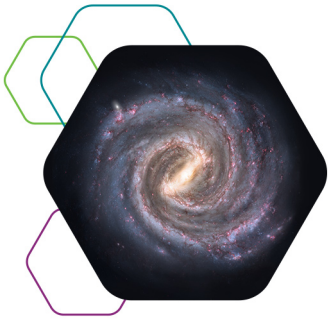

FACILITATOR GUIDE

Orbiting Objects

Learning objectives

This activity explores the following ideas:

- The force of gravity influences everything (with mass) in space.
- Every object in space exerts a gravitational pull on every other object.
- Gravity keeps objects orbiting other objects, and prevents them from flying off into space.

Materials

- Gravity well (see below for assembly instructions)
- 2-pound ball bearing (center weight)
- Assorted balls (different sizes and weights)
- Hunting for Planets information sheet
- Birth of the Solar System information sheet
- Observing Earth information sheet
- Activity guide

The Explore Science toolkit comes complete with all necessary materials for this activity. Materials are also readily available to create or restock activity kits. Graphic files can be downloaded from www.nisenet.org. To make your own tabletop-sized gravity well, you can use a 12-inch diameter (or larger) metal ring, such as a cake pan or springform pan, four-way stretch fabric, foam tape (along the outside edge of ring to keep it from slipping), and two mini bungee cords. *Note: It is important to use true four-way stretch fabric in this model. You can find four-way stretch fabric through local fabric stores or online retailers.*

Safety

Some of the smaller assorted balls will present a choking hazard to visitors under the age of three. Be sure to supervise participants carefully during this activity, keep track of all the balls, and pick them all up when you're finished. Do not allow small children to place any of the balls into their mouths. The largest ball can be a drop hazard and could hurt someone's foot if it fell. Discourage tossing the balls around or rolling them off a table.

Advance preparation

You will need:

- 16 pieces of PVC pipe with elbows
- 8 14" lengths of PVC pipe
- 16 PVC snap clamps
- 16 blue slip tees
- 1 piece of black four-way stretch fabric

Step-by-step instructions with photos are included in the *Orbiting Objects: Gravity Well Assembly Instructions* document.

- Place a blue slip tee onto each of the 16 pieces of PVC pipe with attached elbows and then connect them to each other to create two equal-sized octagonal rings.
- Use the 14" lengths of pipe to connect the two hexagonal rings together to create a stand
- Drape the fabric over the stand and pull it as tight as possible
- Secure the fabric with the snap claps, one on each side of the slip tee.

Note: This structure is designed for repeated assembly and disassembly for ease of storage and transportation. The structure can be made permanent by applying PVC glue to each of the connections.

Notes to the presenter

There is a knack to getting the balls to "orbit" in the gravity well. Practice for a bit before doing this activity with guests. You should experiment with different balls too, so you can see how they behave in different combinations. This will give you ideas for suggestions of things guests might try, and let you support them in observing the balls' behavior.

This activity works well as an open-ended exploration of the effect of gravity on rolling balls. Encourage visitors to experiment with different balls in the center, with different numbers of balls in "orbit," and with different placement of the balls to start. Here are some things to try:

- Place the largest ball in the center and try to get two or three of the smaller balls to orbit around it.
- Try to get two similarly sized balls to orbit around each other.
- Place the largest ball in the middle and try to orbit a medium-sized ball, and watch the center ball very closely. Can you see a wobble?

You may find that the fabric loosens a little bit over time, you can just pull down occasionally on the sides to tighten it back up. You may also find that the PVC stand wobbles a bit over time, especially if participants knock the bottom ring with their feet and loosen the connections. You can hand-tighten the pieces between visitor groups.

Conversational prompts

While participants are engaged with this activity you can explore additional content together. Many countries, including the United States, send satellites into orbit to look down and study Earth from above. There are many international laws and treaties governing what can be sent up into space. Engage participants in conversations using these suggested prompts:

- One international treaty specifies that weapons cannot be launched into orbit around Earth. Can you think of other important agreements we should make about what happens in space?

- Sometimes scientists of different nationalities work together to collect and share data, and sometimes information is kept more private. Do you think that the information we gather about Earth should be shared with everyone?
- The area just outside of Earth's atmosphere is getting crowded. Debris from previous missions is floating around and cluttering space. Whose job is it to clean up all that trash?

Difficult concepts

Many people find it difficult to understand what causes gravity and where it has an effect. Gravitational forces exist between any objects with mass, and it is most certainly present in space. Gravity is the force that keeps us planted firmly on the ground, causes an apple to fall from a tree, and creates a pull between orbiting bodies in space.

If participants suggest that only very large things (planets, stars) exert a gravitational pull, you might try saying something like, "Yes, those big things exert a lot of gravity. In reality, everything that has mass (Earth, your body, a marble, a paper clip) exerts a gravitational pull on everything else. The gravity from your body is pulling on a distant star right now, and that star is pulling on you too. But, the amount of gravity being exerted depends on the mass of the object (more massive objects have more gravitational pull) and how far apart the two objects are (the farther they are, the weaker the pull). To help participants see the effects of gravity, you can prompt them to notice how the small heavy ball makes the large ball wobble visibly. We can also see in our model that distance plays a role in the force of gravity. The closer a small ball gets to the center, the faster it orbits and falls.

Gravity can be a tricky concept. Listen to responses or watch for interactions with guests that might indicate they are struggling to understand. Remember:

- Gravity does not need air to work.
- Gravity and magnetism are different forces.
- Gravity is a pull between objects. Earth does not "have" or "make" gravity by itself.
- Something in orbit (like an astronaut on a space station) is still experiencing gravity and constantly falling toward Earth, which is curving away.

Staff training resources

Refer to the *Tips for Leading Hands-on Activities* sheet in your activity materials.

- An activity training video is available at vimeo.com/191167711.

- A content training video is available at vimeo.com/191171759.

The NISE Network has a curated list of programs, media, and professional development resources in the NASA Wavelength Digital Library that directly relate to the toolkit. These resources can be viewed and downloaded from nasawavelength.org/users/nisenet.

Credits and rights

This activity was adapted from Gravity Well Exploration, developed by the Science Museum of Minnesota and the Black Hole No Escape demo, developed by the Astronomical Society of the Pacific for the Night Sky Network. Retrieved from: http://nightsky.jpl.nasa.gov/docs/BHNoEscape.pdf

Illustration of the orbits in the solar system courtesy Emily Maletz for the NISE Network.

Image of light reflectors on the moon courtesy NASA.

Illustration of Gliese 581c and artist's impression for the solar system courtesy NASA/ JPL-Caltech.

Image of satellites orbiting Earth courtesy NASA/EOS.

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