

TIDE GENERATING FORCES

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Lunar tide-producing forces

Consider the earth moon system. For the earth and the moon to be in equilibrium, the total attractive forces for all particles on the earth by the moon should balance the total centrifugal forces, resulting from the rotation of the earth. The centrifugal force is v^2/R (for unit mass) and is directed outward along the radius. The attractive force varies for different points on the earth. Even though, a balance between these two forces exists for the entire earth, it does not exist for particular points on the earth. The attractive force at the centre of the earth is given by xM/a^2 , where x is the Gravitational constant, M is the mass of the moon and a is the distance between the centres of the earth and moon. Let R be the radius of the earth (Fig. 1) and μ a mass element on the earth.

	Zenith	Centre of the earth	Nadir
The force of attraction	$\frac{x \mu M}{(a - R)^2}$	$\frac{x \mu M}{a^2}$	$\frac{x \mu M}{(a + R)^2}$
The centrifugal force	$\frac{-x \mu M}{a^2}$	$\frac{-x \mu M}{a^2}$	$\frac{-x \mu M}{a^2}$
The tide-producing force	$\frac{x \mu M 2 R}{a^3}$	0	$\frac{-x \mu M 2 R}{a^3}$

Note: The centrifugal force is equated with negative attractive force at the centre of the earth.

Variations in lunar-induced tides

(i) Moon's declination:

So far, we considered the moon in the equatorial plane of the earth for deducing tide-producing forces. Declination of the moon is 28° . The line joining the centre of the moon varies upto 28° on either side with respect to the earth's equatorial plane over a cycle of 27.2 days (Fig. 2).

At point Y, large high tide occurs and at point X, small high tide occurs. When the moon is at a large angle of declination, the plane of the two tidal bulges will be off set with respect to the equator, and their effect at a given latitude will be unequal particularly at mid-latitudes.

The effect of a diurnal component is to produce unequal highs and unequal lows in an otherwise dominant semi-diurnal component. When the declination is maximum, diurnal variation is maximum, the tides are known as tropic tides. At minimum declination there is no diurnal variation and the tides are called equatorial tides.

(ii) Lunar day:

The moon revolves around the earth over every 27.3 days. This makes the period of the earth's rotation with respect to the moon 24 hours and 50 minutes (a lunar day). This makes the time of high tide at a given location later by about an hour every successive day.

(iii) Moon's elliptical orbit:

Perigee is the nearest point to the earth and apogee the farthest in the moon's elliptical orbit around the earth. The interval between successive perigees is 27.5 days. At perigee, the moon's tide-producing force is increased by about 20% over the average value and vice versa during apogee.

Solar tide-producing forces

The magnitude of the tide-producing forces by the sun is about 0.46 times that of the moon. Other planets are either too small or too far away to produce any effect.

The orbit of the earth around the sun is elliptical. When the distance is minimum, the earth is said to be at perihelion and when the distance is maximum, the earth is said to be at aphelion. The difference in distance between perihelion and aphelion is only about 4%.

Interaction between solar and lunar tides

When the tide-producing forces between the sun and the moon act in the same direction, (during full moon and new moon) the tidal range becomes maximum and the tides are called spring tides. The collective term used is that the moon is said to be in syzygy. When the sun and moon act at right angles to each other, the solar and lunar tides are out of phase. The tidal range becomes minimum and the tides are known as neap tides. The complete cycle of events from one full moon the another takes 29.5 days i.e., spring tides occur every 14.75 days.

Suggested Reading

1. Defant, A (1961). *Volume II of Physical Oceanography*, Pergamon Press, 598 pp.
2. Doodson, A.T. and Warburg, H.D. (1941). *Admiralty Manual of Tides*. Her Majesty's Stationery Office, London. 270 pp.
3. The Open University Course Team (1989). *Waves, Tides and Shallow-water Processes*. Pergamon Press, 187 pp.

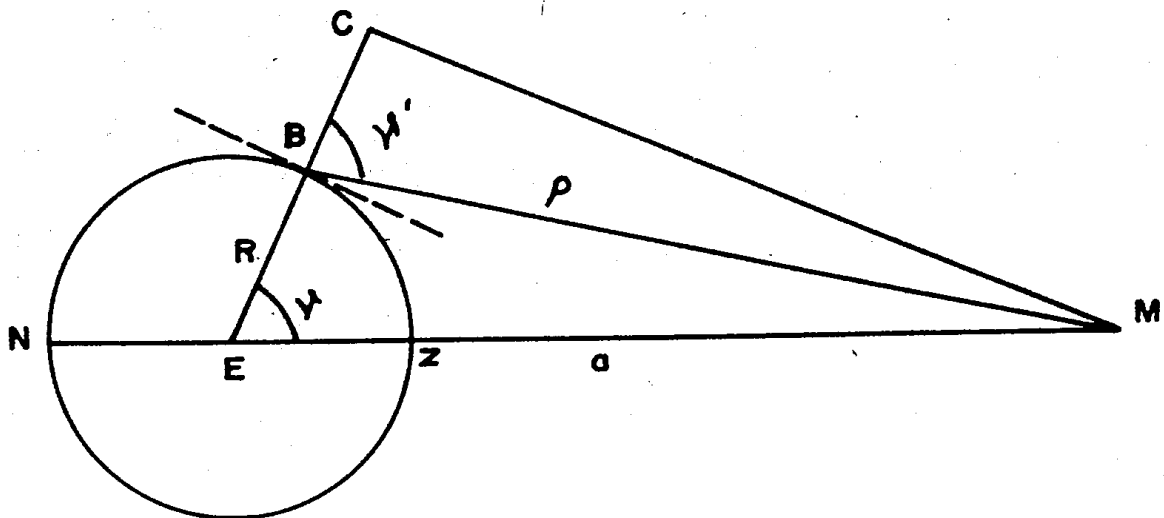


Fig 1.

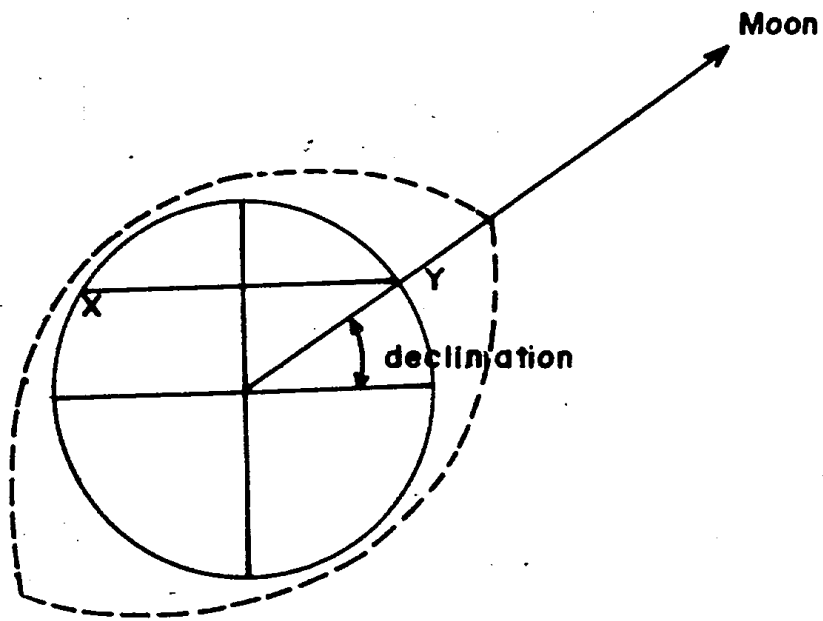


Fig 2.