While Unit 2 has a space context that is similar to Unit 1 and continues to explore some physical science concepts, it more heavily focuses on concepts related to Earth’s place in the universe. In doing so, students move away from contact forces and instead focus on the non-contact forces that might affect a telescope’s route through the solar system, which serves as the culminating project for this unit. As students progress through this unit, they will form a more complex picture of the solar system as a whole, which they will use to explain some of the everyday phenomena they experience.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans five different Disciplinary Core Ideas: ESS1.A. The Universe and Its Stars, ESS1.B. Earth and the Solar System, PS2.B. Types of Interactions, PS3.A. Definitions of Energy, and PS3.C. Relationships Between Energy and Forces.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Asking Questions and Defining Problems, Developing and Using Models, Planning and Carrying Out Investigations, Analyzing and Interpreting Data, and Engaging in Arguments From Evidence. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns; Cause and Effect; Scale, Proportion, and Quantity; and Systems and System Models.

\*This summary is based on information found in the NGSS Framework.

**K-8 Progression of Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for Unit 2**

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| **Disciplinary Core Ideas** | **K-2** | **3-5** | **6-8** |
| **ESS1.A**  **The Universe and Its Stars** | Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. | The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. | Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted and explained with models. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. |
| **ESS1.B**  **Earth and the Solar System** | Seasonal patterns of sunrise and sunset can be observed, described, and predicted. | The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. | 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 model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. |
| **PS2.B**  **Types of Interactions** | N/A (in relation to non-contact types of interactions) | Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center. | Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. Forces that act at a distance (electric and magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). |
| **PS3.A**  **Definitions of Energy** | N/A | Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form. | Motion energy is properly called kinetic energy. A system of objects may also contain stored (potential) energy, depending on their relative positions. |
| **PS3.C**  **Relationships Between Energy and Forces** | A bigger push or pull makes things go faster. | When objects collide, the contact forces transfer energy so as to change the objects’ motions. | When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. |

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| **Science and Engineering Practices** | **K-2** | **3-5** | **6-8** |
| **Asking Questions and Defining Problems\*** | Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested.   * Ask and/or identify questions that can be answered by an investigation. | Asking questions and defining problems in 3-5 builds on prior experiences and progresses to specifying qualitative relationships.   * Identify scientific (testable) and non-scientific (non-testable) questions. * Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. | Asking questions and defining problems in 6-8 builds on prior experiences and progresses to specifying relationships between variables, and clarifying arguments and models.   * Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. |
| **Developing and Using Models\*** | Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.   * Develop and/or use a model to represent amounts, relationships, relative scales (bigger/smaller), and/or patterns in the natural and designed world(s). | Modeling in 3-5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions.   * Develop and/or use models to describe and/or predict phenomena. * Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. | Modeling in 6-8 builds on prior experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.   * Develop and use a model to describe phenomena. * Develop a model to describe unobservable mechanisms. |
| **Planning and Carrying Out Investigations** | Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.   * Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. | Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on prior experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.   * Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. | Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on prior experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.   * Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. |
| **Analyzing and Interpreting Data** | Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.   * N/A | Analyzing data in 3-5 builds on prior experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.   * Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. | Analyzing data in 6-8 builds on prior 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. |
| **Engaging in Argument from Evidence\*** | Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).   * Construct an argument with evidence to support a claim. | Engaging in argument from evidence in 3-5 builds on prior experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).   * Construct and/or support an argument with evidence, data, and/or a model. * Use data to evaluate claims about cause and effect. | Engaging in argument from evidence in 6-8 builds on prior experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).   * Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. |

\*These SEPs are summatively assessed using the Culminating Project.

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| **Crosscutting Concepts** | **K-2** | **3-5** | **6-8** |
| **Patterns\*** | Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.   * Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. | Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.   * Patterns of change can be used to make predictions. * Patterns can be used as evidence to support an explanation. | Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.   * Patterns can be used to identify cause-and-effect relationships. |
| **Cause and Effect\*** | Students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.   * Events have causes that generate observable patterns. | Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.   * Cause and effect relationships are routinely identified, tested, and used to explain change. | Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.   * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| **Scale, Proportion, and Quantity\*** | Students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.   * Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). | Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.   * Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. | Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.   * Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. |
| **Systems and System Models\*** | Students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.   * Objects and organisms can be described in terms of their parts. * Systems in the natural and designed world have parts that work together. | Students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.   * A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. * A system can be described in terms of its components and their interactions. | Students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.   * Models can be used to represent systems and their interactions. * Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. |

\*These CCCs are summatively assessed using the Culminating Project.

**Progression of Knowledge from Kindergarten – 8th Grade**

ESS1.A. The Universe and Its Stars: As with most of the DCIs, students begin their experience in kindergarten – second grade with an experience of the relevant phenomena—in this case, the appearance of the sun, moon, and stars. At this level, students are making observations to describe patterns that they will be able to utilize again in this eighth grade unit. In third – fifth grade, students begin to investigate the why, or the science behind, one of these phenomena: why does the sun and some stars appear brighter than other stars? Here, students are connecting mere observations to the scientific reason behind them, a process they will continue in this eighth grade unit. By the time they reach this unit, they will be ready to develop a model of the Earth-sun-moon system and use it to explain the phenomena they first analyzed as first graders, like the apparent motion of the sun, the moon, and stars. Depending on the phenomena being investigated and the practice used to investigate it at the given grade level, the crosscutting concepts range from Patterns to Scale, Proportion, and Quantity to Systems and System Models. Similarly, the science and engineering practices range from Analyzing and Interpreting Data to Engaging in Argument From Evidence to Developing and Using Models.

The following is the progression of the Performance Expectations for this DCI:

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| **1-ESS1-1.** | Use observations of the sun, moon, and stars to describe patterns that can be predicted. |
| **5-ESS1-1.** | Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. |
| **MS-ESS1-1.** | Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. |
| **MS-ESS1-2.** | Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. |

ESS1.B. Earth and the Solar System: While this DCI is very similar to the DCI above, you will notice some key differences. In Kindergarten - second grade, students engage with this DCI at the same grade level as ESS1.A, but rather than making observations of celestial objects in the sky, they focus on the amount of daylight at different times of year. In third – fifth grade, students advance this data collection to include more specific measures, such as length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. All of these observations serve as evidence that the Earth orbits around the sun and rotates on its axis once a day, which is what is causing these observable phenomena. By the time students get to this unit, they are able to use this prior knowledge to draw an Earth-sun-moon system model and use it to explain some of the phenomena identified in the paragraph above. However, in this unit, students take it farther than just the Earth-sun-moon system to develop an understanding of the whole solar system as a collection of objects held in orbit around the sun by its gravitational pull on them. To explore this DCI, students focus on the science and engineering practices of Analyzing and Interpreting Data and using that data to Develop and Use Models. Students use the crosscutting concept of Patterns to analyze data, and the crosscutting concepts of Scale, Proportion, and Quantity as well as Systems and System Models when developing their models.

The following is the progression of the Performance Expectations for this DCI:

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| **1-ESS1-2.** | Make observations at different times of year to relate the amount of daylight to the time of year. |
| **5-ESS1-2.** | Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in they sky. |
| **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. |

PS2.B. Types of Interactions: In Kindergarten - second grade, students are introduced to this DCI within the context of contact forces, which are not explored in this unit (but were explored in Unit 1). In third grade, however, students begin to investigate non-contact forces, such as electric and magnetic forces. By asking questions that lead to investigations and design solutions, students discover that electric and magnetic forces do not require that the objects be in contact. By experimenting with magnets, they will also find that the sizes of these forces can vary depending on the properties of the objects, their distances apart, and even their orientation to each other. This sets the stage for students to continue these investigations in this eighth grade unit, as they not only find evidence that the fields exist but identify factors that can affect the strength of these fields. In fifth grade, students engage with another non-contact force—gravity—by gathering evidence that gravity exerted on objects is directed down towards Earth. In this eighth grade unit, students build off their understanding of gravity from Unit 1 to explore this concept again, but within the context of the whole solar system, rather than just Earth. They will find that gravity is attractive with other objects of large mass, like other planets. At all grade levels, students are utilizing the crosscutting concept of Cause and Effect as they engage with this DCI through different practices like Asking Questions and Defining Problems, Engaging in Argument From Evidence, and Planning and Carrying Out Investigations.

The following is the progression of the Performance Expectations for this DCI:

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| **3-PS2-2.** | Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. |
| **3-PS2-3.** | Define a simple design problem that can be solved by applying scientific ideas about magnets. |
| **5-PS2-1.** | Support an argument that the gravitational force exerted by Earth on objects is directed down. |
| **MS-PS2-3.** | Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. |
| **MS-PS2-4.** | Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. |
| **MS-PS2-5.** | Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. |

PS3.A. Definitions of Energy: Students do not engage with this DCI until the fourth grade. In third – fifth grade, students begin to connect motion with energy, asking questions like: What is energy and how is it related to motion? How is energy transferred? Because energy is a difficult concept for students to conceptualize at this age, these performance expectations deal mostly with experiential knowledge. By the end of this grade band, students will understand that the faster a given object is moving, the more energy it possesses, and that objects can transfer energy not just through collisions (as they studied in Unit 1), but also by sound, light, heat, and electric currents. In the first unit of eighth grade, students gave motion energy its proper name as kinetic energy and explored its relationship to the mass and speed of the object in question. This is crucial to this eighth grade unit, as students take their understanding of kinetic energy and apply it to other concepts, such as potential energy and how this is affected by the arrangement of objects interacting at a distance. At the fourth grade level, students focused on the crosscutting concept of Energy and Matter as they conducted investigations to gather evidence for explanations of these phenomena. However, by this unit, students move towards Developing Models to explain the phenomenon as a system.

The following is the progression of the Performance Expectations for this DCI:

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| **4-PS3-1.** | Use evidence to construct an explanation relating the speed of an object to the energy of that object. |
| **4-PS3-2.** | Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. |
| **MS-PS3-2.** | Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. |

PS3.C. Relationships Between Energy and Forces: In Kindergarten - second grade, students are not explicitly introduced to this DCI, but it does serve as the secondary DCI for K-PS2-1 below. This PE allows students to establish a basic relationship between force and energy by experiencing that a bigger push or pull makes things speed up or slow down more quickly. While third – fifth grade does access this DCI, it only does so in relation to objects that physically collide, transferring energy that changes the objects’ motion. This is a concept explored in Unit 1, but not in this particular eighth grade unit. In this unit, students investigate this relationship between force and energy in a way that is far more difficult to visualize. Here, students consider how when two magnetic objects interact from a distance, the magnetic potential energy can result in kinetic energy of that object. To demonstrate this, students develop and use a model through the lens of Systems and System Models.

The following is the progression of the Performance Expectations for this DCI:

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| **K-PS2-1.** | Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. |
| **4-PS3-3.** | Ask questions and predict outcomes about the changes in energy that occur when objects collide. |
| **MS-PS3-2.** | Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. |