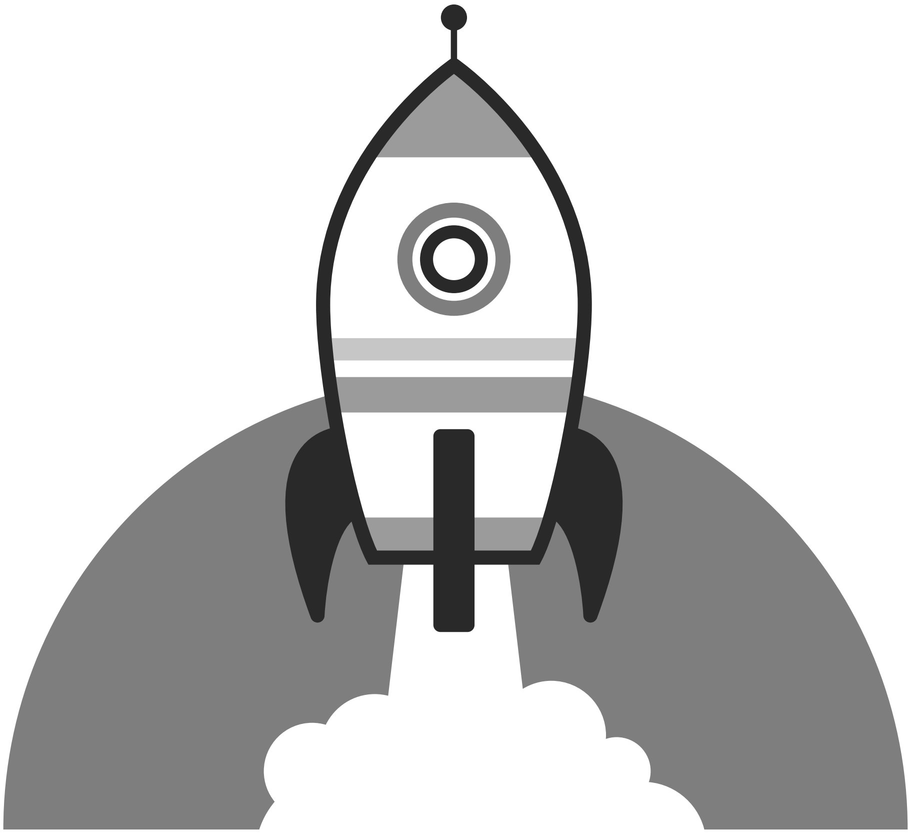
4 - H
NATIONAL
YOUTH
SCIENCE DAY



4 - H NATIONAL YOUTH SCIENCE DAY

ROCKETS TO THE RESCUE

FACILITATOR GUIDE

4-H PLEDGE

HEAD | HEART | HANDS | HEALTH

I PLEDGE MY **HEAD** TO CLEARER THINKING,

MY **HEART** TO GREATER LOYALTY,

MY **HANDS** TO LARGER SERVICE, AND

MY **HEALTH** TO BETTER LIVING,

FOR MY CLUB, MY COMMUNITY, MY COUNTRY,

AND MY WORLD.

INTRODUCTION

In October 2014, millions of young people across the nation will become scientists for the day during the seventh annual ***4-H National Youth Science Day*** (**NYSD**). **NYSD** is the premiere national rallying event for 4-H Science year-round programming. It brings together thousands of youth, volunteers and educators from the nation's 109 land-grant colleges and universities to simultaneously complete the National Science Experiment.

The **2014 National Science Experiment, *Rockets to the Rescue***, provides young scientists the opportunity to explore how aerospace engineering can be used to solve real world challenges—such as food distribution in emergency situations—to make a positive impact in our world.

4 - H NATIONAL YOUTH SCIENCE DAY
ROCKETS TO THE RESCUE

Rockets to the Rescue captures many of the wonders and issues of modern day engineering. It emphasizes aerospace engineering, as it incorporates lessons related to math, science and physics. While it is a fictional scenario, it has real life parallels.

This activity is appropriate for youth in grades 4 and above.

CONTEXT

When disasters strike, logistics can be a key challenge for emergency responders trying to deliver food aid and supplies to the people who need it most. Severe storms can flood roads, and take out bridges, ports and runways. This can make normal transportation options practically impossible.

WHY AEROSPACE ENGINEERING?

Professional aerospace engineers frequently encounter design challenges when developing, manufacturing and testing aircraft and aerospace products. They are given goals, requirements and constraints—and must use their creativity and imagination to best solve the problem.

As an aspiring aerospace engineer, your challenge is to come up with an aerospace design idea for solving this problem. This is the premise for the 2014 National Youth Science Day Experiment.

THE EXPERIMENT

Rockets to the Rescue is an engaging activity that gives young scientists an opportunity to let their imagination take flight and explore how aerospace engineering addresses real world problems, such as delivering food and supplies in emergency situations.

Participants will apply lessons in science, math and physics to design and build an aerodynamic Food Transportation Device (FTD) that can deliver a payload to a desired target using different trajectories.

A Science Framework for K-12 Education

The **2014 National Science Experiment** is designed to align with the Science and Engineering Practices defined by *A Science Framework for K-12 Science Education*, the blueprint for developing the *Next Generation Science Standards (NGSS)*.

Objectives and Outcomes

1. Develop a basic understanding of aerospace engineering through hands-on activities that motivate scientific inquiry through the engineering design process.
2. Analyze proportional relationships and use them to solve real world and mathematical problems.
3. Pique curiosity and inspire interest in multiple aerospace engineering disciplines.

USING THIS GUIDE

The facilitator guide for ***Rockets to the Rescue*** features content found in the Youth Guide as well as additional information that can assist you in teaching and overseeing each part of the experiment.

Throughout the guide, you will find:

TAKE THE LEAD

Instructions for performing specific tasks related to the experiment.

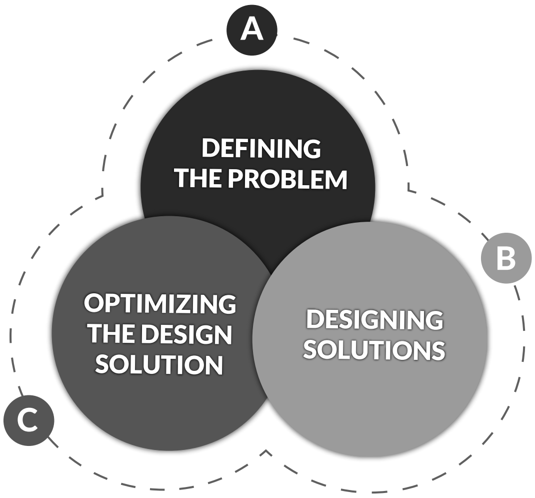
TALK ABOUT IT

Questions that can be used to facilitate group discussions and inquiry.

LEADER NOTES

Additional background information and tips for facilitating each experiment.

Core Engineering Design Process



A **Defining engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.

B **Designing solutions to engineering problems** begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.

C **Optimizing the design solution** involves a process in which solutions are systematically tested and refined, and the final design is improved by trading off less important features for those that are more important.

The Next Generation Science Standards identifies content and science and engineering practices that all students should learn from kindergarten to high school graduation.

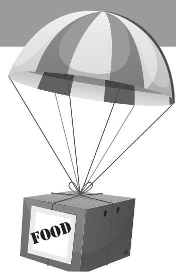
ROCKETS TO THE RESCUE

Food Delivery Takes Flight

Getting Started

TAKE THE LEAD

Before starting the activities, it may be helpful to talk about food security, as well as how aeronautics is currently being used—not only for space exploration and discovery, but also to address real world challenges that exist closer to home.

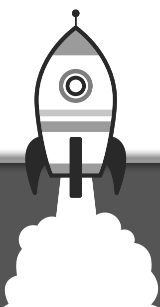


In emergency situations, such as a natural disaster, logistics can be an incredible challenge. Speed is the name of the game. *What is the quickest and most efficient way to gather and deliver vital resources and supplies—such as food—to the people who need it most? Can we use rocket science to help people in the affected communities survive and recover?*

Imagine being stranded on a remote island without food, water, shelter or medical supplies for a week. This was a real situation for thousands of Filipinos in November 2013. In that month, Typhoon Haiyan, estimated to be one of the worst storms ever recorded, struck the Philippines. It killed thousands of people and destroyed entire towns and cities on six of the major islands, displacing millions of people.

Could aerospace engineering principles be used to help in an emergency situation? Let's find out.

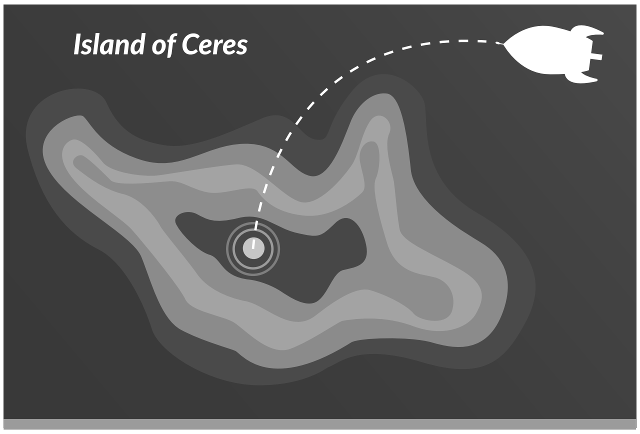
3-2-1 Lift Off! | ***4-H aerospace engineers to the rescue!***



THE CHALLENGE

TAKE THE LEAD

Introduce the challenge by announcing to the group that they are all now aerospace engineers tasked with designing a solution for a catastrophic event that recently took place on the island of **Ceres**.



A severe storm just hit several islands in the Pacific, resulting in damage of historic proportions. Bridges are gone. Harbors are destroyed. Roads have disappeared. Communications systems have been uprooted. Entire towns have been wiped out as a result of storm surges and tsunamis.

The inhabitants of a small island named **Ceres** have been completely cut off from all food deliveries. After nearly a week, they are close to starvation. Ships are on the way but will not arrive for several more days. Airplanes cannot land because the runways are destroyed. Helicopters are not a viable solution.

As a team of aspiring aerospace engineers, you have been asked to use a rocket propulsion system to launch and deliver a payload of food to this island. The food needs to arrive intact and stay fresh, so that the people of Ceres can survive long enough until normal transportation options have been restored.

The situation is urgent. You and your team do not have much time.

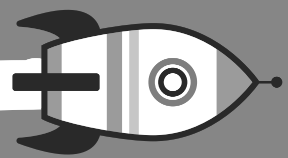
Are you up for the task?* | *Let's Go!

THE EXPERIMENT

Time required: 90 minutes

OBJECTIVE

Design, build and test a propulsion system and prototype Food Transportation Device (FTD) that can accurately deliver its food payload to a specific target.



MATERIALS

To build the FTD, each team will need:

- 1 FTD Construction Kit *(enclosed in a large plastic bag)*
  - » 2 sheets of 8 ½ X 11 cardstock
  - » 3 sheets of paper
  - » 10 rubber bands
  - » 1 plastic grocery bag
  - » 3 feet of string
  - » 4 cotton balls
  - » 1 rubber cork
  - » 4 straws
  - » 2 pipe cleaners
  - » 1 sheet of gift tissue paper
  - » 12” section of ½” PVC pipe for rolling tube *(Use one of the 3 sections provided for the launcher. Teams will need to share.)*
- 4 raisins

Not included in the kit:

- Packing tape
- Scissors

FOR THE LAUNCH YOU WILL NEED:

- 1 rocket launcher kit *(This is built in Step #3.)*
- Safety goggles for each participant

Not included in the kit:

- Hula hoops, rope or chalk to create and mark different targets
- Measuring tape
- Duct tape

TAKE THE LEAD

The faciltator will need to prepare a bag of materials for each of the five teams in advance of the activity. Use the five plastic bags provided and place 1/5 of the materials from the kit into each bag as indicated above. In each kit there are enough materials for 15 participants, assuming there will be five teams of three youths.

LEADER NOTES

- Plan on 30 minutes set-up time.
- Read through the activity to become familiar with the set-up requirements and each step.
- Watch the video **(www.4-H.org/nysdvideo)** to learn more about the experiment as well as how to set up the rocket launcher and assemble a Food Transportation Device (FTD).
- Identify a launch location that is in an open area and free of any obstructions and traffic.
- Use hula hoops, loops of rope or chalk to establish the desired target areas.

TAKE THE LEAD

You may wish to begin with a short discussion with youth about rockets. What do they know about rockets? How are they shaped? Why do you think they are shaped that way? What are the primary parts of this vessel, and what does each one do? What is a propulsion system? What is a payload?

Step 1: Identify the problem.

Explain to the group that they have been tasked with designing, building and testing a Food Transportation Device (FTD) that can accurately deliver food to the island.

Step 2: Form teams and secure materials.

Divide the group into teams of 2-3 participants. Each team will be given a plastic bag that contains their materials. Facilitators may choose to have the teams identify roles for each team member, such as chief engineer, materials specialist, builder, recorder, reporter, etc.

Explain that the FTD is comprised of two parts – a **propulsion system** and a **payload container**. Tell them that they will work together to design, construct, and test their FTD (using the materials they have been provided).

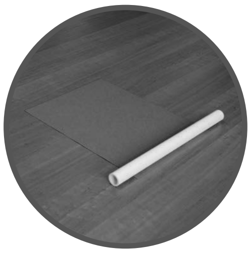
TALK ABOUT IT

- What shapes in nature are the most resistant to outside pressures?
- What shapes are the most sleek and aerodynamic?
- How will you create space for your payload?
- How will the role of **gravity** affect your design?
- How might you lessen the impact of a hard landing?
- What **angle** is going to be best for your **trajectory**?

Step 3: Build a launcher.

Using *Appendix B*, construct a launcher that will be shared by by the five teams of engineers.

Step 4: Build a propulsion system.



A | Place the PVC rolling tube at the narrow end of the one sheet of cardstock.

B | Roll the entire sheet of paper tightly around the rolling tube.

C | The paper tube should be relatively tight, but not too tight. If it is too loose or too tight, it will not work well as a propulsion system.

D | Seal the edges of the cardstock paper with packing tape. Be careful not to tape it to the PVC rolling tube.

E | Carefully slide the cardboard tube off the PVC rolling tube. This is now your propulsion system.

F | Place a rubber cork into one end of the paper tube and secure with packing tape. Leave the other end open. This is the part that will go over a tube on the launcher.

G | Place the propulsion system back on the PVC rolling tube. Try sliding it back and forth on the tube to ensure that the propulsion system hasn't changed diameter or is too tight. If so, you will need to start over.

Step 5: Test launch your propulsion system.

Explain to the group that they will test their propulsion systems on the launcher to ensure the integrity of their designs and estimate the correct angle and trajectory they will need to successfully launch their FTD.

Use instructions in *Appendix C* to test the propulsion system *without* a payload. Have the teams take turns launching their propulsion systems using a variety of angles for the launch tube and measuring the distance of each to get an idea of the capacity of the launcher. Instruct them to record what they observe in their notebooks.

Step 6: Build your FTD.

The next step will be designing a FTD prototype using only the materials they have been provided in the plastic bag. As designers, it is important that they think carefully about their concept.

Their FTDs will need to be:

- Capable of carrying a specified payload of food items – in this case, four raisins.
- Aerodynamically shaped (not a ball) with recognizable sections and a forward/up orientation.
- Durable enough to survive the impact of landing. The payload must not be damaged.
- Inexpensive and easy to replicate by others.

Give each team about 30 minutes to build their FTD.

Instruct each team to create a team name, as well as a name for their FTD and write it on their propulsion system. This will be important for tracking their results later.

If time permits, allow the teams to vote on the most creative design, as well as which design they think might be the most successful.

TEAM NAME:

FTD NAME:

LEADER NOTES

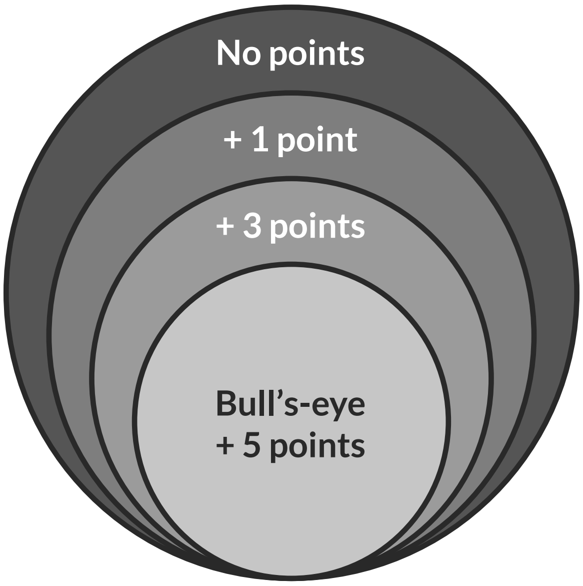
- **Use this time to set up the testing area. Place the target 35 feet from the launch pad. You can use different sized hula hoops, rope or chalk to create the different points for accuracy.**
- **Make sure the landing zone is in an open area with little traffic.**

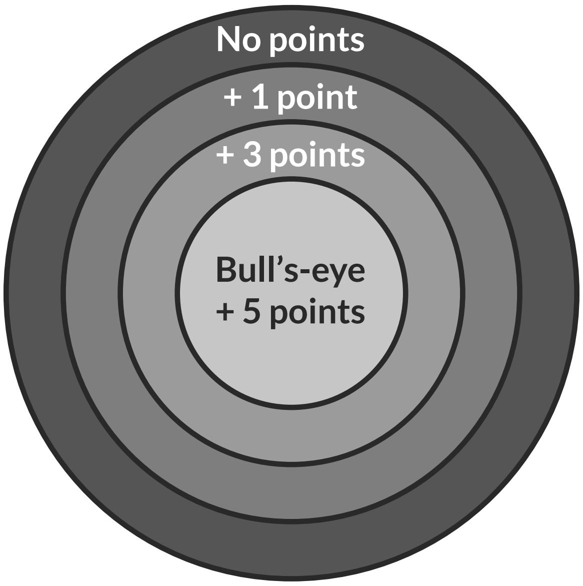
Step 7: Launch your FTD.

Using the launching instructions in *Appendix C*, demonstrate to the group how to launch their FTDs. Explain that their goal is to land in the target area.

The target should have values clearly written—a bull's-eye is 5 points, the second level is 3 points and the outside circle is 1 point. No points are awarded for failing to get within one of the 3 rings of the target area.

While configurations may vary, here are two possible designs for the landing zone.





Explain to the group that each team will have the opportunity to launch their FTD several times. The first launch will be an opportunity to test their FTD on the launcher to ensure the integrity of their designs, as well as estimate the correct angle and trajectory they will need to successfully launch their FTD. They will then have the opportunity to make adjustments, refine their designs and launch their FTDs again. This process may be repeated as many times as needed or as time allows.

Let each of the teams test their systems and record their information.

LEADER NOTES

- **Make sure all participants wear safety goggles when launching their FTDs.**

Step 8: Record your data.

Record your data using the chart below. Only alter one variable at a time!

Team Name:
Location of Launch (indoors/outdoors)
Team Members:

FTD Name:
Wind Conditions (if outdoors):

Trial #	Angle of Launch Tube *(in degrees)*	FTD Position on Launch Tube *(all the way, half-way down, ¼)*	Person Stomping on Bottle	FTD Design and/or Adjustments Since Previous Launch/Trial	Points Scored *(0, 1, 3, or 5)* and Observations
1					
2					
3					
4					
5					
6					
7					
8					

LEADER NOTES

- You may want to consider drawing this table on a large piece of poster board or paper so that everyone can see and discuss it later.
- It may be helpful to assign one person to record the data for all of the teams.
- Discuss the importance of changing only one variable at a time. Other variables may be added to the table, such as fresh vs. fatigued bottle, 1L vs. 2L bottle, bottle design, etc.

Step 9: Reflect, discuss, and redesign (then repeat steps #7-9).

When all groups have had a chance to launch their rockets, provide participants the opportunity to compare observations and data. These discussions should be held in the middle of their launch trials—so that they can apply what they've learned to redesign their FTD—as well as at the end of this activity.

As you discuss what is working and about what isn't working, write the key points on the board or on chart paper so youth have a chance to refer back to it when deciding how to redesign their FTDs.

For example:

What Works	What Doesn't Work
Fresh bottle	Fatigued bottle
Stable launcher	Too much weight on the front of FTD
Load FTD halfway down on launch tube	Going against the wind
	Too much or too little mass jumping onto bottle

Encourage the youth to incorporate what they learn into each new launch.

TALK ABOUT IT

- Which FTD landed closest to the target?
- Which designs worked well? Which designs didn't work?
- What did you learn when testing your FTD?
- What did you learn about the angle and trajectory you used?
- What changes did you make in your design after observing other launches?
- What might you have tried earlier in the design and build process to improve your success rate?
- What were some of the tradeoffs you considered when developing your design?

Step 10: Apply what you learned.
Remind the group of their original goal: to design a solution capable of bringing food to the people of Ceres. Discuss how what they learned from this activity could be applied to real world situations.

THINK ABOUT IT

- In thinking about world food distribution problems, what can you suggest that might help quickly get food to people in need?
- Are there better ways to quickly deliver food to isolated populations? Given that devastating storms are just as likely to occur again, how might countries better prepare for such catastrophes?
- What other long-term and sustainable ideas can you come up with for feeding hungry people?

READY FOR MORE?

Now that you have completed Activity 1, continue your engineering exploration with two additional activities, available for download at **www.4-H.org/NYSDregister**.

Activity 2: Incoming! Fragile Fruity Payload

Activity 3: Really Fast Food to the Rescue ($E=mc^2$)

TAKE IT FURTHER

Don't forget to register at **www.4-H.org/NYSDregister** to access supplemental *Rockets to the Rescue* activities, register your local event and much more.

ADDITIONAL ACTIVITIES RELATED TO THIS EXPERIMENT

- **High-Pressure Foam Rocket**
  http://makezine.com/projects/high-pressure-foam-rocket

- **How to Make Match Rockets**
  http://makezine.com/2012/07/02/how-to-make-match-rockets

- **How High Did it Go? By Robert L. Cannon. Estes Educator.com Elementary Mathematics of Model Rocket Flight**
  http://www.estesrockets.com/rockets

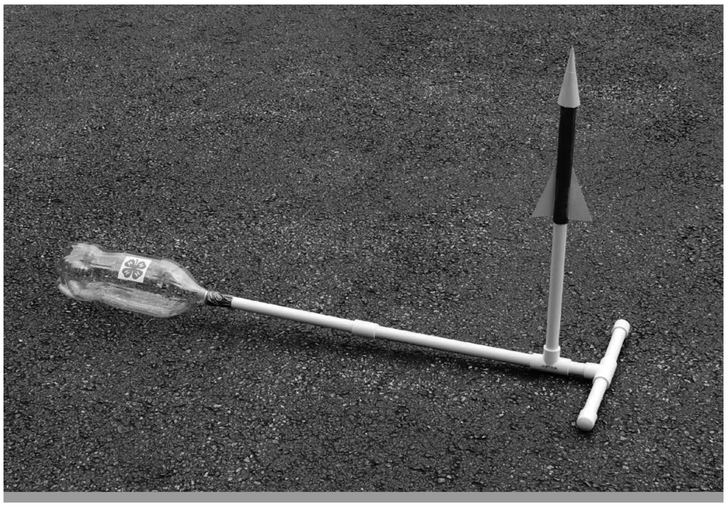
- **How Fast Did it Go? By Robert L. Cannon. Estes Educator.com**
  http://www.estesrockets.com/rockets/

- **Soda Straw Rockets**
  http://www.jpl.nasa.gov/education/images/pdf/sodastrawrocket.pdf

APPENDIX A – MATERIALS FOR GETTING STARTED

Each *Rockets to the Rescue* kit includes enough materials for five teams of participants, with 2-3 youth to a team.

MATERIALS



- 1 *Rockets to the Rescue* set of curriculum *(1 Facilitator Guide, 5 Youth Guides)*
- Enough materials for five teams to build FTDs *(enclosed in a large zip-lock bag)*
- Each of the five teams will receive:
  - » 2 sheets of 8 ½ x 11 cardstock
  - » 3 sheets of paper
  - » 10 rubber bands
  - » 1 plastic grocery bag
  - » 3 feet of string
  - » 4 cotton balls
  - » 1 rubber cork
  - » 4 straws
  - » 2 pipe cleaners
  - » 1 sheet of gift tissue paper
- 1 box of raisins
- Pre-cut components for the Soda Bottle Launcher
  - » 2 - PVC tee connectors
  - » 2 - PVC slip caps
  - » 1 - PVC coupling
  - » 3 - 12” PVC pipes
  - » 2 - 5” PVC pipes
  - » 1 - 2” PVC pipe
  - » 10 - 4-H emblem stickers
- 10 pairs of safety goggles, 1 protractor *(for teams to share)*

Facilitators will also need to provide the following items:

- Several clean and empty 2L plastic bottles used to package Coca-Cola© products. These have shown to be substantially more durable and able to with stand repeated stomping. *(Launcher)*
- Hula hoops, rope or chalk to create and mark different targets *(Landing Zone)*
- Measuring tape *(to set 35 foot target distance and to measure distances traveled during each launch)*
- Packing tape *(FTDs – to tape rolled cardstock propulsion systems)*
- Duct tape *(to connect bottle to launcher)*
- Scissors *(FTDs)*

APPENDIX B – BUILDING THE SODA BOTTLE LAUNCHER

OBJECTIVE

Construct the Soda Bottle Launcher that will be used to launch the Food Transportation Devices (FTDs).

INTRODUCTION

Simple and easy to construct, the Soda Bottle Launcher is an integral part of the experiment. Like a balloon, air pressurizes the bottle rocket. When stomped or jumped on, air escapes the bottle, providing the energy needed to propel the rocket.

MATERIALS

- Pre-cut components for the Soda Bottle Launcher
  - » 2 - PVC tee connectors
  - » 2 - PVC slip caps
  - » 1 - PVC coupling
  - » 3 - 12” PVC pipes
  - » 2 - 5” PVC pipes
  - » 1 - 2” PVC pipe
  - » 10 - 4-H emblem stickers
  - » Eye protection for anyone near launcher

Not included in the kit:

- Several clean and empty 2L plastic soft drink bottles *(see Leader Note on the next page regarding type)*
- Duct tape

TAKE THE LEAD

- Plan on 5 minutes set-up time.
- Read through the assembly instructions to become familiar with each step.

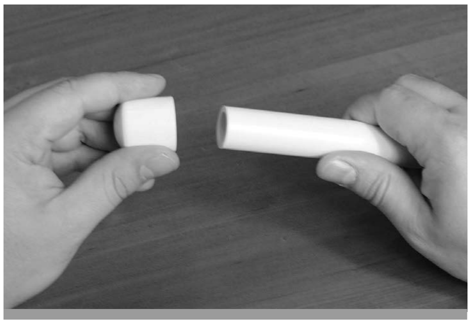
LEADER NOTES

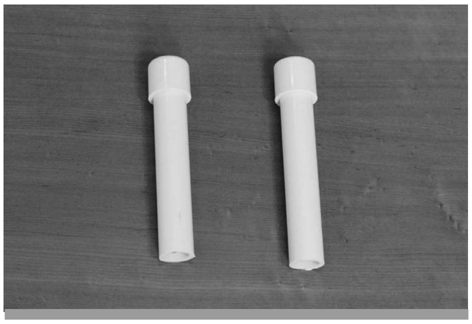
- **The PVC pieces will be held together using friction, not PVC cement.**
- **All plastic bottles will eventually split, crack or otherwise fail. To keep the activity moving, you may want to assemble additional bottles beforehand so that you can easily switch it out if one plastic bottle fails. Alternatively, each team can build their own bottle assembly and use it for their launches.**

- **Important:** We recommend using 2L bottles used to package Coca-Cola© products (left image), as they have shown to be substantially more durable and able to withstand repeated stomping.

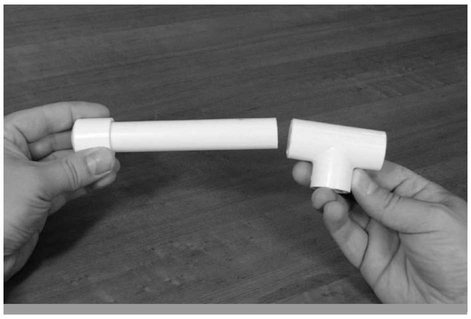
HOW TO ASSEMBLE

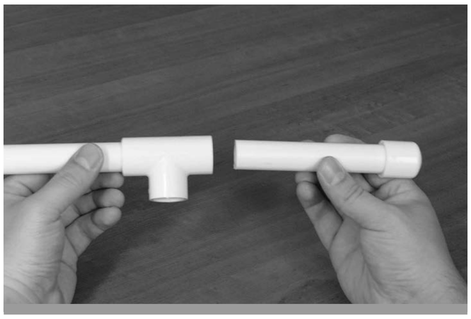
Step 1: Attach PVC caps to the end of the 5” pipe pieces.

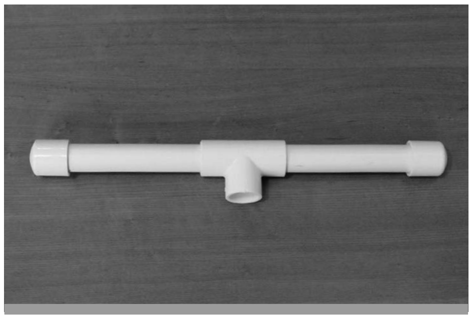




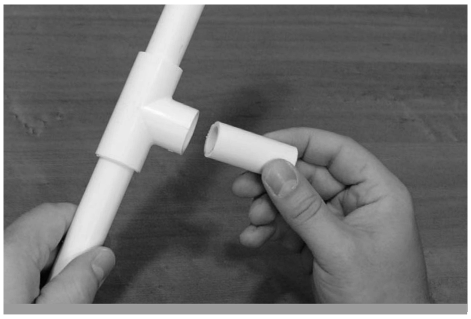
Step 2: Insert the two 5” pipe pieces with the caps into each end of a PVC tee connector.

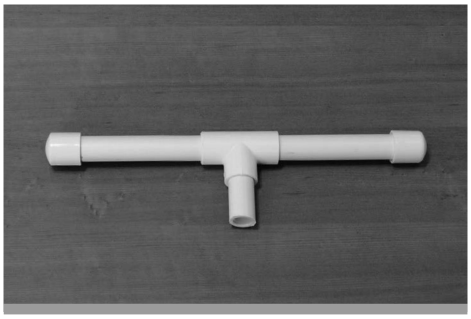




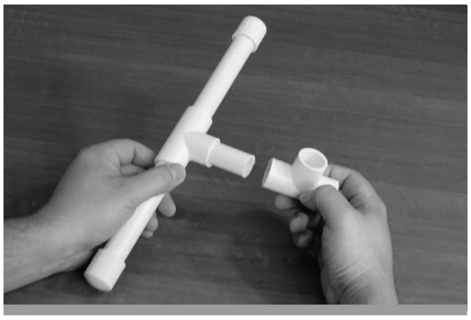


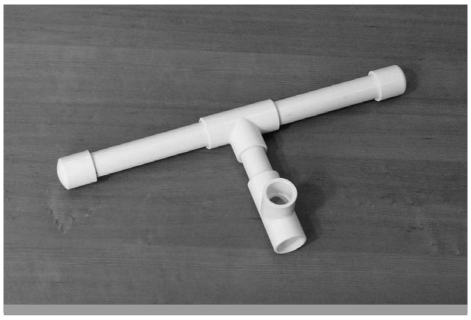
Step 3: Insert the 2” pipe piece into the open connection of PVC tee connector.



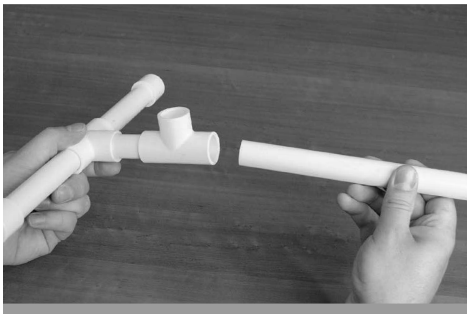


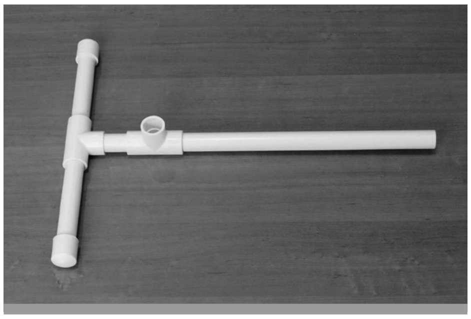
Step 4: Connect the second PVC tee connector to the other end of the 2” pipe piece.



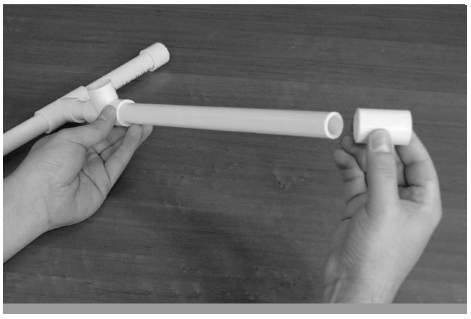


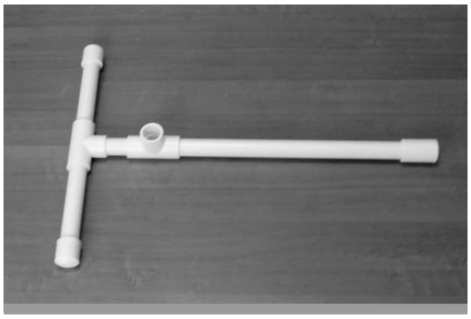
Step 5: Insert one end of a 12” pipe piece into the other end of the PVC tee connector.



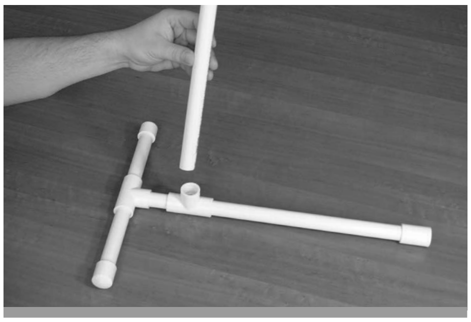


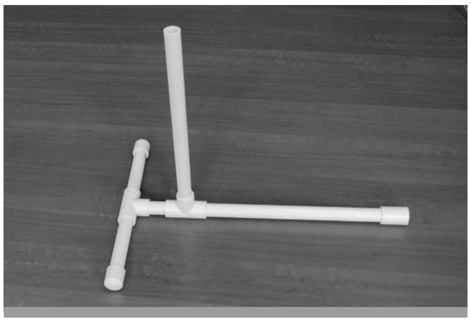
Step 6: Attach the PVC coupling to the other end of the pipe piece.



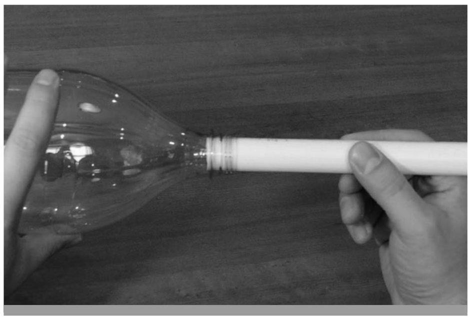


Step 7: Insert a 12” pipe piece into the open connection of the PVC tee connector. This will be the launch tube.

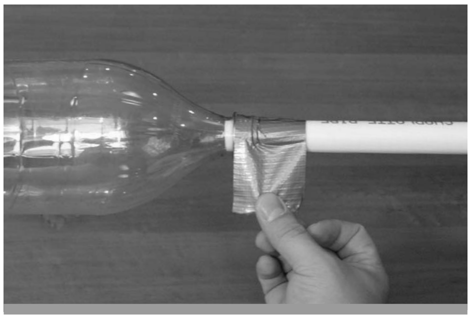


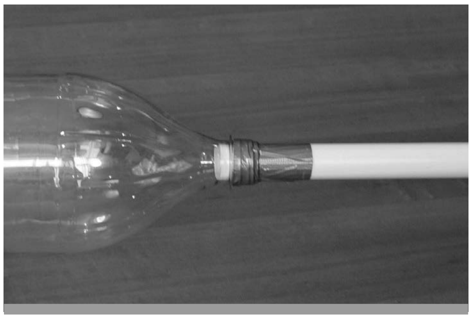


Step 8: Insert the 12” PVC pipe piece into the mouth of the two-liter bottle. It will be a snug fit.



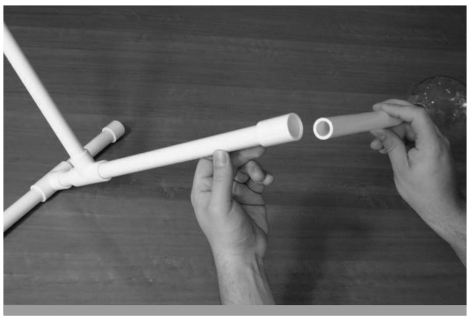
Step 9: Secure the pipe to the bottle using a 4” long piece of duct tape.





Step 10: Place a 4-H sticker on the bottle. This will give the participants a target to jump on, as well as give some depth to the clear bottle.

Step 11: Insert other end of 12” pipe piece to the PVC coupling.



APPENDIX C – HOW TO LAUNCH YOUR FTD

3-2-1 LIFT OFF!

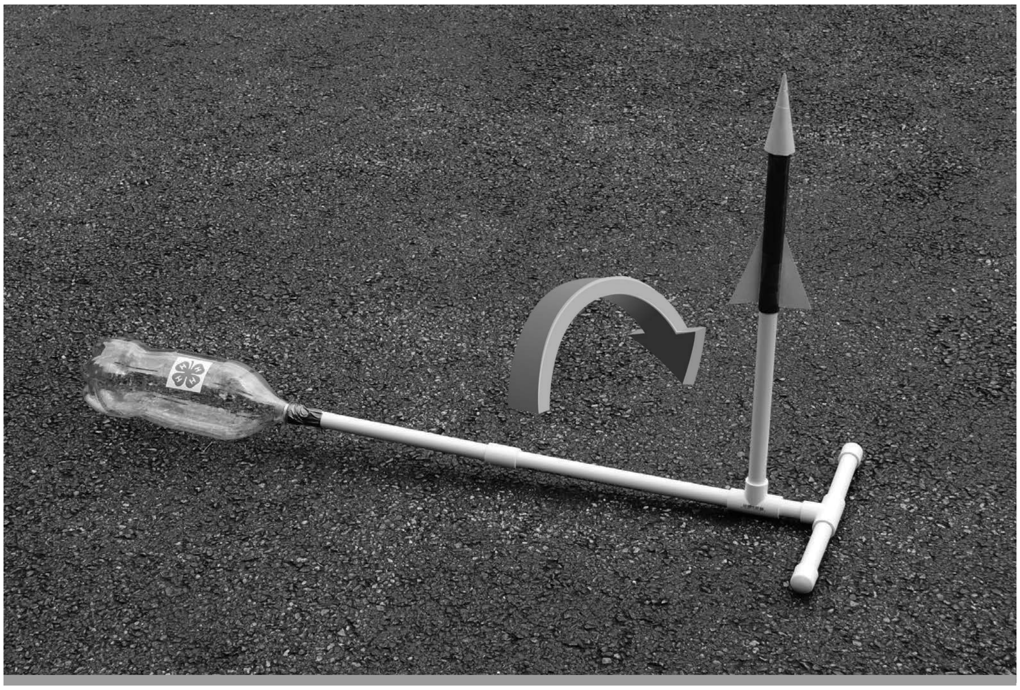
The launch can be performed outdoors in a large open parking lot or field. It may also be done indoors in a gym, large multipurpose room, or cafeteria, which maybe preferred, depending on the weather and wind. The target area should be 35 feet from the launch pad, so you will need approximately 50 feet of room.

Step 1: Place the launcher in an open space.

If the ground is soft, consider putting a solid object, such as a piece of plywood, under the bottle to create a solid surface.

Step 2: Tilt the launch tube in the direction you want the FTD to go.

The launch tube can be aimed at different angles by tilting to one side or another.



Step 3: Slide the rocket down the launch tube.

Step 4: Prepare for take off.

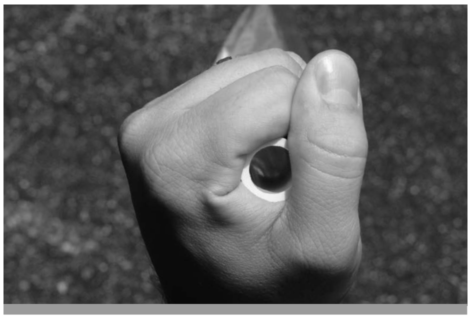
Make sure the landing zone is clear of people and that any participants involved in launching the rocket are wearing eye protection.

Step 5: Countdown to zero.

Stomp or jump on the bottle, using the sticker on the bottle as a target. This will force most of the air inside the bottle through the tubes and will launch the rocket.

Step 6: Re-inflate the bottle.

Separate the bottle from the launcher by pulling it from the connector. Wrap your hand around the pipe end to make a loose fist and blow through the opening into the pipe. Lips should not touch the tube. Use your other hand to help flex the bottle back into its original shape. Reconnect the bottle to the launcher. It is ready to go again.



GLOSSARY

Acceleration - The rate that velocity changes with time. Acceleration has magnitude and direction.

Angle - The figure formed by two lines diverging from a common point. In this experiment, youth will use a protractor to estimate the angle of launch, which will influence trajectory.

Ceres - The Roman goddess of agriculture and the name of an island in the Pacific Ocean.

Drag - The resisting force of an object moving through the air. The force you feel when you put your hand out of the window of a moving car is drag.

Engineering - The application of scientific and mathematical principles to practical ends such as the design, manufacture and operation of efficient and economical structures, machines, processes and systems.

Gravity - The attraction of an object to the mass of the earth.

Kinetic energy - The energy of an object in motion.

Momentum - The product of mass and velocity of a moving object. The momentum is a significant factor in the flight of the FTD.

Objective – A measurable characteristic to be achieved by the system, such as the FTD.

Payload - The cargo carried by a craft for a particular mission.

Potential Energy - Stored energy, such as the air that is compressed in the FTD launcher.

Prototype - An experimental model or example on which a final design is based.

Trajectory - The path an object takes when moving through the air. The trajectory is a function of velocity, momentum and drag.

Velocity - Adds the direction of motion to the speed. For this FTD, the velocity can be given as its speed going away from the launcher at the angle from the ground.

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4-H National Youth Science Day

4-H, the nation's largest youth development and empowerment organization, cultivates confident kids who tackle the issues that matter most in their communities right now. In the United States, 4-H programs empower six million young people through the 109 land-grant universities and Cooperative Extension in more than 3,000 local offices serving every county and parish in the country. Outside the United States, independent, country-led 4-H organizations empower one million young people in more than 50 countries. National 4-H Council is the private sector, non-profit partner of the Cooperative Extension System and 4-H National Headquarters located at the National Institute of Food and Agriculture (NIFA) within the United States Department of Agriculture (USDA).