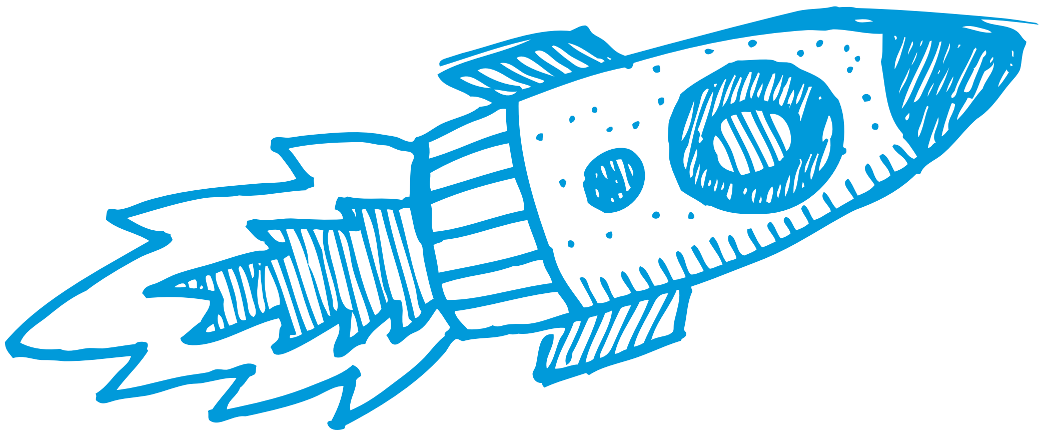

UNIT 4
INTRO TO AERONAUTICS

BOYS & GIRLS CLUBS OF AMERICA

Time Warner Cable®

The Intro to Aeronautics DIY Unit provides members with an exciting way to introduce the four forces of aeronautics – force, drag, lift and weight. In addition to gravity, these affect the movement and interaction of nearly all objects we encounter.

From designing pop, straw and effervescing rockets with ordinary products and ingredients to constructing rockets designed to carry specified payloads, participants will be able to formulate hypotheses about rockets, collect data about their experiments, and verify and interpret their results. Additionally, members will be encouraged throughout the modules to record their data and observations in their scientific notebooks, along with observing safety practices in their laboratory experiments. Unlike most of the activities in DIY STEM, these should be completed in order, as each activity builds upon learning from the previous one.

Each activity and module is aligned with the NGSS to help members and Club facilitators determine how the activities they will complete will prepare them to be successful. Moreover, the practical nature of the experiments will engage and connect with their understanding of how science plays a major role in what they know about force, lift, drag and weight within the field of aeronautics. The approximate cost range for the materials can be found in the Appendix B: Materials List with Estimated Costs.

UNIT 4 – INTRO TO AERONAUTICS		
Activity	**Goals**	**Recommended Time Allotment**
Pop! Rockets	Learning the parts of a rocket by being introduced to the concepts of force, lift and thrust	45-60 min.
Straw Rockets	Launching small paper rockets as they continue to explore the concept of thrust	45-60 min.
Effervescing Rockets	Learning about and building rockets that are powered by a fuel source using the concept of weight	45 min.
Heavy Lifting	Constructing rockets that can carry varying payloads while exploring the relationship between weight and drag	45-60 min.

POP! ROCKETS!
(45-60 MINUTES)

Introduction: Members will build their own rockets including a pressure chamber that will help to propel the rocket through the air. Members will have to make necessary adjustments to the design of their rockets to improve their distance and accuracy throughout the activity.

Objective: For members to design, construct and launch paper rockets.

NGSS Alignment: **MS-PS1-6:** Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature and state of a pure substance when thermal energy is added or removed.

MATERIALS

- ☐ Eye protection
- ☐ Card-stock paper
- ☐ Glue stick
- ☐ Scotch tape
- ☐ Scissors
- ☐ Crayons or colored markers
- ☐ Ruler
- ☐ Instructions and materials to build a Pop Rocket launcher (found online) – requires pre-work and build!
- ☐ Penny
- ☐ Centimeter-long pieces of 1/2" PVC pipes

FACILITATOR'S TIP BLOCK

Prior to this session, print the rocket pattern found at:
http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf

KEY VOCABULARY

Drag – Someone or something that makes action or progress slower or more difficult

Lift – To rise up from the ground or some other surface

Force – Any of the natural influences (as electromagnetism, gravity, the strong force and the weak force) that exist especially between particles to determine the structure of the universe

Thrust – To push (someone or something) with force

Propel – To push or drive (someone or something) forward or in a particular direction

Stability – The quality or state of something that is not easily changed or likely to change

Ask Members:

1. Who can name the parts of a rocket?
2. Who can explain the three parts listed below:
   a. The body or pressure chamber, which stores passengers, machinery and fuel.
   b. Fins, which are necessary for stability.
   c. The nose cone, which assists with direction and reduces the effect of drag on a rocket.
3. Let participants know they are going to explore the following two forces that make it possible for rockets to take flight: lift and thrust.
4. Can anyone give an example of objects that takes advantage of lift and thrust? Examples may include: airplanes, helicopters, drones, space shuttle, slingshots, etc.
5. Let participants know they've been given two rocket patterns and ask them to decide whether they are going to build a one-piece or a three-piece rocket.
6. After participants are finished with their rockets, allow them to decorate their rockets with crayons, colored pencils or markers. Other decorations, such as stickers, may be too heavy and affect the rockets' stability.

POP! ROCKETS! A: ONE-PIECE ROCKET

Instruct Members To:

1. Use a ruler and the edge of a penny to score (dent) the fold lines on their template.
2. Place the ruler along a dashed line and hold their penny at an angle.
3. Run the edge of the penny across the paper to make a small groove. This groove ensures the fold line is both accurate and straight.
4. Cut out the pattern on the solid lines.
5. Tape a penny to the inside of one of the nose cone triangles.
6. Fold the three rectangles into a triangular prism with the large tab inside. Tape the seam.
7. Fold the triangles inward to form the nose cone. The tabs should be inside. They will provide support for taping.
8. Bend the fins outward. The rocket is ready for flight.

POP! ROCKETS! B: THREE-PIECE ROCKET

Instruct Members To:

1. Cut out the three pieces of the template.
2. Press the edge of a ruler to the fold lines for the fins and nose cone to get a straight fold.
3. Fold the fins outward.
4. Tape a penny securely to the inside of one of the nose cone triangles.
5. Slide the pieces together and match-up the sides of the rocket body.
6. Place a strip of tape along the seams. (Do not tape the fins or nose cone pieces yet.)
7. Pick up the rocket, bring the two side pieces together, and tape the seam. It may be helpful to insert the PVC pipe into the rocket before taping.
8. Use a glue stick or tape to join adjacent fins pieces to make three fins. Or, don't tape the fins to make six.
9. Push the PVC pipe inside the rocket body to the position of the nose cone. Use the pipe for support while taping.
10. Fold the three triangles inward and tape the seams.
11. The rocket is ready for launch.

To launch the rockets, follow instructions for the Pop! Rocket Launcher at:
www.nasa.gov/pdf/295790main_Rockets_Pop_Rocket_Launcher.pdf.

*Activity adapted from:
www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf and http://www.nasa.gov/pdf/295790main_Rockets_Pop_Rocket_Launcher.pdf.

Extension Activity Questions:

1. What design changes could you make to your rocket to cause it to fly a greater distance?
2. Which rocket traveled the greatest distance?

STRAW ROCKETS

(45-60 MINUTES)

Introduction: Members will be evaluating the accuracy and stability of the rockets they built. They will need additional guidance about how to measure and follow the trajectory of their rockets so they can evaluate how stable it is and how well it flies through the air. Based on the stability of their rockets, they may have to make some design modifications.

Objective: To introduce participants to the concept of rocket stability as they construct and fly small paper rockets.

NGSS Alignment: MS-PS1-6: Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature and state of a pure substance when thermal energy is added or removed.

MATERIALS

- ☐ Sheet of 8.5 X 11 paper (white or colored)
- ☐ Scotch tape
- ☐ Scissors
- ☐ Ruler
- ☐ Meter stick or tape measure
- ☐ Dowel rods
- ☐ Eye protection
- ☐ Drinking straws
- ☐ Copy of SLS paper rocket plans can be found online *www.nasa.gov/pdf/153413main_Rockets_3_2_1_Puff.pdf*

Facilitators:

1. Cut a strip of paper for the rocket body (about 4 cm wide by 28 cm long) for each member prior to the session.
2. Demonstrate how to make a paper rocket and the technique for launching it with participants before beginning.
3. After members have made their rockets, show them how to perform drop tests to check for stability.

Instruct Members To:

1. Begin with a strip of paper (pre-cut), which will form the body of your rocket.
2. Roll the paper strip around the pencil.
3. Tape along the seam.
4. Close off one end to make a nose cone.
5. Cut out three or four fins.
6. Tape the fins to the open (lower) end of the rocket. Bend them outward to space them equally.

Follow the following instructions and diagrams for making and attaching fins and nose cones: *www.nasa.gov/pdf/153413main_Rockets_3_2_1_Puff.pdf*

7. Hold their rocket horizontally at eye level and drop it to the floor.
8. If the nose of the rocket hits the floor first, the rocket is stable and ready for flight.
9. If the rocket falls horizontally or the fins hit first, the rocket is unstable and you will need larger fins to stabilize it.

Facilitators: The focus on launching a rocket will be stability and accuracy. The members should be guided to make sure the rockets are built to be stable enough to hit the target you designate accurately. Have them make any design adjustments that are necessary.

Instruct Members To:

1. Insert a straw into the rocket body.
2. Aim the rocket at a target directly in front of them, approximately 10 feet away.
3. Puff strongly into the straw to launch their rocket.

Extension Activity Questions:

1. How can a rocket be stable even if it doesn't have fins?
2. How do paper rockets work?

*Adapted from: *http://er.jsc.nasa.gov/seh/3-2-1_Pop!.pdf.*

EFFERVESCING ROCKETS (45 MINUTES)

Introduction: In this activity, members will focus on powering the rocket that they built using an effervescing tablet. They will demonstrate how fuel sources affect the lift and thrust of an object.

Objective: To have participants construct a rocket powered by the pressure generated from an effervescing tablet.

NGSS Alignment: **MS-PS1-6:** Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature and state of a pure substance when thermal energy is added or removed.

KEY VOCABULARY

Variations - Change in the form, position, condition or amount of something

Canister - An often cylindrical container for holding a usually specified object or substance

Effervescing - To bubble, hiss and foam as gas escapes

MATERIALS

- [ ] **Heavy paper** (60-110 index stock or construction paper)
- [ ] **Plastic medicine/pill bottle** (childproof bottle will not work). (Pharmacies are usually pretty generous with these!)
- [ ] **Member worksheets**
- [ ] **Scotch tape**
- [ ] **Scissors**
- [ ] **Effervescing antacid tablet**
- [ ] **Paper towels**
- [ ] **Water**
- [ ] **Eye protection**
- [ ] **Adapted from** (you can also find diagrams and templates for your rockets here): ***http://er.jsc.nasa.gov/seh/3-2-1_Pop!.pdf***

Facilitator: This activity should be completed as a demonstration first. Then each member can construct his or her own rocket. After the demonstration, pass out materials to members.

Pass out a copy of the following diagram to each member found at: *http://er.jsc.nasa.gov/seh/3-2-1_Pop!.pdf.*

EFFERVESCING ROCKETS A: MAKING THE ROCKET

(25 MINUTES)

Instruct Members To:

1. Wrap and tape a tube of paper around the film canister. The lid end of the canister goes down.
2. Tape the fins to the rocket.
3. Roll a cone of paper and tape it to the rocket's upper end.

EFFERVESCING ROCKETS B: LAUNCHING THE ROCKET (20 MINUTES)

Instruct Members To:

1. Launch their rockets two to five times, encouraging them to make variations in:
    a. Amount of water used.
    b. Whole tablet versus half a tablet.
    c. Crushed tablet versus whole tablet.
    d. Use of warm water versus cold water.
2. Put on their eye protection.
3. Turn the rocket upside down and fill the canister one-third of the way with water.
4. Work quickly on the next steps so their rocket will launch! Once they put the tablet in the water, it reacts quickly so they will have to move quickly!
5. Drop 1/2 of an effervescing tablet into the water.
6. Snap the lid on tight.
7. Stand the rocket on the launch platform.
8. Stand back!

Extension Activity Questions:

1. How does the amount of water in the cylinder affect how high the rocket flies?
2. How does the temperature of the water affect how high the rocket flies?
3. How does the amount of tablet used affect how high the rocket flies?
4. What are three ways you could improve your rocket?
5. If we compare the height achieved by the rockets during our activity today to our straw rockets we launched using air, what can we conclude? Answer: the effervescing antacid tablets act as fuel.
6. Why do you think there was such a dramatic difference?

HEAVY LIFTING

(45-60 MINUTES)

Introduction: Members will determine how the weight of their payloads affects the thrust and lift of their rockets. This is an exercise in creativity, skill and problem solving. This activity will also create competitions among the groups for distance and accuracy.

Objective: The goal of this activity is for participants to construct balloon-powered rockets and compete to determine who can launch the greatest payload to the ceiling.

NGSS Alignment: MS-PS1-6: Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature and state of a pure substance when thermal energy is added or removed.

MATERIALS

- ☐ **Large binder clips** (one per launch pad)
- ☐ **Fishing line or smooth string**
- ☐ **Long balloons** (see note following balloon sources)
- ☐ **Paper cup** (3 oz.)
- ☐ **Straight drinking straws** (2)
- ☐ **Small paper clips** (50)
- ☐ **Sandwich size plastic bag**
- ☐ **Masking tape**
- ☐ **Balloon hand pump**

KEY VOCABULARY

Payload – Things that are carried by an aircraft or spacecraft

FACILITATOR'S TIP BLOCK

Continue to emphasize the scientific method with an emphasis on the hypothesis and experiment steps for their experiments. Require members to use their scientific notebook to record their information.

Facilitator: Prepare the classroom by setting up "launch pads" consisting of pieces of fishing line or string suspended from the ceiling (one line per team of members). Make sure the line is long enough to reach the floor. Demonstrate a rocket launch for members before you begin the steps. Let participants know they have 30 minutes to build and test their rockets with varying payload.

Instruct Members To:

1. Tell participants they are challenged to build the most efficient heavy-lift rocket.
2. Each team will use the same set of materials.
3. The team that is able to lift the greatest payload into space (the ceiling) is the winner.
4. Outline the challenge and explain how to use the straws for stability.
5. Tell members that they can use any or all of the parts in their supply kits to build and launch their rockets. The supply kits contain three balloons.

6. Remind members to use their balloons carefully. Then ask them to test their rockets with varying payloads (paper clips).

7. After 30 minutes, participants will test each group's rocket to determine which can carry the greatest payload!

8. Divide members into teams of three or four. Ensure that each team receives identical materials to construct their rockets.

FACILITATOR'S TIP BLOCK

While the teams are getting set up, draw a chart on the board for teams. They can replicate this chart in their scientific notebooks and then record the results. If you have balloon pumps, demonstrate how they are used to inflate the balloons.

Facilitator, review the following construction and launching procedures with members:

1. Explain how the straw is used for guiding the rockets.

2. When the balloon is released, the straw will ride up the line. Stress the importance of holding the lower end of the line to the floor. Slack will cause the rocket to waffle about and not reach the ceiling.

For reference and diagrams please view:
http://www.nasa.gov/pdf/153418main_Rockets_Heavy_Lifting.pdf.