

## Storytelling with Uniview #04: Gravity in Space

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If you read the last *Storytelling with Uniview* column, you will remember that children can have many alternate conceptions about the shape of the Earth. Let's proceed to a topic that can also be visualized to some extent not only in Uniview at the Orbits Table, but at other stations in the *Space Odyssey* exhibit: the effect of gravity on objects in space.

You are probably familiar with the Uniview simulation software's ability to move through time virtually, and portray moons orbiting around their planets, and planets around the Sun. However do not assume after demonstrating these phenomena that you can jump immediately to Kepler's, Newton's, or Einstein's formulations for gravity. Like almost any other topic in physics or astronomy, a variety of misconceptions have been uncovered by researchers in the general public. These surprising results come not only from primary school students, but pupils of all ages up to college graduates. Here are just some of the non-scientific ideas that have been discovered.

1. **Gravity needs air:** The force of gravity is attributed to air pressure holding objects down on Earth. Or the medium of the air allows for the force of gravity to be transmitted.
2. **There is no gravity in space:** Following on the previous point, some people believe that gravity's effect diminishes quickly as you move up the atmosphere, and completely disappears as you reach the edge of space, and the air runs out. Or because the Moon is airless, there is no gravity on its surface. (Footage of Apollo astronauts bounding on its surface is proof of the lack of gravity.) Or gravity is an intrinsic part of the Earth, and since the Moon is far away, there is no gravity there.
3. **Objects in orbit are weightless, so gravity does not affect them:** This misconception is due to the use of the term "weightless" when referring to objects in orbit around the Earth. Even students in physics will get confused because textbooks define weight as the force of gravity on an object, and so "weightlessness" is interpreted as being the absence of gravity.
4. **A propulsive force is needed to keep a satellite in orbit:** If an astronaut exited an orbiting spacecraft and decided to float free, she would slowly descend to Earth because there would no longer be a force keeping her aloft in orbit.
5. **Planets closer to the Sun or which spin faster have more gravity.**

In addition to uncovering misconceptions about gravity, there has also been research to study the effectiveness of various teaching strategies. Students who studied physics generally had a more Newtonian understanding of forces, and so could explain gravity better. It is hard to imagine that a 1 minute (or 30 seconds in some cases) interaction at the Orbits Table in *Space Odyssey* is going to substantially alter someone's prior conceptions, especially if they are deeply held. But just being aware of the general classes of misconceptions listed above, you can be more prepared when dealing with the public, and avoid inadvertently reinforcing non-scientific ideas.

When talking about gravity, here are some suggestions:

1. Mention that anything with mass has gravity. There is a very weak gravitational pull between

you and the visitor, along with everything else in the room. But because the objects in *Space Odyssey* have comparatively little mass compared to the Earth, we do not feel any of these other pulls.

2. The pull of gravity drops off with distance. The inverse square law may be difficult for many to conceptualize, but the general concept can be pointed out by analogy: bright lights and loud sounds also get weaker with distance the same way.
3. The strength of gravity from an object depends on both its mass and your distance from it. If two objects are the same distance away, but the first has four times the mass of the second? Than the former has quadruple the gravitational pull. Move the larger mass to twice the distance? Then suddenly the gravity of each object is now equal in magnitude.
4. Be careful with language: don't throw the term "weightlessness" with abandon, unless you have time to explain it. Use "free fall" instead and get visitors thinking about how that applies when you are in orbit. An analogy for an astronaut in orbit onboard an orbiting spacecraft or space station is someone taking a ride on an elevator when the support cable is cut. Now the elevator and everything inside are "free-falling" toward the ground at the same speed, and there is "weightlessness" for the occupants inside. The only difference between the falling elevator in our thought experiment and an orbiting spacecraft is that the spacecraft has a big horizontal velocity, so that as it falls, it keeps "missing" the ground due to the curvature of the Earth.
5. And to tie it back to a fundamental misconception from our discussion of the shape of the Earth, point out that for spherical bodies like planets, the direction of gravity is towards the center of the sphere. There is no universal "down" direction in space, which is what a flat Earth mental model would imply.
6. For visitors who may be ready for more advanced material, ask them what the net gravitational pull on them on the surface of a planet would be, if you accounted for each parcel of the planet pulling them (and each chunk's distance from them). Isaac Newton solved this and showed that the net effect from a spherical planet is to assume all of the planet's mass is at a single point at the center of the sphere. He also showed that if you were buried beneath the Earth's surface, the net gravity of the shell of the Earth directly above you is zero. Taken to its logical extreme, if you burrowed to the center of the Earth, you wouldn't feel a gravitational pull at all since the mass of the Earth in each direction would cancel out the mass of the Earth in the exact opposite direction.

## Reference

Kavanaugh, C., & Sneider, C. 2007, "Learning about Gravity II. Trajectories and Orbits: A Guide for Teachers and Curriculum Developers," *Astronomy Education Review*, 5(2), pp. 53-102.