

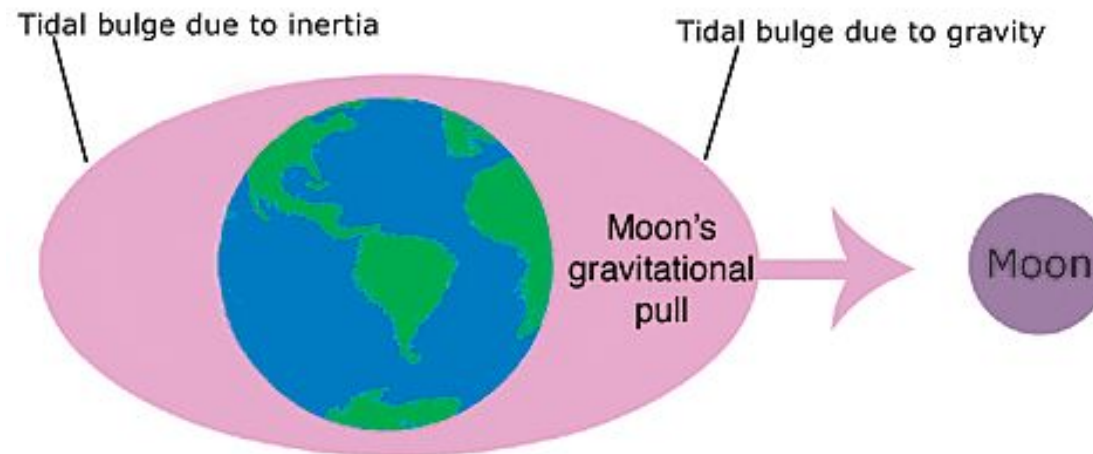


Tides

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What Causes Tides?

- Tides result from an imbalance between gravitational and centripetal force
- The moon is the dominant tidal influence on the Earth
- The Sun contributes to additional tidal forcing
- -> These forces create periodic deformation of the ocean water distribution

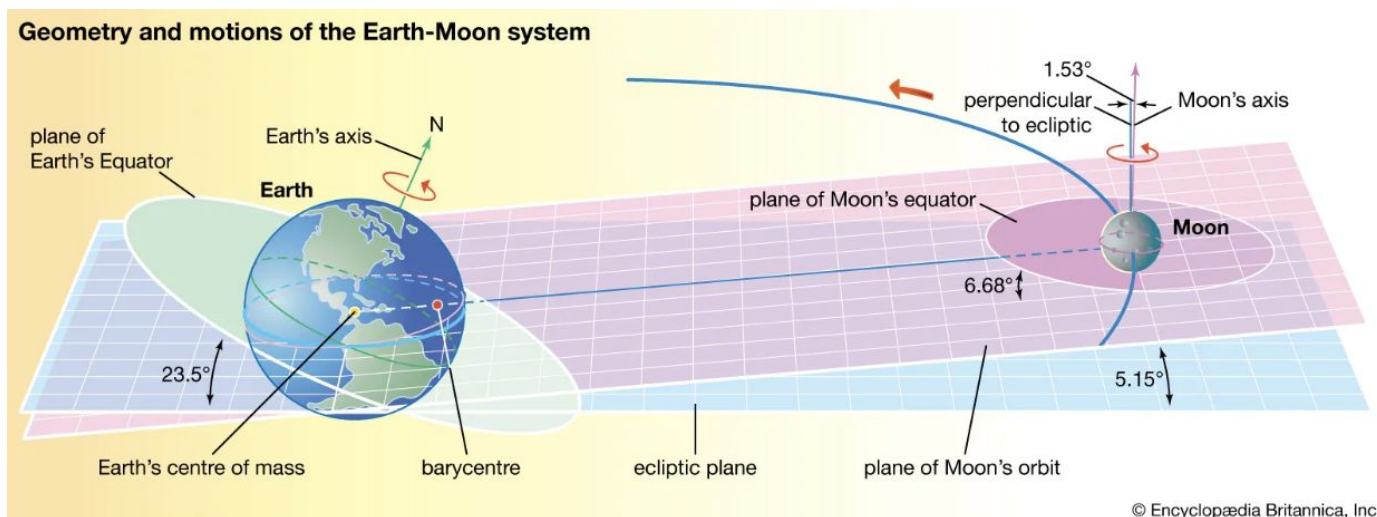


Gravitational Forces

- Gravity increases with mass and decreases rapidly with distance
- Moon's gravitational attraction is strongest at the side of the Earth which is facing the moon
- The far side of the Earth experiences weaker attraction
- Differences in gravitational pull are essential for tide formation

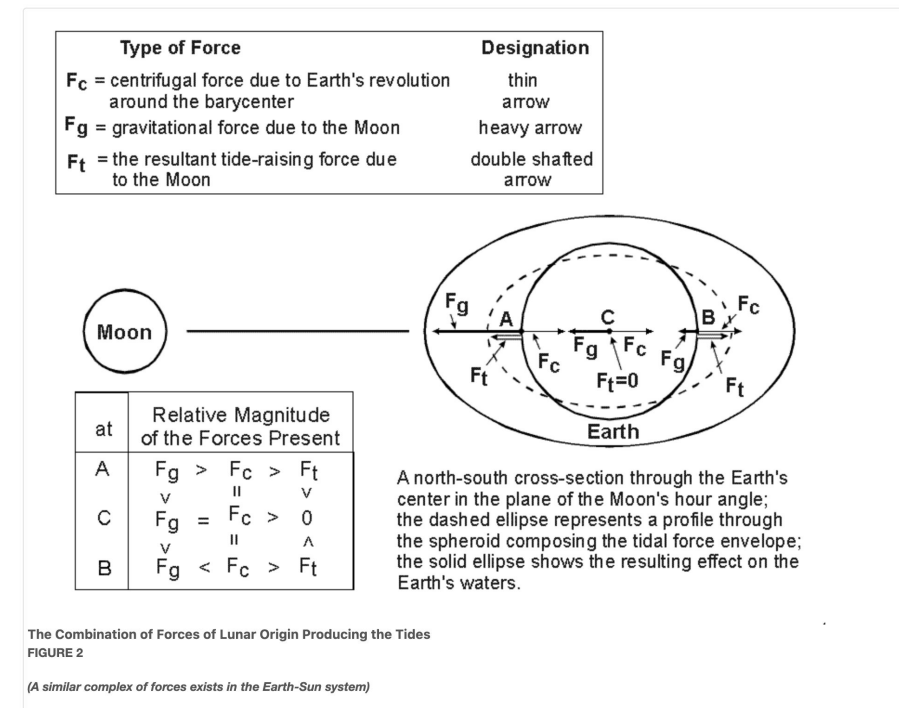
Centripetal Force & Earth-Moon System

- Earth and Moon orbit a common center of mass
- Orbital motion requires a centripetal force
- This force is approximately the same on Earth
- Interaction with gravity produces the net tidal force field



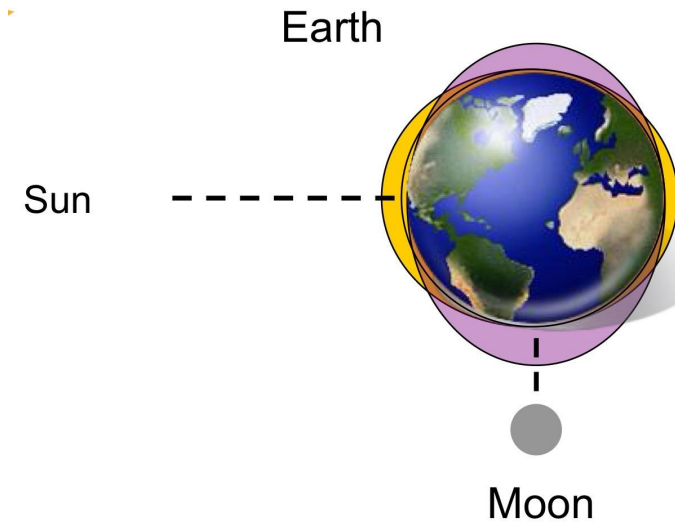
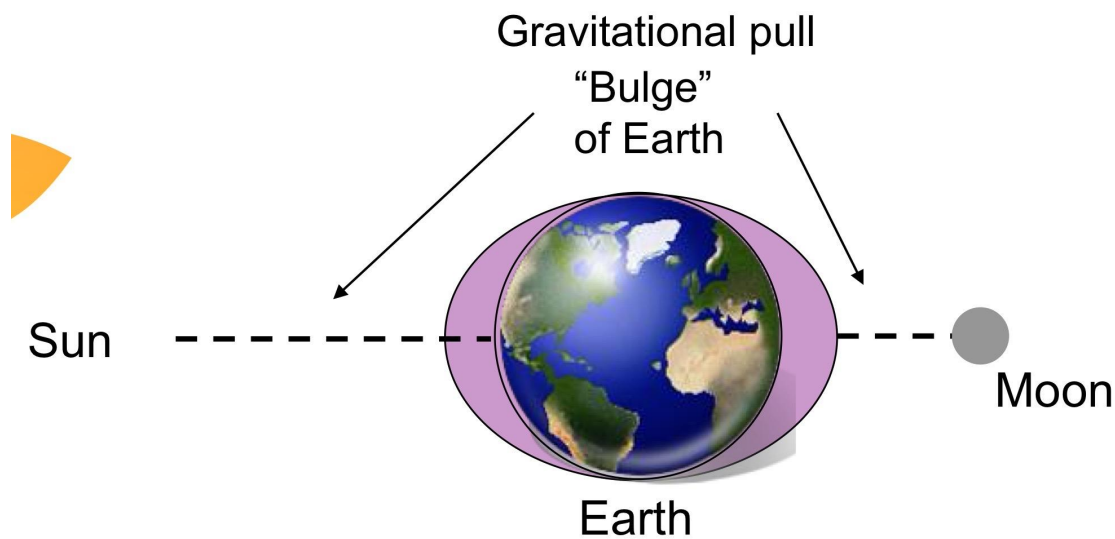
Resultant and Tide-Generating Forces

- Resultant force = gravitational force - centripetal force
- Horizontal components move ocean water most effectively
- Maximum tide-generating forces occur away from the poles and equator
- These forces create the global tidal bulges



Tidal Bulges and Daily Tides

- One bulge forms on the side facing the Moon
- A second bulge forms on the opposite side of Earth
- As Earth rotates, coastlines pass through these bulges
- This produces alternating high and low tides

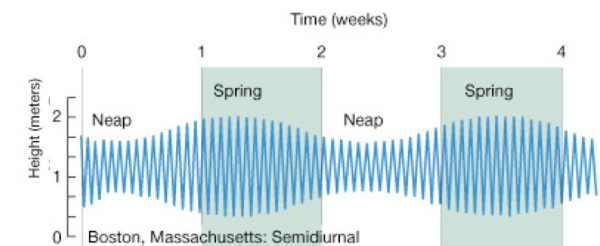
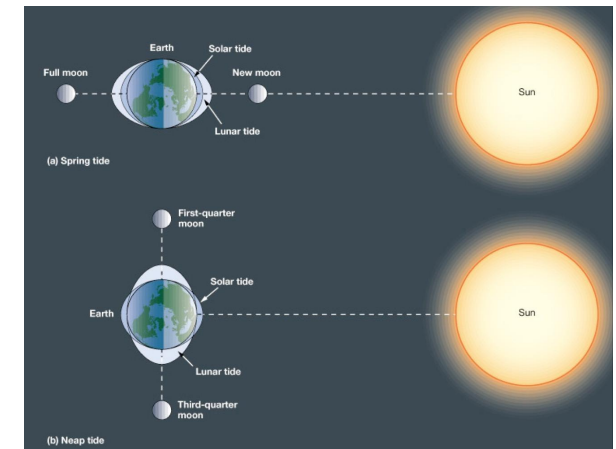


The Lunar Day

- Tidal bulges follow the Moon's orbital motion
- A lunar day lasts approximately 24 h 50 min
- High tide occurs about 50 minutes later each day

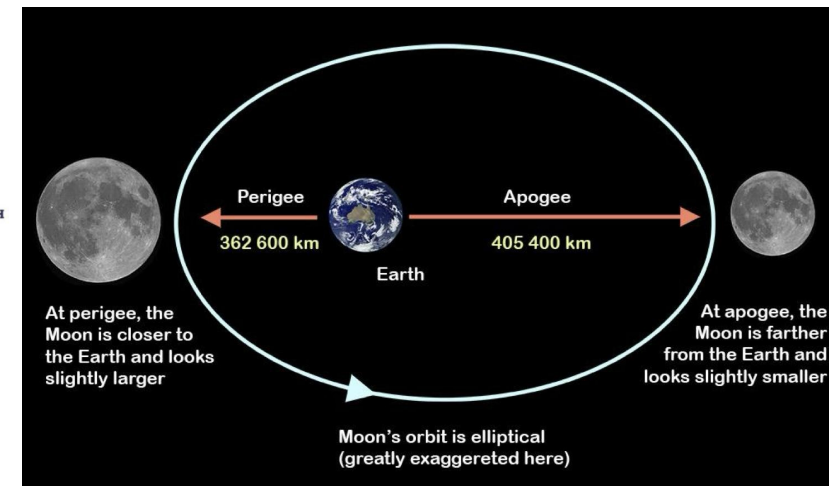
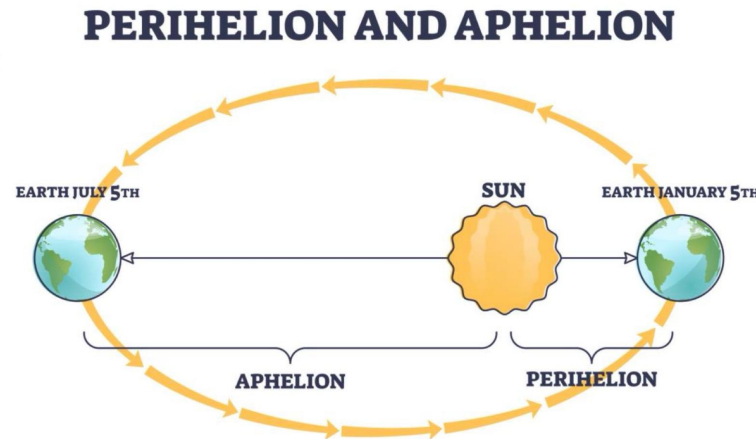
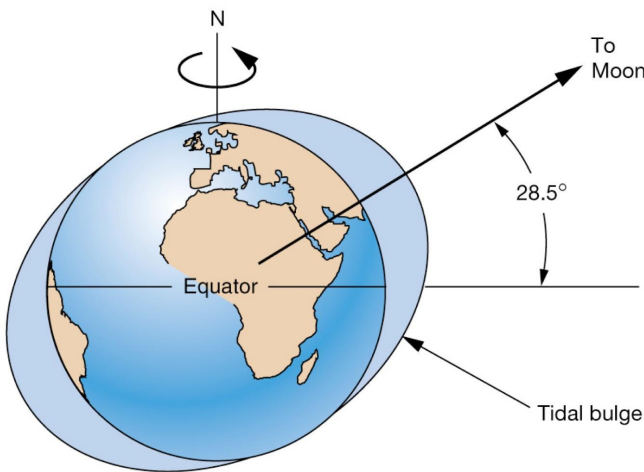
Monthly Tidal Cycle

- In this case: “monthly” = 29 ½ days
- Earth alternates between spring tide and neap tide every 7 days
 - Spring tide:
 - When Earth, Sun and Moon are aligned
 - Lunar and solar bulges constructively interfere
 - Large tidal range
 - Neap tide:
 - When Earth, Sun and Moon are at a right angle
 - Lunar and solar bulges destructively interfere
 - Small tidal range



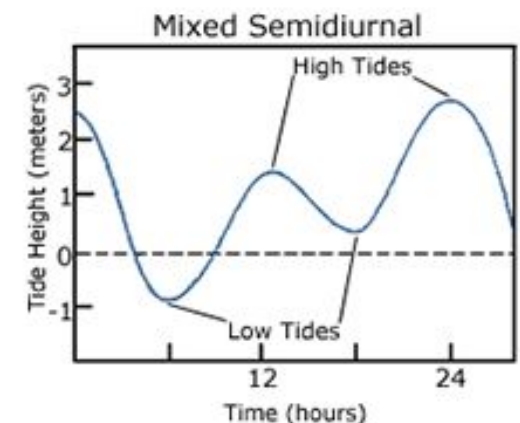
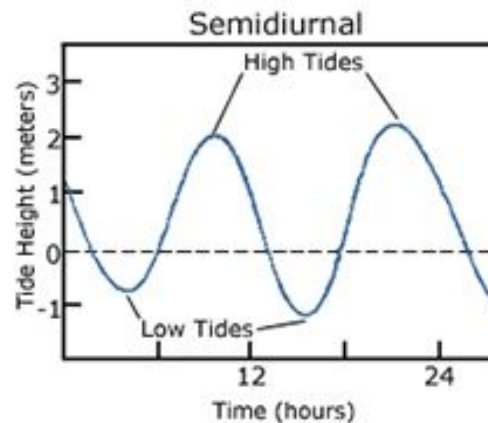
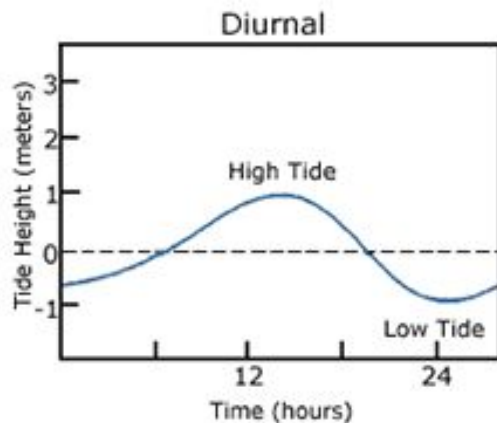
Declination, Perigee, and Perihelion

- Moon's orbit is tilted relative to the ecliptic
- Declination causes unequal successive high and low tides
- Perigee: Moon closest to Earth → stronger tides
- Perihelion: Earth closest to Sun → enhanced solar tidal influence



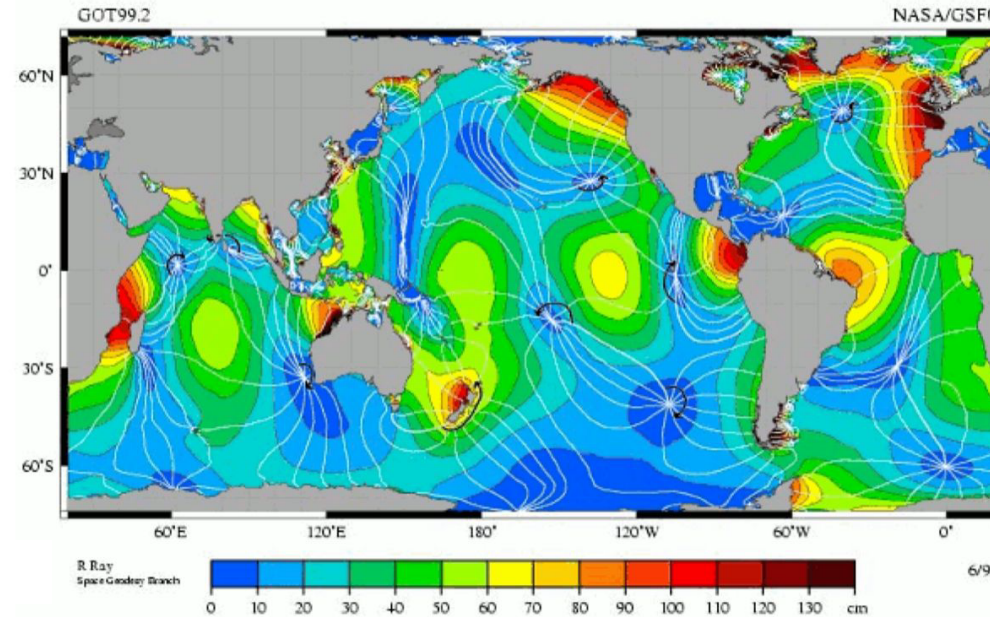
Global Tidal Patterns

- Diurnal: one high and one low tide per lunar day
- Semidiurnal: two highs and two lows of similar height
- Mixed: unequal successive highs and lows
- Pattern depends on three things:
 - Astronomical: lunar vs solar and declination
 - Geographical: Shape & orientation of coastline + width & depth of coastal shelves
 - Ocean basin configuration: large ocean basin or amphidromic system



Oceanic Tides and Amphidromic Systems

- Real oceans do not behave like an idealized water-covered Earth
- Cotidal maps show the propagation of tidal waves
- Tides rotate around amphidromic points
- Tidal range near an amphidromic point is minimal



Tidal range