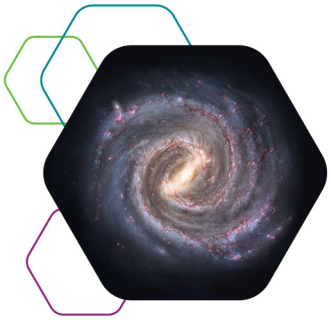

FACILITATOR GUIDE

Objects in Motion

Learning objectives

- Objects in the universe interact in complex but predictable ways.
- Stars, planets, moons, and other objects in space orbit around each other because of gravity.
- NASA scientists use what we know about the laws of physics to make new predictions and discoveries.

Materials

- 12-inch stained wooden rod
- Small leather sling with attached string (medical grade finger sling)
- Acrylic ring
- Playdough
- Sandpaper (to clean the wooden rod)
- Activity and facilitator guides
- Information sheets
- *Tips for Leading Hands-on Activities*
- Digital scale and the *Exploring Ratios* information sheet (optional)

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 apparatus with household items, you can use a wooden dowel or chopstick, and a small binder clip in place of the leather sling—just fold the "wings" up, and tie the string through them. There are many recipes available online for homemade playdough using basic pantry ingredients if you need to restock your playdough.

Notes to the presenter

The wooden rods can sometimes get a little dirty from the playdough. You can easily clean them by gently rubbing the dried playdough off using the small piece of sandpaper included in the toolkit.

Younger visitors may have trouble finding the balance point on the dowel while also holding the ring at the top. You or another participant can help adjust the dowel based on the child's guidance.

In this activity, the participants are making and using a model to observe a real scientific principle. Small, simple models allow us to explore the big motions of planets and stars because the same laws of physics apply.

As this model demonstrates, the mass of one object can affect the motion of another object—even if that object is very small. Remind younger participants that even small objects can make a big difference! This activity offers an excellent opportunity for young children to engage in science process skills, such as making predictions, observing, and constructing explanations. Ask open-ended questions to guide them to a solution, but also give them time and space to try out their own ideas, and be sure to validate their attempts: "I see you added more clay to the ball on this end. What happened when you did that?" Young children may not yet have the vocabulary to verbally articulate the concept, so rather than asking them to do so, encourage them to demonstrate their understanding non-verbally using the model: "On my model, this end is drooping down very low; could you show me how to move the string to make both ends balance?"

Conversational prompts

Ask visitors, "Which ball is moving in a bigger circle?" An easy way for them to answer this question is to hold a finger under one dough ball and follow the ball around its orbit as it moves, and then do the same with the other dough ball. Often, it's easier for younger visitors or participants with low or no vision to interpret the physical sensation of moving their hand in a bigger or smaller circle than to simply watch the balls spin. You may need to hold the ring in order for them to do this.

Play the eclipse game! Designate one ball as Earth, one as the Moon, and the visitor as the Sun. While the visitor holds the spinning dowel, encourage her to say "Eclipse!" any time the Moon passes between her body and Earth.

Visitors generally enjoy talking about Pluto. This activity provides an opportunity to explore one of the features that makes Pluto unique in our solar system. Pluto and its largest moon, Charon (pronounced like the name Sharon), form the only known binary planetary system in our solar neighborhood. This means that the barycenter of every other planet or dwarf planet and its largest moon is within the planet or dwarf planet, while Pluto and Charon orbit a barycenter between both of them, beyond the surface of Pluto.

Optional extension

Extend the exploration and learning in this activity by weighing and measuring the dough to model the mass ratios of real objects in space. The Exploring Ratios information sheet is designed to help visitors model real orbital systems. Use the scale to form two dough balls that have a similar weight ratio in relation to each other as two orbiting bodies in space (e.g., Earth and Moon). This extension works best with older participants.

Familiarize yourself with the Exploring Ratios information sheet, so that each time a visitor tries a new combination of dough balls, you can comment, "Those remind me of Pluto and its moon Charon! One ball is bigger, but the balance point is still in between them."

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 are 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). This model allows visitors to experiment with changing the mass of two objects in a system, while keeping their distance the same.

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.

The definition of a barycenter is complicated because we often mix the terms mass and weight for many purposes here on Earth. In common usage, the mass of an object is often referred to as its weight, though these are in fact different concepts and quantities. In scientific contexts, mass refers loosely to the amount of **matter** in an object, whereas weight refers to the force exerted on an object by gravity.

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/245834676
- A content training video is available at vimeo.com/245835205
- 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 multiple sources including a Barycenter demonstration, developed by Sciencenter.

Image of Moon in front of the Earth courtesy NASA's Goddard Space Flight Center.

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Star and planet system illustration and Pluto and Charon image courtesy NASA.

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