Gravitation and Tides

attraction of bodies due to their mass

- Moon pulls on Earth with force, Fg
- Earth pulls on Moon with opposite force, -Fg
- as Moon orbits, Earth's surface is deformed -> tidal bulge
- Moon orbits at 27.3 days (sidereal month)

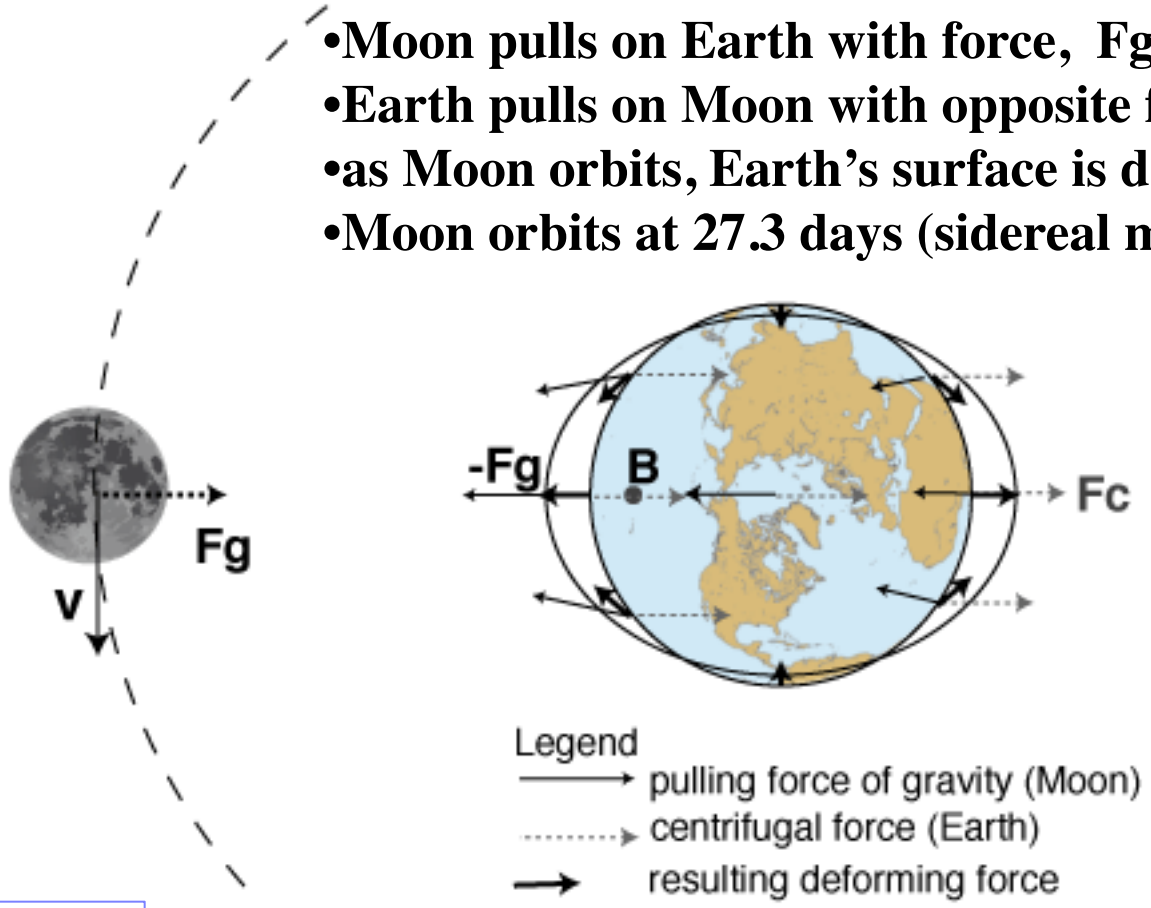
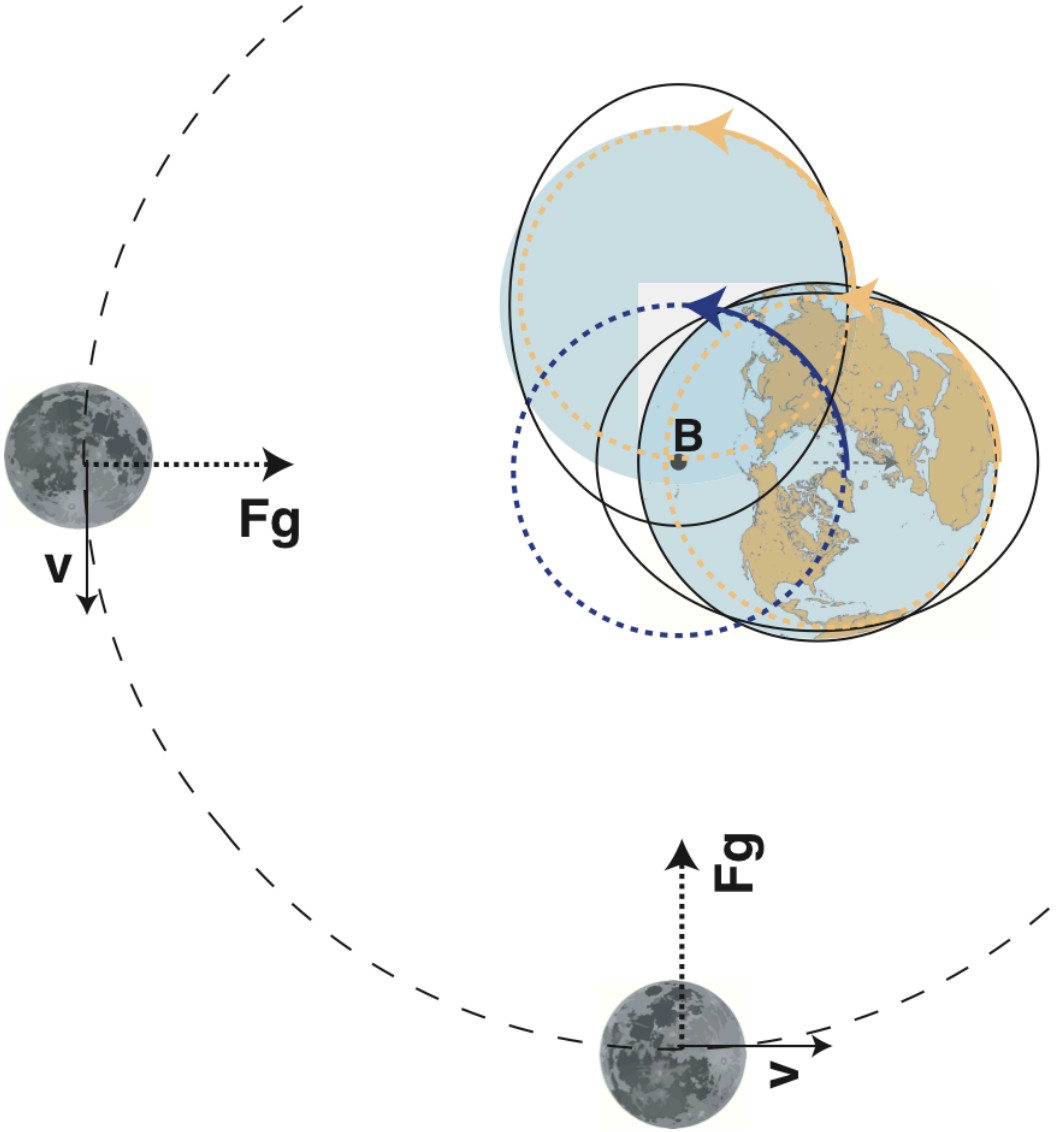


Fig. 2.15

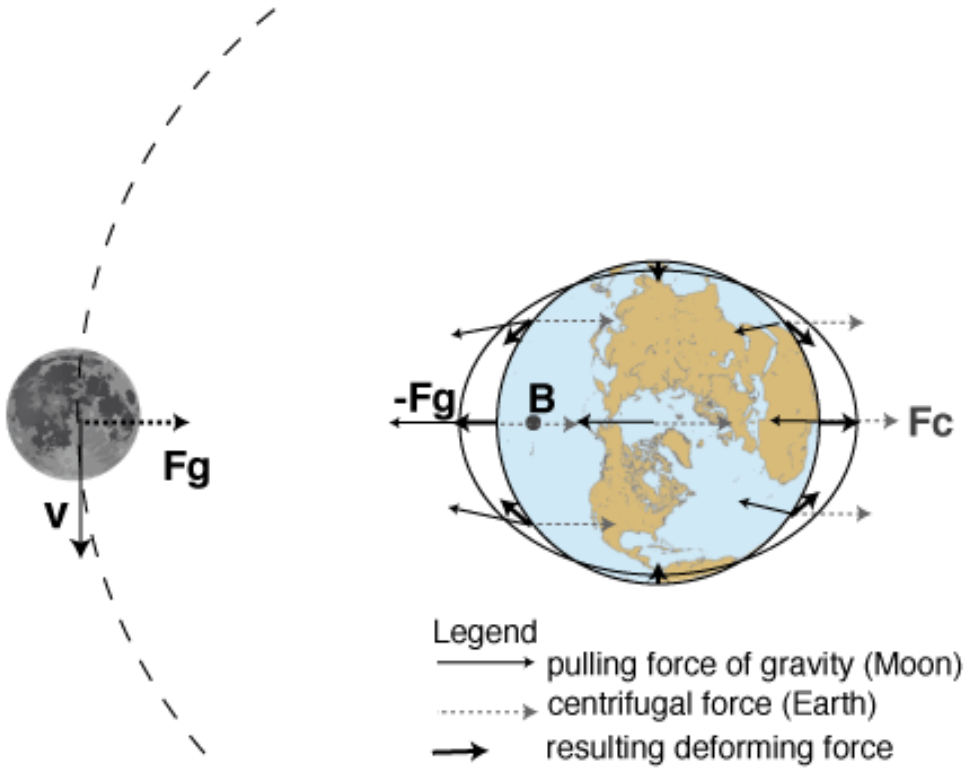
!! Example is shown for equator.

Gravitation and Tides



* Earth's surface feels the pull of the Moon on the near side more than on the far side.

Gravitation and Tides



* Earth's surface feels the pull of the Moon on the near side more than on the far side.

* At the same time, each point on Earth circles the center of mass of the Moon-Earth system (barycenter, B) once for each lunar orbit. Circular motion causes fictitious (apparent, inertial) centrifugal force, Fc, which is the same for each point.

* Forces add up like vectors and deform Earth's surface.

* On the near side, Earth bulges because Fg > Fc
* On the far side, Earth bulges because Fc > Fg

Fig. 2.15

Change of Tides During a Day

- after 6:13h, Earth rotated by 90°, relative to same spot on Moon
- it is NOT 6:00h, because Moon advanced a bit on orbit, so Earth has to catch up
- the bulge (high tide) now moved by 90° (e.g. from central Pacific to South Asia)
- place that had high tide 6:13 h ago now has low tide
- every day, same high tide arrives a bit later (complete cycle is 24 h 50 min)

!! Example is shown for equator.

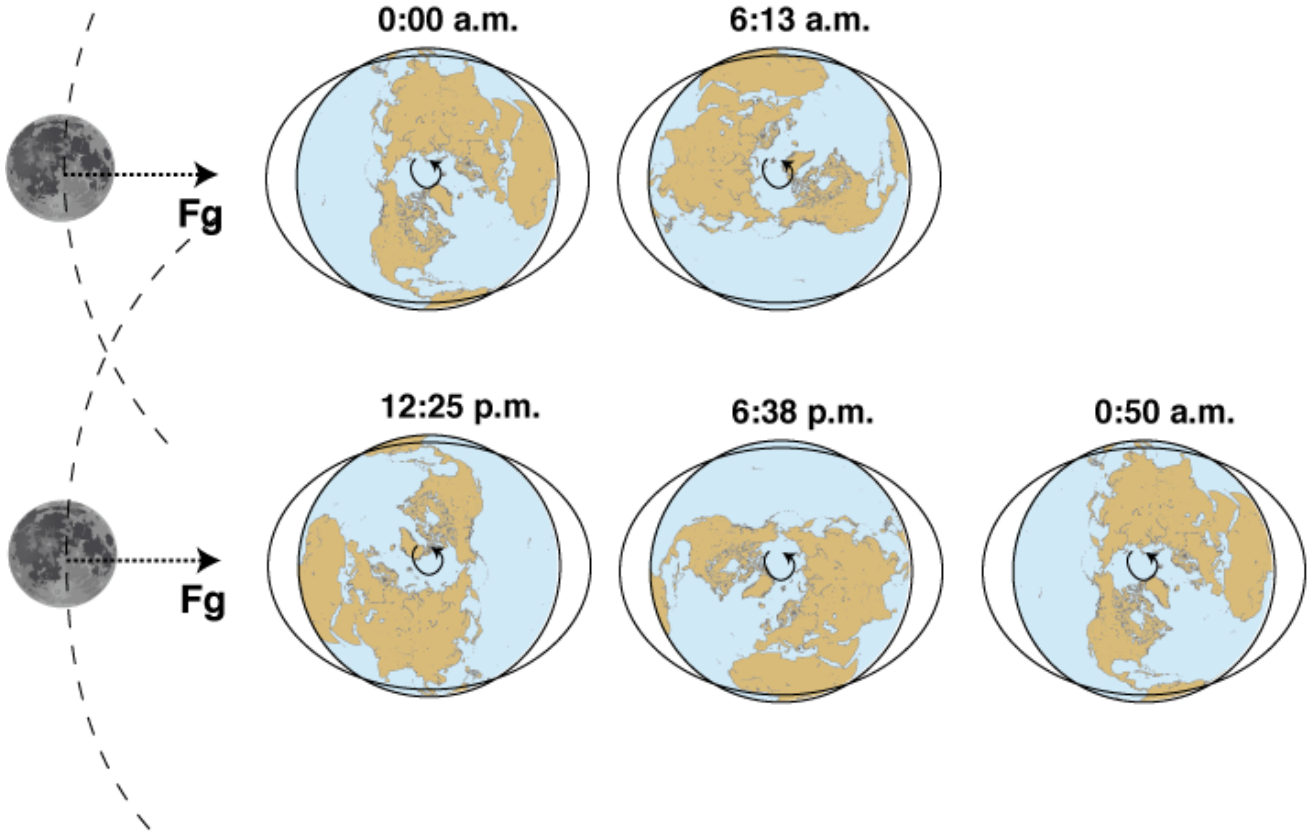


Fig. 2.15

Change of Tides at a Specific Location

Most places on Earth experience two high tides and two low tides per day (*semi-diurnal tides*)**.**

For example, the tides on October 5, 2007 at the SIO pier looked like the diagram to the right:

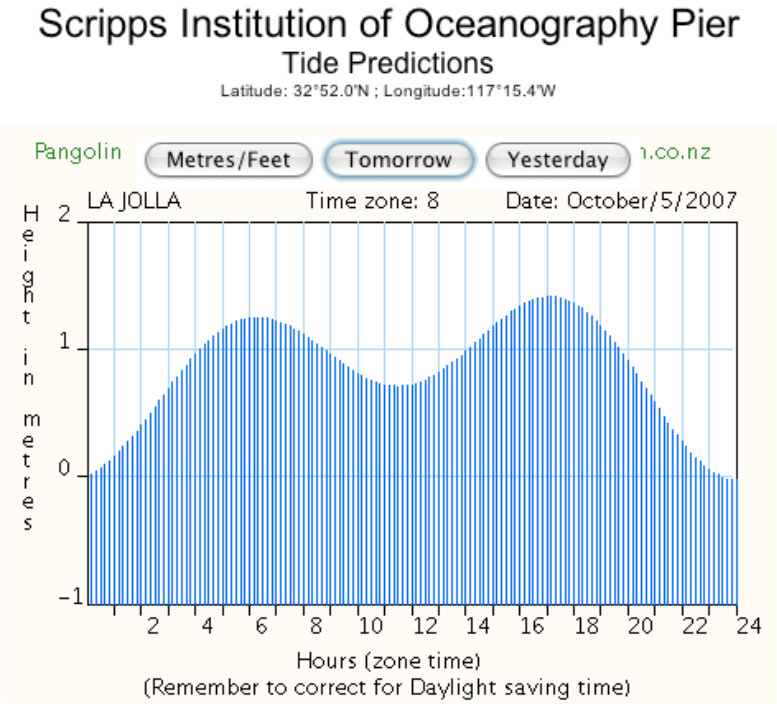
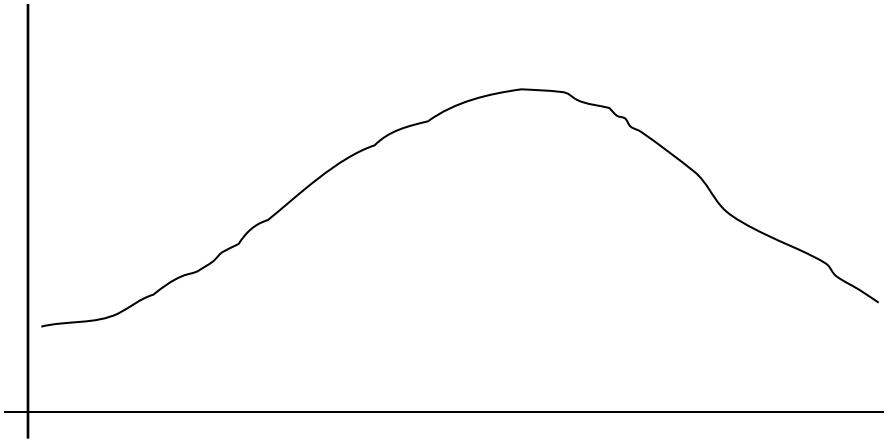


Fig. 2.17

http://ocean.peterbrueggeman.com/piertide.html

A few places experience only one high and one low tide per day (*diurnal tides*)**.**

The tides throughout the day look like this:



Change of Tides at a Specific Location

geographic location of semi-diurnal, diurnal tides and mixed tides (depends on many factors, e.g. water body dimensions, coastlines, geometry of continental shelf)

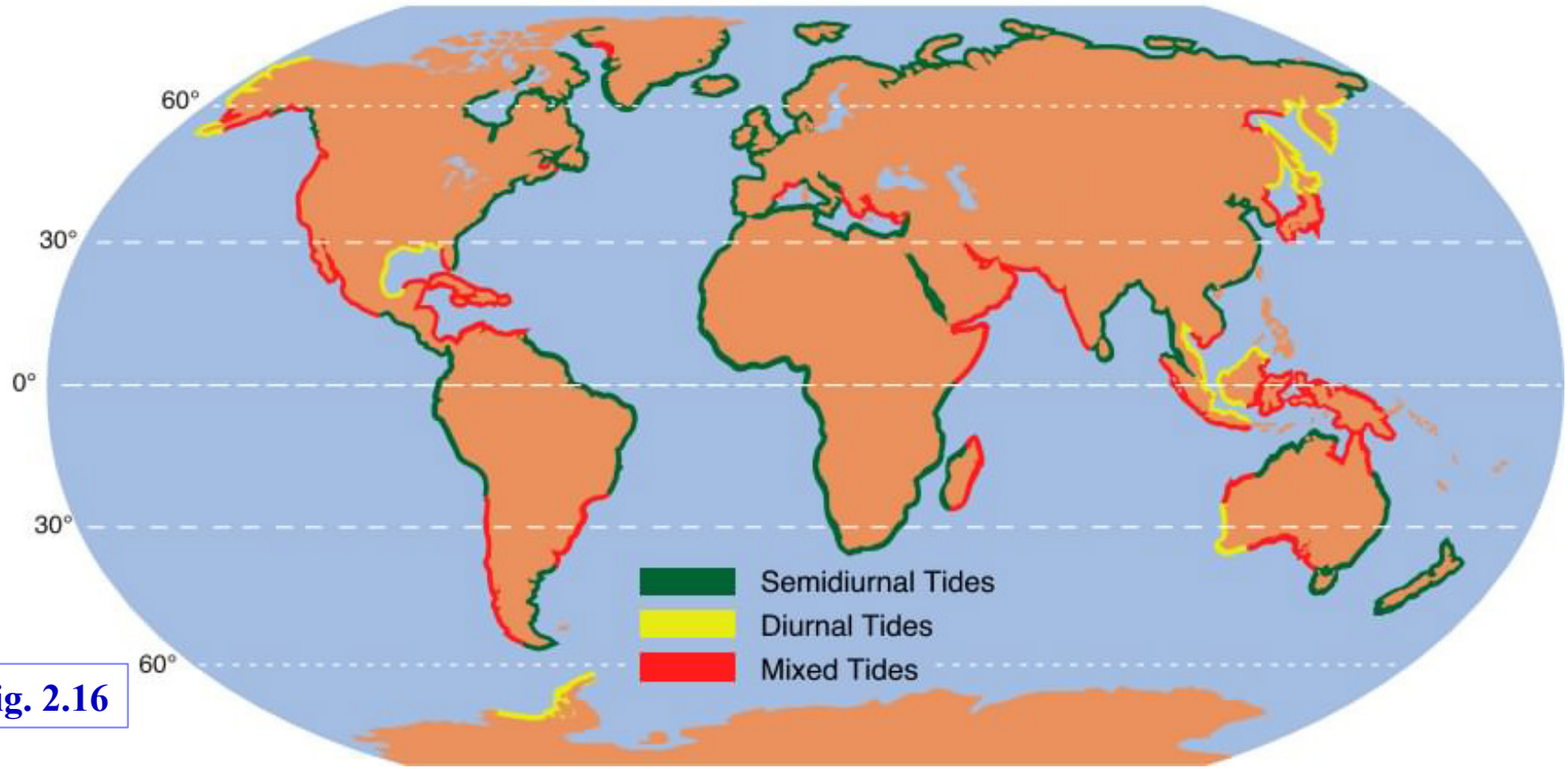
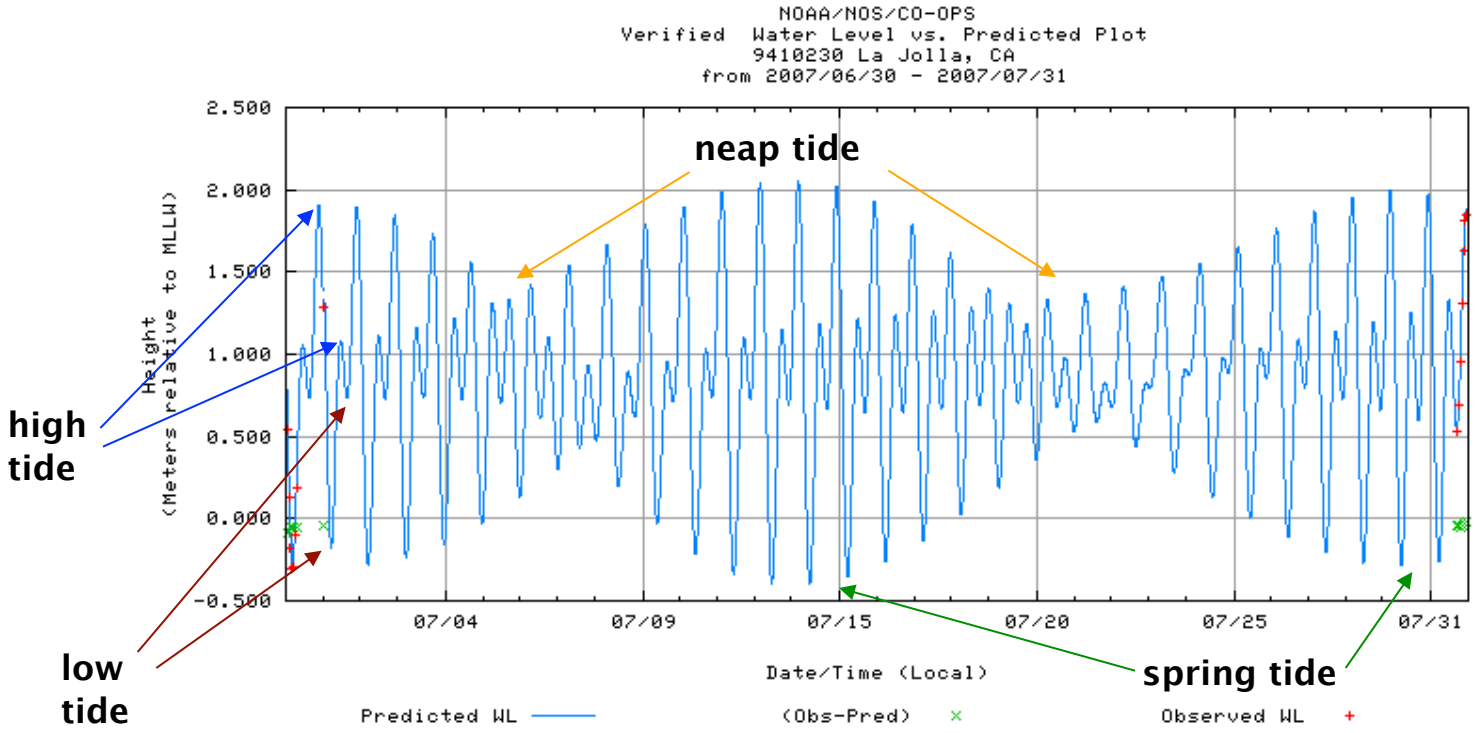


Fig. 2.16

The Moon, Sun and Tides at a Specific Location



http://tidesandcurrents.noaa.gov

during a synodic month, La Jolla experiences two spring tides and two neap tides.

The period between Full Moons is about 29.5 days (synodic month).

The Moon, Sun and Tides

the Sun also pulls on Earth though the lunar (Moon) tides are stronger

Spring tide: when Sun, Earth and Moon are aligned (syzygy), then Sun and Moon pull together. The different between high and low tide is then largest. This happens during Full Moon - when the Moon is on the other side of Earth - and during New Moon - when the Moon is on the same side of Earth as the Sun is.

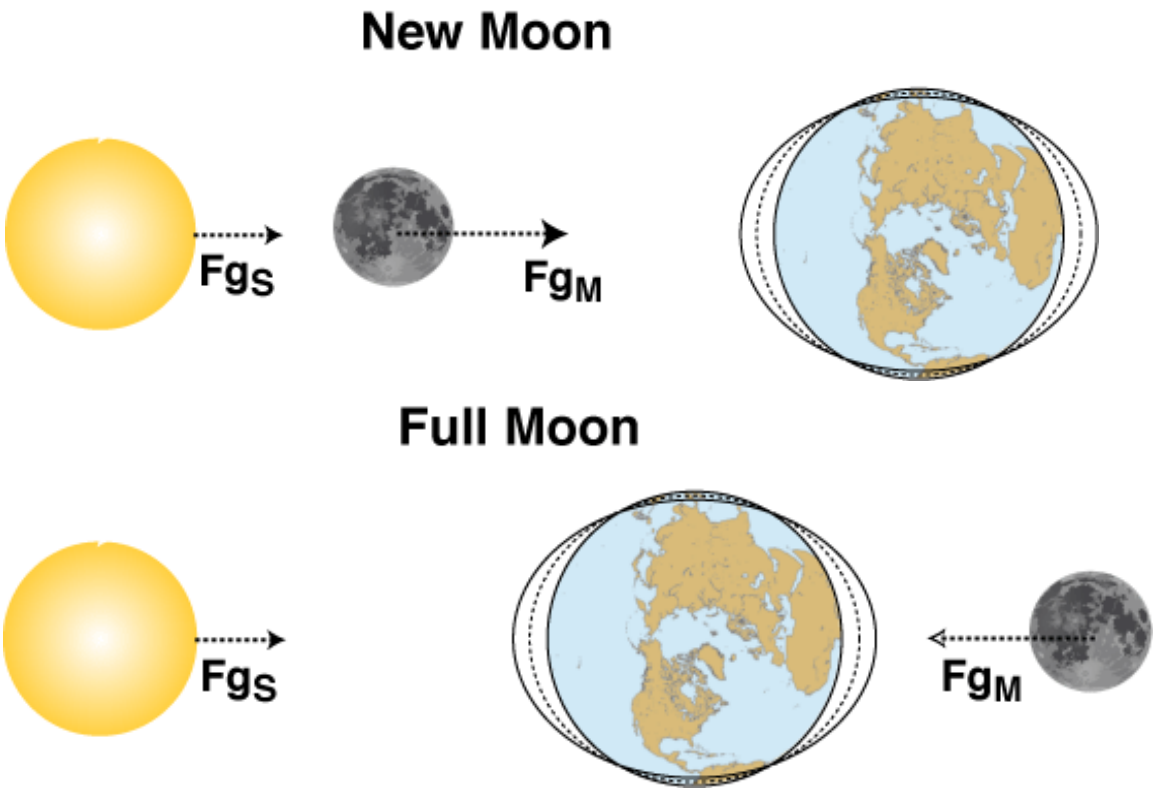


Fig. 2.20

The period between Full Moons is about 29.5 days (synodic month).

The Moon, Sun and Tides

Neap tide: when Sun, Earth and Moon make a right angle where Earth is in the corner. Then Sun's and Moon's effects partially cancel each other. The difference between high and low tide is then smallest. This happens during Quarter Moons twice a month.

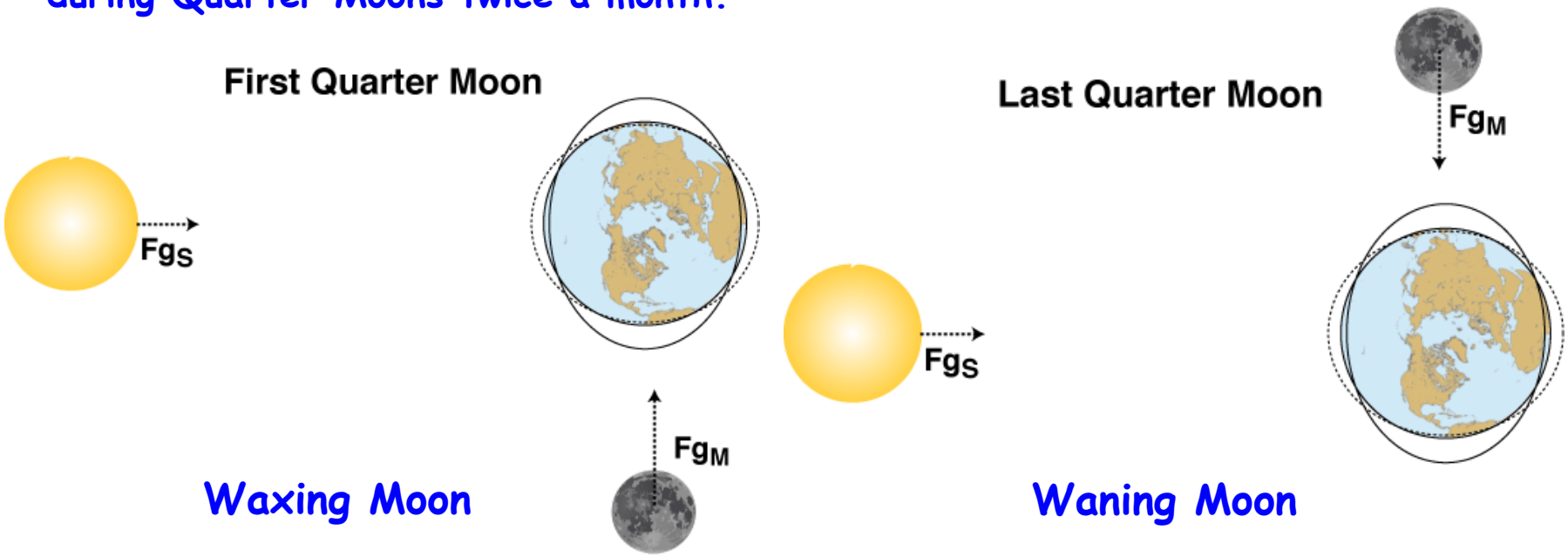


Fig. 2.20

Moon's orbit is actually slightly elliptical. If Moon is at its perigee (point on orbit closest to Earth) then spring tides are higher. Spring tides are particularly high twice a year (Jun/Jul and Dec/Jan). In Dec/Jan, the Moon is near perigee AND Earth is near perihelion. In Jun/Jul, the Earth is near aphelion. The Dec/Jan spring tide is often called the King tide (biggest spring tide of the year).

The Moon, Sun and Tides

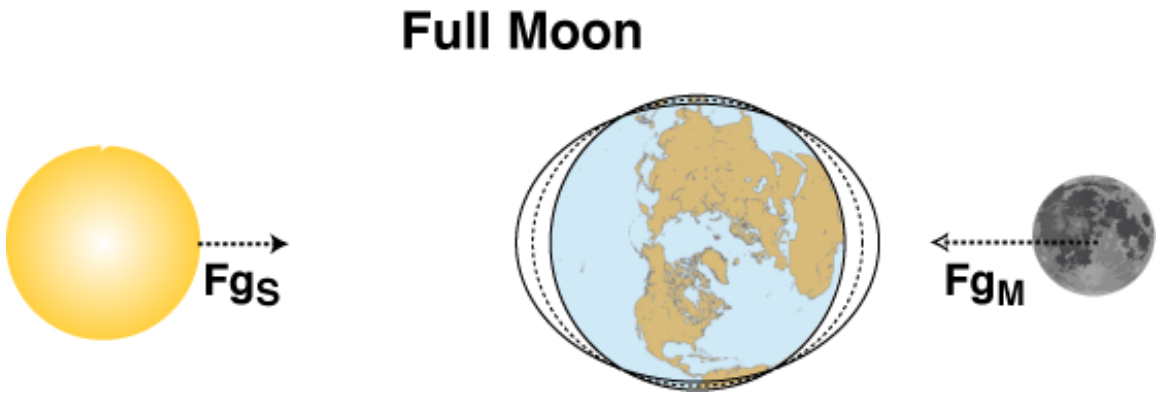


Fig. 2.20

Why is there no lunar eclipse during Full Moon?

Because the Moon's orbit is tilted with respect to Earth's orbit. So a Full Moon is actually above or below Earth's orbit. Only if the Moon is exactly aligned with Sun and Earth does Earth cast a shadow so that we observe a lunar eclipse.

Fig. 2.14