

Rules of Forces and Motion: Teacher's Guide

Grade Level: 4-5

Curriculum Focus: Physical Science

Lesson Duration: 1-2 class periods

Program Description

Facts About Forces (8 min.) – See how gravity and friction keep us grounded. *Laws of Motion* (6 min.) – In this segment, overcome inertia with Newton's laws of motion. *Rotation and Revolution* (4 min.) – Discover why a day is not 24 hours. *How We Fly* (3 min.) – Take to the skies and experience how we fly.

Onscreen Questions

- What types of forces can you name?
 - What is the difference between kinetic friction and static friction?
 - What have you observed about moving objects?
 - Why do Newton's laws of motion explain how objects move?
 - Why do night and day occur?
 - Why do four seasons occur?
 - What is leap year?
 - Why isn't a day really 24 hours long?
 - How do you think an airplane's wings help it fly?
 - Describe how lift helps a plane fly.
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Lesson Plan

Student Objectives

- Demonstrate an understanding of the terms force, gravity, friction, and speed
- Experiment with the effects of mass and friction on speed and motion
- Understand that friction and other forces have an effect on speed and motion

Materials

- *Forces and Motion* video and VCR, or DVD and DVD player
- Books, blocks, or other stacking materials
- 36" x 12" (1 m x 30.5 cm) pieces of smooth plywood or other sturdy, flat material, 1 per group
- Small toy cars with moving wheels, one per student group
- Pennies, washers, or other small uniform objects with weight, 6 per student group
- Tape
- 1-foot (30.5 cm) sheets of heavy duty sand paper, 3 per student group
- 3-foot (1 m) sheets of wax paper, 1 per student group
- 3-foot (1 m) sheets of bubble wrap, 1 per student group
- Pencils and erasers
- Science journals or writing paper
- Stop watch (or watch with second hand), 1 per student group
- Meter stick, 1 per student group
- Computer with Internet access (optional)

Procedures

1. Talk about the concept of motion. How do objects move? A good way to introduce this topic is to review *Forces and Motion*. After watching the program, discuss the different types of forces at work in the world. How do they help or hinder motion? Ask students to describe examples of gravity and friction.
2. Tell students that they will be conducting an experiment with motion and forces. Demonstrate making a ramp by placing one or more books under one end of the plywood. Show students how to gently push the toy car down the ramp and then measure the speed and distance it traveled with a meter stick and stopwatch. Talk about ways to make the car travel faster or go farther. Discuss the forces at work on the car. What makes it move toward the bottom of the ramp? What keeps it from moving faster? Discuss the effects of gravity and friction on the toy car.
3. Divide the class into groups of 3-5. Give each group about 5 books, blocks, or other stacking materials, the plywood, and a toy car and ask them to find an open space in the classroom to set up their ramps. Allow the groups a few minutes to experiment with their ramps, rolling their cars down different height ramps to see what height allows the car to go the fastest and farthest. What does increasing or decreasing the angle of the ramp do for the motion of the car?
4. After this initial exploration, ask groups to stick to the angle of ramp they found works the best for the remainder of the lesson. Have them record a drawing of their ramp in their science journals or on a piece of paper, and, next to the illustration, ask them to write the amount of stacking materials they used to create the ramp and the height of the ramp. Tell them to gently



push the car down the ramp three times and record the distance and speed at which it traveled each time. What is the fastest and farthest their cars traveled? Have them find the average speed and distance their cars traveled down the set ramp and record this in their journals (or on the paper).

5. Give each group six pennies, washers, or other uniform metal objects. Have them all feel one and talk about the weight of it. Then, have them tape three pennies or washers onto the top of their toy car. Ask them to hypothesize whether they think this added weight would make the car move faster or slower. Tell students to again roll the car down the ramp three times, recording the speed and distance for each separately. Then have them find the average of the three trials. Did the car move faster or slower with the added weight? Why do you think this is? Talk about mass and how it affects speed.
6. Have students tape the remaining three metal objects to the top of the car. What will happen this time? Ask them to record their hypotheses before conducting three more trials, remembering to record the speed and distance from each trial and then find the average. What happened this time? Was the hypothesis correct? What forces are at work making the car move differently with the added weight? Ask them to explain the effect a greater mass had on the movement of the car and have an open discussion about gravity and friction.
7. Give each group pieces of sand paper, wax paper, and bubble wrap. Tell the groups that they will now be experimenting with friction. Have them remove the metal objects taped to the car and tape the wax paper to the ramp. Ask them to refer back to their earlier recordings of the speed and distance their cars traveled down the ramp without the added weight. Do you think the car will move faster or slower on the waxy surface? Will it travel as far or farther than on the plywood? After recording their hypotheses, have students conduct three trials on the wax paper ramp, recording the speed and distance their cars traveled each time. Then have them find the average speed and distance. Was the hypothesis correct? Did the waxy surface make a difference in the way the car traveled? Was more or less friction at work?
8. Have students remove the wax paper and attach the sand paper to the ramp. Ask them to hypothesize whether the rough surface will create more or less friction for the car. Will their car move faster or slower on the sand paper? Have students conduct three trials on the sand paper ramp, recording the speed and distance their cars traveled each time. Then have them find the average speed and distance. Was the hypothesis correct? Did the sand paper surface make a difference in the way the car traveled? Was more or less friction at work?
9. Repeat the tasks in Step 8, this time using bubble wrap instead of sand paper. Did the toy car move faster or slower when riding on the bubble wrap? Which of the four surfaces (wood, wax paper, sand paper, or bubble wrap) provided the most friction? Which provided the least?
10. Ask students provide examples of friction. How does rain affect the roads? How does the traction on different tires change how a car moves? Reexamine what they have learned about motion, mass, forces, speed, and friction. If there's time, allow students to continue the experimentation online with an interactive activity on the following Web site:

<http://jersey.uoregon.edu/vlab/KineticEnergy/>

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- **3 points:** Students were highly engaged in class discussions; were highly focused and worked well in their experiment groups; followed directions well and successfully completed the experiments; and were able to demonstrate a solid understanding of the effects friction, gravity, and mass have on motion and speed.
- **2 points:** Students were somewhat engaged in class discussions; were somewhat focused and participated in their experiment groups; followed directions for the most part and successfully completed the experiments with little outside assistance; and were able to demonstrate a basic understanding of the effects friction, gravity, and mass have on motion and speed.
- **1 point:** Students participated minimally in class discussions; were unfocused and did not participate in their group experiments; were unable to follow directions without outside assistance; and were unable to demonstrate a basic understanding of the effects friction, gravity, and mass have on motion and speed.

Vocabulary

acceleration

Definition: The rate of which an object changes its velocity

Context: Acceleration can be positive or negative depending on whether the object is speeding up or slowing down.

force

Definition: A push or a pull exerted on an object

Context: The ball was hit with enough force to send it into the bleachers.

friction

Definition: A force that resists motion between two bodies in contact

Context: Rougher surfaces create more friction than smooth ones when an object comes in contact with them.

gravity

Definition: The natural force that attracts any two objects with mass toward each other

Context: Earth's gravity pulls on anything that is not held up by some other force.

speed

Definition: The rate of motion

Context: The speed of the ball is determined by measuring how far it travels in a certain amount of time.

velocity

Definition: The speed of an object moving in a specific direction

Context: The car's velocity was 55 miles per hour, eastbound.



Academic Standards

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site:

<http://books.nap.edu/html/nses/html/overview.html#content>.

This lesson plan addresses the following national standards:

- Unifying Concepts and Processes: Change, constancy, and measurement
- Science as Inquiry: Abilities necessary to do scientific inquiry; Understanding about scientific inquiry
- Physical Science: Motions and forces; Position and motion of objects

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit

<http://www.mcrel.org/compendium/browse.asp>

This lesson plan addresses the following national standards:

- Science: Physical Science—Understands forces and motion
 - Science: Nature of Science—Understands the nature of scientific knowledge; Understands the nature of scientific inquiry
 - Mathematics – Understands and applies basic and advanced properties of the concepts of measurement
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Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- <http://school.discovery.com/teachingtools/teachingtools.html>
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