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Reaction Rocket

RKT-625, RKT-630

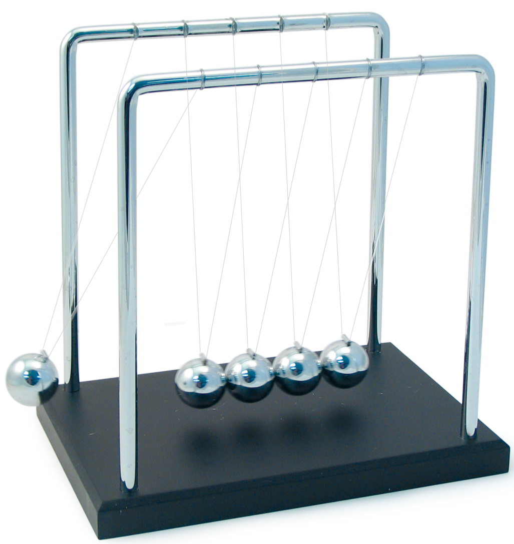
Introduction

Newton's Third Law states,

> *For every action force,*
> *there is an equal and opposite reaction force.*

The Reaction Rocket is an excellent activity to drive this concept home! Before introducing the Reaction Rocket to your students, you may want to first introduce the Newton's Cradle.

The Science behind Newton's Cradle



By pulling the action sphere back, you are storing energy in the sphere (potential energy). When the sphere is released, the potential energy is converted into kinetic energy and the ball stops only when it hits the next stationary ball in line.

The force is transmitted through the spheres and the energy eventually reaches the last sphere (the reacting sphere) in line, and because of the energy it receives from the adjacent sphere, it moves up and away from the other spheres. You can point out that the reacting sphere moves almost as high as the action sphere but no higher.

In theory, because all the metal spheres have the same mass, the reaction sphere should move just as high as the action sphere, but it doesn't. As a matter of fact, over time, the motion of the spheres on the Newton's Cradle will stop altogether. Ask your students for their ideas as to why this is the case.

The reason the reaction sphere doesn't go as high as the action sphere started out is because some of the energy was transferred to friction, heat, and sound.

Ask your students what they think would happen if the reaction sphere were significantly larger than the action sphere? *(It wouldn't move as high.)* What do you think would happen if the reaction sphere had only a fraction of the mass of the action sphere? *(It would move much higher.)*

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NGSS Correlations

Our Reaction Rocket and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

Elementary

4-PS3-4
Students can use Reaction Rocket to design, test, and refine a device that converts energy from one form to another.

3-5-ETS1-3
Students can use Reaction Rocket to plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

K-PS2-2
Students can use the Reaction Rocket in an investigation to explore flight and analyze data to determine if a design solution works as intended to change the speed and direction of an object with a push or a pull.

K-2-ETS1-1
Students can use the Reaction Rocket to plan an investigation to ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2
Students can use the Reaction Rocket to develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3
Students can use the Reaction Rocket in an investigation to utilize engineering skills and proper testing methods of materials and design.

3-PS2-2
Students can make observations and/or measurements of the Reaction Rocket flights in an investigation Students can utilize an object's motion to provide evidence that a pattern can be used to predict future motion.

3-5-ETS1-1
3-5-ETS1-2
3-5-ETS1-3
Students can use the Reaction Rocket in an investigation to plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Middle School

MS-PS3-5
Students can use Reaction Rocket to construct, use and present arguments or experiments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.

MS-ETS1-4
Students can use Reaction Rocket to develop a model or experiment to generate data for iterative testing and modification of a proposed object, tool or process such that an optimal design can be achieved.

MS-PS2-2
Students can use the Reaction Rocket to plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-ETS1-4
Students can utilize the Reaction Rocket as a prototype to develop a model to generate data for interactive testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

NGSS Correlations

continued

High School

HS-PS3-4

Students can use Reaction Rocket to design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-ETS1-2

Students can use Reaction Rocket in an investigation to design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-2

Students can use the Reaction Rocket as a prototype in an investigation to provide evidence that students will use to modify a rocket. Students-can design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-PS2-1

Students can use the Reaction Rocket to plan a flight investigation to gather scientific evidence. Students can analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-ETS1-4

Students can use the Reaction Rocket to plan a flight investigation that includes the use of computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Suggested Science Idea(s)

The Reaction Rocket presents a simple and dramatic demonstration of energy transfer. Students can explore all of Newton's laws of motion, energy transfer, aerodynamics, and more. Students can use the rocket as a prototype for future engineering investigations.

The Reaction Rocket uses gravity for its initial motion and the transfer of elastic potential energy to propel the rocket. Allow students to design and manipulate variables such as drop height and launch surface to explore many facets of flight, force, and motion.

Encourage students to utilize mathematical equations in their investigations for flight and landing proximity. Set up height measurements and targets for criteria based hands-on learning.

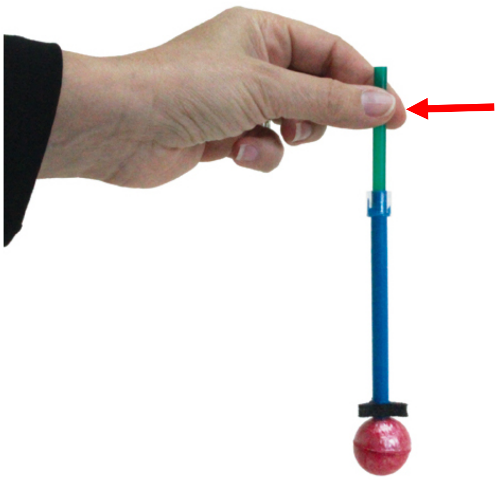
An interesting element to introduce into the lessons and investigations is the use of the slow motion video option on many phones. The slow action will allow students to look more closely at the forces during an investigation. Students can utilize the stop action on the video to collect precise data/measurements to identify parts of flight.

Private industry is now the guiding force in the United States space program. Challenge students to research current space programs and then come up with their own real world problems that need engineering solutions. Enable students to break down the flight tasks to embark on their own Reaction Rocket mission.

Activity 1
Introducing the Reaction Rocket

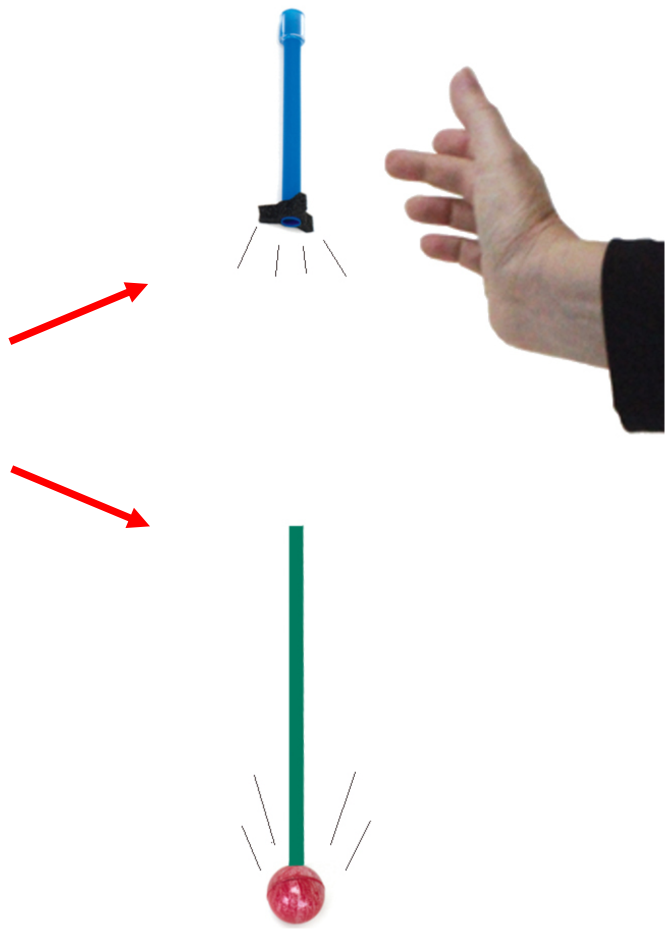
Now, on to the Reaction Rocket!

1. Note that the small rocket has only a fraction of the mass of the rubber ball. Slide the rocket onto the straw so that the fins are next to the ball.



2. Lightly grasp the thin straw of the launcher between your thumb and forefinger, and hold the launcher at arm's length with the rubber ball pointing downward.

3. Let go! The rocket went higher than the starting height, didn't it?



Activity 2
Reaction Rocket Experiment

Instructions

It is best to work in teams of two.

1. Set up a measure tape next to a wall.

2. While one person holds the launcher, the other person makes sure the bottom of the ball is at the desired height. We recommend starting with a drop point of 6" or higher for your first test. Working in pairs, drop the launcher and rocket. Record the highest point the rocket flew on the data sheet (see next page).

3. Repeat step 2 above two more times so you have a total of three drops. Calculate the average height of the drops.

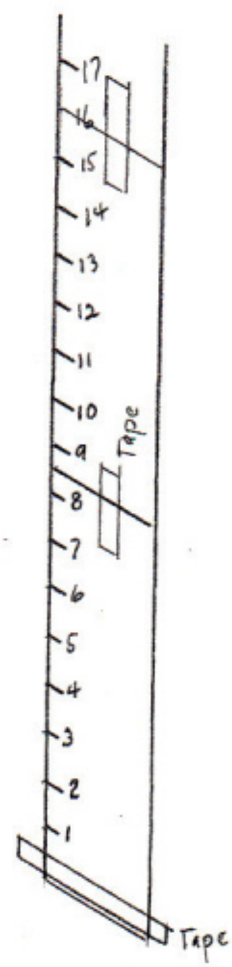
4. Repeat at increasing heights. Stop when the rocket hits the ceiling.

5. Graph the results, using the graph sheet on page 7.

Optional:

Each team can make its own measuring tape using strips of paper (calculator tape will work well).

Mark increments on the strips and tape them to the wall. This will make collecting data easier.



Question:

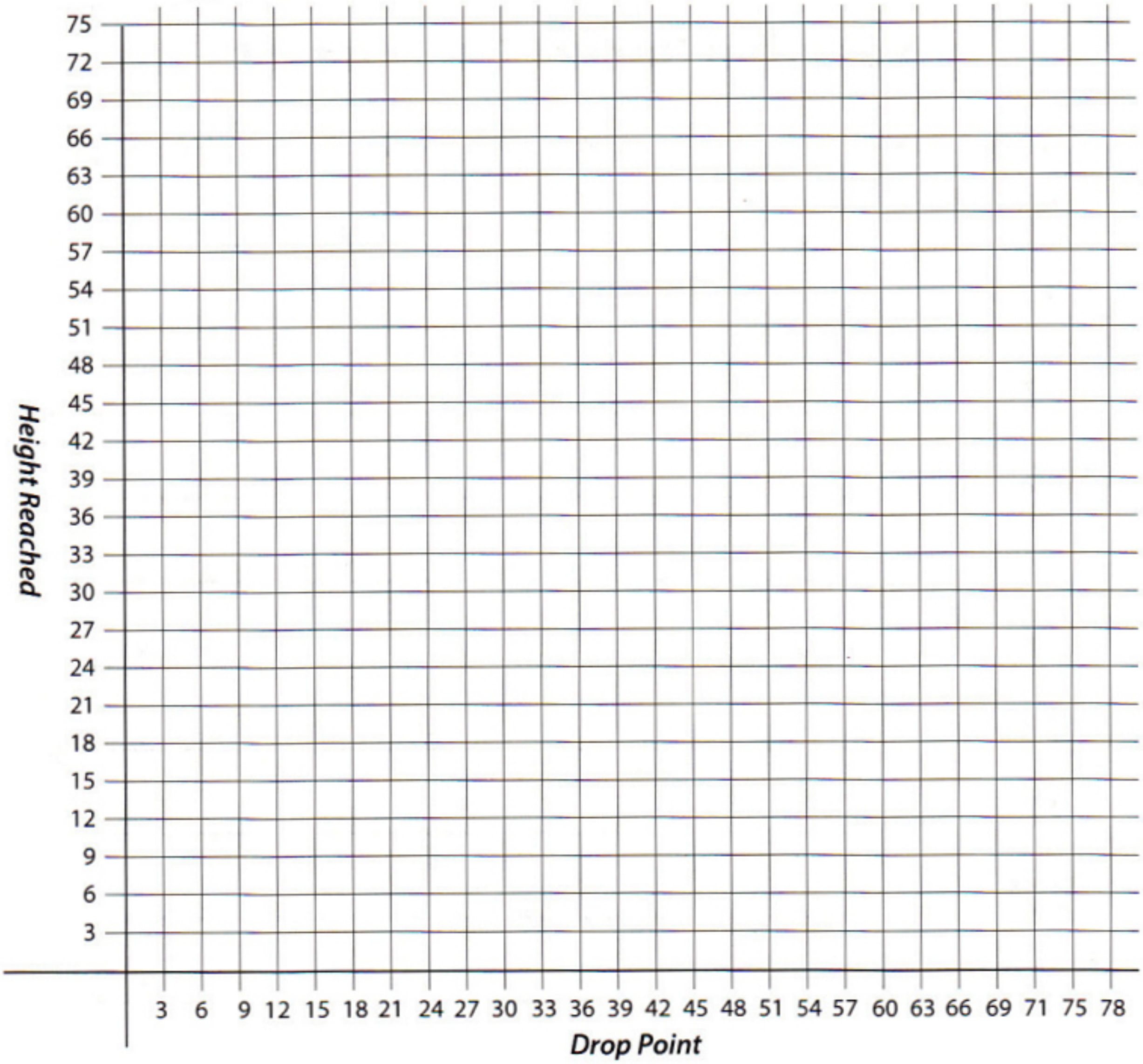
Was the increase constant or did it change? Why?

Activity 2 (continued)

Reaction Rocket Experiment Data Sheet

		Rocket Height			
	Data	1st drop	2nd drop	3rd drop	Average
Drop Height	6"				
	9"				
	12"				
	15"				
	18"				
	21"				
	24"				
	27"				
	30"				
	33"				
	36"				
	39"				
	42"				
	45"				
	48"				
	51"				

Reaction Rocket Experiment Graph



Observations:

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To extend your lesson, consider this Educational Innovations product:

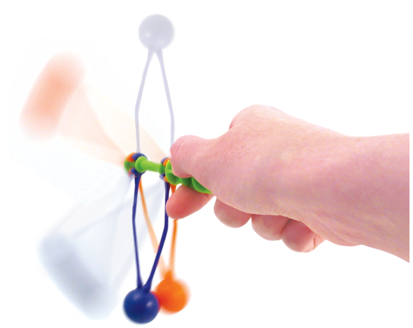
Seismic Accelerator (SS-150)

Several balls are threaded on a wire. When the apparatus is dropped straight down onto a hard surface, the top ball can rebound to a height equal to five times the original drop. Leads into an interesting discussion of what has happened due to the Law of Conservation of Energy. Safety glasses included.

Newton's Cradle (NEW-115)

Find hours of entertainment in this chic, easy to assemble Newton's Cradle! Perfect for teaching your students about Newton's laws of motion, Newton's Cradle makes a great addition to any classroom.

Newton's Kinetic Yo-Yo (NE-120)



Demonstrate Newton's classic laws of physics! With a flick of the wrist, set the spheres in motion. It really is "all in the wrist!" As the first sphere swings around, it stops and transfers its energy to the second ball, forcing it to swing around. With practice, students can even make the spheres ricochet off one another above and below the handle.

Dropper Popper (POP-100)

This incredible device seemingly defies the laws of physics by bouncing higher than where you dropped it from! Requires a small amount of activation energy to work. It is molded into a special shape that allows it to store elastic potential energy and then convert it to kinetic energy with a POP when dropped from a low height. Makes a great activation energy demonstration.