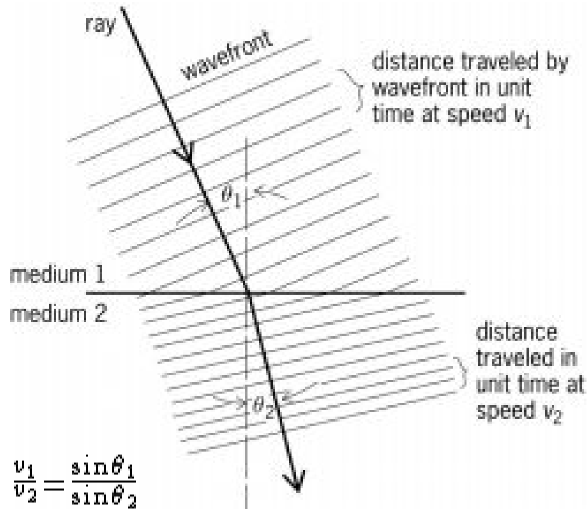
{m/s J per m2 = W / m}

Wave refraction

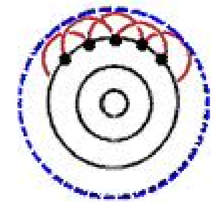
- As waves approach shore, the part of the wave in shallow water slows and part of the wave in deep water continues at its original speed, causing wave crests to **refract (**bend)
- Results in waves lining up nearly parallel to shore
- Wave energy is concentrated at headlands and dispersed in bays







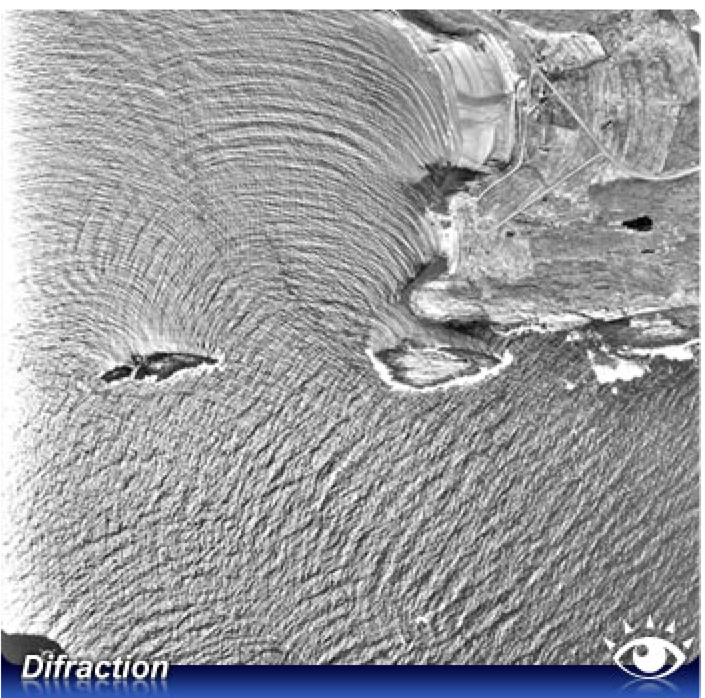
Snell's Law

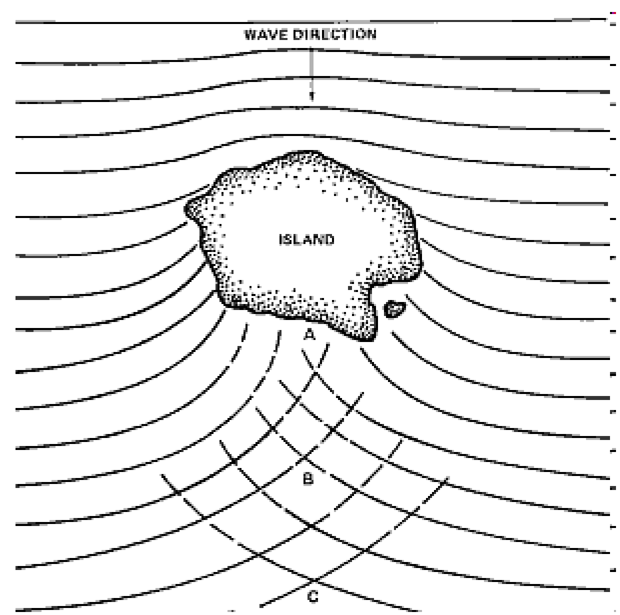


Under Huygen analysis, a wavefront consists of an infinite number of wavelets.

Huygen analysis

Refraction ^ and Diffraction v





http://www.seafriends.org.nz/oceano/bend2.gif

Wave reflection

- Wave energy is **reflected** (bounced back) when it hits a solid object
- Wave reflection produces large waves at “The Wedge” near Newport Harbor, California