This 8th grade integrated curriculum begins with a unit heavily focused on physical science and engineering and design components. In this unit, students begin to consider the factors that affect the motion of objects and use these ideas to inform their experience of collisions. In the culminating project for this unit, students will use the scientific knowledge and skills they gain throughout the unit and apply engineering and design principles to design a solution that can prevent an asteroid collision. These concepts are placed within a space science context—a context they will continue to explore in the next unit.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans seven different Disciplinary Core Ideas: LS4.A. Evidence of Common Ancestry and Diversity, PS2.A. Forces and Motion, PS2.B. Types of Interactions, PS3.A. Definitions of Energy, ETS1.A. Defining and Delimiting Engineering Problems, ETS1.B Developing Possible Solutions, and ETS1.C. Optimizing the Design Solution.

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

\*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 1**

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| **Disciplinary Core Ideas** | **K-2** | **3-5** | **6-8** |
| **LS4.A**  **Evidence of Common Ancestry and Diversity** | N/A | Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago. | The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth’s history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent. |
| **PS2.A**  **Forces and Motion** | Pushes and pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it. | The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center. | The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force. |
| **PS2.B**  **Types of Interactions** | Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object. |
| **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. | Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter. |
| **ETS1.A**  **Defining and Delimiting Engineering Problems** | A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem. | Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. | 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 that are likely to limit possible solutions. |
| **ETS1.B**  **Developing Possible Solutions** | Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. | Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. | A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions. |
| **ETS1.C**  **Optimizing the Design Solution** | Because there is always more than one possible solution to a problem, it is useful to compare and test designs. | Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | 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. 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. |

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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.   * Define a simple problem that can be solved through the development of a new or improved object or tool. | Asking questions and defining problems in 3-5 builds on prior experiences and progresses to specifying qualitative relationships.   * Use prior knowledge to describe problems that can be solved. * Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. | Asking questions and defining problems in 6-8 builds on prior 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 object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. |
| **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.   * Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. | 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 a model to generate data to test ideas about designed systems, including those representing inputs and outputs. |
| **Planning and Carrying Out Investigations\*** | Planning and carrying out investigations 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 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 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.   * Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. |
| **Analyzing and Interpreting Data\*** | Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.   * Compare predictions (based on prior experiences) to what occurred (observable events). | 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. * Represent data in tables and/or various graphical. | 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.\* * Construct and interpret graphical displays of data to identify linear and nonlinear relationships (*addressed in unit, not assessed in project)*. |
| **Designing Solutions\*** | Designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in designing solutions.   * Generate and/or compare multiple solutions to a problem. | Designing solutions in 3-5 builds on prior experiences and progresses to the use of evidence in designing multiple solutions to design problems.   * Apply scientific ideas to solve design problems. | Designing solutions in 6-8 builds on prior experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.   * Apply scientific ideas or principles to design an object, tool, process or system. |
| **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. * Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. | 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. * Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. | 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 an oral and written argument 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. * Evaluate competing design solutions based on jointly developed and agreed-upon criteria. |

\*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.   * Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. | 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.   * Graphs, charts, and images can be used to identify patterns in data. |
| **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.   * Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. |
| **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.   * 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 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—such as inputs, processes and outputs—and energy and matter flows within systems. |
| **Stability and Change** | Students observe some things stay the same while other things change, and things may change slowly or rapidly.   * Some things stay the same while other things change. | Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.   * Change is measured in terms of differences over time and may occur at different rates. | Students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.   * Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. |

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

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

LS4.A. Evidence of Common Ancestry and Diversity: Students do not engage with this DCI until the third grade. In third grade, students begin to ask the question: How are plants, animals, and environments of the past similar or different from current plants, animals, and environments? This gives students a first exposure to the fossil record and introduces them to the idea of the scale of Earth’s long history, concepts that they will build on in the eighth grade unit. At this point, students only make isolated connections between organisms and their environment, comparing data between the past and the present. In this eighth grade unit, students attempt to form a much more cohesive and complex picture of the history of life on Earth. Thus, students move from a focus on Scale, Proportion, and Quantity in early grades to a focus on Patterns to organize the fossil record in later grades. In all grades, however, they are focusing on Analyzing and Interpreting Data as they look at the fossil record.

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

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| **3-LS4-1** | Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. |

**MS-LS4-1** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

PS2.A. Forces and Motion: In Kindergarten through second grade, students engage with the foundational concepts within physics—that pushing or pulling on an object can change the speed or direction of its motion, or even more simply, can start or stop it. They also begin to explore the idea that pushes and pulls can have different strengths and directions. At this point, the concepts are all experiential. In third to fifth grade, the term force is introduced and students begin to define these experiences with more specificity and experiment accordingly. This provides a clear progression into this eighth grade unit, as students continue their investigations with motion, but define them even more specifically within Newton’s laws of motion. As expected with this content, there is a heavy focus in all grades on Planning and Carrying Out Investigations and Analyzing and Interpreting the Data they produce. From Kindergarten – eighth grade, students are using the crosscutting concepts of Patterns to analyze data and Cause and Effect to explain the phenomena they observe. By the time they get to this eighth grade unit, students will be ready to apply these concepts and skills to design a solution related to forces and motion.

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. |
| **K-PS2-2** | Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. |
| **3-PS2-1** | Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. |
| **3-PS2-2** | Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion**.** |
| **MS-PS2-2** | Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. |

PS2.B. Types of Interactions: In Kindergarten to second grade, students observe through investigation that when objects touch or collide, they push on one another and can change motion—a crucial foundation to the project in this eighth grade unit. In third through fifth grade, students continue to investigate this phenomenon, but with the new vocabulary of balanced and unbalanced forces. This grade band also introduces other types of forces: electric and magnetic forces (which is not returned to in this eighth grade unit) and gravity. This prior knowledge of balanced and unbalanced forces and gravity sets the stage for this eighth grade unit as they work to develop their culminating project (preventing an asteroid collision). In eighth grade, students move beyond the concept of gravity as simply attracting objects towards Earth’s center and consider how the mass of different objects might affect gravitational attraction. Throughout the grade levels, students focus on both Planning and Conducting Investigations to investigate these phenomena and also Engaging in Argument from Evidence in order to explain these phenomena. At all grade levels, students are building their ability to use Cause and Effect reasoning to explain these concepts.

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. |
| **3-PS2-1** | Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. |
| **5-PS2-1** | Support an argument that the gravitational force exerted by Earth on objects is directed down. |
| **MS-PS2-1** | Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects. |
| **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. |

PS3.A. Definitions of Energy: Students do not engage with this DCI until the fourth grade. In third through 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 if it collides with another object, it can transfer some of that energy in motion. This is crucial to this eighth grade unit, as students use these ideas to understand the science behind collisions and predict potential effects of an asteroid collision. While the fourth grade performance expectations focus on different science and engineering practices and crosscutting concepts than the eighth grade performance expectation for this unit, they all serve to prepare students for this level of content and application.

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-PS3-3** | Ask questions and predict outcomes about the changes in energy that occur when objects collide. |

**MS-PS3-1** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

ETS1.A. Defining and Delimiting Engineering Problems: From Kindergarten to second grade, students first begin to approach situations as problems to be solved through engineering. They learn to ask questions and gather information to clearly understand a problem. In third through fifth grade, students build on understanding the problem to also identifying criteria and constraints surrounding the problem. In this eighth grade unit, students take this process a step further by defining criteria and constraints more precisely, including consideration of scientific principles and other relevant knowledge. In Kindergarten to second grade, students focus on the science and engineering practice of Asking Questions in order to help them with the practice of Defining Problems, which continues to be the main focus in subsequent grades.

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

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| **K-2-ETS1-1** | Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. |
| **3-5-ETS1-1** | Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. |
| **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. |

ETS1.B. Developing Possible Solutions: During Kindergarten through second grade, students begin communicating multiple designs in the form of diagrams and sketches. By third to fifth grade, students move from mere drawings to actually testing out their designs to see how they perform under different conditions. Students then use this data to make improvements. As in Kindergarten through second grade, students practice the idea that communication of designs with peers is an essential part of the design process. In this eighth grade unit, students move towards more systematic processes to evaluate solutions for how well they meet criteria and constraints. There is also a much greater emphasis on using the data to inform improvements, focusing on the idea that parts of different solutions can be used to make an even better solution. At the different grade levels, students engage in a variety of different science and engineering practices: Developing Models in K-2, Designing Solutions (specifically comparing solutions) in 3-5, and Engaging in Argument From Evidence in 6-8. This is representative of the different practices students are engaging with, described above.

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

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| **K-2-ETS1-2** | Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. |
| **3-5-ETS1-2** | Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. |
| **MS-ETS1-2** | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |

ETS1.C. Optimizing the Design Solution: In Kindergarten to second grade, students begin to understand that because there are always multiple solutions to a problem, it is useful to compare and test designs. Students in third through fifth grade take this skill and use findings from those tests to determine which solution best meets criteria and constraints that they identified through ETS1.A. In accordance with the progression students follow in middle school for ETS1.B, students in this eighth grade unit move towards using data and analysis to identify best characteristics and inform a new and better solution. Thus, it makes sense that at all grade levels, students focus on Science and Engineering Practices related to testing and analyzing: Planning and Carrying Out Investigations and Analyzing and Interpreting Data. At the eighth grade level, students take these skills further to develop models that will generate data to test ideas about designed systems.

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

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| **K-2-ETS1-3** | Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. |
| **3-5-ETS1-3** | Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. |
| **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. |