When Push Comes to Shove

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T.C. Miller Elementary, Lynchburg, VA

Grades: 5 – 8 (Upper Elementary and Middle School)

Time Allotment: Three or four 45 minute sessions

Overview: Force and Motion. This lesson explores Newton's Laws of Motion, including how mass, friction and inertia affect force and how things move.

Subject Matter: Science, Math, Art, History

Learning Objectives:

The student will be able to:
- Plan and conduct investigations that explore Newton's Laws of Motion.
- Identify the concepts involved in force and motion, including the following vocabulary: motion, force, friction, gravity, inertia, mass.
- Create a car to use in force and motion experiments.
- Use historical analysis skills and organize information to research people and events that contribute to understanding the concepts of force and motion.

The student will use the Internet to:
- Conduct investigations involving force and motion, gravity, friction, distance.
- Conduct research on people that contributed to understanding the concept of force and motion, such as Isaac Newton, etc.
- Explore the key concepts involved in the understanding of Newton's Laws of Motion.

Standards:

The objectives listed above may be used to address the following Virginia Standards of Learning available at http://www.pen.k12.va.us/VDOE/Superintendent/Sols/sciencesol.doc

Grade 4:

Science 4.2 The student will investigate and understand characteristics and interaction of moving objects. Key concepts include

a) motion is described by an object's direction and speed;
b) forces cause changes in motion;
c) friction is a force that opposes motion; and
d) moving objects have kinetic energy.

Math 4.10 The student will

a) estimate and measure weight/mass, using actual measuring devices, and describe the results in U.S. Customary/metric units as appropriate, including ounces, pounds, grams, and kilograms.

Math 4.11 The student will

a) estimate and measure length, using actual measuring devices, and describe the results in both metric and U.S. Customary units, including part of an inch (1/2, 1/4, and 1/8), inches, feet, yards, millimeters, centimeters, and meters;

Grade 8:

Physical Science PS.10 The student will investigate and understand scientific principles and technological applications of work, force, and motion. Key concepts include

a) speed, velocity, and acceleration;

b) Newton's laws of motion;

Geometry 8.9 The student will construct a three-dimensional model, given the top, side, and/or bottom views.

Media Components:

Video:

• United Streaming Video: http://www.unitedstreaming.com/index.cfm *Let's Move It: Newton's Laws of Motion*

• Computer with Internet access

Internet Web Sites:

• Forces in Action
http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtml This web site replicates the culminating activity in an interactive way. It includes a data table and a quiz. Two more motion activities can be found on the web site, one that deals with changes in mass, and the other, changes in friction.

• Interactive Quiz on Newton's Laws of Motion
http://www.quia.com/servlets/quia.activities.common.ActivityPlayer?AP_rand=1433311994&APactivityType=2&AP_urlId=19675&AP_continuePlay=true&AP_activityType2&AP_urlId=19675 This web site allows the user to assess their knowledge on Newton's laws of motion

• Name That Motion Interactive Activity
http://www.glenbrook.k12.il.us/gbssci/phys/shwave/ntmintro.htm
This activity presents 11 challenges to students. Each challenge demands that they match the motion of an animated car to the corresponding verbal description of the motion. Once the 11 matches have been completed, students can check their answers. If any of the 11 challenges are incorrect, students can correct their answers and check them again until they are perfect.

• Isaac Newton and Laws of Motion
http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html This NASA website includes a portrait of Isaac Newton and lists/explains his three laws of motion.

• Design a Roller Coaster
http://www.learner.org/exhibits/parkphysics/coaster/ This website allows the user to create their own roller coaster. Students can control the height and shapes of the hills, the loop, and the exit path

• Playground Physics
http://lyra.colorado.edu/sbo/mary/play/ This website includes several motion experiments that students can conduct on the playground at school.

Materials:

Per Class:
• Computer lab with Internet access, or a computer station that students can rotate through to collect their information
• Computer disks for information storage

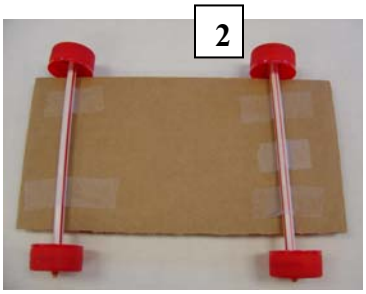
Per Student:
• 1 cardboard rectangle
• 2 drinking straws
• 2 thin wood skewers
• 4 plastic bottle caps with hole in the middle (can be done ahead of time or students can use hammer and a nail to make the hole in each one)
• Glue
• Scotch tape
• Construction paper scraps
• Markers or colored pencils
• Pennies or metal washers
• Student Data Sheet
• Balance

Prep for Teachers:

• Prior to teaching, have all Internet sites bookmarked for easy access throughout the lesson. The web sites should also be bookmarked on classroom computers for easy access by students during their individual time in the computer center, or on the computers in the lab for whole class use.
• You should preview the video clips and cue them as indicated in the Learning Activities section.
• Familiarize yourself with the lesson format and be sure to have all materials ready as listed in the materials section.
• When using media, provide students with a **FOCUS FOR MEDIA INTERACTIO**N, a specific task to complete and/or information to identify during or after viewing of video segments, Web sites, or other multimedia elements.

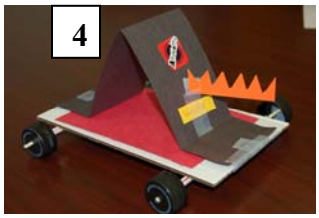
Introductory Activity: Setting the Stage

1. Students will build a car using a cardboard rectangle, 2 straws, 2 skewers, and 4 plastic bottle caps. Give each student 4 plastic bottle caps with pre-made holes, or let them use a hammer and nail to make a hole in the middle of each cap. Insert a skewer through each of the drinking straw "axles" and glue a bottle cap "wheel" on each end of the skewer. (see picture #1) Be sure the wheels are tight on the skewer and that it has room to freely turn inside the straw. This creates the two axles for the car.



2. Next the students should tape each axle assembly one inch from the short ends of the cardboard rectangle. Teacher should demonstrate. (See Picture #2) This is the basic car frame. Teacher should make one car with just the basic frame to use as a control in the experiment.

3. Students should now design the upper body of their car using colored paper scraps, buttons, magazine pictures, or original artwork. Using a digital camera, students can print pictures of themselves to put into their car. (See picture #3 and #4)



4. Students should measure the mass of their car using a balance (mass can be changed by adding or subtracting embellishments.) Have students record the mass of their car on their student data sheet.

Learning Activities:

1. **CUE** the video, *Let's Move It: Newton's Laws of Motion* at the title screen "Let's Move It". (001:17 on video streaming counter) Provide a **Focus for Media Interaction** by saying, "Listen for the name of the scientist who first observed the laws of motion three hundred years ago." **Play** and **Pause** when the narrator says "Sir Isaac Newton". There will be a picture of him on the screen. (01:35) **Ask**: "Can you name the scientist who first observed the laws of motion 300 years ago?" (Sir Isaac Newton) **Ask**: "How many laws of motion are there?" (three) **Ask**: "Can you name the laws of motion?" (take answers, but tell them we will break them down later so they will be easier to understand)
2. Provide a **Focus for Media Interaction** by saying, "Now listen carefully for Newton's first law of motion. Use picture clues from the video to help you explain the first law of motion." **Resume** and **Pause** when the narrator says "…an object in motion stays in motion unless a force acts upon it." (01:55) **Ask**: "Can you tell me the first law of motion? Remember there are two statements in this law of motion" (An object at rest stays at rest unless a force acts on it. An object in motion stays in motion unless a force acts upon it.) **Ask**: "Can anyone give me some examples of this?" (hitting a golf ball from a tee, hitting a hockey puck over the ice, pushing a toy car to make it move, etc.)
3. Provide a **Focus for Media Interaction** by saying, "Now I want you to listen for Newton's second law of motion. Again try to think of an example that would help explain the second law of motion." **Resume** and **Pause** when the narrator says "…depends on the mass of the object and the amount of force applied to it." (02:08) **Ask**: "What is Newton's second law of motion?" (an object's acceleration depends on the mass of the object and the amount of force applied to it.) **Ask**: "Can you give me an example?" (...a bowling ball will move more slowly than a golf ball because its mass is so much more.)
4. Provide a **Focus for Media Interaction** by saying, "Now let's listen to Newton's third law of motion. Be able to discuss this one too, with examples from the picture clues." **Resume** and **Pause** when the narrator says "…every action has an equal and opposite reaction. (02:17) **Ask**: "What is Newton's third law of motion?" (Forces come in pairs. Every action has an equal and opposite reaction.) **Ask**: "What example was shown in the video?" (The movement of the ball coming out of the cannon forces the cannon to recoil, or move back a little. The ball moves one way, the cannon moves the other.)
5. Provide a **Focus for Media Interaction** by saying, "Now we'll go over Newton's first law of motion in more depth. In this segment be able to tell me what makes something start moving, and what will change its direction. Also, what term is used to describe an object staying in motion?" **Resume** and **Pause** when the narrator says, "This is called

inertia." The word *inertia* will be on the screen. (02:51) **Ask**: "What causes something to move or change direction?" (a force) **Ask**: "What term is used to describe an object staying in motion?" (inertia)
6. Provide a **Focus for Media Interaction** by saying, "Now let's listen for some different types of forces that act upon objects." **Resume** and **Pause** when the video shows a girl going down a sliding board. (04:23) **Ask**: "Name some different types of forces that act upon objects?" (push, pull, friction) **Ask**: "What is friction?" (the slowing down of an object because of the rubbing together of two surfaces.) **Ask**: "Can you give me some examples of this?" (bike slows down because of friction of the tires on the road, or air against the surface of the bike, object or person slides slowly down a ramp because of friction of the object against the surface of the ramp)
7. Provide a **Focus for Media Interaction** by saying, "Listen for another type of force that acts on all objects on earth, and explain how it happens."
Resume and **Stop** after the ball is thrown up in the air and it falls back to the ground. (05:00) **Ask**: "What is a force that acts upon all objects on the earth?" (gravity) **Ask**: "How does gravity work?" (Gravity pulls all objects back toward the center of the earth.) **Ask**: "Can you give me some examples?" (Any object thrown into the air will always fall back toward the earth) **Say**: "Now we are going to use the cars we made to experiment with Newton's first law of motion."

Culminating Activity

1. Students should hypothesize which car in the class will travel the longest distance when released at the top of a ramp. **Ask**: "Will the car with the most mass travel farthest or will it be the car with less mass?" Let's try it.
2. Create a ramp by taping a large piece of cardboard on the edge of a table or chair. Now each student should start at the top of the ramp and release their car. Measure the distance the car travels in yards and inches (meters and centimeters.)
3. Discuss what forces come into play in this activity. (push, pull, gravity, friction, inertia) **Ask**: "Was your prediction about which car would travel the longest distance correct?" (yes or no) Explain that the design of their car may have made their car perform in ways they did not expect. Higher paper sculpture on top of the cardboard may have increased wind resistance (friction) or the wheels may have been crooked, so their prediction may not have been correct. The car with the greatest mass should travel farther. This could prompt a discussion on the engineering of a car, and how its design determines how well it performs.
4. Students should change the angle of the ramp and record the number of yards or meters their car travels at different angles and then make a graph showing the results.
5. Divide the class into small groups. Give each group an equal number of pennies or metal washers. They should discuss the mass of the metal, then tape a few pennies or washers somewhere onto their car sculpture. Ask them to hypothesize how the mass will affect the movement of their car. Will the change make it travel a longer distance or not? Remind them that their cars all have a different mass, depending on how they designed the paper sculpture part on top of the base. The cardboard base and the axles are the same. Tell them to repeat the above experiments with the added mass.
6. Have students share the results of their car tests.
7. Students should fill out the rest of their student data sheet.

8. Have students go to the following web site: Forces in Action
http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtml
On this web site they can try out the same activities with an interactive game.

Assessment

1. To test students' knowledge of the concepts of force and motion, have them visit the following website.
Interactive Quiz on Newton's Laws of Motion
http://www.quia.com/servlets/quia.activities.common.ActivityPlayer?AP_rand=1433311994&AP_activityType=2&AP_urlId=19675&AP_continuePlay=true&AP_activityType2&AP_urlId=19675 This website provides a visual and interactive test of students' knowledge of these concepts.
2. Students write a lab conclusion in which they describe how the motion of their car illustrates each of Newton's Laws of Motion.

Cross-Curricular Extensions

Language Arts:

1. Have students read trade books on their reading level about force and motion.
2. Have students write a "How-to" paragraph about the steps necessary to make the car used in the introductory activity.
3. Collect information about Isaac Newton and other scientific pioneers, organize information and write a paper about their contributions to the understanding of motion.

Math:

1. Have students measure the mass of a variety of objects in the classroom.
2. Using the data collected from the class, calculate the mean (average), median (number in the middle of all numbers), and mode (most frequently occurring number) of the distance the cars traveled when manipulating the height of the ramp and the mass of the car. From that data you can discuss the ideal angle of the ramp, tie in engineering to why roads are built to certain angle specifications.

Art**:**

1. Have students use paper sculpture techniques (folding, curling, scoring, etc.) studied in art to embellish their cars.
2. Have students create their car design around a particular style of art (Impressionisn, Pointillism, Surrealism, etc.)

Movement Education:

1. Have students use a variety of movement tools apparatus and machines to practice using the forces of push and pull (wagons, scooters, big wheels, ramps, etc.) Discuss how the forces work, and also how gravity affects the movement of each of the machines.
2. Have students compare the different sports activities in which they participate. (basketball, baseball, football, soccer, swimming, etc.) Have them demonstrate the different forces used in their favorite sports. For example, if a student chooses

basketball, have him or her describe how the sport illustrates Newton's First Law of Motion.

Technology:

1. Have students plan and create a PowerPoint presentation showing what they have learned about Newton's Laws of Motion. They should include graphics to demonstrate how each law works, and a section on the contributions of Sir Isaac Newton to the study and understanding of force and motion
2. Have students visit the following websites to further explore the science of force and motion.

• Name That Motion Interactive Activity
http://www.glenbrook.k12.il.us/gbssci/phys/shwave/ntmintro.htm
This activity presents 11 challenges to students. Each challenge demands that they match the motion of an animated car to the corresponding verbal description of the motion. Once the 11 matches have been completed, students can check their answers. If any of the 11 challenges are incorrect, students can correct their answers and check them again until they are perfect.

• Isaac Newton and Laws of Motion
http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html This NASA website includes a portrait of Isaac Newton and lists/explains his three laws of motion.

• Design a Roller Coaster
http://www.learner.org/exhibits/parkphysics/coaster/ This website allows the user to create their own roller coaster. Students can control the height and shapes of the hills, the loop, and the exit path

• Playground Physics
http://lyra.colorado.edu/sbo/mary/play/ This website includes several motion experiments that students can conduct on the playground at school.

Community Connections:

1. Have a race car driver visit the class to share information about race cars, racing strategy, and how forces make it all work.
2. Visit an amusement park and have students observe, discuss and compare how the different rides work, detailing the forces used in each ride.

Name _____

STUDENT DATA TABLE – When Push Comes to Shove

Mass of car _____

Data Table 1 – Changing the height of the ramp

Ramp	Height (cm)	Trial 1 Distance (m)	Trial 2 Distance (m)	Average Distance (m)
1				
2				
3				

Data Table 2 – Changing the mass of the car

Car	Mass (g)	Trial 1 Distance (m)	Trial 2 Distance (m)	Average Distance (m)
1				
2				