Oceanography Chapter 11: Tides

"Tidal" Wave
>True one is a Tidal Bore – where high tide advances up a narrow river valley.
- Most are about 3 feet, but the biggest is 28 ft and moves at 25 mi/hr .

Wavelengths of tide – are always shallow water waves

Tides are periodic, short-term change in the height of the ocean surface at a particular place caused by a combination of the gravitational force of the moon and the sun and the motion of the earth.

Tides are the longest of all waves and are forced waves, which are never free of the forces that create them.

First studies and ties to the moon- the Greeks – Pytheas (300 BC)

Math description later – Newton – 1687
Mathematical Principals of Natural Philosophy
- Main idea – Pull of gravity between two bodies is proportional to the masses of the bodies, but inversely proportional to the square of the distance between them.

Implications: Heavy bodies attract each other more, G weakens fast with distance

$$F = G \frac{(m_1, m_2)}{r^2}$$

But, the tides are a little different, and are expressed by

$$T = G \frac{(m_1, m_2)}{r^3}$$

r = distance between their centers

Thus, sun is 22 trillion times more massive, but 387 times farther away
- So, its influence is 46% that of the moon's

Newton's Model of Tides- Equilibrium Theory
- Does not function ocean depth or land masses

Dynamic Theory – LaPlace – accounts for these

EQ Theory
Earth and Moon are attracted, but inertia (the tendency of an object to move in a straight line) keeps us in balance.

Insert Pretty Drawing here:

- Sometimes called centrifugal force

Moon revolves around the earth around the center of mass, which is located about 1000 miles down

Figure 11.5: Forces involved in the development of the tidal bulge – Tractive forces

- Points 1-2 G > Inertia (look at arrows)
- Points 3-4 G< Inertia

Only at CE are they equal – solid Earth can't move much, but liquid and gas can.

The bulges stay aligned with the position of moon (Figure 11.6).

- And the earth rotates through the bulges (the crest & trough!)

1) The bulges represent high tides – the crest of the bulge
2) The troughs represent low tides

Figure 11.7 - shows island going through the tides

Complications:
1) Lunar Tides – cycle in 24hrs 50 min
(Cycle rises 50 minutes later each day) - Figure 11.8

2) Moon does not revolve around the earth of the Equator, it's orbit is tilted 28½°
-Fig 11.9
(Other wise we would have lunar/solar eclipses every 2 weeks)

Thus, some highs are higher, some are lunar – Figure 11.10

Solar Tides – gravity between Earth and Sun – only 46%

- Solar Bulge (we are tilted 23½°)

Sun and Moon together – Figure 11.11

- Both Bulges

Remember $F = G \frac{(m_1, m_2)}{r^2}$

and r^2 changes a little

Apogee – Moon's greatest distance
Aphelion – Earth's greatest distance from the sun

Perigee – Moon's closest point
Perihelion – Earth's closest

Dynamic Theory of Tides

- Newton knew his theory was incomplete – theory for Bulge is smaller
- La Place took into account these differences
- First proposes by LaPlace in 1775
- Tides are a form of wave
    - Crests are the total bulge

So tides also behave as shallow water waves.

Types of Tides:

1. Semi – diurnal - 2 highs, 2 lows
2. Diurnal – one high and one low
3. Mixed – successive high or low tides have significantly different heights throughout the cycle

Examples: 11.12-11.13

Figure 11.14 – Pacific Ocean gets all kinds of tides

Why? Amphidromic Circulation

Amphidromic Point - a no tide point in the ocean around which the tidal crest rotates through one tidal cycle. (Figure 11.15)

The highest of the tides are farthest from the amphidromic point

Tidal Datum – reference level to which tidal height is compared

- It is not always mean sea level, which is the height of the ocean surface averaged over a few years time

MLLW – Mean Lower Low Water

- Average level of the lower of the two daily lows (for mixed tides)

MLW – Mean Low Water – average level of all lows (for diurnal & semi)

Tidal Range – High water to low – water height
Lakes – small
Larger enclosed areas (Baltic, Mediterranean) – moderate
Basin is wide and symmetric (Gulf of St. Laurence)

- Mini-amphidromic – Figure 11.17

Basin is narrow and restricted – no AP – simply moves in and out of the bay

- Extreme tides occur in places where arriving tide crests have natural oscillation periods of 12 or 24 hours
- Bay if Fundy – 15m (50 feet) – Figure 11.18/11.19

Tidal Bore – steep wave moving upstream generated by the action of the tide crest in the enclosed area of a river mouth.
SW China, Bay of Fundy, Amazon, Ganges, Delta, Severn River of England

<u>TIDAL CURRENTS</u>
Flood Current- water rushing into an enclosed area because of the rise in sea level as a tide crest approaches

Ebb Current- water rushing out because of the fall in sea level as the tide trough approaches.

Slackwater – no tidal currents

Tidal currents are greatest in bays or estuaries where flow is contained.

Tidal Friction

- Gradually slowing Earth's rotation by a few hundredths of a second per century.

Even a small change has long term planetary effects
350 MYA – 400 – 410 days - 22 hrs
280 MYA – 390 days – 22 ½ hrs

Predicting and Studying Tides
Meteorological Tides - weather affects - difficult

Marine Critters – affected by tidal zones
Grunions- Fig 11.20 – time spawning with Spring Tide

Power from the tides
Ships sail and come back to shore with the tides

First major tidal station – 1966 in France

- Catch flow in and out (Fig 11.21)
- Big one – 850m (2800 ft)