Rocket Performance Analysis & Comparison

Mr. Dahl's 1B Aerospace Engineering Class of 2023-2024

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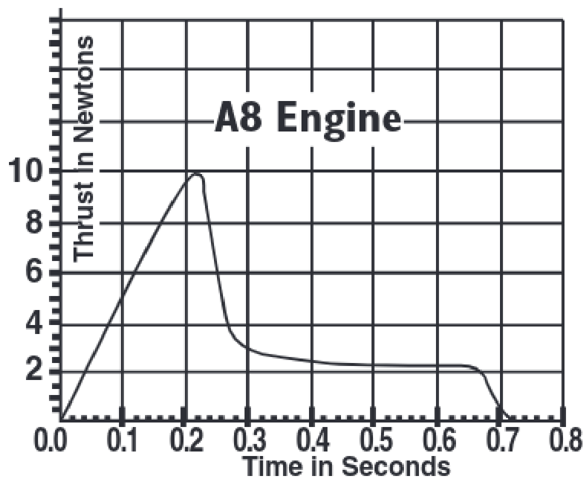
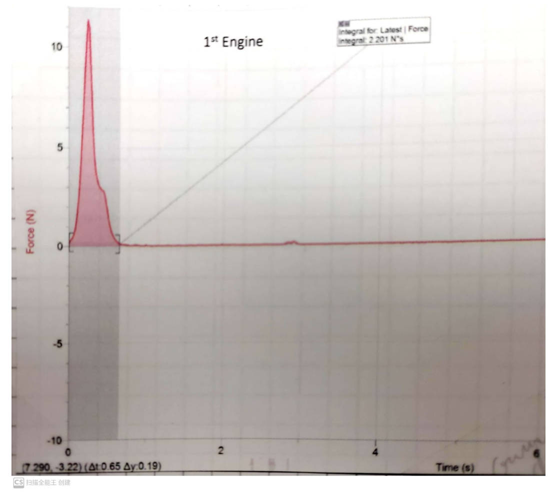
Samiksha Emmaneni and Simon Chen

Rocket Propulsion Introduction

Rocket engines are reaction engines that propel rockets outside the atmosphere by expelling high-speed exhaust gases in one direction. Rocket propulsion, compared with other propulsion types such as propeller, gas, turbine engine, and ramjet, has significant benefits for space travel. In comparison with a ramjet which requires a forward motion to feed air into the engine, rocket propulsion has the benefit of working at zero forward speed. Additionally, because the ramjet uses external air for combustion, it's a more efficient propulsion system for flight within the atmosphere rather than outside. Rocket propulsion on the other hand works for flight outside of the atmosphere as it makes use of exhaust gases that exit much easier and faster to increase thrust. In comparison to turbine engines and propellers, rocket propulsion systems work much more effectively in space. Turbines and propellors don't work in space because there is no atmosphere. Similar to ramjets, turbine engines make use of air from the atmosphere as the working engines while rockets use combustion exhaust gases- making rocket propulsion systems much more viable for flight outside of the atmosphere. Similar to ramjet, turbine, and propellant systems, gas propulsion systems make use of external air. The oxidizer used in this system is the oxygen from the air that's sucked into the engine of the plane. This is different than rocket propulsion systems as the oxidizer is carried with the vehicle. This would make gas propulsion systems ineffective in flight outside of the atmosphere as they won't have the oxidizers necessary for flight.

Engine Test

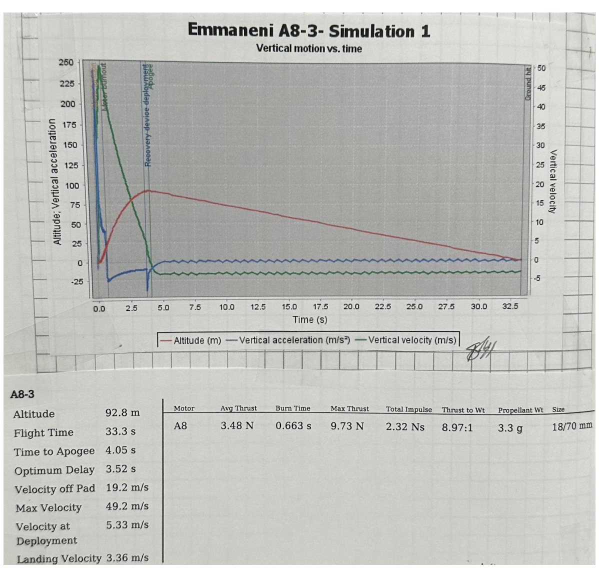


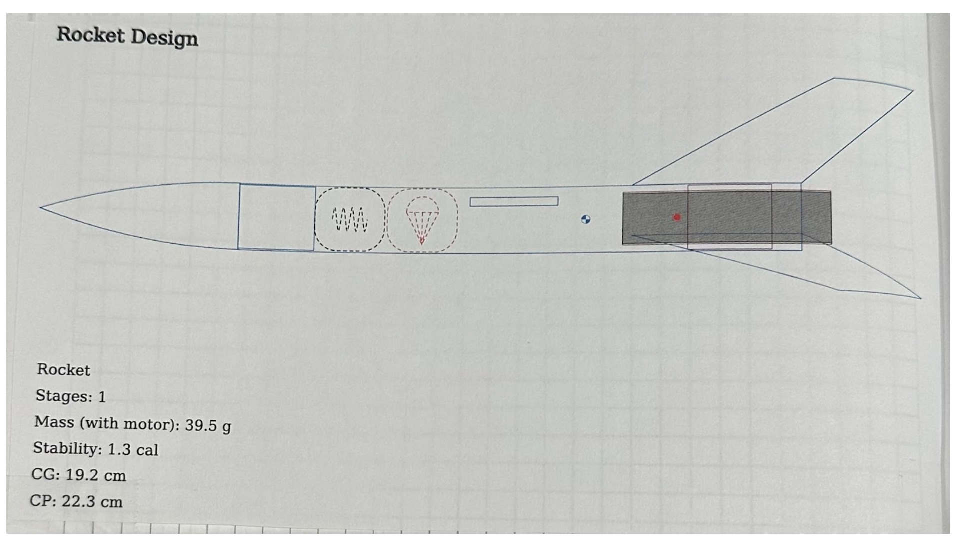


We tested three different types of model rocket engines: A8-3, B6-4, and C6-3. We first set up the testing site by clamping a pole with force sensors on it. The force sensors are connected to a computer to record the testing results. We would use the data that was collected to make a time versus force graph. With these graphs, we would be able to find the total impulse, average, thrust, maximum thrust, and delay time. Using this data, we would be able to compare it with the publicly published technical specifications to see if the data we collected was similar. Through comparison, we were able to see if the model rocket engines were doing what they were supposed to. In addition, we compared this data to see which rocket engine we wanted to use in the rocket that we were building and how much land and space we had to recover the rockets. After analyzing these results we concluded that the A8-3 engine was the best for us to use due to its lower average thrust. This was because a lower average thrust meant that the rocket wouldn’t reach too far up and stay within the launch premises.

Design & Simulate Using Open Rocket

Using Open Rocket, we simulated Estes Alpha Rockets using A8-3, B6-4, and C6-3 engines. The purpose of this was to allow us to design and simulate rockets before actually building and flying them. By accurately measuring and computing the aerodynamic properties of rockets regarding their parts, the results featured indicate essential information such as whether or not the flight is successful. Without these simulations, we wouldn't have been able to identify potential issues. This would have been a problem if we had discovered them while testing as that would have wasted both time and resources. Simulating using these engines also allowed us to obtain data such as the estimated altitude, flight time, and initial and final velocity. Knowing this information would help in making informed decisions during the design and testing phases of rocket development. After running all the simulations with the engines, we decided that the A8-3 engine was best because it didn't take the rocket too far up and had reasonable values for the total thrusts, impulse, and durations.



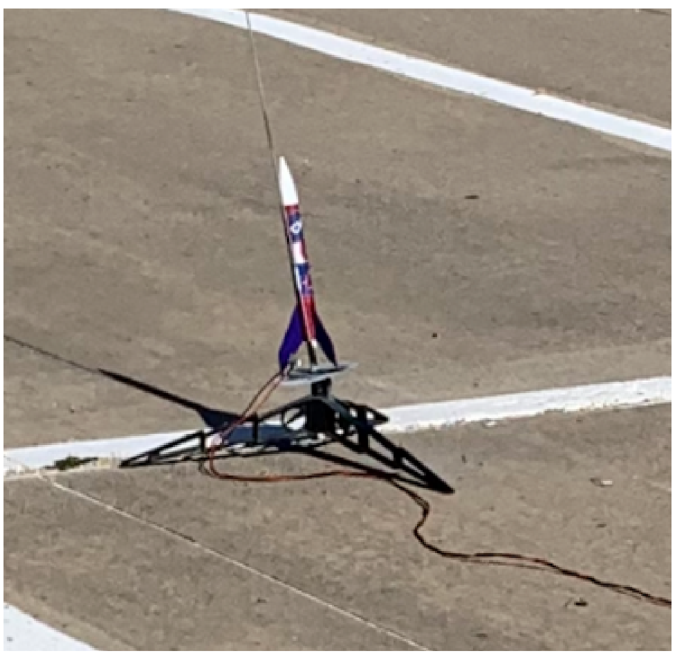


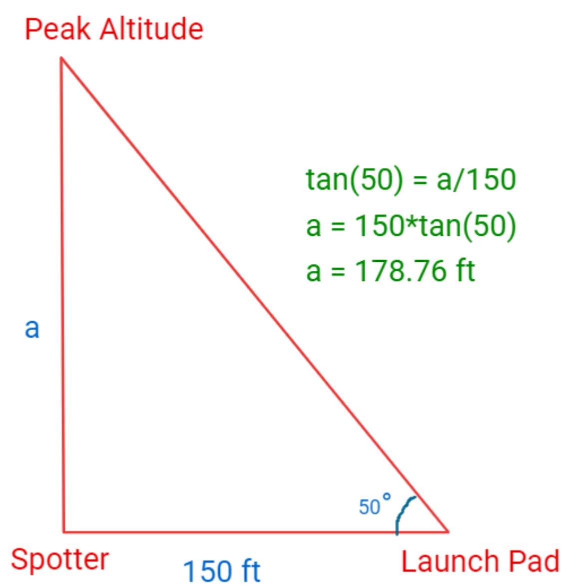
Parts Detail

Sustainer

Nose cone	Polystyrene (1.05 g/cm³)	Ogive	Len: 6.9 cm	Mass: 5.74 g
Body tube	Cardboard (0.68 g/cm³)	Dia$_{in}$ 2.3 cm Dia$_{out}$ 2.4 cm	Len: 19.6 cm	Mass: 4.44 g
Trapezoidal fin set (3)	Balsa (0.17 g/cm³)	Thick: 0.3 cm		Mass: 2.67 g
Launch lug	Polystyrene (1.05 g/cm³)	Dia$_{in}$ 0.118 cm Dia$_{out}$ 0.318 cm	Len: 3.1 cm	Mass: 0.9 g
Inner Tube	Cardboard (0.68 g/cm³)	Dia$_{in}$ 1.8 cm Dia$_{out}$ 1.9 cm	Len: 7 cm	Mass: 1.22 g
Centering ring	Cardboard (0.68 g/cm³)	Dia$_{in}$ 1.9 cm Dia$_{out}$ 2.3 cm	Len: 2.8 cm	Mass: 3.44 g
Shock cord	Elastic cord (round 2 mm, 1/16 in) (1.8 g/m)		Len: 30 cm	Mass: 0.93 g
Parachute	Ripstop nylon (67 g/m²)	Dia$_{out}$ 30 cm	Len: 2.5 cm	Mass: 3.84 g
Shroud Lines	Elastic cord (round 2 mm, 1/16 in) (1.8 g/m)	Lines: 6	Len: 30 cm	

Launch & Performance Analysis





The image on the right gives us an estimate of the actual height achieved from the launch shown in the image on the left. Using trigonometry, the estimated height was around 178.76 feet. This was calculated using a launch angle of 50 degrees from the horizontal, and a distance of 150 ft between the launch pad and spotter. However, in the simulation results with the rocket using the same A8-3 engine, the predicted height was much higher. It was around 92.8 meters which rounds to 304.462 ft. The reason for such a major difference between the predicted and actual height of the rocket was most likely due to the lack of forces accounted for in the simulation. The simulation may have neglected real-world factors such as air resistance, wind, or variations in engine performance which may have been reflected in the predicted height as it considered ideal conditions instead.