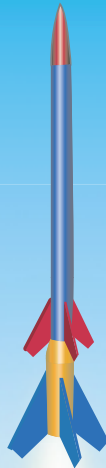


APOGEE

PEAK OF FLIGHT

NEWSLETTER

How To Multi-Stage Rockets - Part 2



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How To Make Better Looking Rockets: Discover The Secret Techniques Used By Master Craftsmen



"The use of videos imbedded into the text made the lessons easy and fun to read. Even my girls could understand!"

-- Craig Christenson

Note: The CD-ROM is not a DVD disk. It is an ordinary computer CD-ROM. It works on both Macintosh and Windows computers. Requires Adobe Acrobat Reader, which can be downloaded free from the Adobe website.

Do you want to "really" know how to build better looking rockets? Would you like stronger rockets? Do you want your rockets to fly higher? Are you pressed for time and looking for ways to build rockets faster? If you answered 'yes' to any of these questions, please read on.

No More Confusion - Your Brain "Gets" This Material Instantly

If you wanted to learn piano, karate, or even business, calculus, or computer programming -- wouldn't you find it easier to learn in a classroom, with a teacher, than at home with a book? Go ahead and try explaining how to tie your shoe to someone without actually showing them. Do you see my point?

It's the same with building and flying model rockets. When you see a master craftsman assemble a rocket right before your eyes, the techniques and procedures crystallize in your brain. This really is the closest thing to having me in your workshop sitting right next to you at your workbench.

Once you watch a video you just pause it and then you go do exactly what you saw me do. If you have a question, just hit "rewind" and instantly access the information you need. You can go at your own pace (fast or slow) because all the information is right at your fingertips. You'll find this video-book indispensable for all your rocket project, both easy and complex. Go to the Apogee web site, and order your copy today! For just \$12.95, you won't find any better rocket education. (www.ApogeeRockets.com/skill_level_1_video.asp)

Building Skill Level 1 Rockets (CD-ROM)

P/N 1065

\$12.⁹⁵



VIRTUAL ROCKET CONTEST



Whether you are just testing RockSim (Demo Version) or are power designer, you can participate in a new rocketry experience. Yes, participate in the Essence's Model Rocketry Reviews' "Virtual" Rocket Contest and win great prizes from Apogee Components.

Deadline: 3/9/03

RockSim Rocket Design Requirements:

- 18mm motor, single
- At least two diameters of body tubes for exterior body, One body tube must be at least 3x the length of the other
- The shortest body tube must be at least 3" in length
- There must be at least 2 sets of 3 or 4 fins, different shapes and the bottom of the root edge at a different place
- Materials must be standard weights that are in the rocksim database
- Materials must be standard thicknesses that are in the rocksim database
- Fins can not be any thinner than 1/16" of an inch
- Must include realistic recovery and launch lugs (motor hook is optional)
- NO CP Overrides, NO Mass Overrides
- NO Mass Objects for adjusting weight and CP other than normal required items like shock cord, eye-screws, etc.
- Must have at least 1 caliber of stability with an Estes C6 loaded
- Select the rocket part colors that you would like to see posted

Your rocket will be flown in (4) "contest" conditions events and will accumulate a total score:

- Versatility: your rocket will fly in "contest" conditions with (3) "contest" motors. The conditions and motors will not be disclosed. The placement score for each flight will be the Maximum Altitude (ft) * Rocket Weight (oz)
- Max Altitude: your rocket will fly with a "contest mass override", "contest conditions", and a "contest" motor. The placement score will be the Altitude (ft) .
- Slow and Low: your rocket will fly in "contest" conditions with (1) "contest" motor. The placement score will be based on highest Time to Apogee (sec) and lowest Altitude (ft).
- Drag Race: your rocket will compete in a double-eliminate drag race in "contest conditions", with a "contest" motor. 3 points are up for grab for each flight. 1st) Fastest to clear launch rail (sec), 2nd Longest time to landing (sec), and 3rd Lowest Range (closest to pad in feet)

Time is running out, so check out all the contest rules at <http://www.rocketreviews.com/specials2.shtml> , or write nick@rocketreviews.com to get all the details!

How Multi-Stage Model Rockets Work

Part 2

By Tim Van Milligan

Introduction: This is the second in a two part article about building and flying multi-stage rockets. In the first article, I explained how multiple-stage rockets work. In this article I'll discuss how to physically arrange the part in your rockets to make sure you get a successful ignition of the rocket engines. I'll also talk about some safety considerations, engine selection, and flying strategies.

Engine mounts & stage coupling

The way the parts are arranged in your rocket will directly affect the success level you achieve. The most critical parts are the engine mounts, and how the stages are coupled together.

When the rocket is "minimum diameter" the method of coupling the stages together can only be done one way. That is the aft end of the upper motor must be inserted into the front end of the lower stage. This is shown in figure 2.

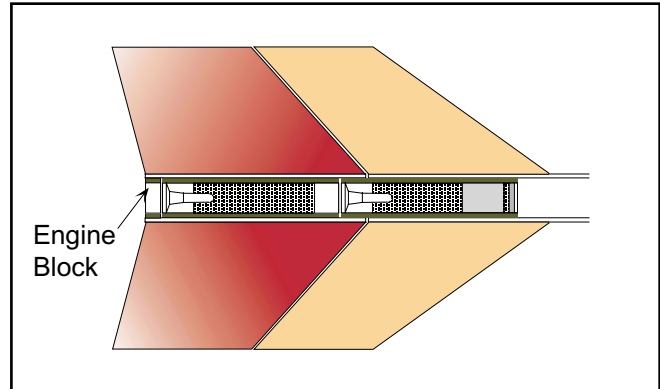
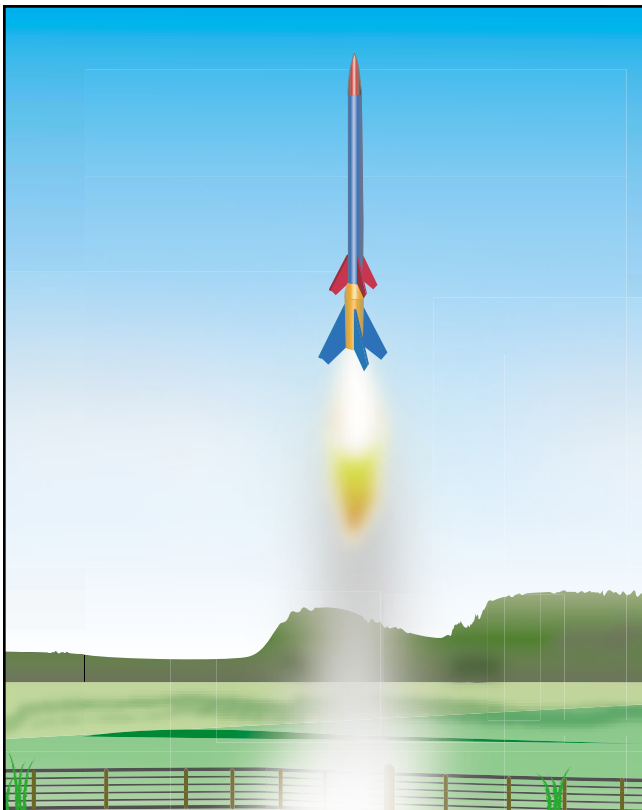


Figure 2: with a minimum diameter rocket, you can use the upper stage motor as a coupler to join the two stages together.

Since we have to insert the booster stage from the forward end, we might as well put an engine block in the back end of the stage to prevent the booster motor from spitting out the back when the rocket stages. This is much simpler than trying to install an engine hook on the booster stage.

The other advantage of this method is that it allows us to tape the motors together. The practice of taping them together goes way back to the beginnings of model rocketry. The tape holds the motors together insuring that the top stage ignites prior to the bottom stage falling away. The heat and flame coming out of the top stage is what melts the tape in half, which allows the bottom stage to fall away.

The procedure for installing the motors then would go like this:

First, tape the motors together, with the booster engine on the bottom. Use only one layer of tape. Note: Cellophane tape is preferred over masking tape, because it melts at a lower temperature.

Second, add masking tape around the outside of the booster stage motor. The purpose of the tape is to create just a little bit of friction to prevent the booster engine from falling out of the stage as it tumbles to the ground. It isn't like friction fitting to keep the motor from popping out at ejection; since the thrust ring does that. It is just keep it from sliding forward as it tumbles to the ground.

Third; friction fit the upper stage motor into the tube of the top stage using masking tape. This time, you'll need a lot of tape to make sure the motor doesn't move forward when the

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parachute comes out of the top stage.

Because of the friction fitting of the motor into the upper stage, this method does have a drawback. It may be hard to remove that motor after you get the rocket back. It would be better to secure the motor differently.

What this means you'll have to make the diameter of the

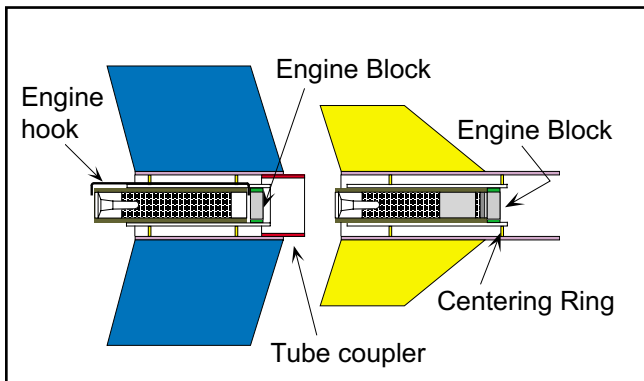


Figure 3: when the outer tubes are larger than the motor diameter, you have more options on how to couple the stages together. Here, a tube coupler (on the lower stage) is used to join the stages together. Note how the aft ring on the top stage is recessed into the tube to allow the coupler to slide into the upper stage.

upper stage bigger to accommodate some type of engine restraint. Personally, I prefer to tape the upper stage into the engine mount tube as shown in Figure 4. If you used any type of engine hook, the nozzle would be just that little bit more further away from the lower motor.

This method of using a coupler on the lower stage that enters in the base of the top stage is the one that I prefer. The

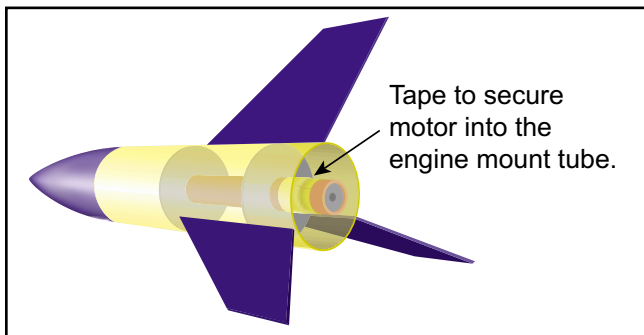


Figure 4: to hold the motor in the upper stage, you can wrap tape around the outside of the tube.

big advantage is that the stages are aligned straighter than if you just use the engine as the coupler (See Figure 2). In that method, the bottom stage can decouple too easily and the rocket may have excessive tip-off at the point of staging.

The biggest drawback is that the tube has to be larger in diameter to accommodate the coupler. The larger the diameter, the more drag the rocket will experience; so it won't fly as high.

Many competition modelers have discovered that they can still make rockets that are fairly small diameter to minimize the drag. See Figure 5.

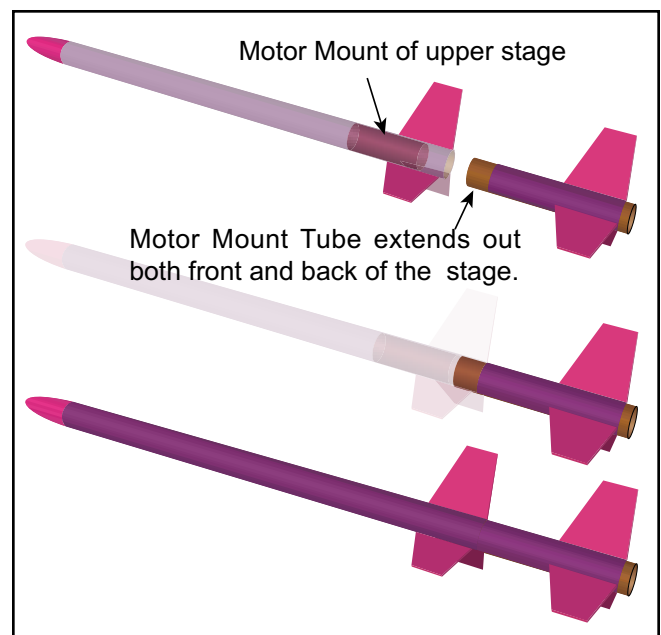
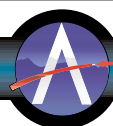


Figure 5: in this "near" minimum diameter design, the motor mount tube of the booster stage extends out both ends of the stage. The front end acts as a coupler to join the stages together. The rear end allows tape to be wrapped around the motor to hold it in place.

The key to the design are the engine mount tubes. In the bottom stage, the engine mount tube extends out both the front and the back. The front portion acts as a tube coupler. It is inserted into the top stage to join the parts together. Since this tube fits over the aft end of the upper stage's rocket motor, the coupler joint is twice as strong. It grips the outside of the motor, and the inside of the tube.

Because of this arrangement, the motor mount tube of the upper stage has to be recessed deep into the top stage (even though the aft end of the engine hangs out the back). This really isn't much of a problem. It just means that the front part

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of the engine is holding the motor in place.

The only drawback in this near minimum diameter design is that the top stage engine has to use the friction fit method to hold it in the stage. I would prefer a mechanical method of engine restraint, but it is acceptable for most small motors like those used in rocketry competitions.

gap-staging Large diameter tubes

In the last issue, we talked about using gap staging when the motors were not in direct contact with each other. Figure 6 shows how this is accomplished when you are using larger diameter tubes.

The first thing to note is that there are holes in both the outside tube, and the motor mount tube. This allows the gases of the booster stage to exit the rocket, instead of pressurizing the volume between the two stages. If there were no holes in the outside tube, the stage would pop off without igniting the top stage motor.

The other thing to notice is that the rear centering ring in the top stage is recessed deep within the tube. This is done to allow the tube coupler to be inserted into the top stage to join

the stages together.

The motor in the top stage can be taped into the mount, like is shown in figure 4. Just be certain to design it so that the tape doesn't interfere with inserting the engine into the tube in the bottom stage.

safety considerations

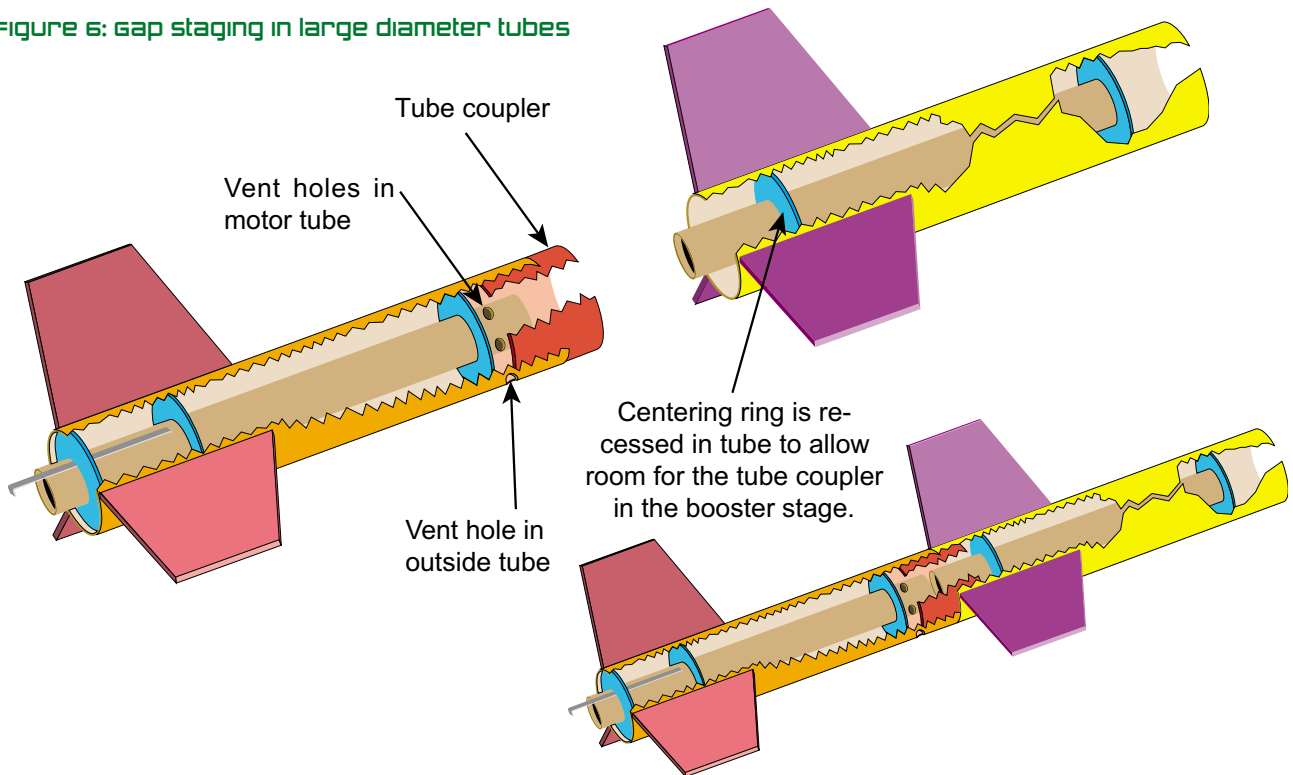
Whenever we add more engines into a rocket, we introduce more chances for things to go wrong. Since we want to maintain a safe flight, we should do everything possible to increase the reliability of the flight. First off, we want to make sure the rocket does actually stage. We don't want the top stage coming in ballistically. For this reason, we never use more than three stages in a model rocket design. Also, the more stages in a rocket the more likely it will weathercock in windy conditions. Therefore, a four-stage rocket is just too risky, and should never be flown.

As mentioned previously, we should also make sure the stages are joined together correctly, and they can only separate in a straight line. This will prevent tip-off. Whenever possible, have a coupler join the stages together, instead of just using the end of the rocket motor.

Rocket motor selection is of critical importance. If your

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Figure 6: gap staging in large diameter tubes



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model comes off the launch rod with insufficient speed, it will weathercock severely. From a safety standpoint, we desire the rocket to go straight up, not horizontally. The motors you select for your rocket will determine the trajectory of the flight.

For more information on how to select rocket motors, please read the short series of articles that appeared in this ezine beginning with issue #38:

<http://www.ApogeeRockets.com/education/newsletter38.asp>

Another element that will affect the trajectory of the rocket is the size of the fins. They determine the Center-of-Pressure (CP) of the model.

The way to determine the fin size on multi-stage rockets was also presented previously in the Apogee e-zine newsletter beginning with issue #96:

<http://www.ApogeeRockets.com/education/downloads/newsletter96.pdf>

Flying strategies

Launching multi-stage rockets always requires more caution and attention to detail than single stage models. Here are some general tips:

1. Have a larger flying field. These models will fly higher, and therefore drift further with the wind. The larger the field, the better your chances of getting the model back to fly it again.

If you use RockSim to estimate the drift distance of the model, you'll quickly see that on a day with a 10 mph wind, the rocket will land roughly two times further away than it goes straight up. So if you expect the rocket to fly 1000 feet into the air, it will most likely land 2000 feet down range. You can reduce this by using a smaller recovery device in the top stage, or by angling the rocket slightly into the wind.

2. Multi-stage rockets are significantly more susceptible to weathercocking than single stage models. So use caution when there is even the slightest breeze. You may want to cant the fins on the booster stage slightly to give it some rotation. While this will lower the predicted altitude, it will give you a straighter flight.

3. A trick that modelers have been using for decades is putting a spill hole in the parachute of the top stage. This allows the rocket to descent faster, so it doesn't drift as far.

4. To help make your rocket easier to spot, you should use tracking powder in the top stage. Tracking powder is any

nonflammable powder placed inside the rocket that is ejected at apogee into a large puff or cloud. The cloud can help you to locate your rocket at a very high altitude. Some powders that work well for this include tempera paint, chalk dust, and talcum powder. The colors that seem to work best are black for cloudy days and red when the sky is blue.

More information

In the book "Model Rocket Design and Construction," you'll find additional information about staging model rockets. The book gives helpful information on: booster stage recovery devices, C.H.A.D. Staging, gliding booster stages, and finally indirect staging techniques.

About the Author

Tim Van Milligan is the owner of Apogee Components (<http://www.apogeerockets.com>) and the new rocketry education web site: <http://www.apogeerockets.com/education>. He is also the author of the books: *Model Rocket Design and Construction*, *69 Simple Science Fair Projects with Model Rockets: Aeronautics* and publisher of the FREE e-zine newsletter about model rockets. You can subscribe to this e-zine at the Apogee Components web site, or sending any message to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject of the message.

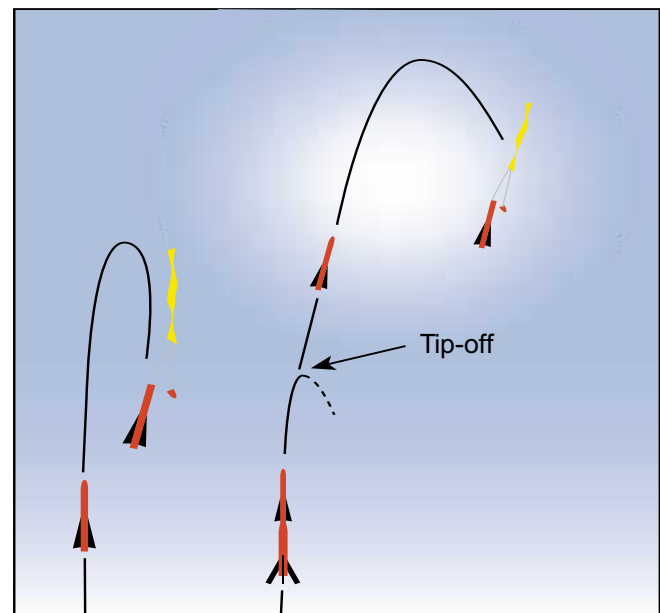


Figure 6: staged rockets can do unpredictable things, so always take precautions.

Archives of this newsletter

All the articles that have appeared in this newsletter are archived at http://www.apogeerockets.com/education/newsletter_archive.asp