ZENITH CLUB

Student Rocket Project Proposal

PROTOTYPE 1

AIM:

To construct and demonstrate a recoverable solid propellent rocket which can reach an altitude of 150m and recovered.

OBJECTIVES:

Laying the groundwork for future development of high-altitude and propulsive reusable rockets. This proposal includes all essential components, fabrication methods, and estimated costs for developing the first rocket at IIT Ropar.

REQUIRED MATERIALS:

1) FUEL OXIDISER MIXTURE – KNO_3 +SUCROSE [65 : 35]

2) PVC PIPE FOR ROCKET MOTOR

3)MSEAL, ARALDITE

4)CLAY

5)BAKING SODA FOR DELAY CHARGE

6)BLACK POWDER

7)VISCO FUSE

8)NOSE CONE

9)SPRINGS

PHASES OF CONSTRUCTION:

THE FIRST FLIGHT IS JUST A DEMOSTRATION OF ROCKET MOTOR AND PARACHUTE DEPLOYEMENT SYSTEM, AND DOES NOT INCLUDE ANY CONTROL/COMMUNICATION SYSTEMS TO RECORD/RELAY ANY TELEMETRY DATA THE LATER ITERATIONS MAY INCLUDE .

PHASE 0: DESIGN

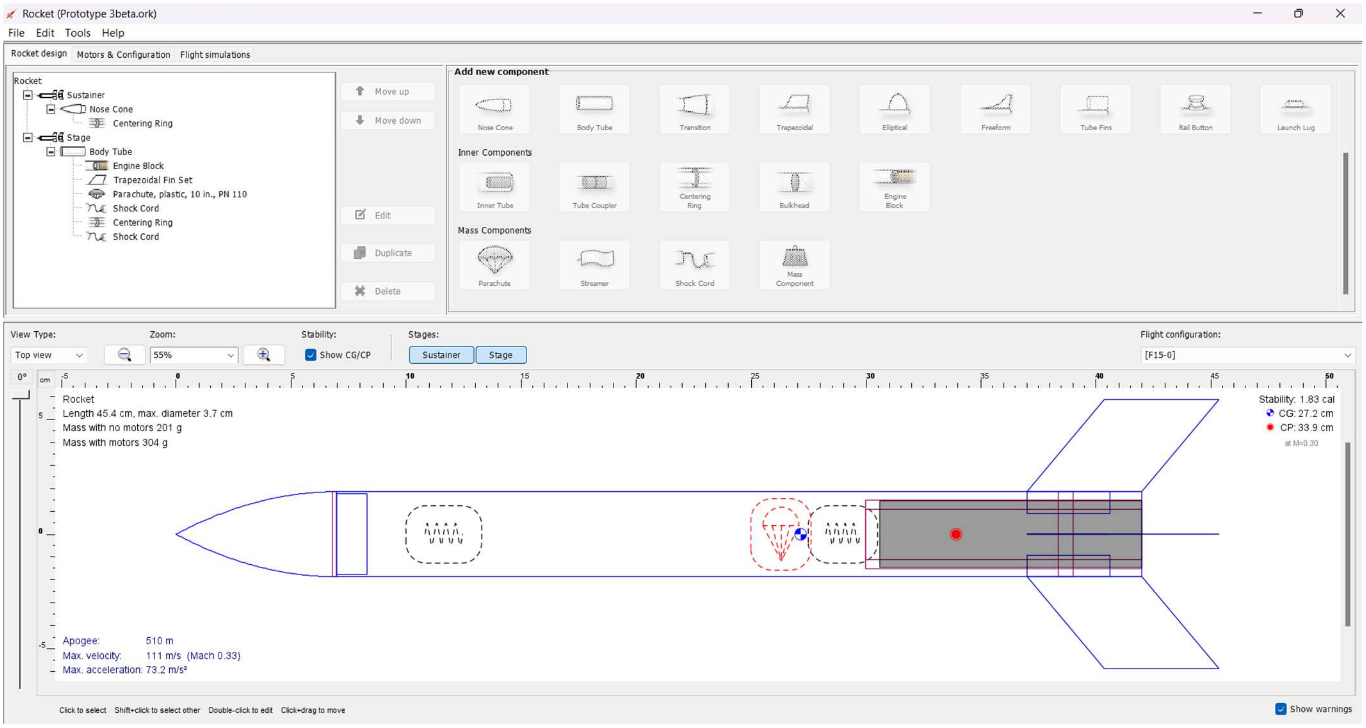
PHASE 1: ROCKET MOTOR FABRICATION

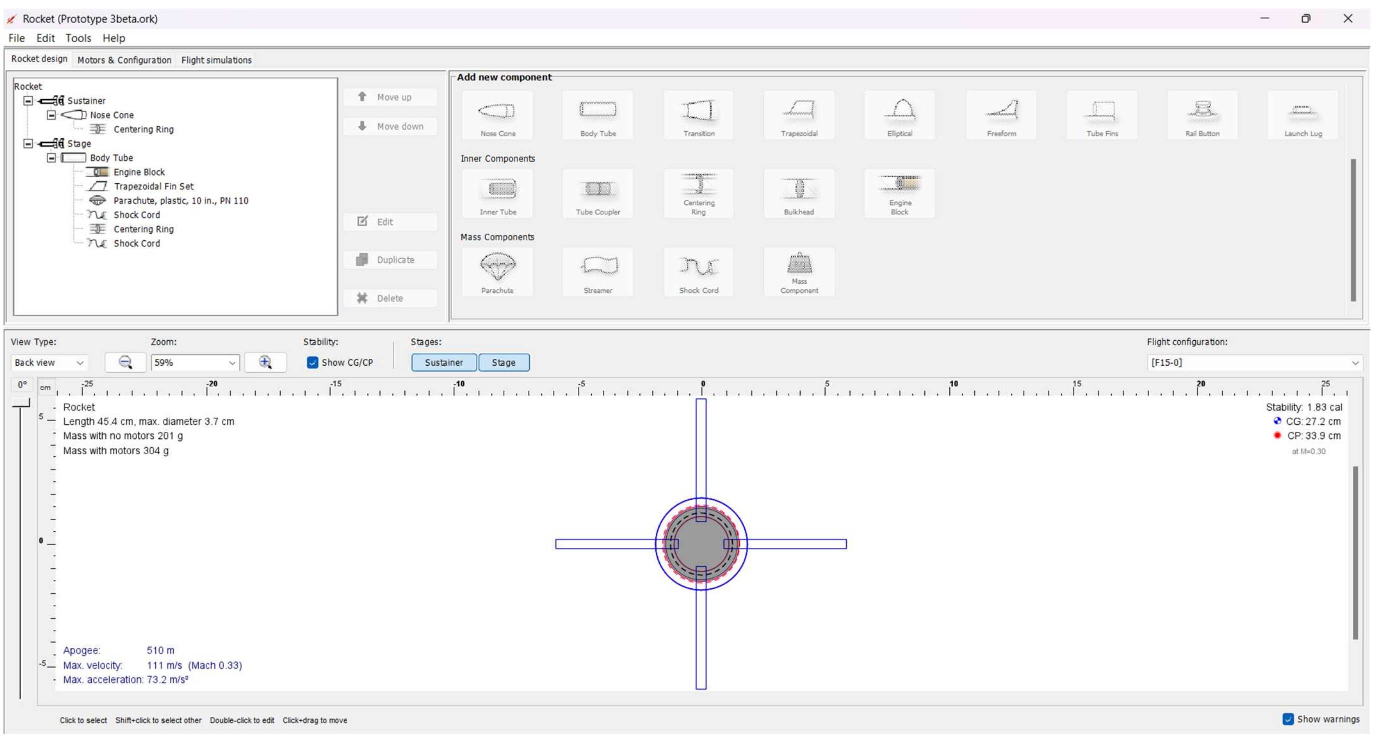
PHASE 2: PARACHUTE AND DEPLOYEMENT MECHANISM

PHASE 3: FINS AND NOSE CONE FABRICATION

PHASE 4: INTEGRATION AND TESTING

PHASE 0: DESIGN



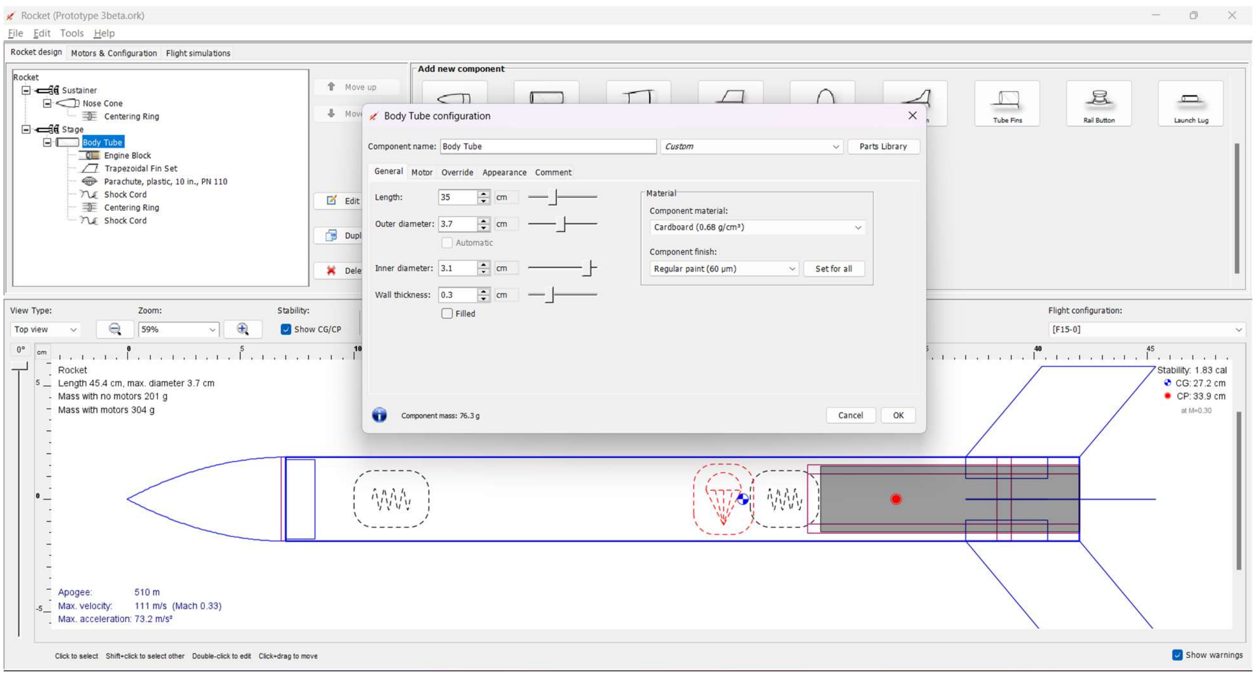


OBJECTIVES OF THE DESIGN :

- **MINIMIZING WEIGHT, MAXIMIZING MAX HEIGHT**
- **IMPROVING AERODYNAMIC STABILITY (>1.5CALIBER) --> CP IS BELOW CG**

(I) ROCKET BODY

1) The main cylindrical Body (L=35cm; d = 3.7 cm) of Rocket is chosen to cardboard (0.68 g/cm^3) to MINIMIZE the weight .
2) The length of the body directly increases the height of CG, and hence the distance from CP which increases the moment generated by CP, hence improving stability.
3) So greater the length of rocket body better the stability, but length increases mass which reduces H_{max} so between a optimal length of 35 cm is chosen as the best balance between tradeoff of height and Stability.

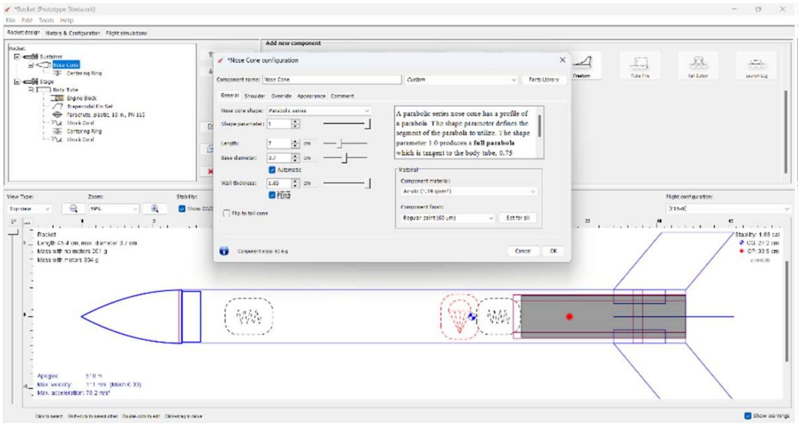


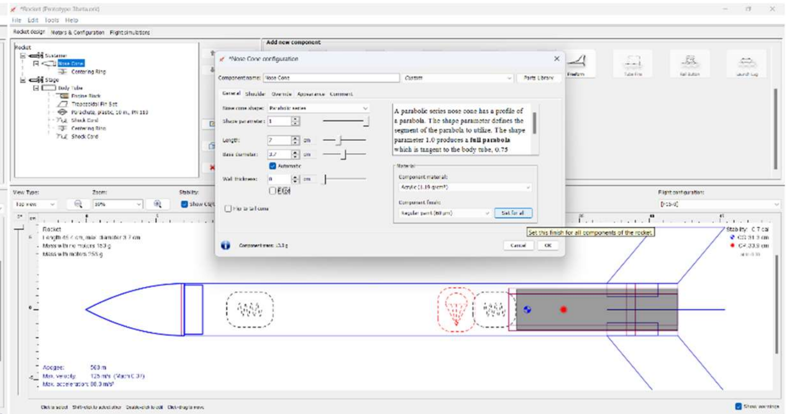
4) Min dia. of 3.1 cm is chosen to exactly fit the rocket motor and any additional dia. is just useless mass.
5) Modifications in length and diameter can be made to increase range and strengths in tradeoff with Stability.

(II) NOSE CONE

1)Similar to body, increasing the nose cone length will increase CG. An optimal length of 7cm is chosen and the nose cone must be solid to keep CG away from CD. If the nose cone is hallow them there is a drastic decrease in Stability [1.83 cal -> 0.7 cal].

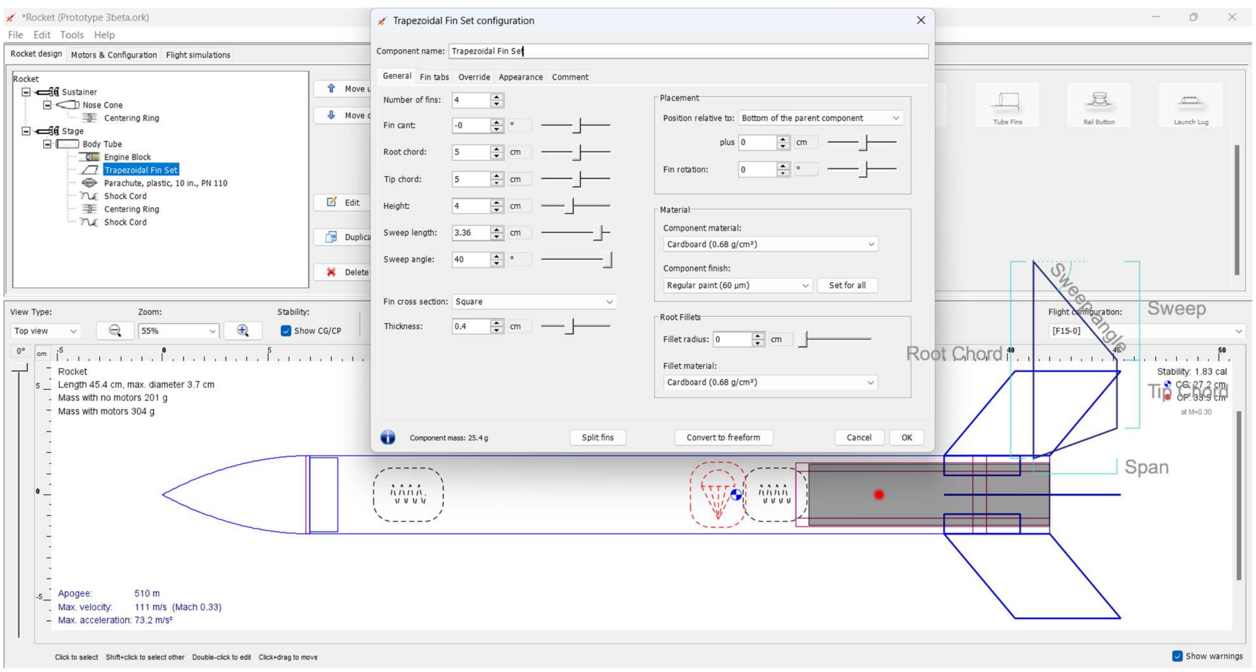
2)O Rings or Springs can be used to Fit the Acrylic Nose cone inside the rocket body.





(III) FINS

1)Fins play the most important role in providing the CP, they contribute to all most all of the Aerodynamic stability.

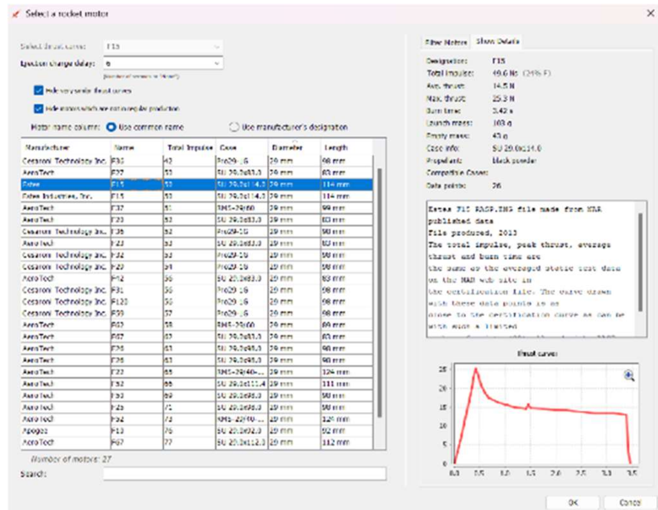


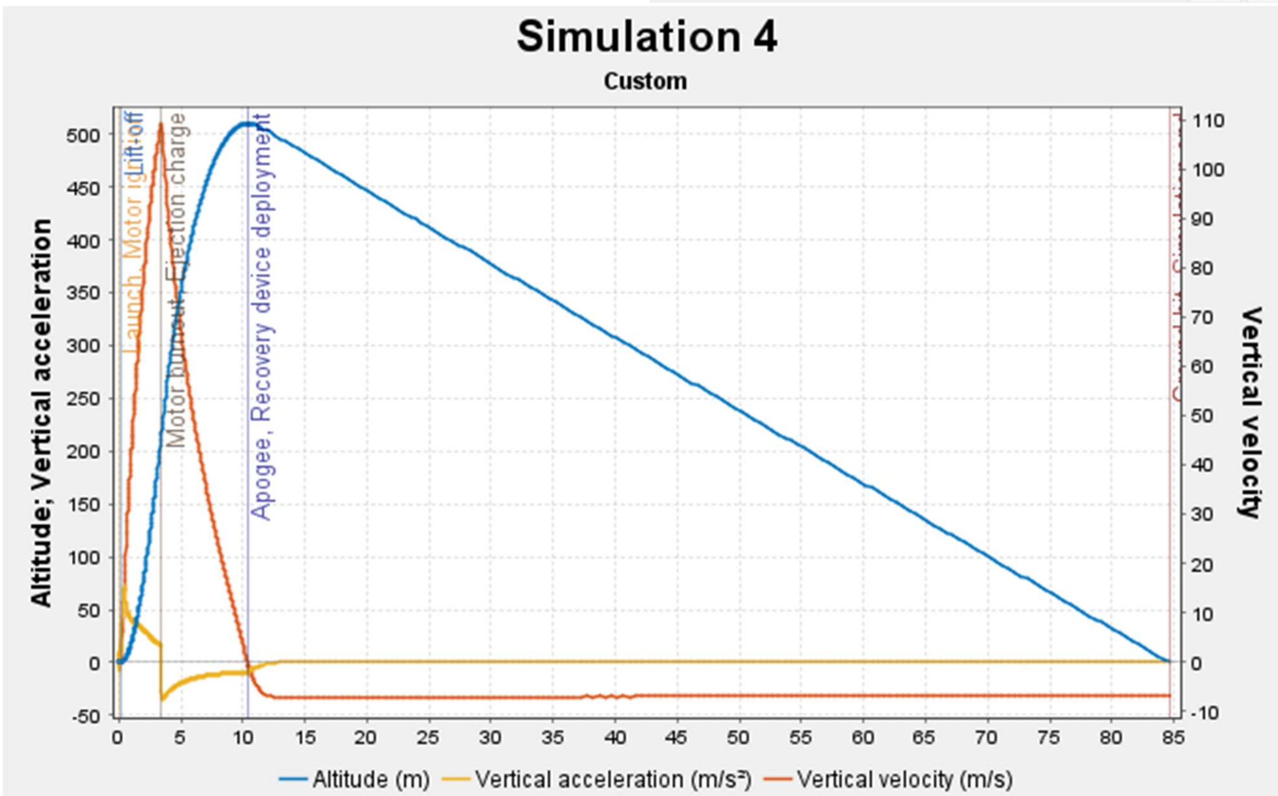
2)The most significant dimension s of cardboard fins that directly affect the stability are Root chord, Height and Sweep angle. An easy to make optimal combination of dimensions are chosen as,

Root Chord = 5cms; Height = 4cms and Sweep angle = 40degrees, gave Stability of 1.83 caliber.

(IV) – ROCKET MOTOR AND SIMULATIONS:

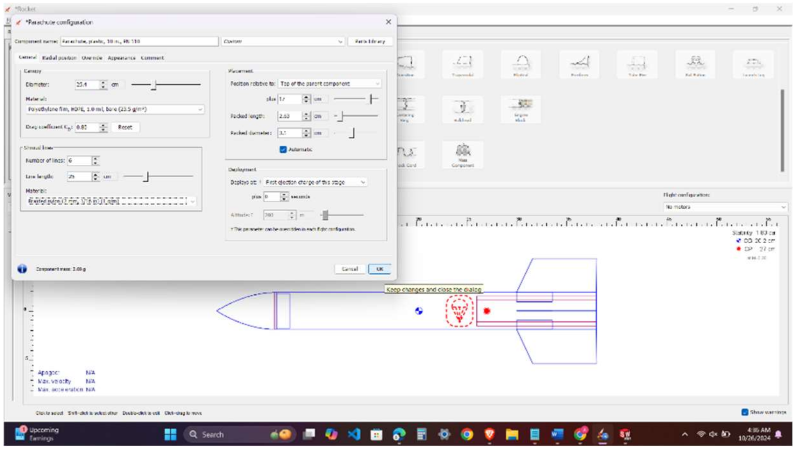
1) The average thrust of a sugar rocket with a diameter of 29 mm is approximately 11 N, which is comparable to that of an F-class rocket motor.
2) Since Open Rocket does not include a sugar rocket motor of these dimensions, I opted for the Estes F15, which uses black powder as its propellant and has a similar average thrust (~15 N) for running these simulations. This is why an abnormal maximum apogee of 500 m is observed; although our motor may not reach 500 m, I am confident it can achieve an apogee greater than 150 m and will follow a similar flight profile.

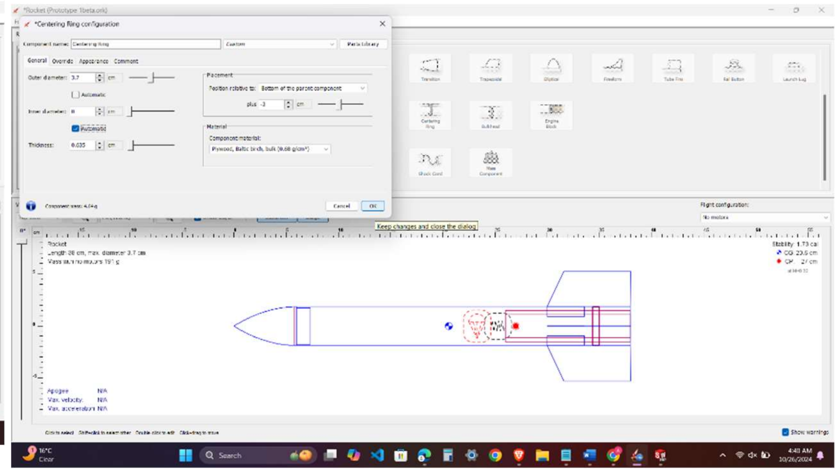


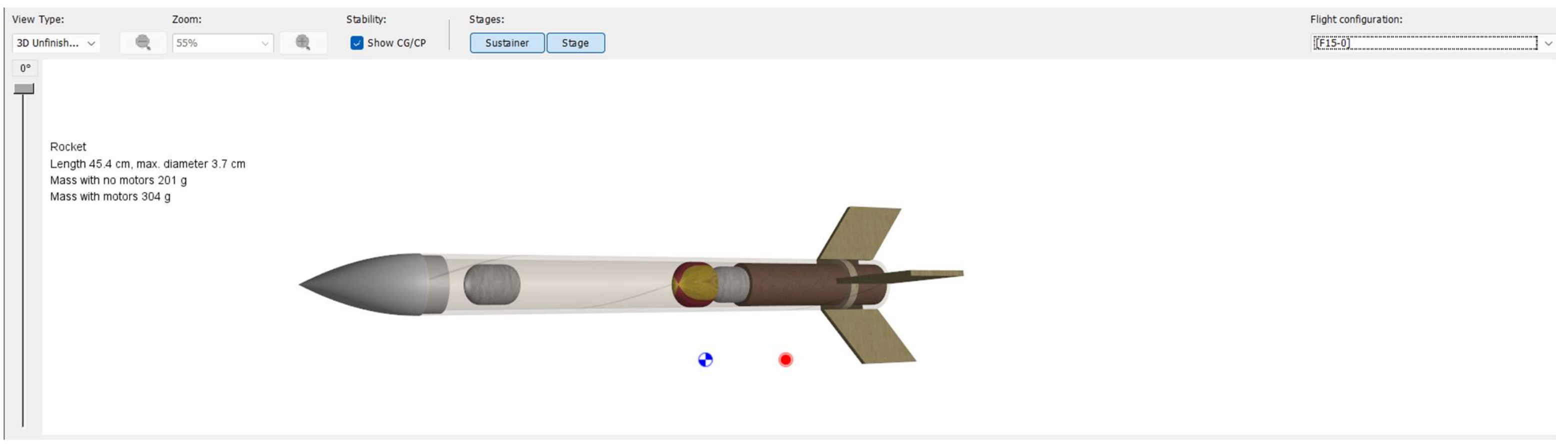


3) Based on Simulations (V(m/s), a (m/s^2), h(m) vs t(sec)) a delay charge of 6-8 sec must be used in the motor to deploy the parachute at Apogee .
4) It is evident that vertical g forces can be structurally sustained by cardboard body.

PARACHUTE AND CENTER RING PARAMETERS







PHASE 1: ROCKET MOTOR FABRICATION

1. Materials Preparation

Gather powdered sugar, potassium nitrate, mseal, ¾" PVC tubing, and a ¾" oak dowel.
Cut the PVC tubing into 5-inch sections, and mark the oak dowel to indicate the required packing heights.

2. Mixing Rocket Fuel

- Weigh 65 grams of potassium nitrate (KNO_3) and blend it into a fine powder using a dedicated blender.
- Add 35 grams of powdered sugar to the potassium nitrate and shake the mix for 3 minutes until evenly blended. This forms the propellant mixture.

3. Assembling the Rocket Motor

- Place a PVC section on a firm surface. Add mseal into the PVC tube and compact it using the oak dowel and a rubber mallet. Repeat this process until the clay plug is ¾" thick.
- Slowly add the mixed propellant into the PVC tube. Compact the propellant by hand, then use the oak dowel and mallet to compact it further.

4. Sealing and Creating the End Cap

- Add a final layer of mseal (¾" thick) on top of the propellant to seal the motor.

- Use the oak dowel to carefully compact this clay layer.

5. Drilling the Nozzle

- Drill a 7/32" hole through the clay and propellant core to create the nozzle. Be cautious to avoid generating heat or friction that might ignite the motor.

6. Final Checks

- Ensure all components are securely compacted and aligned. Store the completed motors safely until testing.

PHASE 2 : PARACHUTE AND DEPLOYEMENT MECHANISM

1. Delay Charge:

After the main fuel burns out, a delay charge with baking soda is set at the top of the motor to slow down the combustion. This delay allows the rocket to reach its maximum altitude before deployment.

2. Deployment Charge :

At the end of the delay charge lies a small quantity of black powder [To be made/Bought]. When ignited, this powder generates high-pressure gas, which breaks the seal and pushes the parachute out of the rocket.

3. Nose Cone Separation :

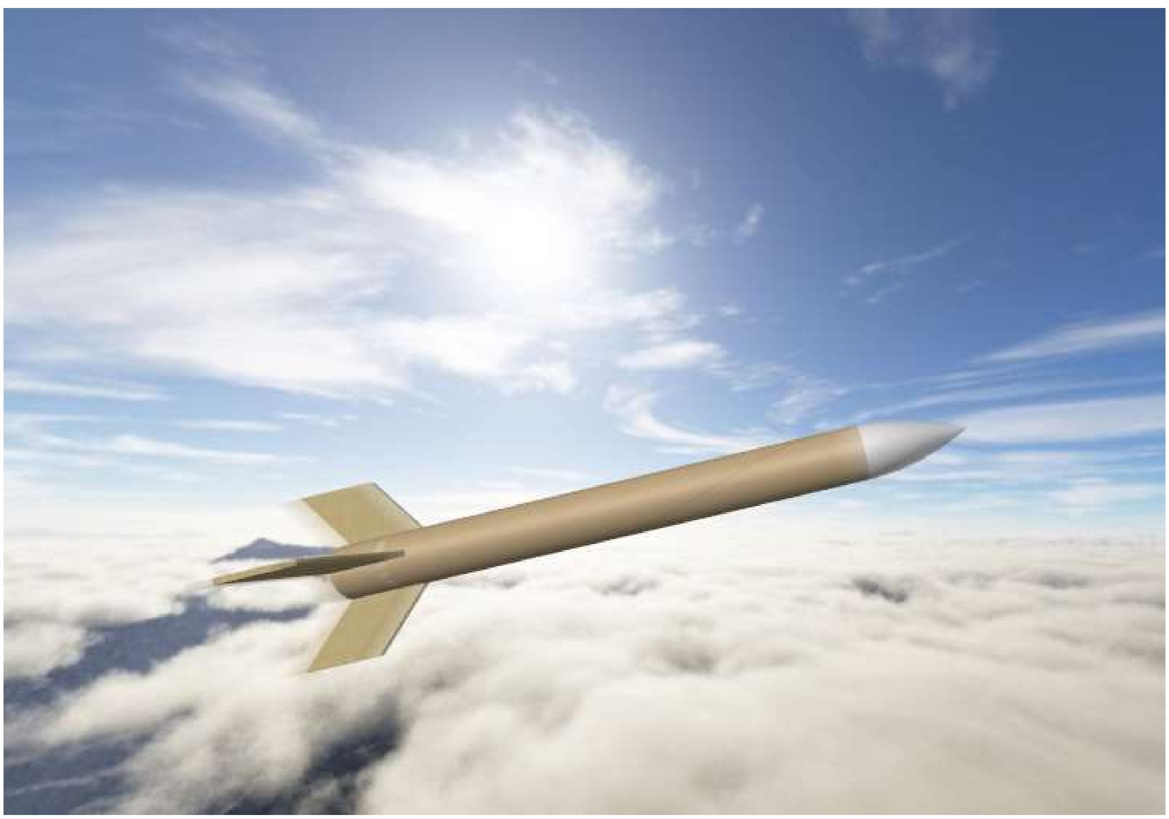
To aid in nose cone separation, springs are positioned at the base, just above the parachute [To be made/Bought] . These springs ensure a smooth release, helping the nose cone detach cleanly when the deployment charge activates.

PHASE 3 : FINS AND NOSE CONE FABRICATION

1. **Nose Cone Fabrication :**
   The nose cone can be either 3D printed from a CAD model or purchased from rocketeers.
2. **Fit and Dimensions :**
   The dimensions of the nose cone must be precise to ensure a secure and tight fit with the rocket body.
3. **Fin Fabrication :**
   Fins can be crafted from sturdy materials like cardboard or 3D printed for added precision and durability.
4. **Drag and Stability :**
   The dimensions of the fins are determined by the drag force they generate, given by $Fd=0.5 \cdot p \cdot v2 \cdot Cd$. This force creates the necessary moment to stabilize the rocket during its flight.

PHASE 4 : INTEGRATION

1. **Motor Attachment:**
   The rocket motor is securely fitted to the cardboard rocket body using O-rings or strong adhesives.
2. **Fin Attachment:**
   The four fins are carefully aligned and glued at 90 degrees to each other using adhesives to ensure stability.
3. **Parachute Placement:**
   The parachute is placed on top of the explosive charge with a thin protective layer. The nose cone and rocket body are connected to the parachute with durable cords.
4. **Spring and Ejection Mechanism:**
   To account for weight constraints, a base or mount points are installed above the parachute. Springs are mounted to these points and connected to the nose cone to provide a forceful ejection mechanism. These springs are isolated and covered to prevent interference with the parachute's deployment.
5. **Nose Cone Fitting:**
   The nose cone is fitted into the rocket body using O-rings or an intermittent dimensional fit for a secure connection.
6. **Final Inspection:**
   The entire assembly is carefully inspected to ensure everything is securely attached and ready for launch.



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