SMS 303: Integrative Marine Sciences III

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- 5 weeks & topics: Coriolis, waves, tides, diffusion and mixing.

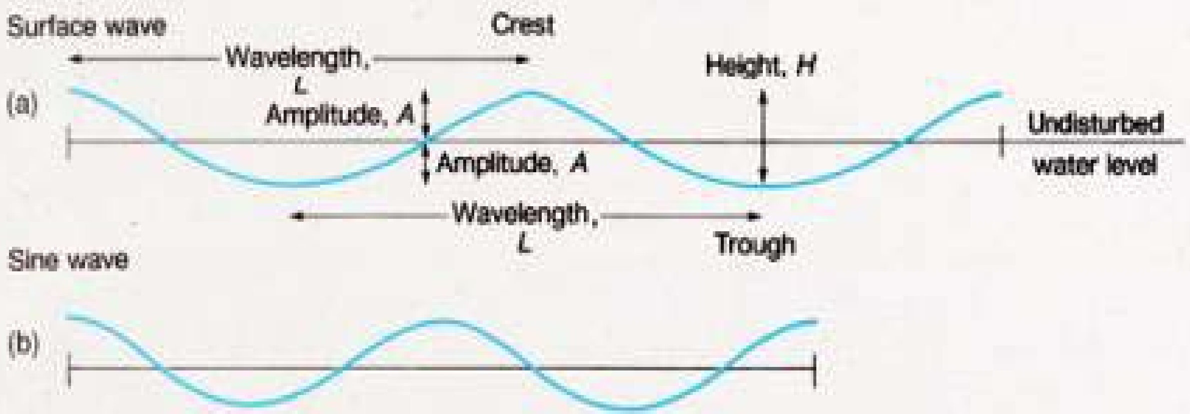
- Class web site:

http://misclab.umeoce.maine.edu/boss/classes/SMS_303_2007/Syllabus.htm

- Don't wait with homework. Start early so you have time to think and ask questions if needed.

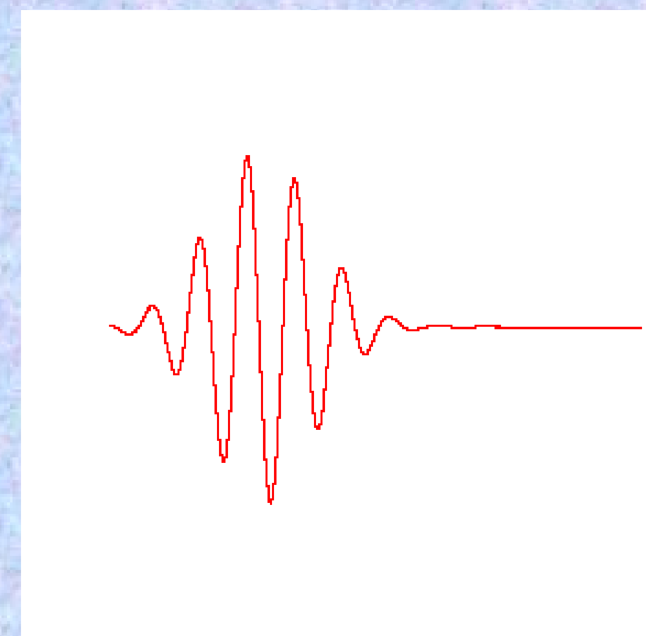
- # Review: Waves
  - ## What characterizes waves:
    - Periodic behavior in time or space.
    - Examples: ???
    - We will focus on *gravity* waves (where gravity is the restoring force).

Anatomy of a wave:



$$A\sin\{2\pi(x/\lambda - t/T)\} + B\cos\{2\pi(x/\lambda - t/T)\} =$$
$$C\sin\{2\pi(x/\lambda - t/T) + \phi\}$$

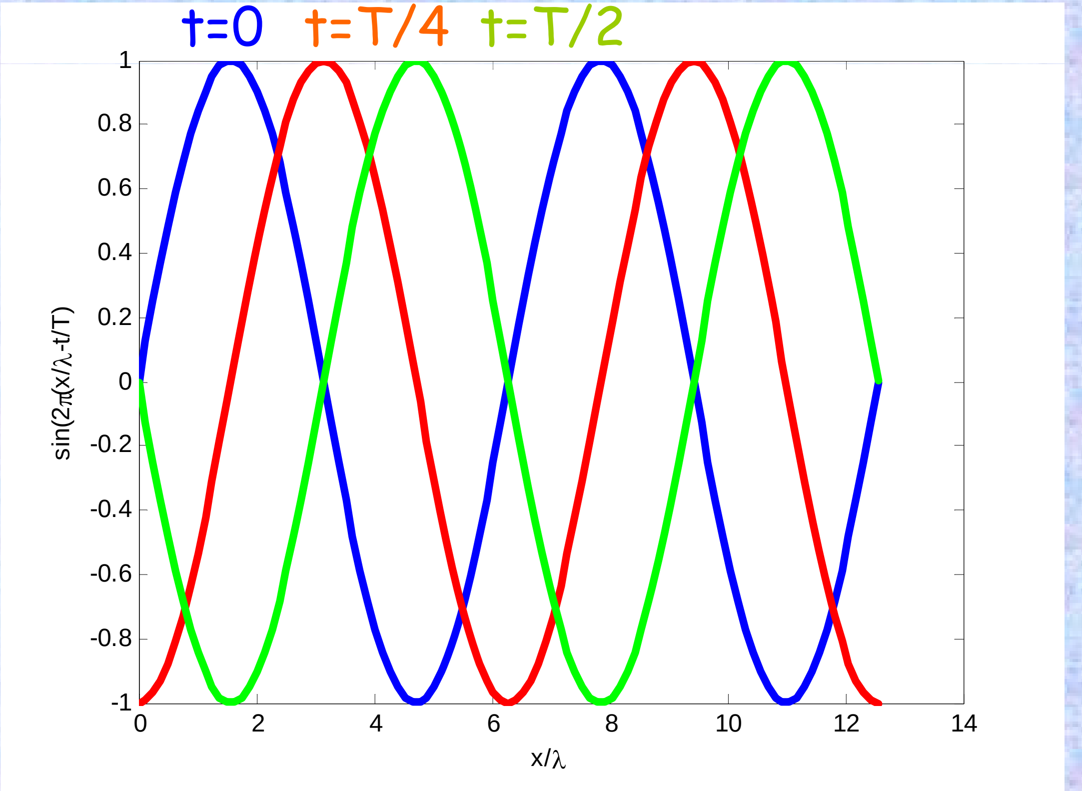
Wave packet:



- Wave propagation:
  - Plane wave propagating in positive x direction:

    $h = A\sin\{2\pi(x/\lambda - t/T) + \phi\}$

    Phase: $2\pi(x/\lambda - t/T) + \phi$



  - Speed of propagation:
    - Phase speed (celerity): $c = \lambda/T$
    - Group speed-speed of energy propagation.
    - Not necessarily the same (or even in the same direction).

- Deep and shallow-water waves (H-water depth):
  - Different behavior

Deep water waves: $\lambda<2H$, $C=[g\lambda/2\pi]^{1/2}$

Different waves (λ) have different speed- *dispersion*.

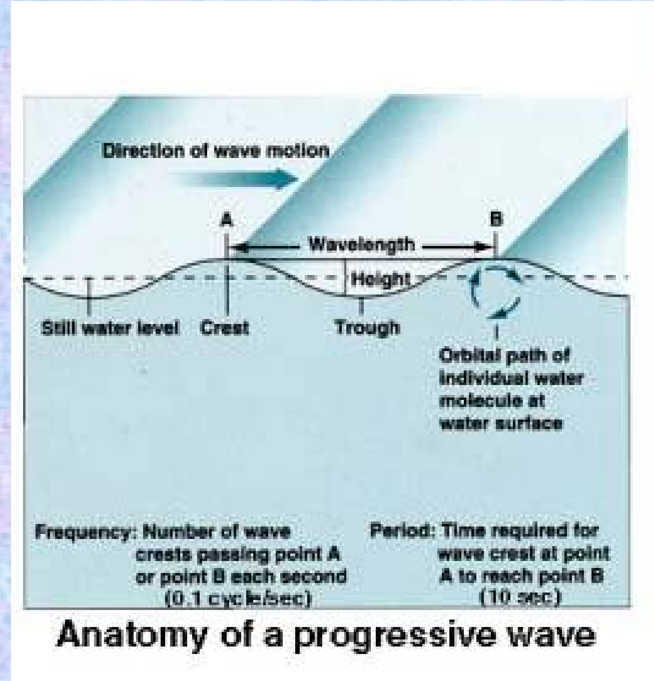
$c_g=0.5C$

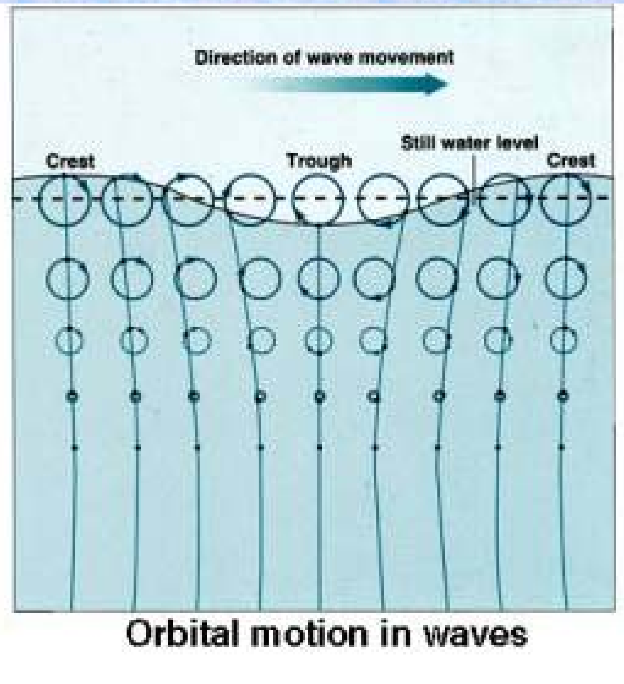
Shallow water waves: $\lambda>20H$, $C=[gH]^{1/2}$

Different waves have the same speed- non-dispersive.

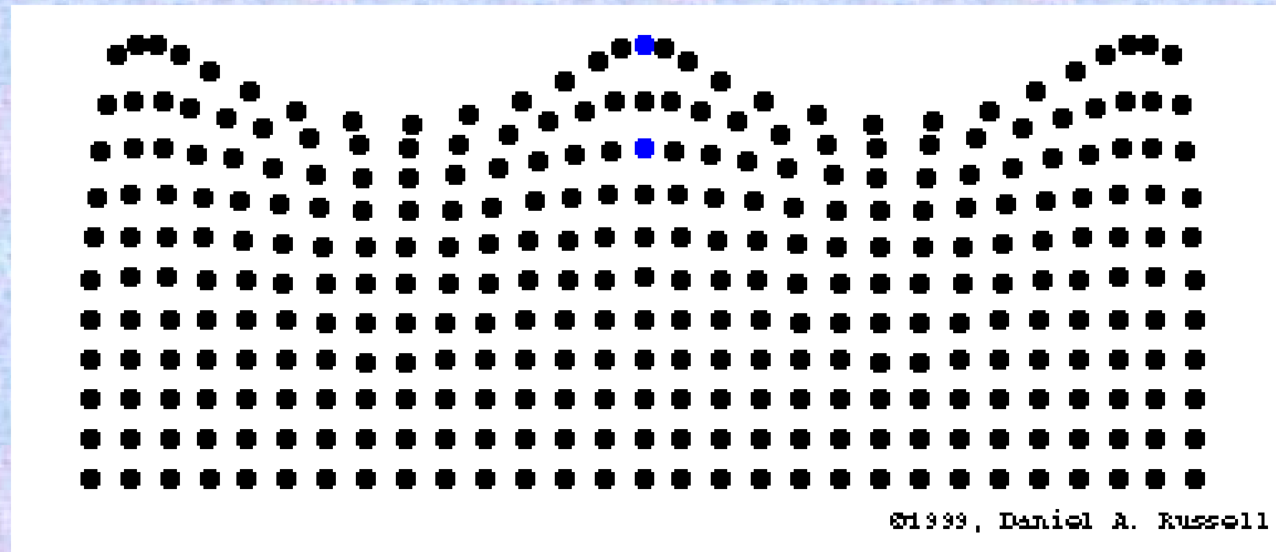
$c_g=C$

- Particle trajectory in a wave:
  - Decay with depth exp(kz), $k=2\pi/\lambda$, z-vertical distance.

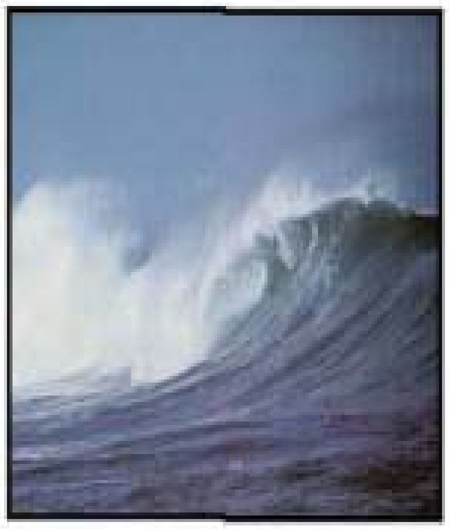




What is propagating with the wave?



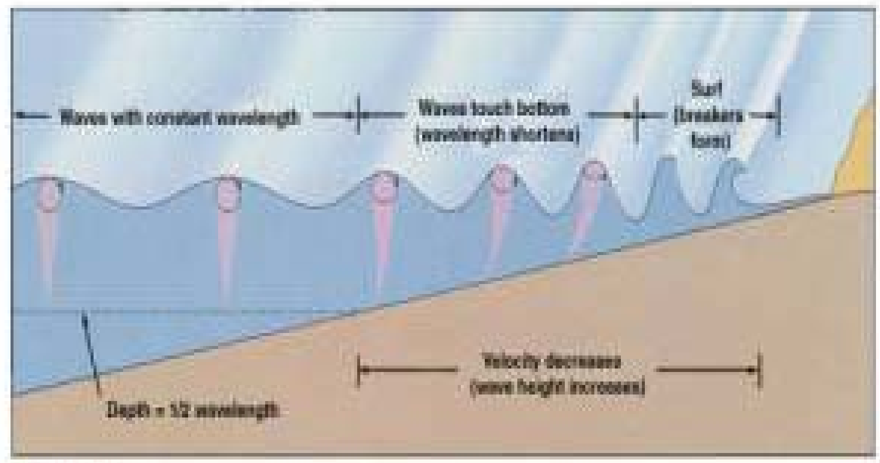
- Breaking waves:
  - As wave approach beach, change in particle trajectory.
  - Change in wavelength
  - When wave steepness ($2a/\lambda$) >1/7 $\rightarrow$breaks.



Breakers

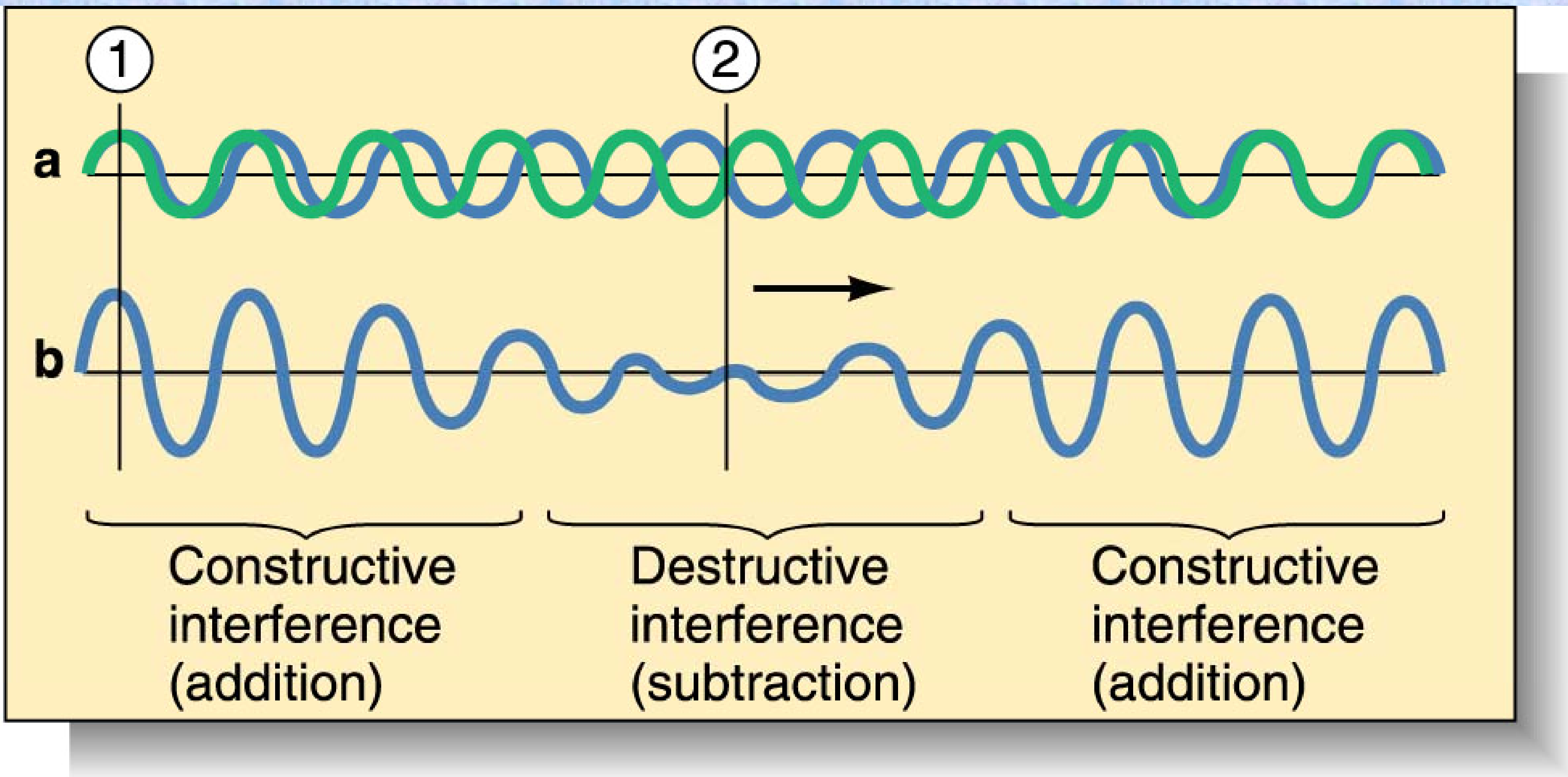
$$\frac{H}{L} \gtrsim \frac{1}{7}$$

Wave Steepness



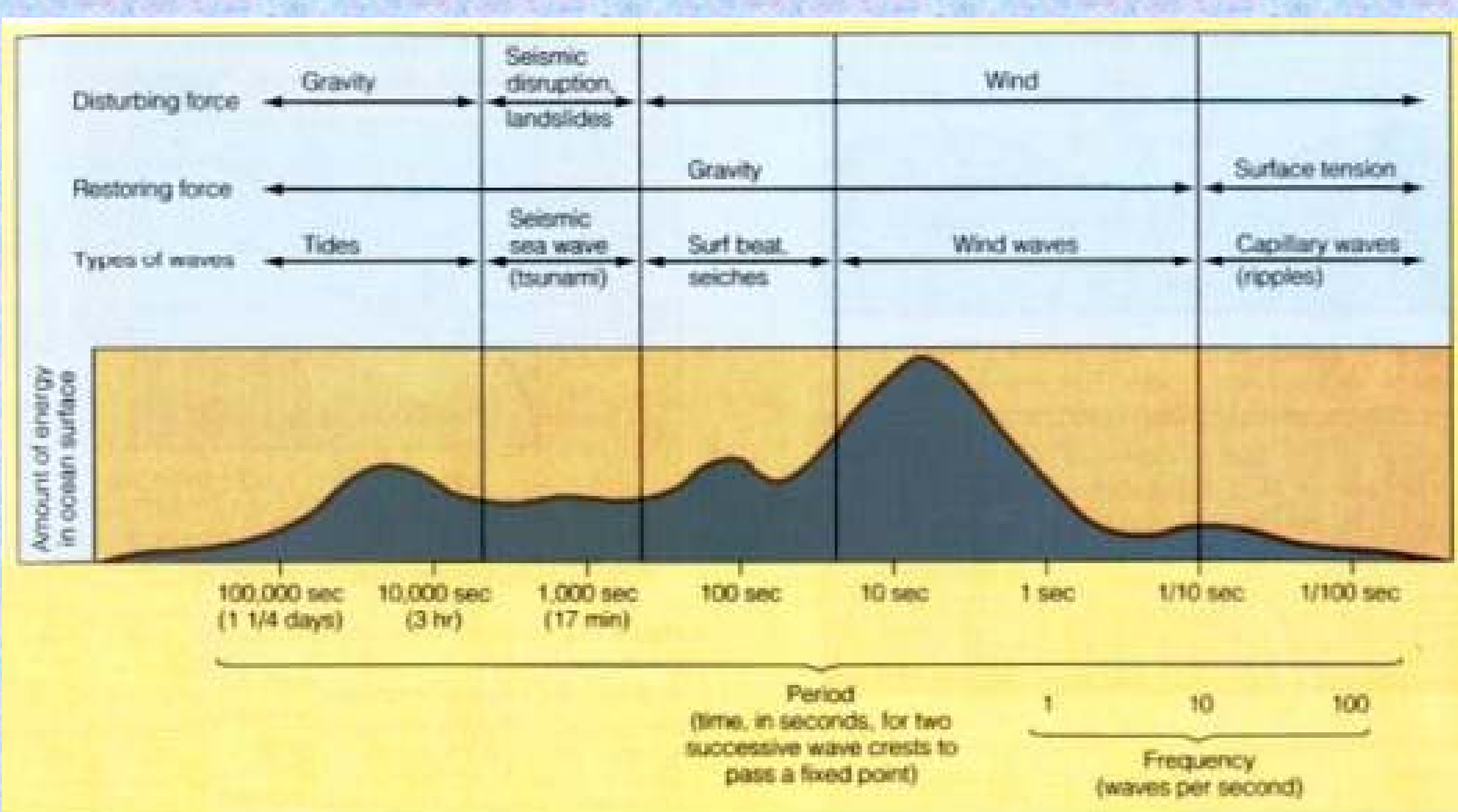
Surf Zone

- Surface: superposition of many waves:

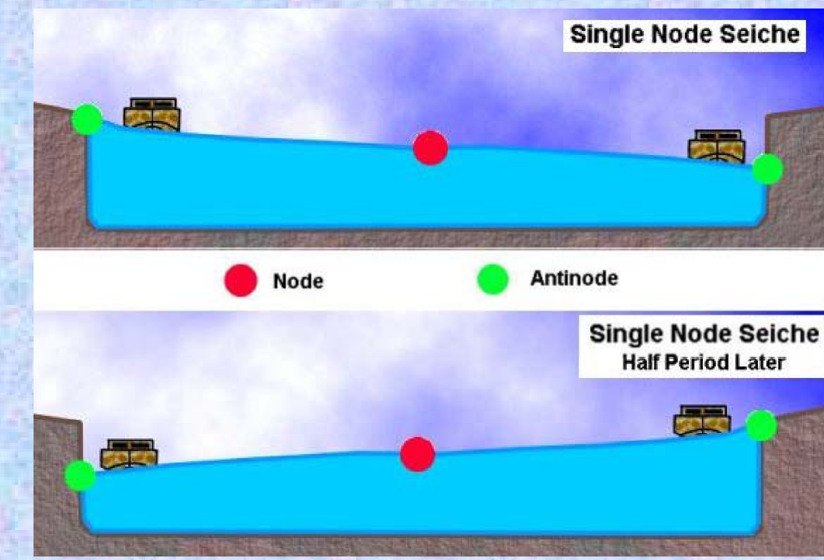


Refraction: change in wave direction due to change in propagation speed

- Wave energy
  - $E=(\rho g a^2)/2$, per L^2 both kinetic and potential
  - Propagate with c_g
  - energy flux (per L of beach): $c_g E$



Seiches – the natural modes of a basin



http://www.islandnet.com/~see/weather/almanac/arc2004/alm04jun.htm

Seiche calculator (http://www.coastal.udel.edu/faculty/rad/seiche.html)

In an enclosed basin: the 1st (usually dominant) mode is half wavelength long.

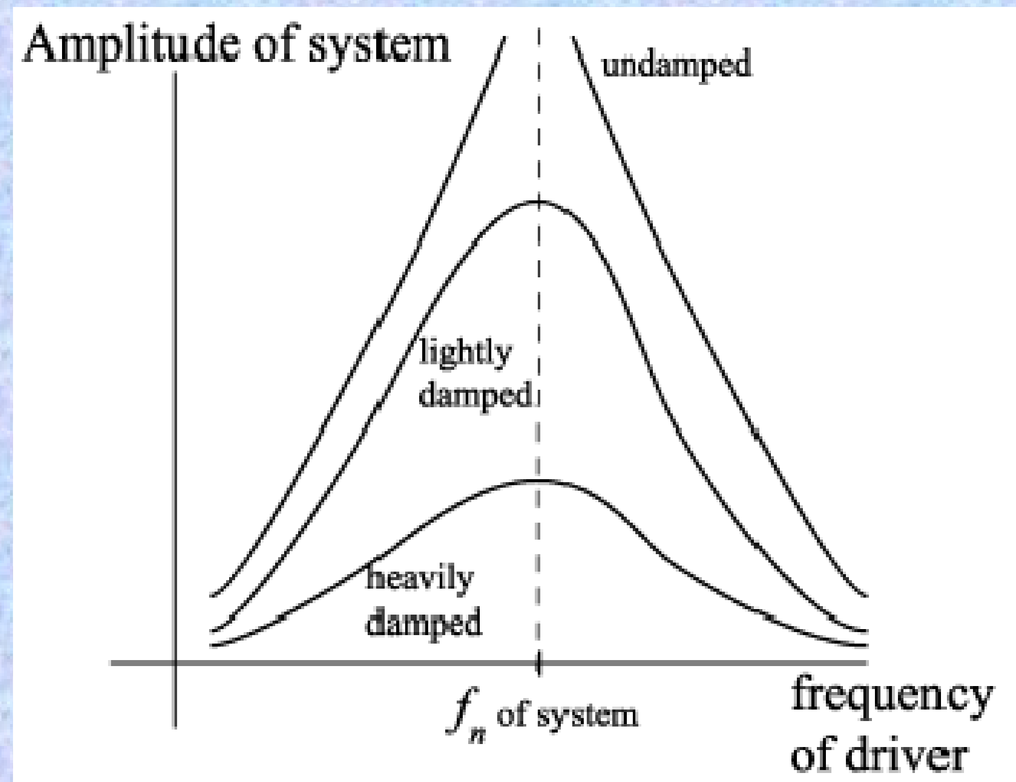
In a basin open at one side: the 1st mode is a quarter wavelength long.

The seiche is the 'natural' wave of the basin.

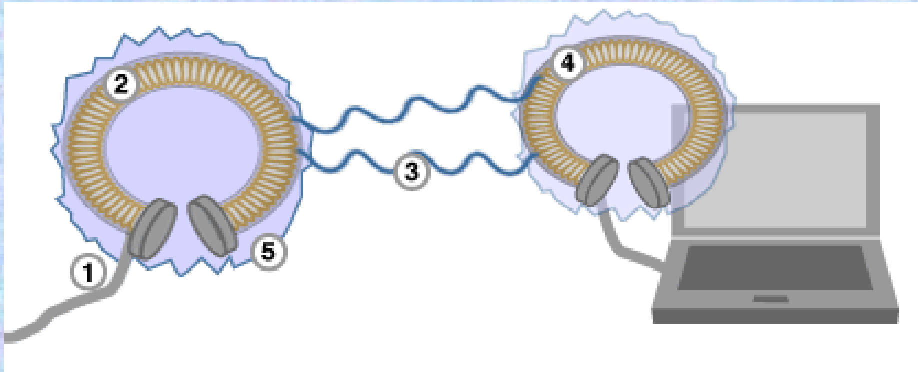
How do we determine the period of a seich for a basin of depth H and length L?

Resonance

- Physical construct have natural frequencies based on their dimensions (think about musical instruments).
- Forcing at these frequencies (among others) result in large response at the resonant (s) frequency (ies).



Breaking news:



Doppler shift

- Change in frequency due to the motion of the source and/or the receiver
- Allows for determination of movement of target.

Stationary source:

$f = c/\lambda$

$f' = (c \pm u_r)/\lambda$

$\rightarrow \Delta f = \pm u_r/\lambda = f u_r/c$

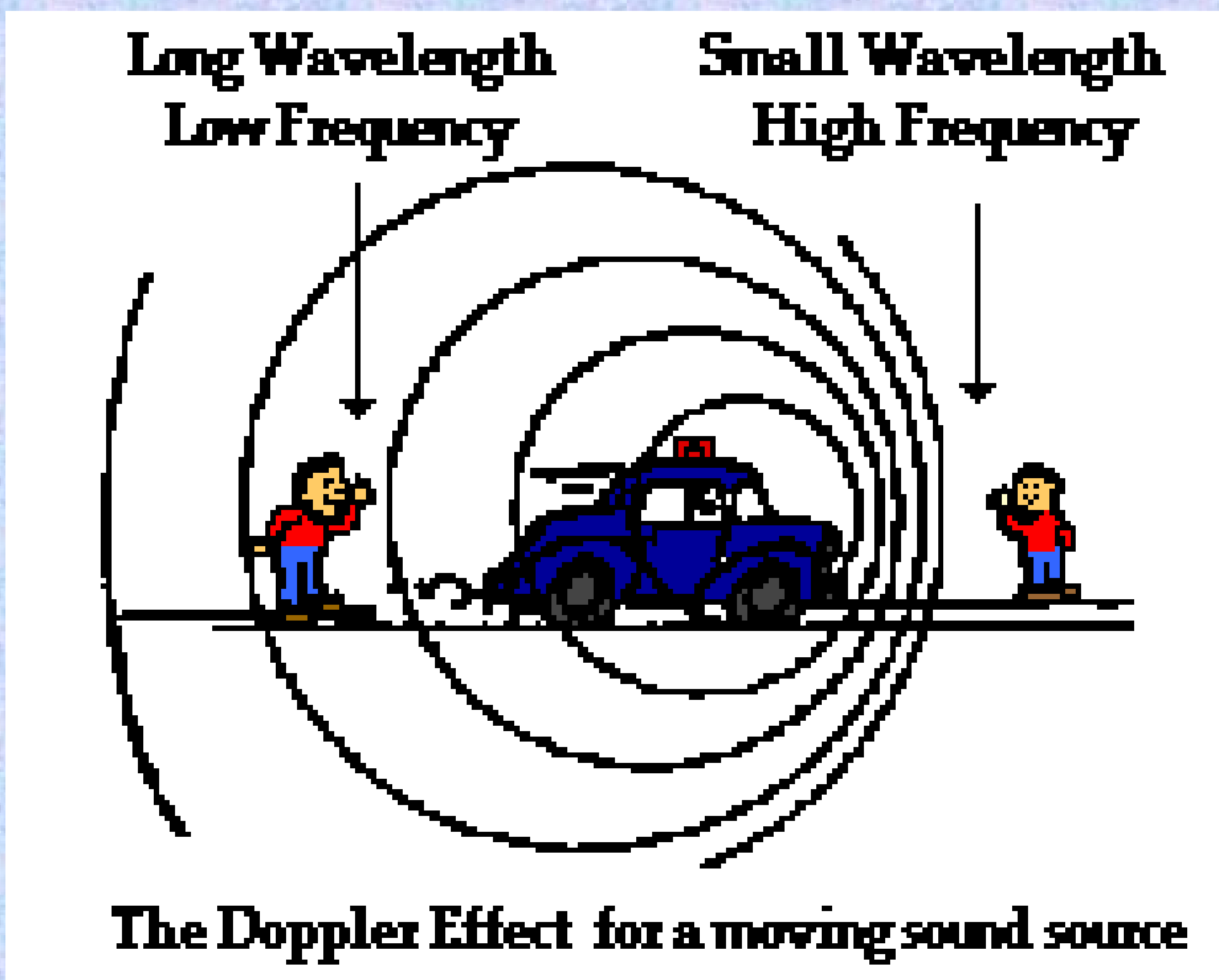
Stationary receiver:

$\Delta f = \pm f u_s/(c \pm u_s) \sim \pm f u_s/c$

Both moving:

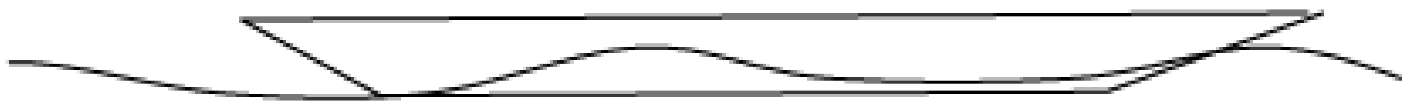
$\Delta f \sim f(\pm u_s \pm u_r)/c$

c-speed
λ-wavelength
f=frequency
$u_{r,s}$-speed of receiver or source



Most common method to measure currents

- Hull speed
  - Speed of wave formed at the surface by moving an object (boat, duck)=$(gL/(2\pi))^{1/2}$
  - Going faster than hull speed results in excessive drag.



A boat moving at slow speeds creates a series of waves with short wavelenths

A boat moving at higher speeds will create longer waves. At a critical speed, called the Hull Speed, the length of the wave will equal the length of the boat, and to go faster, the boat must work against gravity to climb out of the trough of its own wave. Powerboats can exceed Hull Speed by climbing out of the trough and skimming (hydroplaing) on top of the water, but human powered boats cannot.

http://students.washington.edu/~ukc/library/052902-1notes.pdf

The strangest water wave, the internal wave:

Continuously stratified fluid. For more:
http://www.gfd-dennou.org/library/gfd_exp/exp_e/index.htm