**intro:** How to Make Fireworks

There are many types of fireworks, where one of the most common is the aerial shell. The aerial shell is used in fireworks displays, and can be either a round or a cylindrical shape. These aerial shells are loaded into tubes, called "mortars." Once lit, the aerial shell will fly into the air and once the aerial shell is at the highest point (apogee), it will explode and shoot pyrotechnic stars in all directions.

In this instructable I will be talking about the procedure of assembling a round aerial shell.

Note: I do **NOT** recommend the average person to try this! This will be illegal to do without licensence in many cases, it is on your own response wether you do this legally or not.

When working with fireworks it is very important to use proper safety gear while making. It is recommended to wear faceshield or safety goggles during the making. While making the shell, one should do it away from heat sources, such as candles, cigarettes, stoves etc.

If I somehow throw around with a lot of foreign words or have any questions, feel free to ask me.

First, let's see what a typical round aerial shell looks like:

![Image of a typical round aerial shell](http://www.instructables.com/id/How-to-Make-Fireworks/)

**Image Notes**

1. Loop
2. Lifting cup containing lifting charge
3. Quick match (or in this case a shooting-wire)
4. A "rising comet" which will ignite from the lifting charge, and will trace a line where the aerial shell is. It is actually just a big star glued to the shell.
5. The shell itself, containing stars and bursting charge.

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**Image Notes**

1. Is a kind of fuse, which burns extremely fast (up to 100m/sec!) Since an aerial shell is at the bottom of a "mortar" tube, you will need to be able to light the aerial shell without reaching your hand to the bottom of the tube. The quick match will go from outside the "mortar" to the black powder lifting charge.
2. Not really an important thing of the aerial shell, but it keeps the quick match on the north pole of the shell, which might come handy when you load the aerial shell in the tube.
3. These are pellets made from a compressed pyrotechnical composition. Generally there are three types of stars: 1. Rolled stars (Round stars, made by rolling round cores in a star rolling machine, and alternately adding water and pyrotechnical composition.) 2. Pumped stars (Cylindrical stars made by pressing dampened composition in a star pump, think of it as pressing play-doh in a syringe) 3. Cut stars (Cubical stars made by dampening a pyrotechnical composition, flat it out on a surface and cut out squares)
4. This will make the shell explode in the air. Often fine grained black powder (known as meal powder), is coated around rice hulls and used as bursting charge.
5. The outer layer of a shell consist of two things: The two hollow hemispheres which are connected to a sphere, and the "pasting" which are many layers of brown kraft paper with a layer of thin glue, that is glued many times around the sphere. This will create a more powerful explosion once the aerial shell explodes.
6. This is the fuse that will ignite from the lifting charge, and later ignite the bursting charge, and make sure the aerial shell explode at the exactly the right time. A time fuse too short will make the aerial shell explode on it’s way out of the mortar, and a time fuse too long will make the aerial shell explode on the way down, or even land on the ground.
7. The lifting charge will ignite from the quick match and send the aerial shell flying out of the mortar. It will also ignite the time fuse. The lifting charge is in a "lifting cup" which is nothing more than a cup connected to the shell. The lifting charge is often large grains of black powder.
step 1: Shell parts

Let's start making the aerial shell (from now on it will be mentioned as 'shell')

Shell hemispheres
You will need two 3" paper hemispheres to make this shell. Note that the hemispheres themselves are actually not 3", but smaller, since there must be room for pasting and quick match to make the shell fit in the 3" mortar tube.

Stars
A batch of 75 grams of 10 mm pumped "Tiger tail" stars were made for this shell, however only 70 grams were used. Remember always to make more than you need. It's better to have a bit more, than be needing. The stars were primed in meal black powder to ensure ignition. Since Tiger tail stars ignite easy, you might find that this might be unnecessary. If a 'rising comet' is desired, a 20 mm or 3/4" comet is pumped with the composition. Make sure that the comet has a burn time equal to the time fuse or spolette (3 seconds).

Tiger tail stars:
- Potassium nitrate: 44
- Charcoal (Pine airfloat): 44
- Sulphur: 6
- SGRS or Dextrin: 6

Bursting charge
'Meal coated rice hulls' was used in this shell.

Time fuse
A ‘spolette’ is a small tube, where black powder is confined in it. This will act as a time fuse, however one can also buy time fuse from such sites as: Skylighter.com

Pasting
30-40 lbs kraft paper in ~70x15 mm strips are used for pasting the shell using the 3-strip pasting method. If another pasting method is desired, the strips might have to be longer or wider. A glue is needed to paste the strips to the shell. Wheat paste is a cheap solution that works well. Find out how to make it at a tutorial I made:
- Wheat paste tutorial

Wood glue thinned with water can be used, however it is much more expensive.

Lift charge
A lift charge is needed to shoot the shell out of the mortar. Approximately 15 grams of good granulated or corned black powder works well. More or less might be used depending on the quality.

Ignition
For igniting the shell either a piece of visco fuse and quick match or shootings-wire and an e-match can be used. In this tutorial a piece of shooting wire and e-match was used. Note with this way you will need a power supply, and that you can not light the shell with a lighter

Other
You will also need lifting cup, paper tape, scissors, drill, "gummed paper tape" or kraft paper, tissue paper, brush, hot melt glue gun, cotton twine and string.
step 2: Shell Construction

Start by drilling a hole in the pole of one of the paper hemispheres. The diameter of the hole must be the same as the diameter of the time fuse or spolette. Insert the time fuse or spolette about half way in the hole, and hot glue it on both sides. Make absolutely sure that there are no air holes, this will likely result in a flower pot.

Place each hemisphere on a stand, which can simply be made out of an empty toilet roll cut in half. This will prevent the hemispheres from rolling around when you are filling them.
step 3: Filling with stars/burst and closing

Arrange the stars around the wall of the hemispheres to the rim. The stars should be sticking a bit over the rim. If the shell is underfilled it will result in a visible area of no stars when the shell is launched.

Next cut two pieces of tissue paper, one of them with a hole to go over the time fuse or spolette. Put the pieces in each hemispheres against the stars and fill tightly with burst charge to the rim. A bit of "booster", such as whistle mix or flash powder is added in the center of each hemisphere and spread loosely in the burst charge with fingers. Not much should be used, maximum 1g.

Quickly snap the two shell hemispheres together. This is not as hard as it sounds like, but if done too slowly, the stars or burst charge might rearrange or fall out, and the previous steps will need to be repeated. If the rim each paper hemisphere touch each other at this point, the shell is underfilled. However if done correctly there should be a small gap of around 1 cm at equator. Place the shell on the stand time fuse-side down, and use a wooden dowel to gently hit the upper hemisphere on different places. The stars will then arrange inside the shell and hopefully the two hemispheres will reach each other. Seal up around the equator with masking tape to close the shell temporarily. Also put a piece of masking tape around the end of the time fuse or spolette to protect it from being damaged during the next steps.
step 4: Pasting the shell

The next step is pasting the shell, which is the hardest and most time-consuming part of round shells. The pasting method described here is the so-called 3-strip pasting method. Unlike the "normal" pasting method (pasting strips with a length of half the equator around the shell) the 3-strip pasting method does not "build up" near poles.

To make your pasting strips sticky before you paste you will need to add a glue to each 70x15 mm kraft paper strip on one side. This can be done quickly by arranging some strips on a wide wooden board. Next apply a thin, even layer of wheat paste with a brush. These strips are now ready for pasting, but you will need to repeat this step many times, since you will need a lot of strips to complete your shell.

The shell is pasted as showed on the picture. A strip is pasted from the "northpole" pointing towards the "southpole". Then a strip beside is pasted from the "southpole" pointing towards the "northpole". A strip is then pasted between these two strip. This pattern is continuously pasted around the shell. Press out the airbubbles under the strips, this will result in a nice-looking shell. Everytime you finish a way around the shell (layer) make sure to write on the shell how many layers you have pasted so far, you might forget it. When finished pasting the shell, multiply the layer-number by two, since each layer with this pasting method counts for two actual layers.

While pasting the shell, cut a ~8 cm piece of cotton twine and make a loop on it. Hot glue it to the top of the shell (the opposite hemispheres of the one with the time fuse in it) and paste like before, just making the strip covering the twine. This shell needed 10 layers of pasting (~20 layers) to complete. The ideal is to make the shell ~5 mm smaller than the mortar tube, in this case the OD of the shell should be ~7 cm. Making it this diameter might take hours for beginners to complete. After the layers of pasting, let the shell dry completely.

**Image Notes**

1. 3-strip pasting method. Continue this pattern all the way around the shell many times

1. Looped cotton twine hot glued in place.
step 5: Lifting charge

Peel of the making tape that protected the time fuse. Cut two lengths of black match and bend them over the exposed end of the time fuse. Wrap a line of string numerous of time around the black match to secure them to the time fuse. Then either secure the string with a dot of hot glue or tie a knot.

The black match will be a prime for the time fuse and make it easier to ignite. Without it the time fuse might fail to ignite and make it a dud shell.

The next step is the lift. Take your desired lifting cup and poke a hole in the bottom, big enough to put the quick match or shooting wire through. The quick match or shooting wire should be long enough, so that when the shell is loaded in the mortar, there will stick a bit out of the mortar. If you use quick match insert a piece of visco fuse it. This will be the delay between when the shell is ignited, till it shoots out of the mortar.

Next put the quick match (not the visco fuse end) or shooting wire through the hole punched in the lifting cup. If using quick match, tear a bit of the paper off the end, so that the black match will be exposed. If using shooting wire, attach your e-match. Next slide the quick match or shooting wire back, so it centres in the middle of the lifting cup. Secure the hole with a bit of hot glue or gummed paper.

Add you lift charge in the lifting cup, in this example 15.3 grams of pulverone was used. The amount used all depends on the quality of your black powder. The rule of thumb is to use approximately 1/10 lift of the shells weight. The shell's final weight (everything included) was around 150 grams.
step 6: Almost done...

Attach the lifting cup to the shell. The time fuse should be pointed directly down the lifting cup and the quick match or shooting wire should be put inside the loop on the top of the shell. Add a line of hot glue around to secure the lifting cup.

Cut either a strip of gummed paper or kraft paper. The strip should be long enough to fit all the way around the lifting cup plus a little more. Cut the strip halfway all the way down with a distance of ~1" as shown on the picture. If you're using gummed paper activate it with water, if using kraft paper, brush with layer of wheat paste.

Wrap the uncut part around the lifting cup and the cut part around the shell as shown on the picture. Again, make everything as tight as possible.

If you want to add a rising comet to your shell, attach it the same way as the lifting cup was attached: Cutted-up strip with glue and hot glue. About 2 mm of the comet should be exposed to ensure ignition.
**step 7: Finished aerial shell**

The shell is now finished. It is a good idea to attach label in case you keep the shell over a longer time, so you will know what type of shell it is, which stars, amount of lift etc.

The shell can now be fired, but please note that this is obviously the most dangerous part of it all, so proper safety gear must be used.

First of all your eyes, fingers and ears are the most important thing to protect.

Wear **safety goggles/face shield, fireproof gloves and ear plugs/earmuffs** during firing (as a minimum!)

When firing, you can either use a mortar stand to hold your mortar tube if you have one, or you can bury the mortar tube in the ground about 2/3. Next the shell is loaded to the tube with the quick match or shooting wire sticking out - the shell should fall freely, without any help to make it reach the bottom. Also please take care of your surroundings: The shell should be fired a long distance away from people, houses and flammable objects. Run a good long distance after igniting the fuse. If you want to film the shell, it is recommended to be at least two persons: one will be filming, the other will ignite the fuse.

If the shell should somehow fail to lift properly and explode on the ground, you will be glad you did wear safety gear.

Sometimes a "flower pot" happens (mainly if the shell is not sealed well around the time fuse, or if the spolette is not rammed solid enough), which is simply the shell explodes in the mortar, shooting stars into the sky. The mortar may or may not fracture when this happens, but this is where burying the mortar comes in handy: the surroundings of the mortar will absorb most of the shock, and the fragments may not fly very far.

The shell was fired in front of a small audience (consisting of my family) I excuse the annoying voices/laughs/whatever.

Hope you enjoyed this instructable, which is my first one.

To find out more about pyrotechnics go to:
PyroGuide.com

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