# 5th Grade Science Unit:
## May the Force Be With You
### Unit Snapshot

<table>
<thead>
<tr>
<th>Topic: Light, Sound, and Motion</th>
<th>Grade Level: 5</th>
<th>Duration: 13 days</th>
</tr>
</thead>
</table>

**Summary**
The students will explore through experiments, an engineering project and class activities to explain how movement can be measured by speed, how the Earth pulls down on all objects with a gravitational force and changes in speed or direction require a force.

### CLEAR LEARNING TARGETS

**“I can”...statements**
- __explain the gravitational force between an object and the Earth.
- __use the formula (speed= distance ÷ time) in real world situations to calculate speed
- __conduct experiments to explain how the mass of an object affects the amount of force needed to move the object.
- __conduct an experiment and explain how an object will remain at rest if it is not moving, and no force acts upon it.
- __identify that when a force is applied in the same direction of the object’s motion, the speed will increase.
- __identify that when a force is applied in the opposite direction of an object’s motion, the speed will decrease.

### Activity Highlights and Suggested Timeframe

<table>
<thead>
<tr>
<th>Days 1-2</th>
<th>Engagement Options:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Optional Read aloud Newton and Me by Lynne Mayer</td>
</tr>
<tr>
<td></td>
<td>2. Watch <a href="http://www.unitedstreaming.com">www.unitedstreaming.com</a> video and complete vocabulary worksheet</td>
</tr>
<tr>
<td></td>
<td>3. Coin Flip Activity</td>
</tr>
</tbody>
</table>

| Days 3-4 | Exploration: Students complete 2 experiments: The Effect of Friction on Moving Objects and How does the mass of an object affect its motion? |

| Days 5-8 | Explanation: SMARTBoard Lesson; Complete an on-line Aspire lesson to learn how to calculate speed. Use the computer to watch a short video titled Force, Gravity and Weight:[http://www.bbc.co.uk/bitesize/standard/physics/transport/forces_at_work/activity/](http://www.bbc.co.uk/bitesize/standard/physics/transport/forces_at_work/activity/); To understand the vocabulary terms, play I Have Game cards with the whole class or small groups. |

| Days 9-11 | Elaboration: Marble Madness Design Challenge activity. Students will work in groups of 2 or 3 to create an index card ramp that allows a marble to travel at the slowest speed possible. |

| Day 12 and ongoing | Evaluation: Formative: Engage vocabulary worksheet, experiment lab worksheets. Summative: I Have Cards Test and a teacher-created short cycle assessment will be administered at the end of the unit to assess all clear learning targets. |

| Day 13 | Extension/Intervention: Based on the results of the short-cycle assessment, facilitate extension and/or intervention activities. |
NEW LEARNING STANDARDS:
5.PS.1 The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.
- Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t).
- Earth pulls down on all objects with a gravitational force. Weight is a measure of the gravitational force between an object and the Earth.
- Any change in speed or direction of an object requires a force and is affected by the mass* of the object and the amount of force applied.

Note 1: Gravity and magnetism are introduced (through observation) in PS grade 2.
*While mass is the scientifically correct term to use in this context, the NAEP 2009 Science Framework (page 27) recommends using the more familiar term “weight” in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

CONTENT ELABORATION (as stated in Ohio’s New Learning Standards)

The motion of an object can change by speeding up, slowing down or changing direction. Forces cause changes in motion. If a force is applied in the same direction of an object’s motion, the speed will increase. If a force is applied in the opposite direction of an object’s motion, the speed will decrease. Generally, the greater the force acting on an object, the greater the change in motion. Generally, the more mass* an object has, the less influence a given force will have on its motion. If no forces act on an object, the object does not change its motion and moves at constant speed in a given direction. If an object is not moving and no force acts on it, the object will remain at rest.

Movement is measured by speed (how fast or slow the movement is). Speed is measured by time and distance traveled (how long it took the object to go a specific distance). Speed is calculated by dividing distance by time. Speed must be investigated through testing and experimentation. Real-world settings are recommended for the investigations when possible. Virtual investigations and simulations also can be used to demonstrate speed.

An object that moves with constant speed travels the same distance in each successive unit of time. In the same amount of time, a faster object moves a greater distance than a slower object. When an object is speeding up, the distance it travels increases with each successive unit of time. When an object is slowing down, the distance it travels decreases with each successive unit of time.

Speed must be explored and tested through investigations (3-D or virtual) inside and outside of the classroom. Video technology can be used to stop movement and measure changes at different steps in the investigations.

Note 1: This content can be taught in conjunction with the following ESS content: Everything on or anywhere near Earth is pulled toward Earth’s center by gravitational force. Weight is a measure of this force. The planets are kept in orbit due to their gravitational attraction for the sun.

Note 2: While concepts are related to Newton’s second law, remain conceptual at this grade. Knowing the name of the law is not required. Memorizing and reciting words to describe Newton’s second law is not appropriate.

Note 3: Although mathematics is applied to the concept of speed at this grade level, its use should support deeper understanding of the concept of speed and not be taught as the primary definition of speed.
SCIENTIFIC INQUIRY and APPLICATION PRACTICES:
During the years of grades K-12, all students must use the following scientific inquiry and application practices with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas:

- Identify questions that can be answered through scientific investigations
- Design and conduct a scientific investigation
- Use appropriate mathematics, tools and techniques to gather data and information
- Analyze and interpret data; Develop descriptions, models, explanations and predictions
- Think critically and logically to connect evidence and explanations
- Recognize and analyze alternative explanations and predictions
- Communicate scientific procedures and explanations.

COMMON CORE STATE STANDARDS for LITERACY in SCIENCE:

- See attached 5th grade ELA Standards at the end of this unit for: Reading Standards for Informational Text, Writing Standards and Speaking and Listening Standards

*For more information: [http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf](http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf)

MATERIALS:

**Engage**
- Optional: Newton and Me by Lynn Mayer book
- Computer for video
- Vocabulary Worksheet
- Computer access and/or student dictionaries, coins, cups, index cards

**Explore**
- Inclined plane (wood or white board)
- Wax paper
- Sandpaper
- Spring scale
- Book
- String
- Toy cars
- Pennies
- Tape
- Meter sticks
- Lab worksheets

**Explain**
- Computer to complete the Speed Machine Activity from Aspire
- Force and Motion reading material in the curriculum guide (a copy for each student)
- Computer to watch video
- I Have Game cards (1 copy for each group)

VOCABULARY:

**Primary**
- Change in directions
- Change in speed
- Decrease
- Distance traveled
- Force
- Gravitational force
- Gravity
- Increase
- Movement
- Period of time
- Speed
- Successive unit of time
- Weight

**Secondary**
- Acceleration
- Amount of force applied
- Friction
- Magnetism
- Mass
- Mass of object
- Motion of an object
### Elaborate
- 4x6 index cards
- Tape/masking tape
- Marble
- Poster paper for each group
- Open wall space
- Tape measures
- Stop watches
- Lab worksheet

### Evaluate
- Vocabulary worksheet from Explore
- I Have Cards for each student
- Scissors
- Glue
- Worksheet
- Summative Assessment

### SAFETY
- Use all science equipment and materials appropriately according to teacher directions.
- Be respectful of other student’s experiments/projects.

### ADVANCED PREPARATION
- Watch the video segments from [www.unitedstreaming.com](http://www.unitedstreaming.com) to be used with Engage. The Language of Science: Physical Science 3-5: Force and Motion
- Gather student dictionaries to use with vocabulary activity.
- Gather materials for all experiments.
- Watch Force, Gravity and Weight video
- Copy reading material to be used with Explain, copy I Have Game cards,
- Optional: Check-Out Newton and Me by Lynne Mayer from the library

### ENGAGE (2 days)
(What will draw students into the learning? How will you determine what your students already know about the topic? What can be done at this point to identify and address misconceptions? Where can connections are made to the real world?)

**Objective:** To engage students with a book, video or activity while exploring the concepts of gravity, force and motion.

**What is the teacher doing? (Days 1-2)**
- Optional: Read Newton and Me by Lynne Mayer.
- Show [www.unitedstreaming.com](http://www.unitedstreaming.com) video segments from *The Language of Science: Physical Science 3-5: Force and Motion* (about 10 minutes)
- Pass out the vocabulary worksheet. Students will need to have access to student dictionaries or computers to find the definitions for the remaining science vocabulary. (Students will use the definitions later for an I Have game.)

**What are the students doing? (Days 1-2)**
1. Optional: Listening to the book being read aloud.
2. Complete the first 2 pages of the vocabulary worksheet while watching the video segments. Students will fill in appropriate definitions while watching the video.
3. Use computers or student dictionaries to complete the rest of the science vocabulary and create a sentence for each word using the scientific definition. Students need to keep vocabulary for another activity later in the unit.
| **EXPLORE**  
(2 days) | **EXPLAIN**  
(4 days) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(How will the concept be developed? How is this relevant to students’ lives? What can be done at this point to identify and address misconceptions?)</td>
<td>(What products could the students develop and share? How will students share what they have learned? What can be done at this point to identify and address misconceptions?)</td>
</tr>
</tbody>
</table>

**Objective:** Students use experiments to explore how the weight of an object and forces such as friction effect how an object travels.

**What is the teacher doing?**

**DAY 3**
- Gathering materials for experiment. The Effect of Friction on Moving Objects: inclined plane (wood or white board), wax paper, sandpaper, spring scale, book, string, lab worksheet
- Facilitate the activity. See teacher page.

**DAY 4**
- Gather materials for experiment. How does the mass of an object affect its motion? Textbooks and white board to be used as the ramp.
- Facilitate the activity. See teacher page.

**What is the students doing?**

**DAY 3**
1. Students are conducting the Coin Flip Activity along with the lab worksheet.

**DAY 4**
1. Students complete the experiment and complete the lab worksheet. Attach a book and spring scale using string. Pull the book up the ramp (inclined plane) to measure the amount of force it takes to get to the top of the ramp. Explore the force it takes to pull a book up a ramp by using wax paper and sandpaper.

2. Students create a ramp using textbooks and a white board. Roll a toy car down the ramp and use meter sticks to measure the distance the car travels. Add pennies to increase the weight of the car and then measure the distance of the car.

**Objective:** Students will gain knowledge and explain the concepts of speed, force, friction, mass and gravity.

**What is the teacher doing?**

**DAY 5**
- Use Force SMARTBoard Activity. [http://express.smarttech.com/?url=http://exchangedownloads.smarttech.com/public/content/4d/4ddf6368-4705-4b6b-b070-d0dad413e1a3/MaytheForcesofPushandPullBewithYouUS_notebook#](http://express.smarttech.com/?url=http://exchangedownloads.smarttech.com/public/content/4d/4ddf6368-4705-4b6b-b070-d0dad413e1a3/MaytheForcesofPushandPullBewithYouUS_notebook#) The 11 slides explain force, gravity and mass. (This can be used without a SMARTBoard.)

**DAY 6**
- Since force and motion are

**What are the students doing?**

**DAY 5**
1. Students are actively participating with the slides.

**DAY 6**
2. Students are taking turns reading the
not in the 5th grade textbook, use the provided Reading Material: Force & Motion. (Some material taken from: http://www.physics4kids.com/files/motion_velocity.html)

Speed Machines (Day 7)
- Introduction Activity: Create a table on the chalkboard with 4 columns labeled: students, distance, time, average speed.
- Ask 5 students, one at a time, to separately walk in a straight line at whatever pace they like from one end of the classroom to the other. Have another student time (in seconds) how long it takes and report it to the class and record it in the table. Have another student (and a second to check his/her results) measure the distance walked.
- As a class, calculate the average speed at which each student moved.
- Discuss with students what they think average speed means. Most will be familiar with miles per hour as it applies to their family car. If they can remember the unit miles per hour, they can remember the formula for speed: average speed = distance/time
- Compare the results and discuss what factors account for the variation in the results. If you were to make predictions on a race, would they want to collect any data before making their predictions?

Speed Machines (Day 7)
3. Students complete the Introduction Activity. Work as a class to learn to calculate speed using the formula: Average Speed = Distance/Time
**Speed Lesson on the computer:**
- Project the following simulation on the board by using the following link:
  http://aspire.cosmic-ray.org/javalabs/java12/fnm/index.htm?ASPIRE_Session=fb1add45e9d6745893331d97553ec7a
  - Click on Student Lab
- Students will complete Force and Motion, Activity 1: SPEED.

**Directions for Teaching the Lab:**
- Have students use their lab worksheet and read directions.
- Click through the data for each snowmobile. Allow students the time to record the information, calculate speeds, and make their predictions of the winning order of snowmobiles.
- Start the race! Have students record the order of the finish.
- Allow students time for analysis questions and conclusion.

**HOMEWORK:**
- Assign the Speed and Distance Worksheet for practice.

**(Day 8)**
- Watch short video:
- Have students play the I Have Game. There are 12 vocabulary cards to put in correct order.
- The I Have Game can also be used as a summative test for vocabulary mastery.

4. Students will complete the Aspire lesson for Force and Motion, Activity 1: SPEED using the lab worksheet.

5. Students will complete the Speed and Distance Worksheet for homework.

**(Day 8)**

7. Students play the I Have Game for practice.
### OBJECTIVE
Students will build an index card ramp that allows a marble to travel at the slowest speed possible. Students will be able to explain and determine the average speed of their marble as well as the average speed of other group’s marbles.

### ELABORATE
(3 days)

<table>
<thead>
<tr>
<th>What is the teacher doing? (Day 9-11)</th>
<th>What are the students doing? (Day 9-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Gather materials for the Marble Madness Design Challenge: marbles, tape, index cards, open wall space, poster paper, tape measures, stop watches, calculators, and lab worksheet.</td>
<td>1. Complete the Marble Madness Design Challenge with a group. Challenge: Create a pathway that allows a marble to travel at the slowest speed possible.</td>
</tr>
<tr>
<td>- Students should work in pairs or groups of 3 to design their ramps.</td>
<td>2. Students should think about all of the factors that can affect speed (forces – friction and gravity, index card angle, etc.)</td>
</tr>
<tr>
<td>- Each group needs their own wall space and poster paper.</td>
<td>3. Complete the lab worksheet and present the results by measure the distance of the pathway, measuring how long it takes for the marble to move the length of the track, and calculating the average speed.</td>
</tr>
<tr>
<td>- Facilitate the Challenge: Student must design and create a pathway that allows a marble to travel at the slowest speed possible using provided materials. -see pictures of student examples.</td>
<td>4. Compare group results in order to determine which group had the slowest marble.</td>
</tr>
</tbody>
</table>

### EVALUATE
(on-going)

<table>
<thead>
<tr>
<th>Formative</th>
<th>Summative</th>
</tr>
</thead>
<tbody>
<tr>
<td>How will you measure learning as it occurs?</td>
<td>What evidence of learning will demonstrate to you that a student has met the learning objectives?</td>
</tr>
<tr>
<td>1. Engage: Students use the video and dictionary to complete the vocabulary worksheet.</td>
<td>1. I Have Game Cards will assess vocabulary mastery.</td>
</tr>
<tr>
<td>2. The lab worksheets for the experiments can assess student knowledge progression as it relates to forces and speed.</td>
<td>2. Marble Madness Design Challenge will assess the students’ ability to apply knowledge of forces and speed.</td>
</tr>
<tr>
<td></td>
<td>3. A teacher-created short cycle assessment will assess all clear learning targets.</td>
</tr>
</tbody>
</table>

### EXTENSION/INTERVENTION
(1 day or as needed)

<table>
<thead>
<tr>
<th>EXTENSION</th>
<th>INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computer games can be found at <a href="http://www.sciencekids.co.nz">www.sciencekids.co.nz</a>. The games can be used for intervention and extensions. The following link lets students use small and large weights or small and large parachutes to explore force and weight:</td>
<td>1. Computer games can be found at <a href="http://www.sciencekids.co.nz">www.sciencekids.co.nz</a>. The games can be used for intervention and extensions. The following link lets students use small and large weights or small and large parachutes to explore force and weight:</td>
</tr>
</tbody>
</table>
parachutes to explore force and weight:
www.sciencekids.co.nz/gamesactivities/forcesinaction.html

3. ParkWorld Plot is a computer game that has children read all about force, gravity, air resistance and magnetism.
http://www.engineeringinteract.org/resources/parkworldplot.htm
This game will take at least 30 minutes to read all the information and conduct the engineering activities.

3. **FORCE Experiment** for whole class demonstration outdoors: need a golf club, tees, golf ball, ping pong ball, meter sticks or trundle wheel and lab sheet included in the curriculum guide.
What is needed to make a ball sitting on top of a tee start moving down the fairway (playground)? Students take turns swinging the club softly then harder using ping pong balls and golf balls. They should be able to answer the questions: What is force? What did you discover about the golf ball as a force in motion? Which ball produced the greater distance and why? Did the balls move farther when a greater or lesser force was applied? What does weight have to do with force?

4. **How Much Energy? Experiment**
Students will construct and investigate a ramp-marble-speed bump system to test the amount of force (energy) required for the marble to roll over the bump. Students will record and compare the data collected; draw conclusions and provide explanations for ideas.

www.sciencekids.co.nz/gamesactivities/forcesinaction.html

2. Trumbauer, Lisa. Forces and Motion. Newbridge Educational Publishing: New York. 1989. Some schools may have this “big book” and/or smaller books to use as an intervention. The book used to be a 3rd grade resource.

3. **GUEST SPEAKER**
Ask a Columbus City police officer to speak to the class about using radar guns to track speeding drivers. Students could do research on how a radar gun works and use the math formula for speed = distance divided by time to answer real life word problems.

4. Easy game on the computer for friction

COMMON MISCONCEPTIONS

Common Misconceptions:
Common misconceptions about forces and motion at this grade level include:
• Time can be measured without establishing the beginning of the interval.
• The only natural motion is for an object to be at rest.
• If an object is at rest, no forces are acting on the object.
• Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting on it.
• Force is a property of an object.
• An object has force and when it runs out of force, it stops moving.
• The motion of an object is always in the direction of the net force applied to the object.
• Large objects exert a greater force than small objects.
• A force is needed to keep an object moving with a constant speed.

Misconceptions in physical science at this grade level include:
• Any quantity can be measured as accurately as you want.
• The only way to measure time is with a clock or a watch.
• Time has an absolute beginning.
• Gravity only acts on things when they are falling.
• Students think gravity is always pulling us “down.” In reality, gravity is pulling objects toward the center of the Earth, not down.
• Only animate things (people, animals) exert forces; passive ones (tables, floors) do not exert forces.
• A force applied by a hand (or other object), still acts on an object after the object leaves the hand.

DIFFERENTIATION

Lower-level:
• Consider differentiating grouping to meet the needs of individual students:
  Use the I Have Card Game as a whole class or small group. Lay the cards in order together for all students to see the correct order. The computer games can be done as a whole class, small group or individually.
• Consider providing trade books or other appropriate reading-level materials for students.

Higher-Level:
• The following website is a link to practice online tests.
  http://www.linkstolearning.com/links/Ohio/ohio_schools.htm
• During the Explore experiment, The Effect of Friction on Moving Object:
  Have students research other items that would cause less or more friction.
• Also, students could explore real world situations where more or less friction is desired. Examples: pool table, golf, racecars and bike riding.

Strategies for meeting the needs of all learners including gifted students, English Language Learners (ELL) and students with disabilities can be found at the following sites:
ELL Learners:
Gifted Learners:
Students with Disabilities:
ADDITIONAL RESOURCES

Websites:
- www.sciencekids.co.nz
- http://www.engineeringinteract.org/resources/parkworldplot.htm
- PowerPoint for Vocabulary www.slideshare.net/dfarnquist31/force-and-motion-in-elementary-science

Discovery Ed: Unitedstreaming.com
- Physical Science: Force and Gravity (20:20 minutes)
- Roller Coasters: Momentum and energy in action (4:02 minutes)
- Segments from The Language of Science: Physical Science 3-5: Force & Motion
  - Forces (1:10 minutes)
  - Changing Things (1:46 minutes)
  - Moving Faster (1:20 minutes)
  - Moving Slower (2:29 minutes)
  - Gravity (1:19 minutes)

Literature:
- What is Friction?, by Lisa Trumbauer (may be in your building from previous 3rd grade years)
Write the definitions to the science words related to the force and motion unit. Write a sentence for each vocabulary word. Make sure to use the science word correctly.

<table>
<thead>
<tr>
<th>Gravity-</th>
<th>Force-</th>
<th>Friction-</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sentence:</strong></td>
<td><strong>Sentence:</strong></td>
<td><strong>Sentence:</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass-</th>
<th>Speed-</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sentence:</strong></td>
<td><strong>Sentence:</strong></td>
</tr>
</tbody>
</table>
Write the definitions to the science words related to the force and motion unit. Write a sentence for each vocabulary word. Make sure to use the science word correctly.

<table>
<thead>
<tr>
<th>Gravity-</th>
<th>Force-</th>
<th>Friction-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition: The natural force that attracts any two objects with mass toward each other</td>
<td>Definition: A push or a pull exerted on an object</td>
<td>Definition: A force that resists motion between two bodies in contact</td>
</tr>
<tr>
<td>Context: Earth’s gravity pulls on anything that is not held up by some other force.</td>
<td>Context: The ball was hit with enough force to send it into the bleachers.</td>
<td>Context: Rougher surfaces create more friction than smooth ones when an object comes in contact with them.</td>
</tr>
<tr>
<td>Sentence: Answers will vary</td>
<td>Sentence: Answers will vary</td>
<td>Sentence: Answers will vary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass-</th>
<th>Speed-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition: The amount of matter in an object or substance.</td>
<td>Definition: The rate of motion</td>
</tr>
<tr>
<td>Context: Mass is anything that has matter and takes up space.</td>
<td>Context: The speed of the ball is determined by measuring how far it travels in a certain amount of time.</td>
</tr>
<tr>
<td>Context: Mass is anything that has matter and takes up space.</td>
<td>Context: The speed of the ball is determined by measuring how far it travels in a certain amount of time.</td>
</tr>
<tr>
<td>Sentence: Answers will vary</td>
<td>Sentence: Answers will vary</td>
</tr>
</tbody>
</table>
Teacher Reference Page

Coin Flip

Video Demonstration can be found on:
http://www.youtube.com/watch?v=LqnXU5GUnc

Lazy Coin

• Things You Will Need
  ◦ Short drinking glass
  ◦ Index card
  ◦ Nickel

• Do This
  ◦ Place an index card over the mouth of an empty drinking glass.
  ◦ Place a nickel on top of the index card so that it is centered over the mouth of the glass.
  ◦ Quickly and forcefully thump the index card straight forward with your finger. Be sure not to lift up on the edge of the index card when you thump it.
  ◦ If the nickel did not end up inside the glass, repeat the experiment. You may have to repeat the experiment several times before you get the knack of how much force is needed.

• What Should Have Happened

Your finger applies force to the card to cause it to move forward. If this force is very fast and straight forward, very little force is translated to the nickel. The nickel then falls straight down because gravity is the only force acting on it. If the force is not fast enough or kicks the index card at an angle, some force is translated to the nickel, causing the nickel to flip in the direction of the card. This experiment demonstrates the principle of inertia, which states that an object in motion stays in motion and an object at rest stays at rest until another force acts upon that object.

Coin Flip

Directions:

1. Center an index card on top of the cup. Place the coin in the middle of the index card. Using just one or two fingers, flick the index card from the side.

   What happened to the coin? Why?

   ____________________________________________________________
   ____________________________________________________________

2. Now place the coin in a flat, level surface and observe the coin for 2 minutes.

   What happened to the coin? Why?

   ____________________________________________________________
   ____________________________________________________________

3. Now really think about what happened

   Why did the index card move in step 1?

   ____________________________________________________________
   ____________________________________________________________

   Why did the coin move in step 1?

   ____________________________________________________________
   ____________________________________________________________
Coin Flip

Directions:

1. Center an index card on top of the cup. Place the coin in the middle of the index card. Using just one or two fingers, flick the index card from the side. *(the cup should be empty)*

What happened to the coin? Why?
The coin fell in the cup, because gravity was acting upon the coin and pulled the coin into the glass

2. Now place the coin in a flat, level surface and observe the coin for 2 minutes.

What happened to the coin? Why?
Nothing happened to the coin, because no force was acting upon the coin

3. Now really think about what happened. Why did the index card move in step 1?
The index card moved because you acted upon it by flicking the card.

Why did the coin move in step 1?
The coin moved because of gravity…not because you flicked the card. You did not touch the coin when you flicked the card.
The Effect of Friction on Moving Objects

Attach a book and spring scale using string. Pull the book up the ramp (inclined plane) to measure the amount of force it takes to get to the top of the ramp. Explore the force it takes to pull a book up a ramp by using wax paper and sandpaper.

How does the mass of an object affect its motion?
Students will create a ramp using textbooks and a white board. Roll a toy car down the ramp and use meter sticks to measure the distance the car travels. Add pennies to increase the weight of the car and then measure the distance of the car.

Tape pennies to the car to increase weight.

http://www.education.com/science-fair/article/uphill/

Investigation: The Effect of Friction on Moving Objects.

**Step 1:** Attach a long piece of sandpaper to the inclined plane. Attach the spring scale to the loop of string on the book. Drag the book up the inclined plane. Observe how much force it takes by reading the spring scale once you have the book moving at a slow, constant motion.

Force with sandpaper: ________________________________

**Step 2:** Attach a piece of wax paper to the inclined plane. Measure how much force it takes to drag the book up the plane.

Force with wax paper: ________________________________

**Step 3:** Measure how much force it takes to drag the book up the plane without any paper.

Force with no paper: ________________________________

**What Does it Mean?**

1. Which material required the **least** amount of force to pull the book up the inclined plane?

_________________________________________________________________

2. Explain why the different materials required different amounts of force.

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

3. Are there any other substances you could put on the board that might require less force?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

4. What do you think would happen if you increased the weight of the book you were pulling? Would this take more force to pull or less force?

_________________________________________________________________
Investigation: The Effect of Friction on Moving Objects.

Step 1: Attach a long piece of sandpaper to the inclined plane. Attach the spring scale to the loop of string on the book. Drag the book up the inclined plane. Observe how much force it takes by reading the spring scale once you have the book moving at a slow, constant motion. Force with sandpaper: _____ Answers may vary _____

Step 2: Attach a piece of wax paper to the inclined plane. Measure how much force it takes to drag the book up the plane. Force with wax paper: ______ Answers may vary ______

Step 3: Measure how much force it takes to drag the book up the plane without any paper. Force with no paper: _____ Answers may vary _____

What Does it Mean?
1. Which material required the least amount of force to pull the book up the inclined plane? Depends on what the ramp is made out of. The wax paper would require less force because it is the smoothest.

2. Explain why the different materials required different amounts of force. Friction—sandpaper requires more force. The sandpaper is acting as an opposing force to the book. The wax paper and the inclined plane have less friction because there is less opposing force.

3. Are there any other substances you could put on the board that might require less force? Answers may vary: Examples: glossy magazine page, sheet of paper

4. What do you think would happen if you increased the weight of the book you were pulling? Would this take more force to pull or less force? The amount of force would increase on the spring scale. More force is needed to move book.
Investigation: How does the mass of an object affect its motion?

Mass is how much ________________ is in an object.
You can measure mass with a _____________________.

**Prediction:** A heavy car will travel _____________ than a lighter car.

**Procedure:**
1) Make a ramp with your textbooks and white board.
2) Release the car from the top of the ramp with no added weight.
3) Use the meter sticks to measure the distance the car traveled and record it in the table below.
4) Repeat steps 2 and 3 with a car with more weight. (eg. Pennies taped to top of car)
5) Repeat steps 2 and 3 again with the most amount of weight added.

**Results:**

<table>
<thead>
<tr>
<th>Car Weight</th>
<th>Distance 1</th>
<th>Distance 2</th>
<th>Distance 3</th>
<th>Distance Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ________________ car traveled the farthest. The ________________ car traveled the shortest distance.

**Conclusions:** What did you learn about how mass affects an object's motion?
Investigation: How does the mass of an object affect its motion?

Mass is how much _matter________ is in an object.
You can measure mass with a __spring scale/digital scale/triple beam balance___.

**Prediction:** A heavy car will travel ___(ie. faster or slower)____ than a lighter car.

**Procedure:**
1) Make a ramp with your textbooks and white board.
2) Drop the car from the top of the ramp with no added weight.
3) Use the meter sticks to measure the distance the car traveled and record it in the table below.
4) Repeat steps 2 and 3 with a car with more weight. (eg. Pennies taped to top of car)
5) Repeat steps 2 and 3 again with the most amount of weight added.

**Results:**

<table>
<thead>
<tr>
<th>Car Weight</th>
<th>Distance 1</th>
<th>Distance 2</th>
<th>Distance 3</th>
<th>Distance Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answers may vary depending on size of book and ramp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ___most weighted_____ car traveled the farthest. The ___no weight____ car traveled the shortest distance.
Mechanics and Motion

Motion is one of the key topics in physics. Everything in the universe moves. It might only be a small amount of movement and very very slow, but movement does happen. Don't forget that even if you appear to be standing still, the Earth is moving around the Sun, and the Sun is moving around our galaxy. The movement never stops. Motion is one part of what physicists call mechanics. Over the years, scientists have discovered several rules or laws that explain motion and the causes of changes in motion. There are also special laws when you reach the speed of light or when physicists look at very small things like atoms.

Speed it Up, Slow it Down

The physics of motion is all about forces. Forces need to act upon an object to get it moving, or to change its motion. Changes in motion won't just happen on their own. So how is all of this motion measured? Physicists use some basic terms when they look at motion. How fast an object moves, its speed can be influenced by forces. (Note: Even though the terms 'speed' and 'velocity' are often used at the same time, they actually have different meanings.)

A Formula for Speed of an Object

Movement is measured by speed (how fast or slow the movement is). Speed is measured by time and distance traveled (how long it took an object to go a specific distance). Speed is calculated by dividing distance by time. Suppose a gold car drove 50 miles in 2 hours. The gold car would be travelling at a speed of 25 mph (miles per hour).

\[
\text{Speed} = \frac{\text{distance}}{\text{time}} = 50 \div 2 \quad \text{Speed} = 25 \text{mph}
\]
Forces of Nature
Forces are a big part of physics. Physicists devote a lot of time to the study of forces that are found everywhere in the universe. The forces could be big, such as the pull of a star on a planet. The forces could also be very small, such as the pull of a nucleus on an electron. Forces are acting everywhere in the universe at all times.

Examples of Force
If you were a ball sitting on a field and someone kicked you, a force would have acted on you. As a result, you would go bouncing down the field. There are often many forces at work. Physicists might not study them all at the same time, but even if you were standing in one place, you would have many forces acting on you. Those forces would include gravity, the force of air particles hitting your body from all directions (as well as from wind), and the force being exerted by the ground (called the normal force).

Let's look at the forces acting on that soccer ball before you kicked it. As it sat there, the force of gravity was keeping it on the ground, while the ground pushed upward, supporting the ball. On a molecular level, the surface of the ball was holding itself together as the gas inside of the ball tried to escape. There may have also been small forces trying to push it as the wind blew. Those forces were too small to get it rolling, but they were there. And you never know what was under the ball. Maybe an insect was stuck under the ball trying to push it up. That's another force to consider.
Friction Basics

Friction is a **force** that holds back the movement of a sliding object. That's it. Friction is just that simple. You will find friction everywhere that objects come into contact with each other. The force acts in the **opposite** direction to the way an object wants to slide. If a car needs to stop at a stop sign, it slows because of the friction between the brakes and the wheels. If you run down the sidewalk and stop quickly, you can stop because of the friction between your shoes and the cement.

What happens if you run down the sidewalk and you try to stop on a puddle? Friction is still there, but the liquid makes the surfaces smoother and the friction a lot less. Less friction means it is harder to stop. The low friction thing happens to cars when it rains. That's why there are often so many accidents. Even though the friction of the brakes is still there, the brakes may be wet, and the wheels are not in as much contact with the ground. Cars **hydroplane** when they go too fast on puddles of water.

SNOWMOBILE CHALLENGE

Google: ASPIRE Lessons
Click on Force and Motion; Activity One; Student Lab

Snowmobile data: Write down the distances and times for each snowmobile. Calculate each snowmobiles average speed.

Formula: $\text{SPEED} = \frac{\text{Distance}}{\text{Time}}$

<table>
<thead>
<tr>
<th>Snowmobile</th>
<th>Distance</th>
<th>Time</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangler</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otter Pop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slider</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snowflake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Fang</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Outcomes:
Based on your data above…predict the outcome of the race. Write your prediction in the table below. Then, race the snowmobiles. Write the actual outcome in the table below.

<table>
<thead>
<tr>
<th>Place Finishes</th>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd Place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th Place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th Place</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Speed

Name: _____________________

Speed: A measure of motion, = distance divided by time.

Formula: \[ \text{SPEED} = \frac{\text{Distance}}{\text{Time}} \]

| It took Lightning McGreen 2.5 hours to travel 600 miles. How fast was he going in miles per hour? | It took Ms. Rally 4 hours to travel 165 miles due North. What was the speed of her car in miles per hour? |
| What is the speed if distance is 340 km and the time was 3 hours? Was the boy speeding? | How far did Doc Budson travel if he was going 60 miles an hour for 4 straight hours? |
| What is the speed if a runner runs a distance of 400 meters 35 seconds. | Sponge Bob decided to have a jellyfish race. Below are the results of the race. Calculate their speed and determine who was the fastest and the slowest jellyfish. |

<table>
<thead>
<tr>
<th>Jellyfish</th>
<th>Distance (m)</th>
<th>Time (s)</th>
<th>Speed (m/s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lola</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Arnie</td>
<td>100</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Slimy</td>
<td>100</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

Slowest ____________
Fastest ____________
**Speed**

*Speed: A measure of motion, = distance divided by time. D/T*

**Formula:** \[ \text{SPEED} = \frac{\text{Distance}}{\text{Time}} \]

<table>
<thead>
<tr>
<th>It took Lightning McGreen 2.5 hours to travel 600 miles. How fast was he going in miles per hour?</th>
<th>It took Ms. Rally 4 hours to travel 165 miles due North. What was the speed of her car in miles per hour?</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{240 mph} ]</td>
<td>[ \text{41.25 mph} ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is the speed if distance is 340 km and the time was 3 hours? Was the boy speeding?</th>
<th>How far did Doc Budson travel if he was going 60 miles an hour for 4 straight hours?</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{113.3 km/h} ]</td>
<td>[ \text{15 mph} ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is the speed if a runner runs a distance of 400 meters 35 seconds?</th>
<th>Sponge Bob decided to have a jellyfish race. Below are the results of the race. Calculate their speed and determine who was the fastest and the slowest jellyfish.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{11.4 m/s} ]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jellyfish</th>
<th>Distance (m)</th>
<th>Time (s)</th>
<th>Speed (m/s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lola</td>
<td>100 m</td>
<td>50</td>
<td>[ \text{2 m/s} ]</td>
</tr>
<tr>
<td>Arnie</td>
<td>100 m</td>
<td>36</td>
<td>[ \text{2.8 m/s} ]</td>
</tr>
<tr>
<td>Slimy</td>
<td>100 m</td>
<td>47</td>
<td>[ \text{2.1 m/s} ]</td>
</tr>
</tbody>
</table>

Slowest **Lola**
Fastest **Arnie**
TEACHER PAGE

EXPLAIN: Short Video
http://www.bbc.co.uk/bitesize/standard/physics/transport/forces_at_work/activity/

Force and Motion
"I Have.....Who Has....?" Game

Force and Motion, "I Have.....Who Has...?" Game is to help students review important physical science concepts. The game is ready to cut and laminate and use in your classroom. The teacher can use this game two different ways during the Physical Science Unit:

1. Use the I Have Game during the EXPLAIN part of the unit as a whole class or small groups putting the cards in order and

2. At the end of the unit use the cards as a SUMMATIVE TEST, each student has their own set of cards and glues them down in order. The clues with the numbers on them are the answers and are for the teacher's use only.

DIRECTIONS (Explain part of unit)
1. Pass clue cards out to students. Smaller classes can receive more than one card. (It is important that all of the cards are distributed so that the game is not interrupted by a missing clue card.)
2. The student with the first card starts the game. He or she will read their card aloud to the class.
3. Students have to listen carefully to see if they have the card that will give the correct answer to the question that was just given.
4. Repeat these steps until all cards are read.
5. After playing the game a few times, begin timing the students and challenge them to beat their time from previous games.

DIRECTIONS (Summative Test, end of unit)
1. Give each student a copy of the cards, scissors and glue.
2. Each student puts the cards in order according to the definitions and glues them in place for a grade at the end of the unit.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td>I have the first card. You divide the distance you travel by the time it takes to get there. What am I?</td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>That would be <strong>speed</strong>. Movement is measured by speed. I have the amount of space you traveled over a period of time. What am I?</td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>I am <strong>distance</strong>. A faster object moves a greater distance than a slower object. I have: the movement of something in a certain direction. What am I?</td>
</tr>
<tr>
<td><strong>4.</strong></td>
<td>I am <strong>motion</strong>. The motion of an object can change by speeding up, slowing down or changing direction. I have: all objects, large or small, are pulled on by the same noncontact force. What is the name of that force?</td>
</tr>
<tr>
<td><strong>5.</strong></td>
<td>That would be <strong>gravity</strong>. Gravity can make things slow down, speed up or stop. Earth’s gravity attracts and pulls objects toward the Earth regardless of size. I have: what do you call the amount of matter an object has?</td>
</tr>
<tr>
<td><strong>6.</strong></td>
<td>That would be <strong>mass</strong>. Mass is a measure of the amount of matter in an object. I have: It is sometimes confused with this term. What is the term?</td>
</tr>
<tr>
<td><strong>7.</strong></td>
<td>That would be <strong>weight</strong>. Weight is the measure of the force of gravity on an object. I have: what would happen to your weight on the moon?</td>
</tr>
<tr>
<td><strong>8.</strong></td>
<td>You would weigh less on the moon. The moon has much <strong>less mass</strong> than Earth, so the force of <strong>gravity is less</strong> on the moon. I have: the push or pull placed on any object. What am I?</td>
</tr>
<tr>
<td><strong>9.</strong></td>
<td>I have <strong>force</strong>. The greater the force acting on an object the greater the change in motion. I have: the force that resists movement of one surface when moving over another. What am I?</td>
</tr>
<tr>
<td><strong>10.</strong></td>
<td>(last card) That would be <strong>friction</strong>. Friction is a force. Rough surfaces create more friction than smooth ones when an object comes in contact with them.</td>
</tr>
</tbody>
</table>
**Student Cards**

<table>
<thead>
<tr>
<th>**That would be **friction. Friction is a force. Rough surfaces create more friction than smooth ones when an object comes in contact with them.</th>
<th>**That would be **weight. Weight is the measure of the force of gravity on an object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have: what would happen to your weight on the moon?</td>
<td>I have: what would happen to your weight on the moon?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>I am distance.</strong> A faster object moves a greater distance than a slower object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have: the movement of something in a certain direction. What am I?</td>
</tr>
<tr>
<td>I have: what do you call the amount of matter an object has?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>**You would weigh less on the moon. The moon has much **less mass **than Earth, so the force of **gravity is less <strong>on the moon.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>I have: the push or pull placed on any object. What am I?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>**That would be **mass. Mass is a measure of the amount of matter in an object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have: It is sometimes confused with this term. What is the term?</td>
</tr>
<tr>
<td>I have: all objects, large or small, are pulled on by the same noncontact force. What is the name of that force?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>**I have **force. The greater the force acting on an object the greater the change in motion.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have: the force that resists movement of one surface when moving over another. What am I?</td>
</tr>
<tr>
<td>I have the amount of space you traveled over a period of time. What am I?</td>
</tr>
</tbody>
</table>
Name _________________________________  

**Summative Test, glue the cards in the correct order**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
<td>6.</td>
</tr>
<tr>
<td>7.</td>
<td>8.</td>
</tr>
<tr>
<td>9.</td>
<td>10.</td>
</tr>
</tbody>
</table>
**MARBLE MADNESS Design Challenge – Teacher Page**

**Materials:**
- 4x6 index cards
- Tape/masking tape
- Marbles
- Poster Paper
- Other optional supplies such as cotton balls, sandpaper, tissue, paper towel
- Open wall space
- Tape Measures
- Stop Watches

**Suggested Time Frame:**
3-30 minute class periods

**Challenge:** Students will design and build an index card ramp that allows a marble to travel at the slowest speed possible.
- Students will determine the average speed of their marble as well as the average speeds of other group’s marbles.

**Teacher Background**
A FORCE is a push or pull exerted on an object. (Examples: Gravity, Friction, Surface Force, Air Resistance).

GRAVITY is the unbalanced force acting on the marble that causes the marble to move down the ramp.

SURFACE FORCE is the upward force of a surface (index card), that counteracts the force of gravity.

FRICTION is an opposing unbalanced force between two surfaces that are touching which causes an object to slow down.

AVGVERAGE SPEED is the amount of distance traveled in a certain amount of time. Average Speed=distance/time

**Teacher Notes**
This activity is designed to be student centered. As students examine the motion and speed of their marbles, it is recommended that they work in pairs or groups of three.
Student Work Examples
Engage (Warm-up)

1. On the SMARTBoard or board, create a picture of a ramp with a marble rolling down the slope. Have students label the forces acting on the marble on the SMARTBoard and/or on a sheet of paper.
2. Discuss the amount of force and direction of each force. Describe how each force might affect the motion of the marble.

Explore and Explain (Instructional Strategies)

1. Students will work in pairs or groups of three. Each group should have their own wall space and poster paper.
2. Students will use 4X6 index cards to build a ramp that allows a marble to roll down at the slowest speed possible. One way to accomplish this is to fold the index card in half (long ways) and tape one side to the poster paper. Continue to add on index cards to create a pathway for the marble. (Allow 2 class periods for intro and building of the ramps).
3. At the end of day 2, give students about 15 minutes to measure and record data. Students need to measure the total distance of the ramp from start to finish using a tape measure (cm). Then, students should run 3 timed trials. Students should record the time(s) it took for the marble to travel from start to finish 3 times using a stopwatch. Optional: they should calculate the mean and record their results in the data table on the worksheet.
4. At the beginning of the 3rd class period, students should share their data with the class, and all students will record class results on their worksheet.
5. Discuss/remind students how to calculate average speed.
   \[
   \text{SPEED} = \frac{\text{DISTANCE}}{\text{TIME}}
   \]
   Students will then calculate the average speed for each group in order to determine which group had the slowest marble.
6. Students will answer the post-lab questions on the worksheet.
Extension/Elaboration

1. As an extension, discuss how the angle of the index cards (ramp) affects the motion of the marble as it relates to speed and acceleration.
2. As an extension, discuss how the size and mass of the marble affects the motion of the marble as it relates to speed and momentum.
3. As an elaboration, allow students to change one variable as it relates to the construction of the ramp or the marble itself. Have students compare and contrast the motion and speed of the marble as it rolls down the track.
4. As an interdisciplinary connection to math, have students graph the results of the class data in order to compare the various group results.

Reteach Ideas

1. Students should revisit the concept that unbalanced forces cause a change in speed and direction. Discuss the unbalanced forces acting on a car rolling down a hill. For example, gravity pulls down on the car causing it to move, the road/surface force pushes up on the car which opposes the force of gravity, and friction and air resistance oppose the motion of the car causing the car to slow down. Brakes can also be applied (friction) to slow the car.
2. Students can complete practice problems involving calculating the average speed of objects as it relates to the rate of distance traveled in a certain amount of time.

Evaluation (Lesson Assessment)

1. Discuss student data and post-lab question responses.
2. Revisit the force diagram of the marble rolling down the hill from the first day of the lesson. Have students label the force diagram with the appropriate forces.

Additional Resources

Technology:

- **UnitedStreaming**: Example 1: Speed as a Rate [01:33]
  Physical Science: Forces and Gravity [20:20]
- **Website**: [http://www.physics4kids.com](http://www.physics4kids.com)
  [http://www.physicsclassroom.com/class/1dkin/u1l1d.cfm](http://www.physicsclassroom.com/class/1dkin/u1l1d.cfm)
MARBLE MADNESS Design Challenge

Goals: Build an index card ramp that allows a marble to travel at the slowest speed possible.
Be able to determine the average speed of your marble.
Be able to describe how forces affect the speed and motion of your marble.

Directions: Using 4x6 index cards, tape, and other materials provided by your teacher, create a ramp that allows a marble to travel at the slowest speed possible down the ramp. You will continue to build until time is up.

Your marble must move continuously and not stop until the end. When time is up, measure your total distance (cm), and total time (s). Run three time trials and calculate the mean. Record your data below.

<table>
<thead>
<tr>
<th>Trials</th>
<th>Distance (cm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean:

Calculation:
Average Speed = _________________

GROUP | Distance (cm) | Time (seconds) | Average Speed
-----|---------------|----------------|-----------------|
1     |               |                |                 |
2     |               |                |                 |
3     |               |                |                 |
4     |               |                |                 |
5     |               |                |                 |
<table>
<thead>
<tr>
<th>GROUP</th>
<th>Distance (cm)</th>
<th>Time (seconds)</th>
<th>Average Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post-Lab Questions:

1. Which group had the slowest average speed? ________________________________

2. Which group had the fastest average speed? ________________________________

3. Identify any forces acting on the marble and describe how the forces affected the motion of your marble.

4. Explain how you used various forces to keep your marble going the slowest speed possible.

5. If you could change and revise your ramp design, what would you do differently and why?
MARBLE MADNESS – Answer Key

Goals:
- Build an index card ramp that allows a marble to travel at the slowest speed possible.
- Be able to determine the average speed of your marble.
- Be able to describe how forces affect the speed and motion of your marble.

Directions: Using 4x6 index cards and tape, create a ramp on your poster paper that allows a marble to travel at the slowest speed possible down the ramp. You will continue to build until time is up. Your marble must move continuously and not stop until the end. When time is up, measure your total distance (cm), and total time (s). Run three time trials and calculate the mean. Record your data below.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Distance (cm)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Answers Will Vary</td>
<td></td>
</tr>
</tbody>
</table>

Mean:

Calculation:
Average Speed = \( \frac{\text{TOTAL DISTANCE}}{\text{TOTAL TIME}} \)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>Distance (cm)</th>
<th>Time (seconds)</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Answers Will Vary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Group 6

Group 7

Group 8

Group 9

Group 10

Post-Lab Questions:
1. Which group had the slowest average speed?  *Answers Will Vary*

2. Which group had the fastest average speed?  *Answers Will Vary*

3. Identify any forces acting on the marble and describe how the forces affected the motion of your marble.
   *Gravity, Air Resistance, Surface Force, Friction*

4. Explain how you used various forces to keep your marble going the slowest speed possible.
   *Answers Will Vary*

5. If you could change and revise your ramp design, what would you do differently and why?
   *Answers Will Vary*
“FORE!!!” a Force Experiment

What is needed to make a ball sitting on a tee start moving down the fairway (playground)?

Materials: golf club, tees, golf balls, ping pong balls, meter sticks or trundle wheel

Directions:
The experiment is to be conducted outdoors with whole class or small groups. Each student can take turns hitting the golf ball and ping pong ball. If you have more golf clubs, the experiment will go faster than everyone trying to share 1 club.

1. Discuss force and make a prediction.

2. Place the tee in the ground and place the ping pong ball on top of the tee. You will do this 2 times. The first time swing gently to hit the ping pong ball and record the distance. The second time swing a little harder and record the distance.

3. Place the tee in the ground and place the golf ball on top of the tee. You will do this 2 times. The first time swing gently to hit the golf ball and record the distance. The second time swing a little harder and record the distance.

4. All experiments need at least 3 trials. Since this is a whole class experiment you complete 1 trial with the ping pong ball and golf ball. Then choose 2 friends to write their trials on your worksheet.

5. Answer questions

1. What is force? __________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________

2. Prediction: Will the ping pong ball or golf ball go farther? Why?
   ______________________________________________________________________
   ______________________________________________________________________
3.  

<table>
<thead>
<tr>
<th><strong>PING PONG BALL</strong></th>
<th><strong>GOLF BALL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distances</strong></td>
<td><strong>Distances</strong></td>
</tr>
<tr>
<td><strong>Trial 1</strong></td>
<td><strong>Trial 1</strong></td>
</tr>
<tr>
<td>Meters when hit gently=</td>
<td>Meters when hit gently=</td>
</tr>
<tr>
<td>Meters when hit harder =</td>
<td>Meters when hit harder =</td>
</tr>
<tr>
<td><strong>Trial 2</strong></td>
<td><strong>Trial 2</strong></td>
</tr>
<tr>
<td>Meters when hit gently=</td>
<td>Meters when hit gently=</td>
</tr>
<tr>
<td>Meters when hit harder =</td>
<td>Meters when hit harder =</td>
</tr>
<tr>
<td><strong>Trial 3</strong></td>
<td><strong>Trial 3</strong></td>
</tr>
<tr>
<td>Meters when hit gently=</td>
<td>Meters when hit gently=</td>
</tr>
<tr>
<td>Meters when hit harder =</td>
<td>Meters when hit harder =</td>
</tr>
</tbody>
</table>

4. Did the balls move farther when a greater or lesser force was applied? (a gentle or harder swing)
   ________________________________________________________________________
   ________________________________________________________________________

5. Which ball produced the greater distance and why?
   ________________________________________________________________________
   ________________________________________________________________________

6. What does weight (mass) have to do with force?
   ________________________________________________________________________
   ________________________________________________________________________
Assessment Task: **How Much Energy?**

**Description**
Construct and investigate a ramp-marble-speed bump system to test the amount of energy required for the marble to roll over the bump. Record and compare the data collected: draw conclusions and provide explanations for your ideas.

**Materials for each pair or group of students**
- 1 marble
- 28cm x 44cm posterboard pieces (use as the ramp/inclined plane)
- cm ruler
- books
- tape
- lab sheets

**Procedure**

**Step 1:** Each student in the group needs to write their hypothesis on the lab sheet.
Which position of the ramp will provide the amount of energy required for the marble to roll over the speed bump?

**Step 2:** Test the ramp at various heights and record the results.
Students construct the ramp-and-speed bump system with the materials listed.
Place the 28 cm x 44 cm posterboard ramp at a height of 10 cm for the first test.
Tape the bottom of the ramp to the floor.
Make the speed bump by taping the remaining piece of posterboard 40 cm from the bottom of the ramp and bending it to a height of 10 cm. The ends of the posterboard should be flat. (see drawing below)
Place a heavy book behind the speed bump for support. As your group adjusts the height of the ramp, remember that the bottom of the ramp must remain 40cm from the speed bump.

**Step 3:** Each student writes a conclusion and explains their ideas about certain aspects of the ramp and speed bump system.

---

**Ramp and Speed Bump System**

![Diagram of Ramp and Speed Bump System]
Lab Sheet: How Much Energy?

Hypothesis
How high should the ramp be to provide enough energy for the marble to roll over the speed bump?

Experiment
Release the marble on various ramp heights. Record the results and your conclusions on the chart.

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Ramp Height</th>
<th>Over Speed Bump</th>
<th>Distance Traveled in cm</th>
<th>Your Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 cm</td>
<td>no</td>
<td>cm</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>15 cm</td>
<td>yes</td>
<td>cm</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>25 cm</td>
<td>yes</td>
<td>cm</td>
<td></td>
</tr>
<tr>
<td>Your Idea</td>
<td>cm</td>
<td></td>
<td>cm</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion
1. Which ramp gave the marble enough speed to travel over the speed bump? Explain.

2. How does the height of the ramp affect the amount of energy needed for the marble to roll over the speed bump?

3. How did the distance that the marble rolled from the bottom of the ramp to the speed bump affect the amount of energy needed for the marble to roll over the speed bump?

4. How would your results differ if you repeated the activity on a different surface? Example: What if you used a towel, sandpaper, wax paper on the ramp’s surface?
**General Rubric for Experiment**

**Score Point 4**
- demonstrates in depth understanding of concepts and processes
- includes all elements of scientific design
- includes clear and logical ideas; answers all questions
- organizes and completes all data

**Score Point 3**
- demonstrates good understanding of concepts and processes
- includes most elements of scientific design
- includes adequate ideas with minor misconceptions; answers most questions
- organizes and completes most data

**Score Point 2**
- demonstrates limited understanding of concepts and processes
- includes some elements of scientific design
- includes incomplete ideas with many misconceptions; answers some questions
- data is unorganized and incomplete

**Score Point 1**
- demonstrates no understanding of concepts and processes
- lacks elements of scientific design
- includes major misconceptions, or illogical ideas; answers to questions are few or incomplete
- data is unorganized and unclear

**Score Point 0**
- no attempt to respond
- includes inappropriate and/or unrelated responses

---

**Common Core ELA Reading Standards for Informational Text Grade 5**

- **RI 5.1** Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.
- **RI 5.2** Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
- **RI 5.3** Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.
- **RI 5.4** Determine the meaning of general academic and domain-specific words and phrases in a
text relevant to a grade 5 topic or subject area.

• **RI 5.5** Compare and contrast the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in two or more texts.

• **RI 5.6** Analyze multiple accounts of the same event or topic, noting important similarities and differences in the point of view they represent.

• **RI 5.7** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

• **RI 5.8** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

• **RI 5.9** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

• **RI.5.10** By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 4–5 text complexity band independently and proficiently.

### Common Core ELA Writing Standards Grade 5

• **W.5.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
  
  o **W.5.1a** Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer’s purpose.
  
  o **W.5.1b** Provide logically ordered reasons that are supported by facts and details.
  
  o **W.5.1c** Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).
  
  o **W.5.1d** Provide a concluding statement or section related to the opinion presented.

• **W.5.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
  
  o **W.5.2a** Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
  
  o **W.5.2b** Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
  
  o **W.5.2c** Link ideas within and across categories of information using words, phrases, and clauses
  
  o **W.5.2d** Use precise language and domain-specific vocabulary to inform about or explain the
• W.5.2e Provide a concluding statement or section related to the information or explanation presented.

• W.5.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.
  
  o W.5.3a Orient the reader by establishing a situation and introducing a narrator and/or characters; organize an event sequence that unfolds naturally.
  
  o W.5.3b Use narrative techniques, such as dialogue, description, and pacing, to develop experiences and events or show the responses of characters to situations.
  
  o W.5.3c Use a variety of transitional words, phrases, and clauses to manage the sequence of events.
  
  o W.5.3d Use concrete words and phrases and sensory details to convey experiences and events precisely.
  
  o W.5.3e Provide a conclusion that follows from the narrated experiences or events.

• W.5.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)

• W.5.5 With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. (Editing for conventions should demonstrate command of Language standards 1-3 up to and including grade 5 here.)

• W.5.6 With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.

• W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

• W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

• W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
  
  o W.5.9a Apply grade 5 Reading standards to literature (e.g., “Compare and contrast two or more characters, settings, or events in a story or a drama, drawing on specific details in the text [e.g., how characters interact]”).
  
  o W.5.9b Apply grade 5 Reading standards to informational texts (e.g., “Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point[s]”).
• **W.5.10** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

**Common Core ELA Speaking and Listening Standards Grade 5**

• **SL5.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others’ ideas and expressing their own clearly.
  
  o **SL.5.1a** Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
  
  o **SL.5.1b** Follow agreed-upon rules for discussions and carry out assigned roles.
  
  o **SL.5.1c** Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
  
  o gained from the discussions.

• **SL.5.2** Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

• **SL.5.3** Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence.

• **SL.5.4** Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

• **SL.5.5** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

• **SL.5.6** Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation. (See grade 5 Language standards 1 and 3 here for specific expectations.)