Project-Based Inquiry Science: Diving Into Science
Storyline

Targeted Performance Expectations:
· MS-PS2-2 · MS-ETS1-1 · MS-ETS1-2 · MS-ETS1-3 · MS-ETS1-4

Unit Goals:
Students are introduced to and engage in the practices of science and the social practices of the classroom. As students engage in the social practices of scientists they learn what scientists do, and how they do it. Students identify ways that scientists collaborate to answer questions and solve problems. Students work collaboratively to engage in scientific practices, and use science knowledge (related to factors that affect how objects fall, and the forces acting on objects as they fall) to ask and answer questions and define and address problems.

Diving Into Science: What's the Big Question?
How Do Scientists Work Together to Solve Problems?

Storyline

In the *Introduction* to *Diving Into Science*, students are introduced to the *Big Question: How do scientists work together to solve problems?*
The text informs students that scientists work together to answer big questions. In order to tackle the big questions, they need to answer smaller questions. Similarly, students are told that they will engage with small questions in this unit, in order to learn and answer the big question about how scientists work together to solve problems. Students are told that they will work within four challenges that will also help them to become a team of scientists.

Diving Into Science: Learning Set 1
The Book-Support Challenge

Storyline (with Disciplinary Core Ideas and Science Content)	Science and Engineering Practices	Crosscutting Concepts
Introduction to *Learning Set 1*: At the beginning of *Learning Set 1* students are introduced to the first problem they must solve. They are told, through a story, that they must design a support for a book that must be at least 7.5 cm above the desk so that it can be read and the pages turned while the book remains on the support.	**Obtaining, Evaluating, and Communicating Information** (students are provided the challenge and criteria and constraints, and identify the critical information for defining the challenge) **Planning and Carrying Out Investigations** (each team uses the materials provided for the book support to plan and carry out iterative designs that meet the specifications of the challenge.) **Engaging in Argument from Evidence** (sharing data and focusing on the criteria of developing a book support, creating claims about the group's various book support designs and sharing these ideas with others) **Analyzing and Interpreting Data** (groups collect and document book support data including the amount of different materials used, and drawings to document each design iteration, analyze the data and interpret for the goal of creating a book support that best meets the challenge criteria)	Learning Set Level: **Structure and Function** (the shape, strength, and stability of designed structures relates to its function – ability to support a book) **Systems and System Models** (system of gravity acting on the book and the support acting "against" this) Section Level: **Stability and Change** (building a stable book support structure) **Cause and Effect** (the impact of changing the shape/organization of a material and the effect that has on a structure's stability/ability to support a book)
Section 1.1: Before they begin to tackle the problem, students identify the criteria and constraints of the challenge. Within the boundaries of the criteria and constraints the student scientist teams build their first book support. In doing this they learn about the materials they are to use and they begin to identify some design elements that might be important to solving the problem. Then each team shares their solution with the class. They are supported in this by model question prompts focused on the design decisions, the criteria and constraints of the challenge, and the successes and failures of their initial trials. After each group has presented their solutions, the class has the opportunity to update their list of criteria and constraints. **Disciplinary Core Ideas:** **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 that are likely to limit possible solutions. (MS-ETS1-1)		

Section 1.1 (continued) **Disciplinary Core Ideas:** **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)	*Section 1.1 (continued)*	*Section 1.1 (continued)*
Section 1.2: Now that students have experience with the materials and have shared their initial attempts to solve the challenge, they continue the iterative design process and plan a better book support. To do this, student groups are encouraged to use the ideas of other groups, and information they gained from their initial attempts, to develop a plan for an improved book support. After a brief discussion about the purpose and importance of iterative design and keeping records, students iteratively build and test their book support design. As they do this, they record information related to each design iteration. Student groups present their new solutions to other groups during a *Solution Briefing* in which they identify how well they have met the challenge within the context of the criteria and constraints. Students read about the differences between copying work and using and building upon others' ideas and citing the resource. They are encouraged to begin to use others' ideas and to cite them, framing the work they will do, and they ideas they will share, as collaboration. **Disciplinary Core Ideas:** **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)	**Constructing Explanations and Designing Solutions** (using data and experiences along with the science knowledge to improve the design solutions in an iterative cycle) **Asking Questions and Defining Problems** (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)	Learning Set Level: **Structure and Function** (the shape, strength, and stability of designed structures relates to its function – ability to support a book) **Systems and System Models** (system of gravity acting on the book and the support acting "against" this) Section Level: **Stability and Change** (building a stable book support structure) **Cause and Effect** (the impact of changing the shape/organization of a material and the effect that has on a structure's stability/ability to support a book)
Section 1.3: Now that students have experiences building the book support and documenting their results, they read about the science of structures. Students can then use the information and language from this reading to support their understanding and to make future design changes. The reading supports students' understanding of the book as being made up of matter (atoms, molecules, and having volume); and as experiencing a pulling force on it from the earth (gravity). They also learn about what makes a structure strong, and what makes a structure stable. The students can use this reading about different types of strong and stable structures to identify ways in which they can redesign their book support to better meet the challenge. **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** · Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)	**Obtaining, Evaluating, and Communicating Information** (reading about the science of structures and applying this information to the book support design)	Learning Set Level: **Structure and Function** (the shape, strength, and stability of designed structures relates to its function – ability to support a book) **Systems and System Models** (system of gravity acting on the book and the support acting "against" this) Section Level: **Stability and Change** (building a stable book support structure) **Cause and Effect** (the impact of changing the shape/organization of a material and the effect that has on a structure's stability/ability to support a book)

Section 1.4: Using the information from the reading, students update their book support to meet the requirements of the challenge. However, the challenge has changed slightly. In addition to the previous criteria and constraints, the book support must now be cost effective. After planning, building, and testing their designs, students then engage in a *Solution Briefing* to demonstrate their last and best solution to the challenge. In the presentation, students are encouraged to reflect critically upon how well their final design attended to the criteria and constraints of the challenge, this time focusing on the cost of their design. Students who are in the audience are encouraged to ask questions regarding the requirements of the challenge and the ways each group met those requirements. **Disciplinary Core Ideas:** **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)	**Planning and Carrying Out Investigations** (each team uses the materials provided for the book support to plan and carry out iterative designs that meet the specifications of the challenge) **Obtaining, Evaluating, and Communicating Information** (engaging in *Solution Briefings* to share with peers design ideas and iteration outcomes) **Engaging in Argument from Evidence** (sharing data and focusing on the criteria of developing a book support, creating claims about the group's various book support designs and sharing these ideas with others) **Analyzing and Interpreting Data** (groups collect and document book support data including the amount of different materials used, and drawings to document each design iteration, analyze the data and interpret for the goal of creating a book support that best meets the challenge criteria) **Constructing Explanations and Designing Solutions** (using data and experiences along with the science knowledge to improve the design solutions in an iterative cycle)	Learning Set Level: **Structure and Function** (the shape, strength, and stability of designed structures relates to its function – ability to support a book) **Systems and System Models** (system of gravity acting on the book and the support acting "against" this) Section Level: **Stability and Change** (building a stable book support structure) **Cause and Effect** (the impact of changing the shape/organization of a material and the effect that has on a structure's stability/ability to support a book)
Back to the Big Question: The goal of *Diving Into Science* is to provide several contexts through which students begin to collaborate to answer questions and solve problems like scientists and engineers. All of the units' learning tasks are focused on these ideas. In *Learning Set 1* students have learned to work in small groups to solve problems collaboratively and to persevere through a design challenge, updating their own ideas with additional information and using the ideas of others when appropriate (i.e., conducting multiple iterations). They have used criteria and constraints to define the boundaries of the challenge and have learned the importance of record keeping, and using science knowledge. In *Back to the Big Question,* students reflect on this scientific work and begin to identify the importance of using these tools of science when they are searching for answers to questions and addressing design challenges.		

Diving Into Science: Learning Set 2
The Sandwich-Cookie Challenge

<table>
<tr><th>Storyline</th><th>Science and Engineering Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td>Introduction to Learning Set 2:
In Learning Set 2 of Diving Into Science students use the scientists' practices they have learned in Learning Set 1 and apply them to a new challenge. Within this new challenge they learn additional practices and use them in new ways.
In the introduction, students are challenged, through another story, to create an accurate procedure for determining how much water ("cream filling") can be put on a penny ("cookie") without overflowing, and to provide evidence that the procedure is accurate. The development and testing of uniform procedures is foregrounded in this Learning Set.</td><td rowspan="3">Asking Questions and Defining Problems (using criteria and constraints to define the problem, developing additional criteria and constraints with other teams)

Developing and Using Models (physical model of sandwich cookie is used to identify a procedure and collect data)

Planning and Carrying Out Investigations (students plan and carry out investigations to measure water drops on a penny with accuracy in order to make a recommendation for meeting the challenge)

Analyzing and Interpreting Data (small groups collect data, which are then analyzed by creating a class graph using all data points. Data analysis supports students developing an accurate procedure)

Using Mathematics, Information, and Computer Technology and Computational Thinking (students graph and then discuss the data set they created, looking for procedural issues that present themselves because the large range of outlying data points)

Obtaining, Evaluating, and Communicating Information (students share and evaluate their procedural designs and results with each other, receiving feedback)

Engaging in Argument from Evidence (sharing data and focusing on the criteria of meeting the challenge, creating claims about the group's various procedural designs and sharing these ideas with others)</td><td rowspan="2">Learning Set Level:
System and System Models (the system model of the water drops on a penny can be measured and a procedure can be created that allows all groups to be measuring the same quantities)</td></tr>
<tr><td>Section 2.1:
Students identify the criteria and constraints of the challenge and make a public list of the criteria and constraints.

Disciplinary Core Ideas:
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 that are likely to limit possible solutions. (MS-ETS1-1)</td></tr>
<tr><td>Section 2.2:
Students begin to model putting cream filling on a cookie. In this challenge, water provides a physical analog to the cream filling and students measure how many drops it takes to completely cover the "cookie" (a penny) without flowing over the sides. Pairs of students first create an initial procedure, and run their first trials using this procedure. Students are given five pennies, and are asked to conduct five trials and to document their results.
A class graph is created to show the class's results across all trials. The graph, a line plot, shows each individual trial data point on one graph. Students analyze the class graph for information about the efficacy of their procedure. They look for reliability issues within the data by noting the range, distribution, and average of the data. From this data they recognize the need for developing a more thorough and consistently-followed procedure.

Disciplinary Core Ideas:
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)</td><td>Learning Set Level:
System and System Models (the system model of the water drops on a penny can be measured and a procedure can be created that allows all groups to be measuring the same quantities)</td></tr>
</table>

Section 2.3: After analyzing the data and identifying issues of precision and error in their previous procedures, students work as a class to design a new, more precise procedure that is specific, controlled, and replicable. The class procedure focuses on controlling variables and acting as groups of scientists to implement one procedure across all "scientist groups" Their new class procedure will make it possible to collect more useful and accurate data. **Disciplinary Core Ideas:** **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)	**Developing and Using Models** (physical model of sandwich cookie is used to identify a procedure and collect data) **Planning and Carrying Out Investigations** (students plan and carry out investigations to measure water drops on a penny with accuracy in order to make a recommendation for meeting the challenge) **Obtaining, Evaluating, and Communicating Information** (students share and evaluate their procedural designs and results with each other, receiving feedback)	Learning Set Level: **System and System Models** (the system model of the water drops on a penny can be measured and a procedure can be created that allows all groups to be measuring the same quantities)
Section 2.4: Student groups carry out the investigation using their updated procedure, running 5 to 10 trials. They again create a class graph of the data, using the spread of the data to evaluate their new procedure. The class once again identifies ways that the procedure is still not precise enough, and revises their procedure, and runs their investigation once more. This time, their results are much more consistent, providing evidence that a precise procedure ensures reliable results. **Disciplinary Core Ideas:** **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)	**Developing and Using Models** (physical model of sandwich cookie is used to identify a procedure and collect data) **Engaging in Argument from Evidence** (sharing data and focusing on the criteria of meeting the challenge, creating claims about the group's various procedural designs and sharing these ideas with others) **Analyzing and Interpreting Data** (small groups collect data, which are then analyzed by creating a class graph using all data points. Data analysis supports students developing an accurate procedure) **Obtaining, Evaluating, and Communicating Information** (students share and evaluate their procedural designs and results with each other, receiving feedback)	Learning Set Level: **System and System Models** (the system model of the water drops on a penny can be measured and a procedure can be created that allows all groups to be measuring the same quantities)
Back to the Big Question: After focusing students on sharing data and creating a common, accurate, and consistently used procedure, *Learning Set 2* concludes with students returning to the *Big Question*: How do scientists work together to solve problems? In answering the *Big Question* after this *Learning Set*, students will add planning and carrying out investigations, developing and following common procedures, controlling variables, representing and analyzing data, and drawing conclusions from data to their developing understanding of how scientists work.	**Obtaining, Evaluating, and Communicating Information** (students share and evaluate their procedural designs and results with each other, receiving feedback)	Learning Set Level: **System and System Models** (the system model of the water drops on a penny can be measured and a procedure can be created that allows all groups to be measuring the same quantities)

<table>
<tr><th colspan="3">Diving Into Science: Learning Set 3
The Whirligig Challenge</th></tr>
<tr><th>Storyline (with Disciplinary Core Ideas and Science Content)</th><th>Science and Engineering Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td>Introduction to Learning Set 3:
In the Whirligig Challenge, students use the scientists' practices they have been learning and practicing in Learning Sets 1 and 2, and apply them to a new challenge.
In the introduction, students are introduced to the problem: design a slow-falling whirligig. They begin the challenge by identifying the criteria and constraints of the challenge and creating a table that can be referenced and updated throughout the Learning Set.
The purpose of this Learning Set is for students to develop a slow-moving whirligig and explain what affects how objects (a whirligig) fall.

Disciplinary Core Ideas:
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 that are likely to limit possible solutions. (MS-ETS1-1)</td><td>Obtaining, Evaluating, and Communicating Information (students are provided the challenge and criteria and constraints, and identify the critical information for defining the challenge)

Asking Questions and Defining Problems (using criteria and constraints to define the problem)</td><td>Section Level:
Cause and Effect (the impact of changing variables on how the whirligig falls)</td></tr>
<tr><td>Section 3.1:
Students begin thinking about the Whirligig Challenge and about how things fall more generally by predicting, observing, and comparing three demonstrations of falling objects with the same and different weights and surface areas. Students share their observations with their small group in a conference session. Their initial thinking about falling objects is documented (in the What do we think we know? Column) on the Project Board, creating a public artifact of their initial ideas. Questions they would like to investigate, related to the Whirligig Challenge, are also developed and recorded (in the What do we need to investigate? column) on the Project Board.
The students then "Mess About" with whirligigs, focusing on their structure and mechanisms, to further identify what they need to know more about in order to meet the challenge. Section 3.1 concludes with students again updating the class Project Board, which prepares them for designing an experiment in the next section.</td><td rowspan="2">Obtaining, Evaluating, and Communicating Information (students observe demonstrations of objects falling, and Mess About with the Whirligig, and share their ideas with their groups and the whole class on the Project Board)

Asking Questions and Defining Problems (students identify investigative questions to put on the Project Board)

Planning and Carrying Out Investigations (students gain initial experiences with the Whirligig through a Mess About)

Analyzing and Interpreting Data (students collect and analyze anecdotal data during their mess about time with the Whirligig)</td><td rowspan="2">Learning Set Level:
Structure and Function (the blade length, number of paperclips, other variables, affect the function of the whirligig)

Section Level:
Cause and Effect (the impact of changing variables on how the whirligig falls)</td></tr>
<tr><td>Section 3.2:
Students begin to investigate what affects how long it takes a whirligig to fall by being assigned to investigate one of two possible factors, which they learn are called "variables": the length of the whirligig blade (surface area) or the number of paper clips (mass). Students follow a guide provided in the text to design an experiment to examine their assigned variable, and the effect changing that variable has on how long it will take a whirligig to fall. As they write up their plan, students are encouraged to consider their variable, and the predicted impact it will have on the whirligig, as well as what other variables should be controlled, including how to drop the whirligig, and how to measure its performance. Student groups present their experimental designs to their peers, and students are encouraged to compare and revise their plans based on what they see in their peers' plans.</td></tr>
</table>

Section 3.3: Using their revised experimental design from the previous section, students run their experiment to determine how their assigned variable (surface area or mass) affects how the whirligig falls. They collect time data and record their results. They then must interpret their results, identifying trends in their data, which will lead them to develop a claim. Students make a claim about how their assigned variable affects how the whirligig falls, and support their claim with evidence from their experiment. **Disciplinary Core Ideas:** **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)	**Planning and Carrying Out Investigations** (students carry out their investigation of a variable that affects how fast a whirligig falls) **Analyzing and Interpreting Data** (students collect and analyze data from their whirligig experiment) **Constructing Explanations** (students develop evidence-based claims about how a whirligig falls) **Engaging in Argument from Evidence** (students share the results of their experiment and their claims, including how their design met the challenge criteria) **Obtaining, Evaluating, and Communicating Information** (students engage in an *Investigation Expo* to share the results of their experiment, and evaluate the quality of their peers' experiments)	Learning Set Level: **Structure and Function** (the blade length, number of paperclips, other variables, affect the function of the whirligig) **Stability and Change** (designing a consistently falling whirligig) Section Level: **Cause and Effect** (the impact of changing variables on how the whirligig falls)
Section 3.4: Now that students have the experience of experimenting with the whirligig, they read about the science of how the whirligig falls. The reading supports students' understanding of gravitational force pulling objects toward earth, and air resistance pushing up on objects as they fall. The reading also helps them consider how they are changing forces acting on the whirligig in their experiments. Students see how science knowledge about gravitational force and drag found in the reading supports their experimental results from the previous section, and can provide the basis for new ideas about how to best meet the *Learning Set* challenge. The students can use this reading about to develop a scientific explanation in the next section. To conclude this section, students focus on the third (*What are we learning?*) and fourth (*What is our evidence?*) columns as they update the *Project Board* with their claims and evidence from their experiment and the reading. **Disciplinary Core Ideas:** **PS2.A: Forces and Motion** · The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force cause a larger change in motion. (MS-PS2-2) · All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)	**Obtaining, Evaluating, and Communicating Information** (students read about the science of falling, which they can later apply toward meeting the challenge; they also use this information to update the *Project Board*)	Learning Set Level: **Structure and Function** (the blade length, number of paperclips, other variables, affect the function of the whirligig) **Systems and System Models** (system of gravity and air resistance acting on an object, the whirligig)
Section 3.5: In this section, students evaluate and apply the information they have now gathered from several sources (their experiment, the reading, the claims and evidence that they have added to the *Project Board*), to craft a scientific explanation for what affects how objects (the whirligig) fall. Students then share their draft explanations with each other to help support explanation writing and to gain access to and include others' ideas in their revised explanations in the next section.	**Obtaining, Evaluating, and Communicating Information** (students use the information from several sources to help them craft and then share explanations) **Constructing Explanations** (students construct an explanation for what affects how objects fall toward Earth)	Learning Set Level: **Structure and Function** (the blade length, number of paperclips, other variables, affect the function of the whirligig) **Systems and System Models** (system of gravity and air resistance acting on an object [the whirligig]) Section Level: **Cause and Effect** (the impact of changing variables on how the whirligig falls) **Stability and Change** (designing a consistently falling whirligig)

Section 3.6: Students are introduced to the idea that when you try to apply an explanation to a new idea, and the outcome is not as expected, it generally means that one's understanding of the science is incomplete. This is realized through a quick demonstration of the whirligig falling with no paper clips. They observe that the whirligig does not fall as expected, and this challenges the class's previous claim that few paper clips results in the whirligig falling more slowly. Given this discrepancy, students revisit ideas from *Learning Set 1* about stability and center of mass to revise their explanations of falling whirligigs. They then apply and extend their thinking about the whirligig to other falling objects, and how the forces of gravity and air resistance affect those objects. This section concludes with students organizing and connecting ideas as they update the *Project Board*. **Disciplinary Core Ideas:** **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)	**Analyzing and Interpreting Data** (students collect anecdotal observations of a falling whirligig that contradict a previous claim, and must interpret the new data in light of this) **Obtaining, Evaluating, and Communicating Information** (students collect and evaluate more information about falling that help them revise their previous thinking) **Constructing Explanations** (students revise their previous explanation for what affects how objects fall toward the earth, based on new information) **Engaging in Argument from Evidence** (students may have to wrestle a little with seemingly contracting evidence)	Learning Set Level: **Structure and Function** (the blade length, number of paperclips, other variables, affect the function of the whirligig) **Systems and System Models** (system of gravity and air resistance acting on an object [the whirligig]) Section Level: **Cause and Effect** (the impact of changing variables on how the whirligig falls) **Stability and Change** (designing a consistently falling whirligig)
Back to the Big Challenge: In *Learning Set 3*, students apply scientific practices they learned in *Learning Sets 1 and 2* to a new challenge. For example, they developed reliable procedures, conducted experiments, were mindful about controlling variables, analyzed and interpreted their results, collaborated with their peers, and built on each other's ideas. *Learning Set 3* concludes with students first making recommendations about the Whirligig Challenge in the form of a short letter, adding them to the last column in the *Project Board* (*How does this relate to the Big Challenge?*). They then return to the *Big Question*: How do scientists work together to solve problems? In answering the *Big Question* after this *Learning Set*, students will add developing and revising evidence-based claims and explanations to their developing understanding of how scientists work. **Disciplinary Core Ideas:** **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)	**Obtaining, Evaluating, and Communicating Information** (students discuss their recommendations for the challenge, as well as the *Big Question*) **Constructing Explanations** (students develop a recommendation for the challenge)	Learning Set Level: **Structure and Function** (the blade length, number of paperclips, other variables, affect the function of the whirligig) **Systems and System Models** (system of gravity and air resistance acting on an object [the whirligig]) Section Level: **Cause and Effect** (the impact of changing variables on how the whirligig falls) **Stability and Change** (designing a consistently falling whirligig)

Diving Into Science: Learning Set 4
The Parachute Challenge

<table>
<tr><th>Storyline (with Disciplinary Core Ideas and Science Content)</th><th>Science and Engineering Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td>Introduction to Learning Set 4:
In the Parachute Challenge, which is similar to the Whirligig Challenge, students use the science practices they have been learning and practicing in Learning Sets 1, 2, and 3, and apply them to a new challenge. In the introduction, students are introduced to the problem: design a slow-falling parachute for a toy made of coffee filters.
The purpose of this Learning Set is for students to continue to explore how things fall, and to practice using the science practices they have been learning about.</td><td rowspan="2">Obtaining, Evaluating, and Communicating Information (students are provided the challenge and criteria and constraints, and identify the critical information for defining the challenge)

Asking Questions and Defining Problems (using criteria and constraints to define the problem; students also identify investigative questions to help them meet the challenge, which they use to update the Project Board

Planning and Carrying Out Investigations (students gain initial experiences with the parachute through a Mess About)

Analyzing and Interpreting Data (students collect and analyze anecdotal observations about the parachute challenge via a Mess About)</td><td rowspan="2">Learning Set Level:
Structure and Function (how each of the variables affect the function of the parachute)
Systems and System Models (system of gravity and air resistance acting on an object [the parachute])

Section Level:
Cause and Effect (the impact of changing variables on how the parachute falls)
Stability and Change (designing a consistently falling parachute)</td></tr>
<tr><td>Section 4.1:
As they did with the whirligig, students begin this Learning Set by Messing About with the parachute materials. The purpose of the messing about in this instance is to begin to identify what variables might affect how quickly a parachute falls. Students are encouraged to record their observations, ideas, and questions. Based on this, students list the criteria and constraints of the challenge, and update the Project Board from Learning Set 3 with new ideas and questions about how things fall, what might make a parachute fall slowly, and what variables might be worth investigating. Students should identify variables related to the mass, surface area, and stability of the parachute (e.g., string length, canopy size, number of strings, placement of strings, mass of load).

Disciplinary Core Ideas:
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)</td></tr>
</table>

Section 4.2: Student groups each choose one variable, which had been identified in the previous section and documented on the *Project Board*, to investigate. As they did in *Learning Set 3*, they use guidance from the text to help them design an experiment to test their variable's effect on a falling parachute. As they write up their plan, students are encouraged to consider their variable, and the predicted impact it will have on the parachute, as well as what other variables should be controlled, including how to drop the parachute, how to measure its performance, and how many trials to perform. After they have designed their experimental plan, student groups run their experiment, recording their data, and analyzing their results to determine trends. From this, they share their results with the class in an *Investigation Expo*. As they share and listen to each other's findings, students are encouraged to integrate previous experiences designing fair and consistent experiments, and reflect on the quality of the experiments conducted. Based on ideas shared during the *Investigation Expo*, student groups may revise and rerun their experiment. **Disciplinary Core Ideas:** **PS2.A: Forces and Motion** · The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) · All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2) **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)	**Planning and Carrying Out Investigations** (students plan and carry out an investigation of a variable that affects how a parachute will fall; groups may revise their plan after receiving feedback) **Analyzing and Interpreting Data** (students collect, analyze, and identify trends in their experimental data) **Obtaining, Evaluating, and Communicating Information** (students share the results of their experiment in an *Investigation Expo*) **Engaging in Argument from Evidence** (students share the results of their experiment and their claims, including how their design met the challenge criteria)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)
Section 4.3: Students identify evidence-based claims from their experiments in the previous section, and use those to craft explanations and make recommendations about how to design a slow-falling parachute. **Disciplinary Core Ideas:** **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)	**Constructing Explanations** (students develop evidence-based claims and explanations about how a parachute falls, and make recommendations for the challenge) **Engaging in Argument from Evidence** (students share the results of their experiment and their claims, including how their design met the challenge criteria)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)

Section 4.4: Students read about the science of how parachutes work. This reading further reinforces students' understanding about gravity and air resistance, and supports their scientific understanding of the different factors that affect how a parachute falls, such as canopy size, number of washers, string length, number of strings, canopy vents, and canopy shape, and how each of these factors changes the forces acting on the parachute. Further, they make connections between how the parachute falls and how the whirligig falls. With this additional science knowledge, students revise their explanations and recommendations, and present these to the class. To conclude this section, students add what they have learned to the *Project Board*, building upon what they learned in the Whirligig Challenge. **Disciplinary Core Ideas:** **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)	**Obtaining, Evaluating, and Communicating Information** (students read more about the science of falling, and how parachutes work, which they can later apply toward meeting the challenge; they also use this information to update the *Project Board*)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)
Section 4.5: Incorporating what they learned from their parachute experiments, the reading, and the evidence-based claims and recommendations made on the *Project Board*, student groups now plan a design for a slow-falling parachute, and get feedback on their design plans in a *Plan Briefing*. During the *Plan Briefing*, the class asks questions about each other's plans and provide feedback, helping each group to identify weaknesses in their design plans. Using the feedback, and building on the ideas of their peers, groups revise their design plans. **Disciplinary Core Ideas:** **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)	**Planning and Carrying Out Investigations** (students develop a design for a slow-moving parachute, and develop a plan for testing their design) **Obtaining, Evaluating, and Communicating Information** (students share their design ideas with their peers and receive feedback, which they use to revise their design plan as necessary)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)

Section 4.6: In this section students build their parachutes based on their design plans from the previous section. They then test their designs, and revise the design based on their results. Groups are encouraged to continue to iteratively improve and test their design plans, maintaining records of each trial conducted. After student groups build their final design, they share their design with the class in a *Solution Showcase*. The *Solution Showcase* helps students share their complete design process from beginning to end with the class, and allows students to analyze and evaluate what has and has not worked in various design iterations. In a final test of each group's parachute design, the class drops and compares all of the parachute designs. The class discusses the various designs in relation to why some parachutes met the challenge better than others, according to science ideas related to gravity and air resistance. The class then updates the *Project Board* for the final time, focusing on what they learned about how things fall, and how what they learned applies to the Parachute Challenge. **Disciplinary Core Ideas:** **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)	**Planning and Carrying Out Investigations** (students iteratively test their parachute design plan) **Analyzing and Interpreting Data** (students analyze data from their parachute tests and use it to redesign as necessary) **Obtaining, Evaluating, and Communicating Information** (students share the results of their design process, including their final design. The class discusses all the designs and update the *Project Board* based on this discussion) **Engaging in Argument from Evidence** (students share their final design plan with peers in a *Solution Showcase*, and provide information to support how their design did or did not meet the challenge criteria)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)
Back to the Big Challenge: In *Learning Set 4*, students apply scientific practices they learned throughout all previous *Learning Sets* to a new challenge, which builds on the ideas and *Project Board* from the Whirligig Challenge. Throughout *Learning Set 4* students developed reliable procedures, conducted experiments, were mindful about controlling variables, analyzed and interpreted their results, collaborated with their peers, and shared and built on each other's ideas. They also constructed explanations and made recommendations, and iteratively designed and tested ideas. To conclude this *Learning Set*, students write a letter in which they communicate their evidence-based recommendation for meeting the Parachute Challenge. **Disciplinary Core Ideas:** **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)	**Constructing Explanations** (students develop recommendations for meeting the parachute challenge)	Learning Set Level: **Structure and Function** (how each of the variables affect the function of the parachute) **Systems and System Models** (system of gravity and air resistance acting on an object [the parachute]) Section Level: **Cause and Effect** (the impact of changing variables on how the parachute falls) **Stability and Change** (designing a consistently falling parachute)

Diving Into Science: Answer the Big Question How Do Scientists Work Together to Solve Problems?	
Storyline	**Science and Engineering Practices**
At the end of each *Learning Set*, students have reflected on what they have learned about how scientists "work together to solve problems." They have worked collaboratively throughout the unit and have designed procedures, conducted investigations, shared their results and plans, and completed many of the tasks professional scientists and engineers complete. Now that students will be answering the *Big Question*, they begin by watching a video (IDEO) that shows adults engaged in the same processes that they have been engaged in with the focus on solving a problem. The video allows students to see that the work they have been asked to complete mirrors the work of professionals. To complete the unit, students answers questions and discuss how they have learned teamwork, sharing ideas and learning from other students, making informed, evidence-based decisions, and the importance of iteration and identifying and attending to criteria and constraints. Additional discussions around planning and carrying out investigations, the importance of modeling and simulations, and the usefulness of case studies to support reasoned decisions are also included in the *Answer the Big Question*.	**Obtaining, Evaluating, and Communicating Information** (students observe and discuss a video of professionals doing the work they have been doing throughout the unit) **Engaging in Argument from Evidence** (students discuss the ways in which they have been doing work similar to science professionals)