Model Rocket Construction

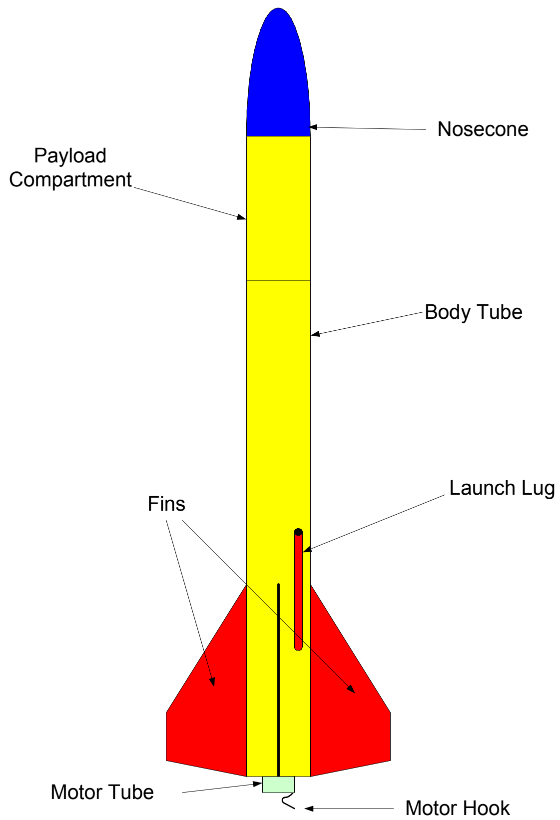
By Phil Charlesworth, UKRA

Most model rocket fliers start by launching a "Ready to Fly" (RTF) kit from a starter pack. After that they usually move on to kits by Estes, Quest, Fliskits or other reputable manufacturers. Eventually they get the urge to design their own rocket but often lack the confidence to make this big step.

This article has been written to help you make that first step towards the most satisfying aspect of this hobby. Why is it so satisfying? Well you're making a rocket that reflects your personality, not the personality of a kit designer. It might be something that looks wildly futuristic, or has two stages, be powered by a cluster of motors, or just be an interesting shape that looks right to you.

Parts of a Rocket

Let's start by describing the parts of a model rocket. Later on we'll have a look at some of the assemblies and materials that are used. The diagram below identifies the main parts of a model rocket.



The nosecone has an aerodynamic shape. Normally nosecones are parabolic (rounded) or ogive (a sort of rounded cone) as these shapes perform well at speeds below a few hundred mph. For really high speed rockets a slender conical nosecone is ideal.

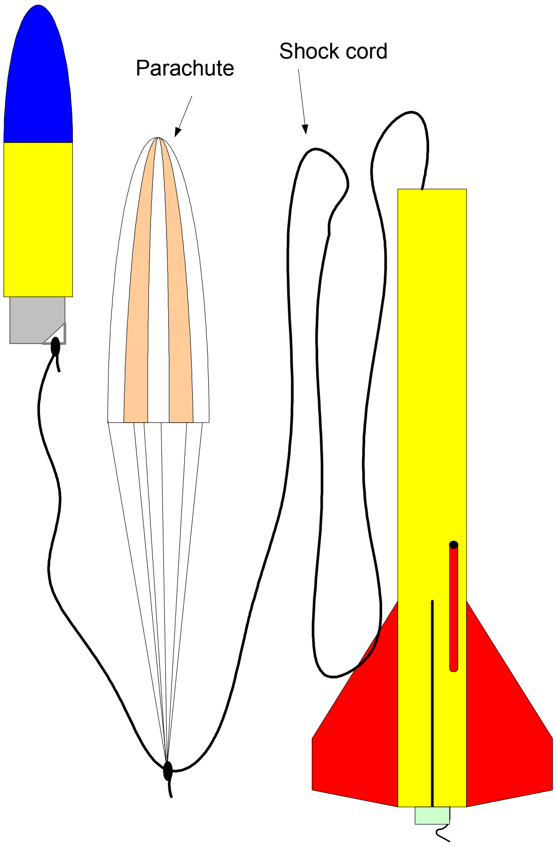
The Payload compartment is for carrying altimeters, cameras, experiments or other payloads. It is an extension to the body tube, but separated from the main body tube by a sealed bulkhead. The bulkhead prevents hot gases from leaking into the payload and damaging experiments. Later on we'll see how a payload compartment can be made.

The body tube contains the parachute and shock cord. Fins are attached to the body tube to make the rocket aerodynamically stable. A motor mount is installed inside rear of the body tube. Later on we'll how to make a simple motor mount.

The launch lug is a hollow tube that is glued to the rocket around its point of balance. This slips over the launch rod, which keeps the rocket pointing upwards as it accelerates.

Inside the Rocket

The rocket breaks in half to deploy the parachute. The two halves of the rocket, the main body and the payload compartment, are held together by a shock cord. A parachute is attached to the shock cord about one-third of the way from the nose. It is normal to attach it at this point to prevents the payload compartment from banging into the main body during descent; this could damage the rocket and interfere with the payload.



This shock cord has to be firmly attached to both the main body and the payload compartment so that it can survive the shock of parachute deployment. It is normal to make the shock cord out of a material with a bit of "give" such as elastic, but be sure to use a material that won't melt. Some advice on shock cord materials can be found in the article "Materials for Model Rockets".

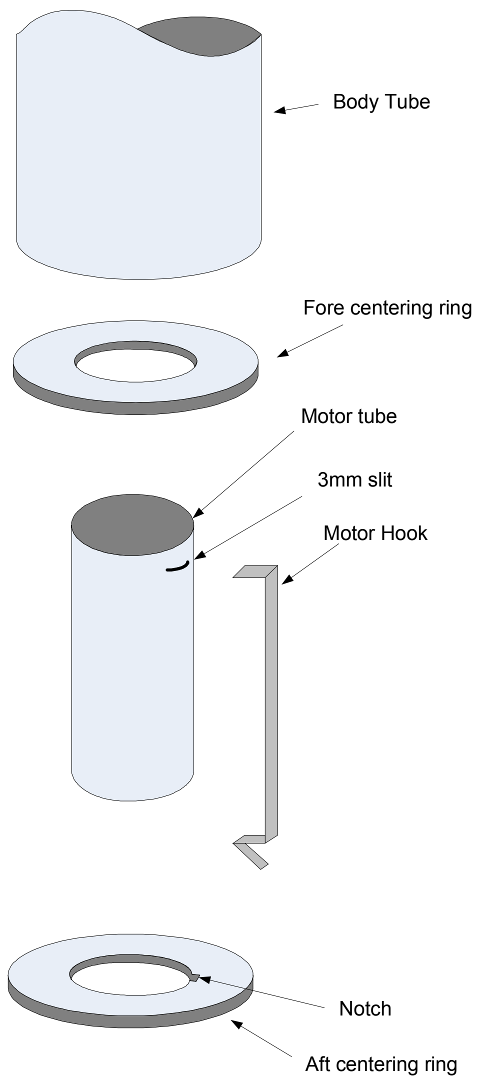
Most model rocket kits include a parachute, usually made from polythene sheet and attached using cotton thread. These parachutes are OK for the first few flights but don't last long. It is worth investing in a good nylon parachute of the same diameter. Most model rocket fliers keep a small stock of nylon parachutes from 9 inches to 24 inches in their flight box. These can be attached to the rocket using "snap swivels", available from fishing tackle shops.

Making a Simple Motor Mount

Motor mounts comprise 4 main parts:

- The fore centering ring
- The aft centering ring
- The motor tube
- The motor hook (sometimes called the motor retainer)

The fore and aft centering rings are used to match the size of the motor tube to the body tube of the rocket. All the thrust of the motor is transferred to the rocket through these two centering rings so they need to be of an appropriately strong but light material. The article "Materials for Model Rockets" discusses suitable materials for making centering rings. Because these two centering rings transfer the thrust they are sometimes referred to as "thrust rings".



The assembly of a motor mount is quite straightforward. A diagram of the main parts is shown to the left. This includes the aft end of the body tube.

Step 1. Using a sharp craft knife, cut a 3mm long horizontal slit about 5mm from the front of the motor tube.

Step 2. Cut a notch in the aft centering ring, wide enough so that it can slip over the motor hook.

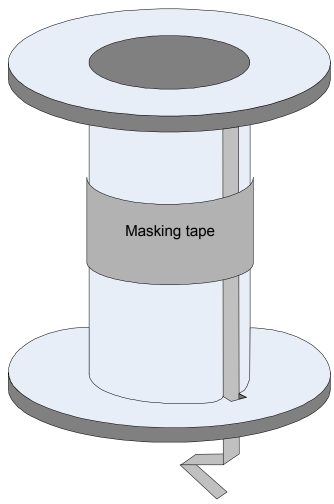
Step 3. Run a thin line of glue all the way around the front edge of the motor tube, and slide the fore centering ring over the tube. Make sure the fore centering ring is straight before the glue sets.

Step 4. Slide the top of the motor hook through the 3mm slit so that the hook lies straight down the side of the motor tube. Tape it in place with 2 turns of masking tape.

Step 5. Run a thin line of glue all the way around the rear edge of the motor tube, and slide the aft centering ring over the tube. Don't forget to line up the notch in the aft centering ring with the motor hook. Make sure the fore centering ring is straight before the glue sets.

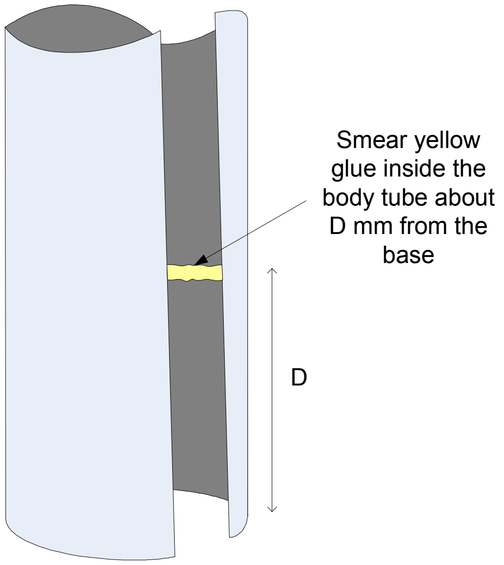
When the glue has set you should end up with an assembled motor mount that looks like the diagram on the right. It is sometimes useful to smear an additional layer of glue over all the joints and press it into the joints. This can give additional strength to the joints.

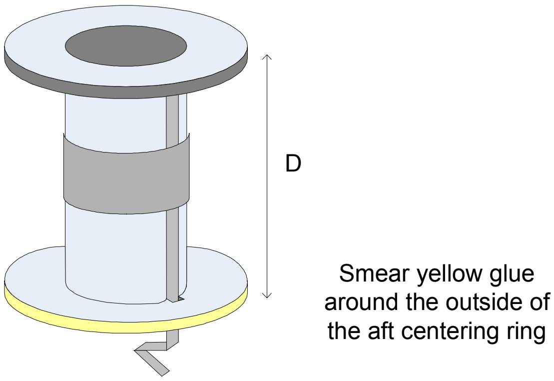
Assembled Motor Mount



Inserting it into the body tube can be quite fiddly, but can be done with a bit of practice. The problem is that that the glue can set before all the parts are installed, so its worth a bit of patience and preparation.

Before applying any glue, take the motor mount and "dry fit" it into the tube. The fore and aft rings will probably bee a tight fit, so get some fine sandpaper and gently sand then to size. Once they fit snugly, you're ready to start.





Note that this diagram is a cutaway of the body tube so you can see what's inside. Don't cut the tube open as it will severely weaken it.

Step 1. Measure the distance between the fore and aft centering rings. Lets call this "D" mm.

Step 2. Take an old lolly stick and smear a ring of glue "D" mm inside the body tube.

Step 3. Run a thin line of glue around the outside edge of the aft centering ring.

Step 4. Slide the fore centering ring into the tube and stop just before the ring comes into contact with the glue.

Step 5. In one smooth motion push the aft centering ring so that it stops about 1mm inside the bottom of the body tube.

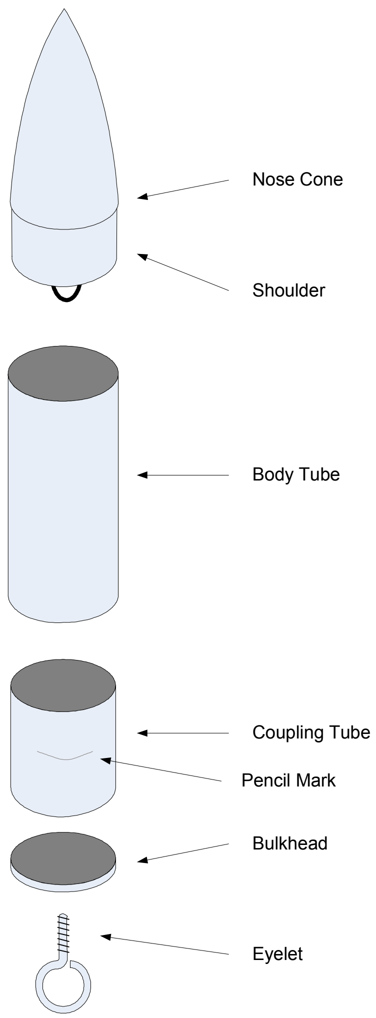
Step 6. For extra strength, apply a thin layer of glue to the joint between the aft centering ring and the body tube and press it into the joint.

It's always a good idea to set the parts aside to dry. Try and keep it upright so that any glue will flow into the joints.

Making a Payload Compartment

At their simplest, payload compartments are just hollow sections of tube behind the nosecone of the rocket. They can be used to carry all sorts of experiments. Cheap digital altimeters can be used to measure the altitude of the rocket. The increasing availability of cheap digital cameras and video cameras has opened up the possibility of aerial photography from model rockets. There are even competitions for carry delicate payloads such as raw eggs.

When designing your payload bay it is worth giving some thought to the payload that it will contain. You'll need to be sure that there's enough space to carry the payload. You will also want to be sure that your payload is adequately protected and that it won't rattle around. Altimeters and cameras will need holes for ventilations and lenses. Eggs and other delicate payloads will need to be padded.



Making a payload compartment is fairly straightforward. You'll need to start with a length of body tube that is long enough to contain the payload. Allow for the length of the nosecones shoulder, as this will fit inside the tube

Step 1. Cut a length of coupling tube that is approximately two tube diameters long. Mark this with a pencil about half way along the tube.

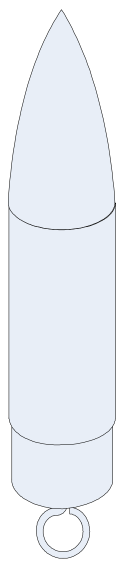
Step 2. Screw the eyelet into the bulkhead. It is sometimes useful to glue a small block of wood to the upper side of the bulkhead to help the screw to purchase.

Step 3. Glue the bulkhead inside the aft end of the coupling tube.

Step 4. Run a smear of glue around the inside of the aft end of the body tube. Slide the coupling tube unto the body tube up to the pencil mark and leave the glue to set.

Step 5. When the glue has set, test the nosecone for fit. It should be a tight fit. If it is too tight then sand the shoulder, of it is too loose then wrap a few layers of sellotape around the shoulder.

The completed payload bay should look like the picture on the right. To open the bay pull hard on the nosecone and it will slip out. When the payload is ready for flight push the nosecone back into the body tube and seal them together with a couple of turns of sellotape.



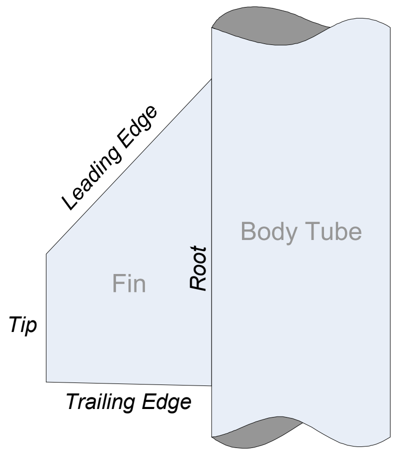
There are many other ways of sealing a payload bay, for example plastic rivets and screws. Some payload bays are designed with tow lengths of body tube that are joined by a coupling tube in the middle. Experiment to find a technique that suits your payload.

The eyelet at the aft end of the payload bay is for attaching the shock cord. Tie the cord in a good knot, then put a blob of white glue over the knot. This will prevent the knot from untying.

Attaching Fins

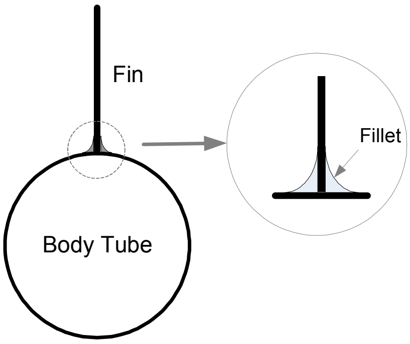
Fins ensure that the rocket travels if a straight line during flight. It is important to attach the fins firmly to the rocket. A rocket that loses its fins will lose directional stability, causing it to tumble or crash. This is not only dangerous, but will result in destruction of the rocket and its payload.

There is a lot of science and mythology about the number and shape of fins. A rocket needs at least 3 fins to be stable. Some would argue that 4 fins is the optimum number. However man fins you go for, they should be evenly spaced around the body tube.



Fins can be rounded, triangular, square, or any number of different shapes. The important thing is that they're strong enough to take the flight loads. Generally this means using a fin material that is thick enough and strong enough. Fin materials are discussed in the article "Materials for Model Rockets".

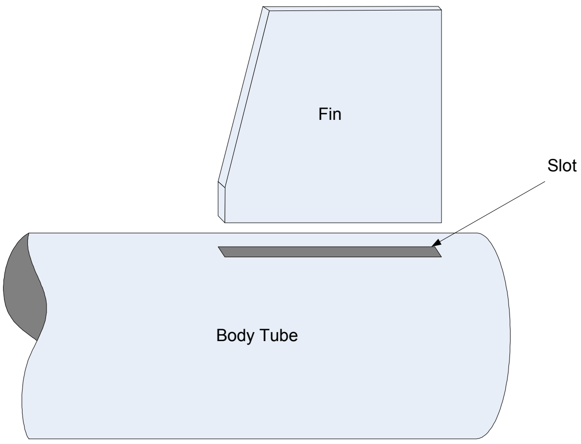
Let's start by looking at the parts of the fin. The fin is attached to the body tube at its **root**. The fore edge of the fin is called the **leading edge**, and the rear is called the **trailing edge**. The end of the fin away from the root is called the **tip**.



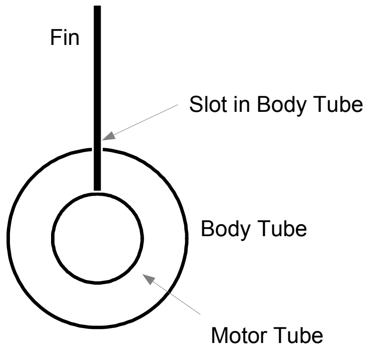
Fins can be glued directly to the body tube. This technique is called "butt mounting". It is very common in low power rockets, but is not recommended for D impulse motors of above. The basic problem with butt mounting is that the fin can tear off at higher speeds, causing the rocket to become unstable.

A butt mounted joint can be strengthened by using a fillet of glue to spread the forces over a larger area. Filleting can add a lot of strength to the joint for relatively little weight. White glue or epoxies are normally used to fillet fins.

A better and much stronger technique is to use "through the wall" (TTW) mounts for fins. The TTW mount is slightly more complex to make, but the result is a very strong joint. To make a TTW joint you need to cut a slot lengthways along the tube.



The slot needs to be the same length as the fin root, and the same width as the fin thickness. Apply some glue to the fin root and push it through until it contacts the motor tube, then apply a fillet to both sides of the fin where it enters the slot. Be very careful to ensure that the fin is straight before the glue sets.



Standard Components

When starting out to build your own rockets it's a lot easier to use standard sized components. These are designed to fit together easily, and solve a lot of the basic problems. Standard components are available from the rocketry vendors on the UKRA website, particularly Apollo, Rockets and Things and Rocket Store.

Most component dimensions are based on a number of standard sized body tubes. The sizes originate from the Estes model rocket kits, and several other manufacturers have adopted the same systems of standard sizes. The smallest standard size is body tube 5 (BT5) and the largest is BT80. BT20 and BT50 are the correct sized tubes for 18mm and 24mm motors respectively. Body tubes usually come in lengths of 17 or 34 inches. The standard diameters are:

Tube	Diameter	Use
BT5	13.2 mm	Body tube, 13mm motor tube
BT20	18.0 mm	Body tube, 18mm motor tube
BT50	24.1 mm	Body tube, 24mm motor tube
BT55	32.6 mm	Body tube
BT60	40.5 mm	Body tube
BT70	55.4 mm	Body tube
BT80	65.7 mm	Body tube

Coupling tubes are designed to fit inside the standard body tube. Thus a CT55 coupling tube has an outside diameter of just under 32.6 mm, allowing it to slide inside BT55 with a thin layer of glue. If a coupling tube is a tight fit in a body tube then gently sand the outside until it fits.

Centering rings are designed to fit over one tube and inside another. Usually the part number gives a clue as to which sized tubes the ring is designed for. Something labelled "CR55-70" is likely to be a tube for fitting a BT55 inside a BT70. Sometimes the centering ring is not a perfect fit, so a little sandpaper is useful.

Nosecones are designed to fit into one of the standard tubes. Nosecone part numbers usually give you a clue about their size and materials, for example a "BNC 20" is probably a balsa nosecone designed to fit BT 20, and a "PNC 70" is a plastic nosecone for BT70. Part numbers sometimes give additional information about shape, for example a "PNC 55 BB" is a plastic nosecone for BT55 styled like the nosecone of a "Black Brant" sounding rocket.