EnVision LABS

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Launch Pro™ Multi-Stage Launcher #20300

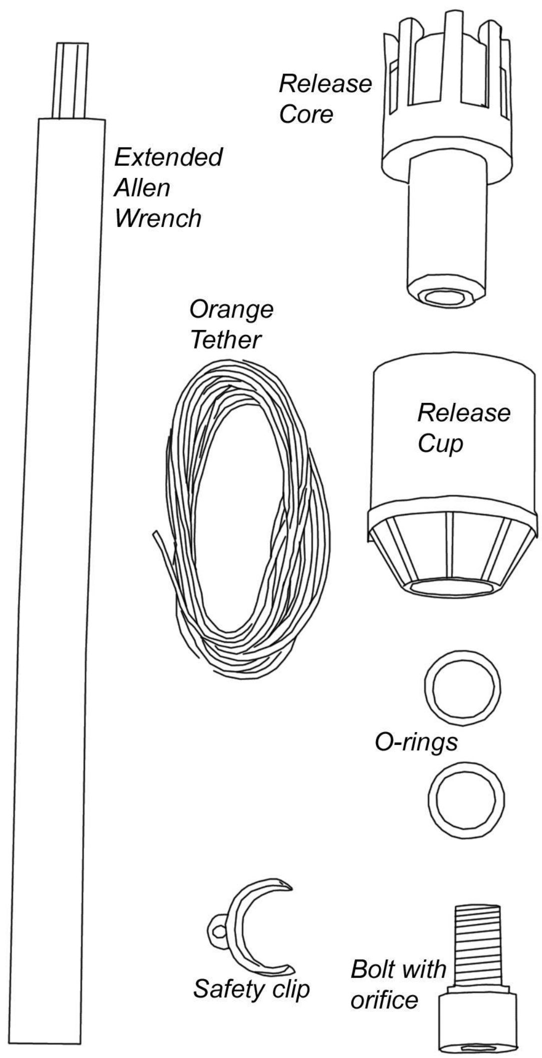

Figure 1 Multi-stage launcher parts.

Materials:

This kit includes:

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- 1 Launch Pro™ Release Core assembly
- 1 Launch Pro™ Release Cup
- 1 Launch Pro™ Bolt with internal orifice
- 1 Safety Clip
- 2 'O' Rings
- 1 Tether
- 1 Launch Pro™ Second Stage Extended allen Wrench

You will need:

- A single stage launcher (such as Launch Pro™ #20100)
- Access to tap water
- Carbonated Beverage Bottle (various sizes)
- Source of Compressed air
  (bicycle pump, or small battery operated air compressor)
- Pressure gage (if not already on the pump or compressor)
- Various soft, light, materials for constructing fins and rocket bodies such as foam insulation tubes or foam swimming tubes
- Tape - 2 inch wide package or storage tape.
- Razor knife
- Drill Bits, 1/8, and a 1/2 inch drill bit with a 3/8 shaft and a electric drill with a 3/8" chuck.

Description:

This launching mechanism is an accessory item for constructing and launching multiple stage water rockets. As an accessory item, it is assumed that you currently have a water rocket launcher such as Launch Pro™ Single Stage Starter Kit #20100, although a launcher from any other manufacturer will also work, if that's what you currently have.

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Precautions:

- **Safety is a state of mind, not just a set of rules**.
- Always THINK before you act. Don't get caught up in the excitement. Keep yourself and everyone around you SAFE. NO ONE wants to get hurt. This is always rule number one in anything that you do, be it a science experiment, or an activity at home.
- Be aware of your surroundings whenever you engage in any activity.
- Stop and think of the possible consequences of what you are doing.

  Remind others around you of any unsafe activity.

  The following is a set of guidelines to assure safe operation of the Launch Pro™ system.

- ***DO*** Completely read and understand the operating instructions and safety guidelines before using the Launch Pro™ system.
- ***DO*** be sure the rocket is stable on the launch base before charging with compressed air. Wait 60 seconds to be sure the rocket remains upright. This is very important in windy conditions. If you are not sure, do not pressurize the rocket.
- ***DO*** wear safety glasses when at the launch site.
- ***DO*** find a large open area for the launch site that is clear of obstructions and obstacles such as buildings, parked cars, people, and roadways. A 150 foot minimum radius from the launcher is recommended. Don't forget, what goes up must come down, and you don't want your returning rocket to hit anyone or anything.
- ***DO*** use soft, light materials such as foam insulation, and tape for constructing your rocket.
- ***ALWAYS,*** when trying out a rocket for the first time, start with low air pressures first! Note that multi-stage rockets require more air pressure to cause proper separation.
- The second stage bottle must ***ALWAYS*** be smaller in volume than the first stage bottle
- ***DO NOT*** exceed 60 PSI(Pounds per Square Inch) when pressurizing the bottles.
- ***DO NOT*** launch in crowded area.
- ***DO NOT*** leave the rocket unattended while it is pressurized.
- ***DO NOT*** use any fluid other than ***water only*** as the fuel for the rocket
- ***NEVER*** use heavy or rigid materials in the construction of your rockets - ***never use*** metal, wood, or thick plastic.
- ***NEVER*** launch a rocket at an individual or object. Rockets in motion can have enough energy to do bodily harm or property damage.
- ***NEVER*** approach a charged rocket system. In the case of an aborted launch, after charging, bleed the pressure off through the charging line. This may take a few minutes. The best way to avoid this situation is to never charge the system until you are certain a launch is safely possible.
- If you decide to use an air compressor, use only a battery operated compressor or one that can be operated from a 12VDC outlet.

Following these simple guidelines will ensure safe launches and hours of fun. So don't forget rule one, nobody hurt, have fun.

Assembly:

Choose a bottle for your first stage that is larger than your second stage bottle. Check to be sure that the bottle orifice fits on the first stage launcher. If it does not fit scrape the inside corner of the bottle opening or choose another bottle.

Before assembling the multi-stage launcher you must drill a hole in the bottom of your first stage bottle. Drilling this hole can be tricky because the drill tends to slide across the dimple on the bottom of the bottle. To prevent this skating action score the bottom of the dimple using a razor knife as shown in Figure 1.

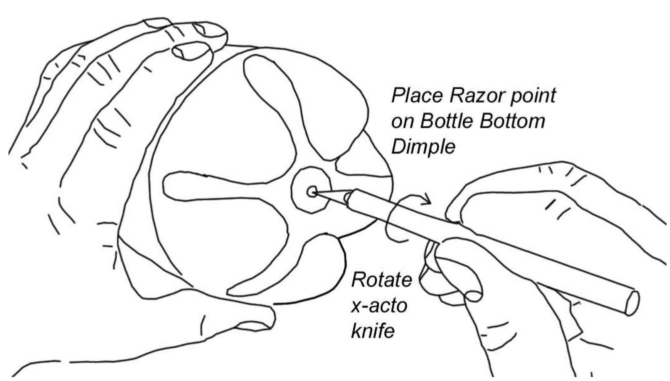

Figure 2 Scoring bottom of bottle.

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Place the razor knife at the center of the dimple and rotate the razor knife as you apply a slight pressure. The PET plastic is a hard material. It may take many rotations to score the bottle. A slight mark is all that is needed to prevent the drill bit from sliding.

After scoring the dimple in the bottle bottom drill a pilot hole using the 1/8" or similar drill bit as shown in Figure 2.

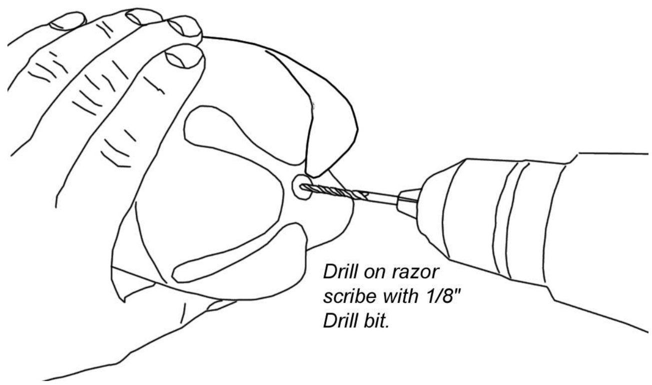

Figure 3 Drill pilot hole.

Place the bottle on a work surface and hold it firmly. Apply a slight pressure to the drill as you start the hole. If the drill bit slides repeat the scoring action with the razor knife. It is important that the pilot hole is drilled in the center of the bottle bottom. After the pilot hole is drilled then enlarge the hole using the 1/2" drill bit. Scrape the excess plastic from the hole. Be sure there is no burrs on the inside and the outside edge of the hole.

Now place one of the o-rings on the threaded end of the bolt and place the bolt on the end of the extended allen wrench. Using the extended allen wrench slide the bolt up through the bottle opening and align the threads into the 1/2" drilled hole as shown in Figure 3.

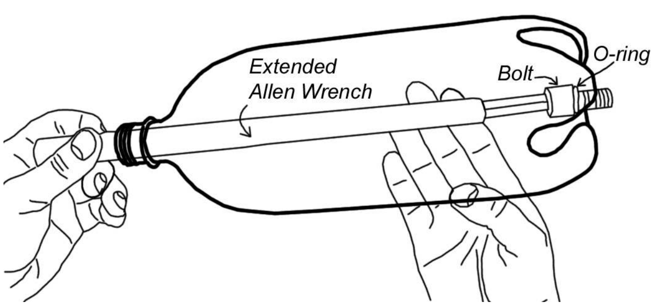

Figure 4 Insert bolt in bottle.

If the bolt slips off the wrench then hold the bottle with the opening downward and give the bottle a quick shake. The bolt will fall out when the threaded portion is aligned to leave the bottle first.

Place the second o-ring over the threaded end of the bolt.

Slide the release cup onto the core so that the locking fingers are completely covered by the release cup.

As shown in Figure 4 thread the release cup and release core assembly onto the bolt. Do Not over tighten the assembly. As you tighten observe the o-rings to be sure one section is not being pinched by the mating surfaces. If an o-ring is being pinched then loosen the bolt a little and tighten the bolt again. If an o-ring is still pinched then loosen the bolt a bit more. Repeat until the o-rings seat evenly around the mating surfaces. Tighten only enough to firmly hold the assembly on to the bottle. Over tightening will simply stress the threads.

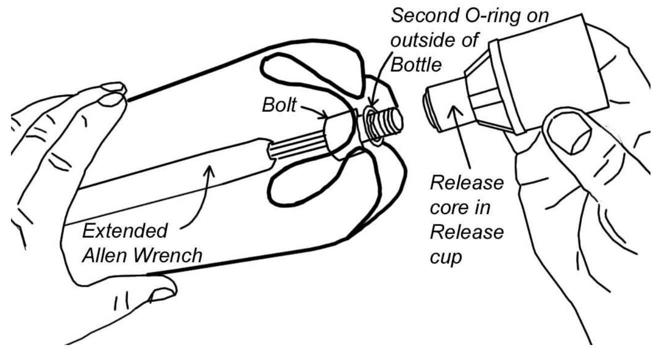

Figure 5 Assemble the launcher.

Check the alignment of the multi-stage launcher with the bottle by holding the release cup while the bottle hangs vertically down. Now spin the bottle and observe any wobble that may exist. A slight wobble is acceptable but an excessive wobble may adversely affect the flight of the rocket.

To remove the wobble disassemble the launcher and scrape the edges of the 1/2" drilled hole. Reassemble and test the wobble. If it is still excessive then find another bottle and drill a new hole.

Tie the tether on to the safety clip using a knot that will not untie with use. See Figure 5. Check this knot when securing the safety clip to the launcher.

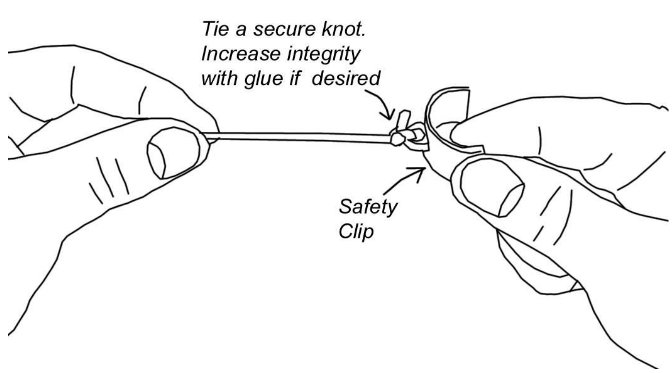

Figure 6 Tie tether to safety clip.

Operation:

The multi-stage launcher is designed to work with any launch base. However, with a two stage rocket the total length of the rocket is greater thus the stability on your chosen base may be a problem. Stabilize your base before launching.

CAUTION:

When launching multi-stage rockets there is the possibility that the stages will not separate. When this occurs the entire 2-stage rocket will fall back to Earth and may separate on impact. The two stages will accelerate in opposite directions. The speed of the bottles will be greatly reduce in comparison to rockets that are aloft due to the following reasons:

- **The first stage has exhausted all of its' energy before separation.**
- **The second stage is venting through the orifice, as the rocket returns to earth, so it's stored energy is reduced.**
- **When the second stage hits horizontally, and separates, the water sits in the bottle and is not totally expelled; the compressed air that is expelled results in a significantly smaller thrust.**
- **Friction between the rocket stages and the ground dissipates the motion of the rocket stages relatively quickly .**

The possibility of a failed separation depends on the following factors:

- **The entire mass of your rocket. If it's too heavy, separation will not occur. (Lift off speed will be too slow to trigger the second stage separation)**
- **The amount of compressed air (potential energy) that you charge your rocket with must be sufficient for your design. (Again, lift off speed will be two slow)**
- **You must lubricate the release core O-rings with silicone grease periodically to reduce friction during separation.**

Failed separations are infrequent, if one occurs, it can be momentarily exciting, but is benign with safe rocket construction and adherence to the practices described below:

Building a Safe Rocket:
Use only light weight, soft materials when building your rockets. A good rocket body can be constructed from foam insulation tubes or expanded foam tubes (swim tubes). Fins can be made using foam board insulation or taped cardboard. The foam insulation can be carved to any desired shape when making fins. Attach body and fins to the beverage bottle using ordinary package or storage tape. ***NEVER*** under any circumstances use heavy or stiff materials such as metal, wood, or thick plastic when constructing your rocket. These materials can be very dangerous if the rocket accidentally strikes someone or something.

Finding a Suitable Site:
Water rockets are capable of traveling great distances. When first launched, the rocket is under power for the first 20 to 30 feet of it's travel and during that time is capable of doing the most harm if it comes in contact with another object or person. Therefore it is critical that you have a clear area ***at least*** 100 feet in all directions from the launch pad. The middle of an athletic field is a good choice for a launch site. Wind can also push the rocket off course and this should also be considered when choosing a site. Stay away from buildings, parked cars, roadways, or anyplace where pedestrian traffic is likely to be.

Do not surround the launch pad with observers. Adhere to the diagram in Figure 6 when launching.

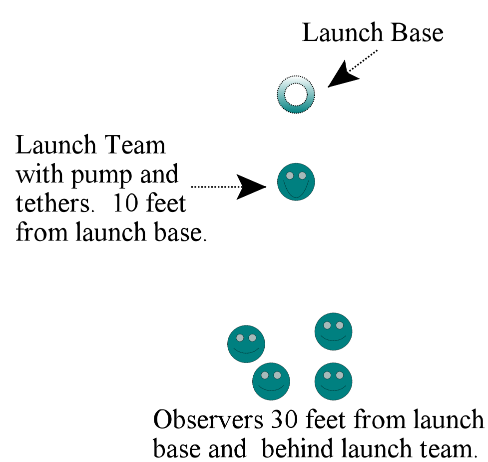

Figure 7 Placement of launch team and observers.

Setting up the Equipment:
Set up the launch base as required by the manufacturers instructions. Be certain your launch base is stable. Secure the base as necessary. When launching in windy conditions you may need extra stability. Plan ahead. When in doubt do not

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launch.

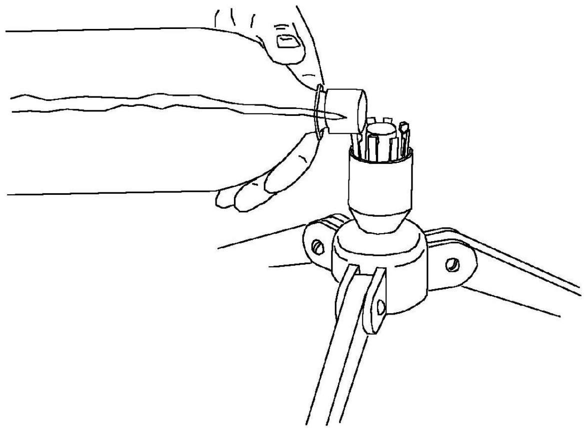

Figure 8 Placing the bottle on the launch pad.

Fueling the Rocket:
Fill the first stage bottle about half full of water. After filling with water, bring the bottle to the launch pad, and quickly, but carefully, tip the neck of the bottle onto the core of the launcher. See Figure 7. Press the bottle all the way onto the core, twisting the bottle if necessary, so
that the gripping fingers clip over the top of the bottle's neck ring. When the bottle is in place, lift the release cup up so that it completely covers the gripping fingers and then clip the safety clip around the core just below the release cup. This will prevent the cup from sliding down into the release position.

Repeat this procedure with the second stage rocket. The second stage bottle must ALWAYS be smaller in volume than the first stage bottle.

Check the stability of your system. In windy conditions be certain that the rocket will not be toppled by a gust of wind. When in doubt do not launch.

The Pre-Launch Checklist:
Before each launch read through a checklist making sure everything is in order:

- Rocket is in good order, no loose fins, or broken parts
- Launch pad is in good working order, no broken parts.
- Release core has visible silicone grease around o-rings.
- Base legs are secure
- Fuel the rocket with water
- Place rocket on launcher
- Release cup is in locked position
- Safety clip is in place
- All tethers are secure (no loose knots)
- Tethers are lead 10 feet away, up wind and remain on ground until needed for launch.
- Wind check (allow wind to die down)
- Clear the launch area and alert spectators.
- Check that spectators are at least 30 feet behind launch team.
- Safety glasses ON

Pressurizing the Rocket:
When the launch area is clear of obstructions, the wind is calm, the prelaunch checklist has been completed, and everyone is alerted that the launch is ready to proceed, only then, are you ready to pressurize the rocket.

Connect the pressure source to the fueling hose and begin pressurizing the rocket to 60psi. Check the pressure frequently and do not exceed 60psi. Small leaks around the bottle and connectors are not unusual and will not affect the performance of the rocket. If you detect a large leak, stop pressurizing the rocket and release the pressure from the bottle rocket by pressing the tire valve before fixing the leak.

Launching checklist:
Always be cautious and assume the rocket may launch whenever the safety clip is removed. This may occur if there is too much lubricant on the inside of the release cup.

- Safety Glasses - ON
- Pressurize the rocket
- Countdown to launch - 10, 9, 8 ...
- Pull safety clip tethers (orange) on the count of 3
- Pull launch tether (green) on the count of 0

When the count down reaches zero, give a short quick tug on the trigger tether, this will pull the release cup downward and allow the rocket to escape from the launch pad.

Maintenance:

- To keep your Launch Pro™ Bottle Rocked Launcher in the best possible operating condition always rinse the launcher with clean water after use.
- To clean, wipe with a clean damp cloth or soap if necessary. ***Do not use solvents of any kind.***
- Avoid using abrasive cleansers that may scratch the plastic finish.
- Lubricate the 'O' rings that form a seal between the bottle and the core before each session or as necessary with silicone grease to insure smooth, trouble free launches.
- Inspect the pressurization hose valves periodically for grit or dirt and rinse clean with water if necessary.

Water Rockets: How they Work

A water rocket is powered by water and compressed air. The water provides the mass which is expelled from the rocket at high speed by the compressed air within the bottle which acts

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like a spring to store energy until it is released. The higher the pressure, the tighter the "spring" is compressed and the more energy is stored. As more energy is stored, the rocket's potential to travel further is increased.

Rocket propulsion is based upon the principle of ***Conservation of Momentum***. Momentum is the product of an object's mass and it's velocity, and can be written mathematically as:

$$p = mv$$

where:

- p is the momentum of an object
- m is the mass of the object and
- v is the objects velocity

As water is expelled from the rocket, it's mass is forced outward with a velocity determined by the amount of pressure within the bottle. This mass times it's velocity is the momentum of the water leaving the rocket. To conserve momentum, the rocket must move in the opposite direction from the water being expelled and the change in momentum of the rocket must equal the change in the momentum of the escaping water. This can be written mathematically as:

$$\Delta p_{fuel} = \Delta p_{rocket}$$

where the Δ symbol means "change". If we substitute mv for the momentum, p in the above equation, we have:

$$m_{fuel}\,\Delta v_{fuel} = m_{rocket}\,\Delta v_{rocket}$$

For example, if 10 grams of water were expelled from the rocket, at 50 meters/ second, and the rocket with the water it carried had a mass of 2 kilograms, then the change in speed that the rocket would experience can be found by:

$$\Delta v_{rocket} = m_{expelled\ fuel}\,\Delta v_{expelled\ fuel} / m_{rocket}$$

If we substitute the numbers from the example into this equation, we have:

$$\Delta v_{rocket} = 0.01kg \cdot 50m/sec / 2kg$$

Doing the math gives us:

$$\Delta v_{rocket} = 0.25 \text{ m/sec change in velocity}$$

Estimating Altitude:

The height of any object (including rockets!)can be estimated by knowing your horizontal distance from the object and then measuring the angle above the horizontal to the top of the object. The height can then be calculated by:

$$H = D \cdot Tan(\theta)$$

where:

- H is the height of the object or rocket
- D is the horizontal distance to the object and
- θ is the angle above the horizontal to the highest point of the object.

The most accurate measurements will be made when you are standing approximately as far away from the object as the object is tall (this will be an angle of 45 degrees). When measuring the altitude of a rocket, this is sometimes tricky because the wind or the rockets trajectory will place it's highest point of travel somewhere other than directly over the launching site. In this case, you may need to estimate where the highest point of it's travel is over the ground and then measure your horizontal distance to *that* point instead.

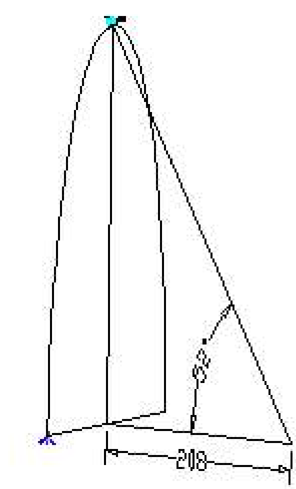

Figure 9 Measuring a rocket's altitude.

In this example, the horizontal distance is 208 feet and the angle is 52 degrees. Using the above equation, the rocket's altitude is:

$$H = 208 \text{ feet} \cdot Tan(52)$$

$$H = 266 \text{ feet}$$

A simple way to measure the angle of elevation is use a protractor with a small weight tied to a string that is attached to the center of the protractor. Sight along the straight edge of the protractor to the object of interest while the round portion of the protractor is towards the ground. The weighted string will indicate the angle of elevation.

Experiments:

- What team can design a rocket that reaches the highest altitude.
- Vary the amount of water and measure the effect this has on altitude or horizontal range.
- Vary the pressure and measure the effect this has on altitude or horizontal range.
- Delay the separation of the second stage. This is easily accomplished with a 6 foot tether. Tie this 6 foot tether to the second stage safety clip and the other end to the rocket base. Leave the safety clip on the release core when the rocket is launched. This will delay the separation until both stages are 6 feet off the base. The safety clip will then drop off and the second stage will separate with acceleration that is greatly increased. When all goes well this will boost your second stage rocket an additional 100 feet or more. In this situation the possibility of the stages not separating is increased. Pay close attention to the above precautions. This is truly an exciting launch compared to all others.
- Purposely make your rocket aerodynamically “dirty” by taping a piece of cardboard to the nose cone. Recommended for single stage rockets only.
- Purposely cause your rocket to mis a separation and observe the behavior of the stages when they separate on impact. Again pay close attention to the above precautions.
- Design fins to make the rocket twirl as it goes skyward. Explain why the altitude is greatly reduced.
- Design a whistle that is light enough to be mounted on the rocket. If the whistle sounds at a constant tone then the Doppler effect can be heard as the rocket shoots skyward.
- Design a nose cone that bounces when the rocket impacts the earth. How high can you make your rocket bounce?
- Design a nose cone that does not bounce when it impacts the earth. Thus the nose cone is destroyed on impact.
- Design a parachute recovery system for your rocket.
- Design a rocket that floats back to earth horizontally. This rocket will be close to instability during flight. Too much and it will tumble.
- Design a rocket that tumbles. How many tumbles does your rocket perform?
- Launch rockets so that they will land in a ring. Extra credit for a bulls-eye.
- Design a rocket that carries an egg and safely returns it to earth.
- Design a rocket that stays aloft for the maximum amount of time.

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