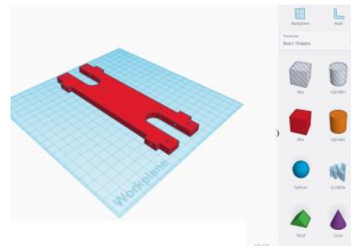
Speed, Velocity and Acceleration



Speed, velocity, and acceleration are fundamental aspects of all motorsports activities. During this lesson students engage with these topics utilizing a STEM focused approach initiated during the Engineering Design Process Module. Students began developing an MSTEM Acceleration car that will be utilized during the hands-on experiment of this module. This data collection activity is modified from the “Hardware Store Science” investigation where teams of students construct their own testing model using both familiar technology like hand tools and simple power tools (drill and jigsaw for example), by adding modeling software combined with 3D printing. In the process, students learn how to measure, cut, and join pieces of wood and/or plastic to build their own testing apparatus. Each of these activities provide opportunities for students to learn, not only in-depth science topics but how to assemble complex mechanical devices.

Hardware store science is based on the philosophy that students use materials available from the local hardware store during the building process, and create innovative ways of solving real world problems. Students are able to see integration of science, technology, engineering, and math as they apply their knowledge to investigating everyday phenomena. The key component of the hardware store science program is the projects and investigations. Each one includes basic making skills, integrates all components of STEM (Science, Technology, Engineering, Math), and provides an authentic means of encouraging student engagement. Each investigation is surrounded by a robust set of additional resources enabling the program to address state and national standards within a wide variety of topics during a one-year introductory physical science course like ICP (Integrated Chemistry and Physics).

The goal of engaging students with the STEM disciplines, by radically changing the educational delivery mechanism is to create greater student engagement and for them to become active participants in their learning success. The MSTEM Weighted Acceleration car investigation is the first challenge developed within this program of interesting, fun; topic centered inquiry experiments. Each investigation is used by a small team of students to discover key physical science principles while enhancing excitement and interest for science, the discovery process, and STEM career opportunities.

While this module focuses on understanding speed, velocity, and acceleration, students will also learn to derive units of measurement from 7 fundamental units: length, mass, time, current, temperature, amount, luminous intensity. The content in future modules will build upon these concepts. The complete set of Hardware Store Science experiments covers each of the mechanics, chemistry, and electricity topics in a typical Integrated Chemistry Physics (ICP) science course. The focus is not changing the content, just the delivery mechanism. Hardware Store Science incorporates an easily understandable 5-E lesson approach (engage, explore, explain, engineer, evaluate) that aligns with the most up to date research into the learning process of all students (not just the academically gifted). Each activity provides students with an opportunity to learn fundamental science content while integrating career specific technology, principles of engineering, and applied mathematics.

Purpose and Learning Objectives

Statement of Purpose

This is an extended lesson that will take approximately 8 days to complete. Students begin with housekeeping items. Discussing and laying out expectations is an important factor in setting up the course and providing students with a context for the learning they will experience during the course.

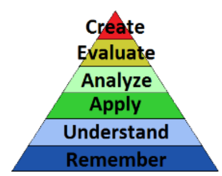
Students will review their understanding of speed and velocity by looking at how to describe motion. During this discussion, focus will be put on frames of reference, distance versus displacement, and comparing and contrasting speed and velocity. Students will successfully complete a mini activity requiring them to determine the speed at which a stack of dominoes falls over.

Next, students will review acceleration as the teacher uses a weighted acceleration car to discuss how to calculate acceleration, the scientific definition of acceleration, and Newton's 1st and 2nd laws. Students will practice using the equation for acceleration as they solve for unknown variables. Students constructing their own weighted acceleration car will follow this and investigate how acceleration varies based on height of an inclined ramp and weight of the car. Students are then encouraged to explore additional variables that may affect acceleration.

As students become familiar with the base units of measurement, they will be guided through a discussion on the importance of units in science and engineering. This discussion will center on the use of proper terminology, derived units versus base units, and unit conversions. This knowledge is fundamental to everything else throughout the course, and leads directly into a discussion on motion and force review. This review is for gauging student understanding, as this will be expanded upon over the next 4 modules: Levers, Pulleys, Energy Storage, and Launching Station I.

Guiding Question

How can the motion of an object be described using time and distance measurements?



Learning Objectives **(SWBAT)**

- Demonstrate an understanding of motion terms and equations by solving story problems involving speed and velocity.
- Demonstrate and understanding of motion terms and equations by solving story problems involving acceleration.
- Identify derived and base units while converting between different systems of measurement.
- Investigate the relationship between an object's mass and its motion using velocity and acceleration data.
- Demonstrate an understanding of speed, velocity, acceleration, and units by obtaining a minimum score of 70% on the prior knowledge review assessment.

Deliverables

Measuring Motion Review
Acceleration Review
Units and Quantities Vocabulary Terms (Optional)
Units and Quantities Conversions
Dimensions Quantity Analysis
Systems of Measurements
Testing Reaction Time Quick Lab
Weighted Acceleration Car Investigation

Speed Velocity Acceleration Review Practice Problems

Topics Covered

Science	Technology	Engineering	Math	Polytechnic Skills
Speed Velocity Acceleration Measurement Units	3D Printing Hand Tools Measuring instruments Video Recording Fabrication	Design Process Peer Review Accuracy	Manipulation of equations Units Unit Conversion	Measurements Design Skills Documentation Skills Computer Skills Presentation Skills

Lesson Timeframe

Traditional Classroom – 8 Days (45-55 minutes)

Key Concepts

- Acceleration
- Balanced Force
- Conversion Factor
- Distance
- Force
- Length
- Mass
- S.I. Units
- Speed
- Unbalanced Force
- Unit of measurement
- Velocity

Global/Local Issue

In this lesson students will engage in activities and topics related to the motion of objects. objects in motion are a fundamental aspect of everyday life, occurring within career fields, public life, and political situations. Specifically, students will learn accurate ways of describing, quantifying, and analyzing motion in a manner that can be communicated globally. Student teams will creatively explore systems of measurement and determine ways of quantifying and describing motion based on interacting forces. Finally, students will gain an appreciation for issues regarding automotive safety and travel as it relates to inclined surfaces.

Enduring Understanding

Students will understand that objects located on inclined surfaces have forces acting upon them directed towards the bottom of the incline. Students will use modeling and testing as a means of refining ideas and understanding of topics. Students will be aware of the fact that the design process is fundamental to all aspects of STEM education and careers. Students will accurately convert between different units of measurements, scaling quantities up and down as needed to accomplish tasks. Students will apply terms representing object motion in a manner that provides an accurate representation of observed phenomenon. Students will understand the value of collecting accurate and consistent data during laboratory investigations and activities.

Required Prior Knowledge & Skills

- Ability to describe basic motion of objects (speed, velocity, acceleration, etc.)
- Some experience technical drawing (using ruler, scale, labeling, etc.)
- Hand tool use (basic understanding of how to use hand tools - hand saw)

Assessment

- ***Weighted Acceleration Car Investigation*** to assess student understanding of speed and acceleration associated with an incline plane; speed and acceleration data and computational analysis.

- ***Speed, Velocity, Acceleration Practice Problems*** to assess student learning and understanding of speed, velocity, acceleration, and the concept of force without mathematical calculations.
- ***Activity: Testing Reaction Time*** to assess student understanding of collecting data, time management, computational analysis, and ability to follow directions with minimal supervision
- ***Speed, Velocity, Acceleration Practice Quiz*** to assess student understanding of speed versus velocity, acceleration, and converting between units

Instructional Sequence and Duration – 7-8 DAYS *(Classroom duration assumed to be 45-55 minutes in length)* Purchase materials for building weighted acceleration cars to be utilized when investigating velocity and acceleration during the Weighted Acceleration Car Investigation. Arrange for the construction of enough 4-foot tracks to use as incline planes for the weighted acceleration car investigation.

Engage: Students will engage in classroom discussions and activities designed to review the fundamentals of speed and velocity learned during previous science classes. Students will review how to identify motion and develop an understanding of frames-of-reference as well as a working knowledge of distance, displacement, speed, and velocity. Students will apply the concepts of speed and velocity while investigating the optimal distance between dominoes in order to maximize the rate at which they topple over. If time permits, students may participate in an optional activity requiring them to apply velocity and displacement to rocket motion. (*lesson Duration: 75-85 minutes)* ***(ICP1.1, 1.3, 1.4)***

Lead In: 10 – 15 minutes

1. **Objective:** Demonstrate an understanding of motion terms and equations by solving story problems involving speed and velocity. *(This should be written in a prominent location within the classroom and easily identifiable by students.)* Provide students with a copy of the ***Lesson Log*** as they enter the classroom.
2. **Bell Assignment/Affirmations/Good News/Objectives** *(7-10 minutes)*
   - **Warm Up -** *(4-5 minutes)*
     - Have students answer the questions in the Warm-up/Do Now section of their daily lesson log, their engineering notebook, or their science journal/notebook.
       1. Define velocity. *(Velocity is a vector quantity that describes the rate at which an object's position changes)*
       2. Explain the difference between speed and velocity. *(Answer vary, velocity requires a direction while speed does not)*
       3. Explain the difference between distance and displacement *(Answers vary, should be similar to - distance is the of the route taken from point A to point B while displacement is the straight line measurement between point A and B.)*
3. **Agenda/Activities –** Point out the objective and have students record this in their Lesson Log/Notes. Point out key activities that directly relate to the stated objective. Connect student prior knowledge with the day's objective and build upon student background knowledge. Explain what students will need to complete, and turn in, by the end of the class period.

Activity: 50 – 60 minutes

4. **Teacher Demonstration, Observing Motion,** Start walking around the room and **ask** students how they know that you are moving. *(Accept all answers.)* Then, stop moving and instruct students to close their eyes. While the students' eyes are closed, quietly move to another location in the room. Tell students to open their eyes and **ask** if you've moved and how they know that you moved. *(Sample answer: You used to be next to your desk and now you aren't.)* **Ask** students if Earth is

moving and how they know that it is moving. *(Accept all answers.)* **Ask** students how early astronomers learned that Earth is moving. *(Astronomers saw that the positions of the sun and the stars changed and realized that the motion of Earth caused those changes.)* Finally, lead a discussion about detecting motion. Help students understand that motion is observed when an object changes position in relation to a frame of reference. Have students take notes during this discussion in their Lesson Log etc.

Demonstration Note:

- Doing this activity will help students understand the importance of using accurate terminology when describing motion. By beginning with students describing observable motion they are able to successfully connect working vocabulary with the concept of motion. Having students repeat the process with their eyes closed requires them to make more concrete, data driven, observations.
- By asking "how" questions, students are challenged to defend their reasoning using terms, phrases, and comparisons that are rooted in measurable units, quantities, and values. This will naturally lead into a discussion on frame of reference, distance versus displacement, and speed versus velocity.

5. **Teaching Key Ideas,** Remind students that they are to record all notes in the Daily Notes section of their Daily Log. If more space is needed, students may use the Classroom Activity section provided they leave space for recording information about the day's activity.
    a. **Frames of Reference and Motion,** Explain to students that anything near a moving object can be used as a frame of reference for describing motion. The chalkboard in a classroom can be a frame of reference for anything in the room. A tree outside can be a frame of reference for a bird flying by. Further, explain that motion can sometimes be described by using more than one frame of reference. For example, a person sitting on a bus is not moving in relation to the seats in the bus, but the person is moving in relation to the ground. **Ask** students to describe other frames of reference. *(Sample answers: A train station is a frame of reference for a train. A city is a frame of reference for an airplane.)*
    b. **Distance Versus Displacement** Use the following questions to help students distinguish between distance and displacement: **Ask** "Would you use distance or displacement when calculating how many gallons of gas you will need for a road trip?" *(distance)* **Ask** "Which does the saying 'as the crow flies' refer to?" *(displacement)* **Ask** "Would my motion earlier, be discussed as displacement or distance?" *(If length was measured from start point to stop point ONLY, then it is displacement. If length was measured from start point to stop point, and all the twists and turns in between, then it is distance.)*
    c. **How are Speed and Velocity Different?** Help students distinguish between speed and velocity by describing a car moving at constant speed as it rounds a curve. The speed remains constant, but its velocity has changed because the direction in which the car is moving has changed. Point out that cars have *speedometers*, not "velocitometers." It may be helpful to point out to students that the direction of the velocity vector is simply the same as the direction that an object is moving. It does not matter whether the object is speeding up or slowing down. If an object is moving downwards, then its velocity is described as downwards.
6. **Quick Lab, Measuring Speed, Materials per Group: 25** dominoes, meter stick, stopwatch. **Explain** to students that they will Stand up 25 dominoes in a straight line. Ensure that students keep equal spacing between individual dominoes. Next use a meter stick to measure the total length of their row of dominoes and record the length. Finally, upon the signal from the teacher students will tip over the first domino and use a stopwatch to time how long it takes for all of the dominoes to fall. Repeat this process 2-3 more times using smaller and larger distances between the dominoes.

Remind students that they are to record all information about this activity in the Classroom Activity section of their Daily Log.

Quick Lab Notes:

- It may be helpful to create a slide with the directions for this activity. No formal instructions or data sheet has been given for this activity as it is assumed that students have experience with setting up and knocking down dominoes. The important aspect of this activity is for students to get use to timing the length of an observable phenomenon. Learning to accurately start and stop a stopwatch will increase the accuracy of future collected data sets.
- Students can line up their dominoes along the edge of the meter stick to ensure that the dominoes are in a straight line. Ask students to calculate the average speed for each trial, by dividing the total length of the line of dominoes by the time that it takes the dominoes to fall. **Ask** "How did the spacing between dominoes affect the average speed?" *(Putting dominoes very close together and putting them very far apart both lead to slower average speed. The average speed is fastest when the distance between the dominoes is about half the length of a domino.)* **Ask** "Is this the result that you expected?" *(Students will likely find that the results do not confirm their predictions. They will probably have predicted that placing the dominoes very close together would increase the average speed.)*
- You may wish to invite students to download an app that will allow them to create videos of their observation with a stopwatch included. This would allow students to more accurately assess start points and end points of an observation. These videos can be used to support reports, presentations, and discussions.
- It is important to end this activity with the question "Is this the result that you expected?" All students complete an activity expecting some sort of outcome. It is important for students to voice this expected outcome and relate that outcome to the observed result. This is an important aspect of doing science. Students need practice with predicting outcomes based on prior knowledge. As student knowledge increases, their expected outcomes should take into account new knowledge and blend that knowledge with prior experience. This is the essence of scaffolding and development of analytical reasoning.

7. ***Optional Student Activity, Rocket Motion*** *There is a lot of cool data on the NASA website https://forum.nasaspaceflight.com/ index.php?topic=40983.0 On the website there are videos of space launches from NASA, SpaceX, etc., where the author has then processed the data to get the altitude and velocity from the launch videos. Have the students download some of the launch data and have students create a 3 to 5-minute presentation on their space launch. Have students include images and a discussion concerning distance (i.e. the total distance that the spacecraft has traveled), displacement (i.e. the difference between vertical distance and horizontal distance), speed, and velocity (with the* δ_r *component perpendicular to the earth and the* δ_θ *direction tangent to the surface of the earth)*

Wrap-up: 5 – 8 minutes

8. **Close and Launch –** Direct student attention to the daily objective. Ask for a student volunteer to read the day's objective and discuss how they were able to meet the day's objective. *(Take a moment to review the day's activities and how they relate to the stated objective)*
   - **Assignment - Measuring Motion Review,** Distribute worksheet 4.3a and **a**ssign questions 1-6 as a review. This assignment consists of word problems at a basic understanding level.
   - **Exit Ticket/Assessment –** *(Display the daily exit ticket and have students complete their exit ticket in the appropriate section of the lesson log.)* Have student pairs answer the following questions in the Exit Ticket section of their Daily Log.
     1. What is one thing you learned today that you didn't know before? *(Answers vary – should*

be directly related to classroom notes and/or activity.)

2. How would you convert MPH to inches per second? *(Accept all reasonable answers. Convert miles to inches and hours to seconds then divide, or, multiply MPH by a conversion factor. This question is meant to gauge student knowledge in preparation for future lessons.)*

- **Collect – Lesson Log,** This should contain the questions from the warmup activity, Lesson Objective, Notes taken during classroom discussion, Classroom Activity, and answers to the Exit Ticket. *(End each lesson with a positive and encouraging statement for students to remember as they leave the classroom)*

Explore: Students will expand upon their knowledge of speed and velocity by reviewing acceleration. Students will learn to identify positive and negative acceleration, while observing the motion of an object. Students will use observed motion to calculate the magnitude of acceleration. Students will connect changes in velocity to acceleration and explain the difference between constant velocity and constant acceleration. If time permits, students will learn to identify the components of centripetal acceleration. This topic will be covered in depth later in the course. *(Lesson Duration: 45-55 minutes)* ***(ICP.2.1, 2.2)***

Lead In: 10 – 15 minutes

1. **Objective:** Demonstrate and understanding of motion terms and equations by solving story problems involving acceleration. *(This should be written in a prominent location within the classroom and easily identifiable by students.)* Provide students with a copy of the ***Lesson Log*** as they enter the classroom.
2. **Bell Assignment/Affirmations/Good News/Objectives** *(7-10 minutes)*
   - **Warm Up -** *(4-5 minutes)*
     - Have students answer the questions in the Warm-up/Do Now section of their daily lesson log, their engineering notebook, or their science journal/notebook.
       1. Define acceleration. *(Acceleration is a vector quantity that is defined as the rate at which an object changes its velocity)*
       2. Explain how acceleration is different from speed or velocity. *(Answer vary, is the rate at which speed or velocity changes)*
       3. Explain how acceleration is similar to speed and velocity *(Answers vary, all three deal the time required to travel a given distance)*
3. **Agenda/Activities –** Point out the objective and have students record this in their Lesson Log/Notes. Point out key activities that directly relate to the stated objective. Connect student prior knowledge with the day's objective and build upon student background knowledge. Explain what students will need to complete, and turn in, by the end of the class period.

Activity: 30 – 35 minutes

4. **Demonstrate, Acceleration,** You will need to build your own weighted acceleration car. This will allow you to know how to best assist groups as they build their cars during the next lesson. Use your car, an inclined plane, tape, stopwatch, and tape measure during this demonstration. Set up a ramp using a 4-foot section of "track" and a stack of textbooks. Have a student volunteer release the car from the top of the ramp. Ask students to observe the motion of the car. **Ask** "Where is speed the slowest?" *(top)* **Ask** "Where is speed the fastest?" *(bottom)* Discuss the locations of lowest speed and highest speed in terms of gravity and its ability to pull objects down. Repeat at a different angle and/or with added weight. Add quantitative values by asking a student to timing the runs. This can be done by placing a piece of tape near the top of the plane to serve as a start line and at the bottom to serve as a stop line for starting and stopping the stopwatch. Measure the

length of the plane. Have students record the time for several trials. Calculate the velocity and acceleration of the car down the ramp.

5. **Teaching Key Ideas Discussion,**
   a. **Calculating Acceleration,** Explain to students, in order to find the acceleration of an object moving in a straight line, you need to measure the object's velocity at different points.

$$acceleration = \frac{final\ velocity - initial\ velocity}{time}$$

$$a = \frac{\Delta v}{t}$$

   Point out that the change in an object's velocity is symbolized by Δ*v* *(delta V)*. Explain to students that some acceleration problems give only one numerical value for velocity to use in the calculation. Explain to students that they must read the problem carefully to determine the other value of velocity to use. For example, if an object starts at rest, its initial velocity is zero. Similarly, if an object comes to a stop, its final velocity is zero. Students should also learn to look for word clues such as "twice as fast" and "half the original speed."

   b. **Vocabulary,** Some students may associate a negative acceleration with the term *deceleration.* In science, acceleration can be either positive or negative. Speeding up is a positive acceleration, while slowing down is a negative acceleration. Provide students with situations where the acceleration would be negative and discuss what this value is saying about the object's motion

   c. **Changes in Direction,** Students may wonder why a change in direction is considered to be an acceleration. At this point, emphasize that because velocity involves both magnitude and direction, a change in either is a change in velocity, or acceleration. You can return to this concept when students study Newton's 2nd law. According to this law, force is proportional to acceleration. Any object experiencing a net force – such as a satellite in orbit around Earth acted upon by the force of gravity – must accelerate. (See optional demonstration below)

6. **Math Skills, Acceleration,** Walk students through solving the following sample problem. A flowerpot falls off a second-story windowsill. The flowerpot starts from rest and hits the sidewalk 1.5 s later with a velocity of 14.7 m/s. Find the average acceleration of the flowerpot.

   Given:

   time, t = 1.5 s

   initial velocity, v_i = 0 m/s

   final velocity, v_f = 14.7 m/s down

   Unknown:

   acceleration, a = ? m/s^2 (and direction)

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{14.7\frac{m}{s} - 0\frac{m}{s}}{1.5s} = 9.8\frac{m}{s^2}$$

   Display the following scenarios and have students work in pairs to solve the problem then invite different class members to share their solution to a problem with the rest of the class.

   a. Natalie accelerates her skateboard along a straight path from 0 m/s to 4.0 m/s in 2.5 s. Find her average acceleration.

   b. A turtle swimming in a straight line toward shore has a speed of 0.50 m/s. After 4.0 s, its speed is 0.80 m/s. What is the turtle's average acceleration?

c. Find the average acceleration of a north-bound subway train that slows down from 12 m/s to 9.6 m/s in 0.8 s.
d. Mai's car accelerates at an average rate of 2.6 m/s2. How long will it take her car to speed up from 24.6 m/s to 26.8 m/s?
e. A cyclist travels at a constant velocity of 4.5 m/s westward and then speeds up with a steady acceleration of 2.3 m/s2. Calculate the cyclist's speed after accelerating for 5.0 s.

7. **Optional Demonstration, Centripetal Acceleration,** If you do not have a safe area in which to do this demonstration you may choose to take students outside or the gymnasium to demonstrate centripetal acceleration. Demonstrate the circular motion of a ball twirled at the end of a string. As you twirl the ball, **Ask** students, "Is this ball changing speed?" *(no)* **Ask** "Is this ball changing direction as I twirl it?" (yes) "Is this ball accelerating?" (yes) "What kind of acceleration is taking place?" *(centripetal acceleration)* **Ask** "How would this ball move if I were to let go of the string?" *(The ball would fly in a straight line.)* Make sure students are out of the way, then release the ball so students can observe the ball's straight-line motion.

Wrap-up: 5 – 8 minutes

8. **Close and Launch –** Direct student attention to the daily objective. Ask for a student volunteer to read the day's objective and discuss how they were able to meet the day's objective. *(Take a moment to review the day's activities and how they relate to the stated objective)*
   - **Assignment - Acceleration Review,** Distribute worksheet 4.3b and assign questions 1-5 as a review. This assignment consists of word problems at a basic understanding level.
   - **Exit Ticket/Assessment –** Have student pairs answer the following questions in the Exit Ticket section of their Daily Log.
     1. What is one thing you learned today that you didn't know before? *(Answers vary – examples would include that acceleration could be positive or negative. Another might be that the ball traveled in a straight line after being released.)*
     2. Why is it important to distinguish the difference between positive and negative acceleration? *The sign of acceleration tells whether the object is decreasing in velocity or increasing in velocity.)*
   - **Collect – Measuring Motion Review, Lesson Log,** This should contain the questions from the warmup activity, Lesson Objective, Notes taken during classroom discussion, Classroom Activity, and answers to the Exit Ticket. *(End each lesson with a positive and encouraging statement for students to remember as they leave the classroom)*

Explain: Students will identify key features associated with units applied to numerical values. Students will explain how units are derived from fundamental measurements of length, mass, time, volume, current, temperature, luminous intensity, and amount of substance. Students will apply the SI system of measurement to the fundamental and derived units and convert between different types of units and systems of measurement. Finally, students will work backwards from a derived unit and determine the fundamental units that make up the unit in question. *(Lesson Duration: 75-85 minutes)* ***(PS.4, 6)***

Lead In: 10 – 15 minutes

1. **Objective:** Identify derived and base units while converting between different systems of measurement. *(This should be written in a prominent location within the classroom and easily identifiable by students.)* Provide students with a copy of the ***Lesson Log*** as they enter the classroom.
2. **Bell Assignment/Affirmations/Good News/Objectives** *(7-10 minutes)*

- **Warm Up -** *(4-5 minutes)*
    - Have students complete warmup/bell ringer activity. **MUTT Article, NASA Finally Goes Metric,** Use your own mark-up the text strategy or have students do the following. Have students read the article. As they do so, have them mark-up the text by putting a circle around key terms and underlining the definitions. Have students place an exclamation point (!) next to information they find interesting. Have students place question marks next to items students do not understand or they question. Have students place a star next to the article's key statement.

3. **Agenda/Activities –** Point out the objective and have students record this in their Lesson Log/Notes. Point out key activities that directly relate to the stated objective. Connect student prior knowledge with the day's objective and build upon student background knowledge. Explain what students will need to complete, and turn in, by the end of the class period.

Activity: 50 – 60 minutes

4. **Classroom Discussion, Units and Quantities Vocabulary,** Use this slideshow to facilitate a discussion about units of measurement. Ensure students understand the difference between "standard" and "metric" systems of measurement. Discuss the seven (7) base units of measurement and their symbols. Introduce the idea of derived units by discussing the units for acceleration. You may choose to utilize the Units and Quantities Vocabulary worksheet 4.3c in addition. If so, work with students to complete the practice problems.
5. **Classroom Activity, Units and Quantities Conversions Practice,** Distribute activity sheet 4.3d, Units and Quantities Conversions. Point out that the background information is a review of the classroom discussion, followed by information about unit conversions. Ensure students are aware of the diagram illustrating how derived units are formed. Talk through the section titled "The Conversion Factor" by working through the practice problem. Assign students to complete question 1 then review their answers. Point out potential errors and how to correct mistakes. Allow student time to complete questions 2-10. This can be done individually or with a partner.
6. **Small Group Activity, System of Measurements,** Divide students into groups of 3 to 4 individuals and distribute the Systems of Measurements 4.3f worksheet. Explain to students that in 1958 a group of students at MIT decided to create their own measurement system for the length of the bridge between Boston and Cambridge across the Charles River. Their unit of measurement was Oliver R. Smoot who was an MIT freshman, whom they laid end-to-end and then painted a mark on the bridge every 10 smoots. The length of the bridge is 364.4 smoots + 1 ear, where each smoot is 5ft and 7in in the more conventional English system of units. The smoot marks on the bridge are painted every year by MIT students, and it is the official unit of measure on the bridge – when there is an auto accident on the bridge the police report that it happened, for example, at the 270 smoot mark. Oliver Smoot went on to become president of both the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO). Assign each group the task of creating their own unit of measure for determining the length of objects (large and small). Their measurement system must include a minimum of 4 distinct lengths (similar to the concept of - inch, foot, yard, mile or millimeter, centimeter, meter, kilometer). Groups will use their system to determine the length of a football field, the length of a pencil, the distance to your home, and the height of a flagpole. They will then create a short presentation explaining their measurement system. Presentation must include: Name of your system; Each length division - name and sample measurement using that division; Comparison to either the metric or standard measurement system.

Wrap-up: 5 – 8 minutes

7. **Close and Launch –** Direct student attention to the daily objective. Ask for a student volunteer to read the day's objective and discuss how they were able to meet the day's objective. *(Take a moment to review the day's activities and how they relate to the stated objective)*
   - **Assignment – Dimensions and Quantity Analysis,** Assign students to read the background information and complete the two questions.
   - **Exit Ticket/Assessment –** Have students transfer, or complete, questions 8-10 from their Units and Quantities Conversions worksheet to the Exit Ticket section of their Daily Log.
     1. A block occupies 0.2587 ft^3. What is its volume in mm^3?

$$0.2587ft^3 = \frac{1{,}728in^3}{1ft^3} \times \frac{16.387cm^3}{1cm^3} = \frac{1{,}000mm^3}{1cm^3} = 7{,}325{,}568mm^3 = 7.3x10^6mm^3$$

     2. If you are going 55 mph, what is your speed in meters per second?

$$55MPH = \frac{55miles \times \frac{5280ft}{1mile} \times \frac{12in}{1ft} \times \frac{2.54cm}{1in} \times \frac{1m}{100cm}}{1hr \times \frac{60min}{1hr} \times \frac{60s}{1min}} = \frac{88{,}513.92m}{3{,}600s} = 24.6\frac{m}{s}$$

     3. If the density of an object is 2.87 lbs/cubic inch, what is its density in g/mL?

$$2.87\frac{lb}{in^3} = \frac{2.87lb}{1in^3} = \frac{2.87lb \times \frac{454g}{1lb}}{1in^3 \times \frac{16.387cm^3}{1in^3} \times \frac{1{,}000mL}{1cm^3}} = \frac{1{,}303g}{16{,}387mL} = 0.08\frac{g}{mL}$$

   - **Collect – Acceleration Review, Units and Quantities Conversion Practice, Lesson Log,** This should contain the questions from the warmup activity, Lesson Objective, Notes taken during classroom discussion, Classroom Activity, and answers to the Exit Ticket. *(End each lesson with a positive and encouraging statement for students to remember as they leave the classroom)*

Engineer: Students are organized into lab groups of 3 to 4 individuals and tasked with the creation of a four wheeled "car" for investigating how mass affects velocity and acceleration of the car as it travels down an incline plane. Group members will utilize a common wood saw for cutting 1/4 thick wood material that will allow them to attach wheels. Their car must allow them to add weight in different locations and ensure the added weight remains attached to the car during its journey down the incline plane. Groups will collect time and distance measurements as the car travels down the incline plane and on level ground after leaving the incline plane. Students will review instruction received on the use of hand saws, cordless drill/drivers, and a standard retractable tape measure. *(Classroom Duration: 90-110 minutes)* ***(SEPS.2, 3, 4; PS.4, 6; ICP.1.4, 2.1, 2.2; IED-0.1, 2.6; POE-5.3, 5.4)***

Investigation Note:
The resources required for this investigation are dependent upon which investigation model chassis you decide to have students design and build.

Wood Model
1/4 plywood (2-1/4 inches wide)
4 – (1/4 x 3/4) # 6 screw spaces
Hand Saw with Miter Box
Standard tape measure
Hot glue gun
Scale
EUDAX 82 pcs Plastic Gear Set with Wheels and Axles

3D Printer Model
3D Printer with filament
#1 Phillips head screwdriver
Standard tape measure
Hex Nuts (3/4" - 10 Grade 2 Course Thread)
Hot glue gun
Scale
Model .STL file – downloadable version of the model illustrated can be found at https://www.tinkercad.com/things/4GO9Jw4ZSed

EUDAX 82 pcs Plastic Gear Set with Wheels and Axles

It is important to ensure that each group has access to the equipment, tools, and supplies to conduct the investigation. This does not mean each group has all equipment and tools, nor would each group need an incline plane, as these items may be shared. You will need to fabricate an appropriate ramp prior to data collection. One way to do so would be the following.

Weighted Acceleration Car Build Instructions for Educator

1. Use a table saw to cut a 2 x 2 sheet of 1/4 inch plywood into 2-1/4-inch-wide strips, creating 8 – 24-inch-long boards.
2. Use a table saw to cut a 4 x 4 sheet of 1/4 inch plywood into 6-inch-wide strips, creating 8 – 48 inch long boards.
3. Complete the track by attaching a piece of cereal box cardboard one end of the board. This will allow for a smoother transition from the inclined surface of the track to the flat surface of the tabletop or floor.
   - It is helpful to use a piece of painter's tape to attach the cardboard to the surface of the 6" x 48" piece of plywood. 1 cereal box would complete 8 ramps.
4. It will be important to assist students in ensuring that the screw spacers line up with the grooves cut into their car chassis. Help students accomplish this by reminding them to use a firm pressure when setting the screw spacers in the hot glue.

It is assumed students are familiar with some sort of reporting style and format, based on their previous experience within a science classroom. This experiment can easily be turned into a formal Lab Report, mini Science Fair, Classroom Presentation, or even Journaling activity. It is encouraged however to use a rubric similar to the one included in the teacher resources as a means of assessing student learning and skill progress.

Lead In: 10 – 15 minutes

1. **Objective:** Investigate the relationship between an object's mass and its motion using velocity and acceleration data. *(This should be written in a prominent location within the classroom and easily identifiable by students.)* Provide students with a copy of the ***Lesson Log*** as they enter the classroom.
2. **Bell Assignment/Affirmations/Good News/Objectives** *(7-10 minutes)*
   - **Warm Up -** *(4-5 minutes)*
     - Have students answer the questions in the Warm-up/Do Now section of their daily lesson log, their engineering notebook, or their science journal/notebook.
       1. Explain what you think will happen to the distance the car travels after leaving the ramp, as mass increases. *(Answers vary, accept all logical explanations, point out errors in explanations to individual student responses)*
       2. What force do you think is causing the car to accelerate down the ramp? *(Gravity)*
       3. What force do you think causes the car to slow down and stop, after leaving the ramp? *(Friction between the axle and the chassis)*
3. **Agenda/Activities –** Point out the objective and have students record this in their Lesson Log/Notes. Point out key activities that directly relate to the stated objective. Connect student prior knowledge with the day's objective and build upon student background knowledge. Explain what students will need to complete, and turn in, by the end of the class period.

Activity: 90 – 105 minutes

4. **Maker Time, Building Acceleration Car,** Divide students into groups of 2 or 3. Distribute the Weighted Acceleration Car Investigation Data Sheet 4.2a/b to student groups. Take a couple minutes to discuss the Build It Yourself section with students. If students are to complete the entire build process, discuss how to use a hand saw, drill/driver, tape measure, and/or screwdriver. Ensure students understand classroom expectations while using hand tools. If students are not completing the entire build process, be sure to discuss those aspects that apply to their build process. Point out the materials available to them as well as any special instructions that relate to your classroom, then assist groups with the build process. ***If you are using the MSTEM Accel Car model created during the engineering design process lessons, you will need to communicate the changes to the investigation sheet to students. This means that students would not be completing the build process as they will have already 3D printed and assembled their MSTEM Acceleration Car Chassis.***
5. **Data Collection, Weighted Acceleration Car Investigation,**
    a. Have groups complete the first experiment from this activity. Take a couple minutes to explain the information in the Background Information section of their packet and data collection. Then, move around the classroom and assist students as needed. Ensure students are collecting data that is fairly consistent between runs.
    b. Once students have collected their data, have them calculate the velocity and acceleration of their car. Assist groups with these calculations as needed.
    c. Assign groups to complete the data analysis section of their investigation data sheet and any exploration activities you deem appropriate. At this point you may collect their packets or have them complete a more formal lab report. If a report is collected, you may consider grading it using the scoring rubric which accompanies this unit. Always grade for accuracy of answers, use of collected data, and supporting evidence.

Wrap-up: 5 – 8 minutes

6. **Close and Launch –** Direct student attention to the daily objective. Ask for a student volunteer to read the day's objective and discuss how they were able to meet the day's objective. *(Take a moment to review the day's activities and how they relate to the stated objective)*
    - **Assignment – Velocity and Acceleration Using a Weighted Car,** Assign any data analysis questions not completed during class as homework.
    - **Exit Ticket/Assessment –** Have student pairs answer the following questions in the Exit Ticket section of their Daily Log.
        1. What is one thing you learned today that you didn't know before? *(Answers vary – Example would be the distance traveled after the ramp is nearly the same as the length of the ramp.)*
        2. Why is it important to distinguish between acceleration on the ramp and acceleration after the ramp? *Acceleration on the ramp is positive, causing the car to speed up. Accleration after the ramp is negative, causing the car to slow down.)*
        3. Make a copy of your data table in the classroom activity section of your lesson log.
    - **Collect – Dimensions and Quantity Analysis, Lesson Log,** This should contain the questions from the warmup activity, Lesson Objective, Notes taken during classroom discussion, Classroom Activity, and answers to the Exit Ticket. *(End each lesson with a positive and encouraging statement for students to remember as they leave the classroom)*

Investigation Scoring Rubric:

- Assigning grades on a percentage scale may not work with all experiments. The following rubric describes six levels of student performance associated with all experiments students conduct. To use this 4-point scale, read the description of each level and decide which description most accurately reflects each experiment you grade.

- A helpful strategy may be to create a file of past papers that you feel exemplifies each level of the rubric. These could be scanned and kept as a digital file or hard copy, whichever works best for you. You would then be able to make this file available to students as a guideline.

Evaluate: Students will participate in an activity designed to review their understanding of speed, velocity, acceleration, units, and balanced and unbalanced forces. They will be assessed on the module learning objectives and activities. The practice quiz assessment will cover speed, velocity, acceleration, units, and balanced and unbalanced forces. *(Classroom Duration: 45-55 minutes)* ***(ICP.1.1, 1.3, 1.4, 2.1, 2.2)***

Lead In: 10 – 15 minutes

1. **Objective:** Demonstrate an understanding of speed, velocity, acceleration, and units by obtaining a minimum score of 70% on the prior knowledge review assessment. *(This should be written in a prominent location within the classroom and easily identifiable by students.)* Provide students with a copy of the ***Lesson Log*** as they enter the classroom.
2. **Bell Assignment/Affirmations/Good News/Objectives** *(7-10 minutes)*
   - **Warm Up -** *(4-5 minutes) (See Module 1 Warm-up Activities and Exit Tickets)*
     - Have students complete warmup/bell ringer activity. **MUTT Article, Drag Racing History**, Use your own mark-up the text strategy or have students do the following. Have students read the article. As they do so, have them mark-up the text by putting a circle around key terms and underlining the definitions. Have students place an exclamation point (!) next to information they find interesting. Have students place question marks next to items students do not understand or they question. Have students place a star next to the article's key statement.
3. **Agenda/Activities –** Point out the objective and have students record this in their Lesson Log/Notes. Point out key activities that directly relate to the stated objective. Connect student prior knowledge with the day's objective and build upon student background knowledge. Explain what students will need to complete, and turn in, by the end of the class period.

Activity: 30 – 35 minutes

4. **Quick Lab Activity, Testing Reaction Time,** Distribute Testing Reaction Time Activity and have students work with partners to do this activity. During this activity one student drops a meter stick while the other student attempts to grab the meter stick before it hits the ground. Students will take turns dropping the meter stick and collecting data on the other student in order to determine each student's reaction time.
5. **Classroom Practice, Speed Velocity Acceleration Review,** Distribute Practice Problems Student Activity Sheet 4.4. Have students complete the practice problems. This may be collected and graded for accuracy.
6. **Assessment, Speed, Velocity, Acceleration Practice Quiz,** If time permits, you may wish to have students complete the unit quiz as their exit ticket for the day. This quiz is 10 questions long and has students work problems from each lesson from this module. The quantities for each question have been changed, however the wording and method for solving the problems remains the same.

Wrap-up: 5 – 8 minutes

7. **Close and Launch –** Direct student attention to the daily objective. Ask for a student volunteer to read the day's objective and discuss how they were able to meet the day's objective. *(Take a moment to review the day's activities and how they relate to the stated objective)*
   - **Assignment -** No homework is assigned this lesson due to students completing the module assessment.

- **Exit Ticket/Assessment –** No exit ticket is assigned this lesson due to students completing the module assessment.
- **Collect – Weighted Acceleration Data Sheet, Speed Velocity Acceleration Review, Practice Quiz, Lesson Log,** This should contain the questions from the warmup activity, Lesson Objective, Notes taken during classroom discussion, Classroom Activity, and answers to the Exit Ticket. *(End each lesson with a positive and encouraging statement for students to remember as they leave the classroom)*

Tools / Materials / Equipment: *Required tools, materials, and equipment to fully utilize the lesson plan.*

Investigation Materials per group
- 1/4 plywood (2-1/4 inches wide) (1/4" x 2 x 2 ACX Handi-Panel, $5.19 @ Menards)
- 4 – (1/4 x 3/4) #6 Screw Spacer (Midwest Fastener® #6 x ¼" x ¾" Aluminum Spacer for $0.79 @ Menards)
- EUDAX 82 pcs Plastic Gear Set with Wheels and Axles ($8.99 @ https://www.amazon.com/EUDAX-Plastic-Assortment-accessories-Bushings/dp/B0776ZPP7V?ref_=ast_sto_dp) *This set will be used for future investigations into gears, and during the Chemistry and Electricity Modules*
- Dominoes (Double Nine Dominoes in Tin, $9.97 @ Walmart)
- Yardstick (36" Yardstick, $0.89 @ Menards)
- Hex Nuts (Midwest Fastener ® 3/4" - 10 Zinc Grade 2 Course Thread Hex Nut – 87 Count, $23.61 @ Menards)
- Hand Saw with Miter Box base (MasterForce® 14" Hand Back Saw with Miter Box, $7.98 @ Menards)
- Tape measure (Performax 12 foot, $4.99 @ Menards)
- Hot glue gun with glue stick (Best 20-Watt Hot Glue Gun with 25 Bonus Sticks, $3.99 @ Menards)
- Small Carpenter's Square (12-inch Plastic Combo Square, $4.99 @ Menards)
- Scale (Mainstays Slim Digital Scale, $14.86 @ Walmart)

Optional Materials
- 3-D Printed M-STEM Accel Car Body (STL file found at hardwarestorescience.org This file will open using Ultimaker Cura software, a free software download. The File can also be found at Tinkercad.com by searching M-STEM Accel Car Body)
- 3-D Printed M-STEM Wheels (STL file found at hardwarestorescience.org This file will open using Ultimaker Cura software, a free software download. The File can also be found at Tinkercad.com by searching M-STEM Wheels)
- 3-D Printed M-STEM Accel Car Body and Wheels (STL file found at hardwarestorescience.org This file will open using Ultimaker Cura software, a free software download. The File can also be found at Tinkercad.com by searching Chassis and Wheels)
- Wire Clothes hanger (10 pack, $1.44 @ Walmart)
- #20 O-Ring (1-3/16" O.D. x 1" I.D., $0.79 @ Menards) (Qty – 4)

Resources (Student, Teacher, & Assessment): *List of assessment tools, worksheets, or other teacher resources needed to assess the work done by students.*

- Documents
  - Daily Lesson Log
  - ABC Vocabulary Reading Strategy
  - Weighted Acceleration Car Investigation Data Sheet 4.2a
  - Reaction Time Investigation Data Sheet 4.2b
  - Measuring Motion Review Activity Sheet for Students 4.3a

- Acceleration Review Activity Sheet for Students 4.3b
    - Units and Quantities Vocabulary Activity Sheet for Students 4.3c
    - Units and Quantities Conversions Activity Sheet for Students 4.3d
    - Dimensions Quantity Analysis Activity Sheet for Students 4.3e
    - Systems of Measurements Activity Sheet for Students 4.3f
    - Speed, Velocity, Acceleration Practice Problems Activity Sheet for Students 4.4
    - Nasa Finally Goes Metric MUTT Article 4.5d
    - Drag Racing History MUTT Article 4.5e
    - Practice Problems Answer Key 4.5a
- Slideshow Presentations
    - Units and Quantities Vocabulary 4.3c
- Additional Resources
    - Speed Velocity and Vectors Activity Sheet for Students 4.3g
    - Prior Knowledge Warm-up Exercises Slideshow 4.5b
    - Middle School Science Review Slideshow 4.5c
    - MSTEM Accel Car Body STL file - (The File can also be found at Tinkercad.com by searching M-STEM Accel Car Body)
    - MSTEM Accel Car Topper STL file - (The File can also be found at Tinkercad.com by searching M-STEM Accel Car Body)

Vocabulary: *List of necessary, and unique, vocabulary for this lesson.*

- **Acceleration –** the rate at which an object changes its velocity. $acceleration = \frac{\Delta v}{t}$
- **Action –** the force acting in one direction
- **Balanced forces –** two forces acting in opposite directions on an object, and equal in size
- **Conversion Factor –** an arithmetical multiplier for converting a quantity expressed in one set of units into an equivalent expressed in another
- **Displacement –** a vector quantity representing the shortest distance from the initial to final position of an object in motion.
- **Distance –** a scalar quantity that refers to "how much ground an object has covered" during its motion
- **Force –** a push or pull upon an object resulting from the object's interaction with another object
- **Length –** the straight-line distance between two points
- **Mass –** the quantity of matter in a body regardless of its volume or of any forces acting on it.
- **Newton's 1st Law of Motion –** An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
- **Newton's 3rd Law of Motion –** For every action, there is an equal and opposite reaction.
- **Normal Force –** the support force exerted upon an object that is in contact with another stable object.
- **Scalar quantity –** A quantity that fully describes only a magnitude or numerical value
- **Speed –** The distance traveled per unit of time. It is how fast an object is moving. $speed = \frac{distance}{time}$
- **S.I. Units –** the modern form of the metric system
- **Unbalanced forces –** two forces acting in opposite directions on an object, and not equal in size
- **Unit of measurement –** a definite magnitude of a quantity, defined and adopted by convention or by law, that is used as a standard for measurement of the same kind of quantity
- **Vector quantity –** A quantity that are fully describes both a magnitude and a direction
- **Velocity –** A vector quantity that refers to the rate at which an object changes its position. $v = \frac{d}{t}$
- **Velocity –** A vector quantity that refers to the rate at which an object changes its position.
- **Vector quantity –** a quantity that is fully describes both a magnitude and a direction

Indiana Academic Standards

- Science and Engineering Process Standards:
  - SEPS.2 Developing and using models and tools
  - SEPS.3 Constructing and performing investigations
  - SEPS.4 Analyzing and interpreting data
- ICP Content Standards:
  - ICP.1.1 Develop graphical, mathematical, and pictorial representations (such as a motion map) that describe the relationship between the clock reading (time) and position of an object moving at a constant velocity and apply those representations to qualitatively and quantitatively describe the motion of an object.
  - ICP.1.3 Distinguish between the terms "distance" and "displacement," and determine the value of either given a graphical or mathematical representation of position vs. clock reading (time).
  - ICP.1.4 Distinguish between the terms "speed," "velocity," "average speed," and "average velocity" and determine the value of any of these measurements given either a graphical or mathematical representation.
  - ICP.2.1 Develop graphical, mathematical, and pictorial representations (such as a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a constant acceleration and apply those representations to qualitatively and quantitatively describe the motion of an object in terms of its change in position or velocity.
  - ICP.2.2 Describe the differences between average velocity and instantaneous velocity and be able to determine either quantity given a graph of position vs clock reading (time).
- Math Process Standards
  - PS.4 Model with mathematics – Apply math to everyday problems, use real-life situations to capture results (charts, graphs, etc.), represent using multiple ways
  - PS.6 Attend to precision – Communicate precisely, use terms and symbols appropriately, specify units of measure, and calculate accurately and efficiently
- Introduction to Engineering Design Standards
  - IED-0.1 Students will exhibit appropriate safety practices while working with tools and equipment – Demonstrate relevant safety practices when using tools and equipment as determined by task, materials, environment, and protective attire. Apply corrective action(s) to eliminate hazards.
  - IED-2.6 Students will produce industry standard sketches and drawings to allow for universal communication – Interpret and develop appropriate annotations for technical drawings. Determine the appropriate number of views, including alternate views (auxiliary, section, detail), to fully document the details of a design. Apply industry accepted dimensioning practices to technical drawings in order to annotate design features.
- Principles of Engineering non-PLTW Standards
  - POE-5.3 Students apply the laws of motion as they apply to principles of engineering – Explain how gravity impacts motion.
  - POE-5.4 Students apply the laws of motion as they apply to principles of engineering – Apply the laws of motion to solutions.

Additional Resources: Speed, Velocity, Acceleration Module

Reading Strategies

These reading tools will help students learn the material in this unit: Science Terms, Mathematical Language, and Concept maps. These are just a few suggestions that might be used to assist students in learning the material of this unit. They could be used as bell ringers, exit tickets, homework, or in class activities.

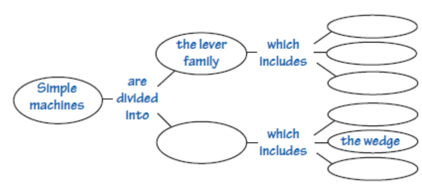
Science Terms, Many words used in science are familiar words from everyday speech. However, when these words are used in science, their meanings are often different from or are more precise than the everyday meanings. As students pay attention to the definitions of these words their correct use of them in scientific contexts will improve. Have students set up a table in their scientific/engineering notebooks or lesson log with three columns as seen below. As students are introduced to vocabulary, have them complete the table for the new term. Terms for this unit include momentum, acceleration, speed and others.

Word	Everyday Meaning	Scientific Meaning
speed	The act of moving fast	The distance an object travels divided by the time interval over which the motion occurs
velocity	speed	
acceleration	An increase in speed	

Mathematical Language Word problems describe science or math problems in words. To solve a word problem, you need to translate the language of words to the language of equations, mathematical symbols, variables, and numbers. Students would complete a table like the one to the right for the following word problem. *A crane uses an average force of 5,200 N to lift a girder 25 m. How much work does the crane do on the girder?* This type of activity helps students learn to pick up on important clues and information that may be discussed within the words of a story problem.

PHRASE	VARIABLE	VALUE
uses an average force of 5,200 N	force, F	
	distance, d	25 m
How much work		unknown

Concept Maps, A concept map is a diagram that helps you see relationships between the key ideas and categories of a topic. To construct a concept map, do the following: Select a main concept for the map. List all of the other related concepts. Build the map by arranging the concepts according to their importance under the main concept. Add linking words to give meaning to the arrangement of concepts.



Bell Ringers/Warm-up Exercises

1. **Mark Up The Text (MUTT) – Drag Racing** Have students answer the following questions on their Journal or Daily Lesson Log once they have completed **MUTT**ing the article: What did you learn from the article? What is one fact that surprised you from the article? What is one question you have after reading the article?
2. **Mark Up The Text (MUTT) – NASA Goes Metric**, Have students answer the following questions on their Journal or Daily Lesson Log once they have completed **MUTT**ing the article: What did you learn from the article? What is one fact that surprised you from the article? What is one question you have after reading the article?

3. **PowerPoint Slide Deck, Prior Knowledge Warm-up Exercises,** This slide deck has a series of warm-up activities that can be projected onto a screen. Students would complete the required activities/questions/practice problems upon entering the classroom.

PowerPoint Slide Show Presentations

The following presentation resources are available on the Hardware Stores Science website.

PowerPoint Slide Show Presentation, Units and Quantities Vocabulary, This slideshow covers the fundamentals of units. It is the same information found in the background activity sheet 0.3c. This information discusses systems of measurements, comparing metric to standard. The 7 base units are introduced followed by a short discussion on derived quantities. Determining the base units for acceleration is followed by a series of questions for student practice.

PowerPoint Slide Show Presentation, Middle School Science Review, Use this slide show to review with students the concepts of motion, force, and friction discussed in Middle school. This slideshow is meant to be a minimum of information students should be familiar with prior to beginning module 1: Levers. This slideshow could be integrated throughout this module with slides 1-10 being used during the Speed versus Velocity Review lesson. Slides 11-16 can be used during the Acceleration Review lesson. Slides 17-27 can be utilized during the Motion and Forces Review lesson.

Printable Resources

The following resources are available on the Hardware Stores Science website.

Science Content – Speed, Velocity, and Acceleration.
Daily Lesson Log
Educator Practice Problems Answer Key
Maker skills

Online Resources

The following resources are found online, and can be accessed through their individual websites or in a word document version at the Hardware Store Science website. One advantage of using the word document version of this article is that educators are able to download and edit the document with questions, writing prompts or other student suggestions.

NASA Finally Goes Metric – This article was written January 8, 2007. It can be found on the Space.com website at https://www.space.com/3332-nasa-finally-metric.html or a word document of this article, without the ads and other distractors, can be found at hardwarestorescience.org

Drag Racing – This article was made available on pbs.org as part of their History Detectives Special Investigations https://www.pbs.org/opb/historydetectives/feature/drag-racing/ or a word document of this article, without the ads and other distractors, can be found at hardwarestorescience.org

