Unit Title: Force and Motion	**Content Area:** Physical Science	**Grade Level:** 7

Unit Summary: The FOSS Force and Motion Course investigates linear motion, including position and several aspects of change of position—distance, displacement, speed, velocity, and acceleration. The unit also investigates fundamental forces (gravity and electromagnetism) in familiar environments, such as pushes, pulls, impacts, and falls. Interaction and outcomes are represented graphically to help students think mathematically about their observations. Investigations of opposing forces and additive forces help students develop the idea that a net force on an object produces motion. An object in motion has momentum, which is conserved. Students acquire the most fundamental and important understanding about the interplay between force and motion. A SPECIAL NOTE ON ACCELERATION: In this unit there is specialized equipment related to the Electronic Dot-Car. This requires the downloading of software from the website and being able to establish a link between the software and the computer being used. NPS has not allowed the software to be downloaded, you will need to talk to a tech administrator for this to happen, and there is no guarantee that a link can be established between the Dot-Car and the computer being used. As of this writing efforts are being made to remedy the situation. In any event, those lessons regarding acceleration and the electronic Dot-Car will be included in this curriculum for the time being. However, the teacher is invited to read pages 194-201 for a comprehensive overview of the use of the electronic Dot-Car. Also, it is strongly recommended that the teacher visit www.fossweb.com to register and receive an access code in order to active a given module. The Foss web site is user friendly and offers valuable information to enhance the teaching experience.

Unit Essential Questions:

- How do we know that things have energy?
- How can energy be transferred from one material or an object to another? What happens to a material or an object when energy is transferred to it?
- How does a frame of reference affect our perception of location and motion?
- How can we determine the speed of a moving object?
- How can we use mathematics to solve speed problems?
- How do balanced and unbalanced forces affect the motion of objects?
- How can we use evidence to explain constant velocity and acceleration?
- What forces come into play for a moving object to come to a halt?
- How does the force affect the motion of an object?

Unit Enduring Understandings:

- Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
- Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.

NJCCCS:

- 5.2.8.C.2. Model and explain current technologies used to capture solar energy for the purposes of converting it to electrical energy STRAND D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.
- 5.2.8.D.1. Relate the kinetic and potential energies of a roller coaster at various points on its path. STRAND E. Forces and Motion: It takes energy to change the motion of objects. The energy change is understood in terms of forces. 8.E.1 An object is in motion when its position is changing. The speed of an object is defined by how far it travels divided by the amount of time it took to travel that far.
- 5.2.8.E.1. Calculate the speed of an object when given distance and time. 8.E.2 Forces have magnitude and direction. Forces can be added. The net force on an object is the sum of all the forces acting on the object. An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force.
- 5.2.8.E2: Compare the motion of an object acted on by balanced forces with the motion of an object acted on by unbalanced forces in a given specific scenario.

NGSS Performance Expectations: *Students who demonstrate understanding can…*

- MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- 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.
- MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
- 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.
- 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.

Primary ELA Connections: ELA/Literacy - RST.6-8.7Integrate 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). (MS-PS1-1)

Primary CCSS Mathematics Connections:
MP.2Reason abstractly and quantitatively. (MS-PS1-1)MP.4Model with mathematics. (MS-PS1-1)6.RP.A.3Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1)8.EE.A.3Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. (MS-PS1-1)

Lesson Pace & Sequence					
Lesson Title/Number: Determining Distance Frame of Reference		**Objective:** To use frame of references to determine distance. To be able to explain the difference between displacement and distance.		**Lesson Duration:** 100 minutes	
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Asking questions about what methods are used to determine distance. For example: How would you determine the distance of our hallway? What units does one use? How far is it from room 207 to room 212?	• Prentice Hall Science Explorer- Motion, Forces and Energy, Chapter 1, section 1: Describing and measuring motion; pp. 4-18.Moving along http://www.fossweb.com/modulesMS/kit_multimedia/ForceandMotion/teacherguide/index.html	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Engage students in a discussion about the use of centimeters and meters in determining distance	• Moving along http://www.fossweb.com/modulesMS/kit_multimedia/ForceandMotion/teacherguide/index.html	Engaging in Argument from Evidence: Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solution to determine the merits of arguments	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Explore: What hands-on/minds-on common experience(s) will you provide for students?	In an area that is marked off by tape in metered distances, students will measure the distances between frames of references in the classroom or hallway.(DETERMINING DISPLACEMENT) Next the students will take the total displacements and determine the distance travelled.	• National Science Digital Library, Science Refreshers: http://nsdl.org/refreshers/science/	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Explain: How will you help students connect their exploration to the concept/topic under investigation?		• National Science Digital Library, Science Refreshers: http://nsdl.org/refreshers/science/	Using Mathematics and Computational Thinking: Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems.		
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will be given road maps and using mileage markings on the map determine the displacement from one city to another. Then calculate the distances from major location to another. From example: Newark to Chicago, or Fort Lauderdale, FL.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Students will create mini presentations to explain to the class the process of determining displacements and total distance.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Extend: How will students deepen their conceptual understanding through use in new context?	Students will create a map of their immediate surroundings, i.e. home and surrounding points of references.		Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Lesson Title: Investigation 2: Calculating Speeds	**Learning Objective(s):** To understand distance and time as a function of speed.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Introduce road races using road race A/B	• Transparency #3 Road Races A/ • Transparency #4 Road Races B	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Read the article: Time: The Infinite Line	• Force and Motion Resource books p. 1 "The Infinite Line"	Engaging in Argument from Evidence: Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solution to determine the merits of arguments	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Engage students in a discussion about covering distances. For example: Ask: "You arrive at a party before your best friend. You both live 5 km from the house. You both leave your houses at the same time. Who travelled faster and how can you show that mathematically?		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Explain: How will you help students connect their exploration to the concept/topic under investigation?	As students calculate the distance and find the time it takes to travel that distance they will begin to understand the correlation between distance and time to determine the speed.		Engaging in Argument from Evidence: Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solution to determine the merits of arguments	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Completion on "Who Got There First" LNp13, 14,15	• -Student sheet- Race 1, 2 and 3, • -LB pp.13, 14, 15.		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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Successfully completing LN p 13, 14, 15	• -Student sheet- Race 1, 2 and 3, • -LB pp.13, 14, 15.		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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Extend: How will students deepen their conceptual understanding through use in new context?	Students will deepen their understanding moving forward through the direct application of the distance/time/speed formula.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	•Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.
Lesson Title/Number: Investigation 2: part 2 Time Travel		**Learning Objective(s):** Determine an algorithm to ascertain speed using time and distance.			**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Discus why it is necessary to know either how long it took for a vehicle to travel the distance, or how fast the vehicle was going, or any object or person.	• TE Pages 84-86 • Lab Notebook page 16	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Referring to Lab notebook Page 16. Students should work in small groups (3-4) to answer the questions but most importantly to derive a formula for calculating speed: Question 1-d on the page.	• TE Pages 84-86 • Lab Notebook page 16	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	•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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explain: How will you help students connect their exploration to the concept/topic under investigation?	Student will use the page's clocks which indicate time elapsed vs. the distance travelled. From their discussions the Speed formula should begin to take shape. Allow 15 for this activity.	• TE Pages 84-86 • Lab Notebook page 16	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	•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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Additional problems should be presented to cement the concept from the discussion.	• TE Pages 84-86 • Lab Notebook page 16	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Using a Distance-Time-Speed Chart as the students work in groups, they will complete the chart based on the presented problems.	• Teacher made but also found on page 86 of the TE	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and	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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

			independent variables.		
Extend: How will students deepen their conceptual understanding through use in new context?	Speed, Distance practice problem.	• Page 18 of the Lab Notebook			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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Lesson Title/Number: Investigation 2 Part 3 Time Travel	**Learning Objective(s):** Determine an algorithm to ascertain speed using time and distance.	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Review the key concept as to why it is important to know how fast an object moves from one point to another. Discus why it is necessary to know either how long it took for a vehicle to travel the distance, or how fast the vehicle was going, or any object or person.	• TE pages 87-88 • Lab notebook page 17 and 18	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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.	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Provide examples of speed or velocities: Speed of light, rate of Earth's rotation, the speed of an electron around a nucleus, or the velocity a bullet shot from a pistol. It is important to note that the students should be aware that speeds and velocities are given in m/s(meters per second), M/hr (miles per hour), km/h (kilometers per hour). What is important is the students recognize that the units of speed and velocity are a function of distance and time. Also, here is the time to introduce the symbol for change: Delta.	• TE pages 87-88 • Lab notebook page 17 and 18	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	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.	•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. (MS-PS3-1),(MS-PS3-4)

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Refer to lab notebook page 17 taking note of the initial and final position of the vehicles, As this is a continuation of the last period, allow students to complete the questions on their groups.		Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	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.	
Explain: How will you help students connect their exploration to the concept/topic under investigation?	As the students work through the problems, creating a chart as in the last part of the lesson will help students see the relationships among distance/time and speed.				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. (MS-PS3-2)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	In the group setting have the students discuss and present what the mathematical operations were necessary to achieve the answer. Students should begin to see that there are permutations to the formula: d=v x t; t = d / v.	• TE pages 87-88 • Lab notebook page 17 and 18.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	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.	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. (MS-PS3-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Pass out student response sheet or create one of your own to assess students' progress with the use of the speed and distance equations.	• Student response sheet • Lab notebook page 21	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).		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. (MS-PS3-2)

Extend: How will students deepen their conceptual understanding through use in new context?	*Assign reading: First in Flight.*	• Article found in Student resource book page	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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.	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. (MS-PS3-2)

Lesson Title/Number: Measuring Time and Distance	**Learning Objective(s):** Using Dot Car and Ramps, students will investigate the relationship of DISTNACE AND TIME to calculate speed.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Review what variables are necessary to calculate the speed of an object.	• TE page 93	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	ETS1.A: Defining and Delimiting an Engineering Problem •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. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Introduce and demonstrate the use of the Dot Car.	• TE page 94	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).		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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Discuss a procedure for determining speed using the ramp set-ups in class.	• TE page 95 • Lab notebook page 23	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).		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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will conduct an experiment using the dot car as it travels down a 200 cm ramp to calculate the speed of the car.	• TE page 95 • Lab notebook page 23	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will conduct their data collection process in groups of 3 or 4 depending on the size of the class. This process will take about 20 minutes to accomplish this task, including the breaking down of the ramps and putting them away.	• TE page 96	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Students will have their data tables completed reflecting several trials down this ramp. Additionally, students need to graph their results. Students will have demonstrated success if they have calculated the speeds correctly with units, set up the graphs properly, and executed the graph correctly.	• TE page 97-98	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Extend: How will students deepen their conceptual understanding through use in new context?	**After the graphing is completed, a class discussion will follow to analyze the graph and calculate the speeds of the dot cars. Note: If the students need to be taught how to graph data along an X-Y axis plane, then it will be necessary to plan another lesson in that skill. One cannot assume that students know how to do this. On pages 24-25 of the Lab Notebook students are afforded opportunities to work with word problems. These can be used for evaluation, homework, or again if necessary another lesson to teach how to set up word problems and solve them.**	• TE page 99 • Lab Notebook pages 24-25.	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Lesson Title/Number: Using Air Trolleys to Determine Speed		**Learning Objective(s):** Using a different model, students will calculate speed/velocity using air trolleys.			**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Review what variables are necessary to calculate the speed of an object.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Students will be given the materials(air trolley, measuring tape, stop watch) to devise a plan to calculate the speed of the air trolley.	• Air trolley set up • Stop watches • Measuring tapes, TE: 48-50	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will perform the investigation and collect the necessary data to apply the speed formula and determine the speed of the air trolley.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will determine that in order to find the speed they will need to find the distance and the time it takes to travel that distance.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will think of another scenario in which they can calculate the speed of a moving object by following the same procedure. They will work in groups of 3-4 to share their thinking.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Using p 9 student will create a data graph that includes distance and time in order to represent speed.	• Lab Notebook p. 9	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Extend: How will students deepen their conceptual understanding through use in new context?	This is an excellent opportunity to introduce the concepts of potential and kinetic energy.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Lesson Title/Number: Representing Motion Part 1-Show Time	**Learning Objective(s):**Transform narrative accounts of motion events into graphic representations.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Preview transparency no 16 Position Graphs to ensure understanding of motion represented by each graph.	• TE p. 139 • Interpretation of the graphs on TE 144 Step 12 • Transparency no 16	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Review graphing speed to discuss benefits of using graphs as a means of studying speed data.	• TE p 140 step 1-2	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will open lab notebooks to p. 36: Show Time. Project Transparency #15 and read the scenario.	• TE p 141-142	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	It is essential that the students understand the symbols used in the data table. Direct teaching is suggested at this point. Emphasis must be placed on the symbol Delta (Change) and the concept of each movement or change constitutes a "Leg". Next, allow students time (10 + minutes) to discuss and determine the proper placement of the data in the table. For this part of the lesson, pair and share is suggested. This is the bulk of the lesson about 25 minutes.	• TE page 142-143	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	As an open class discussion, students can fill in the data table with the teacher to prevent any misconceptions. Students will begin to graph their data tables as well. Students should also engage in a conversation about how to apply the speed formula to this scenario to calculate the average speed in the scenario,	• TE page 142-143	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Teacher observation and analysis of the data table, but also students should produce a completed graph of Show Time.,	• TE page 143-144	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Extend: How will students deepen their conceptual understanding through use in new context?	Have the students write a scenario of their own for homework.			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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	

Lesson Title/Number: Representing Motion Part 2- Clancey's Afternoon, Parts A and B.		**Learning Objective(s):**Transform narrative accounts of motion events into graphic representations.			**Lesson Duration:** 50 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Present Clancey's Afternoon, Lab notebook, pages 38-39 and Transparency 17. Review the procedure from the last lesson.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Discuss that in this lesson students will generate another data table but also create 2 graphs-one depicting motion and one depicting movement-change of position.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	In small group-pairs or groups of 3, students will read the scenario and begin to complete the data table. Review the meaning of the symbols and determine if the students have a complete understanding of them.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students should be allowed time to complete the data table and start on the Distance graph.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	In an open forum allow the students to discuss the placement of data and demonstrate the placement of the data on the graph. Special attention should be made to the ranges on both the X and Y Axes. Next, the student should be allowed to start on the position graph. Here it is important to note that the position is always relative to the start point or "0". Here again the students should engage in a discussion on how to apply the speed formula to calculate Clancy's Average speed.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Teacher observation and as in the first part students should produce completed graphs.	• TE page 144-45	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Extend: How will students deepen their conceptual understanding through use in new context?	Ask students to place their scenarios into a data table and generate both a distance and position graphs.		Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Lesson Title/Number: Representing Motion Part 3: Leisurely Walks	**Learning Objective(s):** Students will transform narrative accounts into a graph for a number of scenarios. Note: This lesson's sequence is progressively more difficult. As the students work through the scenarios they will encounter different challenges.	**Lesson Duration:** 50-100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Students will be asked about the process from the 2 pervious lessons.	• TE pg. 146 and 147 • Lab notebook page 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	The students will be asked to move onto more challenging scenarios to test their skills in representing motion.	• TE pg. 146 and 147 • Lab notebook 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will be given the sheet, leisurely walks, which includes 3 scenarios of increasing difficulty.	• TE pg. 146 and 147 • Lab notebook 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will take the brief scenarios, place the data from each and place it into a provided data table. Next, students will generate a position and distance on the provided graph grids. This should take no more than 15-20 minutes. Students should be working in pairs to accomplish this task.	• TE pg. 146 and 147 • Lab notebook 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	As a class the scenarios will be gone over and discussed. It is strongly suggested that students be reminded that as the object or, in the case of the scenarios, the person moves back towards "0" the positions number is negative.	• TE pg. 146-147 • Lab notebook 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Completed scenario data tables and graphs should be collected and evaluated.	• Lab notebook 41	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)

Extend: How will students deepen their conceptual understanding through use in new context?	Students will have the opportunity to extend their learning by starting Rita's Road Trip. NOTE: THIS ASSIGNMENT CAN BE USED FOR ANOTHER ENTIRE LESSON, OR CAN BE APPLIED AS A HOMEWORK ASSIGNMENT TO BE REVIEWED THE NEXT CLASS PERIOD. THIS IS UP TO THE TEACHER'S DISCRETION. HOWEVER, RITA'S ROAD TRIP PROVIDES A CHALLENGING OPPPORTUNITY TO MASTER THIS SKILL.	• TE pg. 150-151 • Lab notebook page 42 and 43	Obtaining, Evaluating, and Communicating Information: Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	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. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)	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. (MS-PS3-1),(MS-PS3-4)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. (MS-PS3-2)
Lesson Title/Number: Comparing Speeds: Boat Races		**Learning Objective(s):** As a review of use of the speed formula and practice graphing Distance Vs. Time, students will generate a comparison graph from 4 sets of data.			**Lesson Duration:** 50 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Review the variables which make up the speed formula. Discuss with the students the x and y axis of a plane coordinate graph.	• Previous notes and lab notebook pages on distance and time. • Lab Notebook p 31-Boat Speed Graphs.			

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Ask the students to look at the data from the lab notebook. Ask the students what would be 3 ways they can come up with to determine which boat ran the fastest.	• LN p. 30 • Transparency # 14.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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.	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.
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Ask the students to create 4 separate graphs on the same coordinate grid. This should be done as a pair and share activity. This may take up to 25 minutes as the students will need to determine ranges for the X and Y axes.	• LN p. 31- Boat Speed Graphs • Rulers	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and	PS2.A 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.	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.

			independent variables.		
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Through open class discussion. Students will explain that each line on the graph represents a separate boat speed.	• LN p. 31- Boat Speed Graphs • Rulers	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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.	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.

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will be given a new problem: TE p.123 #5. This is another sliding graph line situation.	• TE p. 123 #5	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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.	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.
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Students will complete a response sheet in which they will respond to a conclusion reached by two students in the scenario.	• TE p. 120 • Lab Notebook p. 33-Response sheet-comparing speeds	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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.	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.

Extend: How will students deepen their conceptual understanding through use in new context?	Students will complete a response sheet in which they will respond to a conclusion reached by two students in the scenario.	• TE p. 122 • Lab Notebook p. 30	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits of data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	Lesson Title/Number: Investigation 4: Representing Motion	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.

Lesson Title/Number: Investigation 5: Acceleration Part 1: Faster and Faster	**Learning Objective(s):** Students learn to calculate acceleration as a function of a change in velocity in a time interval. NOTE: Calculating acceleration is a difficult concept for middle schoolers to master. It requires the student to have integrated the concept of velocity as a vector quantity (basically speed in a straight line). The teacher is invited to not limit her/himself to these lessons but also to research and explore other visuals which can deepen the understanding of acceleration. For example: Models or experiments which demonstrate the acceleration linearly and acceleration due to gravity. Some suggested lessons will be offered in this unit, which are not a part of the FOSS kit. For this lesson, some preparation is required. You will need to find an area in which the students can race such as in a playground or gym. The Foss TE has explicit directions but they can be modified to suit your needs as required. Subsequent lessons will focus on Acceleration as a factor in force coming to the equation which is essentially Newton's Second Law: $f=m_xa$.	**Lesson Duration:** 50-100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Ask students to explain the difference between speed and velocity.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. • Lab notebooks pages 48 and 49.	Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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	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.
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	One way is to show a short video of athletes running a race down a straight track and asking if the velocity of the runners changed during the race. Or, in a similar fashion show a video of drag racers. Ask it the students can determine a way to calculate the average speed of a particular car. Then ask if they can find a way to determine how fast the car got faster. From there the discussion can be centered around the concept of acceleration.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. • Lab notebooks pages 48 and 49.	Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	PS2.A 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	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.

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Have students in groups of 3-4 depending on the size of the class. In a marked area students will race down 2 distinct tracts and be timed as they move from one marker to another. Complete the data collection according to the specifications in the TE.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. • Lab notebooks pages 48 and 49.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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	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.
Explain: How will you help students connect their exploration to the concept/topic under investigation?	After the data collection the students will complete the provided data table and being to calculate the velocity and acceleration of the various teams.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. • Lab notebooks pages 48 and 49.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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	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.
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Through experience and data analysis, students will develop a more comprehensive understanding of Acceleration in linear movement.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. Lab notebooks pages 48 and 49.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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	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.
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Students will be able to calculate acceleration using the equation: a= v/t.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. Lab notebooks pages 48 and 49.	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.

Extend: How will students deepen their conceptual understanding through use in new context?	In the next lesson students will be given graphics that highlight the concept of acceleration.	• TE 170-174. It is highly recommended that the teacher read through this section well in advance of the lesson to prepare the lesson in detail. Lab notebooks pages 48 and 49.			
Lesson Title/Number: Acceleration part 2: Using the Mechanical dot car.		**Learning Objective(s):** Using a graphic generated by the mechanical dot car, students will be able to calculate the average velocity, acceleration and deceleration of the movement of the mechanical dot car. NOTES: This lesson will ask the students to measure the acceleration and deceleration of the velocity of the mechanical dot car. It is suggested that the teacher demonstrates how the tapes were made but the tapes should be made in advance of the lesson.			**Lesson Duration:** 100 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Review the prior lesson's concepts regarding the change of velocity over time and specifically ask what the formula is for calculating acceleration.	• TE pages 177-187 • Lab notebook, page 51	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Demonstrate and explain the motion of the mechanical dot car. Show what the pattern looks like on a piece of register tape, provided in the kit. Explain to the students that they will in groups of 2-3 measure the distances between the dots and knowing that the dots are made every 1/2 second they will be able to calculate the average speed and the acceleration of the dot car.	• TE pages 177-187 • Lab notebook, page 51	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will be given a register tape with dots generated by the mechanical dot car. From this they will calculate the average velocity and acceleration-deceleration of the car. As they do so they will be completing a data table.	• TE pages 177-187 Also • Lab notebook, page 51	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.
Explain: How will you help students connect their exploration to the concept/topic under investigation?	As the students complete their data table and calculations it will be necessary to move about the room correcting any misconceptions and errors typically made by the students.	• TE pages 177-187 • Lab notebook, page 51	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will work on response sheets in the lab notebooks pages 54-55.	• TE pages 177-187 • Lab notebook, page 51	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.
Evaluate: How will students	Completed data tables and	• TE pages 177-187	Analyzing and Interpreting Data:	PS2.A All positions of objects	Scale, Proportion, and Quantity -

demonstrate their mastery of the learning objective(s)?	calculations will show evidence of mastery.	• Lab notebook, page 51	Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	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.	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.
Extend: How will students deepen their conceptual understanding through use in new context?	Students will be asked to apply this knowledge to everyday life experiences: a car moving along a highway, a cat chasing a rabbit, a jet taking off by explaining how acceleration is being applied. NOTE: THE TEACHER CAN USE LAB NOTEBOOK PAGES 52 AND 53 AS A FOLLOW-UP TO THIS LAB. It is recommended to use the graphic pages AFTER the Dot Car maker lab because it is felt that the student can receive a better visualization if they "see" the process first. From experience this has proven to be more effective to enhance the concept.	• Reading found in Lab notebook: Faster and Faster, Force and motion Resource book page 32	Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	PS2.A 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.	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.

Lesson Title/Number: Application of Force: Push/Pull	**Learning Objective(s):** Applied forces can be considered to be a push or a pull and can be measured in Newtons. Notes: For this lesson a fair amount of preparation is required. Pages 218-222 give detailed information on how to construct the pusher device. It is strongly suggested that you allow yourself about 1 solid hour to prepare the devices. You will need enough for 1 complete class set, but they can be used by all your classes.	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	In a quick write ask the students to review the types of motion investigated thus far.	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Demonstrate Pusher device described in the notes above.	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded,	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) 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	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. (MS-PS2-2) 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. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-

			and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)	3),(MS-PS2-5)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will engage in an investigation which will show how applied force is measured. While each student will utilize a pusher device, students should be grouped in to 3 or 4 per group.	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will write their detailed observations in their lab notebooks as a group and make conclusions based on these observations.	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or	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	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. (MS-PS2-2) Systems and System Models - Models can be used to represent systems and their interactions—

			design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	larger change in motion. (MS-PS2-2) 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)	such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	In class discussion students will share observations and conclusions reached	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Students will need to demonstrate understanding that forces can be added or subtracted and that an applied force's magnitude and direction of the application determines movement of an object.	• TE pages 218-227 • Lab Notebook pages 63-66	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1),(MS-PS2-4)Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Lesson Title/Number: Investigating Friction		**Learning Objective:** Students will be able to explain that Friction is a force that exists when two surfaces are in contact. As in the previous lesson, there is some preparation necessary before the investigation. It is suggested that the teacher builds enough devices for the class.			**Lesson Duration:**
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	Ask students questions similar to the following: In the last investigation how did you get the objects to move? What is the scientific term when you push or pull and object? Do masses always move when you apply a force? Why?	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Demonstrate the pulley device and explain that during the course of the investigation students will collect data and from that data discuss what forces are being applied and what effect these forces have on the mass being pulled.	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded,	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) 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	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-

			and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)	3),(MS-PS2-5)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will conduct the investigation over a period of about 30 minutes. Collecting data and organizing it into a data table.	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will discuss their data and from this generate a set of observations and conclusion based on them.	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or	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	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. (MS-PS2-2) Systems and System Models - Models can be used to represent systems and their interactions—

			design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	larger change in motion. (MS-PS2-2) 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)	such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will work on notebook page 67, focusing on questions 1-4 and as a class discuss the concept of friction with teacher guidance.	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)

Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Question 5 of page 67 will demonstrate mastery if the student can explicitly articulate that friction is a force that acts when 2 surfaces are in contact and resists motion.	• TE pages 229-235 • Lab notebook page 67	Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	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) 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)	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
Extend: How will students deepen their conceptual understanding through use in new context?	Ask the students why is it harder to walk on a freshly waxed floor or a sidewalk covered with ice?		Planning and Carrying Out Investigations- Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded,	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) 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	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. (MS-PS2-2) 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. (MS-PS2-1), (MS-PS2-4) Cause and Effect - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-

			and how many data are needed to support a claim. (MS-PS2-2)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. (MS-PS2-5)	achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)	3),(MS-PS2-5)