Basic Model Rocketry

Lesson Plan
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Mission Team Leaders Notes

The best way to teach kids something is to let them do it. People who teach poetry and music will tell you this. Nothing works as well as letting the kids actually write poetry or make music. The poetry may be good only for greeting cards, and the music may be only slightly this side of noise, but it works. The kids will come to understand and appreciate what they're doing, and sooner or later some of them will become poets and musicians.

Some of us find poetry in watching numbers snap into a formula, and the sound of a rocket motor firing up is music to us. We'd love to help other people get the same thrills we do. Fortunately, we have this unusual hobby.

Discussion

Hobby rocketry

Unlike other activities that grew out of cultural trends or societies, hobby rocketry was invented for a purpose. In the late Fifties, after Sputnik was launched and people got interested in space, young people wanted to make rockets. Many of them tried it, and many of them were injured in the process. Kids used to try stuffing match heads into old CO-2 cartridges. They lost fingers and eyes.

A writer named G. Harry Stine, who wrote a regular column in Mechanix Illustrated magazine, pointed out that these accidents were happening because young people were curious. He lamented that there was no safe way for people to learn about rocketry.

That article was read by a gentleman in Norfolk, Nebraska named Orville Carlisle. Carlisle's hobby was making fireworks, and he was well aware of the risks involved with working with rocket propellants. He devised a tiny solid fuel rocket motor with three distinct functions. When ignited, it produced a set amount of thrust. Then the thrust stopped and the motor produced only smoke, allowing the rocket to use up its momentum and coast to its peak altitude. Finally, Carlisle's motor had a small charge in the top that pushed forward to eject a parachute or similar recovery device. This meant that the rocket could be used more than once, by simply replacing the motor. Carlisle sent a few of his little rockets to Stine to try out. The rest, as they say, is history.

Over 45 years later, almost 50 million model rockets have been built and flown in this country, without a single serious injury. The hobby and sport of rocketry has grown in ways no one could have imagined: Olympic-level competitions, national conventions with thousands of participants, and millions of school Mission Team members getting a chance to take something they built and fly it.

Organizations

The oldest organization of rocket builders and fliers is the National Association of Rocketry (NAR). Founded by Harry Stine and Orville Carlisle, the NAR has a proud history of organizing, controlling and promoting the sport. Over 45 years, NAR has built a remarkable library of resources for educators and modelers. Their bimonthly magazine, Sport Rocketry, is an important benefit of membership. Each member of NAR is covered with liability insurance for their rocketry related activities. NAR works as an advocate with national, state and local governments, to make sure that they understand how safe and educational the sport is.

NAR sponsors three major events each year. The National Convention is a collection of seminars and symposia where rocket modelers trade knowledge and information. The National Sport Launch is a long weekend of fun flying. The week-long NAR Annual Meet (NARAM) is the culmination of the Contest Year, where NAR members who have accumulated Contest Points by flying in Local and Regional competitions try their skills to determine the National Champion in each of the four age divisions.

The Tripoli Rocketry Association was founded to promote the safe flying of larger rockets, models that weigh more than one kilogram (3.3 pounds). Models like this are subject to airspace regulations, and cannot be flown without permission from the Federal Aviation Administration. Tripoli grew from the efforts of local clubs to obtain flying sites and permissions to fly these “high power” rockets. Tripoli has developed safety codes and resources to make it possible for adults to pursue advanced rocketry projects.

Resources

As always, the World Wide Web is an excellent resource for rocketry. You will find links to rocketry and space resources on the Galaxy Explorers Web site, and that’s the best place to start.

The National Association of Rocketry (NAR) Web site (http://www.nar.org) has a great deal of helpful information. Most important is their directory of local clubs and events. If you find a club within driving distance, contact them! They will be more than willing to help you. Spectators are always welcome at club launches and competitions. Most local clubs also maintain Web sites, with current information on their activities.

The NAR Web site has an extensive Library section that you will find useful. Many other teachers have written papers, articles and lesson plans based on their rocketry experiences, and these are archived on the NAR Web site.

Mission Team Leader preparation

Introducing Rocketry and Space

Rocketry has applications to just about anything you’re teaching, from industrial arts (sorry, Tech Ed) to humanities to earth science. Of course, it’s an excellent way to introduce aviation and space history. There are some excellent online resources that will take you where you want to go; check the Galaxy Explorers site for links.

I was once confronted with a high school class where all the kids had built rockets before, and they were unimpressed with the idea of doing it again. So, while we assembled the kits, we analyzed them from the standpoint of producing them as a commercial product. I asked them to consider what they would do if, instead of building one rocket, they wanted to build 10,000 of them and sell them. We discussed supply, sourcing, labor and overhead costs. We drew a spreadsheet that made a cost analysis of each part of the kit, did a labor analysis, and discussed how to set the retail price. ("Yes, that part costs five cents. But every time an employee picks it up and moves it somewhere else, it costs five cents more.") We still built the kits, but the kids were looking at the parts in a different way.

One of my favorite bits of information while teaching model rocket sessions has to do with the balsa wood that is used to make the fins. Balsa wood is wonderful stuff. If you have taught ecology or earth science to your group, you've undoubtedly talked about rain forests. Balsa trees play an essential and interesting part in maintaining rain forests.

Balsa trees don't grow together in groups; there are no balsa forests. They have two unique characteristics: they grow very fast, often reaching maturity in less than ten years; and they have broad, flat leaves.

When a rainforest is cut down or burned away, the balsa trees are the first ones to sprout. They grow rapidly, and their leaves provide a lot of shade. This is important because the seedlings of the huge oak trees that form the foundation of rain forests cannot grow in direct South American sunlight; it's too strong for them. The balsa trees provide the vital protection from the Equatorial sun that allows the oaks to get established. In ten or fifteen years, the balsas are mature and fall over; the oaks are strong enough to grow into new rainforest. That's why balsa trees are often called "nursemaid trees."

Planning a Launch

Your first step should be to check to make sure that you won't be running afoul of local regulations or ordinances by launching model rockets. There are very few places in the country that have laws specifically banning model rocketry, but in some cases obsolete fireworks laws can cause problems. Your school representative or Sector Leader will coordinate with the NAR to find whether you have a local problem. Areas that have problems with fire control or drought zones may have restrictions in place that must be followed.

Once you've secured permission to launch, you can start to organize the event.

Equipment

You will require at least one launch pad. This is a device, usually a small plastic tripod that supports a metal rod in a vertical position. The rod is 1/8 inch in diameter and 24 to 36 inches long. Its purpose is to guide the rocket at ignition, until the rocket has built up enough speed for its fins to be effective. The launch pad also has a metal or ceramic blast deflector, to keep the rocket motor's exhaust from hitting the ground at ignition.

The other essential piece of equipment is an electrical launch system. Model rocket motors are ignited by heating a piece of resistance wire that has been inserted into the nozzle. You need a launch system that will allow you to be at least 15 feet away from the launch pad. The system must have a safety interlock feature that will make it impossible for power to reach the igniter while the system is being connected. It must have a power supply of sufficient voltage to heat the igniter to the motor's ignition temperature. 6 to 12 volt batteries are the standard power sources.

Model Rocket Starter Sets are an excellent source of launch pads and electrical launch systems. These sets are usually available at larger toy stores. They come with a rocket and a few motors, but the launch pad and electrical launch system can be used for the rockets your group will build.

Galaxy Explorers offers a complete launch package designed for us, called the Class Act. It includes two launch pads and a special launch system that plugs into a car cigar lighter for power. The launch pads can be selected independently. The Class Act system is excellent for larger groups, since it can be set up so that one pad is being loaded while the other is launching. Two lines, no waiting! Go to the Galaxy Explorers web site for more information.

Space

How much room will you need to launch these rockets? The Galaxy Explorers rocket kits are all designed to be flown on relatively small spaces. A typical school soccer field will be adequate. There should be no other activities on the field while you are flying, so you can be certain that everyone is paying attention to what is going on.

Logistics

You will need to determine how many rocket kits you need, and order them through the Galaxy Explorers web site. Ordering two or three more than you need is a good plan; often, when people see what you are doing, they want to get in on the fun. Be sure to order one for yourself!

The Galaxy Explorers web site will also help you locate launch equipment and rocket motors for the kits.

If you have a hobby shop in your community, ask them about the possibility of ordering model rocket motors for your group. Often the stores will offer you motors and supplies at an educational discount. They are usually an excellent resource for you.

Building Rockets

Work Space

You will need flat table/desk space. Depending on the size of your group, you can work from kitchen tables or school desks. Protecting the surfaces from glue spills is a good idea, but it's not necessary to work on newspapers or butcher paper.

Supplies and Tools

Since all the rocket kit parts are pre-cut, knives will not be necessary. Scissors are used to cut out the fin marking guides from the instruction sheets. A small piece of tape is needed to hold the fin marking guide in place, and a pencil to make the marks.

Since we are gluing lightweight wood to paper tubes, common casein (white) glue is just fine. Carpenters' yellow (aliphatic) glue is acceptable. Avoid craft glues that are too flexible when they dry. Hot melt craft glue doesn't work; we've tried. We do not recommend cyanoacrylate "super" glues for safety reasons. Plastic cements can work in a pinch, but take a long time to set.

When dealing with large groups, we like to get a half gallon container of white glue ("Elmer's" or "Weldbond") and divide it up into small paper cups. Mission Team members apply the glue with Q-tips or wooden toothpicks. This makes it much easier to share the glue and get it applied properly (as in "not too much").

A roll of paper towels or a stack of napkins is essential.

Photocopy enough copies of the rocket kit instructions to make sure that every Mission Team members has a copy.

Each Mission Team members will need to have one of the rocket motors that they will use to fly the rockets, to get the proper spacing for the rocket's motor mount.

Potential Trouble Spots

Boredom is your biggest enemy. The kit instructions have been organized in a way that should keep everyone busy if they do the steps in order. Naturally, some will take longer over certain steps than others. You should make it clear that it's OK to proceed to the next step if you have completed the one you're working on.

The thing that takes the longest is waiting for the glue to dry on the fins. Everyone is eager to see what the model will look like when they're done, so they will stick on a second fin before the glue on the first fin has had a chance to grab. The kit instructions are organized to address this, by describing a technique called "double gluing." We'll cover this technique again here, and go into a bit more detail.

The Mission Team members marks the rocket body tube with pencil marks, using the fin alignment guide to get straight lines in the right places. Next, the Mission Team member picks up a fin and determines which edge is the "root" edge, the one that is glued to the body tube. This is done by looking at the illustrations in the instructions. Here's an important rule of model rocket fins: the grain of the wood must be parallel to the leading edge of the fin. Balsa wood is weak when stressed along the grain, but remarkably strong when stressed against the grain. You want the strength of the wood to be parallel to the rocket body, so the fins don't snap off. Fortunately, the grain in balsa wood is very easily seen.

You apply glue to the root edge of the fin. Next, place root edge on one of the alignment marks on the tube. Now remove the fin. Remove? Yes. If you leave it there, you're depending on the glue to hold the fin in place, and it can't do this until it has dried. You could hold the fin on, correcting it if (when) it sags, for about ten minutes…or you can remove it, leaving a line of glue on the tube and a corresponding line of glue on the root edge of the fin. Set the fin aside, and repeat the process with the other two. You should have three fins with a layer of glue on their root edges, and a tube with three straight lines of glue on it.

Now the instructions direct you to other parts of the construction process. The glue is soaking into the wood and the tube, and drying on the surface. Ten to fifteen minutes later, it will be about half dry, and will have formed a nice bond.

Pick up a fin, and run a small amount of glue down the root edge, over the top of the dried glue that you put there 15 minutes ago. Wipe off the excess. Your purpose here is to moisten that layer of glue that has dried on the root edge. Finally, press the fin with the moistened glue against one of the lines of dried glue on the tube. The wet glue will bond quickly to the dried surface of the glue on the tube. You'll be amazed at how quickly it grabs. You can put all three fins on the rocket this way, and it'll be able to stand up on those fins when you finish.

When construction is complete, you should let the glue dry for at least an hour before handling the model. If you have the time, it's a good idea to run a "fillet" of glue along the joint where the fin touches the body, on both sides of the fin. Use your finger to smooth out the glue. Use the glue sparingly, or you will moisten and weaken the layers of glue holding the fin to the tube.

Finishing

Galaxy Explorers kits use cardboard tubes that have been wrapped with a layer of vellum paper. This is done to make it easy to decorate them with markers, which are a lot easier to manage in a classroom environment than pots of paint and brushes.

The fins can be decorated with markers as-is, or sanded smooth and sealed to provide a smooth surface. I often use a can of automotive primer spray paint or white primer. Apply a light coat, and sand with 600 grit (extra fine) paper. Two or three coats will produce a very nice surface for your color coat.

Flying Rockets

Find a club if you can

You can save yourself a great deal of effort, and get a nice demonstration in the bargain, by having your Sector Leader contact a local rocket club to come and help you. They are all eager to work with Mission Team members and to show off what they do. Check the club listings at the National Association of Rocketry web site. http://www.nar.org.

If there's no club in your neighborhood, don't panic; you can do it. Line up a launch pad or two, as described in the Equipment section above. You can buy a model rocket starter set at a local toy store or hobby shop, which will give you one launch pad and electrical launch system. You can buy pads and systems through the Galaxy Explorers web site. The Federation of Galaxy Explorers receives organizational discounts and is able to provide members with systems at discounted rates. Or you can find plans for making your own launch supplies on the NAR web site.

Safety

Model rocketry has an incredibly good safety record, because we follow strict safety rules whenever we launch. Here are some basic rules to keep in mind at all times.

Make sure that no one is closer than 20 feet to the launch pad.
Be certain that everyone in the area knows what you are doing. Announce in a LOUD voice that a launch is imminent.
Keep control of the electrical launch system at all times. If it has a removable safety key, keep it in your possession.
Before arming the launch controller, do a final check of the field and sky.
Count down from 5 in a LOUD voice.
If you have a misfire and the rocket motor doesn't ignite, disarm the launch system and wait at least one minute before approaching the pad.

Rocket motors

Each model rocket motor is used for only one flight. The motors are installed in the rocket body tube with the nozzle pointed down. (Don't laugh, someone always asks.)

Igniters

Each rocket motor comes with an igniter. Read the manufacturer's directions on how the igniter is to be installed in the nozzle of the motor. This is best done as the last step before going out to the flying field; small parts have a habit of getting lost in the grass if you wait until the last moment.

Fitting the Motor in the Rocket

The motors must be securely fitted into the rockets by sliding them into the back of the rocket body tube until they touch the thrust ring glued inside the tube. A bit of masking tape at the rear of the rocket motor will help to create enough friction for a tight fit. There should be about a quarter inch of the motor sticking out from the end of the tube, to make it easier to remove and replace it after the flight.

The motor has to stay in place when the ejection charge pushes the streamer out the front of the tube. Fortunately, this doesn't require much effort, so you only have to fit the motor in tighter than the nose cone. You only have to fit it tightly enough to deal with Newton's law about equal and opposite reactions. If the motor goes in so tightly that you're worried about twisting or crushing the body tube, it's too tight. Try less tape.

Two Pads, No Waiting

If you are using two pads (for larger groups); set up the pads 50 feet apart, with the launch control system in the middle. You can have Mission Team members load each pad, then come to the launch control and fire their rockets one at a time. You can have one pad loading while the other pad fires. You can even fire both pads at once, "salvo" style. This last technique is a crowd-pleaser.

Launch Operations

Get the rockets ready indoors if possible, before you come out to your launch site.

Lay out your launch area in a way that keeps the crowd back behind you. Go over the rules before you start flying, or you'll get a stampede from behind as soon as the first rocket leaves the pad.

Only the owner of the rocket and an assistant (preferably an adult) can be at the launch pad. The assistant is there to make sure the electrical launch system is properly connected to the rocket motor igniter. Check the instructions that came with the rocket motor for details.

Only the owner of the rocket or a designated helper should be permitted to recover it. If there is too large a "recovery crew," rockets get trampled.

Public Relations

If you think your group will get some attention, it's a good idea to designate a group member as Public Relations Officer. Make sure this person has plenty of information and is good at imparting it. Over the

years, hobby rocketry has suffered from the automatic assumption that it's fireworks. Your PRO should be prepared to stress the safety of your project, and make sure that its positive image is clear.

Brochures and handout materials are available from Federation of Galaxy Explorers and from the National Association of Rocketry at no charge. If you think there is any chance that someone will come and ask about what you're doing, order some of these handouts. They are always useful.

Contact us

I hope that you find this information useful, and that it helps make your rocket sessions easy and fun. We are always looking for new information, and if you are willing to share your experiences and advice, it will be gratefully received. You can write to Galaxy Scouts headquarters, or contact me directly via email at dad@pratthobbies.com.

About the Author

Douglas R. Pratt answered a tiny ad in Popular Science Magazine in 1960 that offered "real flying rockets!" He's still flying them with as much pleasure as those first attempts. Doug's book, "Basics of Model Rocketry," was published in 1980 and was the first of nine hobby books he has written. In 1993 he started Pratt Hobbies (http://www.pratthobbies.com) to produce inexpensive rocket and science kits for schools and groups. He and his son Brian designed the Galaxy Explorers model rocket kits. He is presently revising "Basics of Model Rocketry" into a new edition, which will be self-published.