8th Grade Science Unit: May the Force Be with You
Unit Snapshot

Topic: Forces and Motion

| Grade Level: 8 | Unit Duration: 13 Days |

Summary
The following activities allow students to discover that forces have magnitude and direction through exploration of net force, force diagrams, investigations, and a design challenge involving various types of forces and how they impact/influence motion.

CLEAR LEARNING TARGETS
“I can”...statements

_____ demonstrate how forces can oppose the motion of an object.
_____ describe a force by its magnitude and direction.
_____ construct a force diagram.
_____ describe how net force affects an object’s direction and/or speed.
_____ demonstrate how forces are related to Newton’s 1st Law of Motion (inertia).
_____ apply knowledge about forces to solve a problem by designing a solution.

Activity Highlights and Suggested Timeframe

| Day 1 | Engagement: Students will be engaged in a discrepant event called “The Disappearing Penny” |
| Days 2-3 | Exploration: Students will explore opposing forces such as friction and air resistance through watching a video clip about the sport of curling and completing the CPO Physical Science Investigation 4B: Friction. |
| Days 4-6 | Explanation: Students will practice related vocabulary and concepts related to Forces, Motion, Force Diagrams and Net Force. |
| Days 7-11 | Elaboration: Students will apply their knowledge of forces and motion during the Egg Car Seat Belt Engineering Design Challenge. |
| Day 12 and on-going | Evaluation: Formative and summative assessments are used to assess student knowledge and growth to gain evidence of student learning or progress throughout the unit, and to become aware of students misconceptions related to forces and motion. A teacher-created short cycle assessment should be administered at the end of the unit to assess all clear learning targets (Day 12). |
| Day 13 | Extension/Intervention: Based on the results of the short-cycle assessment, facilitate extension and/or intervention activities. |
### NEW LEARNING STANDARDS:

**8.PS.2 Forces have magnitude and direction.**
- The motion of an object is always measured with respect to a reference point.
- Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The net force acting on an object can change the object’s direction and/or speed.
- When the net force is greater than zero, the object’s speed and/or direction will change (acceleration).
- When the net force is zero, the object remains at rest or continues to move at a constant speed in a straight line.

### 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:*
- Asking questions (for science) and defining problems (for engineering) that guide scientific investigations
- Developing descriptions, models, explanations and predictions.
- Planning and carrying out investigations
- Constructing explanations (for science) and designing solutions (for engineering) that conclude scientific investigations
- Using appropriate mathematics, tools, and techniques to gather data/information, and analyze and interpret data
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating scientific procedures and explanations

*These practices are a combination of ODE Science Inquiry and Application and Frame-work for K-12 Science Education Scientific and Engineering Practices*

### COMMON CORE STATE STANDARDS for LITERACY in SCIENCE:

- **CCSS.ELA-Literacy.RST.6-8.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.
- **CCSS.ELA-Literacy.RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts.
- **CCSS.ELA-Literacy.W.8.2d** Use precise language and domain-specific vocabulary to inform about or explain the topic.
- **CCSS.ELA-Literacy.SL.8.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

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

### STUDENT KNOWLEDGE:

**Prior Concepts Related to Forces**
- **K-2:** Forces are introduced as pushes and pulls that can change the motion of objects. Forces are required to change the motion of an object. Greater force on a given object results in greater change of motion.
- **Grades 3-5:** The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.
- **Grades 6-7:** An object’s motion can be described by its speed and the direction in which it is moving. An object’s position and speed can be measured and graphed as a function of time.

*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.*

**Future Application of Concepts**
- **High School:** Newton’s second law will be developed quantitatively and situations will be explored mathematically.
MATERIALS:

**Engage**
- Index Card
- Penny
- Beaker
- CPO Physical Science Text pp. 80 – 92

**Explore**
- Computer/Internet/Projector
- *See CPO Investigations Physical Science* pp18-20: Friction
- **CPO Kits** (1/group) Car and Ramp, Physics stand, CPO timer and photogates
- Tongue Depressors/craftsticks
- Large Paper Plates
- Tape
- Calculators

**Explain**
- Computer/Internet/Projector
- Part A: Sources to look up vocabulary
- Part B: Practice Worksheets
- Part C:
  - **Various spheres** (bowling ball, tennis ball, golf ball, ping pong ball, wiffle ball, shot put, billiard ball, marble, foam ball, etc.)
  - **Various rods** (broom, meter stick, cardboard tubes, baseball bat, wiffle bat, foam tube, cue stick, etc.)
  - **Various ropes** (heavy rope, twine, string, thread, fishing line, yam, etc.)
  - **Misc. high mass items** (brick, 2 liter bottles filled with water, book, rock, sand or bean bag, etc.)
  - **Misc. low mass items** (Styrofoam peanuts, inflated balloon, plastic toy, wood block, empty water bottle, etc.)

**Elaborate**
- Materials will vary with student group needs.
- It is suggested that the teacher anticipate that many groups will not be able to bring in supplies. Collect a large box of junk materials such as straws, craft sticks, bottle/jar lids, small boxes, recycling paper/cardboard/plastic bottles, string, rubber bands, masking tape, glue, etc.
- Eggs (teacher’s choice raw or hard boiled) or Plastic eggs with weight added (clay, pennies, etc.) to simulate the weight of eggs used in challenge

VOCABULARY:

**Primary**
- Air Resistance (Drag)
- Balanced Forces
- Force Diagram
- Friction
- Gravity
- Inertia
- Magnitude(strength)
- Mass
- Net Force
- Unbalanced Force
- Weight

**Secondary**
- Motion
- Reference Point
- Speed
<table>
<thead>
<tr>
<th>SAFETY</th>
<th>• See CCS Lab Safety Contracts. All Lab rules and procedures apply.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADVANCED PREPARATION</strong></td>
<td>Engage</td>
</tr>
<tr>
<td></td>
<td>• Set up materials for demo, and practice procedure</td>
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<td></td>
<td>• Copy <a href="#">Disappearing Penny</a> and <a href="#">The Science of Fun</a></td>
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<tr>
<td></td>
<td>Explore</td>
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<td></td>
<td>• Set up all labs (4B) and familiarize yourself with the procedures</td>
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<td></td>
<td>• Set up materials table with paper plates, tape, tongue depressors</td>
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<td></td>
<td>• and <em>Investigations</em> books.</td>
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<tr>
<td></td>
<td>• Copy <a href="#">4B Lab Report</a> for each group</td>
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<tr>
<td></td>
<td>Explain</td>
</tr>
<tr>
<td></td>
<td>• Copy <a href="#">Vocabulary Show Down worksheets</a> 1/student</td>
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<td></td>
<td>• Set up the materials table for the Lab activity</td>
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<td></td>
<td>• Copies of Net Force Practice Worksheets</td>
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<td></td>
<td>Elaborate</td>
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<td></td>
<td>• View Engineering Design Sample Activity</td>
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<tr>
<td></td>
<td>• Copy <a href="#">Egg Car Design Challenge handout and Rubric</a> 1/group</td>
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<td></td>
<td>• Gather junk/recycling materials in a large box for students to use for their cars</td>
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<td></td>
<td>• Construct a crash track (ramp + flat stretch that ends at a wall). Some simple ramps could be a foldable table with one set of legs folded, or a very long box cut to make a track, then supported by a chair.</td>
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<td></td>
<td>• Prepare 1 plastic fillable egg with clay or pennies added to simulate the weight of an egg.)</td>
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<td></td>
<td>• If you are going to use hard-boiled eggs instead of raw eggs, you will need to boil and refrigerate them.</td>
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<td></td>
<td>• Consider inviting a parent to video tape the “crashes”</td>
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<td></td>
<td>• Collect quality student examples for use later</td>
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<tr>
<td><strong>ENGAGE</strong> (1 Day)</td>
<td><strong>Objective:</strong> Students are engaged in a demonstration and questioning in order to formatively assess prior knowledge and misconceptions.</td>
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<tr>
<td>(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 be made to the real world?)</td>
<td></td>
</tr>
<tr>
<td><strong>What is the teacher doing?</strong></td>
<td><strong>The Disappearing Penny (Day 1)</strong></td>
</tr>
<tr>
<td></td>
<td>• This demo is done silently, with the teacher adding no discussion.</td>
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<tr>
<td></td>
<td>• Set a beaker where the students can easily observe it</td>
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<tr>
<td></td>
<td>• Place an index card on top of the beaker</td>
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<tr>
<td></td>
<td>• Place a penny on the card, so that it is centered above the beaker.</td>
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<td></td>
<td>• Firmly and swiftly flick the edge of the card with a finger to move it out from under the penny. The penny should fall straight down. If it does not, repeat the procedure until you successfully accomplish this.</td>
</tr>
</tbody>
</table>
Don’t be concerned about misfires. It adds to the questioning.  
- Engage the students to make observations of what they saw. Share and note any questions raised by the students.  
- Think-Pair-Share: Ask students to discuss with a partner their hypotheses about why the penny fell like it did and share out their hypotheses.  
- Repeat the demo, this time gently push the card instead of flicking it.  
- Think-Pair-Share: Ask students to discuss with a partner their hypotheses about why the penny stayed on the card like it did.  
- Distribute “Disappearing Penny” Have students draw the penny-card-cup system diagrams.  
- Observe the students’ diagrams for a pre-assessment on their understanding of the forces involved and the direction of the net forces. Ask questions like: What force caused the penny to fall when the card was flicked? (gravity) What force must have been greater than gravity to keep the penny on the card when the card was pushed? (friction)  
- As time permits, have students scan the CPO text pp. 80-92 for information to explain the activity.  
- Pass out, “The Science of Fun!” for homework. This text is at a 3rd grade reading level to ensure independent success at all levels.  

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1.</td>
<td>Students make and share observations.</td>
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<tr>
<td>2.</td>
<td>Students hypothesize about net forces.</td>
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<tr>
<td>3.</td>
<td>Students draw before/after diagrams and label forces</td>
</tr>
<tr>
<td>4.</td>
<td>Reading text for information</td>
</tr>
<tr>
<td>5.</td>
<td>Complete “The Science of Fun!” for HW or during RICA.</td>
</tr>
</tbody>
</table>
**Objective:** Students will gain hands-on experience with forces, their magnitude, and direction in which they act on an object through investigation using CPO Physical Science Lab Equipment.

<table>
<thead>
<tr>
<th>What is the teacher doing?</th>
<th>CPO Lab Investigation 4B: Friction (Days 2 &amp; 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Show the NBC Learn Video: Science Friction – Curling… [5:00]</td>
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<td></td>
<td>Set up physics stands, ramps, cars, timers, and photogates before class. Set up supplemental supply table</td>
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<td></td>
<td>Divide the class into small lab groups of 4-6 students based on differentiation needs and supply availability.</td>
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<td></td>
<td>Facilitate group role assignments: materials handler, recorder, data observer, mathematician, manipulator(s), construction engineer</td>
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<td><strong>NOTE:</strong> If this is the first time using the CPO ramps and timers, allow an extra day to explore their use (See Lab 4B)</td>
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<td></td>
<td>Go over directions for Lab 4B, briefly demonstrating the procedures.</td>
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<td></td>
<td>Students go to their lab areas and conduct the investigation, while teacher monitors and facilitates the investigation. Address any misconceptions, especially the direction that gravity is pulling. (<strong>Straight</strong> down, NOT parallel to the ramp, but perpendicular to the floor)</td>
</tr>
<tr>
<td></td>
<td>Students complete <strong>4B Lab Report</strong>, including questions on the back.</td>
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<tr>
<td></td>
<td>Class cleans up lab areas and gathers to summarize the investigation.</td>
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<tr>
<td></td>
<td>Follow-up with a class discussion related to lab results.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What are the students doing?</th>
<th>CPO Lab Investigation 4B: Friction (Days 2 &amp; 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Watch the science behind the sport of curling.</td>
</tr>
<tr>
<td>2.</td>
<td>Students complete investigation and worksheet.</td>
</tr>
</tbody>
</table>
### Objective:
Students demonstrate their knowledge gained in Engage and Explore and combine it with text research to explain and demonstrate their understanding of key terms and concepts of forces.

### What is the teacher doing?

**Vocabulary Showdown, Force Diagrams and Calculating Net Force (Day 4-5)**
- **See Teacher Reference Page for Instruction**
- Show the NBC Learn Video: Science of NHL Hockey Newton’s Three Laws of Motion [5:32]  
  [http://www.nbclearn.com/nhl](http://www.nbclearn.com/nhl)
- It is not important for students to know the 3 laws of motion, but instead understand how forces influence motion.

**Part A:** Facilitate as students work through defining vocabulary words.

**Part B:** Teacher leads students through Net force diagram examples and calculations.
- Review the CPO car and ramp system with students. Assist students in determining the forces acting on the car as it travels down the ramp.
- Create a force diagram to show all forces acting on the car.
- Discuss how Net Force is calculated and its effect on the motion of the object(s)
- Facilitate as students practice Net force calculations and diagramming.

### Student Demonstrations (Day 6)
- Facilitate as students create their own demonstrations that model how forces act on objects.
- Present demonstrations with explanation to the class.
- See Teacher Page

### What are the students doing?

**Vocabulary Showdown, Force Diagrams and Calculating Net Force (Day 4-5)**


2. **Part A:** In groups, students are using various resources to research and learn the meaning of key terms

3. **Part B:** Participate in class discussion related to diagramming forces and calculating Net Force.


**Student Demonstrations (Day 6)**

5. Students work in their groups to develop a demonstration using various objects, to show and explain how forces act on those objects.

6. Complete a force diagram related to the demonstration.  
   - See student worksheet.
## Columbus City Schools
### Curriculum Leadership and Development
#### Science Department

**June 2013**

### ELABORATE

(How will the new knowledge be reinforced, transferred to new and unique situations, or integrated with related concepts?)

| Objective: To reinforce that an object can be acted on multiple forces, in different magnitudes and directions, which can cause a change in the object’s motion. Students will relate the concept of inertia to the situation of an “Egg Car Crash Seat Belt Inquiry” in an engineering and design format. |
| What is the teacher doing? |
| **Egg Car Design Challenge** (Day 7-8) |
| • Teacher: Pre-view the video of Crash tests [http://www.youtube.com/watch?v=u49JdRXu_mC](http://www.youtube.com/watch?v=u49JdRXu_mC) |
| • Explain that the class will be doing a challenge. |
| • Distribute Egg Car Design Challenge handout and Rubric |
| • Discuss the parameters of the challenge |
| • Divide the class into groups of 4-5 students. |
| • Student groups work on their proposals, obtain approval and begin working on their cars. |
| • Teacher facilitates small groups. |

(Days 9-11)

| What are the students doing? |
| **Egg Car Design Challenge** (Day 7-8) |
| 1. Students will be introduced to the scenario. |
| 2. Students define the problem they will solve. |
| 3. Students will brainstorm design ideas. |
| 4. Using the Engineering Design Challenge template, student groups will design and create an Egg Car that they can test. |

(Days 9-11)

| 5. Students test their designs. |
| 6. Students will evaluate their designs (solutions to the problems) and propose an improvement to optimize their safety factor. |

OPTIONAL: Students present their designs using the rubrics to ensure they have met all the criteria for success. (See Rubric)

• Introduce to students the problem of the egg crash car. |
• Explain the Design Process they will use to solve this problem. |
• Facilitate groups’ planning and building. |
• Evaluating students’ solutions to the engineering problem. |

OPTIONAL: Student presentations
**Objective:** Teacher will gather data on student learning throughout the unit and use this data for intervention and extension. Students will demonstrate their understanding of forces and motion through various activities.

**EVALUATE**

(on-going)

(What opportunities will students have to express their thinking? When will students reflect on what they have learned? How will you measure learning as it occurs? What evidence of student learning will you be looking for and/or collecting?)

<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>• Consider developing a teacher-created formative assessment.</td>
<td>1. Developing demonstrations of forces on objects can be used to assess applied knowledge related to forces, motion, and force diagrams.</td>
</tr>
<tr>
<td>1. Engage Activity Questions, CPO 4B Lab Sheet, Vocabulary Show Down Sheet, practice problems can all be used to assess on-going students learning, formative assessment, and misconceptions.</td>
<td>2. Egg Car Challenge Design Challenge can be used to assess applied knowledge of forces and motion.</td>
</tr>
<tr>
<td></td>
<td>3. Teacher-created short cycle assessment will assess all clear learning targets <em>(Day 12).</em></td>
</tr>
</tbody>
</table>

**EXTENSION/INTERVENTION**

**EXTENSION**

2. Newton’s First Law of Motion: [http://sciencespot.net/Media/newtonlab.pdf](http://sciencespot.net/Media/newtonlab.pdf)

**INTERVENTION**

1. Force and Fan Carts Gizmo at ExploreLearning.com
2. Dueling Forces CCS Lessons on CIMS.

**COMMON MISCONCEPTIONS**

- 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.
- A force is needed to keep an object moving with a constant speed. Students do not realize that gravity and friction are forces.
- Gravity pulls in the direction of motion on a ramp. (In fact gravity always pulls in the direction of the center of gravity of the larger mass. On Earth, this means straight down, in a line that would go to the Earth’s center.)

Misconceptions can be addressed through DiscoveryEd videoclips, hands-investigations, models, and on-line simulations.

**DIFFERENTIATION**

Lower-Level: Open Inquiry can be adapted so student groups have a choice between teacher created “Solutions” or seat belts. This cuts down on materials needed, and allows lower-level students to experience the effects of force on an object.

Higher-Level: Students can modify their cars and test them or create cars with multiple passengers. Consider assigning extension activities.
### ADDITIONAL RESOURCES

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:**

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### Textbooks:
- CPO Physical Science Text pp. 80 – 92
- CPO Investigations Physical Science 4B pp. 8-20

### Websites:
- [http://phet.colorado.edu/en/simulation/forces-1d](http://phet.colorado.edu/en/simulation/forces-1d)

### Discovery Ed:
- TLC Elementary School: Rules of Motion and Forces  24:33]

### Literature:
Disappearing Penny

Draw a before and after diagram that shows how the penny, card and cup moved. Label the directions of movement with arrows.
Bello Nock recently raced up a thin wire on a motorcycle. He drove the motorcycle high over thousands of spectators' heads. He’s a clown with the Ringling Bros. and Barnum & Bailey circus. To the spectators below, Bello's stunt looked dangerous - and it was. But Bello knew a secret. He was using science to help keep himself safe.

Circus Science

Bello began performing circus stunts when he was nine years old. He walked on a thin wire that was stretched nine feet off the ground. To stay on a wire without falling, Bello needs to keep his center of gravity low. An object's center of gravity is usually located in the middle of the object. That is where the object's weight is centered. By crouching and keeping low, Bello keeps his center of gravity low. The lower his center of gravity, the harder it is for Bello to fall. Bello often carries a heavy metal stick when he performs. The stick bends downward, lowering his center of gravity.

Moving On

Bello also uses Newton’s first law of motion when he performs. That law is named for Isaac Newton. He was a scientist who lived about 275 years ago. Newton's First Law of Motion says that a moving object will keep moving unless an outside force acts on it. (The law also says that an object at rest will stay that way unless an outside force acts on it.) Bello uses that law when he rides his miniature, or tiny bike.

As Bello speeds along on his tiny bike, he sometimes has to stop before slamming into a wall. To stop, Bello uses the bike's brakes. The brakes create friction between the bike's tires and the ground. The friction is an outside force that slows the bike. Friction also changes the bike's motion into heat energy. You could say that Bello's act is really hot!

To see how friction works, rub your hands together as fast as you can. When you rub your hands together, they should start to feel warm. Friction between your hands changes into heat energy. Bello always puts on a high-energy show. “I always want to capture the attention of children,” he said. He captures their attention with science.
1. According to the passage, what does friction do with the motion of the bike?

A Friction makes Bello less likely to fall off the bike.
B Friction changes the motion into heat energy.
C Friction helps keep the bike’s center of gravity low.
D Friction means that Bello can rub his hands together while he rides.

2. Which of the following does the author describe first in the passage?

A The author describes Bello’s high-energy show as a tightrope walker.
B The author describes Bello’s life as a clown in the circus.
C The author describes Bello’s decision to use Newton’s first law of motion.
D The author describes Bello’s circus act of riding a motorcycle on a wire.

3. It can be inferred from the passage that

A Bello will probably stop performing as a circus clown soon because it is too dangerous
B Bello only knows how to ride a motorcycle, not a bicycle
C Bello is a very inexperienced clown, and this inexperience shows in his act
D the children in the audience at the circus may not understand the science behind Bello’s act

4. Read the following sentence: “To the spectators below, Bello’s stunt looked dangerous.”
   In this sentence stunt means

A trick
B motorcycle
C secret
D motion

5. This passage is mostly about

A how a clown got his start as a circus performer
B how a clown enjoys his life performing in the circus
C how a clown uses science to stay safe as he does stunts
D how a clown puts on a high-energy show

6. Why does Bello often carry a heavy metal stick when he performs?

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
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   D how a clown puts on a high-energy show.

6. Why does Bello often carry a heavy metal stick when he performs?

   Bello uses the metal stick to lower his center of gravity which helps him to stay balanced.
CPO Investigations:  4B Friction Lab Report

Question: How does friction affect a car’s motion?

Hypothesis: _________________________________________________________________

Experiment: Equipment and Procedure (see Investigations book pp 18-19)

Data Collection:

Table 1: Control Speeds

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time A to B (s)</th>
<th>Speed (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Average Speed  ______________

Table 2: Experimental Speeds

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<thead>
<tr>
<th>Trial</th>
<th>Time A to B (s)</th>
<th>Speed (cm/s)</th>
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Average Speed  ______________

Conclusion: ________________________________________________________________

________________________________________________________________________
Applying what you have learned

a. Friction is a force that opposes motion. Explain where the friction force on the sail comes from.

_______________________________________________________________________________

_______________________________________________________________________________

b. Is the sail the only source of friction? Does the car have any friction forces acting on it other than air friction? Explain.

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

c. For the car to be moving down the ramp, the net total of the forces acting on the car must be downward. What downward force must be acting on the car with a greater magnitude than the force of friction and the force of the ramp surface?

_______________________________________________________________________________

d. Thinking back to the Disappearing Penny demonstration, what role(s) did the forces of friction and gravity play on the motion of the card and penny?

_______________________________________________________________________________

_______________________________________________________________________________

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**Vocabulary Show Down - Teacher Page & Answers**

- It is not important for students to know the 3 laws of motion, but instead understand how forces influence motion.

**PART A:**

1. Distribute *Vocabulary Show Down worksheets* to each student.

2. Ask the students to identify resources they could use to find the meaning of the terms in Part A. (textbooks, other students, complete lab sheets, notes, internet, etc.)

3. Give students time to complete their definitions. Depending on the teacher’s comfort with movement in the class, this could be done quietly and independently or collaboratively.

4. Teacher walks around assessing the students’ accuracy in creating working definitions and makes notes of grouping to ensure there is at least one person in each group with an accurate definition for each term.

**Mass:** The measure of the amount of matter in an object.

**Weight:** The force exerted on an object due to the acceleration due to gravity.

**Gravity:** The force that attracts something toward the center of Earth or toward any other physical body having mass.

**Friction:** The force acting between two objects that are touching and opposes motion.

**Net Force:** The combination of all forces acting on an object.

**Balanced Forces:** A combination of forces in which the net force is zero.

**Unbalanced Forces:** A combination of forces in which the net force is not zero, resulting in a change in motion.

**Inertia:** Objects in motion, will stay in motion at the same speed and direction unless acted on by a force.

**Force Diagram:** A diagram showing the direction and magnitude of all forces acting on an object.

**PART B:**

5. Model the drawing of a force diagram by reviewing the CPO Lab set-up (car and ramp).

---

Columbus City Schools
Curriculum Leadership and Development
Science Department June 2013
6. Model how to calculate net force using the example problems at the top of the student worksheet.
   **Rules:** If forces are acting in the same direction = ADD them together
   If forces are acting in opposite directions = SUBTRACT one from the other

**EXAMPLES**

* Forces are in the same Direction

\[
1500 + 2000 + 2500 + 1500 + 2000 \\
\text{Net Force} = 9500 \text{N} \\
\text{Direction} = \text{Truck will move backwards}
\]

* Forces are in opposite directions

\[
1500 \text{N} - 1000 \text{N} \\
\text{Net Force} = 500 \text{N} \\
\text{Direction} = \text{Left man will move backwards (our left)}
\]

7. Assist students as they complete the practice problems.
Vocabulary Show Down

A. Use your resources to explain the meanings in your own words

1. Mass _________________________________________________________________

2. Weight _____________________________________________________________

3. Gravity _____________________________________________________________

4. Friction _____________________________________________________________

5. Net Force ___________________________________________________________

6. Balanced Forces _____________________________________________________

7. Unbalanced Forces ___________________________________________________

8. Inertia _____________________________________________________________

9. Force Diagram ______________________________________________________
EXAMPLES

PRACTICE PROBLEMS

Find the net force for the given problems.

a. 10 N → and 15 N → = _____ N Which direction? _______

b. 20 N ← and 60 N → = _____ N Which direction? _______

c. 30 N → and 20 N ← = _____ N Which direction? _______

d. 40 N ← and 50 N ← = _____ N Which direction? _______

e. 70 N down and 30 N up = _____ N Which direction? _______

Use the following picture to answer the questions. Circle the correct answer in parentheses.

1. The forces shown above are (PUSHING / PULLING) forces.

2. The forces shown above are (WORKING TOGETHER / OPPOSITE) forces.

3. The forces are (EQUAL / NOT EQUAL).

4. The forces are (BALANCED / UNBALANCED).

5. The net force is (1000 N TO THE RIGHT / 1000 N TO THE LEFT / ZERO).

6. There (IS / IS NO) motion.
DETERMINING NET FORCE

Directions: 1. Write the correct net force equation for each picture. 2. Solve, and determine the direction of motion. 3. Determine if the forces are balanced or unbalanced and circle the word.

Example

Net Force: 300 N − 250 N = 50 N

Circle One: Balanced or Unbalanced

1. Write the correct net force equation for each picture.

2. Solve, and determine the direction of motion.

3. Determine if the forces are balanced or unbalanced and circle the word.

For the plane to be moving forward, what must the relationship between z and y be?
EXAMPLES

PRACTICE PROBLEMS

Find the net force for the given problems.

a. 10 N and 15 N = 25 N  Which direction? Right

b. 20 N and 60 N = 40 N  Which direction? Right

c. 30 N and 20 N = 10 N  Which direction? Right

d. 40 N and 50 N = 90 N  Which direction? Left

e. 70 N down and 30 N up = 40 N  Which direction? Down

Use the following picture to answer the questions. Circle the correct answer in parentheses.

1. The forces shown above are (PUSHING  PULLING) forces.
2. The forces shown above are (WORKING TOGETHER  OPPOSITE) forces.
3. The forces are (EQUAL  NOT EQUAL).
4. The forces are (BALANCED  UNBALANCED).
5. The net force is (1000 N TO THE RIGHT  1000 N TO THE LEFT  ZERO).
6. There (IS  IS NO) motion.
**DETERMINING NET FORCE**

**Directions:** 1. Write the correct net force equation for each picture. 2. Solve, and determine the direction of motion. 3. Determine if the forces are balanced or unbalanced and circle the word.

**Example**

![Picture 1](image1.png)

Net Force: 300 N – 250 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*Opposite Forces are equal. Therefore the net force is zero and there will be no change in motion.*

**Picture 2**

![Picture 2](image2.png)

Net Force: 13,000N – 20,000N = 5,000N

Circle One: Balanced or Unbalanced

**Picture 3**

![Picture 3](image3.png)

Net Force = 1000N + 750N + 1200N + 1000N = 3950N

Circle One: Balanced or Unbalanced

**Picture 4**

![Picture 4](image4.png)

Net Force = 5000N + 4500N + 6300N = 15,800N

Circle One: Balanced or Unbalanced

**Picture 5**

![Picture 5](image5.png)

Net Force: 20,000N – 15,000N = 5,000N

Circle One: Balanced or Unbalanced

**Picture 6**

![Picture 6](image6.png)

Net Force: 250 N – 300 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*The boat is floating on top of the water. Therefore opposing forces must be equal.*

**Picture 7**

![Picture 7](image7.png)

Net Force: 300 N – 250 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*Opposite Forces are equal. Therefore the net force is zero and there will be no change in motion.*

**Picture 8**

![Picture 8](image8.png)

Net Force: 300 N – 250 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*The boat is floating on top of the water. Therefore opposing forces must be equal.*

**Picture 9**

![Picture 9](image9.png)

Net Force: 300 N – 250 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*Opposite Forces are equal. Therefore the net force is zero and there will be no change in motion.*

**Picture 10**

![Picture 10](image10.png)

Net Force: 300 N – 250 N = 50 N

Circle One: Balanced or Unbalanced

**How do you know – what is your evidence?**

*Opposite Forces are equal. Therefore the net force is zero and there will be no change in motion.*
PART C: Your task is to demonstrate forces acting on an object. You will receive points for the use of the vocabulary in Part A. Be sure to point out the direction and magnitude (strength) of the forces involved. Draw a force diagram based on the demonstration. Label the forces and use arrows to show the magnitude and direction of the forces.

OBJECT(s): __________________________________________________

FORCE DIAGRAM:
EGG CAR DESIGN CHALLENGE

The Problem:
Seat belts saved over 75,000 lives from 2004-2008; however, seat belts are only 50% effective in preventing injury. Broken ribs, whip lash, and lacerations are just some of these injuries that occur from seat belt use. Although these ailments are far better than the death that will likely occur from not wearing a seat belt, a company has decided to challenge all science students to help them find a solution.

The Parameters
Your group will submit a proposal to this problem; test your solution using the following experiment specifications. The car must “seat” one egg.

Size
Length= 20 cm minimum, 30 cm maximum
Width= 5 cm minimum, 10 cm maximum
Height= 5 cm minimum, 15 cm maximum
Four wheels, any source is acceptable, even hand made
Two axles

Legal Features
• Bumpers
• Roll bars
• Air bags
• Crush zones
• Break-away parts
• Lamination
• Seat belts
• Form-fitting seats

Illegal Features
• Brakes-of any kind
• Parachutes, scoops, or any other device that slows the vehicle’s speed
• Extra wheels
• Foreign objects applied directly to the egg “passenger” for protection (cotton, Styrofoam, bubble wrap, etc.)
• Tape, staples applied to passenger

Proposal for Solution
Your group must first write a proposal for solution to submit to your teacher. Start your proposal for solution with “I (We) propose to…” This would be followed by a brief description of your solution. This solution would include the following:
• Design sketch/description
• Safety Procedures that need to be followed
• Materials list
• Group members Roles/Responsibilities

**Once your proposal is completed and approved you may construct and test your vehicle.
**Testing Parameters**

Data collected during testing must include the average speed of the car with the egg, as well as the “injuries” suffered by the “passenger.”

Remember that

\[
\text{Speed} = \frac{\text{Distance}}{\text{Time}}
\]

The final portion of this challenge is to evaluate your car, and propose a redesign modification to improve your initial solution. Good Luck!!!
Engineering Design Challenge

1) **Define** the problem.
   While observing, what were the questions that came to your mind?

2) **Brainstorm** several ways that may solve the problem. Sketch ideas or write out.
   What do you want the solution to do? Scientific Hypothesis: each solution should be testable. The final solution will be modified and optimized several times after repeated tests.

3) **Develop the Solution**. Pick ONE of your brainstorms. Explain why it will work the best.
   Scientific Hypothesis: Would this solution answer the problem? Is this the simplest solution?
4) **Constraints.** Identify materials needed to build your solution. How much time will be required? Where will you obtain the materials? List any safety concerns?

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5) **Optimize.** Draw a picture of your design. Label each part. Identify the materials used. Describe how it will be created or assembled.

6) **Build your prototype.** *Engineering: Stick to the design and record all modifications.*
7) **Improve.** Did your prototype work as you expected it would?

8) **Optimize.** Can it be made simpler or with less materials?

9) **Define the Problem.** Does the solution create any additional problems that need addressed?

Return to step 1
## EGG CAR Design Challenge Rubric

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| **Plan**                  |   |   |   |   |
| Plan is neat with clear   | 4 | 3 | 2 | 1 |
| Includes sketch and       |   |   |   |   |
| description. Safety       |   |   |   |   |
| procedures are listed. A  |   |   |   |   |
| complete materials list is included. | | | | |
| Plan is unclear, and      |   |   |   |   |
| does not include sketch,  |   |   |   |   |
| description, safety       |   |   |   |   |
| procedures, or a materials list. | | | | |

| **Presentation**          |   |   |   |   |
| Presentation of findings  | 4 | 3 | 2 | 1 |
| is focused using relevant |   |   |   |   |
| scientific content. Good   |   |   |   |   |
| use of eye contact with   |   |   |   |   |
| audience and a clear      |   |   |   |   |
| and appropriate volume.   |   |   |   |   |
| Presentation of findings  |   |   |   |   |
| is focused using relevant |   |   |   |   |
| scientific content. Good   |   |   |   |   |
| use of eye contact with   |   |   |   |   |
| audience.                |   |   |   |   |
| Little evidence of        |   |   |   |   |
| focused presentation of   |   |   |   |   |
| findings.                |   |   |   |   |

| **Modification**          |   |   |   |   |
| (Individual work)         |   |   |   |   |
| Student 1.cites data      | 4 | 3 | 2 | 1 |
| from the presentation to  |   |   |   |   |
| identify an area for      |   |   |   |   |
| improvement. 2. articulates |   |   |   |   |
| a clear plan for improving |   |   |   |   |
| their design, and 3.      |   |   |   |   |
| includes a labeled before/after diagram. | | | | |
| Student fulfills 2/3 of   |   |   |   |   |
| the criteria.             |   |   |   |   |
| Student fulfills 1/3 of   |   |   |   |   |
| the criteria.             |   |   |   |   |