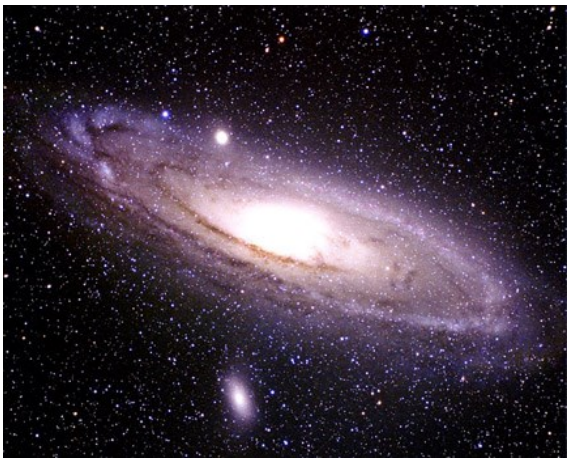
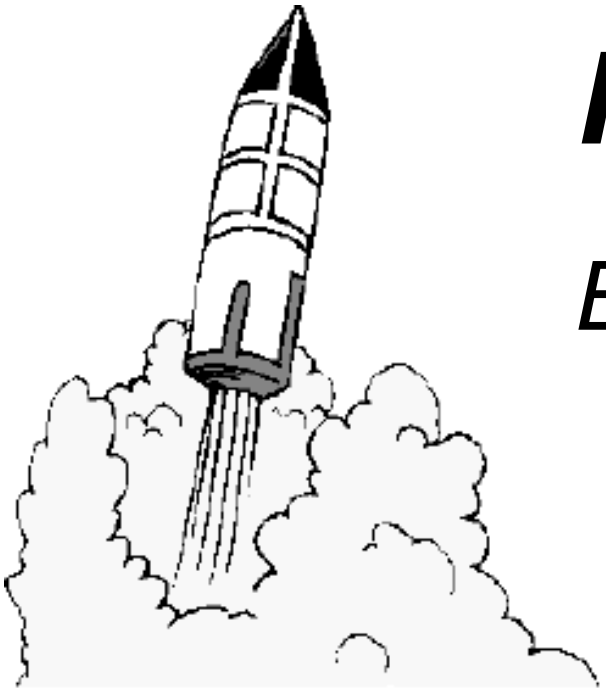
PURDUE UNIVERSITY | Extension - Elkhart County



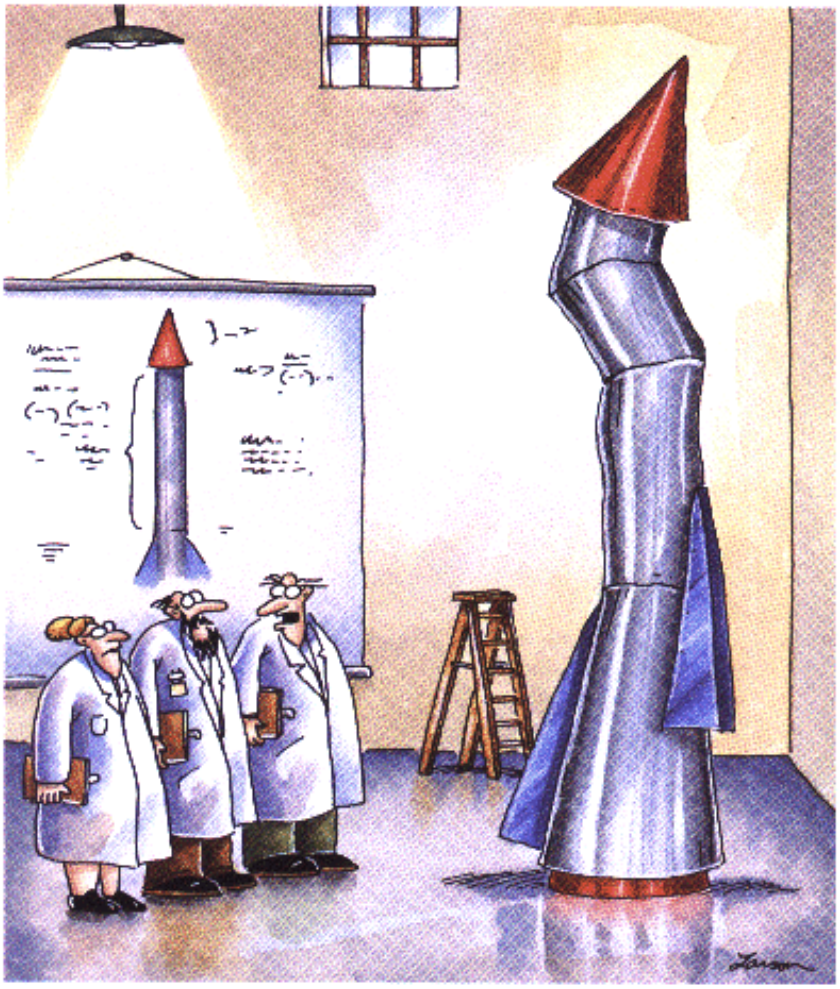
4-H MODEL
ROCKETS

Elkhart County



Revised September 2021
Elkhart County 4-H

This Manual is Designed to be Used for 4-H Model Rockets Levels A, B & C



"It's time we face reality, my friends. … We're not exactly rocket scientists."

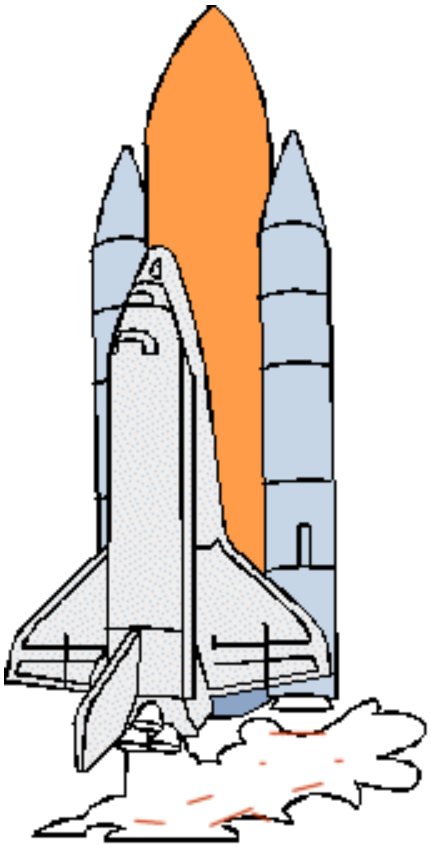
MODEL ROCKETRY

You've probably built a plastic model. Perhaps you started by folding paper airplanes or making model cars. You're probably ready to try a new challenge...model rocketry.

Model rockets can offer a new adventure for you. These models actually fly at more than 300 mile an hour and may soar to 2,000 feet and higher in the air. They are relatively inexpensive, fun to build and exciting to launch.

More than that, model rockets can launch you into an exciting space-age career. Many model rocketeers become scientist, engineers and mathematicians.

You can become a model rocket builder if you follow scientific principles, follow the safety code, follow directions and have patience.



A SPACE-AGE HOBBY

The "space-age" arrived in 1957 when the Soviet Union launched Sputnik I. Since that time, the number of model rocketees has increased. So model rocketry is usually thought of as a space-age hobby.

Early man studied the stars and even wrote stories about trips to the moon. Rockets themselves have been known since the thirteenth century when the were invented by the Chinese. Then, in 1926, the first liquid fueled rocket was launched. Robert Goddard is credited as being one of the first rocketeers. Today, thousands of workers are part of the space industry. Maybe you will be part of that industry someday, too.

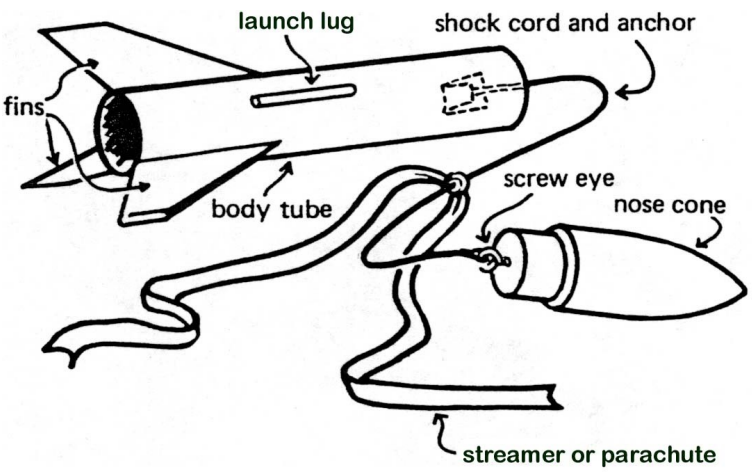
ROCKETRY

Rockets come in all sizes, from the tiny model to the giant manned space vehicles. There are other differences too. Some designs differences can be seen from the outside; others are inside the rocket body. Before you build a rocket, you should be aware of the many possibilities.

Body Tubes are available in many sizes from your hobby dealer. Some experienced model builders custom make their body tubes from a sheet of paper rolled around a rod and then glued.

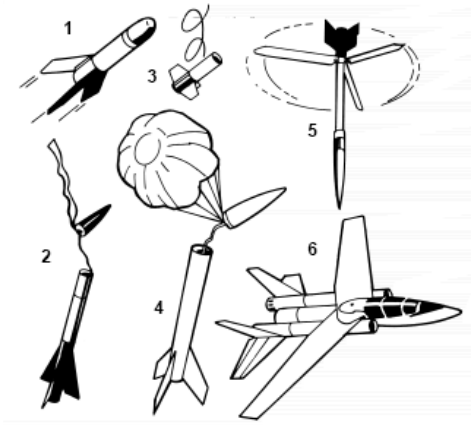
Nose Cones, too can be purchased or built according to your own design. Balsa wood is the best material for nose cones because it is light and easy to carve. Don't forget that metal is dangerous and should not be used by the model rocketeer. Another safety rule to remember is that rounded cones are safer than pointed ones. Besides, rounded cones will perform better at model rocket speeds.

Fins come is many shapes and sizes. Generally they should be as large as possible and securely glued to the rocket body. The idea material for fins is sheet balsa wood.



Recovery Systems also vary from rocket to rocket. There are six main systems, each designed to return your rocket safely to earth.

1. Featherweight—When the engine is ejected from the lightweight model, the rocket lands safely because it is so light compared to it's size.
2. Streamer—A streamer is ejected to slow the rocket on it's trip back to earth.
3. Tumble—The rocket with this recovery system tumbles slowly to earth when the ejection charge of the engine unbalances the rocket.
4. Parachute—A parachute is ejected to support the rocket on it's return trip to earth.
5. Helicopter— Vanes on the rocket cause it to slowly spin to the ground.
6. Glide—Wings on the model cause the rocket to glide down.



GENERAL NOTES for LEVELS A, B and C

ROCKET SKILL LEVELS

Skill levels are based on those established by model rocket kit manufacturers and suppliers. Most manufacturers follow similar skill level ratings.

"Almost Ready to Fly", "E2X",
"Ready to Fly" (RTF) and "Snap Together" rockets **are not acceptable** for display.

(E2X is a registered trademark of Estes Industries.)

Skill Level 1

Simple body tube; one set of fins; single stage; up to a "C" engine; and basic painting techniques. Some skill level 1 rocket kits use a "pre-assembled" fin assembly. **These are not acceptable.**

Skill Level 2

More complex body tube and/or fin design; often 2 sets of fins; sometimes 2 or more stages; may include a payload such as glider(s); sometimes a recovery system other than tumble, streamer or parachute; may handle up to "D" size engine; higher degree of painting/ marking techniques than skill level 1.

Skill Level 3

Items mentioned in skill level 2 plus engine sizes up to "E"; sometimes longer than 30" and/ or highly detailed; often this rocket will be a scale model of a real rocket or a model of a rocket that appears on TV or in the movies; advanced finishing and painting techniques required.

Skill Level 4

Items mentioned in skill level 3 plus cluster engines or at least a single "C" engine; sometimes heavier body tubes and through-the-wall fin mounting; the rocket will be designed to withstand the stress of higher-powered flight.

Rocket powered R/C (remote controlled) gliders will be considered skill level 4.

Some changes have occurred in the skill level classifications.

Some manufacturers have moved to "Building Classifications" instead of Skill Level.

Building Classifications

"B" - Beginner
"I" - Intermediate
"A" - Advanced
"E" - Expert
"M" - Master

SCRATCH BUILDING

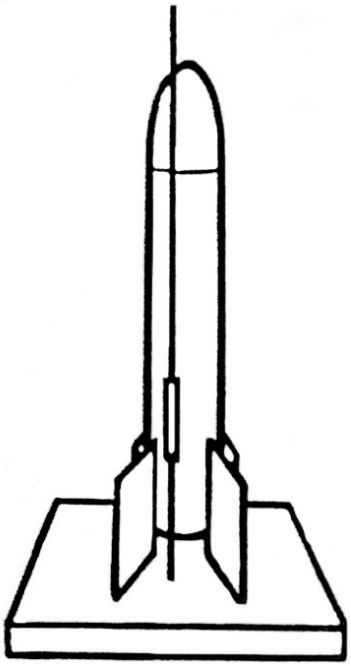
For those wishing to design and construct a rocket from "scratch", not a kit, close attention needs to be given to the design in order to insure a safe and stable flight. The material you use may be paper/ cardboard, wood or plastic. You will find the "Helpful Hints" section of this manual to be very useful during construction. Also, during the design stage you will need to calculate/locate you rockets "Center of Gravity" and "Center of Pressure". Use the descriptions in the preceding Skill Levels as a guide.

GENERAL NOTES for LEVELS A, B and C
Cont'd.

FAIR EXHIBIT

All rockets should be displayed on a stand/base. Due to limited space, do not use a manufactured tri-pod launch stands.

Display stands can be made from a piece of wood and a cloth hanger. The wood base should be no larger than 1" around the fins. The support rod can be made from a coat hanger, steel rod, etc. Drill a small hole in the wood base push the rod into the hole (should fit tight). The length of the rod should be no longer than 3" above the rockets nose cone. **DISPLAY STANDS WILL NOT BE JUDGED**.



Display Stand

IT IS RECOMMENDED THE 4-H'ER BRING THE DATA SHEET OR PACKAGE INSERT FROM THE ROCKET KIT WHEN THEY CHECK THEIR ROCKET IN AT THE FAIR FOR JUDGING. IF YOU ARE MODIFYING A ROCKET FROM A KIT, YOU MUST BRING THE KIT DATA SHEET OR KIT INSERT WHEN YOU CHECK IN YOUR ROCKET. THIS WILL HELP IF THERE ARE ANY QUESTIONS REGARDING PROPER SKILL LEVELS. YOU MUST ALSO COMPLETE THE ROCKET INFORMATION SHEET.

LEVEL A
Grades 3, 4 & 5

ROCKET REQUIREMENTS

1. Build a single-stage model rocket. The rocket must be from Skill Level 1, 2 or comparable difficulty. ***(SEE "GENERAL NOTES" PAGE FOR DESCRIPTION OF SKILL LEVELS.)*** Cluster engine rockets and rockets that take an engine "D" and above are not permitted in this level. Scratch built rockets are not allowed in Level A.
2. Decide on the type of engine that will safely fly the rocket. HOWEVER, FOR EXHIBITING, DO NOT LOAD THE ENGINE IN THE ROCKET.
3. Sand rocket and use filler on the fins and body.
4. Reinforce the fins on the rocket.
5. Paint the rocket and add decals. (Decals are optional in Level A.)
6. Correctly pack the parachute or recovery system.
7. Place rocket on a display stand. (See directions on page 4.)

PROJECT COMPLETION

1. Build a model rocket following the requirements.
2. Complete the Rocket information sheet and include it with your exhibit.
3. Exhibit the rocket at the County 4-H Fair before you launch it.
4. Launch the rocket at the 4-H Rocket Launch. (Optional)
5. Keep records of the flights your rocket has made. (Optional)
6. Attend a county workshop on rocketry. (If offered.)

NOTE: "A DIFFERENT ROCKET MUST BE MADE AND EXHIBITED EACH YEAR."

ROCKET SAFETY

Remember, this project is for building and flying model rockets and at all times members will follow the Model Safety Code of the National Association of Rocketry (NAR). These rules are listed at the rear of this manual.

LEVEL B
Grades 6, 7 & 8

ROCKET REQUIREMENTS

1. Build a more complex single-stage or multi-stage model rocket. More complex than in Level A. The rocket needs to be from Skill Levels 2, 3 or comparable difficulty. ***(SEE "GENERAL NOTES" PAGE FOR DESCRIPTION OF SKILL LEVELS.)*** Cluster engine rockets and rockets that take an engine "E" and above are not permitted in this level. Scratch built rockets are not allowed in Level B.
2. Decide on the type of engine. HOWEVER, FOR EXHIBITING, DO NOT LOAD THE ENGINE IN THE ROCKET.
3. Sand rocket and use filler on the fins and body.
4. Reinforce the fins on the rocket.
5. Paint the rocket and add decals.
6. Pack the parachute or recovery system.
7. Place rocket on a display stand. (See directions on page 4.)

PROJECT COMPLETION

1. Build a model rocket following the requirements.
2. Complete the Rocket information sheet and include it with your exhibit.
3. Exhibit the rocket at the County 4-H Fair before you launch it.
4. Launch the rocket at the 4-H Rocket Launch. (Optional)
5. Keep records of the flights your rocket has made. (Optional)
6. Attend a county workshop on rocketry. (If offered.)

NOTE: "A DIFFERENT ROCKET MUST BE MADE AND EXHIBITED EACH YEAR."

ROCKET SAFETY

Remember, this project is for building and flying model rockets and at all times members will follow the Model Safety Code of the National Association of Rocketry (NAR). These rules are listed at the rear of this manual.

LEVEL C
Grades 9 - 12

ROCKET REQUIREMENTS

1. Build a more complex single-stage or multi-stage model rocket. More complex than in Level B. The rocket needs to be from Skill Levels 3 or above. You may also design your own model rocket. (Scratch build.) The rocket must be equivalent to a Skill Level 3 or above. Rockets that take an engine "G" and above are not permitted in this level.
   (* Note: If Scratch Building you must include a sketch showing your rocket's location of the "Center of Gravity" and the "Center of Pressure". Also, list the work you have done building the rocket.)

(SEE "GENERAL NOTES" PAGE FOR DESCRIPTION OF SKILL LEVELS.)

2. Decide on the type of engine. HOWEVER, FOR EXHIBITING, DO NOT LOAD THE ENGINE IN THE ROCKET.
3. Sand rocket and use filler on the fins and body.
4. Reinforce the fins on the rocket.
5. Paint the rocket and add decals.
6. Pack the parachute or recovery system.
7. Place rocket on a display stand. (See directions on page 4.)

PROJECT COMPLETION

1. Build a model rocket following the requirements.
2. Complete the Rocket information sheet and include it with your exhibit.
3. Exhibit the rocket at the County 4-H Fair before you launch it.
4. Launch the rocket at the 4-H Rocket Launch. (Optional)
5. Keep records of the flights your rocket has made. (Optional)
6. Attend a county workshop on rocketry. (If offered.)

NOTE: "A DIFFERENT ROCKET MUST BE MADE AND EXHIBITED EACH YEAR."

ROCKET SAFETY

Remember, this project is for building and flying model rockets and at all times members will follow the Model Safety Code of the National Association of Rocketry (NAR). These rules are listed at the rear of this manual.

ROCKET SAFETY

As a model rocketeer in the 4-H Rocketry Project, you have pledged yourself to follow this “Model Rocketeer’s Safety Code”.

NAR Model Rocket Safety Code

From NAR website September 2021

1. Materials

I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.

2. Motors

I will use only certified, commercially made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

3. Ignition System

I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the “off” position when released.

4. Misfires

If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

5. Launch Safety

I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance. When conducting a simultaneous launch of more than ten rockets, I will observe a safe distance of 1.5 times the maximum expected altitude of any launched rocket.

6. Launcher

I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is

NAR Model Rocket Safety Code
Cont'd.

above eye level or will cap the end of the rod when it is not in use.

7. Size

My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse.

8. Flight Safety

I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

9. Launch Site

I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. Recovery System

I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

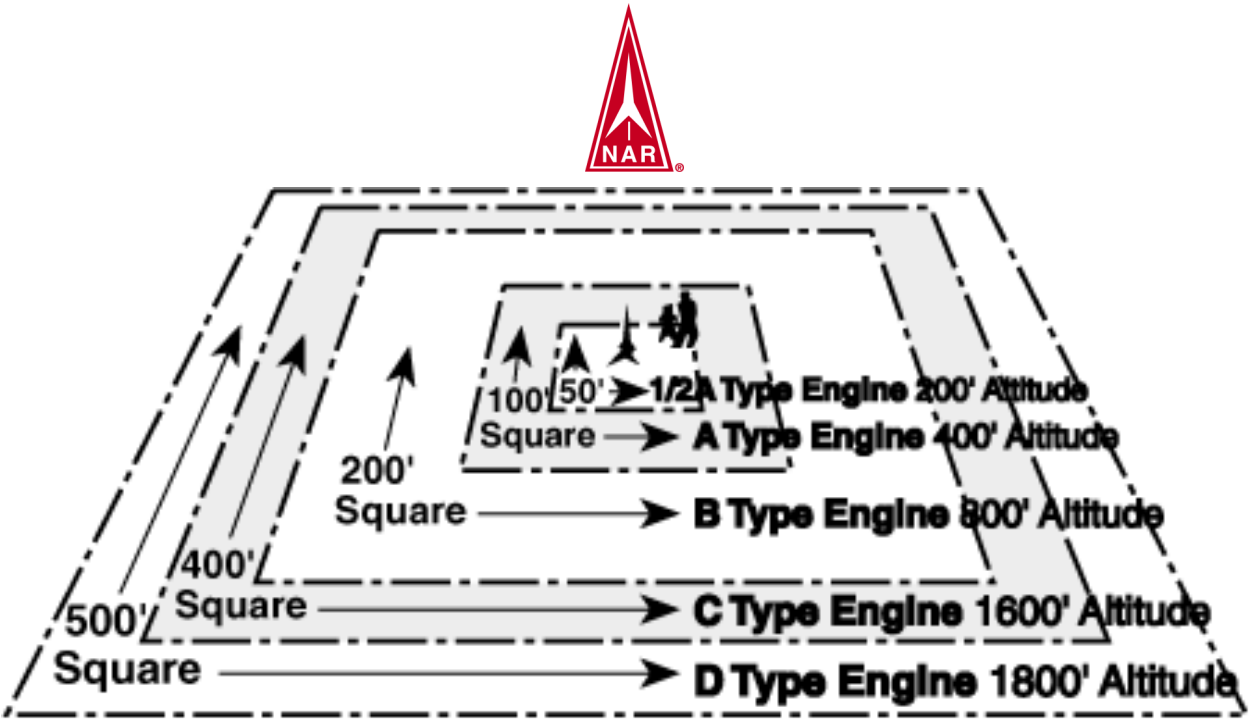
11. Recovery Safety

I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

NAR Model Rocket Safety Code
Cont'd.

LAUNCH SITE DIMENSIONS

Installed Total Impulse (N-sec)	Equivalent Motor Type	Minimum Site Dimensions (ft.)
0.00--1.25	1/4A, 1/2A	50
1.26--2.50	A	100
2.51--5.00	B	200
5.01--10.00	C	400
10.01--20.00	D	500
20.01--40.00	E	1,000
40.01--80.00	F	1,000
80.01--160.00	G	1,000
160.01--320.00	Two Gs	1,500



HELPFUL HINTS!

CONSTRUCTION

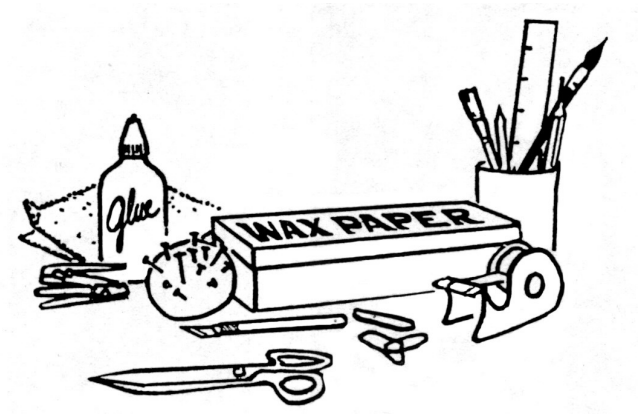
Tools:

Good workmen, whether they are working on a model or a real spacecraft, find it easier to gather their materials around them before they begin to work. You will find these tools helpful: pins, wax paper, rubber bands, glue, pincher type clothespins, pliers, hobby knife, scissors, pencil, sandpaper, file, ruler and tape.
If you are a beginner, follow the instructions carefully. As you gain experience, you may want to experiment with variations. It is a good idea to protect your plans while working and to cover your work area with old newspaper or wax paper.

Glues:

The best glues for most model rocket construction will be a "white" or "yellow carpenters" glue. Do not use water-based glues. The clean-up maybe easy, but it will not hold very well. On larger rockets, "E" engines and above, use "epoxy" glue for the engine mounts because of the added strength it provides. For plastic parts, use tube-type "plastic model cement". Epoxy also works on plastics, but it is a little overkill.

A glue that works well to tack the fins and the launch lug to the body tube is an "instant" glue (cyanoacrylate). This glue sets-up quick. You only have 10—15 seconds to make any adjustments. If you need to harden the glue even faster, an accelerator is available. You must then go back and use a wood glue to strengthen the components that you tacked. (See "Attaching the Fins" later in this manual) Use extreme caution...if you get

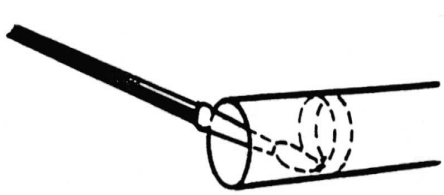


this glue on your fingers and touch them together, you will have to use a special glue remover to get your fingers apart. Younger rocket builders should not use this glue un-supervised.

There are some glues that are not good to use when building model rockets. "Hotmelt" or "hot" glue is one example. It tends to stay a little gummy and flexible, even after it dries. This is not good for rocket fins. Hot glue is also very heavy and can drastically reduce your rocket's altitude. Other glues that should not be used are "hide" and "expanding".

Mounting the Engine:

A ring called the "engine block" will keep the engine in place and prevent it from traveling forward in the rocket body. A stick or paintbrush can be used to glue the ring inside of the tube. Clean the glue off the brush before it dries so you do not ruin the brush.



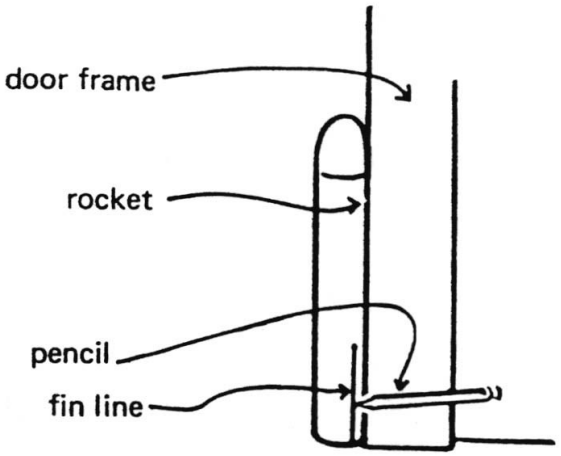
HELPFUL HINTS!
Cont'd.

Mounting the Shock Cord:

Remember the 'shock cord" must be longer than the parachute strings. Use plenty of glue to mount the shock cord and attach it firmly in place.

Marking the Body:

Marking guidelines on the rocket body will help you glue the fins in the right place. Some kits include marking guides which can be cut out. Use a pencil to mark the fin positions on the body tube.



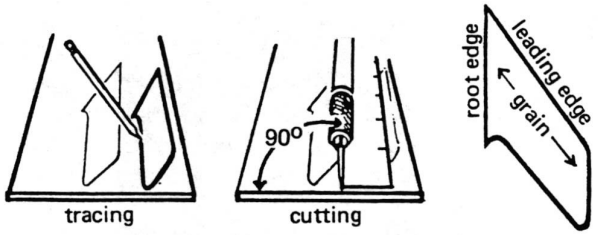
Making the Fins:

The directions with your kit will have a fin pattern designed for the model you are making. In many kits, whether the fins are balsa or cardboard, they have been die-cut at the factory. All you will need to do is trim the fins out of a larger piece.

If you do not have die-cut fins, you will need to make a pattern of the fin out of a lightweight cardboard. After you have cut out the cardboard pattern, use it to trace your fins on a thin sheet of balsa wood. Be sure the grain lines of the balsa run parallel to the leading edge of the fin.

To cut the fin, lay a metal ruler or straight edge along the pattern lines and cut with a hobby knife. Cutting takes practice, so don't be discouraged if the first one doesn't look right.

Round the edges of the fin with sandpaper, except for the "root edge". It will be glued to the rocket body.



Attaching the Fins:

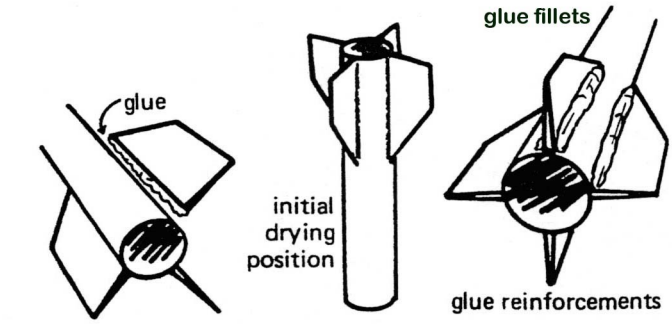
To attach the fins to the rocket's body use a white or yellow glue. (Do not use a water soluble glue.) The glue should be placed along the root edge (the edge that will be joined to the rocket's body) and let it dry for a minute. Attach the fins to the body so that they stick straight out from the rocket. If the fins tilt, the rocket might wobble in flight or even crash.

Let the fins dry with the rocket in a vertical position, fins sticking straight out. If the fins start to slip, you may find it necessary to place the rocket in a horizontal position and only attach one fin at a time. The fin will then be sticking straight up from the rocket's body. Allow plenty of time for the glue to dry before moving on to the next fin.

After the glue is dry, reinforce the joints by applying a thin line of glue where the fin meets the rocket's body. This is

HELPFUL HINTS!
Cont'd.

known as a fillet. This will provide additional strength to the glue joint, plus it creates a smooth finish joint. Start by applying a small bead of white or yellow glue along the joint. Then with the end of your finger smooth the glue out along the joint by dragging from one end to the other end of the joint. This creates the fillet.



Wipe off any excess glue. Let the fillet dry with the rocket laying in the horizontal position until the glue sets-up so it does not run. You can usually only do two (2) fin joints at a time. You may need to apply more than one layer of fillet to get a smooth contour.

The Parachute:

Models with parachute recovery systems often come with their own parachutes. You might want to make a pattern of your parachute in case you need a new one. You can replace a parachute by using plastic sheeting and fishing cord.

FINISHING AND PAINTING

Touch-Ups:

Before painting the rocket sanding and sealing must be done. Use extra fine sandpaper to sand your rocket and then cover the balsa parts with a light coat of sanding sealer. You may need to repeat the procedure 2—3 times until you get a smooth surface. Another option is to brush on a thin coat of white glue and then sand the balsa. Be careful about using a lot of glue on the fins. Glue can become quit heavy.

Yet another option is to use automotive body putty. Spread the putty on with a plastic putty knife, working it into the balsa. As it starts to set-up, scrape away the excess. Then sand smooth. Usually, one application is all that is needed.

You may find it more convenient to seal or smooth the balsa surfaces (fins and nose cone) before gluing them to the body.

Painting:

Models can be ruined because of a bad paint job. Sometimes, people put one heavy coat on and get drips or loose some fine details in a pool of dried paint. To get the best paint job you will want to use spray paint.

Before you start painting it is important to cover your rocket with a good coat of primer or light colored paint (white). Primer should be sprayed on thinly and sanded lightly to help the final coats of paint stick. After sanding be sure to clean the dust away with a damp cloth or painters tack cloth.

Enamel and acrylic spray paints will work the best. Spray the paint on in thin coats. Sand between them if needed. Remember, humidity affects the drying process.

HELPFUL HINTS!
Cont'd.

You may need to wait several hours to a day between applications.

Make sure that when you paint, you are not near anything you don't want painted. Spray paints are misty and will get on nearby objects. Young modelers may require supervision during the painting process.

When you are done, that means AFTER you apply decals, you may want to coat the whole rocket with a crystal clear acrylic coating to give it a nice look and to protect the decals.

Masking:

Whenever you paint a model with more than one color, it is usually necessary to mask off certain parts of the rocket. This gives you clean edges and sharp colors. Usually, masking is done with masking tape. Try to find a tape that holds well, but doesn't leave any residue behind or peels the paint when removed. Painters "blue" masking tape works well.

If you need to cover a large area, you can use sheets of paper or plastic bags with the edges taped down.

Decals:

Some kits will come with decals to represent a certain type of rocket. Decals can add the finishing touches to a model rocket. Applying and aligning decals require patience. If you follow the directions, getting the decal prepared is easy.

You will first cut the decal you wish to work with from the other decals. Then soak the decal paper in slightly warm water for 30—45 seconds, remove it and let it rest on a towel for a couple of seconds. This will remove some of the excess wetness. Then place one edge of the decal on the rocket where you want it and hold that end in place. Then slide the paper out from under the decal, keeping it as close to the model as possible. You can then slide the decal around (very carefully) and into position. If it doesn't slide easily, put a drop or two of water on it. When the decal is where you want it, put the edge of a tissue or paper towel near it to wick some of the water away. Lightly press the decal with a tissue to work any air bubbles out. **Be careful, decals will tear very easily.** Let the decals dry overnight.

GETTING READY FOR LAUNCH

Your rocket kit will provide detailed instructions on preparing your rocket for flight. All rocketeers, whether model rocketeers or professional, must follow instructions carefully. Not only is it essential to the flight of the rocket, but it is essential to the safety of the rocketeer and any observers.

Wadding:

Follow your directions and pack recovery wadding into the body tube from the nose cone end. The wadding helps protect the recovery system from the heat of the engine. Wadding is made from special flameproof paper. It looks similar tissue.

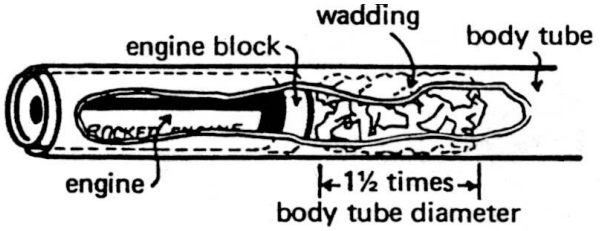
The instructions will also show you how to fold your recovery system (parachute, streamer, etc.) into the rocket body and put the nose cone in place.

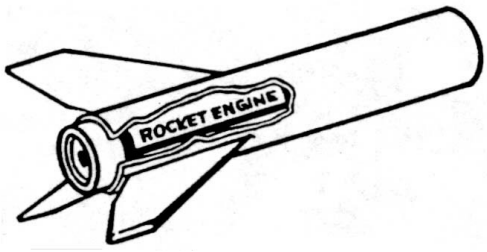
HELPFUL HINTS!
Cont'd.

Engines:

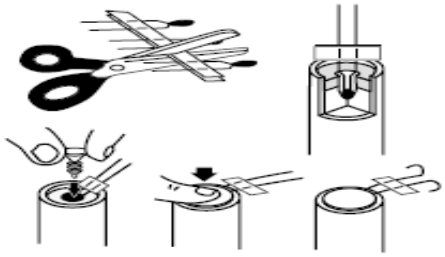
The next step is the engine, the driving force for your rocket. Engines can be dangerous or safe...it depends on you. Buy commercially manufactured, solid propellant engines. The engines are inexpensive and easy to use. Homemade engines may be ***very dangerous*** because the wrong chemical mixtures can cause ***serious accidents***. **ALWAYS BUY COMMERCIALLY-MADE ENGINES!!!**

The engine you buy looks like a thick paper tube. Inside is a powerhouse of fuel.





Engines come in many sizes. The instructions included with your rocket kit will suggest the correct engine for the rocket you are building.
Instructions are packed with the engines. Follow them carefully. The directions will tell you how to insert the engine into the rocket to make sure it fits snugly. The instructions will also tell you how to insert the nichrome wire into the ceramic nozzle end of the engine. When you launch your rocket, the igniter will become hot.



Standard Motor Codes

How To Interpret Rocket Motor Codes
Sport rocket motors approved for sale in the United States are stamped with a three-part code that gives the modeler some basic information about the motor's power and behavior:

1. A letter specifying the total impulse ("C");
2. A number specifying the average thrust ("6");
3. A number specifying the time delay between burnout and recovery ejection ("3").

Total Impulse

Total impulse is a measure of the overall total energy contained in a motor, and is measured in Newton-seconds. The letter "C" in our example motor above tells us that there is anywhere from 5.01 to 10.0 N-sec of total impulse available in this motor.
In a typical hobby store you will be able to find engines in power classes from 1/8A to D. However, E, F, and some G motors are also classified as model

HELPFUL HINTS!
Cont'd.

rocket motors, and modelers certified for high power rocketry by the NAR can purchase motors ranging from G to O.

Since each letter represents twice the power range of the previous letter, total available power increases rapidly the further you progress through the alphabet.

Hobby Rocket Motor Information			
Classification	**Impulse Range**	**Impulse Limit**	**Category**
Model Rocket	1/8A	0.3125	Micro
	1/4A	0.625	Low Power
	1/2A	1.25	
	A	2.5	
	B	5	
	C	10	
	D	20	
	E	40	Mid Power
	F	80	
	G	160	
High Power	H	320	Level 1
	I	640	
	J	1280	Level 2
	K	2560	
	L	5120	
	M	10240	Level 3
	N	20480	
	O	40960	

HELPFUL HINTS!
Cont'd.

SCRATCH BUILDING

If you decide to build a rocket of your own design or modify a kit rocket, the hints on the previous pages will be useful to you.

Remember the rocket must be equivalent to Level C.

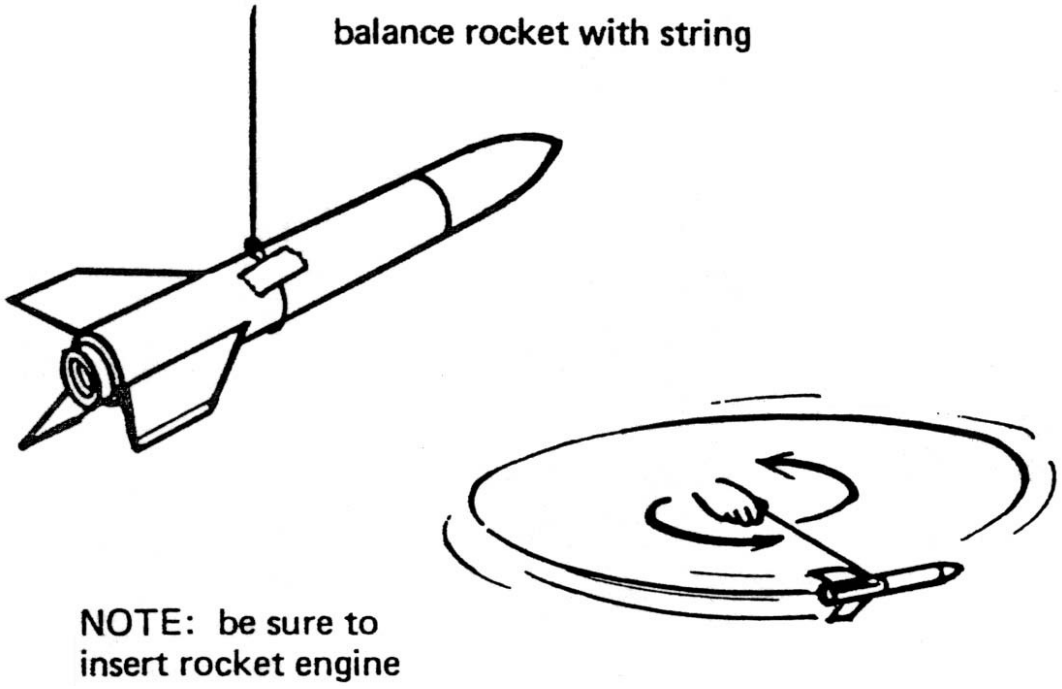
You must include a sketch showing your rocket's location of the "Center of Gravity" and the "Center of Pressure". You must also submit a detailed list of the modifications you have made to the rocket that are different from the original design. If you have "Scratch Built" the rocket, list all the work you have done.)

Test for Stability:

Before scientists send a rocket into space, they put it through pretests to make sure it will perform. Model rocketeers do the same with their rockets. You will want to pretest your rocket for stability. A stable rocket will keep it's nose pointed in the same direction while flying upward.

To be sure the rocket is stable, make a loop in the end of a string 6 to 10 feet long. Slip the rocket body, with the engine is place, through the loop, balancing the rocket horizontally. The point at which the rocket is balanced is called the "center of gravity". Tape the string to the rocket body at this point.

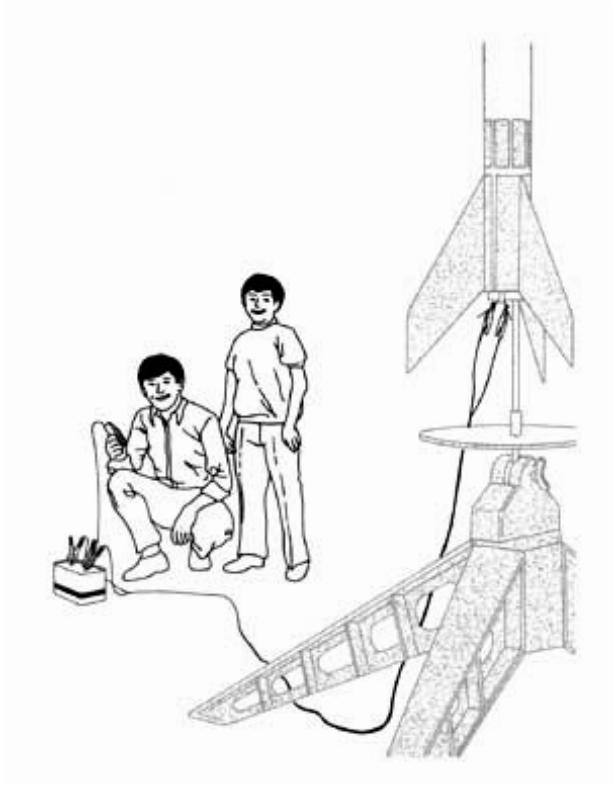
Now swing the rocket is a circle over your head. If the rocket is stable, it will point forward. You might have to throw the rocket into position to get it to fly straight. An unstable rocket can be made stable by adding a weight to the base of the nose cone. Do not add weight to the tail of the rocket. If your rocket is stable, it is ready for the launch pad.



LAUNCHING

Launch Pads

Launch pads can either be homemade or purchased. The most popular pad is a metal rod (1/8 inch in diameter and up to 36 inches tall) set in a wood or plastic base. The rocket attaches to the rod by a launch lug. The lug is a piece if drinking straw glued to the outside of the rocket body. The rod guides the rocket into the air.

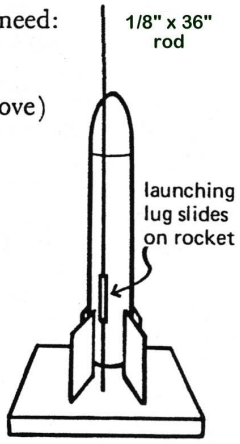


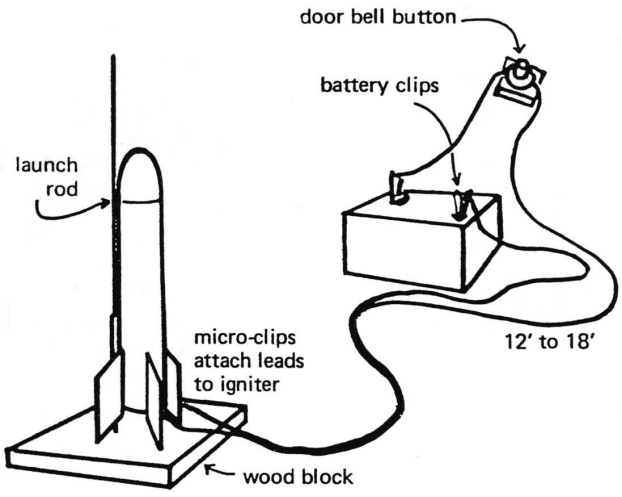
All model rockets are launched by electric power. You can buy launch pads with the electric power right in the base. If you build your own launcher, you will need a source of electric power. A 6—12 volt battery will serve as a good source.

Build the launcher according to the diagram. Before launching, pretest to make sure the launcher will work. A light bulb of the same voltage as the battery can be used in place of the rocket. To test, connect the light bulb to the micro clips. You should not see the bulb light until you press switch (button). If it does, re-check your wiring.

To build a launcher, you will need:

1 battery
1 launch rod (as described above)
2 battery clips
2 micro clips
1 spring return launch switch (like a doorbell button)
12 feet of 18 gauge, 2 conductor wire
1 wood block





LAUNCHING
Cont'd.

Safety First

Remember the safety rules.

SAFETY IS IMPORTANT !!!!!!!!!

- Launch rockets only if they have a recovery system.
- Launch rockets upward, never to the side.
- Launch rockets away from tall trees and buildings.
- Launch rockets on calm days, never in high winds.

Countdown

You are ready for the launch. Make sure your electric supply of OFF. Connect the micro clips to the nichrome wire igniter extending from the engine. Clear the launch area, making sure no one is within 10 feet of the rocket.

It is a good idea to have a countdown, just as professionals do. A countdown will give warning to all spectators.

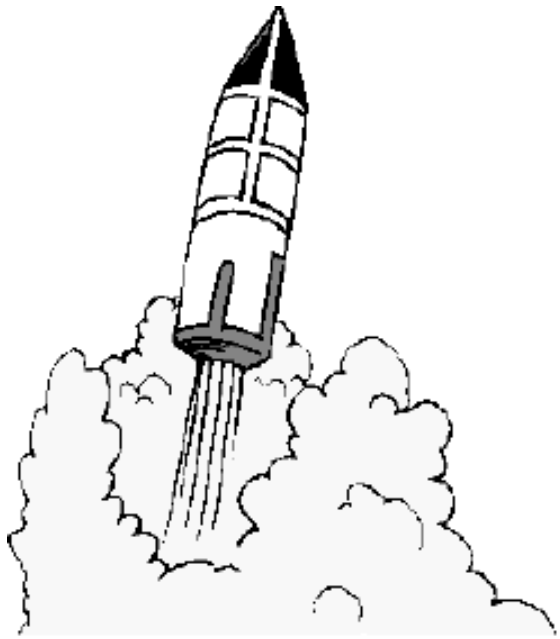
5….4….3….2….1
BLAST OFF !!!

Press the switch and launch your rocket.

Remember what goes up, must come down. Watch your rocket until it has returned to earth.

What If It Doesn't Fly?

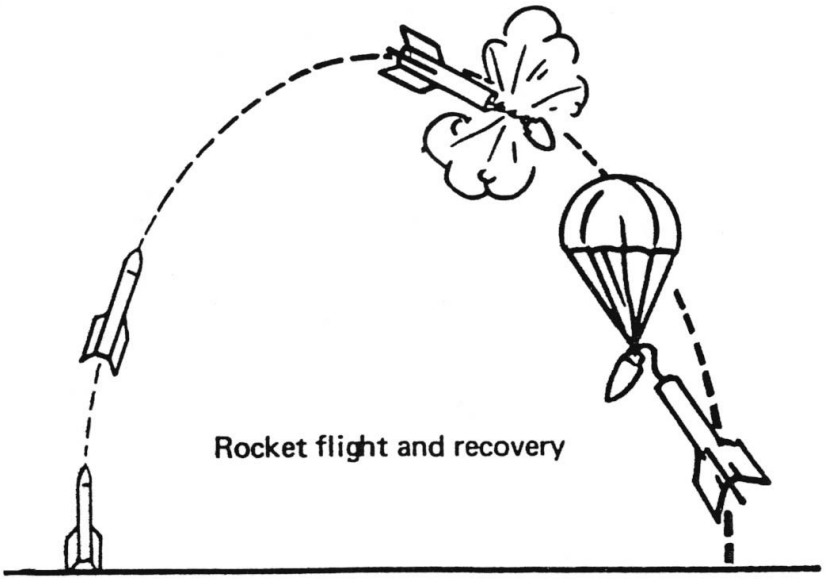
Once in awhile, your rocket might not go up when you press the switch. If your rocket malfunctions, turn off the switch and disconnect the battery clips. Wait a few minutes before inspecting the rocket to find out why it didn't fly. Perhaps you will need to replace the nichrome wire igniter or install a new battery. Or, maybe the micro clips on the igniter wire came loose.



WHAT MADE IT FLY??

Many things helped your rocket fly. You helped it by carefully building it and then following the safety rules during launch.

The Engine helped by giving the rocket thrust. As the first section of the engine burned, hot gas escaped from the ceramic nozzle, making the rocket move much like a balloon moves when air is released.



Thrust gave the rocket lift. As the rocket lifted, it pushed against the air. The air helped stabilize the rocket and it also slowed the rocket down. Because the air slows the rocket down, this is called Drag.

It is the engine's job to overcome the weight of the rocket (gravity) and the air drag. When the engine functions the rocket flies.

ACKNOWLEDGMENTS

"NAR" is the registered trademarks of the National Association of Rocketry

Some material and drawings of rocket engines was based on information available from the Estes web site. "Rocketry 101" and the "Rocket Library". Several pictures of model rockets have been taken from the Estes online Model Rocket catalog. https://www.estesrockets.com

"Estes" is the registered trademarks of Estes-Cox Corporation, 1295 H Street, Penrose, CO 81240.

Some pictures of model rockets have been taken from the Apogee Components online catalog. http://www.apogeerockets.com
Apogee Components, Inc., 1130 Elkton Drive, Ste A, Colorado Springs, CO 80907

Some pictures of model rockets have been taken from the Quest Aerospace online catalog. http://www.questaerospace.com

"Quest" is the registered trademark of Quest Aerospace, Inc., PO Box 7888, Cave Creek, AZ 85327-7888

Some material contained in this manual was based on information obtained from Model Rocketry Members Manual (4-H-BU0255), Minnesota Extension Service, University of Minnesota, St. Paul, MN 55108

Some information has been taken from various internet rocketry forums and chat rooms.

Also, we wish to thank:

- Patricia and David Johnson for their many helpful tips during the development of the original 4-H Model Rocket Manual for Elkhart County.
- Wayne Robinson for the update and re-write of the 4-H Model Rockets Manual for Elkhart County. (Revised October 2006, November 2009, October 2013 and September 2021)

SAFETY COMES FIRST !!

Always Follow the Safety Rules