Bottle Racers

Grade Level:	**Total Time Required:**
6	Two 50 minute class sessions

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Lesson Objectives:

Students will design and build a small model of a car that will be propelled by a number of different energy sources.

Students will be able to:

1. Design a car using a plastic bottle as a basis for their design.
2. Choose from a number of different types of methods to propel their car that will change potential energy into kinetic energy.
3. Perform an experiment involving a chemical reaction to power the car.
4. Discuss the difference between potential and kinetic energy.

Indiana Standards:

6.PS.3 Describe how potential and kinetic energy can be transferred from one form to another.

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

Next Generation Science Standards:

S-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ET1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Concepts and Vocabulary

Term	***Defined by a scientist or engineer***	***Defined by a student***
Kinetic energy	Energy associated with motion of an object.	Energy in motion
Potential energy	Energy an object has because of its relative location.	Energy at rest
Gravitational force	Force exerted between the Earth and an object that attracts the object toward the Earth.	A force that pulls an object down
Gravitational potential energy	Energy an object possesses because of its position in a gravitational field Ex: a child on the top of a seesaw	
Elastic potential energy	Potential energy stored as a result of deformation of an elastic object Ex: a stretched rubber band	Energy in a rubber band
Chemical potential energy	A form of potential energy related to the structural arrangement of atoms or molecules. Ex: a fully charged battery	
Conservation of Energy (optional)	The principle that the total energy of any isolated system is constant and independent of any changes occurring within the system.	
Friction	A force that resists the relative motion or tendency to such motion of two bodies or substances in contact; The rubbing of one object or surface against another.	Rubbing one object against another

Equipment, Materials, and Tools

Materials		
Plastic Bottle	Springs	Straws
Balloons	Wooden Shish Kabob Sticks	Duct Tape
Rubber Bands (multiple Sizes)	Plastic Water Bottle Caps for Wheels	Vinegar
Baking Soda		

Tools		
Knife (cut hole in the bottle)	Small hand pump	

Science Content - Basics

<u>Chemistry Behind the Reaction of Vinegar and Baking Soda</u>

Vinegar is a colorless liquid that is a 4-8% (typically 5%) solution of acetic acid in water. It is made by fermenting alcohol and its name means sour wine.

Chemical Formula CH_3CO_2H

Baking Soda is sodium bicarbonate and exists as a white powder that dissolves readily in water to form sodium cations (Na^+) and bicarbonate anions (HCO_3^-).

Chemical Formula $NaHCO_3$

They react on mixing and the acid transfers a proton to the bicarbonate anion to form carbonic acid (H_2CO_3). Carbonic acid rapidly falls apart to form water and the gas carbon dioxide. The bubbles are the carbon dioxide and it pressurizes the container to drive the car. Sodium ions and acetate ions are left in solution.

This reaction is used in cooking to create fluffy muffins, cakes etc. It happens much more slowly there because dough is more viscous (stickier) than water.

Reaction Equation: $CH_3CO_2H + NaHCO_3 \rightarrow CH_3CO_2Na + H_2O + CO_2$

Note: Baking powder uses the same chemistry. It is a combination of a solid acid, potassium hydrogen tartrate, with solid sodium bicarbonate with cornstarch filler. Reaction does not take place until the solids are moistened with water.

Science Behind Energy Transfer to Heat when Stretching a Balloon or Rubber Band

Stretching the balloon requires us to exert some energy. Because the balloon is elastic and can snap back, some of the energy we used to stretch the balloon is stored in the balloon as elastic energy. But not all the energy is stored. Some of it is lost because of friction within the balloon as molecules slide past one another. Rub your hand quickly back and forth on your leg. Can you feel the heat that is generated as you move your hand back and forth? This heat is produced due to the friction from rubbing your hand against your leg. We can sense the lost energy as heat. Now, hold the balloon to your upper lip and stretch it quickly while the balloon touches your skin. Can you feel the heat that is generated? That is the energy that is lost when you stretch the balloon. This energy can no longer be used for the balloon to snap back to its original shape.

Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

Problem:	Gasoline powered vehicles harm the environment and car manufacturers are looking for alternative energy sources to power their vehicles.
Goal:	Design a car that uses a new energy source rather than a traditional gasoline powered vehicle.
Who is the client:	Boiler Stream Line
End-User:	Car owners
What is the design:	Design a car that uses a new energy source rather than a traditional gasoline powered vehicle.
Criteria:	• The car should move forward when released from a state of rest. • Students may use the back of a wall to provide a backing for the car to move forward. For example, if a compressed spring is used to power the car, the student may compress the spring by pushing it up against a wall.
Constraints:	• The car may not be pushed by the student to make it go forward. • Only materials provided may be used.

Lesson Plan #1

Guiding Question – How does air occupy a space?

Time: 50 minutes

Procedure:

1. Have the students put a balloon in the bottle and seal the opening of the balloon around the opening of the bottle (see picture below).

Hole for air release (hole added in step 3)

2. Let the students attempt to blow up the balloon in the bottle.

   The students will not be able to blow up the balloon (provided it is sealed correctly), because air is occupying the space in the bottle. In other words, the balloon is not able to expand because of the air already in the bottle.

3. Poke a hole in the bottle to allow air to be released from the bottle. NOTE: The teacher should perform this operation with a knife or sharp end of a pair of scissors. The location of the hole is important for the next demonstration. It should be located at the bottom of the bottle and opposite side of the wheels (see picture above).

4. Have the students attempt to blow up the balloon again.

5. Discuss how air that you cannot see is released from the bottle in order for the balloon to expand in the bottle.

Lesson Plan #2

Guiding Question – Can you use chemical energy as an Alternative way to Power the Car?

Time: 50 minutes

Procedure:

NOTE: THIS IS A MESSY OUTSIDE ACTIVITY!

1. Discuss with the class chemical reactions and how energy to power the car can be generated from a chemical reaction.

2. Take the students outside to a flat cement or asphalt area. Pour about ½ cup of vinegar in the bottle while keeping a finger over the hole in the bottom of the bottle. Ready the car at the starting line and have the cap ready to seal the bottle. (Ensure that students are not standing behind the car.) Put approximately 2 tablespoons of baking soda in the bottle and quickly seal the cap. Place the car on the ground and release the finger covering the hole.

   The car should go a short distance powered by the gas generated by the chemical reaction.

Lesson Plan #3

Guiding Question - Can You Design a Car that Uses an Alternative Energy Source?

Time: 50 minutes

Procedure:

1. Distribute the design challenge.

   Ask: *What is the goal?*
   Who is the user or client?
   What is the problem?
   What are the constraints?
   What materials will you use?

2. Instruct students to develop his/her individual plan in his/her design notebooks. Encourage students to label their sketches, include dimensions, and list the materials they will use. Students should write a short paragraph explaining what type of system they will use to power their car (such as balloon, rubber band, etc.) and how their energy source powers the car. They should note from where the energy initially comes (blowing up a balloon, stretching a rubber band, etc.) and how it is converted.

3. Instruct students to work in small teams to share their plans. Next, instruct students to decide on one plan or design and to select a representative from the team to share his/her plan to the teacher for his/her approval.

4. After the design has been selected and approved, the students can construct their cars.

Lesson Plan #4

Guiding Question – Testing Your Design

Time: one 30-minute session

Procedure:

1. Create a starting line for the students to use. The line should be close to a wall for teams using the energy from a compressed spring.

2. Instruct students to conduct three trials of their designs. Students record the distance the car traveled during each trial.

Table 1: Distance Traveled during each Trial

Trial	***Distance Traveled (cm)***
1	
2	
3	
Average	

3. Students share their results and explain to the class how their car works and what was the potential and kinetic energy used to power their car.

4. Have the students note redesigns in their notebooks and why something worked or didn't work.

Assessment

The following are possible sources of formative and summative assessment:

Formative assessment:

- Presentation of design to class by the team. Provide positive design attributes, how design criteria where met, and possible redesigns.
- Participation (group) – Note level of engagement; questions students asked; how well they worked in a group; how well each team met the goals of the task

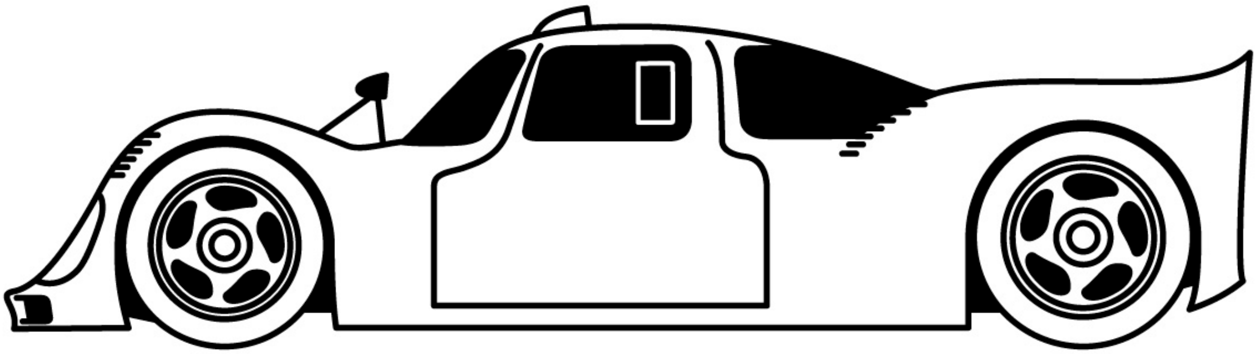
Summative assessment:

- Design notebooks (individual) – Note how students identify and clearly label their drawings; Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used); Note how students record data from testing their prototypes and how well they explain their results (patters in the data).
- Create a short pre and posttest that highlights key science vocabulary terms; Present a new situation or new problem on the same theme

Lesson Extensions and Resources

Activity Extensions:

Design Activity
Student Resource



Design a Bottle Racer

Boiler Stream Line, a company in Elkhart, Indiana, makes recreational vehicles for camping. They have decided that they want to manufacture a car that uses a new energy source rather than a traditional gasoline powered vehicle. They also want the car to be very efficient and use a new type of energy to power the car. One important design criteria is how far the car can go with the new energy source. In this lesson, you will test your design skills by building a small model of a car and using a new energy source to power the car.

Design Criteria:
1. The car should move forward when released from a state of rest.
2. Students may use the back of a wall to provide a backing for the car to move forward. For example, if a compressed spring is used to power the car, the student may compress the spring by pushing it up against a wall.

Design Constraints:
1. The car may not be pushed by the student to make it go forward.
2. Only the materials provided may be used.

Item Costs:

Bottle	$15
Balloon	$10
Spring	$10
Wheel	$5
Straw	$2
Rubber Band	$2
Wooden Stick	$1
Packet	$40

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