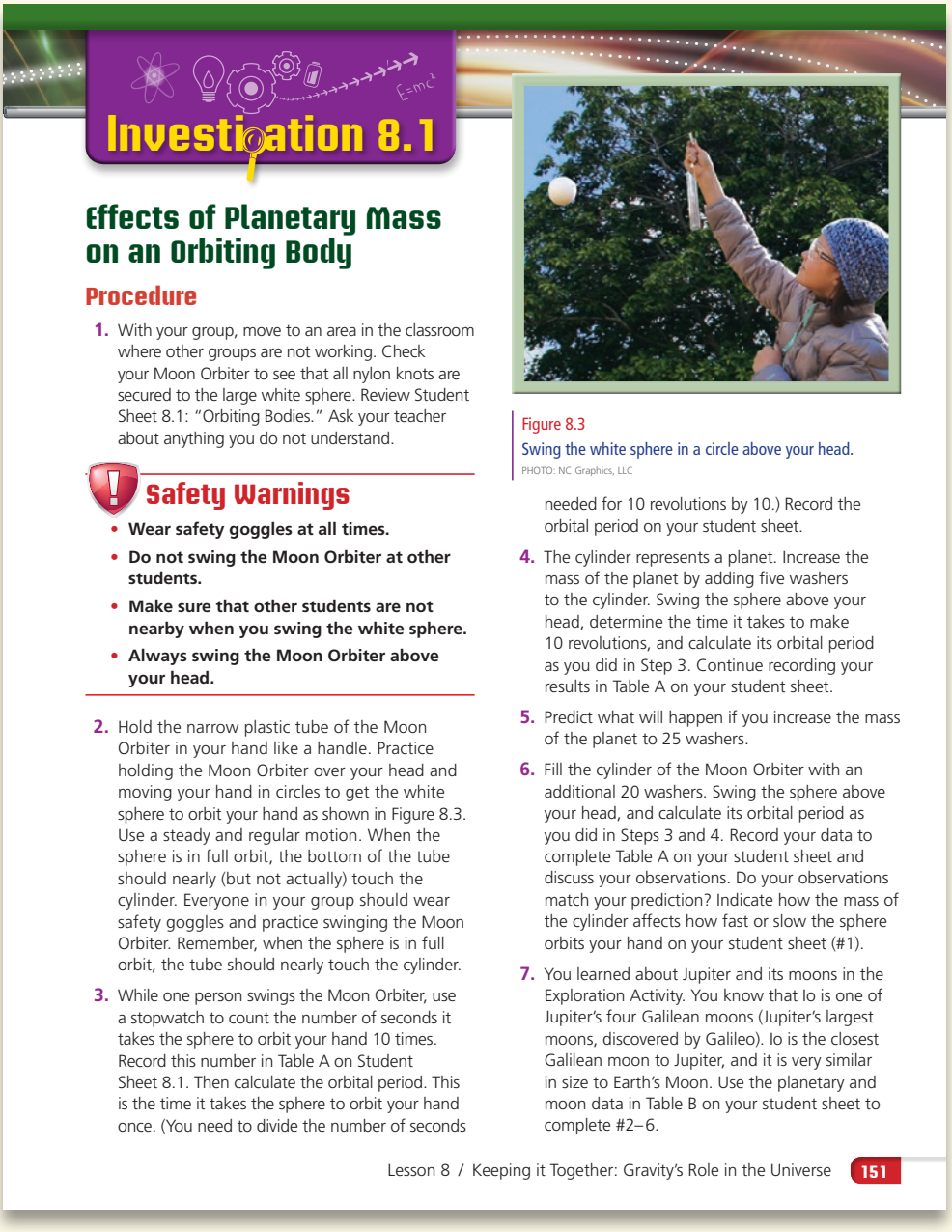
Investigation 8.1: Effects of Planetary Mass on an Orbiting Body

Procedure

1. Have students check the knots on the string to be sure everything is secure. Review the safety warnings for the investigation. Make sure that students review and understand Student Sheet 8.1.

Safety Warnings

- **Students should wear safety goggles at all times.**
- **Students should not swing the Moon Orbiter at other students.**
- **Students should make sure that others are not nearby when they swing the white sphere.**
- **Students should always swing the Moon Orbiter above their head.**



Investigation 8.1

Effects of Planetary Mass on an Orbiting Body

Procedure

1. With your group, move to an area in the classroom where other groups are not working. Check your Moon Orbiter to see that all nylon knots are secured to the large white sphere. Review Student Sheet 8.1: "Orbiting Bodies." Ask your teacher about anything you do not understand.

Safety Warnings

- **Wear safety goggles at all times.**
- **Do not swing the Moon Orbiter at other students.**
- **Make sure that other students are not nearby when you swing the white sphere.**
- **Always swing the Moon Orbiter above your head.**

2. Hold the narrow plastic tube of the Moon Orbiter in your hand like a handle. Practice holding the Moon Orbiter over your head and moving your hand in circles to get the white sphere to orbit your hand as shown in Figure 8.3. Use a steady and regular motion. When the sphere is in full orbit, the bottom of the tube should nearly (but not actually) touch the cylinder. Everyone in your group should wear safety goggles and practice swinging the Moon Orbiter. Remember, when the sphere is in full orbit, the tube should nearly touch the cylinder.
3. While one person swings the Moon Orbiter, use a stopwatch to count the number of seconds it takes the sphere to orbit your hand 10 times. Record this number in Table A on Student Sheet 8.1. Then calculate the orbital period. This is the time it takes the sphere to orbit your hand once. (You need to divide the number of seconds needed for 10 revolutions by 10.) Record the orbital period on your student sheet.
4. The cylinder represents a planet. Increase the mass of the planet by adding five washers to the cylinder. Swing the sphere above your head, determine the time it takes to make 10 revolutions, and calculate its orbital period as you did in Step 3. Continue recording your results in Table A on your student sheet.
5. Predict what will happen if you increase the mass of the planet to 25 washers.
6. Fill the cylinder of the Moon Orbiter with an additional 20 washers. Swing the sphere above your head, and calculate its orbital period as you did in Steps 3 and 4. Record your data to complete Table A on your student sheet and discuss your observations. Do your observations match your prediction? Indicate how the mass of the cylinder affects how fast or slow the sphere orbits your hand on your student sheet (#1).
7. You learned about Jupiter and its moons in the Exploration Activity. You know that Io is one of Jupiter's four Galilean moons (Jupiter's largest moons, discovered by Galileo). Io is the closest Galilean moon to Jupiter, and it is very similar in size to Earth's Moon. Use the planetary and moon data in Table B on your student sheet to complete #2–6.

Figure 8.3
Swing the white sphere in a circle above your head.
PHOTO: NC Graphics, LLC

Keeping It Together: Gravity's Role in the Universe

2. Students will need to practice using the orbiter before they can get data. Some students will be able to twirl the sphere better than others. Encourage groups to find out who does this best and have that student twirl the sphere. Make sure everyone gets a chance to twirl the sphere of the orbiter even though some students will be more successful at twirling it than others.

Note

The bottom of the tube and the cylinder should not touch when the student is twirling the sphere. If the cylinder touches the tube, students may not get the intended results for this investigation.

3. Make sure that each group can use the stopwatch properly. Tell students to have one person swing the orbiter, one keep time, and another count the number of revolutions between start and stop times. The fourth person can record the data collected.

$$\text{PERIOD} = \frac{\text{TIME FOR 10 REVOLUTIONS}}{10}$$

4. Assist students in adding the washers as needed.
5. Remind students to make a prediction before proceeding. Make a list of group names on the board and ask each group to write their prediction next to their group's name. Students should predict that the increased mass will make it more difficult to keep the sphere in motion. The sphere will need to orbit the cylinder faster to stay in orbit.
6. Assist students in adding the washers as needed.
7. Tell students to hand in their student sheets when they are finished. Use Lesson Master 8.1 to assess student work.

Connections to Common Core Common Core English Language Arts Standards:

- CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- CCSS.ELA-Literacy.WHST.6-8.1: Write arguments focused on discipline-specific content.

Connections to Common Core Mathematics Standards:

- CCSS.Math.Content.7.NS.A.3: Solve real-world and mathematical problems involving the four operations with rational numbers.
- CCSS.Math.Content.7.RP.A.2: Recognize and represent proportional relationships between quantities.

Assembling a Moon Orbiter

In this section, students will draw connections between the Moon Orbiter investigations and "How Gravity Shapes the Universe" by answering questions about the effects of gravity on orbits. Use Lesson Master 8.R: "Sample Answers to Gravity Explanation" to review students' answers. Encourage students to speculate how the orbits would change if gravity did not exist. Allow half a class period for students to complete Reflecting on What You've Done.

1. Write the Getting Started questions on the board.
2. Assemble one Moon Orbiter for each group. To build each model, do the following:
   1. Place a few drops of glue along the threads of the screw eye.
   2. Thread the screw into the sphere. Allow the glue to dry.
   3. Punch two opposing holes approximately 1 cm (.5 in) from the top of the plastic cylinder (see Figure 8.2). Be careful not to punch the holes too high or the plastic will rip.
   4. Thread a 1 m (39 in) piece of nylon line through the eye of the screw, and then knot it. Make sure that it is very secure.
   5. Thread the other end of the nylon line through the plastic tubing, through the two opposing holes in the plastic cylinder, and then back up through the plastic tubing. Knot the end of the nylon in the eye of the screw.

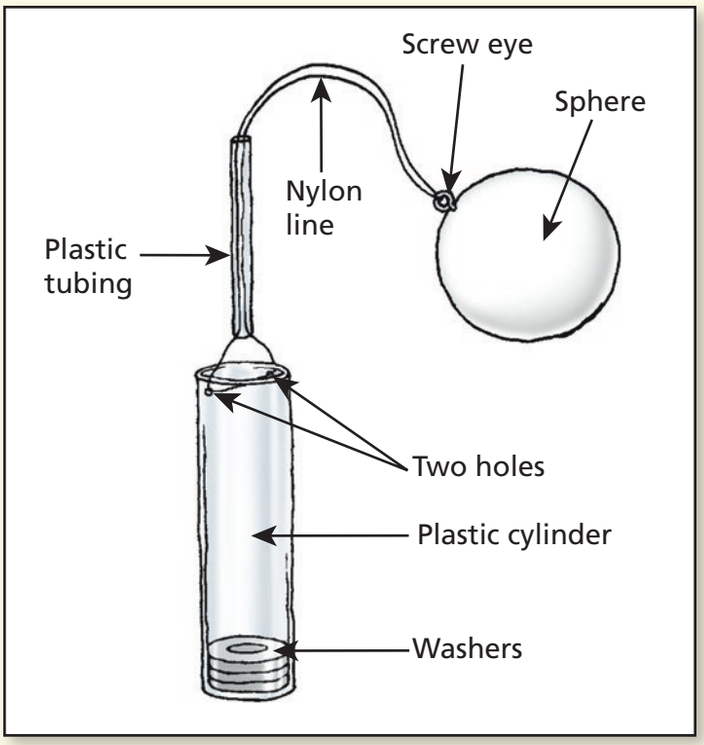


Figure 8.2
Assembled Moon Orbiter