Parametric Rocket: Phase 1

SolidWorks CAD modeling and mass properties

What I did

I designed the rocket in SolidWorks as five separate parts: a body tube, a tangent ogive nose cone, a motor mount tube, a centering ring (used twice), and a fin (used three times). I gave each part a real material, assembled them with mates, and ran Mass Properties on the full assembly. That gave me the dry mass, center of mass, and moment of inertia that I carried into the OpenRocket simulation in Phase 2, so the simulation would use numbers from the rocket I designed instead of the simulator's own estimates.

The nose cone

The nose cone is a 150 mm tangent ogive with a 41.3 mm base diameter. I built the profile from the ogive formula and revolved it around a centerline, so the shape comes from an equation instead of a hand-drawn arc. It was the hardest part to model, so I did it early while I had the most patience for troubleshooting.

The fin

The fin is a trapezoid sketched with explicit dimensions: a 120 mm root chord, 70 mm span, and 60 mm sweep. The 10 mm offset at the trailing edge leaves a 50 mm tip chord (120 - 60 - 10). I extruded it 3 mm thick, set the material to plywood at 700 kg/m^3, and patterned it three times around the body tube in the assembly.

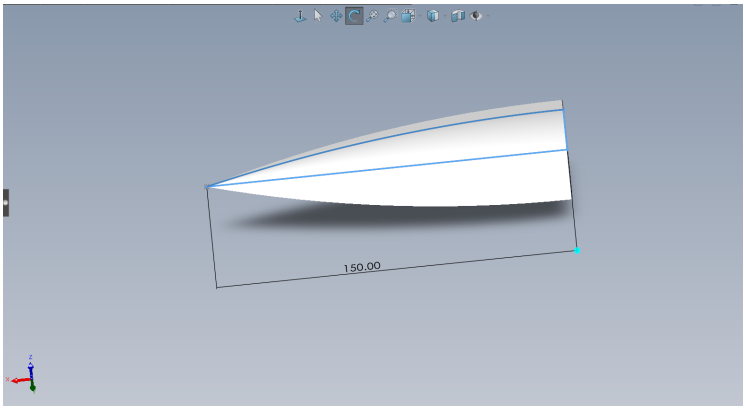


Figure 1. Ogive nose cone, 150 mm long, with the profile curve and length dimension.

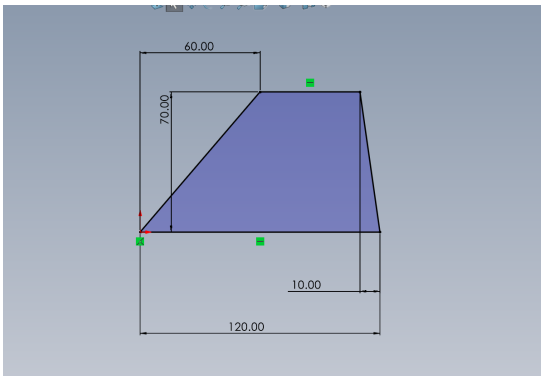


Figure 2. Fin sketch with root chord, span, sweep, and trailing-edge offset dimensioned.

Assembly mass properties

With all parts mated, I ran Mass Properties on the assembly with no motor installed. The results are below.

Property	Value
Dry mass (no motor)	121.00 g
Center of mass, from nose tip	398.35 mm (about 61% of the 650 mm length)
Moment of inertia, pitch and yaw (Lyy = Lzz)	3,877,270.91 g·mm^2 (3.877 x 10^{-3} kg·m^2)
Moment of inertia, roll (Lxx)	140,916.61 g·mm^2 (1.409 x 10^{-4} kg·m^2)

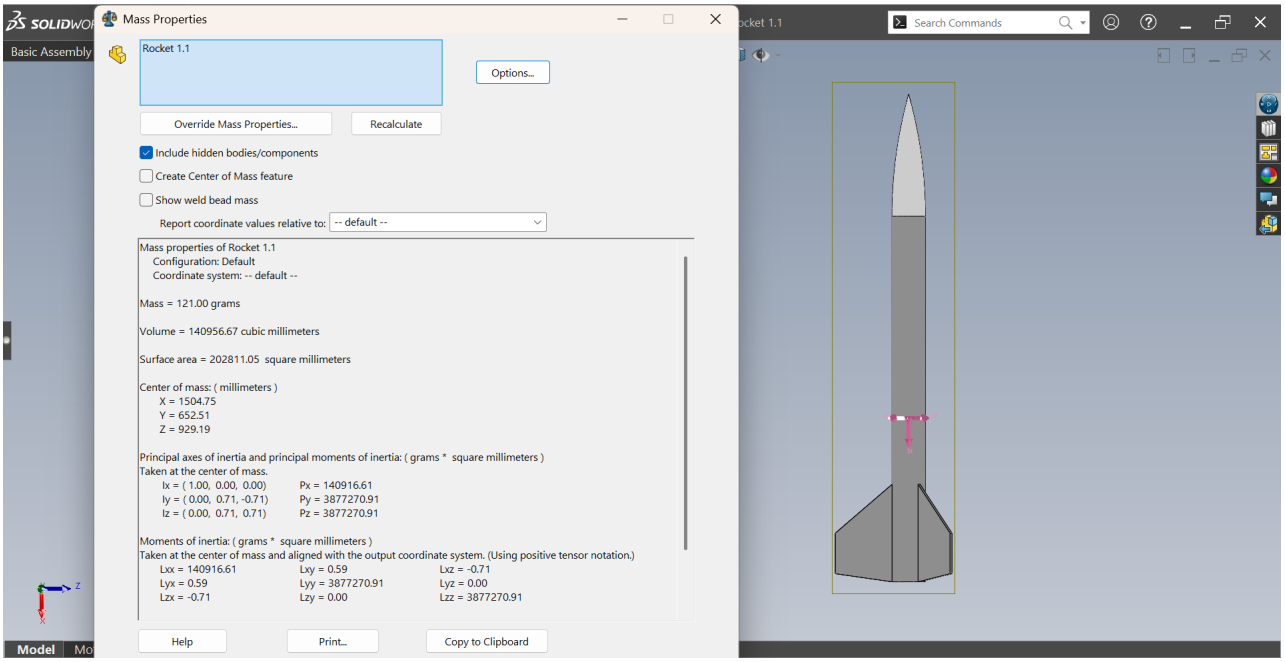
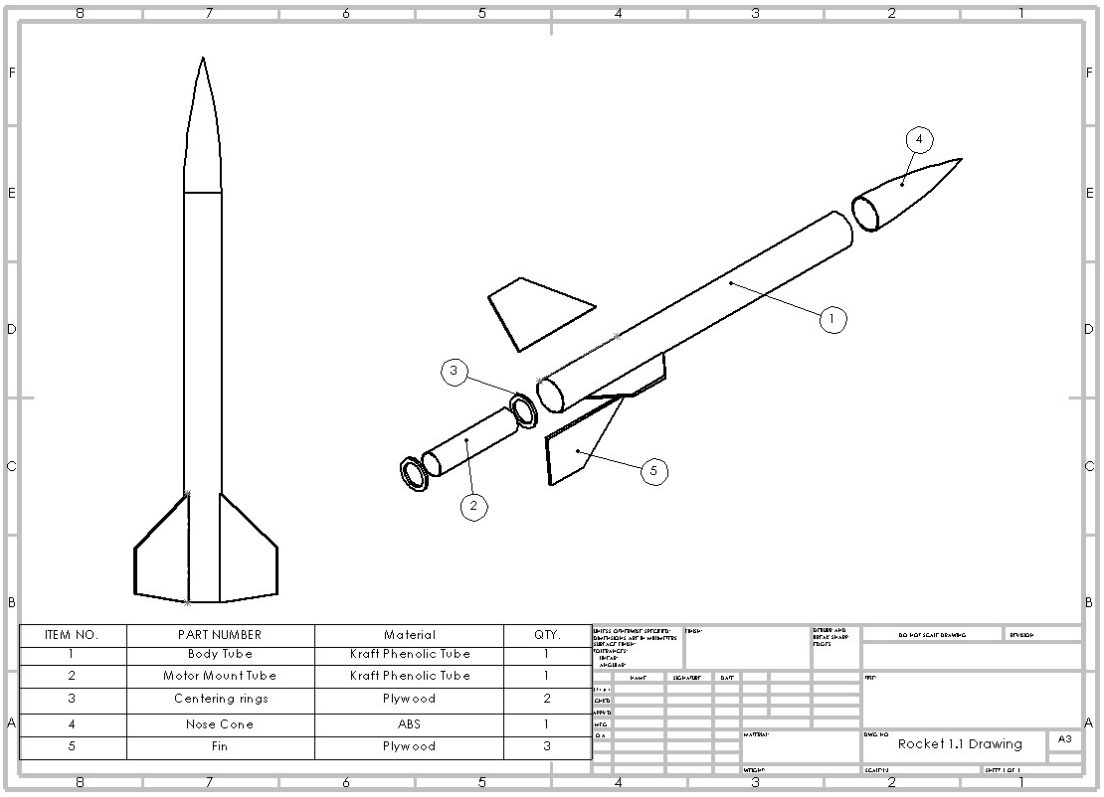


Figure 3. SolidWorks Mass Properties window for the full rocket assembly. SolidWorks reports the center of mass in its default coordinate system, so I converted it to a distance from the nose tip.

Assembly drawing

I documented the design in an assembly drawing with a front view, an exploded isometric view with numbered balloons, and a bill of materials listing each part's material and quantity.



ITEM NO.	PART NUMBER	Material	QTY.
1	Body Tube	Kraft Phenolic Tube	1
2	Motor Mount Tube	Kraft Phenolic Tube	1
3	Centering rings	Plywood	2
4	Nose Cone	ABS	1
5	Fin	Plywood	3

Figure 4. Assembly drawing (A3): front view, exploded view, and BOM. Kraft phenolic tubes, plywood centering rings and fins, and an ABS nose cone.

What I learned

- **Check the spec before modeling.** Two dimensions in my spec did not fit together. The centering ring OD was listed as 41.3 mm, which is the outside of the body tube, so the ring could not fit inside it. I changed it to 39.3 mm (the tube ID). The 29 mm motor mount "ID" and the ring "ID" also described two different surfaces, so I treated 29 mm as the mount tube OD. Catching this first saved me from chasing mate errors in the assembly.
- **Materials decide the mass properties.** The geometry alone says nothing about mass. Setting plywood, ABS, and kraft phenolic on each part is what made the mass and center of mass meaningful.
- **Reading the inertia numbers.** The pitch and yaw moments are equal, as expected for a rocket that is nearly symmetric around its long axis. The roll moment is about 27 times smaller, because most of the mass sits close to the centerline.
- **The model is lighter than my target.** The assembly came out at 121 g, below the 180-220 g range in my spec. The model only includes the five structural parts, so glue, paint, a parachute, and shock cord would add to it on a built rocket.

Next: these values go into OpenRocket in Phase 2.