Sci-Port: LOUISIANA'S Science Center

Marble Mania

Grades: 5th- 12th

Duration: 60 minutes

Program Description

Create crazy contraptions with your classmates to create the longest, slowest moving marble coaster ride! Students will discover how angles, friction, and gravity affect the acceleration of an object and how to apply those tools to make a successful marble coaster!

Louisiana GLE:

Science:

5th Grade:

9. Use computers and/or calculators to analyze and interpret quantitative data (SI-M-A3)
10. Identify the difference between description and explanation (SI-M-A4)

5th-8th Grade

1. Generate testable questions about objects, organisms, and events that can be answered through scientific investigation (SI-M-A1)
2. Identify problems, factors, and questions that must be considered in a scientific investigation (SI-M-A1)
3. Use a variety of sources to answer questions (SI-M-A1)
4. Design, predict outcomes, and conduct experiments to answer guiding questions (SI-M-A2)
6. Select and use appropriate equipment, technology, tools, and metric system units of measurement to make observations (SI-M-A3)
8. Use consistency and precision in data collection, analysis, and reporting (SI-M-A3)
19. Communicate ideas in a variety of ways (e.g., symbols, illustrations, graphs, charts, spreadsheets, concept maps, oral and written reports, equations) (SI-M-A7)
33. Evaluate models, identify problems in design, and make recommendations for improvement (SI-M-B4)

6th Grade:

17. Describe and demonstrate that friction is a force that acts whenever two surfaces or objects move past one another (PS-M-B2)
19. Identify forces acting on all objects (PS-M-B3)
22. Demonstrate that an object will remain at rest or move at a constant speed and in a straight line if it is not subjected to an unbalanced force (PS-M-B5) (PS-M-B3)
23. Predict the direction of a force applied to an object and how it will change the speed and direction of the object (PS-M-B5)

24. Describe and give examples of how all forms of energy may be classified as potential or kinetic energy (PS-M-C1)
27. Explain the relationship between work input and work output by using simple machines (PS-M-C2)

9th-12th Grade:

2. Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
3. Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
4. Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5. Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
7. Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9. Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)

Physical Science

34. Demonstrate Newton's three laws of motion (e.g., inertia, net force using F = ma, equal and opposite forces) (PS-H-E3)
38. Analyze diagrams to identify changes in kinetic and potential energy (PS-H-F2)

Physics

19. Explain quantitatively the conversion between kinetic and potential energy for objects in motion (e.g., roller coaster, pendulum) (PS-H-F1)

Key Terms:

Friction: Surface resistance to relative motion, as of a body sliding or rolling.

Gravity: The attraction between all objects that manifests itself via a gravitational force

Inertia: The ability of an object to resist a change in its motion or position and is based on the amount of mass and the way the mass is distributed

Kinetic Energy: The energy possessed by a body because of its motion, equal to one half the mass of the body times the square of its speed.

Laws of motion - three laws developed by Issac Newton that describe the motions of a macroscopic object and ignores the effect of quantum mechanics

Potential Energy: The energy of a particle or system of particles derived from position, or condition, rather than motion. A raised weight, coiled spring, or charged battery has potential energy.

Connections to Permanent Exhibits:

Ball Machine: Watch a specific ball. How many different tracts are there in one section? In the whole machine?

Gravity Well: Your students can roll coins around an inverted cone. The coin's path, projected on a horizontal plane, simulates the orbits of the planets. (Coins collected from the exhibit are used to for a matching grant Sci-Port Discover y Center's new space expansion.)

Ned Kahn Art-Science: These sculptures engage students in the beauty of the forces in our physical world: Tornado, Turbulent Orb (in the Lobby Balcony), Making Waves (in the Lobby Balcony) and Chaotic Pendulum (in the Lobby Balcony)

Domino Table : Working together, students overcome many obstacles caused by Newton's Laws of Motion to complete a network of domino pieces.

Gear Wall: Gears of different shapes and sizes are wall mounted to be touched, turned and explored.

Chutes and Wheels: Onto a wall are mounted simple pipes, corners and other fittings; design a course for the ball to navigate.

Ball Ramps: Children roll balls down a straight and a wavy ramp and observe the timing differences. Predict which one you think will win? Which one wins? Were you right?

Web Resources:

Fear of Physics.com
www.fearofphysics.com/Friction/frintro.html

What is Friction? Friction is the "evil" of all motion. No matter which direction something moves in, friction pulls it the other way.

Friction
hyperphysics.phy-astr.gsu.edu/hbase/frict2.html

It is that threshold of motion which is characterized by the coefficient of static friction.

Pre-Visit Activities

TITLE OF LESSON PLAN: Friction in Our Lives

LENGTH OF LESSON: Two class periods

GRADE LEVEL:5-8

CREDIT:
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OBJECTIVES:
Students will understand the following:
1. Friction is a force that opposes motion, or makes it difficult for an object to move across a surface.
2. The amount of friction depends on the surface type and the force pressing two surfaces together.
3. Everyday life provides examples of how friction both helps and hinders everything we do.

MATERIALS:
For this lesson, you will need:
Several matchbox cars of the same size (three to four for every team)
Several large, thick books, such as encyclopedias (when stacked, they should be about 1 foot high)

Large piece of foam board
Beach towel
Yardstick
Masking tape
Textbooks
Pencils
Chalkboard, overhead projector, or chart paper
Crayons, markers, colored pencils
Friction Activity Sheet (one for each student)

PROCEDURE:

1. Create a learning web with your students on what stops motion. On an overhead, chalkboard, or chart paper write “Motion stops because . . .” and draw a circle around it. Elicit students' responses and write their responses as “branches” off of the web. Focus student responses by providing prompts, such as: What would make a car stop? A dancer? A football? A plane? A baseball player sliding into home?

2. Tell your students that the web they have created shows examples of forces that may slow down, stop, or make it hard for an object to move. Explain that these forces acting on objects and people are called friction. Refer back to the web and underline those ideas that clearly demonstrate the role that friction plays in stopping motion. Ask students in what context they have heard the word *friction* before. (They may offer the following contexts: friction between people in a fight or rubbing hands together.)

3. Explain to students that the amount or force of friction depends on two things: the type of surfaces that are touching (e.g., waxed kitchen floor versus rocky pavement) and the force pressing the surfaces together (e.g., pulling an empty wagon versus one filled with bricks).

4. Now divide the class into groups of four to five students. Explain to students that the following activity will help them understand how friction can be increased and decreased. Each group should receive three to four matchbox cars, foam board, a beach towel, masking tape, a yardstick, several large, thick books (that equal about a foot when stacked), two textbooks, and a Friction Activity Sheet. The groups will be observing and recording how the matchbox cars move on two surfaces: a smooth surface and rough surface.

5. Read the first activity question to the class: “Will the matchbox car move faster on the smooth surface or the rough surface?” Then show them the two surfaces they will be testing, the plain foam board and the beach towel.

6. Next, have students create a “ramp” by placing a stack of books (about 1 foot high) under one end of the foam board. (You may want to place a brick or heavy object at the other end to keep the board from sliding.)

7. Students will be looking at how a surface can effect car speed. In order to gauge the results of this activity accurately, they will need to use matchbox cars that travel at about the same speed. Have students “race” the matchbox cars they've been given down their ramp to find two that move at generally the same speed. To do this, line up the cars at the top of the ramp and hold them back with the yardstick. Have one student hold the yardstick at each end and lift it suddenly to let the cars race down the ramp. Do this a few times to make sure the two cars you select move at about the same speed

8. Now have each group cover the left-hand side of its foam board with the beach towel, using masking tape to secure the towel to the back of the board (to keep it from slipping). Their foam boards should now have two “tracks”—a plain track and a towel track.

9. Before students perform their race, have them complete the prediction portion of their activity sheets. Students should write one sentence indicating which surface they believe the car will travel faster on.

10. Now have the students race the two cars they chose (that were about the same speed).

Using the yardstick to ensure the same “start time,” have students race one car on the plain (smooth) track and the second on the towel (rough) track. They will need to write one to two sentences that describe how the two cars moved. Then have them determine on which surface they saw more friction.

11. Gather students together to discuss their findings and observations. Focus students' attention to the relationship between the surface type and the amount of friction there is between the car and surface, as demonstrated by the ability of the car to move across each surface. (The rougher the surface, the more friction there is.)

12. Read the second activity question to students: “Will it be easier to move one or two textbooks across your desk with your pinky?” Demonstrate how students will move the textbooks across their desks and have them complete the prediction section of their activity sheets. Remind students to record their observations on the activity sheet as they did in the first activity.

13. Gather students together to discuss the second activity. Ask students to share their observations. Encourage students to think about the relationship between the size/weight of an object and how easily it moves across a surface. Ask students if they needed to use more force from their pinkies to push two textbooks than just pushing one across the desk.

14. To reinforce the concepts demonstrated in the hands-on activities, on the board list the two factors that determine the amount of friction there is between two surfaces (surface type and force on a surface). Explain that friction plays many roles in our everyday lives. Sometimes we try to increase friction, while other times we try to decrease the amount of friction.

15. Use sports as a starting point to think of some examples. In some sports and recreational activities, you may want to increase or decrease the amount of friction present. Using what students have learned about surface type and force on the surface, create a T chart of sports and activities where increasing the amount of friction is helpful and those in which it is better to reduce the amount of friction. (For example: gymnasts use chalk on their hands to reduce friction between their hands and uneven bars; cleats help football players have better traction while running; bobsledders need to be light to travel faster in the Olympics; swimmers shave their arms and legs to increase their speed in races.)

16. Have students create a mini news article for a recreation or sports magazine about how friction plays a role in a sport of their choice. Students will need to include a colorful, creative picture of the sport in action and describe in a paragraph of four to six sentences how friction affects a player's performance in that sport. Have students present their articles and display them on the bulletin board. Physical education and health teachers can be invited to the class presentations

ADAPTATIONS FOR OLDER STUDENTS:
For older students, you can explain the role of friction as an unbalanced force and how it relates to Newton's first law of motion—inertia. Students can use the Internet and other multimedia resources to create a slide-show presentation for the class about how friction and Newton's laws of motion play a role in sports. Have students design their own friction experiments and present their materials, procedure, data, and analysis in a written lab report.

DISCUSSION QUESTIONS:
1. Explain how surface type influences the amount of friction there is.

2. Discuss the relationship between the size and weight of an object and the amount of friction that is present.

3. Analyze how friction can be both a positive and negative aspect in our everyday lives. Use examples to support your statements.

4. Sports such as soccer involve running, stopping, jumping, and kicking. Discuss how friction helps players.

5. Describe a situation in which using wheels would reduce friction between a moving object and the surface over which it travels.

6. Hypothesize what your life would be like if there were no friction. Which actions would be more difficult? Which would be easier?

EVALUATION:
Assess students' understanding of concepts with a third friction activity similar to the ones done in class—with a question, prediction, observation, and analysis. For example, have students use a heavier toy car or truck to move across a rough surface (outside gravel, for example) and compare it with a lighter car moving on the same rough surface. Students should be able to explain that there is a lot of friction because of the rough surface, but a heavier/bigger car creates a larger force between the car and the rough surface, increasing the amount of friction.

In addition, a three-point rubric can be used to assess students' news articles about friction in sports:

- **Three points:** includes a colorful, creative picture of the sport in action; explains what role friction plays in terms of helping or hindering the activity; discusses how friction is either increased or decreased by a surface type and by the force/mass of an object
- **Two points:** displays minor misunderstandings in explaining friction's role and/or how to increase or decrease the amount of friction
- **One point:**displays major misunderstandings of the role and/or how to increase or decrease friction

EXTENSION:
Friction Forever Journal
Ask your students to keep a journal tracking all the activities they perform in one day where friction plays a role. Create a class list to see how friction will “forever” affect our lives.

Fords, Freights, Flights, & Friction
Invite your students to investigate the way friction is reduced or increased in various modes of transportation. Have them create miniature models of these machines and demonstrate to the class how friction plays an important role in motion.

SUGGESTED READINGS:
Planes and Other Aircraft: Learn the Science – Build the Model
Nigel Hawkes, Alex Pang [Illustrator]. Millbrook Press, 1999
Using color artwork and photography this book explains the science of flight and how it translates into mechanical principals and aircraft design.

Eyewitness: Train (Dorling Kindersley Eyewitness Books)
John Coiley, Mike Dunning [Photographer]. DK Publishing, 2000
More than just a reference book, this offers striking color photography and rich content to describe how trains operate. It is a compelling book that traces the history of locomotives from the early steam trains to today's electromagnetic trains.

Friction Activity Sheet

Name:

Activity No. 1: Matchbox Cars

Will the matchbox car move faster on a smooth surface or a rough surface?

1. Prediction:

2. Observations:

a. Car moving on smooth surface (plain foam board):

b. Car moving on rough surface (beach towel):

3. Where is more friction present?

Activity No. 2: Moving Textbooks

Will it be easier to move one book or two books with your pinky across the desk?

1. Prediction:

2. Observation:

a. Moving one book with pinky:

b. Moving two books with pinky:

3. Where is more friction present?

Friction-Fear of Physics
This is an on-line experiment with different sized cars and different surfaces. Have your students use the data sheet below and try to determine what distance is appropriate to stop without crashing into the car in front on different surfaces.

This experiment is found on-line at
http://www.fearofphysics.com/Friction/friction.html

Names: _____

On-Line Friction Experiment

Trial/Vehicle	Distance	Speed	Surface	Result
1/Big Red Truck				
2/Big Red Truck				
3/Big Red Truck				
4/Big Red Truck				
5/Big Red Truck				
6/Big Red Truck				
7/Big Red Truck				
1/Sport Utlility Vehicle				
2/Sport Utlility Vehicle				
3/Sport Utlility Vehicle				
4/Sport Utlility Vehicle				
5/Sport Utlility Vehicle				
6/Sport Utlility Vehicle				
7/Sport Utlility Vehicle				
1/Motorcycle				
2/Motorcycle				
3/Motorcycle				
4/Motorcycle				
5/Motorcycle				
6/Motorcycle				
7/Motorcycle				
1/Scooter				
2/Scooter				
3/Scooter				
4/Scooter				
5/Scooter				
6/Scooter				
7/Scooter				

Post-Visit Activity

Roller Coaster Interactives-Amusement Park Physics
This is an interactive where students can build a roller coaster. They are given choices for the components of their roller coaster. Once they have designed their coaster they will be given a safety and fun rating based upon their design. They can then see the answer or try to redesign their amusement ride so it is fun and safe.

This interactive is found on-line at
http://www.learner.org/interactives/parkphysics/coaster.html

Coaster-Funderstanding
This is an interactivce experiment where your students design a roller coaster. They must decide the height of each of the three roller coaster components, the speed of their car, the mass of their car, the gravitational force and friction. When they are successful the Java applet gives them their speed and time. Each component of the coaster has a question mark by it so the students may get hints based on physics to perfect their design. This experiment is appropriate for high school and may easily be adapted to lower grades by limiting the number of variables.

This experiment is found on-line at
http://www.funderstanding.com/coaster