NGSS OVERVIEW

FIELDS AND INTERACTIONS

Performance Expectation MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

Performance Expectation 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.

Performance Expectation 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.

Performance Expectation 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.

Performance Expectation 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.

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

Performance Expectation 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.

Performance Expectation 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.

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **Problem Solving: Save the Astronaut!** Students are introduced to the process of engineering with a scenario that engages them in solving a simple problem. The activity elicits and builds on students' ideas about how to define a problem and develop a successful solution. The process of solving the problem is compared and contrasted with the work of scientists and engineers. Students then generate questions and define problems in their everyday lives.	MS-ETS1.B	Asking Questions and Defining Problems Analyzing and Interpreting Data Using Mathematics and Computational Thinking	Systems and System Models	ELA/Literacy: SL8.5
2. **Reading: The Apollo Missions** Students continue to investigate the process of engineering with a historical engineering case. While investigating the Apollo missions, students identify important criteria and constraints faced by NASA during the development of the space program. The activity elicits and builds on students' ideas about how to define a problem and develop a successful solution. The reading provides examples of how technologies are driven by individual or societal needs, desires, and values.	MS-ETS1.A MS-ETS1.B MS-ETS1.C	Analyzing and Interpreting Data	Connections to Nature of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	Mathematics: MP.2 ELA/Literacy: SL8.5 RST.6-8.1

FIELDS AND INTERACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
3. **Design: Gravitational Transporter** Students begin to investigate gravitational potential energy in a system of interacting objects. Using a system model, students investigate how the release height and/or mass of a cart will affect the amount of kinetic energy transfer in a collision. Through a process of testing, evaluating, and redesigning, students optimize their solutions by controlling the initial amount of gravitational potential energy of the transporter. They use this model to make conceptual connections between their evidence and explanations of gravitational potential energy.	MS-PS3.A MS-PS2.B MS-ETS1.A MS-ETS1.B	Developing and Using Models Engaging in Argument from Evidence Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence Analyzing and Interpreting Data Asking Questions and Defining Problems	Systems and System Models Connections to Nature of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	Mathematics: MP.2 ELA/Literacy: SL8.5 RST.6-8.1
4. **Investigation: Gravitational Force** Students analyze and interpret data to learn about the relationship between the gravitational force between two objects, the mass of those objects, and the distance between them. Students create and analyze graphs that provide evidence that gravitational force is directly proportional to the mass of the objects interacting and inversely proportional to the distances between the objects.	MS-PS2.B MS-PS3.C	Engaging in Argument from Evidence Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence Analyzing and Interpreting Data Constructing Explanations and Designing Solutions	Systems and System Models Patterns	ELA/Literacy: SL8.5 WHST.6-8.1
5. **Investigation: Mapping Magnetic Fields** Students provide evidence that there are other forces besides gravity that can act at a distance. To do this, students conduct an investigation related to the phenomenon of magnetism. In their exploration, they analyze and interpret data related to the direction of magnetic fields at different locations in those fields. They use the effects seen in one magnetic field map to predict another magnetic field map. By mapping different magnetic fields, students are able to provide evidence that fields exist between objects, exerting forces on each other even though the objects are not in contact.	MS-PS2.B MS-PS3.C	Planning and Carrying Out Investigations Analyzing and Interpreting Data	Cause and Effect	ELA/Literacy: RST.6-8.3

FIELDS AND INTERACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
6. **Design: Magnetic Transporter** Students apply what they have learned on the phenomena of gravity and magnetism to design a magnetic transporter. They define a design problem that can be solved through the development of an object that meets multiple criteria and constraints. They use an iterative testing procedure to optimize the transporter to carry as much weight as possible. This activity provides a formal assessment opportunity for Performance Expectation MS-ETS1-1.	MS-PS3.A MS-PS2.B MS-ETS1.A MS-ETS1.B MS-ETS1.C	Developing and Using Models Analyzing and Interpreting Data Asking Questions and Defining Problems Engaging in Argument from Evidence Constructing Explanations and Designing Solutions	Systems and System Models Connections to Nature of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	ELA/Literacy: SL8.5 RST.6-8.7
7. **Reading: Gravitational and Magnetic Fields** Students synthesize their knowledge of gravitational and magnetic fields in a reading that compares and contrasts these two kinds of fields. The reading helps students summarize what influences the magnitude and direction of forces resulting from field interactions. Students also reflect on how energy stored within a system of interacting objects relates to the relative positions of the objects interacting. These relationships are examined through the lens of the crosscutting concept of cause and effect. This activity provides a formal assessment opportunity for Performance Expectation MS-PS2-4.	MS-PS2.B MS-PS3.A MS-PS3.C	Developing and Using Models Asking Questions and Defining Problems Engaging in Argument from Evidence Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Cause and Effect Systems and System Models	Mathematics: MP.2 ELA/Literacy: WHST.6-8.1
8. **Investigation: Static Electricity** Students ask questions about and then investigate how static charge can sometimes cause objects to be attracted to, and at other times repelled by, each other. By rubbing certain materials together to generate static electricity, students are able to observe that these interactions provide evidence for forces that act at a distance, which means that they can be explained by fields that extend through space. Students use a simulation to further investigate the cause and effect of phenomena related to static, since charged particles occur at scales too small to observe.	MS-PS2.B	Asking Questions and Defining Problems	Cause and Effect	

FIELDS AND INTERACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
9. **Laboratory: Electrostatic Force** Students are introduced to a tool—an electroscope— that can show relative strengths of forces resulting from static electricity. Students then plan and conduct their own investigations using the electroscope to see if there is a relationship between the amount of electric charge, the distance between charged objects, and the amount of force. Students are asked to use the results of their investigations as well as evidence from previous activities to verify that fields exist between objects exerting forces on each other even though the objects are not in contact.	MS-PS2.B	Planning and Carrying Out Investigations Asking Questions and Defining Problems Analyzing and Interpreting Data	Cause and Effect	ELA/Literacy: WHST.6-8.7 RST.6-8.3
10. **Computer Simulation: Visualizing an Electric Field** Students use a computer simulation to support their understanding of an electrostatic field. The simulation allows students to visualize the interaction between static charges. The model enables students to ask and then investigate questions about what affects the direction and magnitude of forces in an electric field. Students also investigate the potential energy stored in the system of interacting charges.	MS-PS3.A MS-PS2.B	Asking Questions and Defining Problems Constructing Explanations and Designing Solutions	Cause and Effect Systems and System Models	ELA/Literacy: WHST.6-8.7 RST.6-8.3
11. **Modeling: Electric Field Transporter** Students apply what they have learned about electric and gravitational fields to design a hovering transporter cart that depends on electrostatic force to move. They develop a model in a computer simulation where they can manipulate the arrangement of charges to design the system. By testing, analyzing data, and redesigning, students combine the best characteristics of each design to make a new solution that better meets the criteria of the transporter. This activity provides a formal assessment opportunity for Performance Expectation MS-PS3-2.	MS-PS3.A MS-PS3.C MS-ETS1.B MS-ETS1.C	Developing and Using Models	Systems and System Models Scale, Proportion, and Quantity	Mathematics: MP.2

FIELDS AND INTERACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
12. **Investigation: Electric and Magnetic Fields** Students investigate the induction of electric and magnetic fields through a series of hands-on investigations. Students complete two explorations on the relationship between electricity and magnetism. After observing the effects of electromagnetic induction, students then conduct investigations to determine the factors that affect the strength of magnetic fields from an electromagnetic coil on a test object. Students evaluate the designs of their experiments for the quantity and quality of evidence of what factors affect the strength of electric and magnetic fields. This activity provides a formal assessment opportunity for Performance Expectation MS-PS2-5.	MS-ETS1.B MS-PS2.B	Asking Questions and Defining Problems Developing and Using Models Planning and Carrying Out Investigations	Cause and Effect Patterns	Mathematics: MP.2 ELA/Literacy: RST.6-8.3
13. **Design: Gyrosphere Rescue** In this engineering design challenge, students apply their scientific knowledge about what affects the strength of an electromagnetic field to build a device to move steel bearings from one location to another. They collect data, test and redesign several solutions to optimize their designs, and develop the most successful designs for the criteria. Then they evaluate others' designs and discuss the design trade-offs. Students also consider the scientific investigations they have been conducting and identify what information is needed in order to determine the strength of electric and magnetic forces. This activity provides formal assessment opportunities for Performance Expectations MS-ETS1-4 and MS-PS2-3.	MS-PS2.B MS-ETS1.B MS-ETS1.C	Asking Questions and Defining Problems Analyzing and Interpreting Data Developing and Using Models Engaging in Argument from Evidence Constructing Explanations and Designing Solutions	Cause and Effect	Mathematics: MP.2

FIELDS AND INTERACTIONS (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
14. **Reading: Electric and Electromagnetic Fields** This reading provides a synthesis of the information in the unit on electric and electromagnetic fields. The factors that determine the strength and direction of these fields is presented. Students are given an opportunity to further explore how electric and electromagnetic fields are distinct from gravitational and magnetic fields. Technology that depends on the phenomena of electric and electromagnetic fields are presented in the context of everyday use. The cause-and-effect relationship between the fields and forces allows students to understand how phenomena are used in these designed systems.	MS-PS2.B	Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence	Cause and Effect	Mathematics: MP.2 ELA/Literacy: RST.6-8.1
15. **Talking It Over: Evaluating Transporter Designs** Students use the scientific knowledge they have accumulated in this unit to systematically evaluate competing design solutions based on scientific validity and design success. After evaluating four proposals, students combine the best aspects of the proposals into their own designs. This activity provides a formal assessment opportunity for Performance Expectations MS-ETS1-2 and MS-ETS1-3.	MS-ETS1.B MS-ETS1.C	Engaging in Argument from Evidence Analyzing and Interpreting Data Developing and Using Models Using Mathematics and Computational Thinking	Connections to Nature of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	Mathematics: MP.2 ELA/Literacy: WHST.6-8.9 RST.6-8.1

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS

FIELDS AND INTERACTIONS

Unit Issue: How the characteristics of fields can be incorporated into engineering design solutions.

Anchoring Phenomenon: Objects can be observed to interact with other objects even when they are not in contact with one another. Examples explored include static electricity, the behavior of magnets, and the observation that objects fall toward the earth. Students generate and answer questions such as: How do objects interact at a distance? What is a field? How does a field store energy? How do people use fields to design solutions to problems?

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Gravity, magnetism, electricity, and electromagnetism are used in designed systems.	How do engineers solve problems related to gravity?	What approaches can be used to solve a problem? (Activity 1)	1, 2	ETS1-1 ETS1-2 ETS1-3 ETS1-4	Engineers solve all sorts of problems. For every problem to be solved, there are different tools and scientific concepts that can be used to help design solutions. One scientific concept used in many design solutions is gravity. Gravity can be used when engineering a transportation system on the Moon.
		How do engineers use a design process to solve problems? (Activity 2)			NASA's Apollo missions are an example of a practical application of gravity. Engineers accounted for gravity in their designs of spacecraft that brought astronauts to the Moon. By making use of the engineering design process and understanding the criteria and constraints of the design task, NASA astronauts were able to reach, and return from, the Moon.
When an object is released in the air, it falls to the ground.	What determines the strength of gravitational forces?	How is energy transferred with a transporter set in motion by gravity?(Activity 3)	3, 4	PS3-2 PS2-4	When designing solutions to transportation problems, the amount of energy stored in the system is important to consider. By changing a transporter's mass or height, the energy stored in the system changes. This change is due to gravitational potential energy.
		What determines the amount of gravitational force between objects? (Activity 4)			Scientific investigations to learn more about gravity can be conducted on the two variables that seem to affect gravitational force: mass and distance. Beyond simple classroom investigations, observations of objects interacting gravitationally gives evidence that gravity is a force at a distance. That is, gravitational force is able to affect interacting objects even if those two objects are not touching.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Magnets are attracted to or repelled by other magnets.	How do magnetic forces work?	How can we visualize a magnetic field? (Activity 5)	5	PS2-5	The ability for objects to interact without being in physical contact is evidence for, and can be explained by, fields. While gravitational fields exist around all objects with mass, there are other types of familiar fields, like magnetic fields. A field, such as a magnetic field, can be mapped using tools that sense a field's direction and/or strength. For instance, a compass placed in a magnetic field will point in the direction of the field at that location.
Gravity, magnetism, electricity, and electromagnetism are used in designed systems.	How can engineers solve problems using magnetism and gravity?	How can magnetic fields be used to design a transporter prototype? (Activity 6)	6	PS2-3 PS2-4 ETS1-1 ETS1-2 ETS1-3 ETS1-4	What happens if an object is experiencing a force at a distance due to more than one field? The object will move in the direction of the stronger force until the two forces are balanced. Balanced forces from magnetic and gravitational fields can be used to design a hovering transporter. Depending on how much mass needs to be moved, the magnetic field needs to be strong enough to balance the gravitational force on the transporter. Designing a hovering transporter includes analyzing data from tests to create new improved solutions.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Gravity and magnetism both affect objects at a distance.	What are fields?	What factors affect the strength of a field? (Activity 7)	7	PS2-3 PS2-4 PS2-5 PS3-2	While gravitational fields and magnetic fields are similar in that they can exert a force at a distance, they also have some important differences. Magnetic fields exist only around magnetized objects, whereas gravitational fields exist around all objects with mass. Also, gravitational fields are only and always attractive, whereas magnetic fields can be attractive or repulsive depending on the relative orientations of the interacting magnetized objects. An important aspect of fields is that they can store potential energy. An object in a field has potential energy due to its location in that field. If an object changes its location in a field, then the potential energy of the object due to the field has either increased or decreased depending on if energy was transferred to or from that object.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
When a balloon is rubbed on hair, the hair will be attracted to the balloon even as the balloon is pulled away.	What is static electricity? How can we generate more static electricity?	What are the effects of static electricity? (Activity 8)	8, 9, 10	PS2-3 PS2-5 PS3-2	Gravitational and magnetic fields are not the only types of fields. Electric phenomena are due to electric fields. The everyday experience of static electricity demonstrates the properties of an electric field. Objects with static electricity can be attracted to or repelled from other objects due to electric fields.
		What determines the amount and direction of electrostatic force? (Activity 9)			An object becomes charged when there is a difference between the number of positive and negative charges on it. A more highly charged object will have a larger effect on nearby charges. Also, the closer that object gets to nearby charges, the larger effect it will have.
		What effect does an electric charge have on the space around it? (Activity 10)			Electric fields are a result of electric charges. Charges can be either negative or positive. Two electric charges with the same charge will repel each other, whereas two electric charges with opposite charge will attract each other. Like gravity and magnetism, electric fields also store potential energy.
Gravity, magnetism, electricity, and electromagnetism are used in designed systems.	How can engineers solve problems using electric fields?	How can the Moon transporter use an electric field? (Activity 11)	11	PS2-3 PS3-2 ETS1-2 ETS1-3 ETS1-4	Engineers can use electric fields in the hover transporter design in a manner similar to the magnetic hover transporter. Electric charges can be built up on the transporter and track, which provides an electrostatic force that balances the force of gravity. By testing and manipulating the charge on the transporter and track, the transporter's design can be optimized. If the repulsion gets strong enough, charges can actually be forced off of the charged object, causing discharge. This is one of the reasons why electric fields are not as practical as magnetic fields in this application. A field, such as a magnetic field, can be mapped using tools that sense a field's direction and/or strength. For instance, a compass placed in a magnetic field will point in the direction of the field at that location.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Metals that are not magnetic can be affected by moving magnets, and moving charges can generate magnetic fields.	How are electric fields and magnetic fields related?	What is the relationship between electric and magnetic fields? (Activity 12)	12, 13, 14	PS2-3 PS2-5 ETS1-4	Since electric fields can cause electric charges to move, electric fields can cause charges to move through wires to make electric current. As electric current moves through a wire, a magnetic field is produced around the wire. Likewise, if a magnetic field is moved near a wire, electric charges start to move, creating electric current. This relationship between electric current and magnetism allows for the creation of electromagnets.
		How can an electromagnet be used to design a rescue device? (Activity 13)			Electromagnets create a magnetic field only when there is an electric current flowing. Unlike permanent magnets, electromagnets can have their magnetic field turned on and off. This is a useful property used by engineers for all types of design tasks. A stronger electromagnet can be built by winding coils with a high number of turns of wire per length of coil and/or increasing the current through the wire.
		How do electric and electromagnetic fields work? (Activity 14)			It is because of the relationship between magnetism and electricity that scientists often refer to an "electromagnetic field" instead of the separate magnetic and electric fields. This larger, more-encompassing field interacts with both magnetic and electric fields and shares properties with each. Electromagnetic fields are used in many devices and products that we use every day. In fact, a certain type of transportation, known as magnetic levitation, uses electromagnetism to hover trains above their track and move them at high speeds along the track all while in a gravitational field. Fields, such as electromagnetic and gravitational, are useful in designing a transporter on the Moon where one of the constraints is that combustion cannot be used.

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FIELDS AND INTERACTIONS (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Gravity, magnetism, electricity, and electromagnetism are used in designed systems.	How can engineers solve problems using electricity, magnetism, and gravity?	Which is the best design for the Moon transporter? (Activity 15)	15	ETS1-2 ETS1-3	To choose the best design from proposed solutions, scientists and engineers systematically compare possible solutions to see how they meet the criteria and constraints of the challenge. It is these systematic processes that allow engineers and scientists to develop, test, and improve solutions before deciding on a final design.

NGSS CORRELATIONS

FIELDS AND INTERACTIONS

Crosscutting Concepts		Activity number
Cause and Effect	Cause and effect relationships may be used to predict phenomena in natural or designed systems.	5, 7, 8, 9, 10, 12, 13, 14
Patterns	Graphs, charts, and images can be used to identify patterns in data.	4, 12
Scale, Proportion, and Quantity	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.	11
Systems and System Models	Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.	1, 3, 4, 6, 7, 10, 11
Connections to Engineering, Technology, and Applications of Science	The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	2, 6, 15
	All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment.	3, 6
Science and Engineering Practices		**Activity number**
Analyzing and Interpreting Data	Analyze and interpret data to determine similarities and differences in findings.	1, 2, 3, 4, 5, 6, 13, 15
	Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	9
Asking Questions and Defining Problems	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.	1, 3, 6
	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.	7, 8, 10, 12, 13
	Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	12
	Ask questions that require sufficient and appropriate empirical evidence to answer.	9

Science and Engineering Practices		Activity number
Constructing Explanations and Designing Solutions	Construct an explanation that includes qualitative or quantitative relationships between variables that predict or describe phenomena.	4, 10
	Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system.	6, 13
Developing and Using Models	Develop a model to describe unobservable mechanisms.	3, 6, 7, 11
	Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.	3, 6, 11, 12, 13
	Evaluate limitations of a model for a proposed object or tool.	15
Using Mathematics and Computational Thinking	Create algorithms (a series of ordered steps) to solve a problem	1
	Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	15
Engaging in Argument from Evidence	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.	3, 4, 7
	Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	6, 13, 15
	Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.	15
Planning and Carrying Out Investigations	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.	5, 9, 12
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	3, 4, 7, 14

Disciplinary Core Ideas		Activity number
Types of Interactions (PS2.B)	Electrical 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.	7, 8, 9, 12, 13, 14
	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).	3, 4, 6, 7
	Forces that act at a distance (electrical, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball respectively).	5, 7, 9, 10, 12
Definitions of Energy (PS3.A)	A system of objects may also contain stored (potential) energy, depending on their relative positions.	3, 6, 7, 10, 11
Relationship Between Energy and Forces (PS3.C)	When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	4, 5, 7, 11
Defining and Delimiting Engineering Problems (ETS1.A)	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 is likely to limit possible solutions.	2, 3, 6
Developing Possible Solutions (ETS1.B)	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 criteria and constraints of a problem.	2, 3, 6, 11, 13
	There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	6, 13, 15
	Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.	6, 12, 13, 15
	Models of all kinds are important for testing solutions	1, 2, 6, 11, 13
Optimizing the Design Solution (ETS1.C)	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 the characteristics may be incorporated into the new design.	6, 13, 15
	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.	2, 6, 11, 13

Performance Expectations		Activity number
Engineering Design (ETS1)	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)	6
	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)	15
	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-ETS1-3)	15
	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. (MS-ETS1-4)	13
Motion and Stability: Forces and Interactions (PS2)	Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. (MS-PS2-3)	13
	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (MS-PS2-4)	7
	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. (MS-PS2-5)	12
Energy (PS3)	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. (MS-PS3-2)	11

COMMON CORE STATE STANDARDS: CONNECTIONS AND CORRELATIONS

FIELDS AND INTERACTIONS

Making Connections in ELA

As with all SEPUP instructional materials, this unit introduces multiple opportunities for students to engage in a range of ELA practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. Specifically, students engage with readings (RST.6-8.1) that support their sensemaking about the engineering design process in activity 2 and about electric and electromagnetic fields in activity 14. In activity 6, students create and label a diagram to illustrate their understanding of the gravitational and magnetic forces acting on a magnetic hover cart (RST.6-8.7). Students also read and follow a multi-step procedure (RST.6-8.3) in a series of investigations and experiments (activities 5, 9, 10 and 12) as they make sense of magnetic and electric fields. Students communicate their sensemaking in writing as they construct arguments (WHST.6-8.1) in support of explanations of gravity in activity 4 and for an argumentation assessment in activity 7 about the characteristics of gravitational and magnetic fields. In activity 9, students conduct and document their own experiments (WHST.6-8.7) to investigate electrostatic forces, leveraging a variety of equipment and drawing on a variety of available sources of information from the unit. In the final activity of the unit, students evaluate a series of proposals for a Moon transporter design, drawing on evidence from texts and sensemaking they have done throughout the unit to rank and reflect on the designs to develop a written proposal for a new design that incorporates the best features of all proposed designs (WHST.6-8.9). Specific literacy strategies are embedded throughout the unit to support student development of these ELA skills and practices. In addition, Appendix E: Literacy Strategies in the Student Book contains optional resources to support reading, writing and oral communication.

Common Core State Standards – English Language Arts		Activity number
Reading in Science and Technical Subjects (RST)	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (RST.6-8.1)	2, 3, 14, 15
	Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. (RST.6-8.3)	5, 9, 10, 12
	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (RST.6-8.7)	6
Writing in History/ Social Studies, Science, and Technological Subjects (WHST)	Write arguments focused on discipline-specific content. (WHST.6-8.1)	4, 7
	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (WHST6-8.7)	9, 10
	Draw evidence from informational texts to support analysis, reflection, and research. (WHST.6-8.9)	15
Speaking and Listening (SL)	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (SL.8.5)	1, 2, 3, 4, 6

Making Connections in Mathematics

This unit introduces multiple opportunities for students to engage in two math practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. First, abstract and quantitative reasoning (MP.2) plays a key role in the unit as students engage with a variety of mathematical representations and models to explore gravitational energy and gravitational, electric, and magnetic fields. This takes place across multiple activities, allowing students to develop their reasoning skills as they progress their sensemaking. Building on this, students engage with equations and independent and dependent variables (6.EE.C.9) in two different contexts. First in activity 4, they explore the universal law of gravitation and graph the relationship between gravitational pull, distance and mass. In activity 9, students are introduced to Coulomb's law and analyze tabular data to determine the relationship between the strength of an electric field between two charged objects, the distance between two charged objects, and the amount of charge on each object . Both activities contain an extension where students use the equations to make calculations of gravitational or electrostatic force. To support students in creating and interpreting graphical displays of data in activity 4, an optional student sheet entitled "Scatterplot and Line Graphing Checklist" is provided in Appendix C: Science Skills in the Student Book.

Common Core State Standards – Mathematics		Activity number
Mathematical Practice (MP)	Reason abstractly and quantitatively. (MP.2)	2, 3, 7, 11, 12, 13, 14, 15
Expressions and Equations (EE)	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (6.EE.C.9)	4, 9