To Infinity and Beyond

Jessica Choy | Fall 2020

Field(s) of Interest: Astronomy

Brief Overview:
The Solar System includes our home on planet Earth along with seven major planets that orbit around the Sun. In this lesson, mentees will explore the different components that make up the planetary system that we live in.

Agenda:
- Introduction (5 min)
- Module 1: I Need Space (15 min)
    - (Advanced Sites) Module 1: I Need More Space (15 min)
- Module 2: I'm Going Through a Phase (15 min)
- Module 3: A Long Time Ago in a Galaxy Far, Far Away (20 min)
- Conclusion (5 min)

Teaching Goals/Key Terms:
- The **Solar System** is composed of planets, asteroids, and comets that orbit around the Sun.
- **Moons** are natural satellites made of rocks and dust that orbit around planets and asteroids.
- The **phases of the Moon** we observe are casted shadows on the Moon dependent on the orbit of the Moon around the Earth.
- A **nebula** is made of dust and gas that creates stars when it enlarges and collapses due to its gravity.

Mentor Development Notes

Written by Cammie Young

Teaching Space-Related Concepts

Because this lesson is focused on concepts that cannot be seen with the naked eye, it probably will require a lot of imagination from the kids. To help them visualize these concepts, it would be helpful to **provide them with as many pictures and models as possible!** Start off the lesson talking about something the kids would be interested in, something like a rocket ship being sent to the moon! As you move through the modules in the lesson, **strive to teach with a model or picture on hand as a guide for the kids.** In this way, the kid will direct their attention to you and less to background distractors.

A Possible Difficult Situation

Due to her religion, Jane, your mentee, doesn't believe in concepts like the formation of nebulas and the creation of the universe. How would you still engage her in this lesson?

This is a tough situation to be in, but **definitely don't promote any theories of the creation of the universe to your mentee**. Rather, **demonstrate that you have taken their thoughts into consideration** (ex. "I know some people believe..., but here's another way to think about this concept", and ask them to simply ask them to listen and follow along this lesson with curiosity. **Excite them with the activities of the lessons like the colorful, sparkly jars or the oreo map of the moon without going too deep into the science concepts**. In the end, Jane might still say "But I still don't believe in nebulas!" That's all right. Remember, the job of you as a mentor is to help mentees like Jane be exposed to the consensus view of astronomy and not necessarily have them believe in it.

Connecting to the Bigger Picture

At the end of this lesson, we hope that you were able to cater to the different learners that will view the video or attend virtual sites. Zoom bestowed us many technical difficulties, but it also equipped us with numerous interactive platforms and whiteboards to engage the kids. **These tools and skills will help you down the road when you are getting ready to present your research, product, ideas, and etc!**

Background for Mentors: Module 1

Teaching Goals

- Solar System
- Sun
- Planets
  - Terrestrial
  - Jovian

Astronomers estimate that there are billions of galaxies in which there are potentially numerous amounts of planetary systems in the universe. The planetary system we live in, known as the **Solar System**, is located in the Milky Way Galaxy. It is composed of eight major planets, dwarf planets, comets, asteroids, and meteoroids that orbit around the Sun.

The star, a hot ball of gas, that rotates at the center of our Solar System is known as the **Sun**. The planets, comets, and asteroids orbit around the Sun due to its gravity holding them together. The energy released from the Sun is in the form of heat and light.

Planets must orbit around the Sun, have sufficient mass in order for its gravity to mold it into a spherical shape, and have an orbit free of small objects. Eight major planets orbit around the Sun in our Solar System. **Terrestrial planets** (Mercury, Venus, Earth, and Mars) are made of rocky material, relatively smaller in size, have solid surfaces, and do not have rings. **Jovian planets** (Jupitar, Saturn, Uranus, and Neptune) are immense in size, have rings, do not have solid surfaces, and they are further from the Sun. When scientists measure distance in the Solar System, they measure in Astronomical Units, AU. The average distance between the Sun and the Earth is one astronomical unit, which is about 92,000,000 miles.

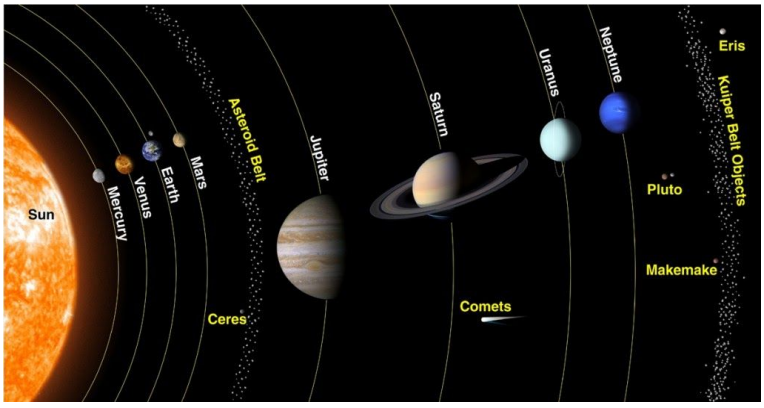

Figure 1: Components of the Solar System

Background for Mentors: Module 2

Teaching Goals

- Moon
- Phases of the Moon
  - Waxing
  - Waning

Moons are natural satellites made of rocks and dust that orbit around planets and asteroids. Earth has only one Moon that orbits around it. Because Earth spins continuously, the Moon rises in the east and sets in the west every day. The Moon's gravitational pull creates a stable climate and the tides on Earth.

The light we see from the Moon on Earth at night is sunlight being reflected off the surface of the Moon. The Sun always illuminates the half of the Moon that is facing the Sun. The eight different **phases of the Moon** are a result of the changing angles and relative positions of the Moon, Earth, and Sun. The Moon completely revolves around the Earth once a month making the lunar cycle 29.5 days. Each cycle begins with the New Moon in which the Sun and the Moon are aligned. A **Waxing Moon** is when the Moon is going from the New Moon to the Full Moon and getting brighter from the right side. A **Waning Moon** is when the Moon is going from the Full Moon to the New Moon and getting brighter from the left side.

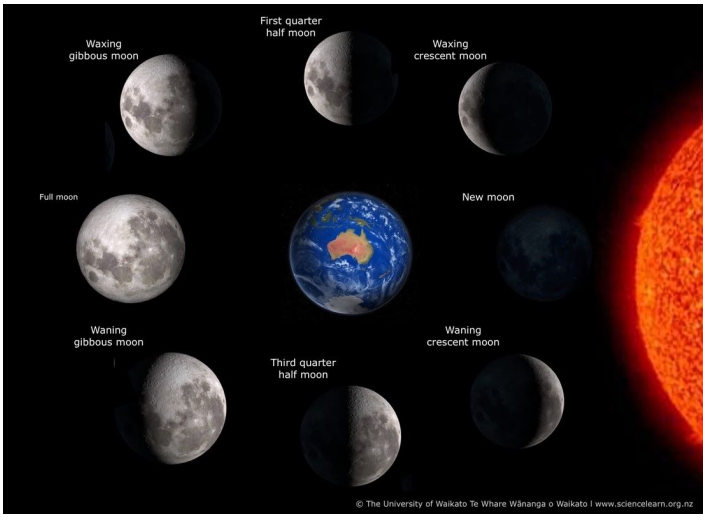

Figure 2: Eight Phases of the Moon

Background for Mentors: Module 3

Teaching Goals

- Nebula
  - Solar Nebula

A **nebula** is a cloud of dust, gas, and plasma in between stars that are formed through the aftermath of a supernova, a nearby exploding star, or through clouds of dust and interstellar gas. Nebulae are formed when gravitational attraction of interstellar matter and particles clump together. Stars emerge from the center of the collapsing material. The gas is visible at optical wavelengths because of the ultraviolet ionizing radiation.

Our Solar System was created approximately 4.5 billion years ago from a cloud of dust and gas. Due to a supernova, the cloud began to collapse and formed the **Solar Nebula**. The gravity caused particles to be pulled into the center which caused the pressure in the core to increase. As a result, hydrogen atoms combined to form helium. The reaction released energy in the form of heat and light creating the Sun. Gravity caused particles to collide and clump together forming larger objects, such as planets and moons. The smaller matter that resulted became asteroids, meteoroids, and comets.

Figure 3: Lagoon Nebula in which Herschel 36, a star, is forming in the center

Introduction

Astronomy is an important field of study because astronomical discoveries and inventions continuously play a major role in the human experience. Studying astronomy allows people to understand the origin, evolution, and the future of the universe. Along with that, astronomy is at the forefront of technological advancements and drives innovations.

Concepts to Introduce ● Here's a video introducing the Solar System ○ Solar System 101 ● To remember the order of the eight planets in order of closest to furthest from the Sun, here is a mnemonic ○ "**M**y **V**ery **E**ducated **M**other **J**ust **S**erved **U**s **N**oodles" ○ Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune ● To introduce the different phases of the Moon, here is a mnemonic ○ Moon Phases ■ "**N**ever **C**an **Q**uit ***G***etting **F**ood" ■ New, Crescent, Quarter, Gibbous, Full Moon ○ Waxing (Growing) vs Waning (Shrinking)	**Current or Past Events** ● SpaceX, a company founded by Elon Musk, successfully launched two astronauts, Robert L. Behnken and Douglas G. Hurley, into orbit on May 30, 2020. ○ SpaceX Launch: Highlights From NASA Astronauts' Trip to Orbit ● Scientists captured the first image of a black hole and its shadow on April 10, 2019. ○ Black Hole Image Makes History; NASA Telescopes Coordinate Observation
Questions to Pique Interest ● To spark mentees' interests, ask questions like ○ Who wants to or has thought about going to space? ○ Who wants to or has thought about being an astronaut? ● Ask mentees if they know anything about space in general!	**Inspiring Scientists, Careers, Applications** ● Astronomy is the scientific study of space, such as planets and stars. This science incorporates many fields of study, like mathematics and physics, to help explain the origin and evolution of the celestial objects and phenomena. ● Mae Jemison was the first African American woman to travel in space in 1992. ○ Mae Jemison ● On July 20, 1969, Neil Armstrong was the first person to walk on the moon. ○ July 20, 1969: One Giant Leap For Mankind

Module 1: I Need Space

This module will teach mentees about the Sun and the eight major planets that make up the Solar System by creating a Solar System Hat.

Teaching Goals	**Materials**
1. **Solar System**: Composed of the Sun, planets, moons, comets, and asteroids 2. **Sun**: Hot ball of gas whose gravity holds the Solar System together 3. **Planets**: Large objects that orbit around the Sun **Tips for Virtual Site** ● Instead of just talking about the ● Screen-share picture of solar system for better understanding	● 1 'Solar System Hat' Template ○ Solar System Hat ● Scissors ● Tape ● (Optional) Markers

Procedure

1. Cut out the eight planets and the hat template.
2. Label the planets 1-8 on the back in order from the closest to the furthest from the Sun.
    a. (1) Mercury, (2) Venus, (3) Earth, (4) Mars, (5) Jupiter, (6) Saturn, (7) Uranus, and (8) Neptune
3. Beginning on the side of the hat with the Sun, tape Mercury, Venus, Earth, and Mars (planets 1-4) to the hat template.
4. On the side with the stars, tape Jupitar, Saturn, Uranus, and Neptune (planets 5-8) to the hat template.
5. Tape together the two halves of the hat template (see Figure 4).
6. Connect the hat together by taping the other side of the hat template (see Figure 5).
7. If time permits, mentees can color the hat.

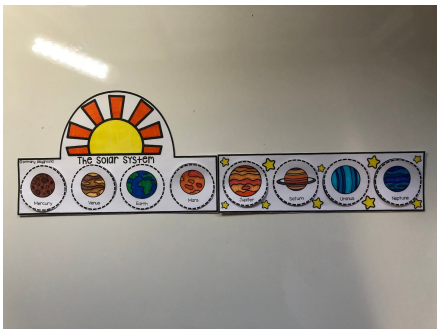

Figure 4: Tape together the two sides of the hat

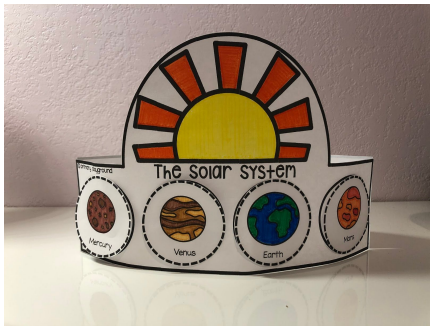

Figure 5: Front of Completed Solar System Hat

Classroom Notes

Try using the mnemonic to help remember the order of the planets! If mentees think that making a hat is tacky, they can always tape the two halves together and leave it flat (see Figure 4).

(Advanced Sites) Module 1: I Need More Space

This module is an alternative of Module 1 for advanced sites. Through this module, mentees will be able to learn about the relative distances between the sun and the eight different planets by creating a scale model of the Solar System.

Teaching Goals

1. **Solar System**: Composed of the Sun, planets, moons, comets, and asteroids
2. **Sun**: Hot ball of gas whose gravity holds the Solar System together
3. **Planets**: Large objects that orbit around the Sun
4. **Terrestrial Planets**: Mercury, Venus, Earth, and Mars
5. **Jovian Planets**: Jupiter, Saturn, Uranus, and Neptune

Tips for Virtual Site

- If possible, you can utilize annotation on Zoom to draw a picture of the solar system and place them accordingly to their relative distance.

Materials

- Toilet Paper
- 1 'Planets' Template
  - Planets
- Scissors
- (Optional) Tape
- (Optional) Markers

- **(Alternative)**
  - Large Area
  - (Optional) 9 water bottles or cups

Procedure

1. Print and cut out the planets.
2. Label the eight planets in order from the closest to furthest from the Sun on the back.
   a. (1) Mercury, (2) Venus, (3) Earth, (4) Mars, (5) Jupiter, (6) Saturn, (7) Uranus, and (8) Neptune
3. Obtain 38 sheets of toilet paper and cut them in half and tape them together to create a long strip of toilet paper.
   a. There should be 76 rectangles total.
4. Find a large area of space (28.5 feet) to do this activity, like the outdoors or in a hallway.
5. Place the Sun at the furthest left end of the toilet paper strip (see Figure 7).
   a. Remember one rectangle of toilet paper is about 36,000,000 miles.
6. (Optional) Have mentees estimate the relative distances between the eight planets and place their guesses on the long strip of toilet paper.

Planet	Distance From Sun (miles)	Relative Number of Toilet Paper From Sun
Mercury	36,000,000	1
Venus	67,000,000	2
Earth	93,000,000	2.5
Mars	142,000,000	4
Jupiter	484,000,000	13
Saturn	888,000,000	24
Uranus	1,800,000,000	49
Neptune	2,800,000,000	76

Figure 6: Chart of Distance and Relative Number of Beans From Sun

a. Ask if mentees think the planets are evenly spaced or lined up randomly? Close or far away from the Sun?

7. Count one rectangle of toilet paper from the Sun and place ‘Mercury’ here.
8. Count 2 rectangles from the Sun and place ‘Venus’ here.
9. Count 2.5 rectangles from the Sun and place ‘Earth’ here.
10. Count 4 rectangles from the Sun and place ‘Mars’ here.
11. Count 13 rectangles from the Sun and place ‘Jupiter’ here.
12. Count 24 rectangles from the Sun and place ‘Saturn’ here.
13. Count 49 rectangles from the Sun and place ‘Uranus’ here.
14. Count 76 rectangles from the Sun and place ‘Neptune’ here.

15. **(Alternative)** If mentees do not want to use toilet paper, they can replace the rectangles of toilet paper with footsteps following the same instructions above (see Figure 8).
    a. For example, in Step 7, mentees will take one step from the Sun and place ‘Mercury’ there.

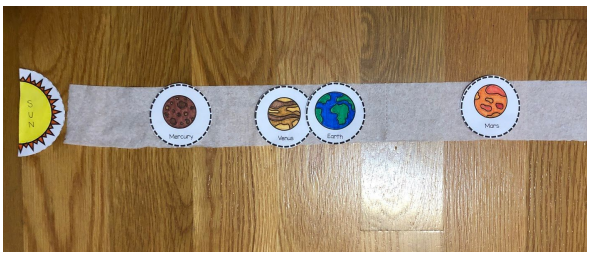

Figure 7: Steps 5 to Steps 9

Figure 8: Alternative if Mentees Do Not Want to Use Toilet Paper (Steps 5 to 9).

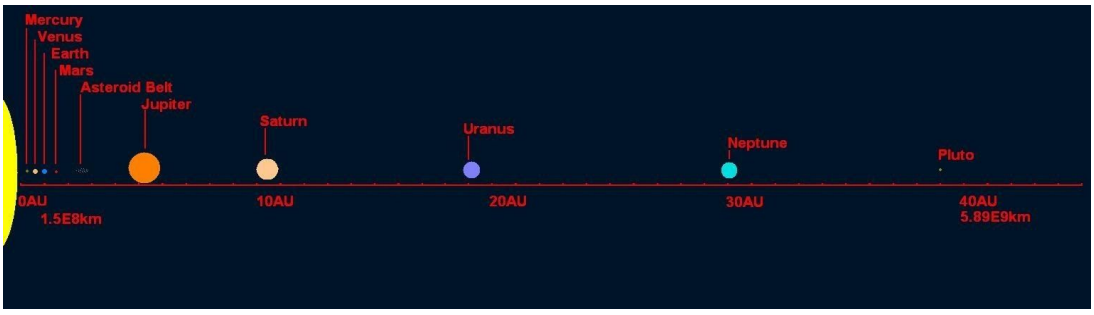

Figure 9: Diagram of Relative Distance of Planets From Sun

Classroom Notes

To save toilet paper and if you have 2-ply, I recommend using 19 sheets of toilet paper and dividing it into two to make 1-ply to get a total of 38 sheets. If you are doing the alternative activity with the steps, I recommend finding a large area, like the outdoors if it is safe. I would tape the

planets onto water bottles or cups to help mentees visualize the relative distances better.

Module 2: I'm Going Through a Phase

Mentees will learn about the Moon and the different phases of the Moon we observe by creating their own model of the lunar cycle.

Teaching Goals	**Materials**
1. **Moon**: Balls of rock and dust that orbit planets and asteroids 2. **Phases of the Moon**: Eight different shapes of the Moon that can be observed from Earth in a month 3. **Waxing**: Moon is "growing" and getting brighter from the right side 4. **Waning**: Moon is "shrinking" and getting brighter from the left side	• 1 Sheet of Construction Paper or Paper Plate • 7 Oreos or Cream-Filled Cookies • 1 Spoon • Markers • **(Alternative)** 1 'Phases of the Moon' template ○ Phases of the Moon • Markers

Procedure

1. To help mentees visualize the relative positions between the Earth, Sun, and the Moon, show this video: Moon Phase Animation.
2. Spilt 7 Oreos in half and keep 7 halves with the cream and 1 half of just the cookie.
3. On a sheet of construction paper, draw a big circle or use a paper plate.
4. (Optional) Draw planet Earth in the center of the circle and draw the Sun on the right side outside of the circle (see Figure 11).
5. Take the half with no cream and place it in the middle right side of the circle.
    a. Label this 'New Moon'.
6. Take one half with all the cream and place it in the middle left side of the circle.
    a. Label this 'Full Moon'.
7. Using a spoon, scrape half of the cream off of 2 Oreos.
8. Place the Oreo with half of the cream facing right on the top middle of the circle.
    a. Label this 'First Quarter'.
9. Place the Oreo with half of the cream facing left on the bottom middle of the circle.

Figure 10: Eight Phases of the Moon Model With Sun and Earth

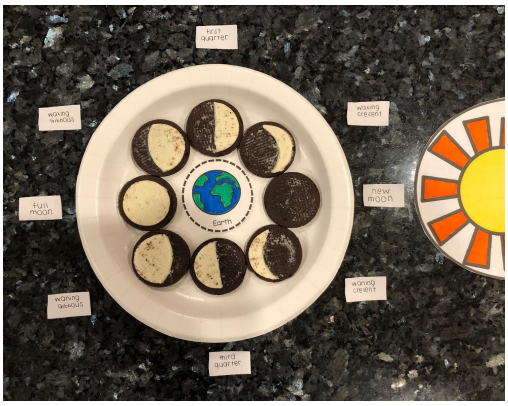

Figure 11: Eight Phases of the Moon Model

    a. Label this ‘Third Quarter’.
10. Scrape ⅔ of the cream off 2 cookies while maintaining a curve to resemble the moon.
11. Place the Oreo with the cream facing right in between the First Quarter and New Moon on the top right side.
    a. Label this ‘Waxing Crescent’.
12. Place the Oreo with the cream facing left in between the New Moon and the Third Quarter on the bottom right side.
    a. Label this ‘Waning Crescent’.
13. Scrape ⅓ of the cream off of 2 cookies while maintaining a curve.
14. Place the Oreo with the cream facing right in between the First Moon and the Full Moon on the top left side.
    a. Label this ‘Waxing Gibbous’.
15. Place the Oreo with the cream facing left in between the Full and Third Quarter moon on the bottom left side.
    a. Label this ‘Waning Gibbous’.

16. **(Alternative)** Instead of using Oreos, have mentees draw and color in the different phases of the moon on the template using the same instructions above (see Figure 12).

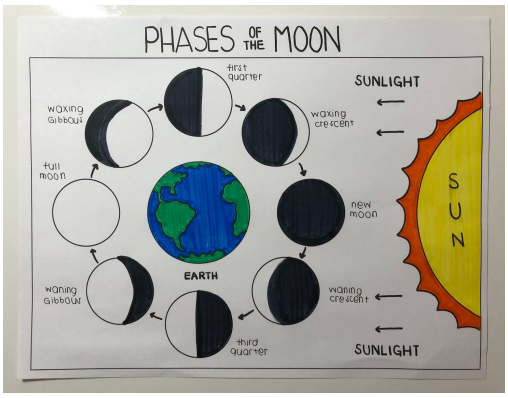

Figure 12: Alternative if Mentees Do Not Have Oreos

Classroom Notes

Drawing the Earth and the Sun in Step 3 is not required, but highly recommended. It would be helpful to draw and mention it to the mentees to help them visualize the orbit of the Moon around Earth and the location of the Sun.

Module 3: A Long Time Ago In a Galaxy Far, Far Away

It is hypothesized that our Solar System was formed by the gravitational collapse of dust and gas, known as the Solar Nebula. Mentees will be able to build a small scale replica of a nebula.

Teaching Goals

1. **Nebula**: Cloud of dust, gas, and plasma
2. **Solar Nebula**: Hypothesis that the origin of the Solar System was created from a concentration of dust and gas forming a molecular cloud

Tips for Virtual Site

- It might be hard to get kids to understand the concept of nebula if they can't see it. Prioritize the activity for the nebula if the mentees have all the materials for it. If not, show additional videos on YouTube to demonstrate this concept.

Materials

- 1 Jar or Empty Plastic Water Bottle
- 25-30 Cotton Balls or Cotton Pads
- 1 Spoon
- 3 Empty Paper Cups
- 3 Colors of Paint or Food Coloring
- Water
- (Optional) 1 Jar of Glitter

Procedure

1. Fill three small cups with water ⅔ of the way.
2. Add 1-3 drops of paint into each cup of water and mix them together with the spoon.
3. Spread the cotton balls apart to elongate them.
    a. If you are using an empty plastic water bottle, you can skip this step and leave the cotton balls round.
4. Line the jar ⅓ of the way with the cotton balls.
    a. The cotton balls represent the dust component of nebulae.
5. Pour 1 cup of colored water until the top of the cotton balls are soaked (see Figure 13).
    a. The colored water represents the gas component of nebulae.
6. Line the jar ⅓ of the way on top of the first layer with cotton balls (see Figure 14).
7. Pour 1 cup of colored water into the jar until the top of the cotton balls are soaked.
8. Line the jar ⅓ of the way on top of the middle layer with cotton balls.
9. Pour the last cup of colored water into the jar.
10. Add a thin layer of glitter to the top of the cotton balls to represent the stars that emerge.

Figure 13: Pour colored water to cover cotton balls and add another layer of cotton balls

Figure 14: Swirl the nebula jar to disperse the glitter

Classroom Notes

If the cotton balls are not fully soaked after you pour in the colored water, you can always add more water directly into the jar until the cotton balls in the layer are soaked. If you are using food coloring, note that the colored water might mix together and not produce the same results.

Conclusion

Ask mentees if they would like to share something that they learned from today's lesson. To spice things up, mentors can come up with quick and easy trivia questions to quiz mentees. Mentors can also flex their knowledge and share fun facts about the planets (see Planet Facts: Interesting Facts about the Eight Planets).

References

- To Infinity and Beyond References

Summary Materials Table

Material	Amount per Site	Expected $$	Vendor (or online link)
Scissors	3-4 pairs per site		
Tape	2-3 rolls per site		
Markers	10-15 per site		
Solar System Hats	1 per mentee		Print: Solar System Hat
Toilet Paper	1 roll per site		
Planets Template	1 per site		Print: Planets
Paper	1 stack per site		
Oreos	7 per 2-3 mentees		
Plastic Spoons	1 per mentee		
Plastic Jars	1 per 3-4 mentees		
Cotton Balls	25-30 per 3-4 mentees		
Paper Cups	3 per 3-4 mentees		
Acrylic Paint	3 per site		
Glitter	1 per site		