Heather Roof
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The Newton Challenge

Staring Pneumatics, Force, Momentum, Friction, and YOU!

The Challenge…

Activity idea

In this activity, students design and build a balloon-powered car to better understand the science ideas related to rocket propulsion. They use ideas of mass and force to work out ways to improve the distance travelled by their car.

By the end of this activity, students should be able to:

- design and build a balloon-powered car
- describe how their car is designed to go as far as possible
- use ideas of mass and forces (such as thrust, air resistance and wheel friction) to describe what might help their car travel further
- explain what causes the balloon car to start moving, using ideas of action and reaction forces
- explain that momentum keeps their balloon car moving once the balloon is no longer applying a force and that it will slow down because of the force of friction.

This activity is ideally done after the teaching and learning activities Introduction to rockets and space and Film canister rockets.

Introduction/background

This activity allows students to develop their ideas about forces and motion as they relate to rocket propulsion. Their goal is to make a balloon-powered car that travels the greatest distance. They have 1 week at home to design and test their cars before the class competition.

Stuff you need to know:

Newton's third law

For every action, there is an equal but opposite reaction. This means that, for every force pushing on an object, there is an equal but opposite force pushing back. The balloon pushes the air in one direction, and the air pushes back on the balloon to make it go in the other direction. A rocket works by pushing gases out one end very quickly, which results in a large force that pushes the rocket in the other direction. If the gases are pushed out faster, this will produce more force to push the rocket.

A good example of Newton's third law is to think of two people standing on skateboards. If one skateboarder pushes the other, both skateboarders will

be pushed apart because there is an equal but opposite force acting on each of them.

Mass
A lighter mass will speed up more quickly than a heavier mass if the same force is applied. A lighter rocket will speed up more quickly and will also be easier to launch because it will have less gravity acting on it. A good example of the effect of mass is to think of a light person and a heavy person sitting on two swings. If each person is given the same size push, the lighter person will speed up more quickly. A light balloon car will speed up more quickly.

Force
A larger force will cause an object to speed up more. For a balloon car, it is good to use a fresh balloon each time and blow it up well. To maximize the forward force, friction from the wheels (and perhaps from air resistance) also needs to be minimized.

Momentum
Once the car is moving, it will keep moving because of its momentum, even though the balloon is deflated. Momentum is equal to mass multiplied by velocity. Newton's first law states that an object at rest will tend to remain at rest and that an object that is moving will tend to keep moving at a constant speed in a straight line until an external force acts on it.

Friction
The car will slow down and stop due to the opposing force of friction. There are two kinds of friction: air resistance and the friction as the surfaces of the axle, body of the car, wheels and ground move past each other. Ideas of streamlining and designing good axles and wheels are intended to reduce friction. In this challenge, minimizing friction caused by surfaces rubbing together is more important than streamlining.

What you need
- Copies of the student worksheet: Make and race a balloon-powered car
- Balloons

- Anything you might find useful such as empty plastic bottles or containers, cardboard boxes and any other bits and pieces, old toys that you can reuse, etc
- Bottle tops can make good wheels
- Wooden skewers inside straws can make good axles
- Tape, cardboard, and straws
- A great imagination!

What to do

1. Explain the challenge to the class: To build a balloon-powered car that travels the greatest distance. They will have 3 classes to build and test their cars before the class competition to see whose car travels the furthest. Give a copy of the student worksheet Make and race a balloon-powered car to each student and ask them to complete it as they work through the activity.

2. Discuss some of the variables that might affect how far the car travels. (Students may come up with ideas about minimizing the mass, maximizing the force, friction, streamlining, how big the balloon is inflated, the size of the hole or tube that the air comes out, direction of the air as it comes out. Suggest using a fresh balloon for each trial and for the competition.)

3. Allow the students come up with their own ideas to develop their problem-solving skills and creativity, using the Engineering Design Process. Encourage them to build and test their models and then to try out different ideas to find out what works best. If kids are having difficulty you can show pictures of other cars, however it is far more beneficial and fun to NOT show them.

4. To run the competition, line the students up on a line at the competition area – a school hall with wooden floors or an outside court with smooth concrete will work well. Count down from 10 to allow students time to blow up their balloons ready to release on "Go!" You may like to repeat the competition several times.
5. Ask the winning students to explain their designs.

6. Discuss the science ideas. In small groups, ask students to describe and evaluate how their cars worked using at least five science words and ideas from this list: force, mass, action-reaction, momentum, friction, speed up, slow down.

7. Ask students to draw and label their cars. Use ideas of force and mass as well as action and reaction forces to explain what made their car work. Write an evaluation of their car and what they would do to improve their designs. Some students will appreciate an opportunity to rebuild their cars for a rematch a few days later.

8. Have students complete the 'Thinking about science ideas' section of the student worksheet and discuss the results.

Discussion questions

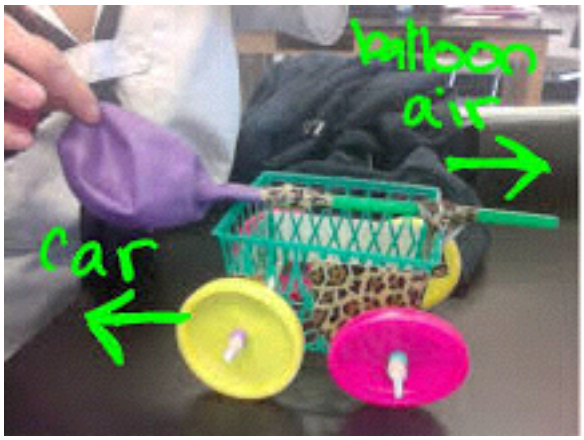
- Which cars worked best? Why?
- How does the mass of the car make a difference? What would happen if the car could be made lighter?
- How could a greater force be applied to the car? How would this affect the speed?
- What is pushing on the car?
- What is the ideal direction for the air to be pushed out the back? (Ideal hole/tube design?)
- Why does the car keep moving even when the balloon has deflated?
- What caused the car to slow down and stop?

Extension ideas

- Experiment to find out what happens if the car has a greater mass.
- Experiment to find out what happens if a greater force is used. (Two balloons? One balloon inside another balloon?)
- Experiment to find the ideal size for the air hole/tube.

Make and race a balloon-powered car

Use the Engineering Design Process to build a balloon powered car that will as far as possible!



The Challenge:

You are a group of engineers competing for a contract with ***Toys R Us***. Your job is to design a car powered by a ballon, showing Newton's Law's. Your design MUST use only recycled parts, no new stuff allowed.

Constraints:

- Your car must only use pneumatic power (a ballon)
- Your car must be recycled products, entirely
- Your car has to run unassisted
- You car must fit within the following measurements:
  - no more than 10 inches long by 5 inches wide
  - no more than 10 inches tall
- HAVE LOTS OF FUN!

Prizes will be awarded for the following:

- Fastest Car
- Most Attractive Car
- Best Epic Fail

Before the competition:

Ask:

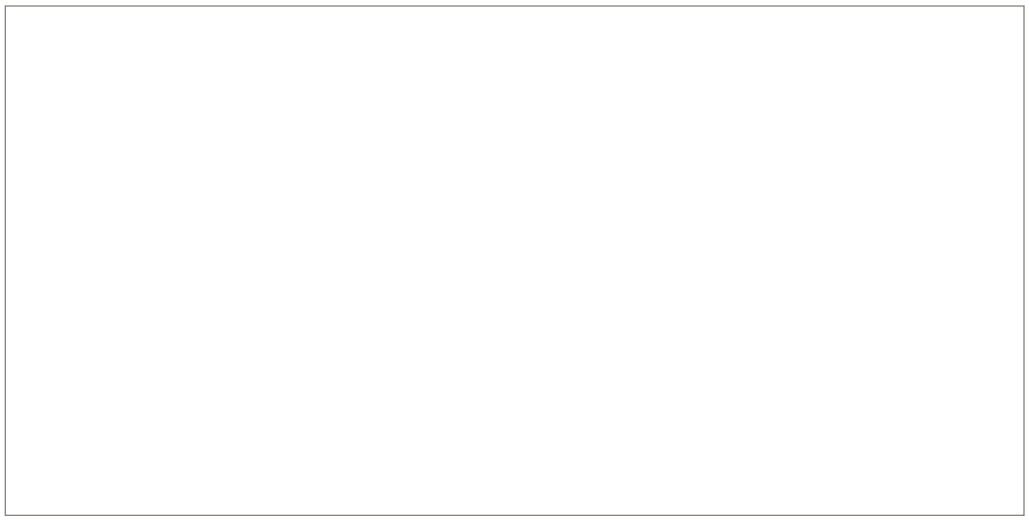
- What are the problems?
- What are the constraints?
- What sort of things might effect how far/fast the car will travel?

Imagine:

- Brainstorm Ideas Collectively as a group
- Pick the best idea

Plan:

- Draw a diagram
- Gather supplies, needed materials



Create:

- Follow the plan!
- Test it out…

Improve: (there is ALWAYS room for improvement!)

- Discuss what can work better
- Repeat the process

Questions to Ponder??

1. How does the mass of the car affect how far it travels? Why?

2. What things did you do to reduce the **mass** of the car as much as possible?

3. What produces the **force** that pushes on the car to make it speed up?

4. What things did you do to make the **force** to push the car forwards as high as possible?

5. What things did you do to reduce **friction** caused by surfaces rubbing together and from air resistance?

6. How far did your balloon car travel during trials?

After the competition

7. How far did your car travel?

8. Evaluation of your car's performance in the competition:

9. How far did the winning car travel?

10. Draw the winning car.

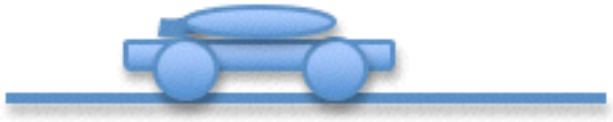
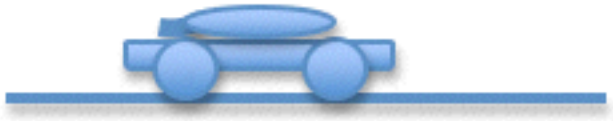
And the Winner is….

11. What made this car so successful?

12. For each of the following stages of a ballon cars motion:

- describe the motion of the car using words such as speeding up, slowing down, moving quickly, moving slowly, stopped and so on
- explain what is causing this motion using science ideas such as mass, force, momentum, friction and so on.

A.  Balloon car just released	The balloon car…(Describe motion) This is because… (Explain motion)
B.  Balloon half deflated	The balloon car… This is because…

C.  Balloon just finished deflating	The balloon car… This is because…
D.  After balloon finished deflating	The balloon car… This is because…
E. **Car 1** – balloon fully inflated  **Car 2** – same mass as car 1 but balloon only half inflated 	**Different force, same mass** Car _____ speeds up more quickly This is because…

F.
Car 1 – balloon fully inflated

Car 2 – twice as much mass as car 1, balloon fully inflated

Same force, different mass

Car _____ speeds up more quickly

This is because…

G. **Car 1** – balloon fully inflated  **Car 2** – same mass as car 1, balloon fully inflated, more friction acting (friction is a force caused by surfaces rubbing together) 	**Same force from balloon, same mass, different friction** Car _____ speeds up more quickly This is because … **What things might cause this extra friction?**

Extension for Gifted:

For each of the balloon car diagrams A–G above:

- use a ruler to draw arrows of different lengths to show the relative sizes of the individual forces acting on the balloon car (e.g. weight, thrust, friction, support of ground).
- label these forces
- use a ruler and a red pen to draw an arrow to show the size and direction of the resultant force.