Lab 8 – Saturn's Rings

ASTR 1010

Name:

Overview:

In this activity, you will explore how Saturn obtained its rings, and why they are confined to a thin, disk structure.

Objectives:

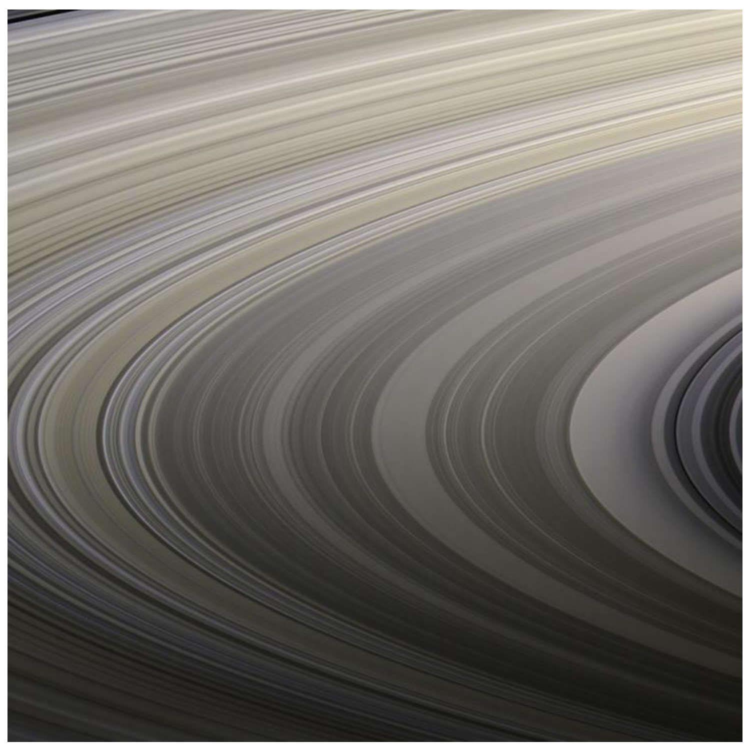
After completing this activity, students will be able to:

- Explain elasticity
- Explain why Saturn's rings are shaped like a disk
- Explain why there are moons within the rings

Definitions

Here are some terms from lecture that we will be using today in lab:

- **Sign of a value** - the positive (+) or negative (-) component of a numerical value
- **Elasticity** - a percentage between 0% and 100% that measures how much of the kinetic energy is lost to deforming or heating the object. An elasticity of 100% means that no energy is lost to deformation or heating, the object is therefore not heated or deformed, and the speed remains constant. An elasticity of 0% means the maximum amount of kinetic energy is lost and the object is deformed or heated and the speed decreases.
- **Kinetic Energy** - the energy of motion. The faster an object moves the larger its kinetic energy.



NASA/ Cassini

- **Inelastic Collision** - a collision that occurs between two objects with an elasticity of 0%. This results in the two objects sticking together.

Part 1: Understanding Elasticity

For Part 1 of this activity you will use the Collision simulator from the University of Colorado – Boulder to investigate simple collisions. The simulation takes a few minutes to load, so be patient! You may need to allow flash (see video in the 'Extra Info' module). The applet can be found here:

https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html

Instructions for funning the applet will be lettered with lowercase letters (a, b, c, etc.…) and questions will be numbered (1, 2, 3, etc.…)

You will start by analyzing the collision of a single ball with the wall of a container.

- **a.** At the top of the window, click on the blue tab labelled "Advanced." Beware of the "Reset All" button, as this will undo all of your setup of the simulator.
- **b.** Click the "Remove Ball" button in the lower left corner of the window to get rid of the green ball so that we can focus on one ball
- **c.** Click the "More Data" button below where the "Remove Ball" button used to be.

The x-component of the velocity (V_x) refers to motion left and right. The y-component of the velocity (V_y) refers to motion up and down. Notice that the velocity vector arrow initially points to the right and up. We want it to just point to the right, so…

- **d.** Type in 0 for V_y.
- **e.** Make sure the elasticity slider on the right side of the window is set to 100%.
- **f.** Click the "Play" button to start the simulator.

1. Describe what you observe.

2. Take note of the sign and the value of the x-component of the velocity before an after the collision. How does the sign change? Explain why this happens.

3. Does the value of the x-component of the velocity change? Explain why this happens.

4. Why does the value remain the same but the sign change?

g. Now click the "Restart" button.
h. Set the elasticity to 75%.
i. Click the "Play" button to start the simulator.

5. What is the speed of the ball before **AND** after it bounces off the wall?

j. Now click the "Restart" button.
k. Set the elasticity to 50%.
l. Click the "Play" button to start the simulator.

6. What is the speed of the ball before **AND** after it bounces off the wall?

m. Now click the "Restart" button.
n. Set the elasticity to 25%.
o. Click the "Play" button to start the simulator.

7. What is the speed of the ball before **AND** after it bounces off the wall?

8. What is the pattern you see between questions 5-7? Hint: Think of how you are changing the elasticity of the simulation and how the speed then changes as a result.

9. As you decrease the elasticity, the speed (or amount of kinetic energy) the ball has after the collision decreases. Why is this?

10. Explain this trend in terms of elasticity and kinetic energy.

Part 2: The Collision of two Particles

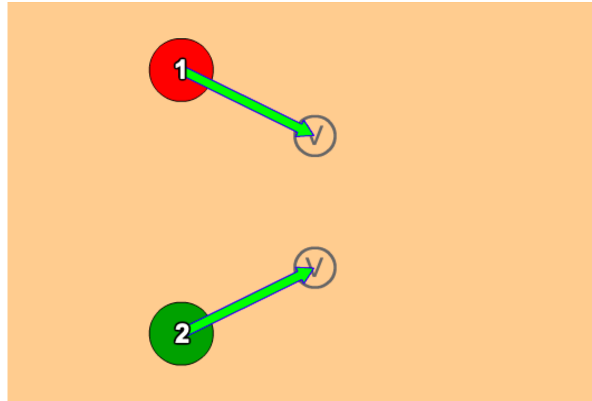
In the previous simulation we modeled elasticity using balls. The same concepts apply to particles which compose the entirety of Saturn's rings. **Note.** Simulator instructions have restarted labeling back at 'a'.

- **a.** Continuing from where we left off in the previous simulation, uncheck the box labelled "Reflecting Border".
- **b.** Click the "Play" button to restart the simulator.
- **c.** Click "Add Ball".
- **d.** Click and drag Ball 2 so that it is below Ball 1, close to the bottom wall of the simulator.
- **e.** Adjust the parameters of the balls to the following values:

Table 1. Simulator Parameters

	Mass	x	y	V_x	V_y
Ball 1	0.5	1.0	0.5	1.0	-0.5
Ball 2	0.5	1.0	-0.5	1.0	0.5

The simulator should now look like this →



- **f.** Check the box labelled "Show Paths".
- **g.** Make sure the elasticity is set to 100%.
- **h.** Start the simulation.

11. Do the x-components of the speed (V_x) change following the collision?

12. Do the y-components of the speed (V_y) change following the collision? Ignore the sign change.

- **i.** Restart the simulation.
- **j.** Set the elasticity to 50%.
- **k.** Start the simulation.

13. Do the y-components of the speed (V_y) change following the collision? Again, ignore the sign change.

14. How does changing the elasticity change the direction of the paths after the collision?

l. Click “Restart”.
m. Set the elasticity to 0. Note: When two objects collide with an elasticity of 0, it is called an inelastic collision.
n. Start the simulation again.

15. How does this change the paths of the particles after the collision?

16. Based on the fact that Astronomers currently believe that planets can form through the combination of many particles into larger and larger spheres, do you think this is a realistic scenario?

17. Based on these experiments, why are Saturn’s rings shaped like a disk?

Part 3: Moons within the Rings

Saturn has 83 moons (53 confirmed and 29 moons are awaiting confirmation and official naming).

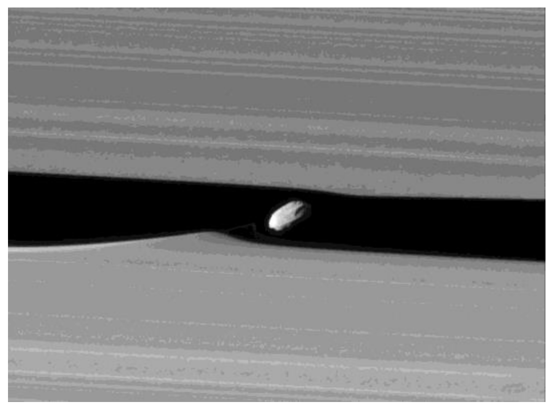
18. Is it possible for particles within Saturn’s rings to coalesce into small moons based on the concepts of elastic and inelastic collisions explored previously? Why or why not?

19. Once a moon has formed, will it continue to accrete more particles from the surrounding rings? Why? Hint: Think of all the debris that would be in the way of the moon as it orbits Saturn.

20. What would this section of the rings look like once a moon has cleared its orbital path around Saturn?

21. Do we see any features in the rings of Saturn that would suggest that there are moons within them? See the picture on the first page.

Here is a picture of Saturn's moon Daphnis (taken by Cassini) to help you verify your answers to Questions 18-21.



Part 4: Formation of the Rings

Saturn is the second largest planet in the Solar System and therefore has the second largest gravitational field of the planets. Due to this large gravitational field, Saturn has captured a plethora of asteroids that strayed too close to the gas giant. Each of these captured asteroids is then classified as a moon of Saturn. The more moons there are orbiting the planet, the more likely they are to collide with each other.

22. What would happen if two moons collided with each other? Hint: Think about what happens when two clumps of dirt collide with each other.

23. What would happen if these progressively smaller clumps continued to collide with each other?

24. Would the same effect we investigated in part 2 have an effect on these particles? Why or why not?

25. What would be the result of these continued collisions?

To complete this assignment for grading:

- File → Save As… → Rename the file 'YourLastName –SaturnsRingsLab'
- Upload to the file to the 'Lab 8 – Saturn's Rings' assignment in iCollege (click Add Attachments → Upload → upload renamed saved file → Update).
- Complete the Reflection activity on iCollege
- Contemplate what you would name one of Saturn's 29 unnamed moons!