NGSS Lesson Plan

Grade/ Grade Band: 8th grade	**Topic:** Scale of the Solar System	**Lesson #** 2 **in a series of** 4 **lesson(s)**

Brief Lesson Description:
By the end of this lesson, students will be able to infer the order of planets in the solar system based on their proximity to the Sun by analyzing orbital period data. LEGO robots will be used to simulate the orbital motion of planets. The students will develop skills in recording and interpreting observations made with a scaled model. This lesson draws from the observational methods used by astronomers in the 16th century to study planetary movements.

Essential Question:
How do we study the behavior of systems that are too large to see in their entirety?

Performance Expectation(s):

MS-ESS1-3.
Analyze and interpret data to determine scale properties of objects in the solar system.

[Clarification Statement:
Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.
Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]

Specific Learning Outcomes:
Students will learn how to use scaled models to simulate the behavior of a large systems i.e. the solar system. They will also develop skills in recording and interpreting observations made with a scaled model. The lesson also aims to develop an appreciation in students for the scientific discovery process.

Narrative / Background Information

Prior Student Knowledge:
- Students should be familiar with gravity.
- Students should be familiar with the solar system, and the differences between stars, planets and satellites.
- Students should be familiar with ratio, proportionality and scales.

Science & Engineering Practices (SEPs)	Disciplinary Core Ideas (DCIs)	Crosscutting Concepts (CCCs)
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. -------------------------------------- ***Connections to Engineering, Technology, and Applications of Science*** --------------------------------------- **Interdependence of Science, Engineering, and Technology** Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

Common Core State Standards (CCSS)

ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics -

MP.2 Reason abstractly and quantitatively.

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.A.2 Recognize and represent proportional relationships between quantities.

Possible Preconceptions/Misconceptions:

- All planets in our solar system are equidistant from each other.
- Most pictures of solar system are drawn to scale.
- All planets take the same amount of time to complete a single revolution around the sun.
- The motion of other planets in the solar system is caused by the Earth.

LESSON PLAN – 5-E Model

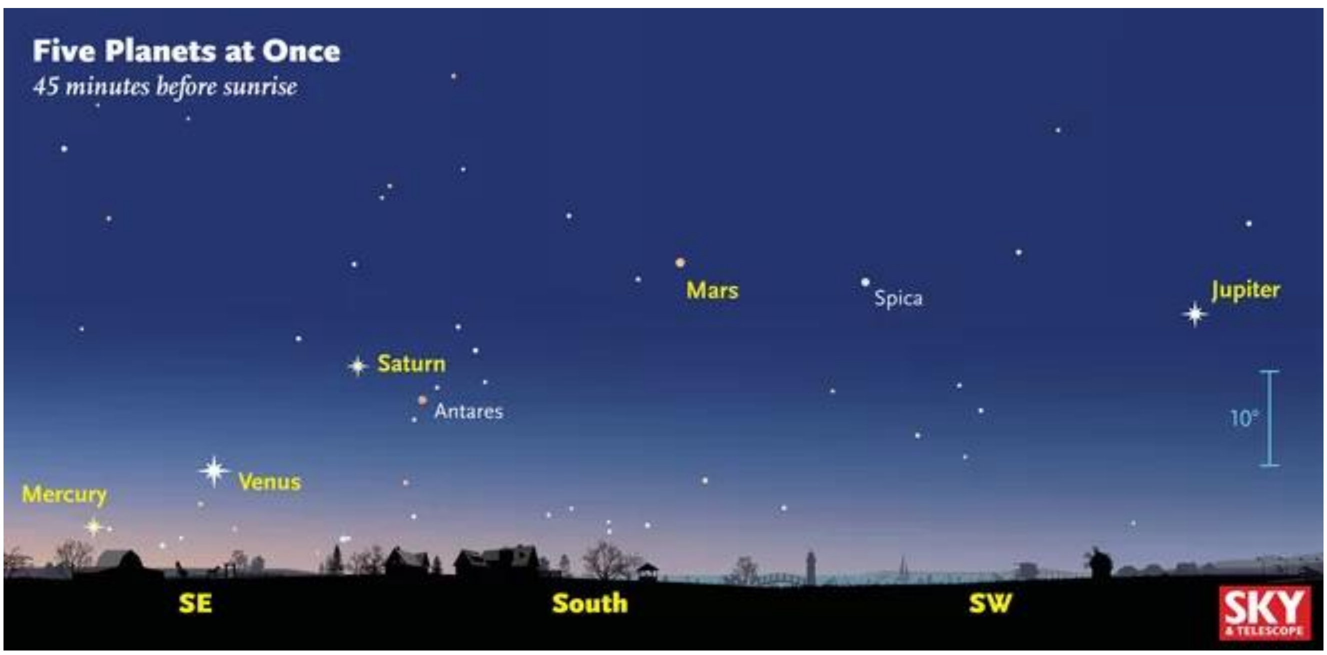
ENGAGE: Opening Activity – What is the order of planets in the solar system?

Teacher will begin the class by asking the students to recall –

- What is the solar system?
- What is the order of the planets in the solar system?
- Which is the closest planet to the Sun?
- Which planets are closer to the Sun compared to the Earth?

Modifications for ENL Students: Students can be provided with labelled cutouts of the nine planets and asked to place them around a circle labelled the Sun on a chart paper.

Students will be provided with an image of the night sky with some stars and planets labeled. (Example picture credit: Space.com)



The teacher asks the students to discuss in groups:

How do we know which of the pinpoints of light in the night sky are planets and which are stars? Imagine you are an ancient astronomer and are staring at the night sky – how would you know the difference between stars and planets? Think back to a time when you looked up at the night sky – did you know which point of light was a star and which was a planet? If you were asked to find out without using Google or looking up the answer anywhere, how would you do so?

Engagement Question: The teacher will summarize the discussion and ask the students how they can determine the order in which the planets orbit the Sun by looking at the night sky.

This exercise serves as a review and will provide background for the work to be carried out in the rest of the lesson. It addresses the **DCI** of **MS-ESS1-3** by stimulating a discussion in which students will recall that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

EXPLORE: Robotic Activity – Observe time taken by a planet to complete one orbit around the sun

The teachers can now inform the students that:

While it would be ideal if the class could observe the path of the planets in the night sky like an early astronomer, for the sake of saving time, they will try to model the behavior of the planets using LEGO robots so that the students can observe the same phenomena at a smaller scale.

The students will be working in groups determined by their teachers, and will have specific roles to perform – such as timer, recorder, operator of robot etc. In order to perform this activity:

1. Clear space in the front of the classroom.
2. Turn on the EV3 and select the folder 'OrbitalPeriods'.
3. Under this folder, select the program labelled 'Earth'.
4. Place the robot on the ground and run the program.
5. Record the time (to two decimal places) it takes for the robot to complete one orbit using a stop watch.
6. Now run the rest of the programs in the order of your choice.
7. Record the respective times (to two decimal places).

Table 1

Planet	**Observed Time to Orbit (seconds)**
Earth	
Mars	
Mercury	
Venus	

Students will analyze the data they have and to use it to order the planets based on their closeness to the sun in increasing order.

Table 2

0	1	2	3	4
Sun				

- This activity explicitly addresses the **CCC** of the standard **MS-ESS1-3** by using a LEGO robot to model the movement of planets around the Sun and explains the need for using models to observe time and space phenomena at various scales to study systems that are too large or too small.
- The **DCI** of **MS-ESS1-3** is implicitly addressed as the activity reinforces that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- The activity makes students aware of how data about the solar system can be recorded from Earth-based instruments, and how to obtain similar data from models, thereby addressing the standard **MS-ESS1-3**.

EXPLAIN: Concepts Explained and Vocabulary Defined:
The teachers can explain that closer the object is to the sun, the shorter will be its orbital period.

Vocabulary:
Planet
Gravitation
Solar System
Revolution
Orbit
Orbital Period

- This section addresses the **DCI** of the standard **MS-ESS1-3** as it contains explanation that includes the information that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This activity also addresses the **CCC** of the standard MS-ESS1-3 as behavior of objects at various scales is being explained.

ELABORATE: Find orbital periods of planets

The following activity will help the students understand scaling.

If
1 box = 1 day
30 boxes = 3 m
1 day = _____ cm

Show your work.
Teacher will lead a discussion in which students verbally describe the strategy they used.

Based on the data collected in Table 1, the students will calculate the time taken by each planet to orbit around the sun. We know that the time required for the Earth to orbit the sun = 365 days.

Table 3

Planet	Observed Orbital Period (seconds)	Actual Orbital Period (Earth Days)
Earth		365.2
Mars		
Mercury		
Venus		

Students will calculate how long it takes for the planet to orbit the sun in terms of number of Earth years.

Table 4

Planet	Actual Orbital Period (Earth Days)	Actual Orbital Period (Earth Years)
Earth	365.2	1
Mars		
Mercury		
Venus		

Students refer to Table 2 that they previously filled out and compare their responses.

- This activity specifically addresses the **CCC** of the standard **MS-ESS1-3** and the students build and use skills related to scaling and proportions of quantity.
- It also addressed the **SEP** which requires the students to analyze and interpret data.
- It addresses the **DCI** of the standard as the students are ordering a collection of objects around the Sun based on their proximity to it.
- This lesson addresses the entire performance standard as it guides the students through analyzing and interpreting data to determine scale properties (orbital periods) of the solar system.

EVALUATE:

Formative Monitoring (Questioning / Discussion):
Teachers will provide the students with actual data for the orbital periods of all the planets in the solar system but withhold the names of the planets. Students will analyze the data presented to them and use it to order the planets based on their distance from the sun, and then identify the planets.

Table 5

Planet	Actual Orbital Period (Earth Days)
Alpha	3.652 x 10^2
Beta	5.98 x 10^4
Gamma	8.8 x 10^1
Delta	9.056 x 10^4
Epsilon	4.331 x 10^3
Zeta	2.247 x 10^2
Eta	1.0747 x 10^4
Theta	6.87 x 10^2
Kappa	3.0589 x 10^4

0	1	2	3	4	5	6	7	8	9
Sun									
Name of Planet									

Word Problem:
How long is one year on Mars in terms of Earth days? If you emigrated to Mars now, what would be your current age in terms of Mars years? Show your work.

- The assessment questions address the **SEP** of the standard **MS-ESS1-3**: Analyze and interpret data to determine similarities and differences in findings.
- It addresses the **DCI** of the standard **MS-ESS1-3** as the students are ordering a collection of objects around the Sun based on their proximity to it.

Elaborate Further / Reflect:

1. Students study the data provided regarding the actual orbital periods in Table 5 and work individually or in groups to determine how to divide the planets into groups. Students will explain the criteria they use to make this grouping.

   Teachers can inform students about inner/outer planets, terrestrial/Jovian planets and discuss the variations in composition, atmosphere etc. between them and illustrate how proximity from sun gives rise to different features of the planets.

2. In this class, why did we use LEGO robots to carry out the activity in this lesson?
   Why did the activity only simulate the motion of the four inner planets using the robots?
   What are the constraints in simulating the motion of the outer planets in the same manner? Ask the students to come up with a model.
   Suggested reference: http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

This will directly address the **SEP** of the standard **MS-ESS1-3**: Analyze and interpret data to determine similarities and differences in findings, as well as show an example of correlation and causation.

Materials Required for This Activity			
Quantity	**Description**	**Potential Supplier (item #)**	**Estimated Price**
1	Robot	n/a	n/a
2	EV3 program – OrbitalPeriods	n/a	n/a
3	Stopwatch		