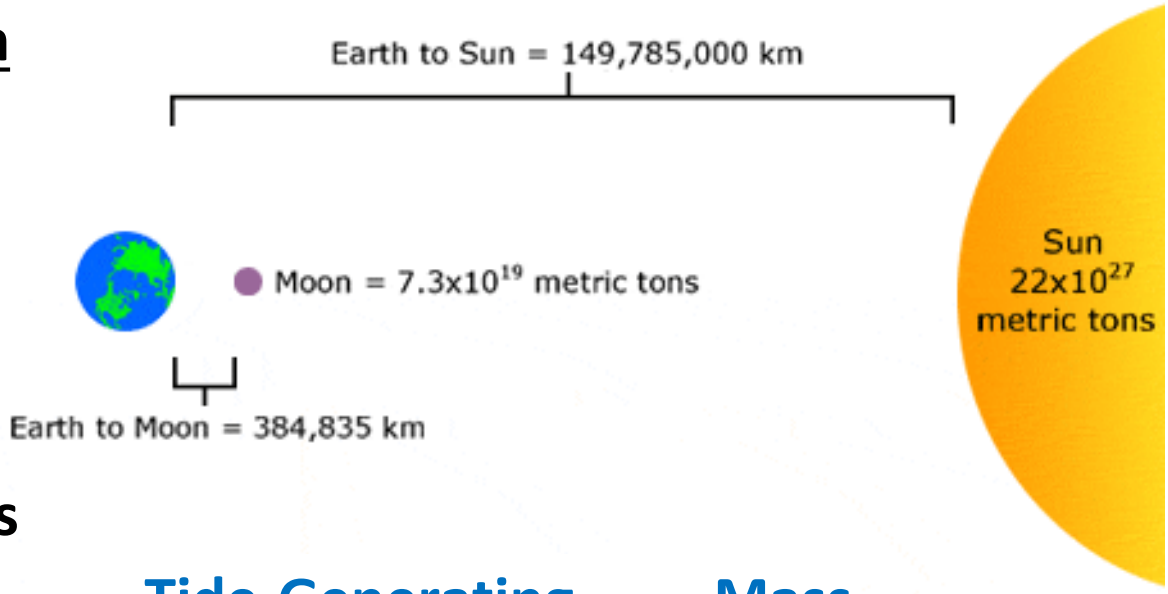
Gravitational Pull of the Moon and Sun

The relationship between the *masses* of the Earth, Moon and Sun and their *distances* to each other play a critical role in affecting the Earth's tides.

- **The Sun is 27 million times more massive than the Moon.**
- **It is also 390 times further away from the Earth than the Moon.**
- **As a result, the Sun's tide-generating force is about half that of the Moon.**



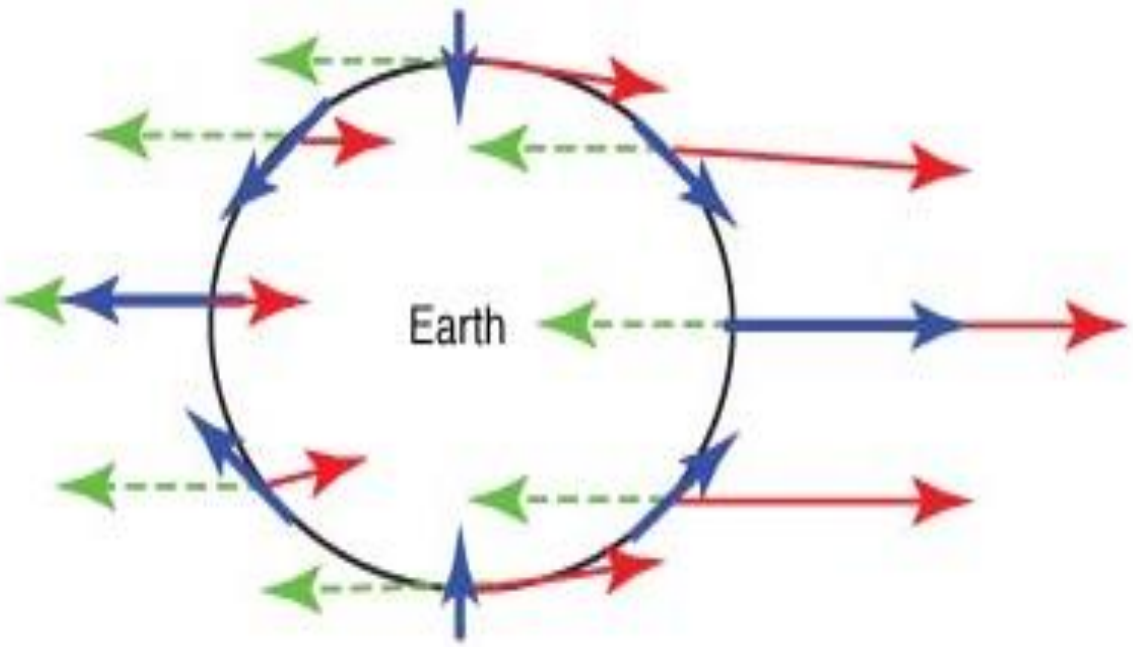
$$\text{Tide-Generating Force} \sim \frac{\text{Mass}}{(\text{Distance})^3}$$

The Moon is the dominant force affecting the Earth's tides.

Tide-Generating Force

For any two massive bodies rotating around the common center, let's consider the following two forces:

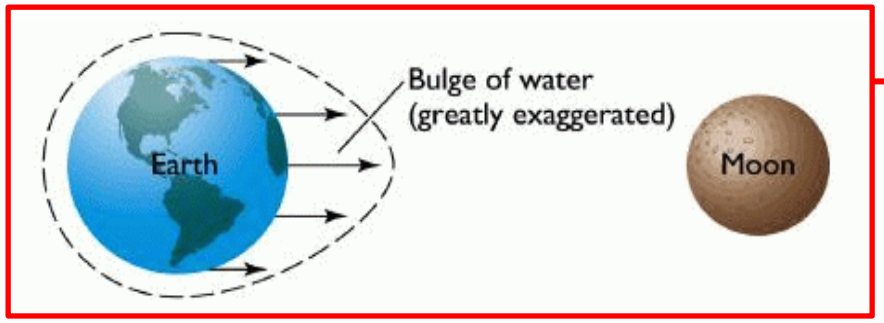
1. **Gravitational pull (varies with distance)**
2. **Apparent centrifugal force (same everywhere)**



Tide-generating force results from their difference

(and is called a *differential force*)

Tidal Bulges



gravitational attraction of the Moon dominates on the near side

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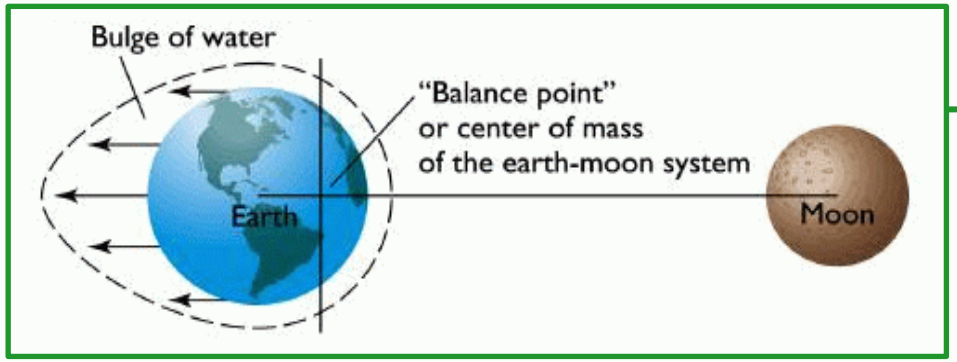
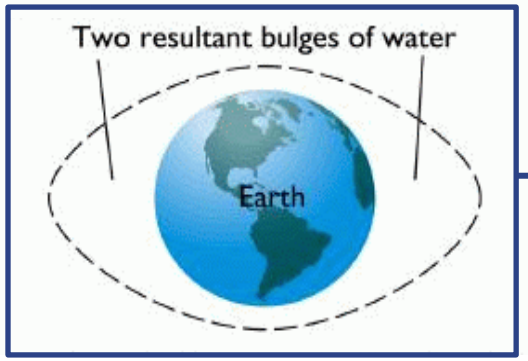


centrifugal force due to Earth-Moon rotation dominates on the opposite side

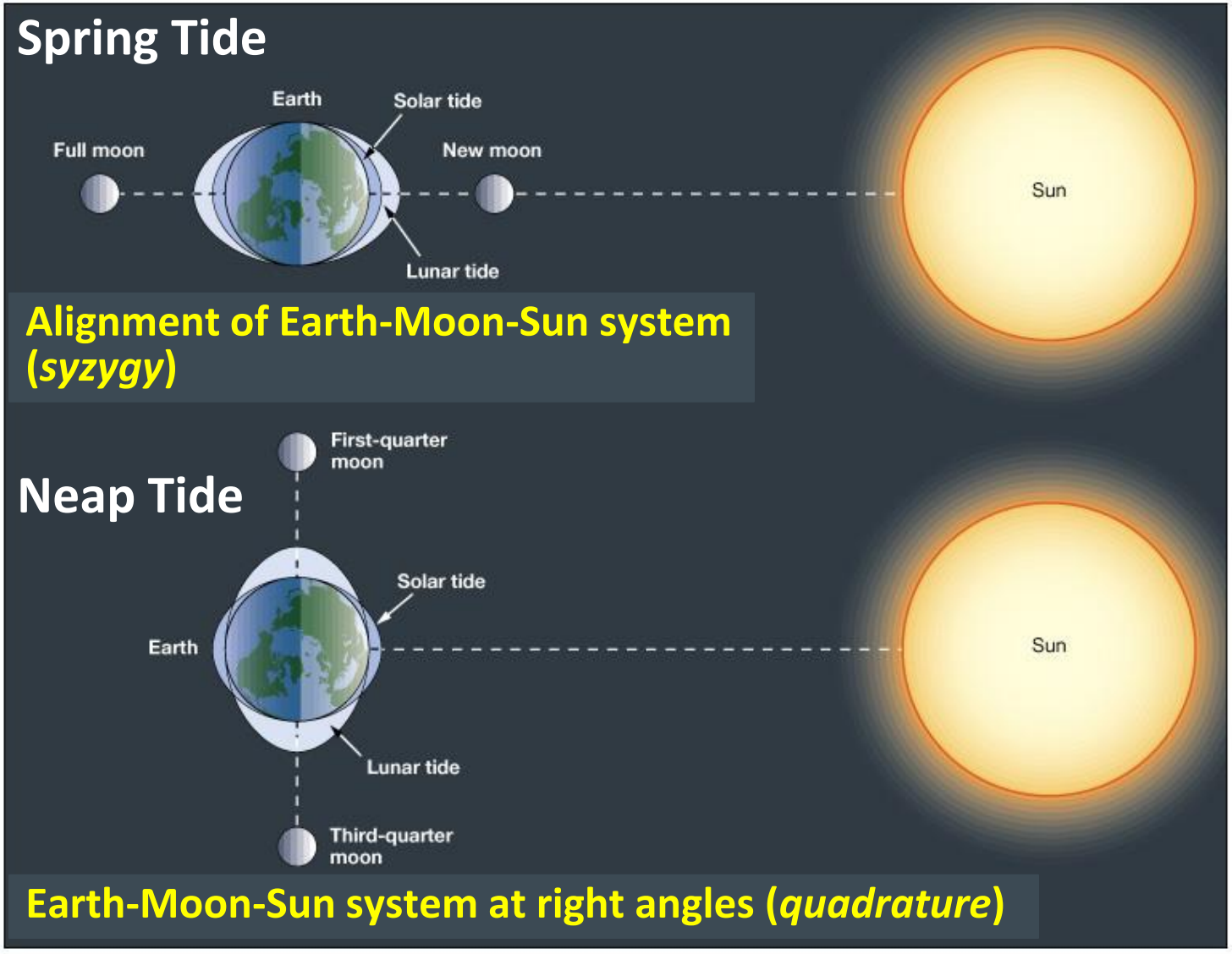


two tidal bulges of water

The Sun has a similar effect, however ~2 times smaller.

Monthly Tidal Cycle (29½ days)

About every 7 days, Earth alternates between:



Spring Tide

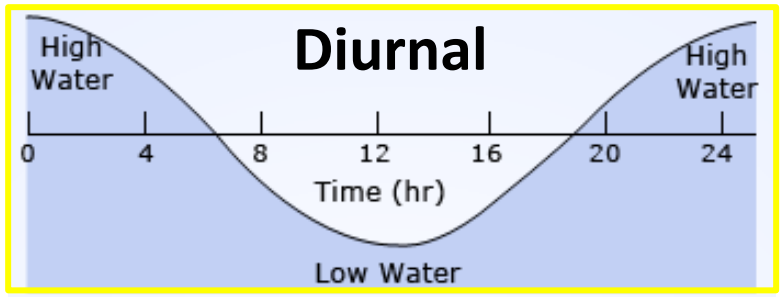
large tidal range,

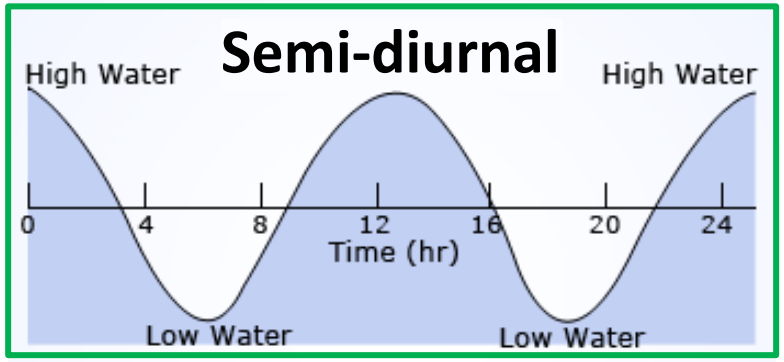
highest high tide and lowest low tide

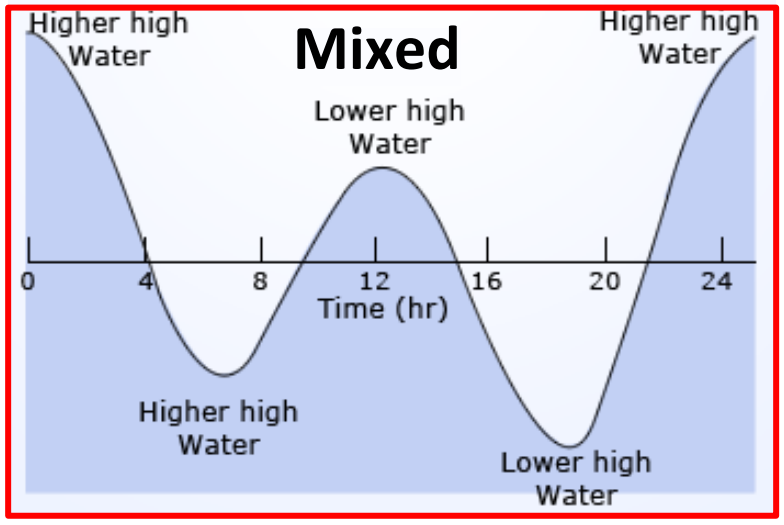
Neap Tide

moderate tidal range

Types of Tides depend strongly on the location and shoreline







- **Diurnal: one tidal cycle per day (Gulf of Mexico)**
- **Semi-diurnal: two high waters and two low waters each day (Boston, MA)**
- **Mixed: two high and two low waters each day, all four with different heights (Los Angeles, CA).**