NGSS OVERVIEW

FORCE AND MOTION

Performance Expectation MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*

Performance Expectation MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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

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.

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **Talking It Over: Improving Car and Driver Safety** Students are introduced to the phenomenon that some vehicles and driving behaviors decrease the chances of getting into a vehicle collision and/or reduce the effects of an collision. Students obtain information about vehicle features and evaluate how those features may affect safety. They are introduced to the kinds of variables that engineers consider when defining problems involving the safety of cars and other vehicles. Throughout the unit, students investigate how these variables affect vehicle safety.	MS-PS2.A MS-PS3.A MS-PS3.C MS-ETS1.A	Obtaining, Evaluating and Communicating Information Asking Questions and Defining Problems	Cause and Effect	ELA/Literacy: RST.6-8.7
2. **Laboratory: Measuring and Graphing Speed** Students use a model cart system to measure the time it takes for a cart to travel a certain distance, and they use their results to calculate speed—a rate, or proportional relationship. They analyze and interpret motion graphs, and they identify that the slope of the motion graph represents the speed of an object at a given point in time. They learn the importance of a reference frame when quantitatively describing a moving object's speed and direction of motion.	MS-PS3.A	Analyzing and Interpreting Data Using Mathematics and Computational Thinking	Scale, Proportion, and Quantity Patterns	Mathematics: 7.RP.A.2 ELA/Literacy: RST.6-8.7

FORCE AND MOTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
3. **Laboratory: Speed and Kinetic Energy** Students further investigate speed by carrying out an investigation that relates the speed of an object to its kinetic energy. Students analyze and interpret data to determine that when their carts are released from a greater height, they go faster (because more gravitational potential energy is transformed into kinetic energy). Students confirm the positive relationship between speed and kinetic energy by examining the transfer of energy from a cart to an object in its path. The quantitative relationship between speed and kinetic energy is examined in a later activity.	MS-PS3.A MS-PS3.C	Analyzing and Interpreting Data Planning and Carrying Out Investigations Constructing Explanations and Designing Solutions	Scale, Proportion, and Quantity Patterns Cause and Effect Energy and Matter	Mathematics: 6.SP.B.5 7.RP.A.2 ELA/Literacy: RST.6-8.3
4. **Laboratory: Mass and Kinetic Energy** Students plan and carry out an investigation to examine the effect of the mass of an object on its kinetic energy. Students vary the mass of their carts and measure how far a block moves after a cart hits it; this is an indicator of how much kinetic energy the cart transfers to the block. Students analyze and interpret their data to determine that mass is positively related to kinetic energy.	MS-PS3.A MS-PS3.C	Planning and Carrying Out Investigations Analyzing and Interpreting Data Constructing Explanations and Designing Solutions	Scale, Proportion, and Quantity Patterns Cause and Effect Energy and Matter	Mathematics: 6.SP.B.5 7.RP.A.2 ELA/Literacy: W.6-8.2
5. **Investigation: Quantifying Kinetic Energy** Students organize and examine data on the kinetic energy of cars differing in mass traveling at a constant speed, and of a car of a specific mass traveling at different speeds. They construct and examine graphs to determine the mathematical relationships between kinetic energy and speed and between kinetic energy and mass. They discover that while kinetic energy increases linearly with an increase in mass, kinetic energy increases with the square of velocity. Students are formally assessed on Performance Expectation MS-PS3-1.	MS-PS3.A MS-PS3.C	Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking	Scale, Proportion, and Quantity Patterns Energy and Matter	Mathematics: 6.SP.B.5 7.RP.A.2 8.EE.A.2 ELA/Literacy: RST.6-8.7 W.6-8.2

FORCE AND MOTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
6. **Laboratory: Changing Direction** Students begin exploring what causes an object's motion to change. They carry out an investigation to determine what will happen to an object in a circular track when the wall of the track is removed. They engage in argument based on evidence to explain the results. Students are informally introduced to the concept of forces; the formal definition will be discussed in the next activity.	MS-PS2.A	Engaging in Argument from Evidence Planning and Carrying Out Investigations Analyzing and Interpreting Data Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Knowledge	Stability and Change Cause and Effect	ELA/Literacy: RST.6-8.3
7. **Laboratory: Changing Speed** Students are introduced to the formal definition of a force, and they consider the characteristics of an object's motion when balanced and unbalanced forces act on it. Students carry out an investigation to measure changes in speed to determine that a larger unbalanced force results in a larger change in speed. When forces are balanced, the object's motion is stable. Students develop an explanation that an object's motion is determined by the sum of forces acting on the object.	MS-PS2.A	Planning and Carrying Out Investigations Analyzing and Interpreting Data Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Knowledge	Stability and Change Cause and Effect Scale, Proportion, and Quantity	Mathematics: 6.SP.B.5 7.RP.A.2 ELA/Literacy: RST.6-8.3
8. **Investigation: Force, Mass, and Acceleration** Students further explore acceleration as a changing rate of speed, and they consider the mathematical relationship between force, acceleration, and mass. Students find the equation that relates force, mass, and acceleration by analyzing provided data. From their calculations, they learn that a larger force results in a larger change in motion, and a greater force is needed to change the motion of a more massive object. Students construct an explanation for what will happen to both a stationary object and a moving object if forces are balanced.	MS-PS2.A	Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking	Stability and Change Scale, Proportion, and Quantity	Mathematics: 7.EE.B.4 7.RP.A.2 ELA/Literacy: RST.6-8.7

FORCE AND MOTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
9. **Reading: Newton's Laws of Motion** Students obtain information from reading about Newton's laws of motion, focusing on the first two laws. Student learn about friction and how accounting for this force on Earth helps explain phenomena that at first glance appear to contradict Newton's laws.	MS-PS2.A	Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions	Stability and Change Cause and Effect Scale, Proportion, and Quantity	Mathematics: MP.2 6.RP.A.2 ELA/Literacy: RST.6-8.1 RST.6-8.2
10. **Investigation: Interacting Objects** In this activity, students begin their investigation into Newton's third law of motion. Through hands-on activities and teacher-led demonstrations, students discover that interacting objects exert forces on each other. They begin to gather evidence that forces applied by interacting objects are equal in strength but in the opposite direction. Students develop and use a model to predict the forces that will occur when objects collide. Students consider how engineers define criteria and constraints to ensure a successful design.	MS-PS2.A MS-PS3.C MS-ETS1.A	Constructing Explanations and Designing Solutions Developing and Using Models Asking Questions and Defining Problems	Stability and Change Systems and System Models	Mathematics: MP.1 ELA/Literacy: RST.6-8.3
11. **Modeling: Newton's Third Law** Students continue their investigation of Newton's third law of motion. To begin, students obtain information from a short passage that describes Newton's third law, which states that for any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction. Throughout the reading, students examine examples of everyday scenarios involving the motion of two interacting objects. Then, students develop their own system models to explain what happens with forces during the interaction between two everyday objects. Finally, students consider how Newton's third law can be used to design a solution to a problem.	MS-PS2.A MS-ETS1.A	Constructing Explanations and Designing Solutions Developing and Using Models	Systems and System Models	ELA/Literacy: RST.6-8.1

FORCE AND MOTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
12. **Problem Solving: Collisions and Changes in Motion** Students use system models to investigate patterns in the motion of two colliding objects in relation to their mass differences. Students apply their understanding of Newton's third law to explain and recommend vehicle safety solutions that account for the effects of mass on both vehicles in a collision. Students are formally assessed on Performance Expectation MS-PS2-1.	MS-PS2.A MS-ETS1.A	Constructing Explanations and Designing Solutions	Systems and System Models Patterns Connections to Engineering, Technology, and Applications of Science	ELA/Literacy: RST.6-8.3
13. **Laboratory: Braking Distance** Students conduct an investigation using a system model to provide evidence that the change in a vehicle's speed results in a change in the braking distance. Then, students plan and carry out their own investigations with the system model. They use evidence to determine that a change in an object's mass results in a change in the braking distance. Student use their evidence from the investigation to support or refute explanations about factors affecting braking distance. Students then define specific criteria and constraints for safety solutions related to braking distance. Students are formally assessed on Performance Expectation MS-PS2-2.	MS-PS2.A MS-ETS1.A	Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Planning and Carrying Out Investigations	Stability and Change Systems and System Models	ELA/Literacy: RST.6-8.3
14. **Problem Solving: Coming to a Stop** Through analysis and interpretation of data, students learn how a car's stopping distance changes in different situations. Students look for patterns in the data to identify the cause-and-effect relationships between road conditions and stopping distance, as well as between driver alertness and stopping distance. Students continue to define the problem of car and driver safety by considering how engineering and technology might be used to address the criteria and constraints in the design of safe vehicles.	MS-ETS1.A MS-PS2.A MS-PS3.C	Asking Questions and Defining Problems Analyzing and Interpreting Data	Patterns Connections to Engineering, Technology, and the Applications of Science Stability and Change	Mathematics: MP.1 ELA/Literacy: RST.6-8.3

FORCE AND MOTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
15. **Design: Designing a Car and Driver Safety System** Students define a design problem by articulating the criteria and constraints of the problem and applying the relevant scientific principles to ensure a successful solution. Students design a system model to show how the components of a system would interact to help a driver keep a safe distance behind another vehicle. Students consider how advancements in technology are driven by societal needs, desires, and values. Students are formally assessed on Performance Expectation MS-ETS1-1.	MS-ETS1.A	Asking Questions and Defining Problems Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information	Connections to Engineering, Technology, and the Applications of Science Systems and System Models	Mathematics: MP.1 ELA/Literacy: RST.6-8.7

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FORCE AND MOTION

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Unit Issue: Car and driver safety, specifically how people can reduce the risk of motor vehicle accidents.

Anchoring Phenomenon: Some cars and driving behaviors result in fewer accidents and less damage than others. Examples explored include speed is a factor in the majority of accidents, and cars following closely behind another car are less able to avoid a collision. Students generate and answer questions such as: How does the speed of a car affect its energy? What happens when objects collide? How can we apply an understanding of force and motion to develop solutions for improving car and driving safety?

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Some cars and driving behaviors are safer than others.	What choices can people make to keep themselves safe while driving?	How do you decide which car is safer? (Activity 1)	1, 2, 4, 13, 14, 15	MS-PS2-1 MS-PS2-2 MS-PS3-1 MS-ETS1-1	Car safety encompasses the design of the car and both the condition and the driving behaviors of the driver.
Some car accidents cause more damage than others.	How can we predict the amount of impact of a car accident?	How can you measure and graph the speed of a moving object? (Activity 2)	2–5	MS-PS3-1	An object's speed can be calculated by measuring the distance an object travels in a particular direction over a certain amount of time. A motion graph can be used to quantitatively describe how an object moves.
		What is the relationship between an object's speed and its kinetic energy? (Activity 3)			Kinetic energy is motion energy and is related to the mass and speed of an object. Kinetic energy is proportional to the object's speed. If the mass of a car remains constant, a change in the car's speed results in a change in kinetic energy.
		How does the mass of a car affect its kinetic energy? (Activity 4)			Kinetic energy is proportional to the mass of the moving object. If there are two cars going at the same speed but with different masses, the more massive vehicle has more kinetic energy.
		What is the mathematical relationship between kinetic energy and speed of an object, and kinetic energy and mass of an object? (Activity 5)			Whereas both speed and mass affect kinetic energy, mass has a linear relationship, and speed has a nonlinear relationship. (Kinetic energy increases with the square of speed.)

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FORCE AND MOTION (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Cars change motion.	What causes a car's motion to change?	What causes an object to change direction? (Activity 6)	6–9	MS-PS2-2	Inertia is the resistance of an object to changes in its motion. An object's motion is determined by the sum of forces acting on it.
		What causes an object to change speed? (Activity 7)			If the forces are balanced, an object's motion will not change. If the forces are unbalanced, an object's motion will change.
		What is the mathematical relationship between force, acceleration, and mass? (Activity 8)			Acceleration is a change in motion. A larger force will result in a larger acceleration.
		What relationships between force and motion did Newton discover? (Activity 9)			How an object's acceleration changes due to an unbalanced force is also dependent on the object's mass. The more mass an object has, the more inertia it has, and the greater the force it takes to change its motion.
When a car accident happens, often both cars are damaged as a result of the collision.	What happens when cars collide?	What happens when objects interact? (Activity 10)	10–12	MS-PS2-1	During a collision, interacting cars exert forces on each other. These forces are equal in size and opposite in direction.
		What additional relationship between force and motion did Newton discover? (Activity 11)			
		How can the motion of interacting objects change due to a collision? (Activity 12)			

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

FORCE AND MOTION (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Engineers design car features that can make cars safer and promote safer driving behaviors.	How can you design a successful solution to help a driver avoid a collision?	What are the effects of speed and mass on braking distance? (Activity 13)	13–15	MS-PS2-2 MS-ETS1-1	A car's braking distance is the distance the car travels from the moment the driver applies the brakes until the car comes to a full stop. The mass of the car and the speed at which it is traveling affect the braking distance of a car. When coming to a stop to avoid a collision where one car might hit the back of another car, drivers need to react to the changes in road conditions and make a decision to apply the brakes. The stopping distance of a car can depend on road conditions (e.g., slick vs. dry) and driving behavior (e.g., distracted drivers and the speed at which the driver is traveling). Therefore, the total stopping distance required for a car to come to a stop and avoid collision is different in different situations. One problem drivers face is leaving enough distance between their car and the car in front of them to ensure they can safely come to a stop in different situations. Designed solutions to this problem must address precisely defined criteria and constraints, as well as take into account scientific principles.
		How does a car's stopping distance change in different situations? (Activity 14)			
		How can you design a system to help drivers keep a safe distance behind another car in different situations? (Activity 15)			

NGSS CORRELATIONS

FORCE AND MOTION

Crosscutting Concepts		Activity number
Cause and Effect	Cause and effect relationships may be used to predict phenomena in natural or designed systems.	1, 3, 4, 6, 7, 9
Energy and Matter	Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).	3, 4, 5
Patterns	Patterns can be used to identify cause and effect relationships.	12, 14
	Graphs, charts, and images can be used to identify patterns in data.	2, 3, 4, 5
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.	2, 3, 4, 5, 7, 8, 9
	Scientific relationships can be represented through the use of algebraic expressions and equations	2, 8
Stability and Change	Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.	6, 7, 8, 9, 10, 13
	Small changes in one part of a system might cause large changes in another part.	14
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.	10, 11, 12, 13, 15
	Models are limited in that they only represent certain aspects of the system under study.	13
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.	1, 12, 14, 15
Science and Engineering Practices		**Activity number**
Analyzing and Interpreting Data	Analyze and interpret data to provide evidence for phenomena.	14
	Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	2, 3, 4, 5, 6, 7, 8
	Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.	3
	Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.	2

Science and Engineering Practices		Activity number
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, 10, 14, 15
Constructing Explanations and Designing Solutions	Apply scientific ideas or principles to design an object, tool, process or system.	10, 11, 12, 13, 15
	Construct an explanation that includes qualitative or quantitative relationships between variables that predict or describe phenomena.	3, 4, 5, 8, 9
	Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	15
Developing and Using Models	Develop a model to describe unobservable mechanisms.	11
	Develop a model to predict and/or describe phenomena.	10
Engaging in Argument from Evidence	Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	6, 13
Obtaining, Evaluating, and Communicating Information	Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	1, 9, 15
Planning and Carrying Out Investigations	Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	13
	Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	3, 4, 6, 7, 13
Using Mathematics and Computational Thinking	Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	2, 5, 8
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	6, 7, 13

Disciplinary Core Ideas		Activity number
Forces and Motion (PS2.A)	For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	1, 10, 11, 12
	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.	1, 6, 7, 8, 9, 13, 14
	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.	1, 6, 7, 8, 9, 13
Definitions of Energy (PS3.A)	Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	1, 2, 3, 4, 5
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.	1, 3, 4, 5, 10, 14
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.	1, 10, 11, 13, 14, 15
Performance Expectations		**Activity number**
Motion and Stability: Forces and Interactions (PS2)	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* (MS-PS2-1)	12
Motion and Stability: Forces and Interactions (PS2)	Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (MS-PS2-2)	13
Energy (PS3)	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1)	5
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)	15

COMMON CORE STATE STANDARDS: CONNECTIONS AND CORRELATIONS

FORCE AND MOTION

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, in activity 1, students create data tables showing different features (mass, top speed, etc.) of two different cars and develop explanations of how these features relate to vehicle safety (RST.6-8.7). Throughout the unit, students engage in experiments, with one example evident in activity 3. In this activity, students collect, analyze and interpret data related to the speed and kinetic energy of an object (RST.6-8.3). In activity 4, students build on their knowledge of energy by investigating the relationship between the mass of an object and its kinetic energy. Students write about the patterns in the data and any conclusions they can make about this topic (WHST.6-8.2). Further along in the unit, in activity 9, students read a text about Newton's first two laws that is supported by a literacy strategy (use of an anticipation guide) meant to address misconceptions about force and motion. Students then apply their understanding from this reading to scenarios in the analysis questions, where they pay close attention to specific calculations and scientific concepts (RST.6-8.2; RST.6-8.1). In activity 11, students read a short text about Newton's third law, apply this knowledge to their own system models, and write an explanation of the ideas depicted in this model (RST.6-8.1). 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)	9, 11
	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (RST.6-8.2)	9
	Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. (RST.6-8.3)	3, 6, 7, 10, 12, 13, 14
	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)	1, 2, 5, 7, 8, 15
Writing in History/ Social Studies, Science, and Technological Subjects (WHST)	Write informative/explanatory texts to examine and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (WHST.6-8.2)	4, 5

Making Connections in Mathematics

This unit introduces multiple opportunities for students to engage in 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. Specifically, in activity 4, students design and conduct an experiment to determine if there is a relationship between mass and speed. Upon collecting and analyzing these quantitative data, students explain the patterns (7.RP.A.2; 6.SP.B.5). In the next activity (5), students examine the non-linear relationship between kinetic energy and speed, and how the kinetic energy is related to the square of the velocity. The teacher and students perform these calculations together so the students can better understand that when the velocity is doubled, the kinetic energy is increased by a factor of four (2 squared) (8.EE.A.2). In activity 8, students develop the equation that relates force, acceleration, and mass, which they discuss as a class (7.EE.B.4). In activity 9, students apply the equation F=ma to determine acceleration of cars with different masses, at a rate of m/s^2 (6.RP.A.2; MP.2). Students continue to use quantitative reasoning as they measure the forces of interacting objects in an investigation found in activity 10 (MP.2). For the activities where students create graphical representations of data to find relationships, an optional student sheet entitled "Scatterplot and Line Graphing Checklist" is provided in Appendix C: Science Skills in the Student Book for students who need additional support.

Common Core State Standards – Mathematics		Activity number
Expressions and Equations (EE)	Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational. (8.EE.A.2)	5
	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations or inequalities to solve problems by reasoning about the quantities. (7.EE.B.4)	8
Mathematical Practice (MP)	Reason abstractly and quantitatively. (MP.2)	9, 10, 14, 15
Ratios and Proportional Reasoning (RP)	Recognize and represent proportional relationships between quantities. (7.RP.A.2)	2, 3, 4, 5, 7, 8
	Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. (6.RP.A.2)	9
Statistics and Probability (SP)	Summarize numerical data sets in relation to their context. (6.SP.B.5)	3, 4, 5, 7