CSEO SCIENTIST IN THE CLASSROOM PARTNERSHIP

K'nex Engineering

Last Updated: July 2022

GOAL: To introduce students to Newton's Third Law of Motion and to have them work cooperatively to design a balloon-powered car using K'nex pieces to illustrate this law.
TN STATE STANDARDS: 8.PS2.5 Evaluate and interpret that for every force exerted on an object there is an equal force exerted in the opposite direction.
PHYS.PS2.8 Use examples of forces between pairs of objects involving gravitation, electrostatic, friction, and normal forces to explain Newton's third law.

This lesson was adapted from Vanderbilt Student Volunteers for Science. Additional information about the lesson may be found at https://studentorg.vanderbilt.edu/vsvs/.

LESSON OUTLINE

I. Introduction

Discuss Newton's Third Law of Motion and how it is applied to the motion of rockets. Mention that friction is an important force that helps vehicles travel upon the ground.

A. Introducing K'nex engineering

Organize students into groups of four. Explain that they will be working together to design a car using K'nex pieces that will be powered by air escaping from a balloon. Demonstrate how to assemble these cars by showing how pieces fit together. Provide helpful hints that can help the groups design and build cars that will travel.

II. Building cars

Let the students build and test their cars. Reconvene the entire group to see how far each group's car can travel.

III. Optional Competition

Give students about 25 minutes to design their cars. Organize a competition to see which group's car is able to travel the furthest. If time permits, allow groups to redesign their cars, given what they observe from other groups' cars.

IV. Review

Review Newton's Third Law of Motion and the concept of friction.

Note on forming groups: You may wish to organize groups into "boys only" and "girls only" groups. This may encourage more girls to take more of a leading role in designing their cars and may encourage more boys to work as a team.

MATERIALS

6 bags of K'nex pieces containing
- rods
- connectors (there will be different numbers of each in each bag)

6 tape measures
6 rolls of Scotch tape
1 bag of wheels
- 6 sets of different sized wheels

1 bag of extra connectors and wheels
Balloons

I. INTRODUCTION

Write the following vocabulary words on the board:

Engineering
Newton's Third Law of Motion
Force
Friction

Ask students, "What do you know about engineering?"

Accept and discuss responses.

Students may mention how engineering (especially mechanical and civil) involves the design and construction of things as simple as machine parts to as complex as cars. Engineering can also involve teams working together to create the designs and the eventual final products. Engineers also must know and work within physical and fundamental laws.

Tell students that they will work in teams as engineers to design and create a balloon-powered car. They will be using a type of construction toy called K'nex. You will show them how the parts fit together and provide them with tips to help in their engineering tasks. However, they will also need to know a few concepts that will help them in creating their cars.

Ask students, "What is force?"

A force is a push or pull. Forces can act upon something to make it move. Explain that the force that will be used to "power" their cars will be air escaping from a balloon that they will attach to their cars.

Ask students to guess why this source of power is able to work on getting their cars to move.

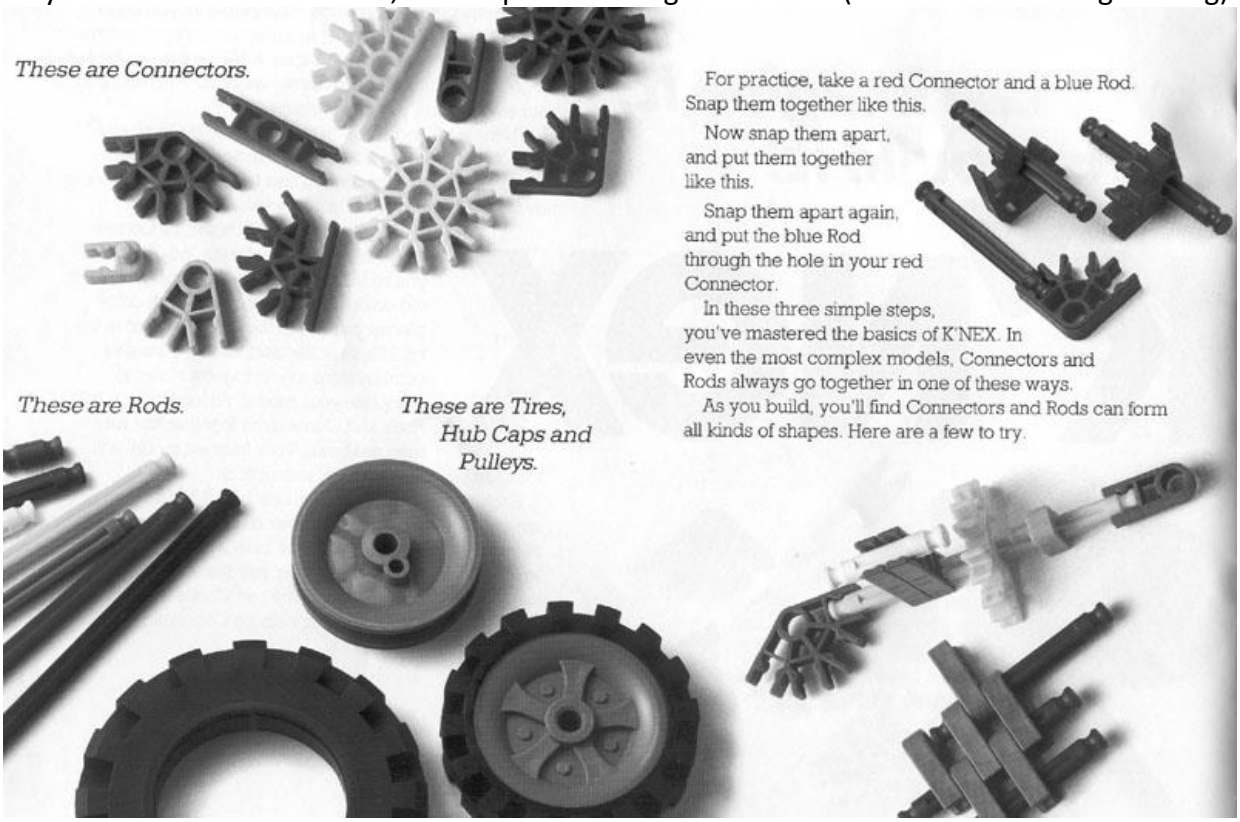
Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction. In this case, we are using the air escaping from the balloon as an exhaust gas that provides the car with thrust (a propulsive force). By pushing the exhaust gas in the direction opposite the direction we want the car to travel, the ejected "fuel" goes one way and the object (the car) goes the other way.

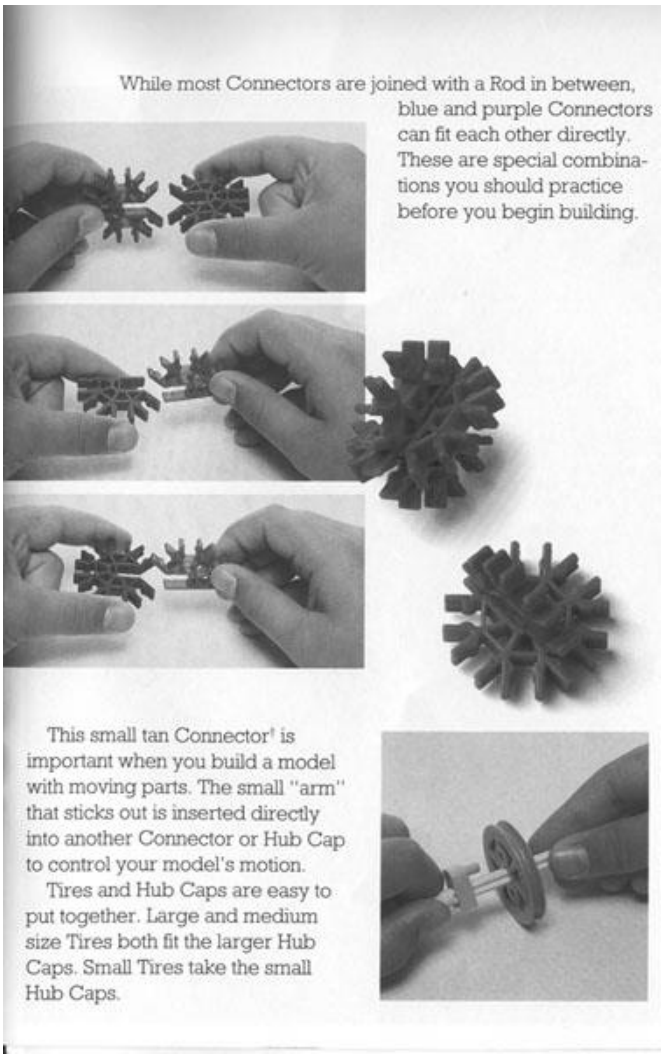
Tell the students that friction is another force that allows the car to move on a surface. Without friction, the car (or anything else, really) will be unable to move. Remind the students how difficult it is to walk on ice.

SET-UP

Tell the students that the kits are made of connectors, rods and wheels (in this case, the wheels are made up of hub caps and tires). Demonstrate how to connect the various parts together as shown in the pictures. Be sure to demonstrate how to attach the small tan connectors to rods holding wheel; this will help the wheels stay in place more effectively (see lower figure).

You may also wish to refer to the included K'nex guide to provide more ways of connecting the various pieces together to make a car. There are also some diagrams of cars that the students may want to use—sometimes, the simpler the design the better (also common in engineering)!





Give the students the following tips to help the students in their building:

1. If the base of the car is relatively large, it will help keep the car on the ground. However, making it too large will mean that there is more mass to push.
2. The balloon should be attached to the car so that it remains pointed in the opposite direction from where the car needs to go. The opening should be large enough so that a steady stream of air will escape from the car, but not so large that all of the air escapes at once.
3. Figure out which end of the car is the front.
4. When testing the cars, it may be helpful if one student holds the balloon in place (regardless of how much tape is used to attach it to the car) while a second student inflates the balloon with the pump.
5. **In engineering, remember that there will be trade-offs. For example, if you design a small car, there may not be enough mass to control the direction of the car. A larger car may have too much mass for the air of the balloon to propel.**

Pass out the bags containing the connectors and rods. Distribute one set of wheels to each group.

II. BUILDING THE CARS

Give the students about 15-20 minutes to build their cars. Be sure to go around to each group to ask about the designs and to provide any help as needed. Provide guidance and suggestions as needed (such as pointing out potential flaws), but don't necessarily do the thinking for them. Remind them that the thinking and planning time is just as important as the building and testing time—it may save them some heartache at the end and this approach is also important in "real life"! Distribute tape measures to the groups so that they can determine how far their designed cars are able to travel.

Important! If you find that the students are getting restless, bored, or frustrated after about 10-15 minutes, you may want to guide their progress by giving them a second balloon or by helping them build the car pictured in the lesson. This will allow them to see a balloon car that works.

III. OPTIONAL COMPETITION

Once all the groups are ready, place a tape measure on the floor. Have each group bring its car and deflated balloon to the "starting line" (the 0 inch/cm measurement on the tape measure). Test each car, making sure that the balloons are inflated just before the car is tested. This will prevent balloon breakage.

IV. DISCUSSION AND REVIEW

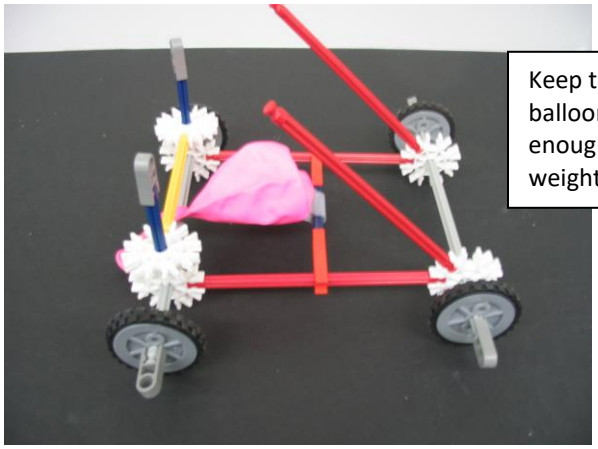
Ask students what design features seemed to be important in designing a car that could go the furthest. Note which cars did not go in a straight line or which cars had difficulty in traveling, due to balloons not being attached properly or having air escape too quickly or slowly.

Ask students to explain why Newton's Third Law of Motion and friction are important concepts to remember when building these types of cars.

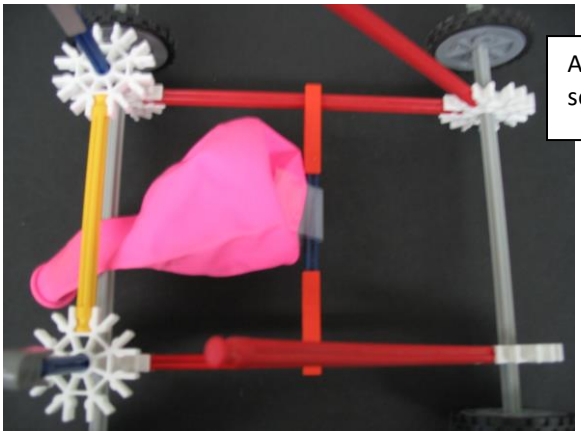
Be sure to collect as many of the pieces as you can—the wheels are the most important, as there are limited numbers of these parts! Make sure that you collect one set of wheels from each group.

Lesson written by Joe Lopez, adapted from
www.ceeo.tufts.edu/ldaps.htdocs/curriculum/design.html

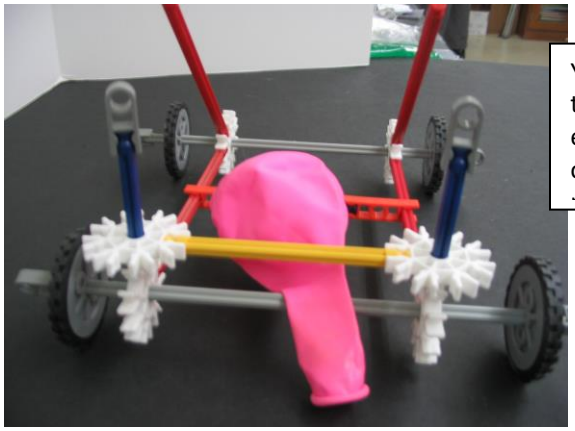
Working Car Example
(with more hints on building a working car)



Keep the car light—the balloon may not have enough air to propel extra weight.

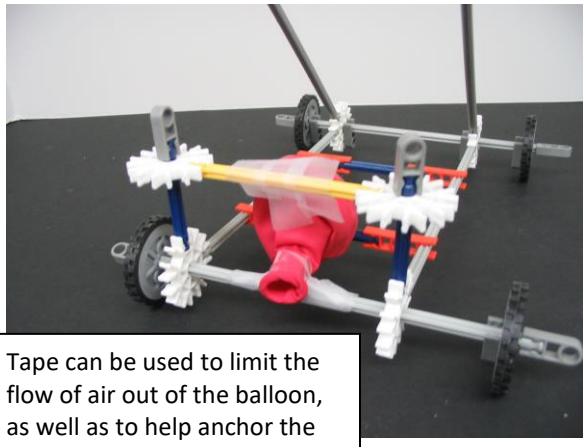


Attach the balloon to the car so that it does not fly off.

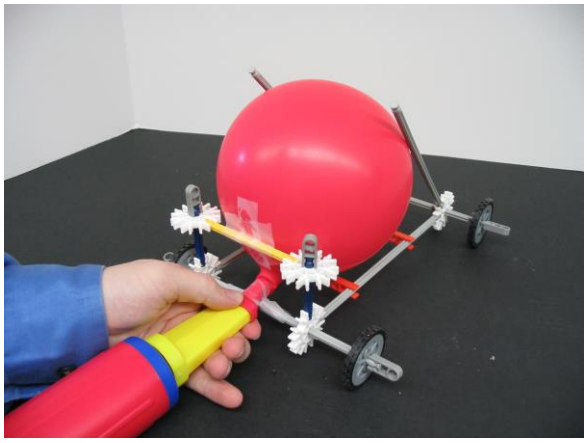


You may want to try to limit the amount of air that escapes from the balloon in order to focus the

More Working Car Designs
(by Ryan Kirkland)

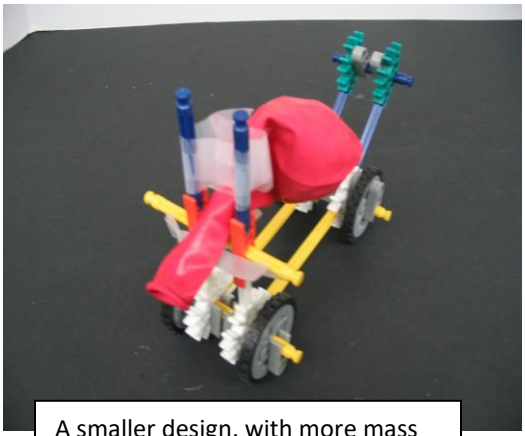


Tape can be used to limit the flow of air out of the balloon, as well as to help anchor the balloon to the car.

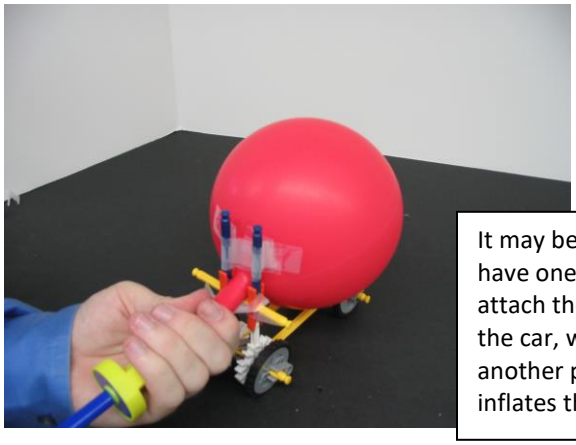


Connectors may also be useful in stabilizing the car.

Clips on either side of the wheels can help in preventing excess friction from slowing down the car (due to the wheels rubbing against the frame of the car).



A smaller design, with more mass on the base of the car.



It may be helpful to have one person attach the balloon to the car, while another person inflates the balloon.