**Problem 1: What are key physical constants related to gravitation and the gravity field of a planet and how well are these known?**

Important constants include mass of the planet (M) and gravitational constant (G).

The gravitational constant is perhaps the most difficult physical constant to measure to high accuracy. In SI units, the 2006 CODATA-recommended value of the gravitational constant is:



GM together is easy to be measured. The value of GM is:



**Problem 2: Name and characterize the main equations related to the gravity potential.**

Newton's law of universal gravitation is:



Gravitational force is conservative. Potential energy defined by it satisfies Laplace or Poisson equation. In an spherical harmonic expansion form, it can be written as:



**Problem 3: How large are the deviations of the geoid from the reference ellipsoid and how are these deviations explained?**

The geoid's total variation is less than 200 m (−106 to +85 m) compared to a perfect mathematical ellipsoid.

These deviations are mostly due to the density difference in the earth media.

**Problem 4: Explain in simple words the origin of tides.**

Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth.

Consider a point on the Earth's surface on the side facing the moon. At this point, being closer to the moon, the gravitational attraction is greater whereas the centrifugal force is about the same as it is at Earth's center. Therefore at this point there is a net greater attraction toward the moon.

At the opposite point on the Earth's surface, on the side facing away from the moon the gravitational attraction less than at Earth's center whereas the centrifugal force is about same. This means there is a net force away from the surface of the Earth. This net force raises water to a higher level just as the net force toward the moon raises water to a higher level there.

**Problem 5: Why do we see ocean tides?**

Tides come from the moon gravitational pull on the earth’s surface. So water will gravitate to towards the moon. Everything on Earth experiences this pull, though it is only noticeable in larger bodies of water. So in fact lakes do also experience tides, just at a much more micro scale. **Problem 6: Why are the amplitude and phases of semidiurnal and diurnal tides varying irregularly in space?**

It is because of dynamic tides. The oceans have eigenperiods in the diurnal to subdiurnal band. This will cause resonance.

**Problem 7: How large is the largest equilibrium tide on Earth?**

<http://en.wikipedia.org/wiki/Tidal_range>

The most extreme tidal range occurs around the time of the full or new moons, when the gravitational forces of both the Sun and Moon are in phase reinforcing each other in the same direction (new moon), or are exactly the opposite phase (full). This type of tide is known as a spring tide.

The average tidal range of all oceans around the globe is 1 meter

**Problem 8: Why does the Moon keep the same face toward the Earth?**

The Moon's rotational period is exactly the same as its orbital period so we always see the same face of the Moon pointed towards the Earth. This synchronicity is a result of friction having slowed down the Moon's rotation in its early history, a process known as tidal locking. As a result of tidal locking, the Earth's rotation is also gradually being slowed down by the Moon, and the Moon is slowly receding from the Earth as the Earth's rotational momentum is transferred to the Moon's orbital momentum. The gravitational attraction that the Moon exerts on the Earth is the cause of tides in the sea. Tidal flow is synchronized to the Moon's orbit around the Earth.

**Problem 9: How large is the tidal bulge of the Moon?**

About 10 cm.

**Problem 10: What are the main rotational eigenmodes of the Earth and to which parts of the Earth are they mainly attributed?**

The first rotational eigenmode is with a period close to 433 days.

The second rotational eigenmode is caused by the fluid core. The period depends on ellipticity of CMB. It corresponds to a nutation of ~460 days.

The third rotational eigenmode is due to the interaction of inner and outer core.