

LESSON

2

3 hrs

MEETS NATIONAL SCIENCE EDUCATION STANDARDS:

Unifying Concepts
and Processes
• *Systems, order,
and organization*

Science as Inquiry
• *Abilities
necessary to do
scientific inquiry*

Earth and Space
Science
• *Earth in the
Solar System*

GETTING TO KNOW SATURN

Saturn's Moons

Students use the data provided on a set of *Saturn Moon Cards* to compare Saturn's moons with Earth's Moon, and to explore moon properties and physical relationships within a planet–moon system. For example, the farther the moon is from the center of the planet, the slower its orbital speed, and the longer its orbital period. The lesson enables students to complete their own *Moon Card* for a mystery moon of Saturn whose size, mass, and distance from the center of Saturn are specified.

PREREQUISITE SKILLS

Working in groups
Reading in the context area of science
Basic familiarity with concepts of mass, surface gravity, orbital period, and orbital speed
Interpreting scientific notation
Using Venn diagrams
Sorting and ordering data

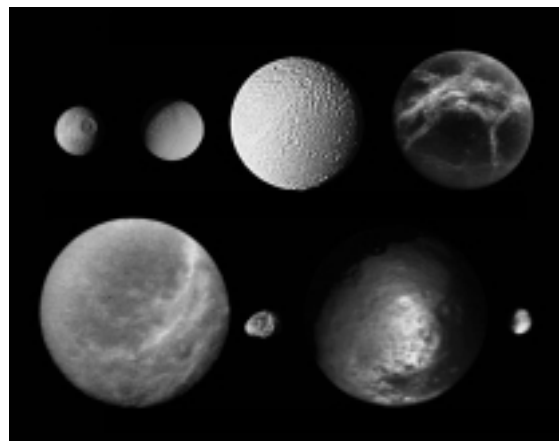
EQUIPMENT, MATERIALS, AND TOOLS

For the teacher

Photocopier (for transparencies & copies)
Overhead projector
Marker to write on transparencies
Chalkboard, whiteboard, or easel with paper; chalk or markers

For each group of 2–3 students

Clear adhesive tape
Notebook paper; pencils



Saturn's eight large icy moons.

BACKGROUND INFORMATION

Background for Lesson Discussion, page 32

Questions, page 37

Answers in Appendix 1, page 225

1–21: Saturn

35–50: Moons

Materials to reproduce

Figures 1–21 are provided at the end of this lesson.

FIGURE	TRANSPARENCY	COPIES
1	1	1 per student
2–19		1 set per group
20	1	optional
21		1 per student



Background for Lesson Discussion

Students may ask about the quantities listed on the *Saturn Moon Cards*.

Radius and size: To determine the actual size of a moon or a planet, scientists make images of it and use the known distance to the object and the resolution of the camera to fix a “scale” for the image (e.g., 1 picture element or “pixel” = 10 km). For example, if a round moon covers 6 pixels in the image, the moon’s diameter is $6 \text{ pixels} \times 10 \text{ km/pixel} = 60 \text{ km}$. Some moons have nonspherical shapes and so there may be more than one size. If a moon is round, then one size (radius) is sufficient.

Distance from the center of Saturn:

Careful measurements of the position of a moon in the sky are used to compute a mathematical expression for the orbit of the moon, including its distance from the center of Saturn. For a quick, less accurate estimate, astronomers make images of the moon and Saturn together and use the scale of the image, just as for determining size.

Orbital speed: Orbital speed is the speed of an object in orbit around another object. To determine the orbital speed of a moon around Saturn, astronomers can take pictures of the moon over a period of time, and measure how far it moves in its orbit around Saturn during that time. This information can be used to compute a speed (speed = distance/time). If you already know the moon’s distance from the center of Saturn, then you can use mathematical equations (Newton’s Laws) to calculate orbital speed. Orbital speed is the same for all objects orbiting the same central body at the same distance from the center. The mathematical expression for a moon’s orbit permits easy computation of its orbital speed.

Orbital period: The orbital period of a moon is the time it takes the moon to go once around in its orbit of a planet. The orbital period can be observed directly or calculated using the moon’s distance from the center of Saturn (Kepler’s Laws — see *Glossary*), and is part of the mathematical expression for the orbit.

Mass: Mass is a measure of the amount of “stuff” that constitutes an object. The most direct way to measure the mass of a moon works only for the larger moons. It involves a spacecraft flying very close to the moon to see how the moon’s gravity influences the speed and direction of travel of the spacecraft. Less easily, the effect of the mass of one moon on the motion of another moon can be used to determine a moon’s mass. From these methods, a mass can be calculated (using Newton’s Laws). These methods do not work well for the smallest moons because they do not have strong enough gravity to have a measurable effect on the speed of a spacecraft or the speed of another moon at long distances. Thus, the masses of the smallest moons are largely unknown.

Surface gravity: Surface gravity of a planet or moon is a measure of the acceleration of gravity at the surface. For Earth, acceleration of gravity is about 9.8 meters/sec². For Earth’s Moon, it is 0.17 times this value, or about 1.7 meters/sec². To calculate surface gravity, you must know the moon’s size (R) and mass (M). Surface gravity = GM/R^2 , where R is the radius of the moon, M is the mass of the moon, and G is the universal gravitational constant. Because the masses of the smaller moons are unknown, their surface gravities are also unknown.





Lesson Plan

Part I: What Do We Know about Earth's Moon?

- 1 Display a transparency of the *Profile of Earth's Moon* (Figure 1). Cover up the half that displays Moon data, showing only the top half of the transparency.
- 2 Ask students the following questions:
What do you know about the Moon? Why do we call it a moon? What have we done to explore the Moon? What Moon mysteries do we still want to solve? Record their responses on the lines on the top half of the transparency.
- 3 Give each student a copy of the *Profile of Earth's Moon*. Allow students time to record responses about the Moon data collected on the transparency. Share the other half of the transparency, briefly review the provided Moon data, and review the terminology used, including terms such as “period of orbit” and “surface gravity.” (See *Background for Lesson Discussion*.)

Part II: Making Connections to Saturn

- 1 Tell the students that this lesson will take a closer look at one of the elements of the Saturn system — the moons. Tell them that, until just recently, Saturn's known moons numbered more* than any other planet's. Draw a line down the center of the chalkboard. At the top of the first column, write “What We Know.” Ask students what they already know about Saturn's moons. Record their responses in the first column.

*As of September 1999, Uranus may be the moon champion — recent discoveries indicate that Uranus may have as many as 21 moons, compared with Saturn's 18 moons. The Cassini mission may discover more moons of Saturn.



- 2 At the top of the second column, write “Questions We Have.” Ask students what they want to learn about Saturn's moons. Record their questions in the second column.

Make a set of *Saturn Moon Cards* (Figures 2–19) for each student group prior to the next portion of the lesson. To make one set, copy the *Saturn Moon Cards* and cut them along the dashed lines, or in half. You may want to use the completed Venn diagram from Lesson 1 to introduce similarities and differences between the Saturn system and the Earth–Moon system. You may want to use Greek mythology to introduce the names of Saturn's moons. See the *Cultural Connections* section or other resources such as children's literature or videos.

- 3 Arrange students in groups of two or three.
Give each group a complete set of *Saturn Moon Cards* (Figures 2–19). Review the meaning of the properties listed on the cards (see *Background for Lesson Discussion*, and the *Glossary*).
- 4 Instruct the groups to study the cards and to select the Saturn moon they believe is most like Earth's Moon. Remind them to use the information on Earth's Moon for comparison. Guide students to consider properties other than surface features and physical appearance, such as distance from the center of the planet, orbital speed and period, radius, mass, and surface gravity. Compute density when possible, and compare it with the Moon's density.
- 5 When the groups find the moon they believe is most like Earth's Moon, have the students create a *Moon Comparison Chart*. Have the group tape their chosen *Saturn Moon Card* to the top half of a sheet of notebook paper and fill in corresponding properties for Earth's Moon on the bottom half. Ask one member of the group to record the explanation of how the group determined that the two moons are alike.





- 6 Have the groups share the *Moon Comparison Charts* they created and explain how they determined that the two moons are alike.

According to the National Science Education Standards, “Abilities necessary to do scientific inquiry” include designing and conducting a scientific investigation (i.e., students should be able to formulate questions, design and execute experiments, interpret data, synthesize evidence into explanations, propose alternative explanations for observations, and critique explanations and procedures).

- 7 Gather the students in an open area in the classroom and tell them that the next part of the lesson is to use the *Saturn Moon Cards* to look for relationships among the various properties of Saturn’s moons. Model how to arrange the cards according to a property listed on their *Saturn Moon Cards*. For example, ask the students to order the cards from least to greatest distance from the center of Saturn. Check to be sure each group has done this properly.

- 8 Explain that relationships can be determined by looking at the other data on the cards when the cards are ordered or sorted in a particular way. For example, ask the students to examine the ordered cards to try to determine what happens to the orbital period as a moon’s distance from the center of Saturn increases.

- 9 Guide students to see that as the distance from the center of Saturn increases, the orbital period also increases. In other words, the farther the moon is from Saturn, the longer the moon takes to orbit the planet.

- 10 Record on the chalkboard: “As the distance from the center of Saturn increases, the orbital period also increases.” Tell students that there are many other relationships to be discovered from the data on the *Saturn Moon Cards*.

- 11 Point to the other properties listed on the cards to show how to look for a pattern of increasing or decreasing quantity. Explain that this is one way to look for relationships. As one set of values increases, does another increase or decrease? How does it change?

- 12 List the following items on the chalkboard:

- Mass — Size
- Size — Shape
- Date of Discovery — Size
- Distance from Center of Saturn — Orbital Speed
- Distance from Center of Saturn — Mass
- Orbital Speed — Mass
- Size — Orbital Speed

- 13 Tell the students that they need to arrange the *Saturn Moon Cards* in different ways to test for the relationships between the pairs of properties listed on the board. Have them record their conclusions about the relationships on a separate sheet of paper. Inform the students that a clear relationship may not exist between some of the pairs of properties.

- 14 Once all the groups have recorded their discoveries, discuss the relationships observed by each group. See the *Saturn Moon Relationships Table* (Figure 20) for a sample of correct answers. Use the figure as a transparency or make copies for the students.

From the National Science Education Standards: “Knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists (e.g., reviewing experimental procedures, examining evidence, identifying faulty reasoning, identifying statements that go beyond the evidence, suggesting alternative explanations).”



Part III: Assessment

1 Tell students that other moons may exist in the Saturn system. Tell them that the next part of the lesson is hypothetical and that they will be creating a *Mystery Moon Card*. They will model their card after the *Saturn Moon Cards*.

2 Write the following information about the mystery moon on the chalkboard:

1) The mystery moon is located in the Saturn system. 2) The mystery moon's distance from the center of Saturn is the same as the distance between Earth and the Moon. 3) The radius, mass, and surface gravity of the mystery moon are the same as those of Earth's Moon.

3 Give each student a copy of the *Mystery Moon Card* (Figure 21). Tell students they should use the *Saturn Moon Cards*, the *Profile of Earth's Moon*, and what they have learned about discovering relationships in the Saturn system to estimate the unknown data on the *Mystery Moon Card*. A helpful hint is to suggest that students order the cards and include the *Profile of Earth's Moon*. Each student should prepare his or her own unique *Mystery Moon Card*.

4 Allow time for the students to work with the *Saturn Moon Cards* and the *Profile of Earth's Moon*. Have the students complete the *Mystery Moon Card*, giving the mystery moon a unique name, drawing the mystery moon, naming himself or herself as discoverer, estimating when the moon would have been discovered by real astronomers, estimating an orbital period and orbital speed, and writing a paragraph about the moon's features.

Assessment Criteria

- *The drawing of the mystery moon is spherical in shape. (Earth's Moon is similar in size to the moons of Saturn that are spherical in shape.)*

- *The Mystery Moon Card data for the date of discovery, orbital period, and orbital speed fall within these ranges:*

DATE OF DISCOVERY: *Between 1655 (Titan) and 1672 (Rhea). The size of Earth's Moon (1,738 km) is between the size of Titan (2,575 km) and Rhea (764 km). Using the relationship between the size and the date of discovery, students can infer that the mystery moon would have been discovered between 1655 and 1672.*

ORBITAL PERIOD: *Between 2.74 days (Dione) and 4.52 days (Rhea). The distance of 384,000 km falls between the orbits of Dione (377,400 km) and Rhea (527,040 km). Because the orbital period increases with distance from the center of the planet, the orbital period of the mystery moon should fall between the orbital period of Dione (2.74 days) and Rhea (4.52 days).*

ORBITAL SPEED: *Between 8.49 km/sec (Rhea) and 10.03 km/sec (Dione). Since orbital speed decreases as distance from the center of the planet increases, the orbital speed of the mystery moon should fall between the orbital speed of Rhea (8.49 km/sec) and Dione (10.03 km/sec).*

- *The mystery moon distance from the center of Saturn is 384,000 km (same as Earth–Moon distance).*

- *The mystery moon data for radius, mass, and surface gravity are:*

RADIUS: *1,738 km (same as Earth's Moon)*

MASS: *735×10^{20} kg (same as Earth's Moon)*

SURFACE GRAVITY: *0.17 of Earth's (same as Earth's Moon)*

- *The student has written a paragraph that describes the surface features of a mystery moon.*



Part IV: Questions for Reflection

- Would the relationships between physical properties (e.g., between orbital speed of a moon and distance from the center of the planet it orbits) be the same for Jupiter and its many moons?
- If you were to send a probe to one of Saturn's moons, which one would it be? Why? What would you hope to discover?



Questions

These questions and their answers can be used to provide background for teachers or to explore prior knowledge and facilitate discussions with students. The answers are found in Appendix 1, starting on page 225.

Saturn

1. When did we discover Saturn?
2. How did Saturn get its name?
3. Where is Saturn located?
4. How old is Saturn?
5. How big is Saturn?
6. If Saturn is so much more massive than Earth, why is it said that Saturn could float in water?
7. What is Saturn made of?
8. Could we breathe Saturn's atmosphere?
9. Pictures of Saturn show that it sort of flattens out near the poles and is wider at the equator. Why is that?
10. Why is Saturn so much larger and more massive than Earth?
11. Since Saturn does not have a solid surface, would I sink to the middle of the planet if I tried to walk there?
12. What's gravity like on Saturn? Would I weigh the same on Saturn as on Earth?
13. What is the temperature on Saturn?
14. Does Saturn have winds and storms?
15. Since Saturn and Jupiter are both made up of mostly hydrogen and helium, why isn't Saturn the same color as Jupiter?
16. Is there life on Saturn?
17. Does Saturn have a magnetic field like Earth's?
18. How long is a day on Saturn?
19. How long is a month on Saturn?
20. How long is a year on Saturn?
21. Does Saturn have seasons like Earth?

Moons

35. How many moons does Saturn have?
36. Who discovered all these moons?
37. How did the moons get their names?
38. Are Saturn's moons like Earth's Moon?
39. Why does Saturn have so many moons, but Earth has only one?
40. Are Saturn's moons in the rings? Do the moons collide with the ring particles?
41. What is the difference between a moon and a ring particle?
42. What's gravity like on Saturn's moons? Could we walk there?
43. Are there volcanoes on any of Saturn's moons?
44. How cold are Saturn's moons?
45. Do any of Saturn's moons have an atmosphere? Could we breathe it?
46. Is there water on Titan?
47. Is there life on Titan?
48. What is the weather like on Titan?
49. Cassini carries a probe that is going to Titan, not Saturn or any other moons. Why Titan?
50. Will there be a mission that takes humans to Titan in the near future?





Materials

Figure 1 **Profile of Earth's Moon**

Figures 2-19 **Saturn Moon Cards**

Figure 20 **Saturn Moon Relationships Table**

Figure 21 **Mystery Moon Card**





Figure 1

Profile of Earth's Moon


Distance from Earth

384,500 km (238,900 mi)

Orbital Period

27.32 days (655.73 hrs)

Orbital Speed

1.02 km/sec (0.67 mi/sec)

Radius

1,738 km (1,080 mi)

Mass

735×10^{20} kg

Density

3.34 g/cm^3

Surface Gravity

0.166 of Earth's

Other Features

- Rocky, cratered, mountainous.
- One side always faces Earth.
- Prominent flat, dark areas known as *maria* on Earth-facing side — lava flows filled gigantic meteorite craters called impact basins.
- Humans first landed there in 1969.



LESSON

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Figure 2

Saturn
Moon Card

Pan

Discovered by Mark Showalter, 1990



One of the tiniest moons in the Saturn system, Pan orbits in the narrow Encke Gap near the outer edge of the A ring and actually clears out ring particles to form the gap. If Pan disappeared, so would the Encke Gap. Voyager took pictures of Pan during the flybys of 1980–81, but the moon was not found until 10 years later, when astronomer Mark Showalter carefully hunted through the Voyager images to see if he could find a moon. *Cassini might answer...* Are there more undiscovered moons like Pan, clearing areas like the Encke Gap in the main rings?

Distance from Center of Saturn

133,583 km (83,000 mi)

Radius

10 km (6 mi)

Orbital Period

0.577 days (13.85 hrs)

Mass

Unknown

Orbital Speed

16.84 km/sec (10.46 mi/sec)

Surface Gravity

Unknown

Figure 3

Saturn
Moon Card

Atlas

Discovered by Richard Terrile and the Voyager team, 1980



Atlas (AT-less) is the second innermost of Saturn's known moons. Astronomers believe it may be maintaining the sharp outer edge of the A ring. *Cassini might answer...* How could a moon like Atlas keep the outer edge of the A ring so sharp?

Distance from Center of Saturn

137,640 km (85,530 mi)

Radius

$18.5 \times 17.2 \times 13.2$ km avg. = 16 km (10 mi)

Orbital Period

0.601 days (14.42 hrs)

Mass

Unknown

Orbital Speed

16.63 km/sec (10.3 mi/sec)

Surface Gravity

Unknown





LESSON

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Figure 4

Saturn
Moon Card

Prometheus

Discovered by Stewart Collins and the Voyager team, 1980



Moving outward from Saturn, Prometheus (pro-MEE-thee-uss) is the third moon. Together with Pandora (the fourth moon), Prometheus acts as a shepherd moon for the F ring. This means the moons' gravity nudges the F ring particles into a thinner ring, much like shepherds keep their flocks of sheep together. Prometheus is extremely elongated, much more so than an egg. *Cassini might answer...* What could have caused Prometheus' odd shape? How do Prometheus and Pandora shepherd the F ring? Are there other moons playing shepherding roles?

Distance from Center of Saturn

139,350 km (86,590 mi)

Radius

$74 \times 50 \times 34$ km avg. = 53 km (33 mi)

Orbital Period

0.613 days (14.71 hrs)

Mass

Unknown

Orbital Speed

16.53 km/sec (10.27 mi/sec)

Surface Gravity

Unknown

Figure 5

Saturn
Moon Card

Pandora

Discovered by Stewart Collins and the Voyager team, 1980



Moving outward from Saturn, Pandora (pan-DOR-uh) is the fourth moon. Together with Prometheus (the third moon) it acts as a shepherd moon for the F ring. This means the moons' gravity nudges the F ring particles into a thinner ring, much like shepherds keep their flocks of sheep together. *Cassini might answer...* How do Prometheus and Pandora shepherd the F ring? Are there other moons playing shepherding roles?

Distance from Center of Saturn

141,700 km (88,050 mi)

Radius

$55 \times 44 \times 31$ km avg. = 43 km (27 mi)

Orbital Period

0.628 days (15.07 hrs)

Mass

Unknown

Orbital Speed

16.38 km/sec (10.18 mi/sec)

Surface Gravity

Unknown





LESSON

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Figure 6

Saturn
Moon Card

Epimetheus



Discovered by Telescope Observation, 1966

The moon Epimetheus (epp-ee-MEE-thee-uss) shares its orbit with its neighbor, Janus. Both moons are in circular orbits around Saturn, with one of them slightly inward of the other. As the inner moon passes the outer one, they swap orbits! The new inner moon — which used to be the outer one — then begins to pull away from its companion, and the whole process begins again. In the image, note the shadow of one of Saturn's rings, like a stripe on the surface. *Cassini might answer...* Are there other moons that swap orbits like these two moons?

Note: The orbital periods for Epimetheus and Janus are slightly different but round off to the same value.

Distance from Center of Saturn

151,422 km (94,090 mi)

Radius

$69 \times 55 \times 55$ km avg. = 60 km (37 mi)

Orbital Period

0.695 days (16.68 hrs)

Mass

Unknown

Orbital Speed

15.87 km/sec (9.86 mi/sec)

Surface Gravity

Unknown

Figure 7

Saturn
Moon Card

Janus



Discovered by Telescope Observation, 1966

The moon Janus (JANE-uss) shares its orbit with its neighbor, Epimetheus. Both moons are in circular orbits around Saturn, with one of them slightly inward of the other. As the inner moon passes the outer one, they swap orbits! The new inner moon — which used to be the outer one — then begins to pull away from its companion, and the whole process begins again. *Cassini might answer...* Are there other moons that swap orbits like these two moons?

Note: The orbital periods for Epimetheus and Janus are slightly different but round off to the same value.

Distance from Center of Saturn

151,472 km (94,120 mi)

Radius

$97 \times 95 \times 77$ km avg. = 90 km (56 mi)

Orbital Period

0.695 days (16.68 hrs)

Mass

Unknown

Orbital Speed

15.85 km/sec (9.85 mi/sec)

Surface Gravity

Unknown





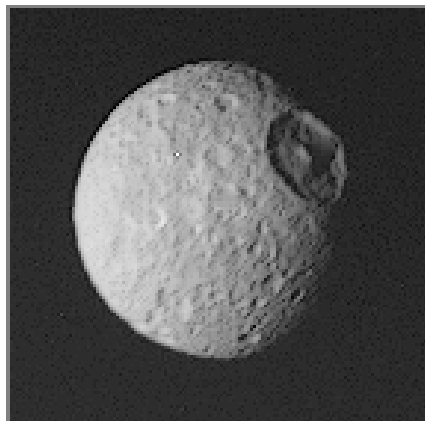
LESSON

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Figure 8

Saturn
Moon Card

Mimas



Discovered by William Herschel, 1789

Mimas (MY-muss), the so-called “Death Star” moon, may have been hit and nearly shattered by a large asteroid or another moon. The massive crater caused by the impact is 130 kilometers (80 miles) in diameter, and in the center of the crater is a mountain more than 10 kilometers (6 miles) high — almost a mile higher than Mt. Everest! Astronomers think that even though Mimas does not orbit in the Cassini Division, its gravity is responsible for making this division (between the bright A and B rings) clear of ring material. *Cassini might answer...* How does the gravity of Mimas clear out the Cassini Division?

Distance from Center of Saturn

185,520 km (115,277 mi)

Radius

199 km (124 mi)

Orbital Period

0.942 days (22.61 hrs)

Mass

0.4×10^{20} kg

Orbital Speed

14.32 km/sec (8.90 mi/sec)

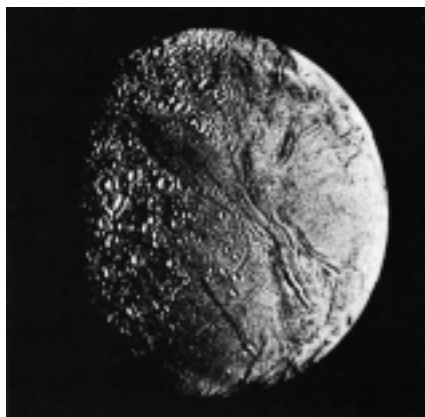
Surface Gravity

0.007 of Earth's

Figure 9

Saturn
Moon Card

Enceladus



Discovered by William Herschel, 1789

Much of the bright surface on Enceladus (en-SELL-uh-duss) consists of water ice. Some parts of the surface are smooth and have only a few impact craters, suggesting that events heated up and melted large areas of the icy surface, erasing many craters. It may even be possible that the gravitational tug of tidal forces from Saturn and other moons have caused the surface of Enceladus to warm and melt, occasionally triggering geysers of ice and water to erupt from the surface! *Cassini might answer...* Are ice geysers from this moon spewing material that becomes the tiny ice particles of the E ring?

Distance from Center of Saturn

238,020 km (147,900 mi)

Radius

249 km (155 mi)

Orbital Period

1.37 days (32.88 hrs)

Mass

0.8×10^{20} kg

Orbital Speed

12.63 km/sec (7.85 mi/sec)

Surface Gravity

0.009 of Earth's





LESSON

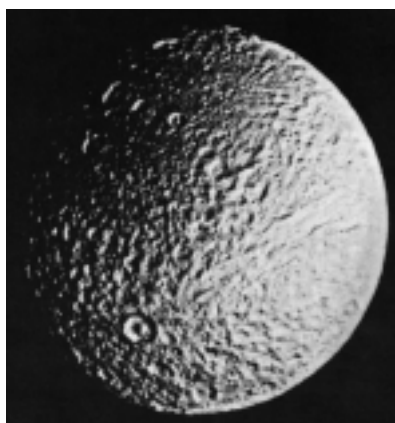
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Figure 10

Saturn
Moon Card

Tethys

Discovered by Jean-Dominique Cassini, 1684



Tethys (TEE-thiss) is full of impact craters, including a large crater over 400 kilometers (250 miles) across — nearly half the diameter of the moon itself. On the opposite side, a giant crack extends over 3/4 of the way around the moon! This enormous canyon on Tethys is many times longer and deeper than the Grand Canyon on Earth. *Cassini might answer...* What more can we learn about the giant crack, named Ithaca Chasma, on this moon? What more can we learn about the giant crater, named Odysseus, on the opposite side? Are they linked?

Distance from Center of Saturn

294,660 km (183,090 mi)

Radius

530 km (329 mi)

Orbital Period

1.888 days (45.31 hrs)

Mass

7.55×10^{20} kg

Orbital Speed

11.34 km/sec (7.04 mi/sec)

Surface Gravity

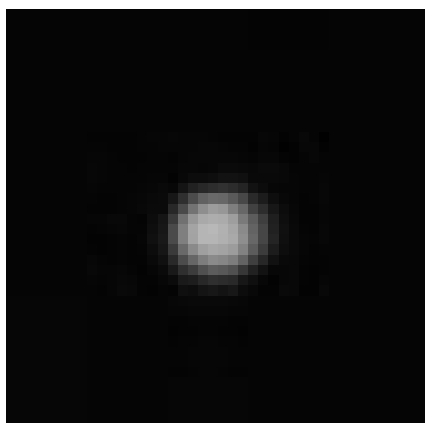
0.018 of Earth's

Figure 11

Saturn
Moon Card

Telesto

Discovered by Brad Smith, Steve Larson, and Harold Reitsema, 1980



The orbit of this moon has a special relationship to that of the large moon Tethys. Telesto (tel-LESS-toe) and Calypso orbit at the same distance from Saturn as Tethys as they travel around Saturn. Telesto always remains 60° behind Tethys at the L5 point, while Calypso is always 60° ahead at the L4 point. Can you draw a labeled diagram to show this? *Cassini might answer...* How did the moons get into this type of shared orbit?

Distance from Center of Saturn

294,660 km (183,090 mi)

Radius

$15 \times 12.5 \times 7.5$ km avg. = 12 km (7 mi)

Orbital Period

1.888 days (45.31 hrs)

Mass

Unknown

Orbital Speed

11.34 km/sec (7.04 mi/sec)

Surface Gravity

Unknown





LESSON

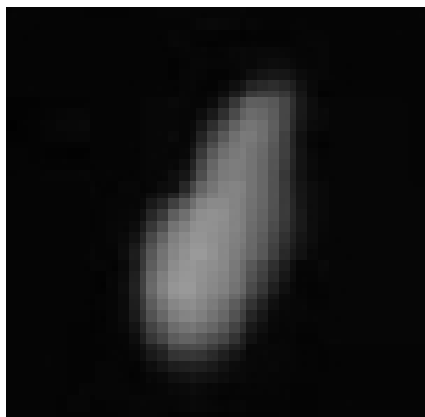
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Figure 12

Saturn
Moon Card

Calypso

Discovered by Dan Pascu, 1980



The orbit of this moon has a special relationship to that of the large moon Tethys. Calypso (kuh-LIP-soh) and Telesto orbit at the same distance from Saturn as Tethys as they travel around Saturn. Telesto always remains 60° behind Tethys at the L5 point, while Calypso is always 60° ahead at the L4 point. Can you draw a labeled diagram to show this? *Cassini might answer...* How did the moons get into this type of shared orbit?

Distance from Center of Saturn

294,660 km (183,090 mi)

Radius

$15 \times 8 \times 8$ km avg. = 10 km (6 mi)

Orbital Period

1.888 days (45.31 hrs)

Mass

Unknown

Orbital Speed

11.34 km/sec (7.04 mi/sec)

Surface Gravity

Unknown

Figure 13

Saturn
Moon Card

Dione

Discovered by Jean-Dominique Cassini, 1684



Dione (die-OH-nee) appears to be covered with water ice and many impact craters. Floods may have filled many of the craters. Bright streaks cover one side of this moon. Dione also appears to control the intensity of radio waves generated by Saturn's magnetic field. *Cassini might answer...* What caused the floods? Why might Dione be affecting Saturn's radio emissions? Does Dione have a magnetic field of its own?

Distance from Center of Saturn

377,400 km (234,500 mi)

Radius

560 km (348 mi)

Orbital Period

2.737 days (65.69 hrs)

Mass

10.5×10^{20} kg

Orbital Speed

10.03 km/sec (6.23 mi/sec)

Surface Gravity

0.023 of Earth's





Figure 14

Saturn
Moon Card

Helene



Discovered by Pierre Laques and Jean Lecacheux, 1980

Helene (huh-LEE-nee) is a small moon orbiting at the exact same distance from Saturn at the L4 point, 60° ahead, of the large moon Dione. Saturn seems to have a long history of “adopting” moons. Most of the smaller moons like Helene are not round, but instead have strange or irregular shapes. *Cassini might answer...* Why do so many of Saturn’s moons share orbits?

Distance from Center of Saturn

377,400 km (234,500 mi)

Radius

17.5 km (11 mi)

Orbital Period

2.737 days (65.69 hrs)

Mass

Unknown

Orbital Speed

10.05 km/sec (6.25 mi/sec)

Surface Gravity

Unknown

Figure 15

Saturn
Moon Card

Rhea



Discovered by Jean-Dominique Cassini, 1672

Rhea (REE-uh) is Saturn’s second largest moon. Like Dione and Tethys, astronomers think it is composed of rock covered by water ice. It has more impact craters than any other moon orbiting Saturn. In the Voyager pictures, we also see wispy, light-colored streaks on one side of the moon. *Cassini might answer...* Why does Rhea have so many craters compared with the other moons? Does it have any connection with geologic activity such as earthquakes or erupting volcanoes? Could the wispy streaks be water released from the interior and frozen on the surface in the distant past? Why are the streaks only on one side?

Distance from Center of Saturn

527,040 km (327,490 mi)

Radius

764 km (475 mi)

Orbital Period

4.517 days (108.42 hrs)

Mass

24.9×10^{20} kg

Orbital Speed

8.49 km/sec (5.27 mi/sec)

Surface Gravity

0.029 of Earth’s





LESSON

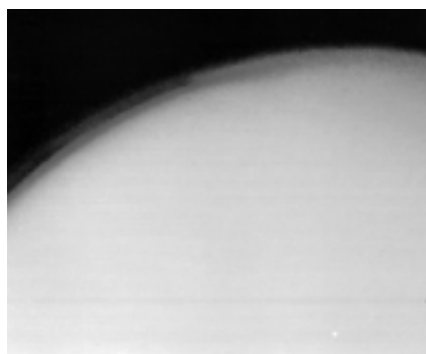
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Figure 16

Saturn
Moon Card

Titan

Discovered by Christiaan Huygens, 1655



Titan (TIE-ten), Saturn's largest moon, is one of the few bodies in the Solar System besides Earth with a dense atmosphere. Like Earth, its atmosphere is made mostly of nitrogen. Scientists believe Titan's atmosphere may be similar to that of the early Earth, before life began. Titan's atmosphere is extremely cold and so hazy that very little sunlight reaches the surface. Titan's temperatures hover around -180°C (-292°F). The Cassini mission's Huygens probe will descend through Titan's atmosphere, taking the first close-up pictures of Titan's surface. *Cassini might answer...* Does Titan have mountains of ice or rock? What color is Titan's surface?

Distance from Center of Saturn
1,221,850 km (759,220 mi)

Radius
2,575 km (1,600 mi)

Orbital Period
15.945 days (382.7 hrs)

Mass
 $1,346 \times 10^{20}$ kg

Orbital Speed
5.57 km/sec (3.46 mi/sec)

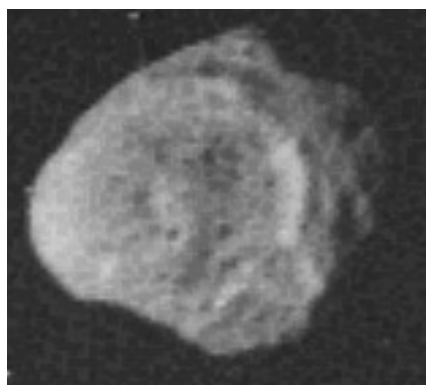
Surface Gravity
0.138 of Earth's

Figure 17

Saturn
Moon Card

Hyperion

Discovered by William Bond, George Bond, and William Lassell, 1848



Little Hyperion (high-PEER-ee-on) is especially interesting. It orbits just beyond Saturn's giant moon, Titan. Why is Hyperion shaped like a dented hamburger? Could it be a fragment of a large moon that was split apart by collision with an asteroid? It tumbles unpredictably in its orbit, causing its north pole to point in different directions. Sometimes it spins slowly, and sometimes quickly! *Cassini might answer...* Could the gravitational tug of Titan be causing Hyperion's wild tumbling?

Distance from Center of Saturn
1,481,100 km (920,310 mi)

Radius
 $180 \times 140 \times 112.5$ km avg. = 144 km (90 mi)

Orbital Period
21.276 days (510.6 hrs)

Mass
Unknown

Orbital Speed
5.06 km/sec (3.15 mi/sec)

Surface Gravity
Unknown





LESSON

2

Figure 18

Saturn
Moon Card

Iapetus

Discovered by Jean-Dominique Cassini, 1671



Iapetus (eye-APP-eh-tuss) is a strange moon that appears bright white on one side and dark, almost black, on the other. The bright area may be water ice, while the dark area — called Cassini Regio — is a mystery! *Cassini might answer...* Why is Iapetus' surface half bright and half dark? Could it come from dark material bubbling out from volcanoes? Or might it come from dust in space being swept up by the moon, like a cosmic broom?

Distance from Center of Saturn
3,561,300 km (2,212,900 mi)

Radius
718 km (446 mi)

Orbital Period
79.331 days (1,904 hrs)

Mass
 18.8×10^{20} kg

Orbital Speed
3.26 km/sec (2.03 mi/sec)

Surface Gravity
0.025 of Earth's

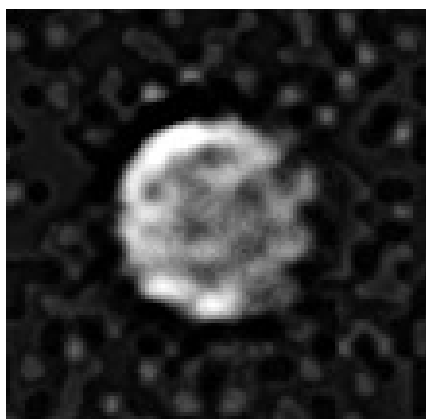


Figure 19

Saturn
Moon Card

Phoebe

Discovered by William Pickering, 1898



Little Phoebe (FEE-bee) is the farthest moon from Saturn yet discovered. Unlike the others, Phoebe and neighboring moon Iapetus have significantly tilted orbits. This means these moons pass above, then below the plane of the rings during their journey around Saturn. Phoebe is a strange, dark moon that orbits Saturn in a direction opposite that of all of the other moons. We don't know why Phoebe is "backwards." *Cassini might answer...* Is Phoebe a captured asteroid? Why is it orbiting backwards compared with the rest of the moons? Will it still be there far in the future?

Distance from Center of Saturn
12,952,000 km (8,048,000 mi)

Radius
 $115 \times 110 \times 105$ km avg. = 110 km (68 mi)

Orbital Period
550.46 days (13,211 hrs)

Mass
Unknown

Orbital Speed
1.71 km/sec (1.06 mi/sec) (reversed)

Surface Gravity
Unknown





Figure 20

Saturn Moon Relationships Table

Compared Properties	Relationship
Mass–Size	As the radius/size of the moon increases, the mass of the moon also increases. This does not mean, however, that larger things are always more massive. Compare a beach ball and a cannonball. Which is larger? Which is more massive?
Size–Shape	As the moons increase in size, the shape becomes spherical. The smaller moons tend to have more irregular shapes.
Date of Discovery–Size	As the size of the moon decreases, the date of discovery is more recent. Bigger moons were discovered before smaller moons. Ask students why they think this is the case. Better technology?
Distance from Center of Saturn–Orbital Speed	As the distance from the center of Saturn increases, the orbital speed decreases. Moons farther away from Saturn move around more slowly. This is a consequence of Newton's Law of Gravity.
Distance from Center of Saturn–Mass	There is no simple physical relationship between a moon's distance from the center of Saturn and its mass.
Orbital Speed–Mass	There is no relationship between the orbital speed of the moons and the mass of the moons. In fact, orbital speed is not at all dependent on mass.
Size–Orbital Speed	There is no physical relationship between the size of the moons and the orbital speed of the moons.





Mystery Moon Card

Name of Moon

Discovered by

Date of Discovery

Drawing of My Mystery Moon

Description of My Mystery Moon

Distance from Center of Saturn

Radius

Orbital Period

Mass

Orbital Speed

Surface Gravity



