Space Telescopes

Overview: NASA's Great Observatories consist of four space telescopes, each designed to look at the universe in one small part of the electromagnetic spectrum: infrared, visible, X-ray, and gamma rays. Each telescope is a satellite that orbits the Earth in a very specific way.

What to Learn: There's a common misconception about gravity and space, in that most folks believe satellites don't move in orbit. The truth is, satellites must maintain a very specific velocity in order to maintain their stable orbits.

Materials

- Five different sizes of small balls: marbles, ping-pong, rubber bouncy, etc.
- Tape
- Sheet of paper

Experiment

1. Curl your paper into a cone shape so one end is wider than the other. It should look like an ice cream cone.
2. Tape the cone into place using your tape. You might need a couple of pieces.
3. Hold the cone with the small end down.
4. Your job is to place your marble on the inside edge of the cone near the top and rotate the cone so that the marble stays near the top edge without falling down inside or flying out of the top.
5. Place your small satellites in order from lightest to heaviest. Enter them in this order in the data table. Record how fast you had to circle the cone to keep the satellite in orbit in the observations column. Did you have to move the satellite slower, faster, or something in between?

Space Telescopes Data Table

Item/Object	Observations

Reading

Many people think that satellites don't move in orbit. Nothing could be further from the truth! If you drop a ball on Earth, it falls 16 feet the first second you release it. If you throw the ball horizontally, it will also fall 16 feet in the first second, even though it is moving horizontally… it moves both away from you and down to the ground.

Now consider another object, like a bullet shot horizontally. It travels a lot faster than you can throw – about 2,000 feet each second. But it will still fall 16 feet during that first second. Gravity pulls on all objects (like the ball and the bullet) the same way, no matter how fast they go.

What if you shoot the bullet faster and faster? Gravity will still pull it down 16 feet during the first second. Remember that the surface of the Earth is round. Can you imagine how fast we'd need to shoot the bullet so that when the bullet falls 16 feet in one second, the Earth curves away from the bullet at the same rate of 16 feet each second?

Answer – that bullet needs to travel nearly *5 miles per second*. This is how satellites stay in orbit – going just fast enough to keep from falling inward and not too fast that they fly out of orbit. Satellites need to constantly course-correct to keep on track.

If we launch a rocket straight into the sky to be in orbit around the Earth, unless we give that rocket a horizontal velocity as well, it's going to crash right back to Earth. Everything that orbits the Earth has a specific speed at which it travels in order to maintain its stable orbit.

The Hubble Space Telescope was launched by the space shuttle in 1990, and is the best-known observatory. Hubble orbits 380 miles above the surface of the Earth and has sent thousands of photos to scientists on Earth to study. Hubble operates in the visible part of the spectrum.

The Compton Observatory was the second to be launched in 1991, and holds the record for heaviest astrophysical payload ever (17 tons). Compton collected information in the gamma ray part of the spectrum, which meant it looked at some of the most violent parts of the universe to record its data. It was safely de-orbited in 2000.

The Chandra Observatory was launched in 1999, and currently studies X-rays from black holes, quasars, dark matter, supernovas, and high temperature gases. Chandra holds the record for the best mirrors: They are the most accurately shaped, precisely aligned, smoothest mirrors ever created. Chandra's alignment is so precise that you can use it to read a newspaper from a half mile away.

The Spitzer Space Telescope was the fourth to be launched into the program in 2003. Spitzer specializes in thermal infrared light, most of which is blocked by the Earth's atmosphere and never makes it to the surface of the Earth. So this scope is seeing things we've never been able to before. Since viewing in the infrared means that you can see through dust and gas particles, Spitzer is able to show us things that would normally be hidden to us if we were to view them optically. Spitzer looks for cooler space objects (thermally speaking) such as small stars, extrasolar planets, and giant molecular clouds.

Exercises

1. What happens when your marble satellite moves too slowly?

2. What happens when the marble satellite orbits too fast?

3. What effect does changing the marble mass have on your satellite speed?

4. How is this model like the real thing?

Answers to Exercises: Space Telescopes

1. What happens when your marble satellite moves too slowly? (It crashes back to Earth.)

2. What happens when the marble satellite orbits too fast? (The satellite leaves orbit.)

3. What effect does changing the marble mass have on your satellite speed? (The heavier the marble, the faster you have to make it move in order to keep its orbit stable.)

4. How is this model like the real thing? (Your marble is your satellite and the top of the cone is the orbit it makes around the Earth.)