Force of Gravity and Tides

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Opening Discussion

- Do you have any questions about the quiz?
- Have you seen anything interesting in the news.
- When you are standing on ice you can't transfer momentum to the Earth easily. Skates do the same for one direction.
- Timing of quizzes and homework assignments.
- http://news.yahoo.com/photos/ss/events/sc/022505marsnasa;_ylt=A

Angular Momentum Demos

- Recall from last time that angular momentum is given by L=mvr and that we said this is a conserved quantity.
- In our everyday life is it helpful to substitute v=αr, where α is the angular speed in radians per unit time, to get $L=m\alpha r^2$. It's proportional to rpms and things you notice about objects.
- Let's look at some examples of what the conservation of this value does in our normal lives.

Gravity on Earth and Orbits

- Here on Earth we feel gravity as a constant acceleration toward the planet. This acceleration, g, is 9.8 m/s^2.
- So every second you fall you gain roughly 10 m/s or about 20 mph.
- $d=\frac{1}{2}at^2+v_0t$ (position under constant acceleration)
- When an object goes into orbit, it simply has to move fast enough that the Earth curves away under it at the same rate that it falls. Of course, air resistance will prevent you doing this at low altitudes.

Newton's Law of Gravity

- Newton also figured out that Kepler's laws could all come about if objects were attracted to one another with the following force law.
- $F = -G\frac{M_1 M_2}{d^2}$
- G is the gravitational constant, $6.67*10^{-11}$ $m^3/(kg*s^2)$ and d is the distance between the two masses.
- This explains why Kepler's laws are what they are and also expands them to govern any object orbiting a larger object.
- You can also have unbound “orbits” of parabolas or hyperbolas.

Newton On Orbits

- By Newton's laws, objects technically orbit in ellipses around the combined center of mass.
- Kepler's third law can have a more general form that allows us to determine the masses of distant objects. We use it to determine masses because the periods and semimajor axis values are typically much easier to measure.

$$p^2 = \frac{4\pi^2}{G(M_1 + M_2)} a^3$$

Tides

- Newton's law of gravity states that gravitational acceleration is faster near an object than it is farther away. For an object that has size, this means that the pull of gravity is stronger on one side than it is on the other.
- This difference in pull is often called a tidal force and it is what causes tides on the Earth. The Earth bulges on the side toward and away from the Moon.
- Spring tides occur at new and full moons while neap tides occur at at first and third quarter.

Tidal Friction

- Because the Earth is spinning under the Moon, and the fact that the Earth can't change shapes instantly, the tidal bulge actually leads the Moon slightly.
- The result of this is that the Moon pulls back on the Earth's spin a bit and the Earth pulls on the Moon to give it extra orbital energy.
- This process eventually leads to tidal locking. That is why the same side of the moon always faces the Earth.

Minute Essay

- Hopefully you are starting to see how knowing some physics helps in astronomy. You should also begin to see how we learn various things by looking at distant objects.
- We have only directly imaged one or two planets outside of our solar system. The 100+ other planets were inferred through indirect observations. What do you think astronomers measure to infer the existence and properties of those planets? (Hint: It was something we talked about today.)