Orbits and Acceleration of Gravity

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Opening Discussion

- Have you seen anything interesting in the news?
- Quiz question #1 – I never gave a speed so you have a hard time using $E=\frac{1}{2}mv^2$.
- Detecting planets around other stars. What happens if you have 3 objects?
- Which pulls harder on the Moon, the Earth or the Sun?
- CNN says moon mission will cost over $100 billion over 13 years.

Reality of Kepler's Laws

- It turns out the Kepler's Laws are just an approximation to what happens if one object orbits another and there is an infinite mass ratio and no other bodies present.
- In reality, since both objects pull on one another and one isn't infinitely more massive than the other, they both move about their common center of mass.
- If any other objects are present, they cause deviations from perfect elliptical orbits as well.

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.

More Orbit Physics

- Orbits have an associated energy. The energy can switch from kinetic energy to potential energy, but the sum of the two is always the same.
- Gravitational potential energy in general is:

$$E = -G\frac{M_1 M_2}{d}$$

- Close encounters between objects can transfer energy from the orbit of one object to another. This is how orbits are modified over time. Close encounters are far more common than collisions.

Putting It To Use

- Now I want to have you work as groups to solve some problems using the physics we have learned.
- Escape velocity is the speed you have to reach to have zero total energy. How fast is that? (You have to be able to derive it, not just copy it from the book.)
- A circular orbit is when the force of gravity exactly counters the centrifugal pseudoforce. How fast is that? ($F_{centripetal}=mv^2/r$)

Minute Essay

- We are about to move from the physics of motion to the physics of light. Are there any areas of what we have discussed that you feel you have particular problems with?