3-2-1 Pop! – An Effervescent Race
Student Version

Adapted from NASA's "Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology"

Why should your team do this activity?

A large part of the Mars Rover Competition, and science in general, is keeping a good lab notebook. A good lab notebook is a daily, detailed account of the design process that many scientists use in their work. If a scientist does not keep a good lab notebook, and one day makes a grand discovery, it is quite possible that the scientist will not fully understand exactly what happened. If the scientist kept really detailed, frequent records during his or her work, then a great discovery is more likely to be well understood. Your Engineering Team will want to keep good records of your Design Process too, because then you will be able to learn which designs worked and which did not, etc.

Engineering Design Process

What exactly is the Design Process, you ask? Well, the Design Process consists of the following steps: identify the problems, set the goals, brainstorm design ideas, select and construct a design, test and revise the model, and finally, present the final product. Let's go into a little detail about these steps:

1. **Identify the problems**
   Your team will need to develop general statements or questions that will spell out what you need to do, and what you have to do it with. For example, a question could be - "How can we design a rocket from the given materials that can fly really high?"
2. **Set the goals**
   After you have a general idea about what your team needs to do, you will then need to break the general idea up into more specific tasks, or goals. Goals should be as specific as possible, and should address the general problems initially identified. For example, one goal could be "Our rocket will be able to fly as high as the ceiling."
3. **Brainstorm design ideas**
   The key to brainstorming is to remember that there are no bad ideas! Each idea, no matter how off-the-wall it seems, should be recorded during the brainstorming session. Try to be creative -- the more ideas generated, the more likely it is that a successful design will result! Ask your teacher for a jump start if you need help to get going.
4. **Select and construct a design**
   After the brainstorming phase, the team will need to decide which ideas it likes best, and then construct prototypes (original design) that turn these ideas into actual creations!

5. **Test and revise the model**
   After initial prototypes have been constructed, your team will need to thoroughly test them in order to see both their strengths and weaknesses. If something doesn't work the way you thought it would, you may want to look at that problem more closely, and set goals to tackle it. For example, you could ask items such as "How high does it fly?" and "Does it fly in a straight line?", and if it does not – you can look at ways of changing your design so it will. Make sure to keep using those brainstorming skills!
6. ***Present the final product!***

   When your team believes it has a final product ready to go, it is time to present this product to the rest of the class and your teacher! Make sure your team includes all of the details of design and construction in your Notebook so that anyone else will be able to build the exact same rocket. You may want to draw a picture of your rocket, or even complete a verbal presentation about your rocket and how you designed it!

Newton's Laws of Motion

Okay…..so now we know about the process of doing great engineering work, so now what? This activity will walk you through the steps of the Design Process and the components of a good lab notebook, while you test how several factors affect the flight of a rocket. But before you start making rockets, you will need to read some background information about an excellent scientist named Sir Issac Newton (he probably had a great lab notebook too!):

In a book published in 1687, Sir Issac Newton stated three important principles that govern the motion of all objects. These principles are now known as **Newton's Laws of Motion**. Newton's Laws state:

- **Law 1**: Objects at rest will stay at rest and objects in motion will stay in motion in a straight line unless acted upon by an unbalanced force
- **Law 2**: Force is equal to mass multiplied by acceleration (F=ma)
- **Law 3**: For every action there is an equal and opposite reaction

These principles are demonstrated when a rocket lifts off. To begin with, a rocket at rest is able to lift off because it is acted upon by an unbalanced force *(First Law)*. This force is produced by the thrust of the engines. The rocket then travels upward with a force that is equal and opposite to the downward force of the engines *(Third Law)*. The amount of force is directly proportional to the mass of fuel expelled from the rocket and how fast it accelerates *(Second Law).*

Now it is time to conduct some research about your rocket's "fuel." Your rocket's base will be made of a film canister with a construction paper nose and fins attached. To make your rocket lift off, you will put some water and part of an antacid tablet in the canister, and then quickly put the lid on. Then just set it on a table and watch it go *(make sure to stand back so you don't get hit by the flying rocket)*! So exactly what is your "fuel?" The reaction that occurs between the water and antacid tablet acts as the rocket propellant, so the water and antacid tablet are your "fuel." Take a minute to read the following background information about rocket propellants:

As rocket propellants burn faster, the mass of the expelled gases increases. Also, the speed of the exhaust gases increases as they accelerate out of the rocket nozzle. Newton's Second Law of Motion states that the force or action of a rocket engine is equal to the mass expelled multiplied by its acceleration. Therefore, increasing the efficiency of rocket fuels also increases the performance of the rocket.

One method for increasing the efficiency of rocket fuels involves surface area. Expanding the burning surface increases the burning rate. This increases the amount of gas and acceleration of the gas as it leaves the rocket engine. In a liquid propellant rocket, liquid propellants spray into a combustion chamber to maximize their surface area. Smaller droplets react more quickly than do larger ones, increasing the acceleration of the escaping gases. How can you alter the surface area of your water/antacid tablet "fuel?"

Another method for increasing the efficiency of rocket fuels involves temperature. In liquid propellant rocket engines, super cold fuel, such as liquid hydrogen, is preheated before being combined with liquid oxygen. This increases the reaction rate and thereby increases the rocket's thrust. How do you think this applies to your rocket's "fuel?"

Now your team is ready to follow the directions below for Propellant Research. The results of this experiment will help you design your rockets. Once you are satisfied with your Propellant Research results, continue with the directions for the Design Process. Have fun, and make sure to keep a great Lab Notebook!

The Necessities

- ★ A timer or watch with a second hand
- ★ 4 Alka-Seltzer or other effervescent tablets
- ★ Tweezers
- ★ 2 beakers
- ★ Warm and cold water
- ★ Thermometer
- ★ 35mm film canisters with internal sealing lids (usually the clear canisters) – *these may need to be purchased online*
- ★ Construction paper
- ★ Tape
- ★ Scissors
- ★ Paper towels
- ★ Pens or pencils
- ★ Your Idaho TECH Lab Notebook

Directions for Propellant Research:

1. Using construction paper, tape, and scissors, design a rocket by wrapping the paper around the outside of a film canister. The lidded end of the canister should provide the base for the rocket (it should face down). Try to create rockets of varying lengths and make sure to include a cone-shaped nose and fins on each rocket.

2. Turn the rocket upside down and fill the canister 1/3 full of water.
3. Drop in half an antacid tablet and *quickly* snap the lid on tight.
4. Quickly stand the rocket on its base (lid down) on the floor or tabletop and stand back! Your rocket should launch in a matter of seconds!
5. Your team should then conduct further launches to help you answer the following questions:
   - How does the amount of water placed in the canister affect how high the rocket will fly?
   - How does the temperature of the rocket affect how high it will fly?
   - How does the amount and surface area of the antacid tablet used affect how high the rocket will fly?
   - How does the length or empty weight of the rocket affect how high it will fly?

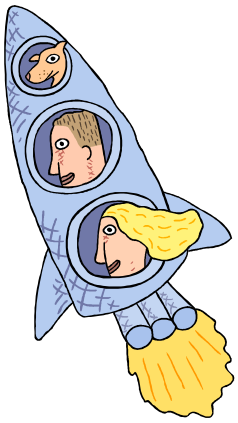
Directions for Design Process:

1. At the top of a page in your Lab Notebook, write the date. On the next line, write the names of the team members present. On the following line, write "**3-2-1 Pop! – An Effervescent Race Activity.**" Now, you are ready to get started with the first step in the Design Process - ***identifying the problems***. Your questions should be general to begin with, and as you test and revise your designs, they will probably become more specific. A good question to start with might be "How can we design a rocket out of the given materials that can fly really high?" Write your questions in your Notebook, under the heading "**Step 1: Identify the Problems**."
2. The second step in the Design Process is ***setting the goals***, so you will need to make another heading called "**Step 2: Set the Goals**" in your Lab Notebook. Under this heading, make a goal for each problem identified. Try to be as specific as possible. For example, a goal for the question in number one above could be "Our rocket will be able to fly as high as the ceiling."
3. The third step in the Process is ***brainstorming design ideas***. What do you think you can do in the design of your rocket that would make it fly really high? Make a list of your ideas in your Lab Notebook under a heading called "**Step 3: Brainstorm Design Ideas.**" You will need to brainstorm design ideas for each goal you create. If you're having trouble thinking of ideas, ask your teacher to help you get started.
4. Now for the fun part!! The next step is to ***select and construct a design***. Pick one of the designs you listed in your Notebook. Choose one member of your team to construct and test the design -- don't worry, everyone will get a turn! You will also need to select one team member who will take notes in the Lab Notebook about the chosen design.

5. Using construction paper, tape and scissors, construct a rocket by wrapping the paper around the outside of a film canister. The lidded end of the canister should provide the base (bottom) of the rocket. Don't forget to include a cone-shaped nose and some fins on your rocket. Remember to follow the design idea that you chose from your list in the Lab Notebook!

6. The team member who is taking notes should write down exactly how the rocket is being constructed. Write these under a heading called "**Step 4: Select and Construct a Design**." How long is the nose? What do the fins look like? Maybe drawing a picture would help. Remember to write neatly, so that anyone else on your team can understand exactly how to build another rocket identical to the one being built.

7. Once the rocket has been built, it is time for the *really* fun part! Make another heading in your Lab Notebook called "**Step 5: Test and Revise the Model**." The rocket builder will test the rocket in Step 8, and the note-taker will take careful notes about how the rocket performs. How high does it fly? Does it fly in a straight line? Make sure to take good notes about the rocket launch!



8. Now it is time to launch your rocket! Remember to have the note-taker take careful notes on this next part, too. How much of each ingredient is used? Does it fly straight? Remember to follow your design idea. The team member who built the rocket can now turn the rocket upside down, place some water and a piece of (or whole) antacid tablet into the film canister, and *quickly* snap the lid on tight (do **NOT** use more than **<u>one</u>** antacid tablet in your launch!). Then, *quickly* stand the rocket on its base (the lid side should be sitting on the floor or on a table) and make sure the whole team stands back to watch the launch!

9. Wow – you launched! Did it go as you had planned? I bet you wish you could change a few things so it will be even better, right? That means it is time to revise your model. This process of ***testing and revising*** will probably take place many times before you reach your final goal. Think about your design and how it can be improved in order to reach your goal. Make another list in your notebook of the new ideas that you brainstorm under a heading called "**Model #2**." Continue repeating the process *(take turns building and testing your rockets <u>and</u> taking notes in your Lab Notebook so it is fair to everyone on your team)* until you have reached your final goal. Your team might encounter new problems needing to be addressed. If you want, you can try to design a rocket that addresses those problems as well.

10. Once the team feels that you have designed a rocket or rockets that accomplish your goals, it is time to ***present your final product!*** Make a heading in your Lab Notebook called "**Step 6: Present the Final Product**." Under this heading, draw (as neatly as you can) a diagram of your final rocket design. Include ALL of the details so that anyone who might pick up your Notebook can build the exact same rocket. You might even want to include a picture of your team with your creation! Be sure to share this part of your Notebook with your teacher so he/she can see how you followed the Engineering Design Process in order to create your final design. You might want to even practice giving a verbal presentation about your rocket to your teacher, since your team will also have to present about your Rover at the Idaho TECH Engineering Design Competition!