

The Hot Wheels logo, featuring the words "HOT WHEELS" in a stylized, flame-like font. The letters are yellow with a red outline, set against a red background that resembles a flame. The logo is positioned in the upper left quadrant of the image.

HOT WHEELS

The word "SPEEDOMETRY" in a bold, black, sans-serif font. To the right of the text is a stylized orange and black speedometer icon. The entire logo is underlined with a thick orange line. The background of the entire image is a vibrant blue sky with white clouds, and the scene is set on an orange Hot Wheels track. In the foreground, a blue Hot Wheels car is shown from a low angle, moving towards the viewer. In the background, a green Hot Wheels car is visible on a curved section of the track, and a red and black Hot Wheels car is on a higher section of the track.

SPEEDOMETRY

INTRODUCTION

Speedometry™ is a 2-unit standards-based curriculum designed to engage 4th grade students in learning STEM content using Hot Wheels™ cars and tracks. The content is aligned to the Common Core Standards in Science and Mathematics, the Next Generation Science Standards, and California State Education Standards in STEM. Speedometry is a fun and engaging way to learn about concepts such as energy, force, and motion. Students also learn scientific and engineering practices such as analyzing and interpreting data.

Both units in the Speedometry Curriculum are designed using the 5E Model (Engage, Explore, Explain, Elaborate, and Evaluate) to support students as they ask questions and conduct experiments to find the answers. The 5Es integrate hands-on activities that help foster conceptual understanding and inspire students to explore further.



5E MODEL PHASES

Engage



Both science and engineering teaching begin with asking questions (science) and defining problems (engineering) that need to be answered or solved about some observed phenomenon or system (e.g., “I wonder what, where, when, how, or why?”). Students’ prior knowledge is accessed and their interest is engaged in the phenomenon..

Explore



Students participate in an activity that facilitates conceptual change.

Explain



Students generate an explanation of the phenomenon.

Elaborate



Students’ understanding of the phenomenon is challenged and deepened through new experiences in related contexts. Real-world applications and new challenges, problems, or tasks solidify and broaden students’ understanding about the implications of what they’ve learned. During this phase, all the lessons learned from the previous activities should be brought together and synergistically integrated into a sensible whole that is greater than the sum of the parts.

Evaluate



Students assess their understanding of the phenomenon.

TABLE OF CONTENTS

UNIT 1: SPEED RAMPS

5 - 37

UNIT 2: MINI COLLISION COURSE

38 - 68



SPEEDOMETRY






GRADE 4 - SPEED RAMPS

Overview: Over the course of 5-6 lessons, students will work in collaborative learning groups to deepen their understanding of potential and kinetic energy by measuring distance to describe energy used, altering more than one variable that affects the potential and kinetic energy of the Hot Wheels cars, and constructing a bar graph and chart to represent their data using decimals or fractions. Students will analyze the patterns in their data and will make reasonable mathematical predictions about future outcomes by explaining the effect that height and other variables have on the energy of Hot Wheels cars in a presentation.

Time: 5-6 lessons that are approximately 45 minutes - 1 hour each. There is also an extension lesson that is 45 minutes long.

Organization: Lessons are designed using the 5E Model (Engage, Explore, Explain, Elaborate, and Evaluate) to support students in asking questions and creating experiments to find the answers. The 5Es integrate hands-on activities that help foster learning and inspire students to explore further. The lessons in this sequence build upon on each other to develop a coherent conceptual understanding of potential and kinetic energy and the transfer of energy. Together, the Speed Ramps and Mini Collision Course Units develop fluency with reading procedural documents and accurately recording data for analysis. The following table outlines how the 5E Model is used during each lesson.



<i>LESSON</i>	<i>DESCRIPTION</i>
 <p>Engage - Students' prior knowledge is accessed and interest engaged in the phenomenon</p>	<p>Students will explore how to increase the potential and kinetic energy of their Hot Wheels by building ramps.</p>
 <p>Explore - Students participate in an activity that facilitates conceptual change</p>	<p>Students will understand potential and kinetic energy. Students will measure distance. Students will create a bar graph and a chart to represent their data.</p>
 <p>Explain - Students generate an explanation of the phenomenon</p>	<p>Students will understand potential and kinetic energy and make reasonable mathematical estimates based on their collected data.</p>
 <p>Elaborate - Students' understanding of the phenomenon is challenged and deepened through new experiences</p>	<p>Students will investigate potential and kinetic energy by introducing different variables (e.g., mass or weight, height, other materials). Students will measure the distance cars travel caused by introducing different variables and design a way to record their data.</p>
 <p>Evaluate - Students assess their understanding of the phenomenon</p>	<p>Students will present their claims, data, and findings from the elaboration phase to the class.</p>
<p>Extension</p>	<p>Students will use what they have learned about potential and kinetic energy to design a racecourse that keeps the car moving as long and as far as possible.</p>

THE SCIENCE BEHIND IT:

Potential energy is energy that is stored. In the case of this unit, the potential energy is in the car set on top of the ramp. The car is at a higher elevation, so it has gravitational potential energy at the top of the ramp because the force of gravity is going to pull it down the hill. When the car is let go, and the energy is being used, it is turned into kinetic energy.

In this unit, students will deepen their ability to accurately describe changes in energy, to conduct an experiment using variables as research, and use measurement to describe an event.

Students will work in collaborative learning groups to deepen their understanding of potential and kinetic energy by measuring distance to describe energy used, altering more than one variable that affects the potential and kinetic energy of the Hot Wheels cars, and constructing a bar graph and chart to represent their data using decimals or fractions. Students will analyze the patterns in their data and will make reasonable mathematical predictions about future outcomes by explaining the effect that height and other variables have on the energy of Hot Wheels cars in a presentation.

For more information, refer to the appendix or these websites.

Energy Education - simply explains potential and kinetic energy:

http://www.energyeducation.tx.gov/energy/section_1/topics/potential_and_kinetic_energy/

A song called “**Kinetic and Potential Energy**” by Tom Glazer and Dottie Evans from the Singing Science Records with animation. Shows different types of Kinetic and Potential Energy:

www.youtube.com/watch?v=vl4g7T5gw1M

This website explains how roller coasters work using potential and kinetic energy. A simple animation shows how much of each type of energy a roller coaster has throughout a course.

<http://science.howstuffworks.com/engineering/structural/roller-coaster3.htm>

STANDARDS ALIGNMENT AND CONNECTIONS

These learning activities support students in the development of capacities described across several key frameworks for standards-based instruction. Teachers can observe student performance related to the following standards from the Next Generation Science Standards (NGSS), Common Core State Standards for English Language Arts/Literacy and Mathematics (CCSS), and the California Department of Education Key STEM Content and Process Standards.



NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS 3-1	Use evidence to construct an explanation relating the speed of an object to energy of that object.
4-PS 3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
PS3.A	Definitions of Energy <ul style="list-style-type: none">• The faster a given object is moving, the more energy it possesses.• Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.
ETS1.a	Defining Engineering Problems <ul style="list-style-type: none">• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solutions is determined by considering the desired features of a solution (criteria).

STANDARDS ALIGNMENT AND CONNECTIONS - CONTINUED



COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.
S.L.4.4	Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

STANDARDS ALIGNMENT AND CONNECTIONS - CONTINUED

COMMON CORE STANDARDS FOR MATHEMATICS

4.MD	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.
4.MD1	Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...
4.MD2	Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems express measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature measurement scale.

STANDARDS ALIGNMENT AND CONNECTIONS - CONTINUED



California Department of
EDUCATION

CALIFORNIA DEPARTMENT OF EDUCATION KEY STEM CONTENT AND PROCESS STANDARDS

Provides the introductory and foundational STEM courses that lead to success in challenging and applied courses in secondary grades.

Introduces awareness of STEM fields and occupations.

Provides standards-based, structured inquiry-based and real-world problem-based learning that interconnects STEM subjects.

Stimulates student interest in “wanting to” rather than “having to” take further STEM related courses.

Bridges and connects in-school and out-of-school learning opportunities.

CREATING AN ENVIRONMENT FOR SUCCESS

Considerations for Diverse Learners

This series of lessons incorporates many Universal Design for Learning (UDL) principles and the 5E model of instruction. The UDL design principles ensure diverse points of engagement during learning and multiple ways that learners can demonstrate or communicate what they understand. The 5E Model (Engage, Explore, Explain, Elaborate and Evaluate) supports students in asking questions and creating experiments to find the answers. The 5Es integrate hands-on activities that help foster learning and inspire students to explore further. Learners are likely to find some phases more engaging or difficult than others depending on their comfort with the knowledge or processes required. It is recommended that all children participate in each phase of learning as designed to deepen both their understanding of science content, but also their ability to use and communicate this knowledge in the everyday world. If students have Individual Education Plans (IEPs), please consult these documents for important modifications or accommodations that should be made for those students.

Strategies for Group Work: Throughout the unit, students will work in cooperative groups. To increase group cohesion and engagement, the teacher may want to name the groups after popular cars or allow students to create their own team names.

The teacher may also assign rotating jobs to each group member, such as timekeeper, recorder, reporter, go-getter.

Discussion: There are many class discussions in this unit. Some strategies to use in the classroom:

- **Think-Pair-Share:** Students are given time to think or write their ideas, then share with a partner before sharing with the class. This gives students time to think of an answer and the support of their classmate's idea. This is particularly useful if there are English learners or students who are shy about talking.
- **Reporter:** Each group can have an assigned reporter. After the group is given time to discuss, the reporter shares the group's ideas with the class. This job should be rotated so that everyone has an opportunity to be the reporter.

CREATING AN ENVIRONMENT FOR SUCCESS - CONTINUED

- Notebooks: Students should have a place to take notes, record their data, write down definitions, and brainstorm their ideas throughout this process. A teacher may want to provide the students with a blank notebook, or can create a notebook using the worksheets provided. This could be a few blank sheets of lined or unlined paper.
- Concepts and Vocabulary: Set up a concept and vocabulary chart somewhere in the room. Add to the chart as students learn new vocabulary or concepts throughout this process.

TIER 2 VOCABULARY	TIER 3 VOCABULARY
Ramp - a slope or inclined plane for joining two different levels.	Kinetic energy - energy that an object possesses by virtue of being in motion.
Mass - the amount of matter that an object contains. Mass can be measured by its acceleration under a given force or by the force exerted on it by a gravitational field.	Potential energy - the energy possessed by an object by virtue of its position relative to others, stresses within itself, gravitational pull, and other factors.
Slope - a surface of which one end or side is at a higher level than another; a rising or falling surface.	
Height - the measurement from base to top or (of a standing person) from head to foot.	
Average - a number expressing the central or typical value in a set of data. The average is calculated by dividing the sum of the values in the set by the number of values in the set.	

CONSIDERATIONS FOR ENGLISH LANGUAGE LEARNERS

When working with English Language Learners, reference the vocabulary chart before, during and after each lesson (this will require additional time). Depending on students' proficiency using English, students may need additional support with terms such as: **speed, distance, and energy**.

A teacher may also want to create a concept chart to help students develop a foundational understanding of potential and kinetic energy. Leave this chart up for the remainder of the unit so that students can refer to it during experimentation and discussion.

NOTE: These can also be effective for students who speak a dialect other than Standard English.

Use the Right Surface:

Hard floors create the most significant speed and distance changes for students to observe and measure. With carpeting, increase the height of the ramps in order to create a noticeable difference in students' recorded data. Students can increase height by using more books to elevate the ramps, holding ramps at determined heights on measuring sticks, or using clamps to attach ramps to chairs or tables.

Observe students while they work and provide criteria-based feedback (formative assessment):

As students work in groups use the Group Discussion Observation Recording Worksheet to record what students are doing and what students are saying. At the end of each class period, give examples of times groups either met or were on their way to meeting the descriptions.

Teachers may also decide to provide students with the Group Discussion Observation Guide so that they are able to reflect on their actions and ways to improve their experiment or explanation.

Suggestions for assessment are included at the end of each lesson and assessment tools are included in the Appendix. Teachers may choose to use these opportunities for assessment in the ways that work best for them and their students.

1.1: ENGAGE

HOT WHEELS AND RAMPS



Essential question: As an engineer, how would you build a ramp to get your Hot Wheels car to go as far as it can?

Objective: Students will begin to explore how to increase the potential and kinetic energy of their Hot Wheels cars by building ramps.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

PS3.A

Definitions of Energy:

- The faster a given object is moving, the more energy it possesses.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3

Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

S.L.4.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.

W.4.7

Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8

Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of resources.

Materials per group of 4-5 students

- 2-4 Hot Wheels cars
- 1-2 long piece of track (If not available, use a measuring stick)
- 3 textbooks (approximately 2 inches thick)



1.1: ENGAGE

HOT WHEELS AND RAMPS - CONTINUED

Time: 35 minutes ⌚

Procedure:

1. **Video:** Show video clip - http://www.youtube.com/watch?v=7SjX7A_FR6g . Ask students to pay attention to how the engineers designed the ramp and track. *(5 minutes)*

2. **Discussion:** Have students discuss whatever they find interesting about the video. *(7 minutes)*

Possible Guiding Questions:

- What did you notice about the design of the ramp?
- How do you think the engineers got the car to do the jump?
- What did you notice about the track and the car?
- How was the car different from cars you usually see people drive?
- How were the tracks different from the streets in your neighborhood?

3. **Introduce materials:** Show students the Hot Wheels cars, tracks (if available, or use measuring sticks), and books to elevate the track. Ask students: As an engineer, how would you build a ramp to get your Hot Wheels car to go as far as it can? Give small groups time to explore the materials and the cars. *(10 minutes)*

Note: *Try not to give the students too much direction. Allow them this time to explore and investigate freely. If some groups are having trouble starting, point out what other groups are doing to give them some guidance. Pay attention to any interesting insights that students have and ask them to share them later during discussion.*

4. Have students write in their notebooks about what they observed about the materials. This will give them time to settle down and think about what they learned. *(2 minutes)*

1.1: ENGAGE

HOT WHEELS AND RAMPS - CONTINUED



5. Have students share what they discovered as they explored the cars and track. Each group can give an example of how they increased the distance their car traveled.

Possible Guiding Questions:

- What do you think caused the car to go farther?
- Do you think the type of car your group used affected your results?
- Does it matter that each group has a different sized and shaped car?

Also guide the discussion by asking students to share anything interesting they observed.

(10 minutes)

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER ENGAGEMENT

Materials

- Group Discussion Observation Guide (for teacher's use)
- Group Discussion Observation Recording Worksheets, 1 per group

Procedure:

1. **Informal:** As students discuss what they discover about their Hot Wheels cars, the teacher circulates and observes student interactions with the cars and listens to their conversation about what is happening. Teachers can use the Group Discussion Observation Guide and Recording Worksheets to make sense of student actions and responses. *Time: 7-10 minutes during group work*

2. **Formal Assessment:** Students write about what they discover about their cars and the ramps in their notebooks. Teachers can review student writing before the next lesson to determine if students recorded observations and if their observations are reasonable, accurate, and precisely recorded. *Time: 20-30 minutes during planning time, depending on class size*



1.2: EXPLORE

EXPERIMENTING WITH RAMPS

Essential question: What happens to the distance your car travels as you increase the height of the ramp?

Objective: Students will understand potential and kinetic energy. Students will measure distance. Students will create a bar graph and chart to represent their data.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.

1.2: EXPLORE

EXPERIMENTING WITH RAMPS - CONTINUED



COMMON CORE STANDARDS FOR MATHEMATICS

4.MD.1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number of pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- 1 Hot Wheels car
- Track or measuring stick
- 3 textbooks (approximately 1-1 1/2 inches thick)
- Ruler for measurement
- “Exploring Hot Wheels with Ramps” Worksheets, 1 per student
- Optional: calculators

Time: 60 minutes ⌚ (may be longer if students need lessons in using a ruler or averages)

Procedure:

1. Explain to students that they are going to explore how making a steeper ramp affects the distance a car travels using their textbooks. They are going to start by building a ramp that is 1 book high and record how far the car travels. Then they will record how far the car travels when the ramp is 2 and 3 books high. Ask students to think about what they did in the previous lesson and discuss with their group how they should construct their ramp. Tell them about the importance of the class having a uniform way to conduct the experiment. (2 minutes)



1.2: EXPLORE

EXPERIMENTING WITH RAMPS - CONTINUED

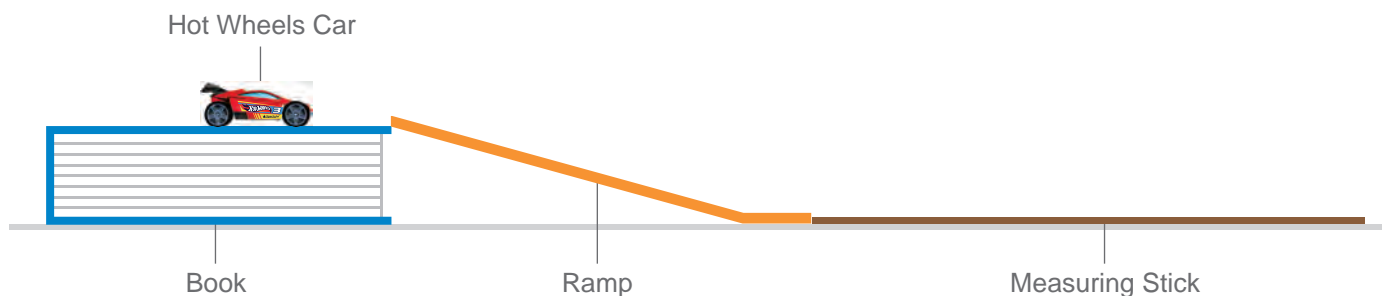
2. As a class, develop an experimental procedure. Discuss the importance of having a consistent procedure so the data is accurate.

The class will need to decide:

- How to construct the ramps: where will you put the end of the ramp on the book?
- How to release the cars: where will you place the car? How will you let it go so you don't push it?
- How to measure the distance: where will you measure from, the end of ramp or from the books? What unit of measure will you use? (Scientists and engineers usually use centimeters, so try to use rulers with centimeter measurements).

Have students record the class set-up in their notebook or record it on the board. (15 minutes)

Note: It doesn't really matter how a participant decides to set up the procedure, just emphasize that scientists need to be consistent in how they conduct an experiment. They need to set up an experiment where the only variable that changes is the height of the ramp. Everything else must be consistent.



3. Distribute the student worksheets. Go over how students are going to record the data. (2 minutes)



1.2: EXPLORE

EXPERIMENTING WITH RAMPS - CONTINUED

Note: It is up to teacher discretion if the group completes the worksheet as a team or individually. If students work cooperatively on their worksheets, the teacher may want to assign each student a role, such as a recorder, an artist, a timekeeper, and a leader.

Note: If students have not had a lot of experience using rulers, a teacher may have to review how to use and read the ruler, and how to record data in decimals or fractions. The data asks students to calculate an average; calculating averages may need to be reviewed. If possible, provide students with calculators. (This may add time to the lesson.)

4. Give students time to conduct their experiments, fill in their data, and draw their ramps. Teachers should circulate to make sure students are following the agreed upon procedure and are correctly using the rulers and correctly recording their data. (20-30 minutes)

Note: Students will share their findings in the next lesson.



1.2: EXPLORE

EXPERIMENTING WITH RAMPS - CONTINUED

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EXPLORING

Materials

- Group Discussion Observation Guide (for teacher's use)
- Group Discussion Observation Recording Worksheets, 1 per group

Procedure:

Opportunities for Formative Assessment:

1. **Informal:** As students use rulers to measure the distance the Hot Wheels cars have traveled, the teacher circulates and observes student interactions with the cars and rulers then listens to their conversations about what is happening. Teachers can use the Group Discussion Observation Recording Guide and Worksheet to make sense of student actions and responses. *Time: 7-10 minutes during group work*

2. **Formal Assessment:** Students will record data on the “Exploring Hot Wheels with Ramps” Student Worksheet. (Each student can fill out a copy of the sheet and add it to their notebook.) Teachers can review student data before the next lesson to determine if students recorded data and if their data is reasonable, accurate, and precisely recorded.

Time: 20-30 minutes during planning time, depending on class size

1.3: EXPLAIN



Essential question: What is potential and kinetic energy?

Objective: Students will understand kinetic and potential energy then will make reasonable mathematical estimates based on their collected data.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of resources.

1.3: EXPLAIN



COMMON CORE STANDARDS FOR MATHEMATICS

4.MD.1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number of pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- Worksheets from previous lesson

For teacher demonstration:

- 1 track or measuring stick
- Hot Wheels cars used by each group in previous lesson
- 4 textbooks

Time: 45-50 minutes ⌚

Procedure:

1. Give groups time to discuss what happened in the last lesson to the measured distance their car traveled as the height of the ramp increased. Ask students to discuss with their groups the pattern in the data they have collected on their worksheet. (5 minutes)

1.3: EXPLAIN



2. Have each group report to the class what happened to the distance the car traveled as they increased the height of their ramp. Record the average of each ramp from each group on chart paper or a copy of the student worksheet. Talk about how the numbers have increased.
- Looking at all the class data, what pattern do you see?

Students should see that the distance traveled is increasing with each book, but is also incrementally less with each book. Discuss how differences in the cars each group used may have affected their results.

- How can you ensure your data is consistent in the next experiments? (By using the same car). *(10 minutes)*

3. A teacher may want students to record the following definitions in their notebooks. Introduce the concepts of kinetic and potential energy: at the top of the ramp, the car has potential energy, and when released down the ramp it turns into kinetic energy that moves the car.

Ask students to use the terms potential and kinetic energy to explain why the distances in their data increased as the height of the ramp increased: as students increase the number of books, they increase the potential energy, which increases the distance the car can travel.

Ask students to label where the kinetic and potential energy would be found on the picture they drew of their ramps. *(10 minutes)*

1.3: EXPLAIN

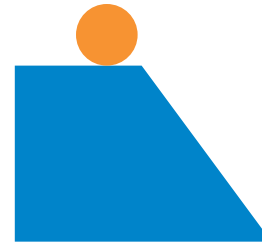


4. Brainstorm other examples of kinetic and potential energy. Create a T-chart to record examples of kinetic and potential energy. Display it and add to it throughout the unit as students think of other examples. (10 minutes)

Some examples of **potential energy**:

- Ball about to be thrown or dropped
- Bow and arrow stretched out to shoot
- Bike rider waiting on crest of a hill
- Runner in the blocks before a race
- Roller coaster at the crest of the hill

Potential



Some examples of **kinetic energy**:

- Ball or arrow flying through the air
- Bike riders coasting down the hill
- Ball rolling down a hill
- Roller coaster going down the track

Kinetic



Note: *If there are visual learners, a teacher may want to draw icons or diagrams to represent the concepts of potential and kinetic energy.*

5. Ask students to predict how far they think their cars would travel if they had a height of 4 books in their ramp. Discuss how scientists have to make estimates that are “reasonable.” Ask them to look at how much their data increased each time they added a new book, and then decide how much farther they think the car will go if the ramp is slightly higher. Have each group share their estimate and record it on the class’s data chart. Discuss which estimates seem reasonable based on the data recorded. (5 minutes)

1.3: EXPLAIN



Note: Students should see that the distance traveled is increasing, but incrementally decreases with each book. Estimates should reasonably follow the pattern, increasing the distance a small amount more than the distance traveled for 3 books.

6. Set up a demonstration ramp with four books. Ask each group to bring over the car they used and test it out using the same experimental procedure from the last lesson. Record the length traveled on the class's data chart. Have groups discuss the accuracy of their estimate and share their results with the class. *(10 minutes)*

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EXPLAINING

Materials

None

Procedure:

1. **Informal:** As students work in groups and report to the class, the teacher circulates, observes, and listens to student conversation and presentation about what is happening. Teachers pay close attention to how students use vocabulary terms in their group and class discussions. *Time: 15-20 minutes during group work and presentations*

2. **Formal Assessment:** Students will record data on the “Exploring Hot Wheels with Ramps” Student Worksheet. (Each student can fill out a copy of the sheet and add it to their notebook.) Teachers can review student work before the next lesson to determine if students recorded data and if their data is reasonable, accurate, and precisely recorded.

Time: 20-30 minutes during planning time, depending on class size

1.4: ELABORATE

OTHER WAYS TO INCREASE THE SPEED



Essential question: How can you change your design to give your cars more energy to go farther?

Objective: Students will investigate potential and kinetic energy by introducing different variables (e.g., mass or weight, height, other materials). Students will measure the distance cars travel caused by introducing different variables and design a way to record their data.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

1.4: ELABORATE

OTHER WAYS TO INCREASE THE SPEED - CONTINUED



COMMON CORE STANDARDS FOR MATHEMATICS

4.MD.1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- 1 Hot Wheels car (same as before)
- Track or measuring stick
- “Ways to Increase Speed: Experimental Plan” Worksheet

Other Optional Materials

- An assortment of different cars (sizes, shapes, colors, types)
- Loops
- Clamps to attach track to shelves, desks, tables, etc.
- Materials to change texture of track such as fabric, sandpaper, tile, carpet samples, cardboard
- Things to attach to the car to increase the mass (erasers, pennies, paperclips) and tape or string

Note: Students will be creative during this phase of the unit and may have elaborate ideas. The optional materials therefore are hard to predict, and will vary. Students may need to bring things from home.

Time: 90 minutes or 2 lessons of 45 minutes



1.4: ELABORATE

OTHER WAYS TO INCREASE THE SPEED - CONTINUED

Procedure:

1. Ask students to brainstorm ideas about how they can change the potential or kinetic energy in their car.

- What can you change in your design to change the energy your cars have and change the distance the cars travel?

Have them discuss in their groups and then share with the class. Create a chart of all student ideas. *(15 minutes)*

Possible Guiding Questions:

- What can you change about the last time you built the ramps?
- What if you change how you let the cars go at the top?
- Could you change the texture of the track?
- Could you change the surface when the car hits the floor?
- Could you somehow change the car to give it more energy?
- What if you used loops in our track?
- Could you use a clamp on something in the classroom to make the ramp even higher at the start?

Note: *Chart all ideas at this stage. If something is unsafe or not feasible in your classroom setting, take it off the list when it comes time to select an idea.*

Examples of ideas:

- Add fabric or sand paper to the track
- Put fabric or sandpaper on the floor at the bottom of the track
- Clamp the track to a bookshelf or desk
- Put loops at the bottom
- Try out different sized cars
- Tape erasers or pennies to the car to make it heavier
- Build the track out on the black top or on a carpet
- Push the car harder in the beginning



1.4: ELABORATE

OTHER WAYS TO INCREASE THE SPEED - CONTINUED

2. Tell students that when scientists create experiments, they only test one variable at a time. In the experiments a student can change only one thing about the last ramp set up. That will be the variable tested.

Ask groups to choose one idea to test. Then give them time to plan their experiment using the “Ways to Increase the Speed: Experimental Plan” worksheet.

Ask them to plan:

- a. How will you set up your ramp? You may want to draw a picture.
- b. What supplies will you need to create your ramp? Are they available in the classroom or will you need to bring them from home?
- c. Your experimental design: how will you release the car and from where on the ramp? How will you measure the distance traveled?
- d. How will you record your data: in a line graph or a bar graph?

They will be creating presentations for the class of their activity and may want to consider ways they can record what they are doing so they can share with the class. They may want to draw their results, photograph or videotape them. Teachers will circulate to aid student groups as they create their plans. *(15-20 minutes)*

Note: If a teacher is not comfortable letting the students choose their own ideas to test, assign each group an idea from the brainstorm list. Make sure students are designing their experiments in ways that are safe for the classroom and are comfortable to conduct.

3. Each group will briefly present their experimental design to the class. Other groups can provide feedback about their design. *(10 minutes)*

POSSIBLE BREAKPOINT IF DOING LESSON OVER 2 DAYS

4. Groups will conduct their experiments and record their data. Teachers should circulate to insure students are safe and are staying focused on their experiment. *(35 minutes)*

1.4: ELABORATE



OTHER WAYS TO INCREASE THE SPEED - CONTINUED

Note: Problems with materials or design may arise as students conduct their experiments. A teacher may help students redesign their experiment, or alter how they are using the materials. A teacher may also allow students to struggle and report on how and why the experiment failed. Use discretion based on what is known about the students.

5. Have groups discuss what they found. Guide them as they draw conclusions about their data. (10 minutes)

Guiding questions:

- Did you increase or decrease the potential energy?
- Did you increase or decrease the kinetic energy?
- What in your experiment caused the energy to increase or decrease?
- How do you know the energy increased or decreased?
- If you didn't change the energy, what do you think happened?
- What would you do differently next time?

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER ELABORATING

Materials

None

Procedure:

1. **Formal Assessment:** Each group will create a plan for their experiment, design a way to record their data, and create a data sheet. (Each student can make a copy of the data sheet and add it to their notebook.) Teachers can review student work before the next lesson to determine if students' data recording sheet and plan for the experiment is reasonable and accurate. *Time: 20-30 minutes during planning time, depending on class size*

1.5: EVALUATE

PRESENTATION OF FINDINGS



Essential question: Were you able to increase or decrease your car's potential or kinetic energy? How?

Objective: Students will present their claims, data, and findings from the Elaboration phase to the class.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces • When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Materials per group of 4-5 students

- Whatever students have created
- Presentation Checklist for each group
- Presentation Rubric for each group (to be used by teacher to assess)

Time: 60 minutes ⌚



1.5: EVALUATE

PRESENTATION OF FINDINGS - CONTINUED

Procedure:

1. Groups will create a short presentation of their results to share with the class answering essential questions. Write on the board or on chart paper that they will need to include the following *(20 minutes)*:

- a. Explain what you did in your experiment. What variable did you test? How did you set up your ramp?
- b. What results did you find?
- c. What conclusions did you draw? (See guiding questions from last lesson)
- d. Make sure to explain the potential and kinetic energy in your design.

2. Discuss with the class how to make a good presentation (eye contact, speak loudly, don't turn your back to the audience). Give each group a "Presentation Checklist Card" to make sure they include everything. Give them time to practice their presentation.

(10 minutes)

3. Groups will present their experiments and findings to the class. If possible, project their data using a document camera. To ensure everyone is paying attention, after each group's presentation ask the other students:

- Were they able to increase the distance their car traveled? How?
- Did they change the cars potential or kinetic energy? *(20 minutes)*

4. Discuss as a class:

- What are some ways you discovered to give a Hot Wheels car more or less energy?
- What happened as a result?
- Thinking back to the stunts we watched at the beginning, how did the engineers change the cars potential and kinetic energy? *(10 minutes)*

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EVALUATE



1.5: EVALUATE

PRESENTATION OF FINDINGS - CONTINUED

Materials

- Presentation Rubric, 1 per group

Procedure:

1. **Formal Assessment:** Groups will present their work from 1:4 Elaborate. Students will incorporate vocabulary and skills learned in this unit. (Use Presentation Rubric for scoring presentations.) *Time: 20 minutes during presentations*

1.6: EXTENSIONS

KEEP ON ROLLIN'

Essential question: How can you design a racecourse that keeps building kinetic and potential energy so your car will keep moving as long as possible?

Objective: Students will use what they have learned about potential and kinetic energy to design a racecourse that keeps the car moving as long and as far as possible.

Materials per group of 4-7 students

- 1 Hot Wheels car
- Lots of track and measuring sticks

Other possible materials:

- Clamps
- Books

Time: 45 minutes ⌚

Procedure:

1. Review what students know about kinetic and potential energy. Ask them to think about how in the experiments they conducted they increased the potential energy in their car. How do roller coasters build potential energy? *(5 minutes)*

A teacher may want to show them this animation:

<http://science.howstuffworks.com/engineering/structural/roller-coaster3.htm>

2. Present students with the challenge of keeping their car moving on a racecourse for as far as possible without pushing or touching it. Tell them that they will compete with the other groups to see which engineers can design a track that keeps building potential energy. Have each group brainstorm how they might keep their car moving. *(5 minutes)*

1.6: EXTENSIONS

Keep on Rollin' - Continued

3. Give each group time to build their tracks and test them out. Remind them as engineers that they can change their design to correct flaws they find as they test. *(15 minutes)*

Note: A teacher may want to limit the time as part of the constraints. Alternatively, the teacher could stretch out the time, and require students to submit a design before they begin to build

4. Race the cars. Depending on classroom set-up, a teacher can have the groups go simultaneously. The last car to stop is the winner. Another option is to have each group go separately and record the amount of time each car traveled. *(10 minutes)*

5. Celebrate the design of the winning group. Discuss what they learned about design from this procedure. What did the winning track do differently? *(10 minutes)*

If time permits, have each group redesign their track and race again.

Opportunities for Formative Assessment during and after EXTENSION

Materials

None

Procedure:

1. As students discuss what they discover about their Hot Wheels cars, the teacher circulates and observes student interactions with the cars and listens to their conversation about what is happening. Teachers can use the Group Discussion Observation Recording Worksheet and Guide to make sense of student actions and responses. *Time: 7-10 minutes during group work*

SPEEDOMETRY






GRADE 4 - MINI COLLISION COURSE

Overview: Over the course of 5-6 lessons, students will work in collaborative learning groups to deepen their understanding of potential and kinetic energy by observing, predicting, measuring, and exploring the effect that the height of a ramp has on the transfer of energy to Hot Wheels cars.

Time: 5-6 lessons that are approximately 45 minutes - 1 hour each.

Organization: Lessons are designed using the 5E Model (Engage, Explore, Explain, Elaborate, and Evaluate) to support students in asking questions and create experiments to find the answers. The 5Es integrate hands-on activities that help foster learning and inspire students to explore further. The following table outlines how the 5E Model is used during each lesson.



LESSON	DESCRIPTION
 <p>Engage - Students' prior knowledge is accessed and interest engaged in the phenomenon</p>	<p>Students will build ramps using the Hot Wheels tracks and experiment with potential and kinetic energy. Students will observe how potential and kinetic energy relate to the transfer of energy from one car to another as they collide.</p>
 <p>Explore - Students participate in an activity that facilitates conceptual change</p>	<p>Students will explore how to measure the transfer of energy through various car collisions. Students will measure the potential and kinetic energy of each car traveling down the ramp and the distance the car at the end of the ramp moves as a result of each collision.</p>
 <p>Explain - Students generate an explanation of the phenomenon</p>	<p>Students will make reasonable mathematical estimates based on collected data from their collision trials.</p>
 <p>Elaborate - Students' understanding of the phenomenon is challenged and deepened through new experiences</p>	<p>Students will investigate the transfer of potential and kinetic energy in car collisions introducing different variable (e.g. mass or weight, height, other materials). Students measure the distance cars travel caused by the collisions and design a way to record their data.</p>
 <p>Evaluate - Students assess their understanding of the phenomenon</p>	<p>Students will present to the class their claims, data, and findings from the Elaborate Phase.</p>
<p>Extension</p>	<p>Students will apply understanding of transferring energy during collisions as they read non-fiction (informational text) articles about car safety.</p>

THE SCIENCE BEHIND IT:

Potential energy is energy that is stored. In the case of this unit, the potential energy is in the car set on top of the ramp. The car is at a higher elevation, so it has gravitational potential energy at the top of the ramp because the force of gravity is going to pull it down the hill. When the car is let go, and the energy is being used, it is turned into kinetic energy.

An example of an inelastic collision is a car crash. When two cars collide, the kinetic energy transfers to sound energy (crash!), thermal energy, and energy used to crumple the cars, or change their shape. A ball dropping is an example of an inelastic collision where part of the kinetic energy is changed to some other form when colliding with a surface.

During these lessons, students will deepen their ability to accurately describe changes in energy, to conduct an experiment using variables as research, and use measurement to describe an event.

Students will build ramps using the Hot Wheels tracks and observe collisions between two Hot Wheels cars, one starting at the top of the ramp and one at the bottom of the ramp. They will incrementally increase the height of the ramps and measure the changes in the distance the car at the bottom of the ramp travels upon impact. By increasing the height of the ramp, they increase the potential and kinetic energy of the car starting at the top of the ramp as it travels down the ramp. That will increase the distance the car at the bottom of the ramp will travel upon impact. At the end of lesson 5, students will expand on what they learn and will explore other ways potential and kinetic energy effect car collisions

For more information, refer to the appendix or these websites.

Energy Education - simply explains potential and kinetic energy with animation:

http://www.energyeducation.tx.gov/energy/section_1/topics/potential_and_kinetic_energy/

The Insurance Institute of Highway Safety - video of a physics lesson about car crashes.

It highlights Isaac Newton and potential and kinetic energy:

“Understanding Car Crashes: It’s Basic Physics.”

www.youtube.com/watch?v=yUpiV2I_IRI

STANDARDS ALIGNMENT AND CONNECTIONS

These learning activities support students in the development of capacities described across several key frameworks for standards based instruction. Teachers can observe student performance related to the following standards from the Next Generation Science Standards (NGSS), the Common Core State Standards for English Language Arts /Literacy and Mathematics (CCSS), and the California Department of Education Key STEM Content and Process Standards.



NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

STANDARDS ALIGNMENT AND CONNECTIONS - CONTINUED



COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own ideas clearly.
S.L.4.4	Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

STANDARDS ALIGNMENT AND CONNECTIONS - CONTINUED

COMMON CORE STANDARDS FOR MATHEMATICS

4.MD1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...



California Department of
EDUCATION

CALIFORNIA DEPARTMENT OF EDUCATION KEY STEM CONTENT AND PROCESS STANDARDS

Provides the introductory and foundational STEM courses that lead to success in challenging and applied courses in secondary grades.

Introduces awareness of STEM fields and occupations.

Provides standards-based, structured inquiry-based and real-world problem-based learning that interconnects STEM subjects.

Stimulates student interest in “wanting to” rather than “having to” take further STEM related courses.

Bridges and connects in-school and out-of-school learning opportunities.

CREATING AN ENVIRONMENT FOR SUCCESS

Considerations for Diverse Learners

This series of lessons incorporates many Universal Design for Learning (UDL) principles and the 5E model of instruction. The UDL design principles ensure diverse points of engagement during learning and multiple ways that learners can demonstrate or communicate what they understand. The 5E Model (Engage, Explore, Explain, Elaborate and Evaluate) supports students in asking questions and creating experiments to find the answers. The 5Es integrate hands-on activities that help foster conceptual understanding and inspire students to explore further. Learners are likely to find some phases more engaging or difficult than others depending on their comfort with the knowledge or processes required. It is recommended that all children participate in each phase of learning as designed to deepen both their understanding of science content, and their ability to use and communicate this knowledge in the everyday world. If students have Individual Education Plans (IEPs), consult these documents for important modifications or accommodations that should be made for those students.

Strategies for Group Work: Throughout the unit students will work in cooperative groups. To increase group cohesion and engagement, a teacher may want to name the groups after popular cars or allow students to create their own team names. A teacher may also assign rotating jobs to each group member, such as timekeeper, recorder, reporter, go-getter.

Discussion: There are many class discussions in this unit. Some strategies to use in the classroom:

- **Think-Pair-Share:** Students are given time to think or write their ideas, then share with a partner before sharing with the class. This gives students time to think of an answer and the support of their classmate's idea. This is particularly useful if there are English learners or students who are shy about talking.
- **Reporter:** Each group can have an assigned reporter. After the group is given time to discuss, the reporter shares the group's ideas with the class. This job should be rotated so that everyone has an opportunity to be the reporter.

CREATING AN ENVIRONMENT FOR SUCCESS - CONTINUED

- **Written Prompts and Procedures:** Teachers can support more independent student-to-student conversation by providing each group a copy of procedural steps including discussion questions and prompts to record data for use during experimentation and discussion.
- **Notebooks:** Students should have a place to take notes, record their data, write down definitions, and brainstorm their ideas throughout this process. A teacher may want to provide the students with a blank notebook, or can create a notebook using the worksheets provided. This could be a few blank sheets of lined or unlined paper.
- **Academic Language:** Explain to the students that they are going to be scientists and race-car drivers and/or car experts. They will need to use “academic vocabulary” and precise language when explaining their thinking throughout the Hot Wheels unit. Each lesson will have relevant academic vocabulary listed. The teacher should introduce the vocabulary at the beginning of each lesson and use it throughout the lesson. Students should be encouraged to use relevant academic language during experimentation and discussion. Some of the journal responses encourage the students to use the appropriate academic vocabulary as well.
- **Concepts and Vocabulary:** Set up a concept and vocabulary chart somewhere in the room. Add to the chart as students learn new vocabulary or concepts throughout this process.

CREATING AN ENVIRONMENT FOR SUCCESS - CONTINUED

ACADEMIC VOCABULARY (TIER 2 WORDS)	CONTENT SPECIFIC VOCABULARY (TIER 3 WORDS)
<p>Ramp - a slope or inclined plane for joining two different levels</p>	<p>Kinetic energy - energy that an object possesses by virtue of being in motion.</p>
<p>Mass - the amount of matter that an object contains. Mass can be measured by its acceleration under a given force or by the force exerted on it by a gravitational field.</p>	<p>Potential energy - the energy possessed by an object by virtue of its position relative to others, stresses within itself, gravitational pull, and other factors.</p>
<p>Slope - a surface of which one end or side is at a higher level than another; a rising or falling surface.</p>	
<p>Height - the measurement from base to top or (of a standing person) from head to foot.</p>	
<p>Average - a number expressing the central or typical value in a set of data. The average is calculated by dividing the sum of the values in the set by the number of values in the set.</p>	

CONSIDERATIONS FOR ENGLISH LANGUAGE LEARNERS

When working with English Language learners, reference the vocabulary chart before, during and after each lesson (this will require additional time). Depending on students' proficiency using English, students may need additional support with terms such as: **speed**, **distance**, and **energy**.

A teacher may also want to create a concept chart to help students develop a foundational understanding of potential and kinetic energy. Leave this chart up for the remainder of the unit so that students can refer to it during experimentation and discussion.

NOTE: These can also be effective for English Language Learners.

Use the Right Surface:

Hard floors create the most significant speed and distance changes for students to observe and measure. With carpeting, increase the height of the ramps in order to create a noticeable difference in students' recorded data. Students can increase height by using more books to elevate the ramps, holding ramps at determined heights on measuring sticks, or using clamps to attach ramps to chairs or tables.

Observe students while they work and provide criteria-based feedback (formative assessment):

As students work in groups use the Group Discussion Observation Recording Worksheet to record what students are doing and what students are saying. At the end of each class period give examples of how groups either met or were on their way to meeting the descriptions.

Teachers may also decide to provide students with the Group Discussion Observation Guide so that they are able to reflect on their actions and ways to improve their experiment or explanation.

Suggestions for assessment are included at the end of each lesson and assessment tools are included in the appendix. Teachers may choose to use these opportunities for assessment in the ways that work best for them and their students.

2.1: ENGAGE

HOT WHEELS AND COLLISIONS



Essential question: “How will the speed of the car affect the collision?”

Objective: Students will experiment with potential and kinetic energy and how it relates to the transfer of energy from one car to another car as they collide.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects’ motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others’ ideas and expressing their own ideas clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.

Materials per group of 4-5 students

- 2 Hot Wheels cars
- 1 long piece of track (If not available, use a measuring stick)
- 4 textbooks
- Ruler, measuring stick, or measuring tape
- Group Observation Discussion Sheets
- Mini Collision Course Worksheets
- Student notebooks and pencils



2.1: ENGAGE

HOT WHEELS AND COLLISIONS - CONTINUED

Time: 40-45 minutes ⌚

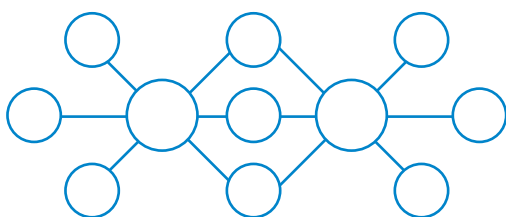
Procedure:

1. Show video clips of safety crash tests with and without safety belts.

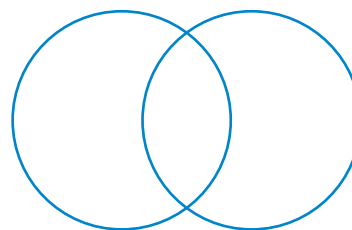
<http://www.youtube.com/watch?v=d7iYZPp2zYY>

2. Have students discuss with a partner what they find interesting about these videos. (3-4 minutes)

3. Have class discussion comparing and contrasting the two types of collisions: “With Seatbelts” and “Without Seatbelts.” You can record student feedback on chart paper or whiteboard using a cause and effect Thinking Map (Double Bubble) or a Venn diagram.



OR



4. Teacher can ask students questions such as:

- “What do you think the engineers need to do to be able to get the cars to be safer?”
- “What do you think the drivers need to do to be able to get the cars to be safer?”
- “How are the cars similar or different from your own car (or cars that you have seen)?”

5. Divide students into small groups of 4-5 students. Introduce materials to the students and explain how the materials will be used.

- 2 Hot Wheels cars
- 1 long piece of track (If not available, use a measuring stick)
- 4 textbooks
- Ruler, measuring stick or measuring tape
- Mini Collision Course Worksheets
- Student notebooks and pencils



2.1: ENGAGE

HOT WHEELS AND COLLISIONS - CONTINUED

Support English Language Learners by allowing time for learners to observe the object and practice saying the word.

6. Ask the Essential Question: “How will the speed of the car affect the collision?”
7. Give groups time to engage the materials and the cars keeping the Essential Question in mind. *(15 minutes)*
 - a. Give students this minimal direction:
 - i. Students build ramps using the Hot Wheels tracks and observe collisions between two Hot Wheels cars, one starting at the top of the ramp and one at the bottom of the ramp.
 - ii. They incrementally increase the height of the ramps and measure the changes in the distance the car at the bottom of the ramp travels upon impact.
 - iii. They record the measurements in their student notebooks.
 - b. Allow them this time to investigate freely. During this time the teacher should observe the activity in each group, only intervening if a group is having trouble or not functioning.

If some groups are having trouble starting, guide them to observe what other groups are doing or repeat the essential question.

8. At the end of the lesson, bring students together and have groups share their observations about energy and collisions. *(10 minutes)*



2.1: ENGAGE

HOT WHEELS AND COLLISIONS - CONTINUED

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER ENGAGE

Materials

- Group Discussion Observation Guide (for teacher's use)
- Group Discussion Observation Recording Sheets, 1 per group

Procedure:

1. **Informal:** As students discuss what they discover about their colliding Hot Wheels cars, the teacher circulates and observes student interactions with the cars and listens to their conversation about what is happening. Teachers can use the Group Discussion Observation Recording Worksheet and Guide to make sense of student actions and responses.

Time: 7-10 minutes during group work

2. **Formal Assessment:** Students will record data on the Group Discussion Observation Recording sheet, noting the collision trials their group performs. (Each student can fill out a copy of the sheet and add it to their notebook.) Teachers can review student work before the next lesson to determine if students recorded data and if their data is reasonable, accurate, and precisely recorded. *Time: 20-30 minutes during planning time, depending on class size*

2.2: EXPLORE



Essential question: “What happens when two cars collide when you change the potential energy?”

Objective: Students will explore how to measure the transfer of energy through various car collisions. Students will measure the potential and kinetic energy of each car traveling down the ramp and the distance the car at the end of the ramp moves as a result of each collision. Students will record their findings.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own ideas clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.



COMMON CORE STANDARDS FOR MATHEMATICS

4.MD1

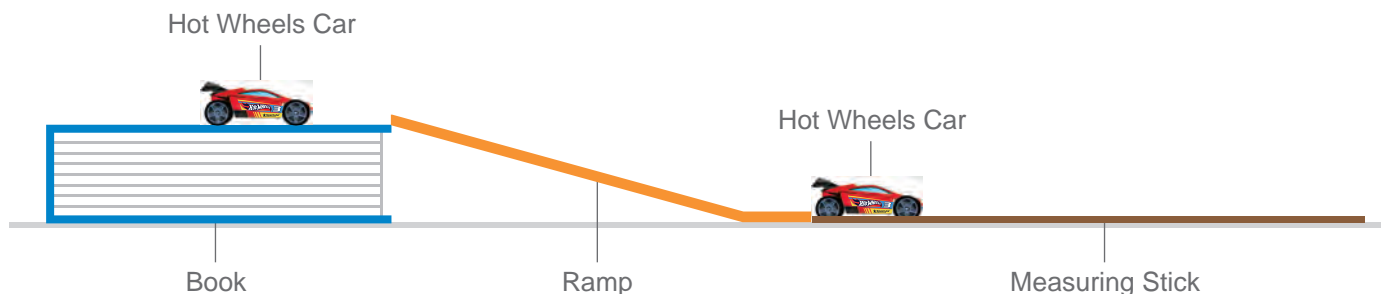
Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- 2 Hot Wheels cars
- 1 long piece of track (If not available, use a measuring stick)
- 4 textbooks
- Ruler, measuring stick, or measuring tape
- Mini Collision Course Worksheets
- Student notebooks and pencils
- Teacher Resource: "Momentum Conservation Principle."

Time: 40-45 minutes ⌚

Procedure:



2.2: EXPLORE



1. Each group will get their set of materials and find a space on the floor to work (see note on Use the Right Surface). Make sure each group has ample space for cars to move and to record their findings.
2. Each student will fill out a Mini Collision Course Worksheet. Preview the worksheet with students. They will put their name where it says: “Student Driver” and the name of the group leader where it says: “Crew Captain.”
3. Each group will conduct Collision Trials A, B, C, and D. They will record their data.
 - a. Before each Trial students will estimate the distance the car at the bottom of the track will travel.
 - b. After each Trial, students will record the actual distance the car at the bottom of the track traveled.
 - c. After determining the actual distance traveled for each Trial, students will determine the difference between the estimate and actual distance traveled. This may help students improve their estimated distance traveled with each trial.
 - d. As a mathematical challenge, students who finish sooner than others can convert their measurements to millimeters (mm), meters (m), and/or yards (yds).
4. As students complete Collision Trials A, B, C, and D direct students in groups to observe patterns they see in their collected data and answer questions 1, 2, and 3 on the worksheet.
5. When all groups finish filling in the worksheet, the class will gather together and each group will use their observations to deepen understanding about the essential question: “What happens when two cars collide when you change the potential energy?”

To develop academic language, restate student responses using relevant terminology: potential energy collides, distance, etc.



2.2: EXPLORE

6. The teacher will then conduct a mini lesson on “energy transfer” and how the energy transferred in the collision. Teacher can guide the discussion based on the groups’ data and observations. See Teacher Resource (in the appendix): “Momentum Conservation Principle.” It is recommended that teachers study this resource before teaching the lesson.

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EXPLORE

Materials

- Group Discussion Observation Guide (for teacher’s use)
- Group Discussion Observation Reporting Worksheets, 1 per group

Procedure:

1. **Informal:** As students discuss what they discover about their colliding Hot Wheels cars, the teacher circulates and observes student interactions with the cars and listens to their conversation about what is happening. Teachers can use the Group Discussion Observation Recording Worksheet and Guide to make sense of student actions and responses.

Time: 7-10 minutes during group work

2. **Formal Assessment:** Students will record data on the “Mini Collision Course” sheet, noting the collision trials their group performs. (Each student can fill out a copy of the sheet and add it to their notebook.) Teachers can review student work before the next lesson to determine if students recorded data and if their data is reasonable, accurate, and precisely recorded. *Time: 20-30 minutes during planning time, depending on class size*

2.3: EXPLAIN



Essential question: When you increase the potential energy, can you accurately predict the distance the car at the bottom of the ramp will travel?

Objective: Students will make reasonable mathematical estimates based on collected data from their collision trials.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
S.L.4.4	Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

2.3: EXPLAIN



COMMON CORE STANDARDS FOR MATHEMATICS

4.MD1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- 2 Hot Wheels cars
- 1 long piece of track (If not available, use a measuring stick)
- 5 textbooks
- Ruler, measuring stick or measuring tape
- Completed Mini Collision Course Worksheets
- Student notebooks and pencils

Time: 20 minutes ⌚

Procedure:

1. Review the concepts of potential and kinetic energy: “At the top of the ramp, the car has potential energy. When the car goes down the ramp, the car has kinetic energy. As we increase the number of books increasing the height of the ramp, we increase the potential energy. This increases the speed of the car, increasing the kinetic energy.”

2.3: EXPLAIN



To support English language learners, use a visual of a car standing still at the top of a ramp to illustrate potential energy and a car moving down the track to illustrate kinetic energy.

2. Have students label where the potential (PE) and kinetic (KE) energy can be found on their Mini Collision Course Worksheet for Trials A, B, C, and D.

3. With the class review data collected from the groups in Part 2: Explore: “What happened to the distance the bottom car traveled as they increased the height of their ramp?” Encourage students to use what they just learned about transferring potential and kinetic energy to explain why the distances increased.

4. Have groups predict how far they think their cars would travel with the ramp height of 5 books. Have each group share their estimate and record them on the board or chart paper, leaving space to compare later actual results. Discuss what would be a reasonable estimate based on the previous data recorded.

Note: The distance the car at the bottom of the ramp traveled increases with each book. However, students will discover the distance traveled is measurably less each time the ramp is raised.

Estimates reasonably follow the patterns observed from their data.

5. Each group will test what happens with their ramp at the height of 5 books. (Or the teacher can set up a ramp and conduct the test for the whole class). Have groups compare their estimates with their actual results.

6. Groups will share their results with the class. (Teacher may record groups’ results next to their estimates, and then compare all groups’ results with their previous estimates.)

2.3: EXPLAIN



OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EXPLAINING

Materials

- None

Procedure:

1. **Informal:** As students share their results with the class, teachers should listen to the comparative statements of each group for accuracy and relevance to the content. *No additional time*
2. **Informal:** As students label where the potential (PE) and kinetic (KE) energy can be found on their Mini Collision Course Worksheet for Trials A, B, C, and D, the teacher circulates and observes student labels. *Time: 2 minutes, as students are labeling*



2.4: ELABORATE

INVESTIGATING DIFFERENT COLLISIONS

Essential question: How do different types of collisions affect how energy transfers from one object to another?

Objective: Students will investigate the transfer of potential and kinetic energy in car collisions introducing different variables (e.g. mass or weight, height, other materials). Students will measure the distance cars travel caused by the collisions and design a way to record their data.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

R.I.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.



2.4: ELABORATE

INVESTIGATING DIFFERENT COLLISIONS

COMMON CORE STANDARDS FOR MATHEMATICS

4.MD1

Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz; l; ml; hr, min, sec within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalence in a two-column table. For example, know that 1 ft is 12 times as long as one in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36), ...

Materials per group of 4-5 students

- 4 Hot Wheels cars (3 different sizes or masses)
- 1-2 tracks
- Measuring stick
- Collision Course Task Card (4 different cards)

Other Optional Material Ideas

- Loops
- Clamps to attach track to shelves

Time: 50-60 minutes ⌚



2.4: ELABORATE

INVESTIGATING DIFFERENT COLLISIONS - CONTINUED

Procedure:

1. Groups will each choose one Collision Course Task Card, create a plan for how they will conduct their investigation, and determine what data they need to collect. This information will be presented in 2.5: EVALUATE. *(10 minutes)*
 - a. Question to help students design data sheet: “What will we measure and how will I record the data?”
 - b. Ideas for recording data: graphs (line, bar, etc.), drawings, photos or videos of experiment.
2. Groups will conduct their investigations and record their data. The teacher should circulate to ensure students are safe and staying focused on their investigations.
3. Guide the students as they draw conclusions about their data. *(10 minutes)*
 - a. Have students answer the following question: “Where are we increasing the energy and what results are we finding?”
4. Groups will prepare a presentation of their investigation and collected data. (Teachers may want to give each group chart paper to create a poster of their work. Groups will create a five-minute presentation of their results to share with their class. *(20 minutes)*
 - a. Presentations will focus on answering the essential question. “Were you able to increase or decrease the transfer of energy from one object to another? If so, how? Did they change the cars’ potential or kinetic energy?”
 - b. Groups will explain how their track design was different from the EXPLORE activity earlier. Groups will explain how their collisions were different this time.
 - c. Each group will reference/show/discuss their data to support their claims.



2.4: ELABORATE

INVESTIGATING DIFFERENT COLLISIONS - CONTINUED

Note: Teacher will want to find a place for students to store their data and materials until their presentation or record a digital image (picture) for later.

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER ELABORATING

Materials

- Group Discussion Observation Guide (for teacher's use)
- Group Discussion Observation Recording Worksheets, 1 per group

Procedure:

1. **Informal:** As students discuss how they will record their data, based on their previous experiences recording data, the teacher will circulate and observe student interactions as they figure out their tasks and worksheets. Teachers can use the Group Discussion Observation Recording Worksheet and Guide to make sense of student interaction and conversation. *Time: 7-10 minutes during group work*

2. **Formal Assessment:** Each group will design a way to record their data, and create a data sheet. (Each student can make a copy of the worksheet and add it to their notebooks.) Teachers can review student work before the next lesson to determine if students recorded data and if their data is reasonable, accurate, and precisely recorded. *Time: 20-30 minutes during planning time, depending on class size*



2.5: EVALUATE

PRESENTATION OF FINDINGS

Essential question: Were you able to increase or decrease the transfer of energy from one object to another?

Objective: Students will present to the class their claims, data, and findings from the Elaborate Phase.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4PS3.C	Relationship Between Energy and Forces <ul style="list-style-type: none">• When objects collide, the contact forces transfer energy so as to change the objects' motions.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS/LITERACY

W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Materials per group of 4-5 students

- Chart paper
- Markers
- Tape
- Materials students used to design their track from their Collision Course Task Card
- Presentation Checklists for Students



2.5: EVALUATE

PRESENTATION OF FINDINGS - CONTINUED

Time: 45-60 minutes ⌚

Procedure:

Discuss with the class how to make a good presentation (eye contact, speak loudly, don't turn your back to the audience). Give each group a "Presentation Checklist Card" to make sure they include everything.

1. Each group will practice their presentation. *(15 minutes)*
2. Groups will present their results to the class. *(20-30 minutes)*
3. Summarize as a class: "What are some ways you discovered to transfer more or less energy to a Hot Wheels car? What happened as a result?"
4. In their science notebook, ask students to write a letter to the National Safety Transportation Board explaining what they've learned about potential and kinetic energy and how energy is transferred. Suggest one thing that every driver should know based on what was learned. *(15 minutes)*

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EVALUATING

Materials

- Presentation Rubric, 1 per group

Procedure:

1. **Formal Assessment:** Groups will present their work from 2.4: ELABORATE. Students will incorporate vocabulary and skills learned in this unit. (Use Presentation Rubric for scoring presentations.) *Time: 20 minutes during presentations*



2.5: EVALUATE

PRESENTATION OF FINDINGS - CONTINUED

2. **Formal Assessment:** Each student will write a summary paragraph reflecting on their work and what they learned in this unit about potential and kinetic energy, as well as how energy is transferred. Review student work to see the degree in which students:

- Introduce a topic clearly.
- Develop the topic with definitions, concrete details, or examples related to the topic.
- Link ideas using words and phrases (e.g., another, for example, also, because).
- Use precise language and domain-specific vocabulary to inform about or explain the topic.
- Provide a concluding statement related to the information or explanation presented.

Time: 20-30 minutes during planning time, depending on class size

2.6: EXTENSIONS

Essential question: Using their understanding of the transfer of potential and kinetic energy, how do engineers and scientists design safer cars?

Objective: Working in groups, students will apply understanding of transferring energy during collisions as they read non-fiction (informational text) articles about car safety.

Materials per group of 4-5 students

- Chart paper
- Markers
- Online articles (4-7 copies of each from Appendix section)

Time: 45 minutes ⌚

Procedure:

1. Teacher will assign each group an article to read and present to the class.
2. Each student in each group will receive a copy of the article that group was assigned and read it.
3. Allow time to read the articles. *(5 minutes)*
4. Each group will create a poster on chart paper that summarizes the article's main ideas. (Thinking maps or outlines) *(15-20 minutes)*
5. Groups will present their article to the class, using their posters, highlighting the main ideas. *(20 minutes)*

2.6: EXTENSIONS

OPPORTUNITIES FOR FORMATIVE ASSESSMENT DURING AND AFTER EXTENSION

Materials

- None

Procedure:

1. **Informal:** Listen to presentations for students' abilities to express their understanding of integrated information from the informational text and the experiments with Hot Wheels cars using a mode of communication of their choice (summary writing, constructing visual representation[s], poetry [shape/rhyming/acrostic]). *Time: 15 minutes during presentations*



SPEEDOMETRY GRADE 4 - APPENDIX

SUPPORTING MATERIALS

This appendix includes materials to support instruction and assessment outlined in Lesson 1: Speed Ramps and Lesson 2: Mini Collision Course.

Lesson 1: Speed Ramps

- Exploring Hot Wheels with Ramps worksheet
- Ways to Increase the Speed: Experimental Plan
- Group Discussion Observation Guide
- Group Discussion Observation Recording Worksheet
- Presentation Checklist Cards
- Presentation Rubric

Lesson 2: Mini Collision Course

- Mini Collision Course Worksheet
- Mini Collision Course Task Cards
- Resource Articles
- Group Discussion Observation Guide
- Group Discussion Observation Recording Worksheet
- Presentation Checklist Cards
- Presentation Rubric



1.2: EXPLORE

"EXPLORING HOT WHEELS WITH RAMPS" WORKSHEET



Name: _____

Date: _____

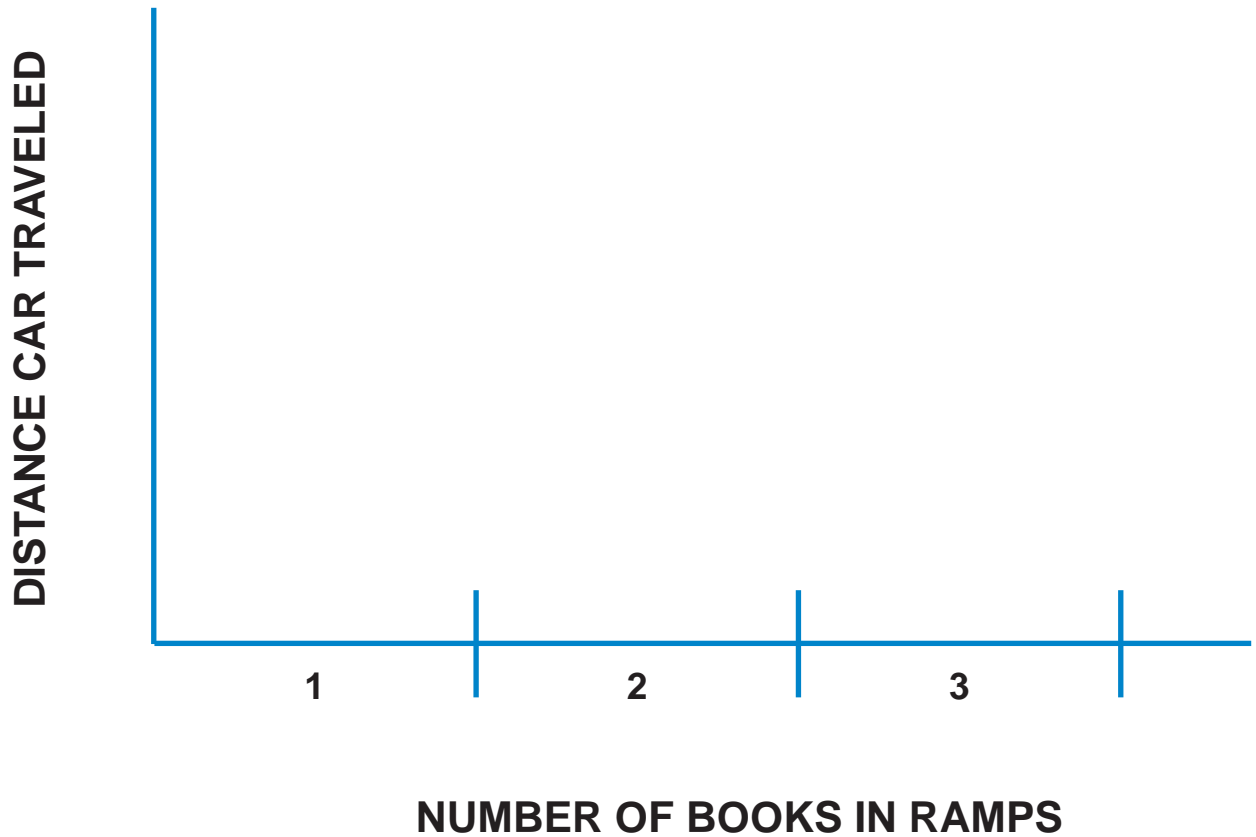
Record how far your car travels after each trial run.

NUMBER OF BOOKS	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
1				
2				
3				

1.2: EXPLORE - CONTINUED



Create a bar graph that depicts the averages of your data. Label your units of measurement.



On the back of this worksheet, draw a picture that shows your ramp with 3 books.



1.4: ELABORATE

"WAYS TO INCREASE THE SPEED: EXPERIMENTAL PLAN" WORKSHEET

Name: _____ Date: _____

The variable you are testing is _____

Briefly explain how you are going to test this variable.

1.4: ELABORATE - CONTINUED



Your Set-Up:

Draw a picture of how you will engineer your ramp:

List the supplies you will need (Circle anything you will need to bring from home):



1.4: ELABORATE - CONTINUED



Design your experimental procedure:

Describe how you will measure and record your data:

GROUP DISCUSSION OBSERVATION GUIDE

Use this set of criteria to observe students as they discuss findings:

- Come to discussions prepared, having completed experiments.
- Draw on experiments and other information known about the topic to explore ideas under discussion.
- Pose and respond to specific questions to clarify or follow-up. Make comments that contribute to the discussion and link to the remarks of others.
- Review the key ideas expressed and have students explain their ideas and understanding of concepts.
- Use grade-appropriate general academic and domain-specific words or phrases (see vocabulary list for key words in this unit).

GROUP DISCUSSION OBSERVATION RECORDING WORKSHEET



PRESENTATION CHECKLIST CARDS FOR STUDENTS

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the kinetic energy in our experiment
- We talked about the potential energy in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the kinetic energy in our experiment
- We talked about the potential energy in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the kinetic energy in our experiment
- We talked about the potential energy in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the kinetic energy in our experiment
- We talked about the potential energy in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION RUBRICS (FOR TEACHER'S USE)

4	<ul style="list-style-type: none">• Clearly explain experiment, results, and conclusions in a way that is engaging• Able to answer questions about their conclusions, using data and examples from experiments• Demonstrate a deeper understanding of kinetic and potential energy in their presentation• All members of the group speak clearly and confidently
3	<ul style="list-style-type: none">• Clearly explain experiment, results, and conclusions• Correctly discuss the kinetic and potential energy in the experiment• All members of the group speak clearly during the presentation
2	<ul style="list-style-type: none">• Explain experiment and results; conclusions may be confusing or inaccurate• Attempt to discuss kinetic and potential energy, but may demonstrate some misunderstanding• 1 or 2 members of the group do not participate in the discussion, or do not speak clearly
1	<ul style="list-style-type: none">• Unable to explain experiment or results• Does not include a description of kinetic or potential energy that demonstrates understanding• Most members of the group do not participate or do not speak clearly

2:1 ENGAGE MINI COLLISION COURSE WORKSHEET

COLLISION TRIALS	ESTIMATED DISTANCE TRAVELED	ACTUAL DISTANCE TRAVELED	DIFFERENCE BETWEEN ESTIMATED & ACTUAL	CHALLENGE: CONVERT TO MM, M OR YDS
	_____ in _____ cm	_____ in _____ cm	_____ in _____ cm	
	_____ in _____ cm	_____ in _____ cm	_____ in _____ cm	
	_____ in _____ cm	_____ in _____ cm	_____ in _____ cm	
	_____ in _____ cm	_____ in _____ cm	_____ in _____ cm	

Scientists and engineers look for patterns in their data. What patterns do you notice in your data?

1. In my Estimated Distance column, I discovered . . . _____

2. In my Actual Distance column, I noticed . . . _____

3. A pattern I observed after calculating _____

2:4 ELABORATE COLLISION COURSE TASK CARDS

TASK CARD 1

BIG, BIGGER, BIGGEST

1. Build a ramp with books and a track (or a ruler).
2. How will the energy of the collisions change when the mass of the moving car is changed?
3. Investigate! Use three different masses or sizes of cars and use a ruler to measure the distances caused by the collisions. Record your data.

Change the mass (weight) of this car



TASK CARD 2

IMPACT INVESTIGATION

1. Build a ramp with books and a track (or a ruler).
2. Investigate! Use three different masses of the stopped car at the bottom of the ramp.
3. How will the transfer of energy be different? Use a ruler to measure the distances caused by the collisions the car at the bottom of the track travels. Record your data.

Change the mass (weight) of this car



TASK CARD 3

BUMPER STUMPER

1. Build a ramp using books and a track (or a ruler).
2. Investigate! Use different designs and materials of bumpers to slow the energy transfer of collisions.
3. Be Creative! Use different materials from your teacher or classroom.
4. Record the distance of each collision for the different bumpers you design.

Create a bumper between cars.



TASK CARD 4

HEAD-TO-HEAD

1. Build two ramps with books and tracks (or rulers).
2. Face the ramps toward each other to have a head-on collision.
3. Investigate! Use three different speeds by changing the angle or steepness of the ramp.
4. Use a ruler to measure the distances caused by the collisions. Record your data.

Change how many books are used under each ramp



TEACHER RESOURCES

Articles for Teacher Reference:

Momentum Conservation Principle:

<http://www.physicsclassroom.com/class/momentum/Lesson-2/Momentum-Conservation-Principle>

Sample Articles:

There are many resources on the web that can be used in your classroom to discuss car safety and collisions. Here are some sample articles for you to review:

Think Safe, Ride Safe, Be Safe: (The kids' program for the National Highway Traffic Safety Administration)

<http://www.safercar.gov/parents/chuggington/main.htm>

Seat Belts on School Buses-May 2006:

<http://www.nhtsa.gov/Vehicle+Safety/Seat+Belts/Seat+Belts+on+School+Buses+--+May+2006>

Airbags and Safety:

<http://www.safercar.gov/Air+Bags>

<http://www.safercar.gov/staticfiles/safercar/animations/airbags/INTRO.swf>



GROUP DISCUSSION OBSERVATION GUIDE

Use this set of criteria to observe students as they discuss findings:

- Come to discussions prepared, having completed experiments.
- Draw on experiments and other information known about the topic to explore ideas under discussion.
- Pose and respond to specific questions to clarify or follow-up. Make comments that contribute to the discussion and link to the remarks of others.
- Review the key ideas expressed and have students explain their ideas and understanding of concepts.
- Use grade-appropriate general academic and domain-specific words or phrases (see vocabulary list for key words in this unit).



GROUP DISCUSSION OBSERVATION RECORDING WORKSHEET



PRESENTATION CHECKLIST CARDS FOR STUDENTS

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the transfer of energy during collisions in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the transfer of energy during collisions in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the transfer of energy during collisions in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION CHECKLIST

- We explained what we did in our experiment
- We showed our results
- We explained the conclusions that we learned from our experiment
- We talked about the transfer of energy during collisions in our experiment
- Everyone in our group talks
- We practiced talking clearly and confidently

PRESENTATION RUBRICS (FOR TEACHER'S USE)

4	<ul style="list-style-type: none">• Clearly explain experiment, results and conclusions in a way that is engaging• Able to answer questions about their conclusions, using data and examples from experiments• Demonstrate a deeper understanding of the transfer of energy during collisions in their presentation• All members of the group speak clearly and confidently
3	<ul style="list-style-type: none">• Clearly explain experiment, results and conclusions• Correctly discuss the transfer of energy during collisions in the experiment• All members of the group speak clearly during the presentation
2	<ul style="list-style-type: none">• Explain experiment and results; conclusions may be confusing or inaccurate• Attempt to discuss the transfer of energy during collisions, but may demonstrate some misunderstanding• 1 or 2 Members of the group do not participate in the discussion, or do not speak clearly
1	<ul style="list-style-type: none">• Unable to explain experiment or results• Does not include a description of the transfer of energy during collisions that demonstrates understanding• Most members of the group do not participate or do not speak clearly