This is a manual for 3D printed model rocket for a model flight competition

The model rocket consists of 3D printed parts listed in Table 1 below. Besides the 3D printed parts some other parts must either be bought or produced.

Table 1

Part no.	Part Name	Length of filament	Estimated time to print	Ultimaker compatible
1	LowerPartWithFins	10.0m	01d 01h 12min	2, 2 ext and 2 ext+
2	MiddlePart1	8.1m	12h 44min	2 ext and 2 ext+
3	MiddlePart2	4.3m	7h 11min	2, 2 ext and 2 ext+
4	Nosecone	0.9m	1h 13min	2, 2 ext and 2 ext+
5	ConnectionPart1	0.62	0h 51min	2, 2 ext and 2 ext+
6	ConnectionPart2			
7	Enginefix	0.16	0h 15min	2, 2 ext and 2 ext+
8	ParachuteRipStoppers			
9	Engine bracket			

The Enginefix should be printed in high quality, for the rest normal quality is suitable. In Figure 1 below the assembly of all parts is shown. It is advised to use modelling glue to secure all parts, <u>except for the Nosecone (part 3 and 4).</u> The Nosecone must be able to separate during flight in order to release the parachute. The Enginefix must be glued in the sleeve embedded in part 1 (LowerPartWithFins).

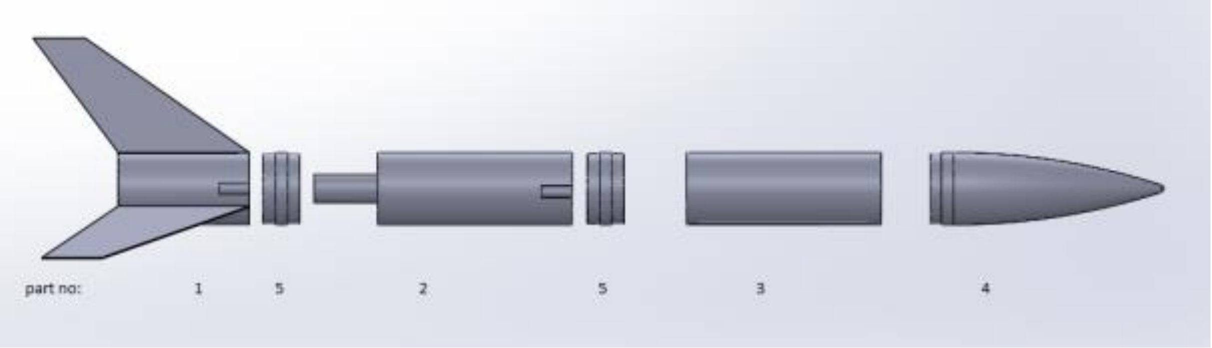


Figure 1; exploded view

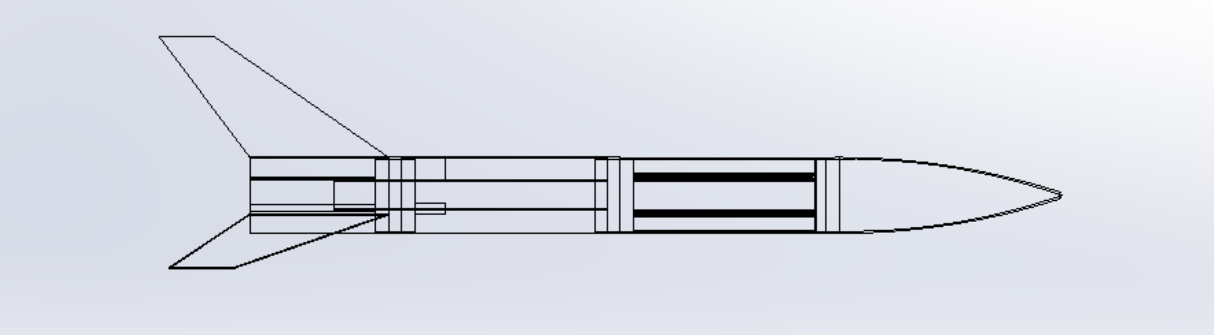


Figure 2; wireframe view

Engine:

The engine for this 3D printed rocket is the D12-3 USA model rocket engine from Estes. The engine will deliver an average propulsive force of about 12 Newtons (1,2kg) for about 1.7 seconds. After that the engine waits about three seconds to deliver a small propulsive force on the top side of the engine to detach the nose cone and open the parachute. The engine can be ordered easily on the internet and costs about 5 euros.

Parachute:

The parachute for this rocket should have a diameter of about 70 cm. The parachute can either be bought by order from the internet (about 5 euros as well) or you can make it yourself. If you want to produce the parachute yourself then find a tough piece of plastic or fabric and cut a hexagon out of the material with the dimensions shown in figure 3 below. 3D Print six parachute rip stoppers and glue them to each corner. The parachute rip stoppers are a means of attaching the lines to the plastic of the parachute and stop any growth of a rip in the parachute produced by the small holes through which the lines are attached. Also add a rubber band somewhere in the line for a spring back in the parachute lines, it will damp the force when opening the parachute.

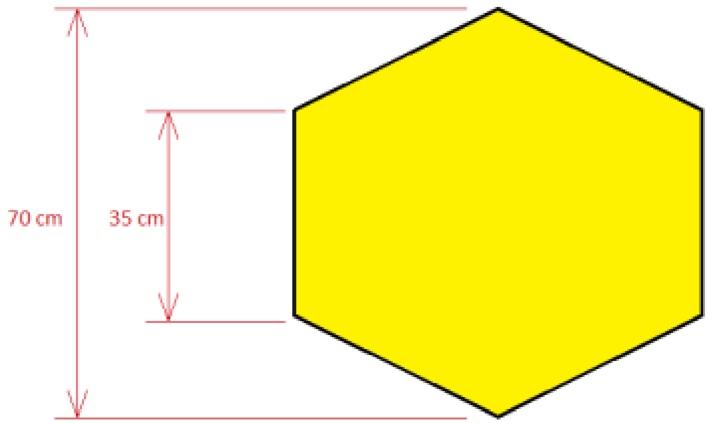


Figure 3

Launch platform and ignition system

The launch platform used for the rocket is the "Estes 302215 Porta-Pad II Launch Pad", this can be ordered online on www.amazon.com but many other sites sell this as well. This Launchpad is recommended for safety, see the figure below.

The ignition system is the "Electron Beam® Launch Controller", which is also wildly available on the internet and on www.amazon.com, www.estesrocket.com and www.modelrakketen.nl . The use of the engine in combination with the ignition system is well explained in the manuals of the launch platform and ignition system, see the figure below.

Example Competition regulations model rocket

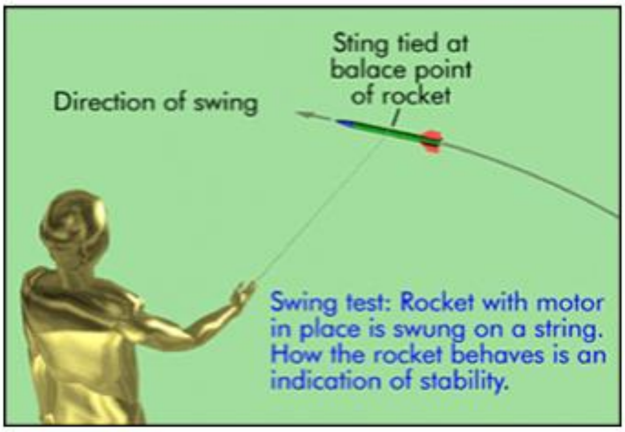
The goal of the rocket competition is to build a printed rocket with a team of 4 students. The designed rocket that launches the highest and that is closest to the calculated values is the winning team. Students will receive standard parts for the rocket (engine). In the OpenRocket software that is available online for free you can dimension the rocket (http://openrocket.sourceforge.net/).

There are some rules and regulations applicable; (they can be expanded by the team if needed)

1. Entrance of the competition
   - 1.1. Entrance of the competition is allowed for everyone.
   - 1.2. Entrance of the competition in groups of 4 persons.
   - 1.3. The competition will continue unless the wind-power is not exceeding 3 Bft.
2. Rocket
   - 2.1. The rocket needs to launch with a sufficient detonator provided by the school.
   - 2.2. The rocket needs to launch from a launch platform provided by the school.
   - 2.3. The rocket needs to launch with a D12-3 motor provided by the school.
   - 2.4. The rocket needs to land by a parachute and has to be intact for second launch, this is a jury decision.
   - 2.5. The structure of the rocket has to be strong and stiff enough.
   - 2.6. The rocket cannot exceed 1m of length.
   - 2.7. The rocket has to have an inner diameter of 24mm, because of the engine casing
   - 2.8. Stability needs to be proven before launch with a simple Swing-test. Look for more information http://www.modelraketten.nl (in Dutch) or in the appendix for a description made by www.rockets4schools.org
   - 2.9. Use the opensource OpenRocket software to calculate the CG and CP. These results have to be checked before launch.
   - 2.10. The rocket cannot exceed a weight of 600 grams in total.
3. Safety
   - 3.1. The engine will be installed by a member of the jury.
   - 3.2. All necessary safety requirements are of means during the installation of the engine.
   - 3.3. A team member can press on the take-off button after countdown.

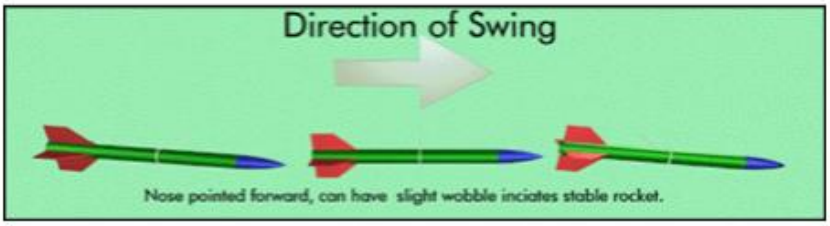
Appendix I – Swing test

The Swing Test

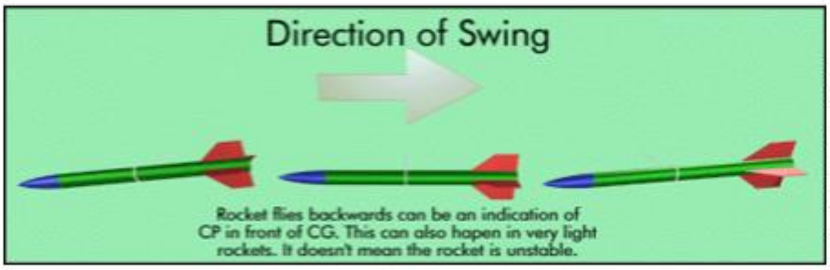


The swing test is a basic test to give you a rough idea how your rocket will fly.

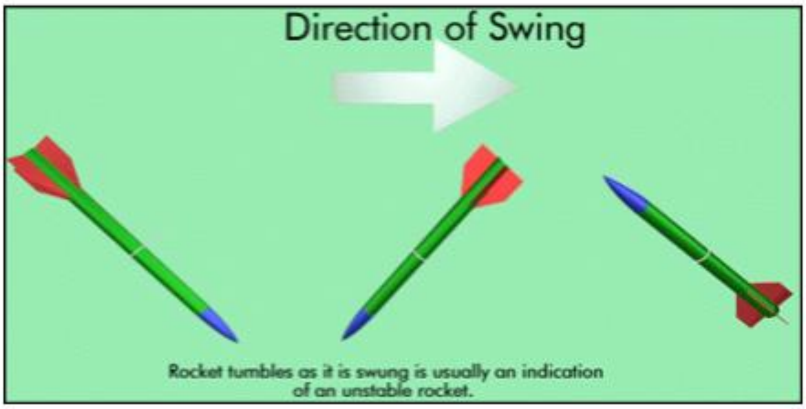
There are basically three things that can happen when you do this test:



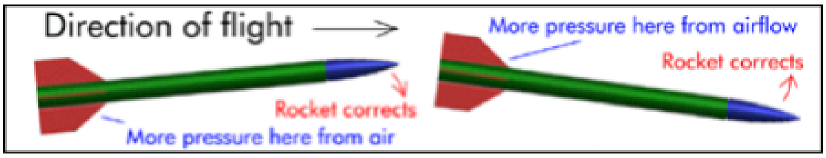
If you swing your rocket and it points in the direction you swing it, it is a good indication that your rocket will be a stable flyer.



Sometimes your rocket flies backwards. I have had this happen when a rocket is very small or light. The motor is so heavy in comparison, that the Center of Gravity is very near the Center of the motor. On a standard type tube-with-fins rocket, if it balances on a string with a motor in it, and it balances in front of the fins and motor, you don't need to worry about it.



Sometimes a rocket will just cartwheel as you swing it. It is usually a sign that the CP and CG are too close together. Try adding a little weight to the nose, and see if your rocket straightens out.



The idea is to make a rocket which will use air pressure to correct its own flight. As the rocket flies upwards, it will try to turn or tumble. As it deviates from straight up, the pressure of the wind will push the tail fins back behind the center of Gravity. *The Center of Pressure always tries to follow the Center of Gravity.* So, you can see that if your Center of Gravity is closer to your fins than your Center of Pressure, your rocket will try to fly backwards! If your rocket is very light, and your motor heavy, this sometimes puts your center of gravity so far back that your rocket becomes unstable. This is one of the things you need to check for when you design your own rockets.

What you can do about it.

There is almost nothing you can do about your Center of Pressure other than to make your fins larger. The bigger your fins, the farther back the CP. You can more easily move your Center of Gravity by adding weight to the nose of your rocket, or making your rocket longer. This moves the CG towards the front. Ideally, you want your Center of Gravity to be one or two body tube diameters in front of your Center of Pressure. This is called one-calibre stability, and most rockets are close to this.