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