American Institute of Aeronautics & Astronautics (AIAA) STEM Outreach Activities

The AIAA Northern Ohio Section (NOS) is committed to supporting the northern Ohio community by engaging and motivating the next generation of scientists and engineers. While the current situation regarding COVID-19 has limited our social, work, and educational activities, there is still so much that we can do to enhance our learning, inspire and teach each other, have some fun, and socialize our enthusiasm for STEM. STEM provides the tools that enable us to improve our lives and the lives of others through advancing technology and our understanding of the world around us. But to do so effectively we need to sharpen those tools and encourage others to do the same. And so, we have compiled several activities to do just that. The activities can be done at home by students through the guidance of an educator, with their parents/guardians, or individually.

Supplies for the activities can mostly be found inside the home. We highly encourage folks to maintain good social distancing and hygiene practices. If you are unable to locate all the supplies that you will need, feel free to improvise with what you have at home. At your own discretion, you can find many of the supplies at grocery/department stores and hardware stores that have remained open. Alternatively, you can attempt to purchase the supplies online and have them shipped to your residence. In any case, we recommend you treat the acquisition and process of acquisition of those supplies in a manner that is consistent with the latest healthcare recommendations (sterilize when able, wash hands frequently, avoid touching your face, let delivered packages sit long enough to allow the virus to die prior to handling, etc.). We want all the students to learn and have fun but we want them to say healthy above all.

While the biggest prize is the reward of knowledge and fun that each participant will receive, the AIAA NOS section is offering some monetary awards to students who tweet a video response to @AIAANorthernOH on Twitter demonstrating their successful project by **June 30th, 2020**, as follows:

- **$20 prize to each of the *first 10* video responses posted**
- **$100 prize to the overall most creative project and video response**

The NOS Twitter is: twitter.com/AIAANorthernOH

Educators are encouraged to share this material with their students, their student's parents/guardians, and other educators. You may consider working some of these projects into your virtual curriculum or supplying them to your students as supplemental learning materials or using them as an extra credit opportunity. For parents/guardians, this may be a good way to stimulate your child's mind and have some fun. You are encouraged to tailor/expand upon the activities provided here to make them less/more challenging and students are encouraged to improve their designs/solutions. In addition, you are encouraged to look for other activities that will stimulate the student's appreciation of engineering and science.

Lastly, the AIAA NOS council would like to extend a special thanks to Ashlie Flegel, an AIAA member who is also one of our co-organizers for our Young Astronaut's Day (YAD) event. She was kind enough to organize the activities provided here. For those of you unfamiliar with YAD, it is a STEM outreach event that we sponsor every year and it typically takes place in November. It provides students with the opportunity to participate and compete in tasks designed to simulate real-world aerospace related engineering problems. The event has been a very successful outreach event and we are leveraging that experience here. If you find value in these projects, you are encouraged to learn more about YAD (visit https://aiaanos.org/yad or tweet @YoungAstroDay) and keep an eye out for the registration opening later this year (openings fill up fast!)

For questions contact the AIAA NOS STEM chair, Jonathan Kratz (aiaanos.stem@gmail.com). Also consider contacting us or learning more about us through the following platforms:

Twitter: www.twitter.com/AIAANorthernOH
Facebook: www.facebook.com/AIAANOS/
AIAA Engage Community: https://engage.aiaa.org/northernohio
Website: https://aiaanos.org

We hope you enjoy the projects and learn something along the way.

Sincerely,
Jonathan Kratz on behalf of the AIAA NOS council

Balloon Propulsion Dash

Background Information:

Traveling into outer space takes enormous amounts of energy. This activity is a simple demonstration of rocket staging that Johann Schmidlap first proposed back in the 16th century. When a lower stage has exhausted its load of propellants, the entire stage drops away making the upper stages more efficient in reaching higher altitudes. In the typical rocket, the stages are mounted one on top of the other. The lowest stage is the largest and heaviest. In the Space Shuttle, the stages attach side by side. The solid rocket boosters attach to the side of the external tank. Also attached to the external tank is the Shuttle orbiter. When exhausted the solid rocket boosters jettison. Later, the orbiter discards the external tank as well.

Objective:

To demonstrate how rockets can achieve greater altitudes by using the technology of staging.

Description:

This activity simulates a multistage rocket launch by using inflated balloons that slide along a fishing line by the thrust produced from escaping air.

Materials:

Balloons (Propulsion)
Straws (Thrust Vector Control)
Tape and Plastic or Styrofoam Cups (Structure)
Scissors (Tools)
Binder Clips (Ground Service Equipment)
Plastic or Styrofoam
Fishing line or string that are attached to two objects to make a course for the rocket.

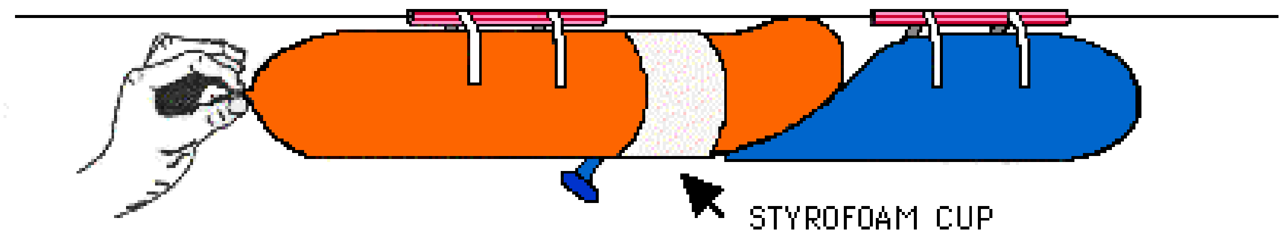
Procedure:

1. Cut the coffee cup in half so that the lip of the cup forms a continuous ring.
2. Stretch the balloons by pre-inflating them. Inflate the first balloon and squeeze its nozzle tight. Pull the nozzle through the ring. Twist the nozzle and hold it shut with the binder clip. Inflate the second balloon. While doing so, make sure the front end of the second balloon extends through the ring a short distance. As the second balloon inflates, it will press against the nozzle of the first balloon and take over the clip's job of holding it shut. It may take a bit of practice to achieve this. Clip the nozzle of the second balloon shut also.

Balloon Propulsion Dash (Continued)

Procedure Continued:

3. Tape each balloon to a straw.
4. Fish the fishing line through the straws that are attached to your balloons.
5. Remove the clips from the balloons and launch the rocket.
6. Record the distance traveled by the rocket.
7. Re-design your rocket to see if you can go further. (e.g., consider single stage, multi-stage, side-by-side arrangement, over-under arrangement etc.).



Marble Roller-Coaster Challenge

Objective
Design and build a roller coaster to carry your marble!

Materials
24 feet of track

3 supporting blocks (this is for the wooden rods to go into)

5 wood support rods

Tape

Small foam block

2 chairs from your team table

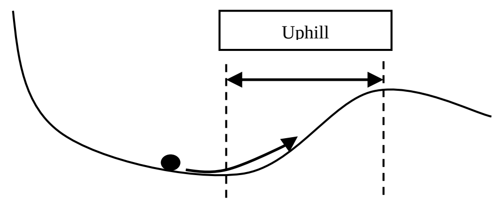
Cup

Directions
Design, build, and test a roller coaster that will carry your marble from one end of your track to the other. Scoring is outlined on the next page. Try to see how high you can make your rollercoaster! The highest point of your roller coaster will be the height of your wood rod sitting on top of a chair.

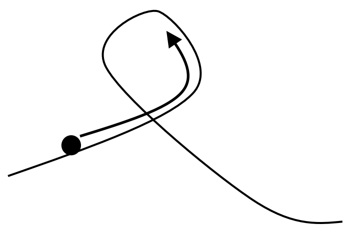
Marble Roller-Coaster Challenge (cont'd)

Scoring

3 points for an uphill section



5 points for a vertical loop

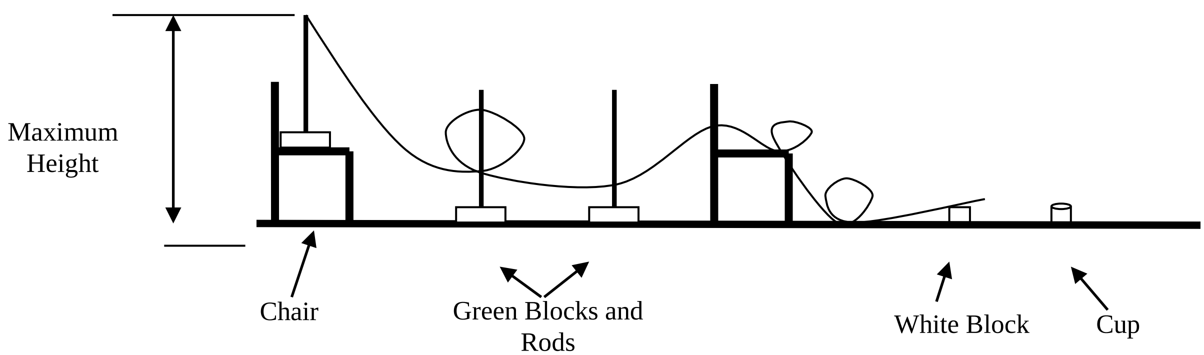


3 points for a horizontal 90 degree turn

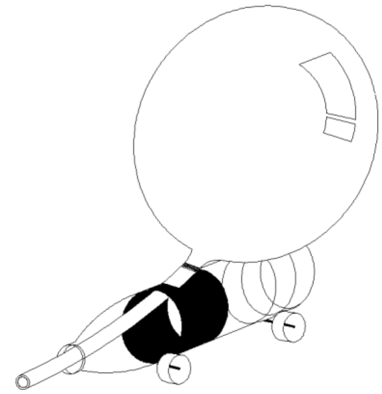
10 points for the marble completing the course

10 points for landing your marble in a cup

Example



Balloon Rocket Car



Summary

Students will learn the concepts of Newton's Law of Motion, friction, jet propulsion, and air resistance by designing and constructing a balloon powered rocket car.

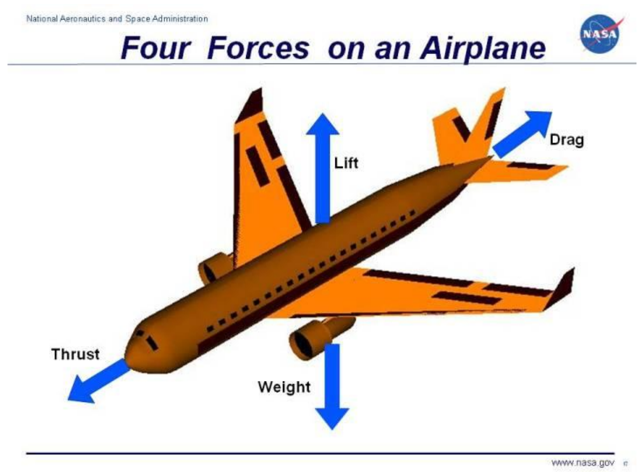
Objective

To build a Balloon Rocket Car that can extract the most energy out of the inflated balloon and make the vehicle travel the longest distance.

Background Information

The thrust of a jet engine is similar to the thrust produced in the balloon rocket car. When the balloon is blown up the air is pushing on the balloon skin keeping it inflated. Covering the nozzle of the balloon keeps this high pressure air trapped and at this point all the forces are balanced. Once the nozzle is opened the forces inside the balloon are no longer balanced and the high pressure air wants to escapes through the nozzle which produces thrust and makes the car accelerate. Similarly, in a jet engine the air enters the engine where it is compressed and heated to create a high pressure region which is then accelerated through a nozzle to produce a thrust force. This principle follows Newton's Second Law of Motion, Force= mass x acceleration. Otherwise stated, "if an object is acted on by an unbalanced force it will undergo an acceleration. The amount of acceleration depends on the force and the mass of the object."

Engines must provide enough thrust to overcome the forces of drag on the aircraft as shown in the illustration below.



http://www.grc.nasa.gov/WWW/K-12/airplane/forces.html

This can also follow Newton's First Law of Motion, "an object at rest will stay at rest and an object in motion will stay motion in a straight line unless acted upon by an unbalanced force." Therefore the forces pushing the engine and aircraft forward should be stronger than the force of the drag. Likewise the thrust of the balloon rocket car must be more than the forces acting on the car itself.

What forces are acting on the balloon rocket car? There are two main forces acting on the balloon rocket car: Friction and Air resistance. The friction force is the resistance between two objects sliding against each other. While building your car identify the places where objects will be rubbing against each other creating friction. Air resistance is also another form of friction where an object is sliding against air particles. You can experience this air resistance when riding a bike and the wind is hitting your face. You must pedal fast enough to overcome the wind. The rocket car has the greatest air resistance when fully inflated and begins moving because there is more area that has to push past the air particles.

Balloon Rocket Car (cont'd)

One last item to consider before constructing the balloon rocket car is how the nozzle size will affect the distance the car will travel. Keep in mind the nozzle size will determine how much pushing force (thrust) the balloon will create. The greater the size the greater the thrust but the faster the air will escape. The smaller the nozzle the smaller the thrust but the car may roll longer.

Materials

□ Water Bottle (Chassis)
□ Balloon, Vinyl Tubing, rubber band (Motor)
□ Wooden Skewers and straws (Axle)
□ Various Materials for wheels – be creative to find wheels around the house.
□ Tape

Procedure

1. Assemble your materials to build a car
2. Assemble the Chassis and Suspension:
    a. Cut the straw into two pieces. The length should be equal to the width of the water bottle.
    b. Tape the two straw pieces underneath the water bottle where you feel the front and rear wheels should go. Keep the straws lined up so the car travels in a straight line.
    c. Cut two pieces of the wooden skewer. The length should be between an inch to an inch and a half longer than the straw that was taped to the bottle.
    d. Put one end of each wooden skewer through your wheel. If the wheel is loose on the skewer use modeling clay to hold in place.
    e. Slide the skewers through the straw and attach the rest of the wheels to the skewer.
    f. Now you should have a rolling chassis!
3. Assemble the Motor:
    a. Insert the nozzle part way into the balloon.
    b. Use a rubber band and secure the nozzle to the balloon.
    c. Insert the nozzle through the slit on the top of your water bottle.
    d. Make sure about an inch of the nozzle is sticking out of the mouth of the bottle.
    e. Now your team is ready to test!
4. Find a clear space for a test track. Blow the balloon up and pinch the balloon at the base so the air won't escape.
5. Line the Rocket car up on the starting line and when the track is clear release the balloon.
6. Record the distance the car went.
7. Re-design your car to see if you can go further!

Internet Resources

This activity is taken from the following resources below:
Home Science Tools http://www.hometrainingtools.com/balloon-rocket-car-project/a/1346/
SAE A World in Motion (AWIM) JetToy http://www.awim.org/curriculum/jettoy/

Paper Bridge

Can you build a bridge that holds 100 pennies, using 1 sheet of paper and up to 5 paper clips? How about 200 pennies? How about 300?

<u>Goal:</u>

See how many total pennies up to four paper/paper clip bridges can hold. The team with the most cumulative number of pennies wins!

<u>Supplies:</u>

One 8 ½ inch by 11 inch sheet of paper (per bridge)
Five Paper Clips (per bridge)
Scissors
Pennies (if you don't have pennies you can use other supplies as weights such as nickels, quarters, hardware such as nuts and bolts, etc. To get a more accurate reading of the weight, you could consider placing the weights in a small container and using a food scale to weigh them prior to placing the container with the weights onto the bridge)

<u>Procedure and Rules:</u>

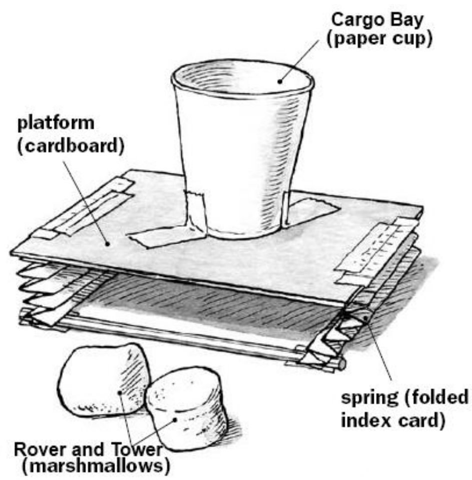
- Build a bridge out of ONE sheet of 8 ½" by 11" paper and up to 5 paper clips that will span a 20 cm (~8 inch) gap and will hold the most number of pennies possible.
  - Your bridge must be able to accommodate the weights (pennies) to test your bridge
  - You can cut the paper or bend paperclips but you only have the amount of supplies given to you for the whole competition
- Test your bridge
  - Place your bridge on two blocks 20 cm apart
    - You cannot attach your bridge to the blocks, it must sit freely on the blocks
  - Place pennies on your bridge until it collapses (at the discretion of the judges)
- Your score will be the number of pennies that your bridge held without collapsing
- Go back to the drawing board and create another bridge, modifying your design if you would like and repeat the test

Planetary Lander

Objective:
Design a shock absorbing method to protect your rover and other hardware from the impact of landing.

Description:
NASA has used a variety of methods to land their spacecraft safely on the surface of the moon and Mars. The most recent Mars lander, Curiosity, used a 'sky crane' along with 'retrorockets' (rockets fired toward the planet to slow down the decent) to lower their lander to the surface. The Pathfinder mission used giant airbags and bounced itself to safety.

However, rockets and giant balloons are not possible for your lander. You must instead build a shock absorbing system to keep your cargo hold upright and your hardware safely inside! You will use two marshmallows that represent your rover and your science hardware. A small cup represents the cargo hold of your lander. Find a way to soften the landing so that your hardware remains in your cargo hold upon impact. A variety of materials can be used as shock absorbing landing pads. These materials could include tape, cardboard, expanding folders/file holders, index cards, rubber bands, pencils, paper clips, and Styrofoam. All of the materials do not need to be use.



Rules:
1. A trial ends when the highest successful height is found or when your lander fails.
2. The cargo bay must be on top of your lander, and the top of your cargo hold must be open and facing upwards.
3. No materials can extend above the cup and nothing can be placed above or over the cup. (This means no parachutes, side walls, etc)
4. There is ONLY room in the cargo hold for your hardware (rover and science equipment, a.k.a, the marshmellows). Nothing else can be inside the cup.
5. The cargo hold cannot be altered in any way (no cuts, folds, etc).
6. The lander's descent must be a free fall… no strings, pulleys, etc are permitted.

Scoring:

- Your score will be based on the maximum drop height achieved. Height is measured from the floor to the bottommost piece of your lander.
- In order for you to score, BOTH marshmallows must be safely in the cup AFTER impact. This means marshmallows that bounce out of the cup, or fall out if the cup tips over, will not be counted.
- You may test at increasing or decreasing heights until your lander fails or your maximum successful height is found. You can choose the drop heights of your lander.
  - NOTE: If your lander breaks on landing but the marshmallows are safe, the score will be counted. But if you start with a high drop and your lander breaks without keeping the marshmallows safe, you will have no score and your trial will end.

Let it Glide Challenge

At NASA Glenn Research Center, engineers are continuously working to improve aircraft efficiency and design as well as using specialized NASA aircraft to conduct scientific research from the air. In this challenge, teams will work to develop and build a cardstock glider that will effectively glide a payload fashioned from a craft roll with dimensions of 3 inches by 1 ¾ inches by 1 inch that will produce the greatest glide slope possible while remaining intact upon “landing”.

The Glide Slope is determined by the ratio of the distance the glider travels to the height of the pilot flying the glider.

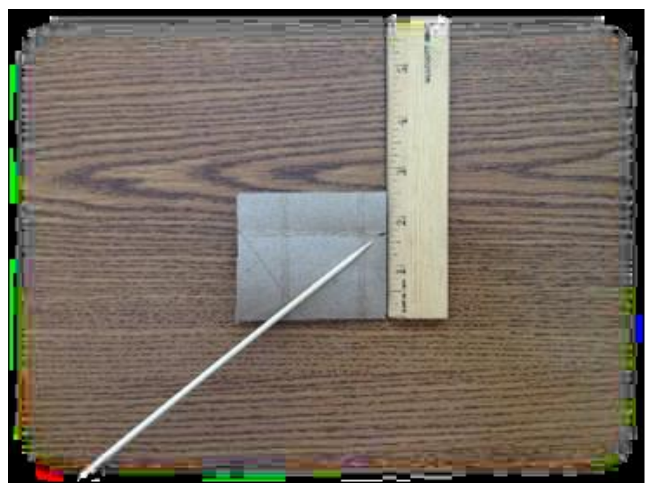
$$Glide\ Slope = Distance\ Glider\ Travels/\ Height\ of\ Pilot\ Flying\ Glider$$

Materials

- Empty toilet paper roll
- Cardstock Paper
- Pencil
- Scissors
- Masking Tape
- 15 Toothpicks
- 5 Pennies
- Ruler

Procedure

1. Cut a 3 inch length of toilet paper roll.
2. Flatten the craft roll to make two creases, measure 1.75 inches from the bottom
3. Flatten along the 1.75 inch mark to make two new creases to form the height and width of a box
4. Using the masking tape, close one of the open ends of the box.
5. Using the masking tape, close the other open end of the box as shown. The box you created will simulate the fuselage of a glider that holds the passengers and scientific instruments for remote sensing.
6. With the cardstock create the following components of your glider:
    a. Nose
    b. Wings
    c. Vertical stabilizer
    d. Tail wing
    e. Horizontal stabilizer
7. Use the toothpicks and tape to reinforce your components.
8. Tape the glider components to the craft roll.
9. Now that your glider is built perform your experiments.



Let it Glide Challenge (continued)

Experiments

Experiment #1: Without adding any pennies for balance, go to the fly zone and fly your glider.
Record the following:

- Height of Pilot:
- Distance “flown”:
- Calculated Glide Slope:
- Observations:

Experiment # 2: Add one penny to the nose and fly your glider.
Record the following:

- Height of Pilot:
- Distance “flown”:
- Calculated Glide Slope:
- Observations:

Experiment # 3: Add one more penny to the other side of the nose and fly your glider.
Record the following:

- Height of Pilot:
- Distance “flown”:
- Calculate the Glide Slope:
- Observations:

Experiment #4 and Beyond: Continue to add pennies in order to achieve the largest glide slope.