Astronomy and Space Science Unit Plan

Unit Title: *Mission to Mars*

Unit Overview:

• The big ideas addressed in this unit revolve around engineering design and Earth's place in the universe.

• This unit combines resources from NASA's JPL and Mission to Mars along with NXT LEGO Mindstorms kits.

• These NASA resources will enhance the engineering, building, and programming aspects of this unit by providing a real-world scenario that is engaging for students while fostering an understanding of our role in the exploration of the universe.

Author: *Rochelle Gimmillaro*

Topic: *How scientists explore Mars with planetary rovers*

Targeted Grade Level: *8th grade*

Time Needed: *14 one-hour periods (meeting every other day)*

Subject Integration: *Science, Technology, Engineering, Math*

Measurable Student Learning Objectives:

Students will be able to…

- *Describe the characteristics of Mars.*
- *Identify the parts and functions of a planetary rover.*
- *Identify forces and describe laws of motion acting on rovers.*
- *Construct and code a LEGO Mindstorm robot to navigate an obstacle course.*
- *Test the programming/coding of the LEGO robot/rover by successfully navigating the obstacle course.*
- *Analyze failures and modify designs.*
- *Communicate and compare results.*

NGSS Standards:

MS-ETS1: Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

MS-ETS1-2. **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

MS-ETS1-3. **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

MS-ETS1-4. **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an	ETS1.A: Defining and Delimiting Engineering Problems • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge	Influence of Science, Engineering, and Technology on Society and the Natural World • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural

object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **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. (MS-ETS1-3) **Engaging in Argument from Evidence** Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	that are likely to limit possible solutions. (MS-ETS1-1) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

Articulation of DCIs across grade-bands:
3-5.ETS1.A (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3); **3-5.ETS1.B** (MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **3-5.ETS1.C** (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **HS.ETS1.A** (MS-ETS1-1),(MS-ETS1-2); **HS.ETS1.B** (MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **HS.ETS1.C** (MS-ETS1-3),(MS-ETS1-4)

WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. *(MS-ETS1-2)*
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ETS1-4)*
Mathematics -	
MP.2	Reason abstractly and quantitatively. *(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4)*
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3)*

MS-ESS1: Earth's Place in the Universe

Students who demonstrate understanding can:

MS-ESS1-2. **Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.**

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.*]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars

- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)

Crosscutting Concepts

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. (MS-ESS1-3),(MS-ESS1-4)

Systems and System Models

abstract phenomena and design systems. • Develop and use a model to describe phenomena. (MS-ESS1-1),(MS-ESS1-2) 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. (MS-ESS1-3) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS1-4)	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. (MS-ESS1-2),(MS-ESS1-3)	• Models can be used to represent systems and their interactions. (MS-ESS1-2) --- *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. (MS-ESS1-3) --- *Connections to Nature of Science* Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1),(MS-ESS1-2)
Articulation of DCIs across grade-bands: **4.ESS1.C** (MS-ESS1-4); **5.PS2.B** (MS-ESS1-1),(MS-ESS1-2)		

Differentiation of Instruction: *For lower-level learners modified obstacle course will have fewer design constraints, as well as additional assistance with coding. In terms of written work, word banks or fill-ins can be used for learning terms and labeling diagrams. And in general, extra time, modified requirements, and/or extra one-on-one support will be provided as needed.*

More advanced students can be further challenged with time trials and additional constraints.

For ESL students, work is provided with a Spanish version when available along with word banks and other modified assignments.

Lessons:

5E Model	5E Objectives
Engage *Learn About Mars* *(1 hour/class period)*	**Procedure:** • *Introduce challenge – to build and code an NXT LEGO Mindstorms rover that can navigate an obstacle course to model how a Mars rover works.* • *View and discuss JPL "Learn About Mars" video - https://www.youtube.com/watch?v=TklEG_49Scs&t=252s* • *Students explore NASA's Mars Exploration/The Red Planet to gather information about Mars - https://mars.nasa.gov/#red_planet* • *Students record information in their journals about Mars to share and discuss with class.* **Standards:** *MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

	Modifications: *One-on-one support accessing and navigating website; specify and guide student to desired information; assistance recording information and/or modified information sheet* **Formative Assessments:** *Journal notes and discussion responses.* **Resources:** *Computer with internet access; student journals/project portfolios*
Explore *Plan Your Mission* *(1 hour/class period)* *Design Your Rover* *(1 hour/class period)* *Build Your Rover* *(3 hours/class periods)*	**Procedure:** *Day 1* • *View and discuss JPL "Plan Your Mission" video – https://youtu.be/PYq1x1nX-Jk* • *Students explore NASA's Mission to Mars homepage - https://mars.nasa.gov/mars2020/* • *Students record additional information in their journals about the Mars Perseverance mission to share and discuss with class.* *Day 2* • *View and discuss JPL "Design Your Spacecraft" video – https://youtu.be/WVyjTH8YGjA* • *Students explore the Perseverance rover in 3D and label a diagram to identify the parts - https://mars.nasa.gov/mars2020/spacecraft/rover/* • *Students compare the parts of Perseverance to the sensors/parts the LEGO Mindstorm models as they inventory their kits.* *Days 3-5* • *Students work with a partner to build their rover model using NXT LEGO Mindstorm kits. Towards the end of the build, students will determine which sensors to use based on their research and the obstacle course restraints.*

	Standards: *MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.* **Modifications:** *One-on-one support accessing and navigating website; modified rover diagram with word bank; assistance as needed identifying LEGO sensors/parts* **Formative Assessments:** *Journal entries, discussion responses, Perseverance diagram* **Summative Assessment:** *Completed NXT LEGO Mindstorm rover* **Resources:** *Computer with internet access, Perseverance diagram, NXT LEGO Mindstorm kits*
Explain *Launch Your Mission* *(1 hour/class period)* *Land on Mars* *(1 hour/class period)*	**Procedure:** *Day 1* • *View and discuss JPL "Launch Your Mission" video – https://youtu.be/LmbkHtnWMWw* • *Students begin to create a Mars exploration game using the Scratch programming language - https://www.jpl.nasa.gov/edu/teach/activity/explore-mars-with-scratch/* *Day 2* • *View and discuss JPL "Land on Mars" video – https://youtu.be/fJZ_LwnT6uM* • *Complete Scratch program.* **Standards:** *MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.* **Modifications:** *Modified game elements based on student ability level and coding experience; assistance as needed with coding*

	Summative Assessments: *Completed Scratch program* **Resources:** *Computer with internet access, Mars rover and surface images, Scratch account*
Elaborate *Surface Operations* *(1 hour/class period)* *Sample Handling* *(1 hour/class period)*	**Procedure:** *Day 1* • *View and discuss JPL "Surface Operations" video – https://youtu.be/VYBo_PouyOU* • *Observe and discuss NASA Perseverance Mission Timeline Surface Operations - https://mars.nasa.gov/mars2020/timeline/surface-operations/* • *Students visit NASA Space Place to play Mars Rover Game - https://spaceplace.nasa.gov/explore-mars/en/* • *Optional: Explore the Mars helicopter - https://mars.nasa.gov/technology/helicopter/* *Day 2* • *View and discuss JPL "Sample Handling" video – https://youtu.be/LY4qotgsN64* • *View NASA Mars 2020 Rover Sample Collection Animation with class - https://mars.nasa.gov/mars2020/multimedia/videos/?v=423* • *Students explore some of the sites the Mars Perseverance rover has studied up close. They view images taken by the rover and learn about key points of interest using the Explore with Perseverance Interactive Experience - https://mars.nasa.gov/mars2020/surface-experience/?drive=0&site=31* **Standards:** *MS-ESS1-2. Analyze and interpret data to determine scale properties of objects in the solar system.* **Modifications:** *One-on-one support accessing and navigating website; specify and guide student to*

	desired information; assistance recording information and/or modified information sheet **Formative Assessments:** *Discussion responses* **Resources:** *Computer with internet access*
Evaluate *Obstacle Course Challenge* *(4 hours/class periods)*	**Procedure:** *Day 1-2* • *Introduce and demonstrate programming software.* • *Reveal obstacle course and constraints.* • *Students use programming software to code LEGO rovers to navigate obstacle course.* *Day 3* • *Students test and modify rovers.* *Day 4* • *Obstacle course trials* **Standards:** *MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.* *MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.* **Modifications:** *Modified obstacle course constraints; assistance with coding and testing as needed.* **Summative Assessments:** *Successful navigation of obstacle course with LEGO Mindstorm rover*

	Resources: *NXT Programming software, completed NXT LEGO Mindstorm rover; obstacle course*

Teacher Reflections:

This is my first year using LEGO Mindstorms. It has been a successful project that students are engaged in, and I have been tailoring the constraints as I gain experience. Still, the project lacked a real-world connection which this course has subsequently provided. The NASA resources that I have been introduced to will take the building and programming of the LEGO robots to the next level by giving genuine meaning to it. While I know that changes will need to be made as these components are incorporated, I am looking forward to enhancing my students learning experience as they further their understanding of our place in the universe.