



TIDES

Tides : the periodic rise and fall of the ocean's surface

➤ **Caused by:**

- **gravitational pull of the Moon**
- **gravitational pull of the Sun**
- **shape of the shoreline**



Tides and the Moon

- **Moon exerts a gravitational attraction on the Earth, drawing matter toward it**
- **This creates a Tidal Bulge**
- **Attraction is stronger on the side of the Earth near the Moon**
- **A Tidal Bulge also forms on the Earth's far side.....WHY ?**

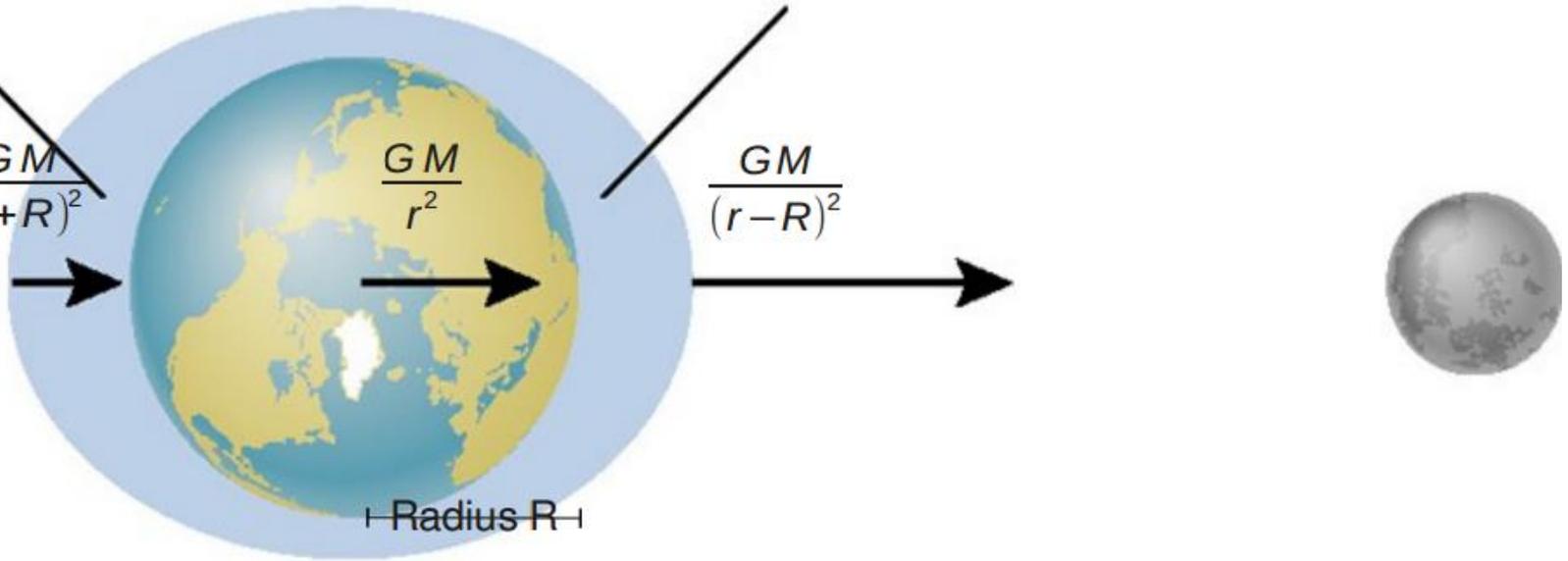
tidal bulge
opposite Moon

tidal bulge
toward Moon

$$\frac{GM}{(r+R)^2}$$

$$\frac{GM}{r^2}$$

$$\frac{GM}{(r-R)^2}$$

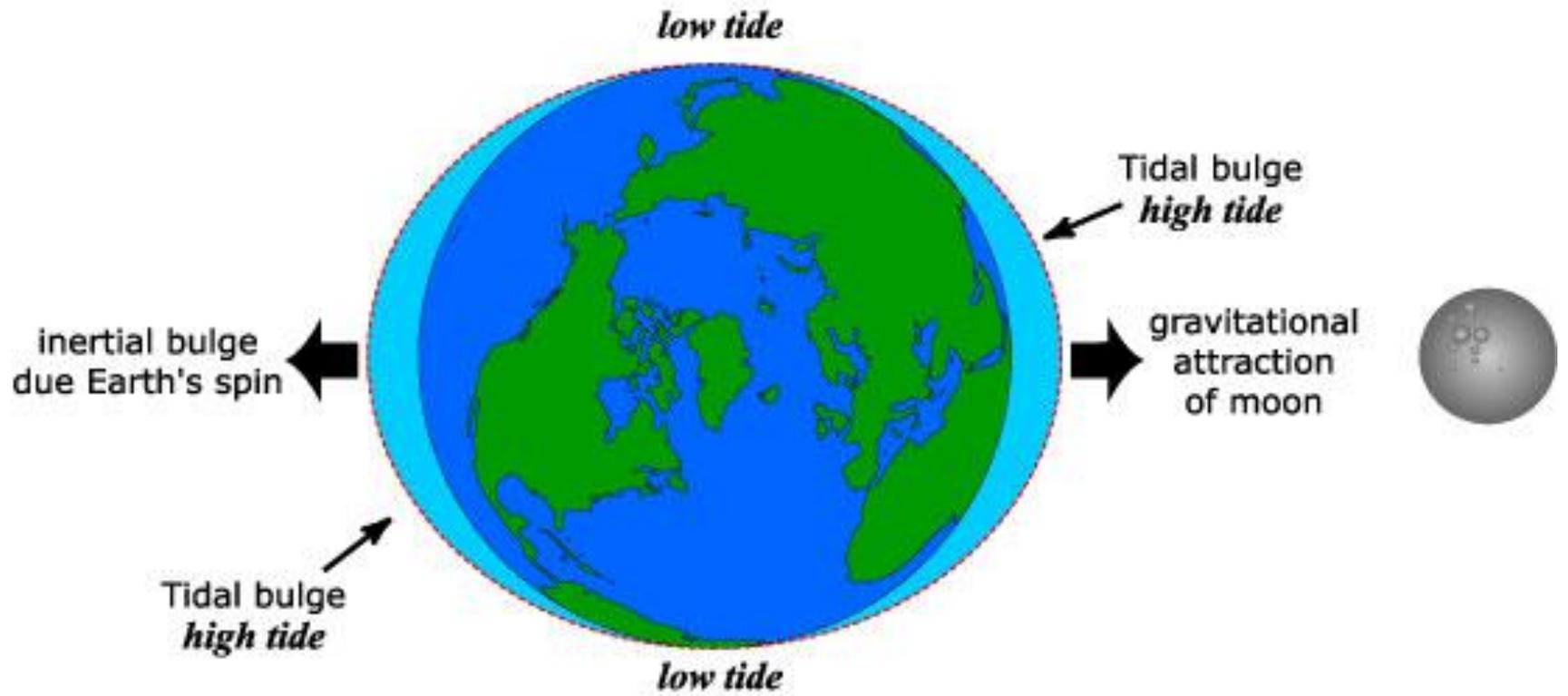


Radius R

Orbital separation r

Far side Tidal Bulge:

- **Moon pulls more strongly on Earth's center than the far side water**
- **Therefore the land mass is pulled leaving the water behind**
- **Centripetal Force and inertia due to the Earth's rotation also contributes**



- **Rotation of the Earth carries an area first into one bulge and then into the next**
- **As an area enters the bulge, water level rises – High Tide**
- **As an area moves out of bulge, water level falls – Low Tide**
- **2 bulges : 2 High Tides and 2 Low tides per day**

PLAYA PALENQUE AT HIGH TIDE



PLAYA PALENQUE AT LOW TIDE





Solar Tides

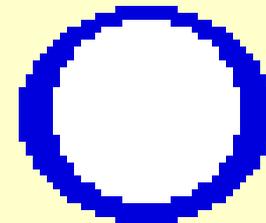
- ❖ **Sun also creates tides on Earth**
- ❖ **Sun's Tidal Force is about half the Moon's ... Why?**
- ❖ **Although sun is more massive, it is much farther away**
- ❖ **Solar and Lunar forces work together**

Spring Tides :

- **Abnormally large tides at New and Full Moon**
- **Occurs when the Sun, Earth, and Moon are lined up**
- **Sun and Moon both create 2 tidal bulges and these bulges add together**

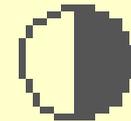


Sun



Earth

Full moon



Moon

Spring Tides

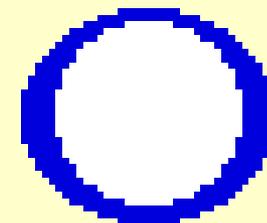


Sun

New moon



Moon



Earth

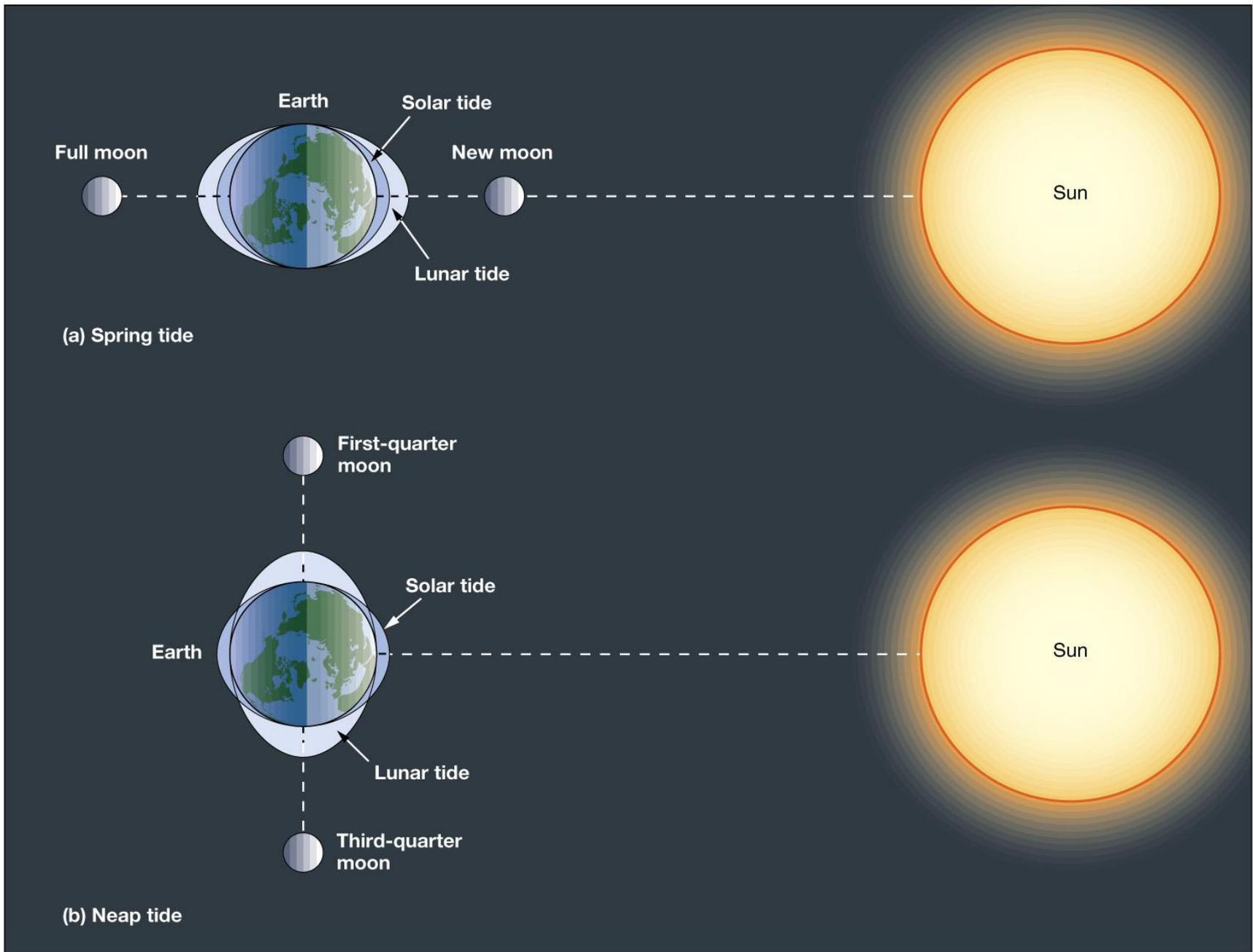
Neap Tides

- **Less extreme than normal high and low tides at First and Third Quarter Moon**
- **High tides that are not very high and low tides that are not very low**
- **Moon and Sun are not in line with Earth**
- **Sun's effect is subtracted from Moons**

NEAP TIDE



Not to Scale



Tidal Braking

- **As Earth spins, Friction between ocean and solid Earth below Drags the Tidal Bulge**
- **This slows Earth's Rotation ; lengthening the day by about 0.002 seconds per day**
- **As Earth slows, the Moon accelerates due to angular momentum and moves farther from Earth**
- **Moon moves away about 4 cm per year**

Projections of Tidal Braking:

- **Earth will eventually rotate synchronously with Moon**
- **Earth and Moon will orbit so each only constantly presents the same face to the other – Moon would only be visible from one side of Earth**
- **Stabilize Climate?**