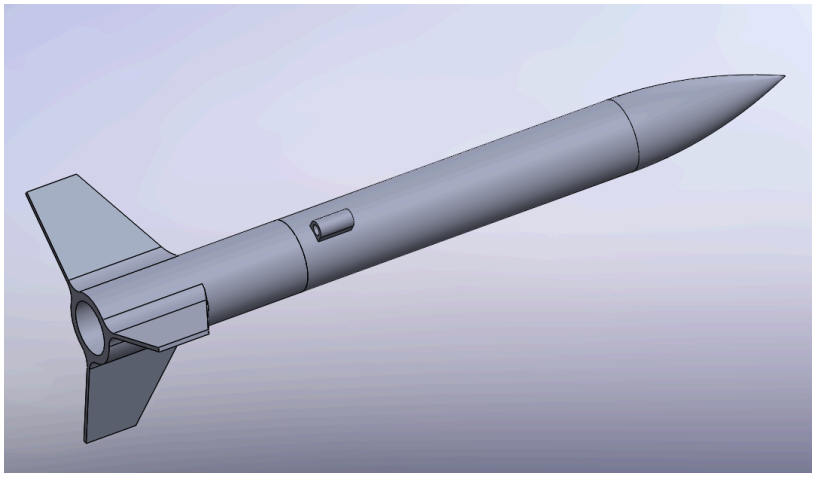
3D Printed Rocket (3DPR)
E1RK - Spring 2025



Introduction

In groups of 2 or 3, you will be constructing a 3D printed, A-class rocket. This project aims to emphasize rapid prototyping, iterative design, rocket design, and manufacturing techniques.

Project Guidelines

Rocket Design

The main criteria for rocket design will be to create a stable design that is producible through 3D printing. All components of the rocket body, fins, and nosecone shall be made of 3D printing plastic material (PLA). The rocket must be able to retain an Estes A8-3 motor and contain a parachute that can be deployed using the built-in ejection charge. You will also be creating your own parachute.

3D Printing Tolerancing and Iterative Design

3D Printing technologies allow for rapid prototyping and quick iterations of design. However, it does come with its limitations. Some of these limitations will arise when designing and manufacturing your rockets. Your rocket will most likely not be perfect the first time. That is alright and in fact preferred! An entire rocket can be printed in about 10 hours, so this allows for multiple versions to be created and tested before submitting your final design for launch (but start early!).

Design Requirements:

Ultimately any rocket design you come up with is encouraged as long as it is safe, manufacturable, and flies well. Carefully consider each of the following requirements so that your design will work without too much trial and error.

OpenRocket Requirements

- Obtain a stability in the range 1.10 - 2.50
- Ensure your ejection of the parachute happens **after** the anticipated apogee. The ejection delay is 3 seconds after motor burnout. The motor burntime is 0.7 seconds.
- No nosecones with a sharp point (just in case recovery is not successful…)
- The rocket should weigh **less than 3 ounces** (including the mass of the motor)
- Your rocket needs to be traveling at least **15.24 m/s (~50 ft/s) at the top of the launch rail** in order to have sufficient stability
- Try to obtain maximum apogee! This means considering the tradeoff between increased stability and increased mass/drag (experiment with the fin and body tube sizing)
- Launch lug near CG (center of gravity)
- **Minimize speed at landing**
- Use a launch rail length of 1 m (39.37 inch)
- **Leave room for parachute and shock cords** (~15 cubic cm assuming 30 cm diameter parachute– add more if larger)
- Add shoulders and couplings to each seam between body parts (default length of shoulders and couplings = diameter of rocket)

CAD/Dimensioning Requirements

*These are guidelines that should help make a usable rocket. They may not produce perfect fitment/alignment and you are free/encouraged to experiment with your own values

- Minimum recommended print wall thickness: 0.16 cm (0.0625 in or 1/16")
- All components must fit together snugly. Diameter tolerancing for body tube-shoulder fitment: 0.0254 cm (0.010 inch) (if you don't quite get the correct tolerance, there's always tape or sandpaper to fix it)
- Upon ignition, there needs to be a retention system in place to prevent the motor from pressing into the body tube (bulkhead)
- There is a black powder ejection charge at the top of the motor that will explode to eject the parachute at apogee (after the timed delay charge). The explosion must be able to push out the parachute (don't make the seal too tight).
- Your rocket must successfully fit on the launch rail, without interference from the fins (launch lug is not directly on top of one of the fins).
- The motor should stick out a bit from the body tube when mounted to allow for its removal after launch (bulkhead slightly less than 70 mm from the bottom of rocket)
- Include **two bars to attach parachute/shock cords** (>= 0.3 cm thick, through the center/slightly to the side of rocket): one in the body tube and one in the nose cone
- Your parachute must be
    - Attached via the shock cord to all rocket components (no loose falling parts!). One possible design is to create places for the shock cord to tie onto the nose cone and fin can (like bars or hooks on the inside).
    - Ejects successfully- there can't be anything blocking the ejection of the parachute
    - Easy to assemble (don't try to tie some string around a bar buried deep inside the tiny body tube) Hint: It may be easier to easily attach the shock cord if you create the fin can and body tube as two separate components.
- Your rocket should look nice! (make filets, rounded corners, and decorate!)

3D Printing requirements

- The maximum print dimensions are 8” x 8” x 8”
- Unsupported components on the vertical axis will be printed with support material beneath them. The minimum unsupported overhang angle is around 45°; if the angle between your geometry and the bed is less than this, it will need support. Create geometry that requires minimal support material (ideally none)
- All components should have a flat bottom to sit securely on the print bed. (This probably means no pointy fins)
- 20% infill is good for most projects (though in this case the geometry is small enough that there won’t be much to infill)
- The printing nozzle thickness is usually 0.2 mm. Any geometry smaller than that will not be printable. (this should give you a decent idea of the tolerances the printer is able to do)
- Orient your prints on the bed to minimize support material
- If you do not know what you’re doing, ask for help to minimize your mass and print time, and optimize the slicer print settings.

Useful Dimensions for Rocket Design

- Motor (Estes A8-3)
  Diameter: 18mm (0.7087 in)
  Motor Length: 70mm (2.7559 in)
- Launch Lug:
  Inner Diameter: 3.81 mm (0.150 in)
  Wall Thickness: ≥ 1.27 mm (0.050 in) (yes, thinner than other parts)
  Length: ≈12.7 mm (0.500 in)

Available Materials

Raw Materials:

- 3D printing capabilities (PLA)
- Kevlar string
- Cardboard
- Hot Glue
- Masking Tape
- Sandpaper

Rocket Parts:

- Motor: Estes A8-3
- Ejection wadding
- Kevlar shock cord
- Parachute cloth (nylon)

Checklist:

- Stability between 1.1 and 2.5
- Ejection is after apogee in OpenRocket plots
- >=15.24 m/s off the rail speed
- <=5 m/s landing speed
- >=15 cubic cm of space left for parachute
- All connecting pieces have a shoulder or coupling
- All parts of rocket that touch/fit in to another has 0.0254 cm of tolerancing
    - Includes between motor and body tube - MAKE SURE YOUR MOTOR FITS
- Launch lug is not directly on top of fins
- All parts of the rocket have bars or hooks (>=0.3 cm thick) to attach shock cords
- Motor block in front of motor
    - Motor block has a hole in it for ejection charge 80-90% of your body tube inner diameter
- Motor sticks out of rocket slightly
- Fins are built into body tube
- Launch lug inner diameter is correct
- Shoulder to connect nosecone and body tube
    - Shoulder is securely connected to the part it is on
- No one part is greater than 8” x 8”x 8”