8. THE TIDES

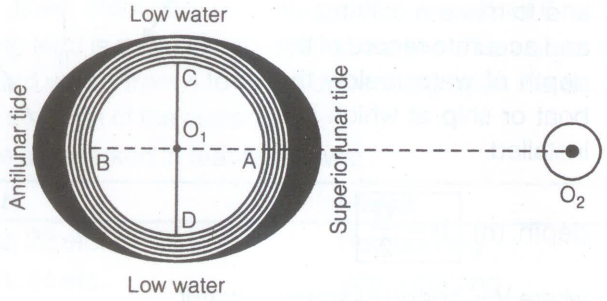
DEFINITION

All celestial bodies exert a gravitational force on each other. These forces of attraction between earth and other celestial bodies (mainly moon and sun) cause periodical variations in the level of a water surface commonly known as tides.

ASSUMPTIONS MADE IN THE EQUILIBRIUM THEORY OF TIDES

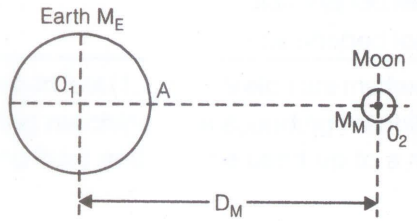
- The earth is covered all round by an ocean of uniform depth.
- The ocean is capable of assuming instantaneously the equilibrium figure required by the tide producing forces.

Lunar tide:



- There are two lunar tides at A and B, two low water positions of C and D.
- The tide of A is called the superior lunar tide or tide of moon's upper transit, while tide at B is called inferior or anti-linear tide.

Solar tide:



- Tide producing force F_M of the Moon on unit mass at A is given by

$$F_M = kM_M\left(\frac{2R}{D_M^3}\right)$$

- Tide producing force F_S of the Sun on unit mass at A is given by

$$F_S = kM_S\left(\frac{2R}{D_S^3}\right)$$

Here, M_S = Mass of Sun
M_M = Mass of Moon
D_M = Mean distance from the centre of earth to the centre of the Moon.
D_S = Mean distance from the centre of earth to the centre of the Sun.
R = Radius of earth.
K = Constant of gravitation

- $\frac{F_S}{F_M} = 0.458$ i.e. Solar tide = 0.458 · Lunar tide
- $M_M = \frac{1}{18}M_E$ and $M_S = 331000\ M_E$

where M_E = Mass of earth

The age of tide varies for different places, upto a maximum of 3 days, and is reckoned to the nearest 1/4 day.
The age of tide is one of the non-harmonic constants.

- Lunitidal interval is the time interval that elapses between the moon's transit and the occurrence of the next high water.
- The time of transit at the given place can be derived by adding 2 m for every hour of west longitude and subtracting 2 m for every hour of east longitude of the place to the time of transit of Greenwich.

VULGAR ESTABLISHMENT

- **Definition:** Vulgar establishment is defined as the value of lunitidal interval on the day of full moon or change of moon.

$$\text{Mean establishment} = \text{Vulgar establishment} - \text{lagging correction}$$

$$\text{Lagging correction} = 26\ M$$

Height of tide: (H)

$$H = h + \frac{1}{2} \cdot r \cos\theta$$

where, h = height of mean tide level above datum
r = range of tide

$$\theta = \frac{\text{Interval from high water}}{\text{Interval between high and low water}} \times 180°$$

Prediction of tide with Harmonic constants:

$$V = fH\cos(E - g)$$

where, V = value of constituent at zero hour on the day
H = mean amplitude (half range) of the constituent at the port
f = factor, the value of which is very near to unity and which varies slowly from year to year.
E = angle (same for all ports)
g = constant, special to the port and the constituent

$$E(\text{at zero hour}) = m + d$$

where, m = value of E at zero hour of the first day of each month
d = increment in E from zero hour of the first day of the month to the zero hour of the day.

Symbol for constituent	Description or name	Period
M_2	Lunar semi-diurnal	$\frac{1}{2}$ Lunar day
S_2	Solar semi-diurnal	$\frac{1}{2}$ Solar day
N_2	Larger elliptic-semi-diurnal	—
K_2	Luni-solar diurnal	$\frac{1}{2}$ Sideral day
K_1	Luni-solar diurnal	Sideral day
O_1	Larger diurnal (declinational)	—
P_1	Solar diurnal (declinational)	—
M_4	First overtake of semi-diurnal	$\frac{1}{4}$ Lunar day
MS_4	Compound luni-solar $\frac{1}{2}$ diurnal	—

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