SPACE: THE FINAL FRONTIER

Astronomy Club, IIT Kanpur

Summer Project, 2021

Objective and Overview

Background

- Streaming of Apollo 11 Documentary even before the project began
- Curiosity towards Space Exploration and Missions

Objective

- Getting the mentees well equipped with the know-hows of the elements associated with rockets ranging from the structural and mechanical systems to studying the aspects of launching a rocket in outer space
- The means of analysing and writing a mission report and simulating a rocket in Kerbal Space Program.
- Have a look at the future of interstellar travel and what we must achieve before our goals become reality.

Methodology

- Developed a theoretical background of several Space Missions
- Introduction to components and systems involved in rocket designing
- Implemented real-world missions using Kerbal Space Program simulations
- Implementation of MOGA Modelling technique and Trajectory Optimization
- Deployed ODEs using MATLAB and used graph-based visualizations to analyze results

Concepts Learned

- Kicking off with the basic anatomy of a rocket, rocket equations were derived using rigorous mathematical calculations
- Took a deep insight into the aerodynamics of rocket which was followed by an in-depth study of heat shields, structure and control
- Introduction to rocket engines and propulsion systems
- Used Shooting method to solve ODEs and implemented MOGA modelling technique for function optimizations.
- Orbital Dynamics and Communication followed by learning about future prospects such as Habitability and Interstellar Voyage

Results

Here is the ideal rocket equation that was derived from momentum conservation:

$$\Delta V = I_{sp}.g_o.ln(\frac{M_o}{M_f}) \qquad (1)$$

We defined two variables τ and λ as followed:

$$\lambda = \frac{M_{struct}}{M_{struct} + M_{pay}} \qquad \tau = \frac{M_{prop}}{M_{prop} + M_{struct} + M_{pay}} \qquad (2)$$

Hence we derived relation between initial mass and structural coefficient (λ) of the rocket.

$$M_0 = \frac{M_{pay}}{1 - \frac{\tau}{1-\lambda}} \qquad (3)$$

The following rocket dynamics equation were derived using various laws of physics as a part of our Project Assignment.

$$\frac{d^2 r}{dt^2} = -\frac{\mu}{r^2} + r\dot{\theta}^2 + \frac{T-D}{m}\cos(\alpha) \qquad (4)$$

$$\frac{d^2\theta}{dt^2} = \frac{T-D}{r*m}\sin(\alpha) \qquad (5)$$

$$\frac{dm}{dt} = -\frac{T}{I_{sp}*g_0} \qquad (6)$$

MOGA

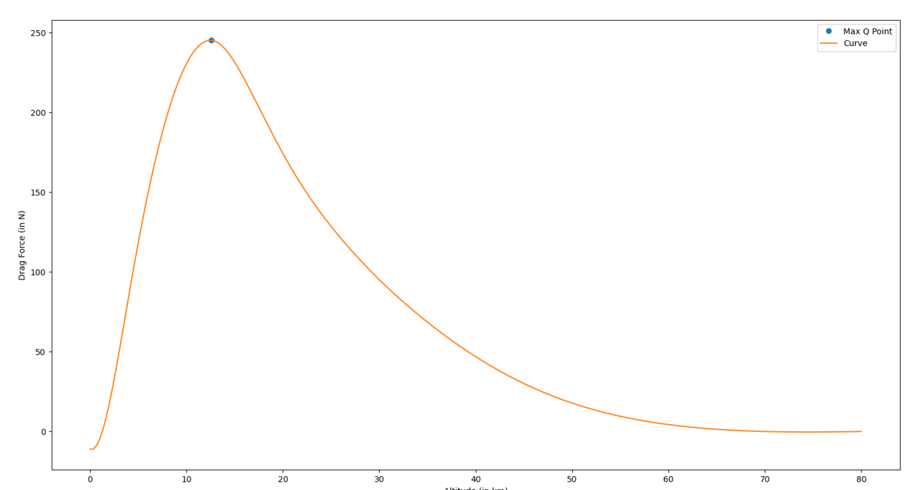


Fig-1: Drag Force v/s Altitude

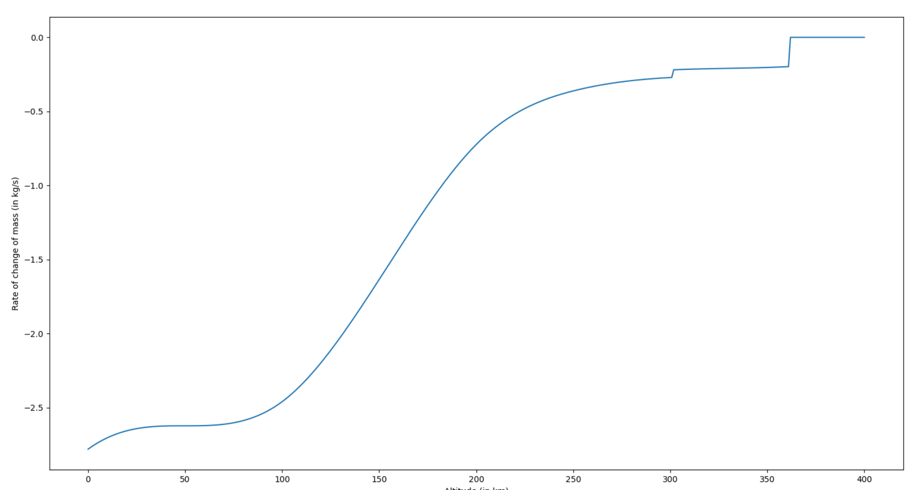


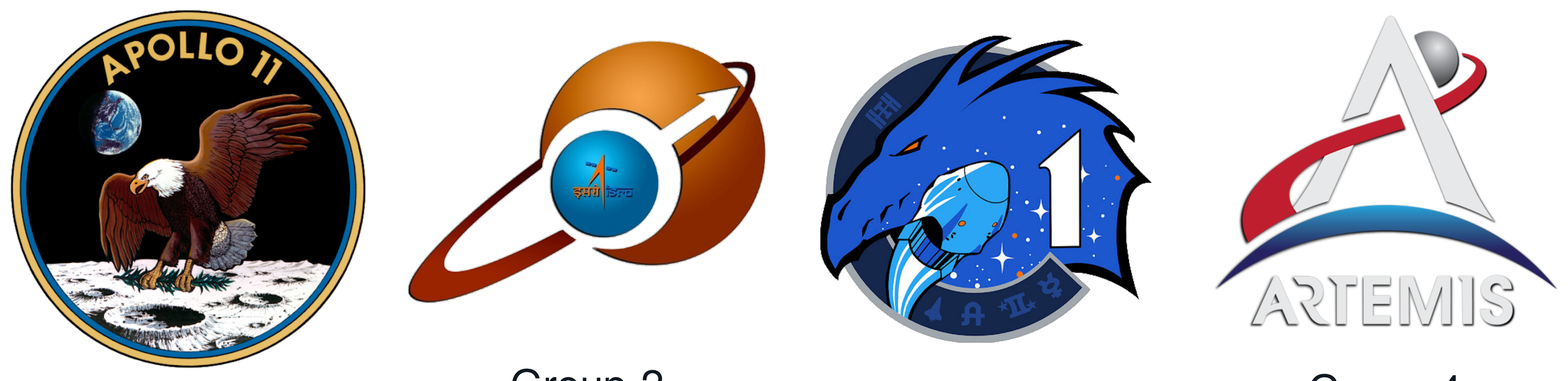
Fig-2: $\frac{dm}{dt}$ v/s Altitude

KSP

Fig-3: Take-off from Kerbin

Fig-4: Successful landing on MUN

Sample Mission Reports



Group-1 Group-2 Group-3 Group-4

Future Goals

- **Future Modelling:** Trying out new modelling techniques other than MOGA such as HCD to get more accurate results.
- **Application:** In depth application of concepts and Orbital Perturbations to be studied

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