BLAST OFF

End Term Project Report

OUR MENTORS -

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Adit Jain

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TIMELINE

SESSION 1

HISTORY OF ROCKETS

SESSION 2

BASIC ANATOMY

SESSION 3

ROCKET EQUATIONS

SESSION 4

SSTO,RE-ENTRY, HEAT SHIELDS

SESSION 5

PROPULSIONS

SESSION 6

ENGINES

SESSION 7

GENETIC ALGORITHM

SESSION 8

TRAJECTORY PLANNING

SESSION 9

APPLICATION OF MOGA TO SSTO

SESSION 10

ORBITAL DYNAMICS

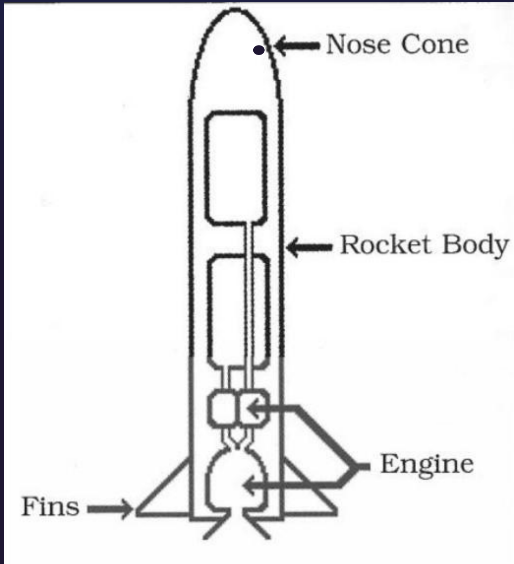
HISTORY OF ROCKETS

GODDARD'S ROCKET

V2 ROCKET

APOLLO 11

STARSHIP

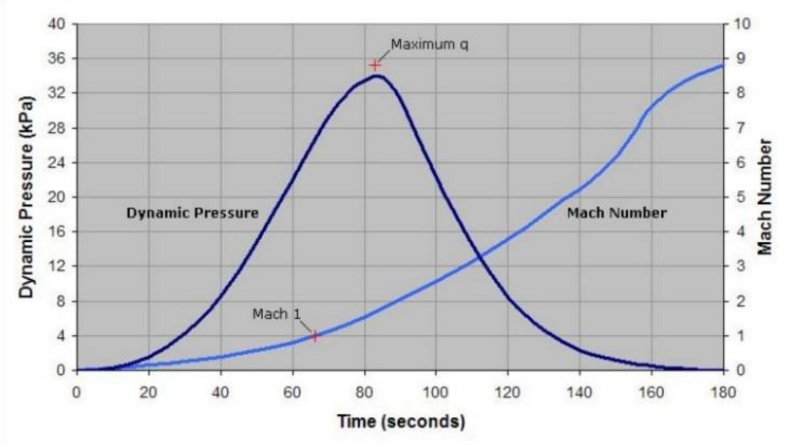


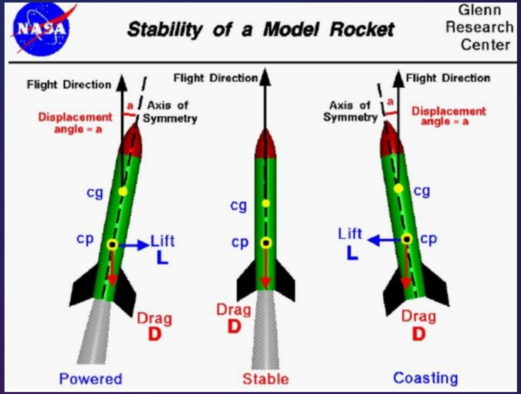
PARTS OF A ROCKET

MS TREE CATCHING A FALCON 9 FAIRING

FAIRING

STRUCTURAL SYSTEM AND STABILITY





Cg should always be higher than Cp!!

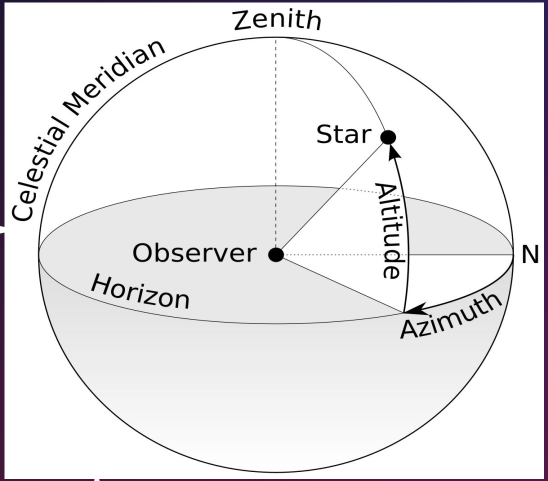
$$q = \frac{1}{2} \rho v^2$$

Dynamic pressure formula

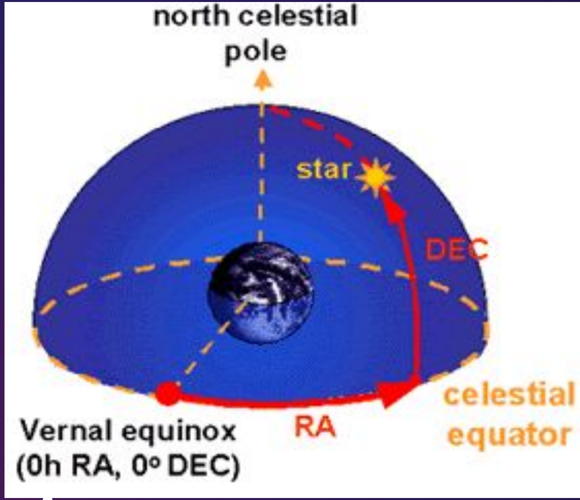
Structural system of rocket

COORDINATE SYSTEMS

ALT-AZ SYSTEM



RA-DEC SYSTEM



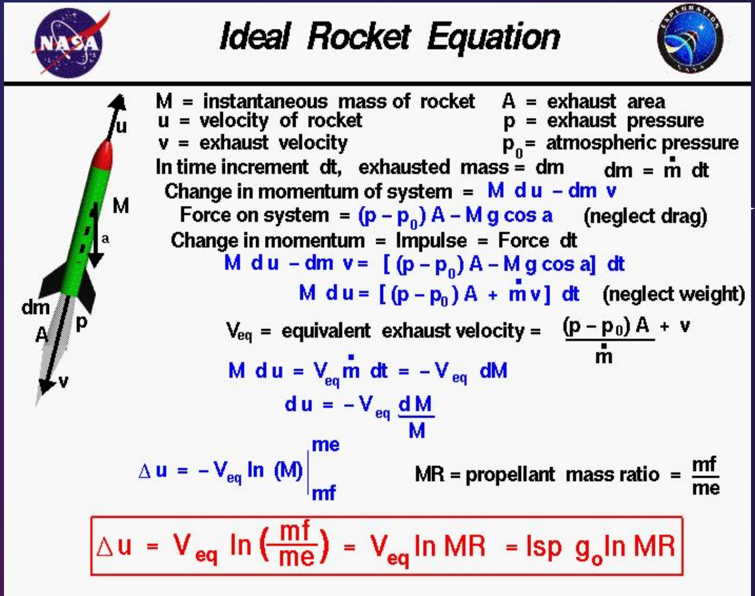
THE ROCKET EQUATIONS

MATHEMATICAL MODEL

$$\Delta M/M = 1 - \exp(\Delta v/v_{ex})$$

SPECIFIC IMPULSE

$$\Delta v = I_{sp}\, g_0 \ln(M_o/M_f)$$

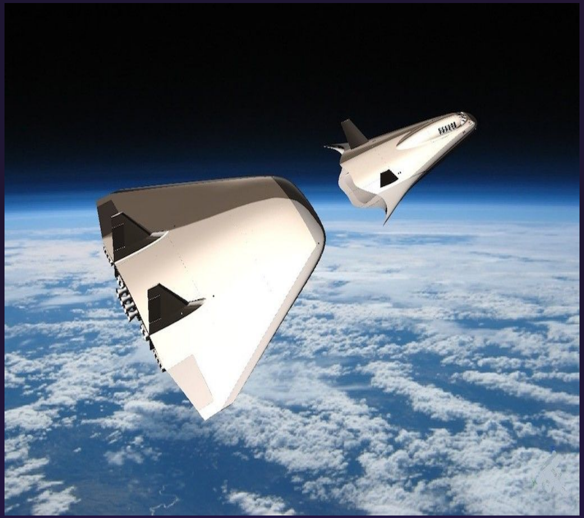


SSTO

SINGLE STAGE TO ORBIT

DSTO

DOUBLE STAGE TO ORBIT



STAGING

PARALLEL STAGING

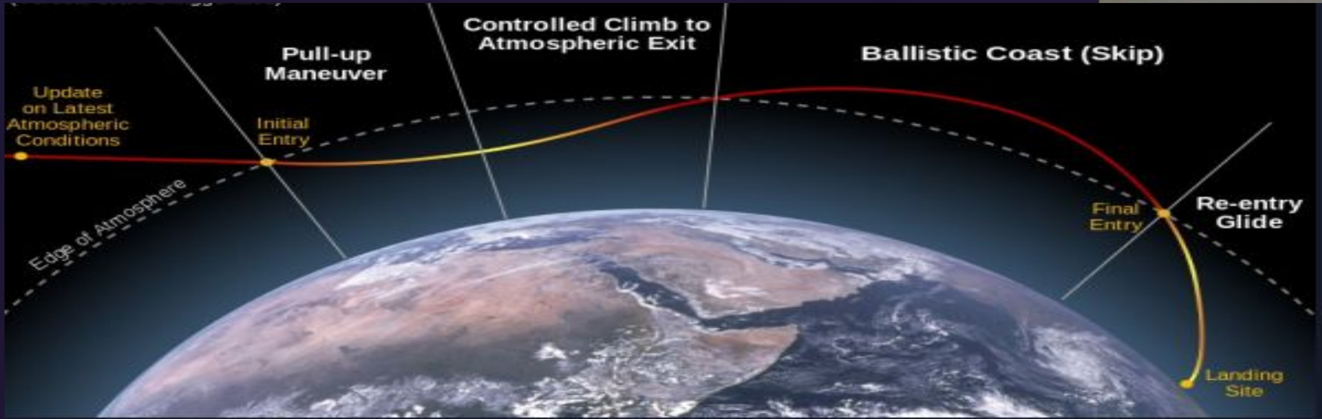
SERIAL STAGING

RE-ENTRY

RE-ENTRY MANEUVER

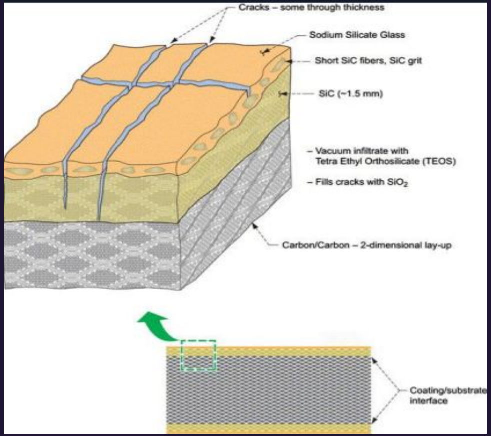
GUIDED

UNGUIDED



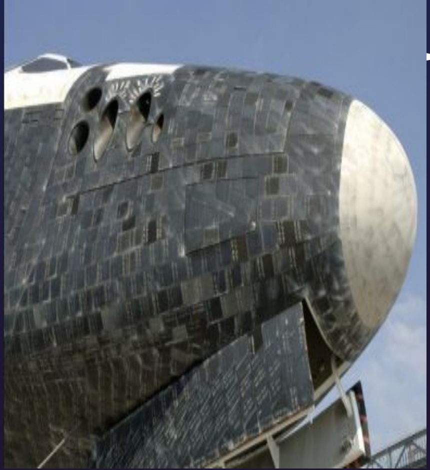
HEAT SHIELDS

INSULATION BLANKET



REINFORCED CARBON CARBON

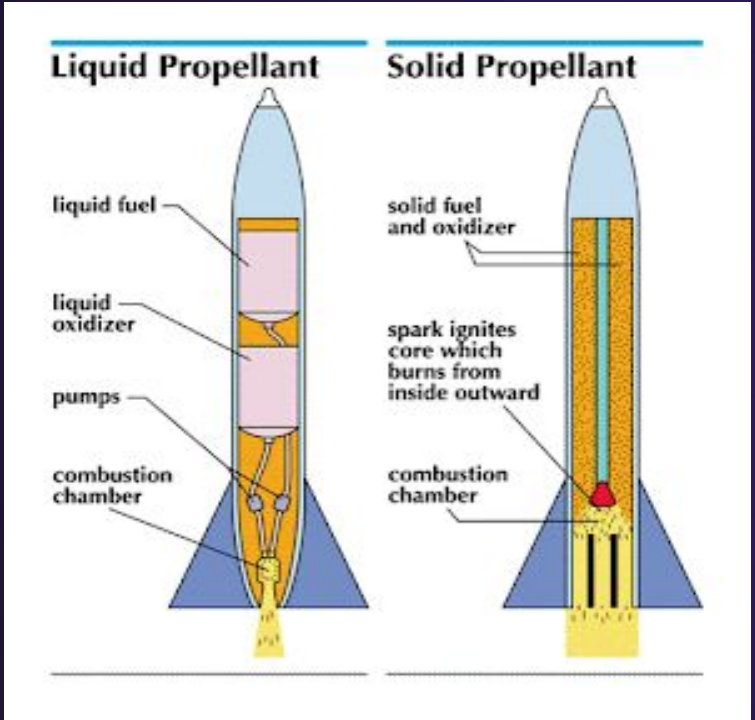
ABLATIVE HEAT SHIELD



INSULATION TILES

REGENERATIVE COOLING

PROPELLANTS

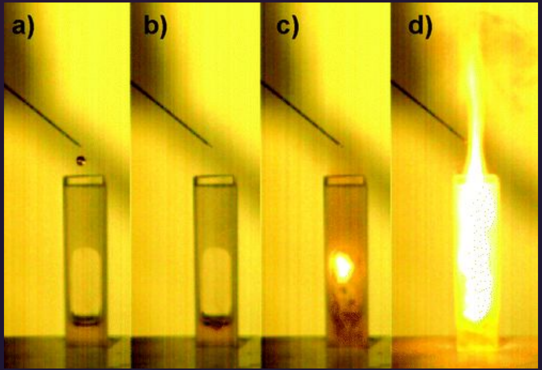


RP1

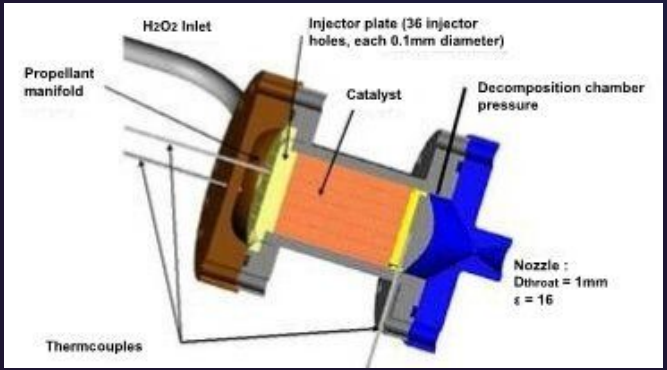
LH2

PROPELLANTS

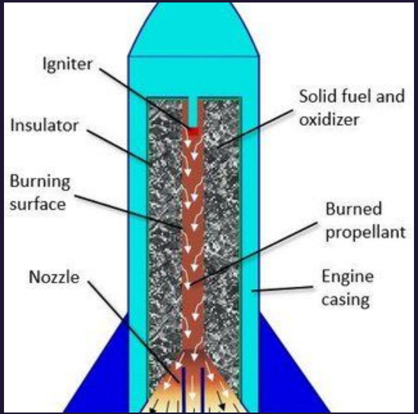
HYPERGOLS



MONOPROPELLANTS



SOLID ROCKET BOOSTERS



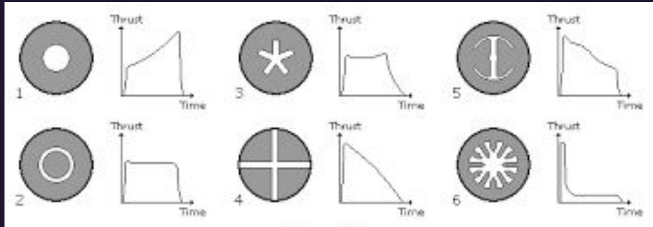
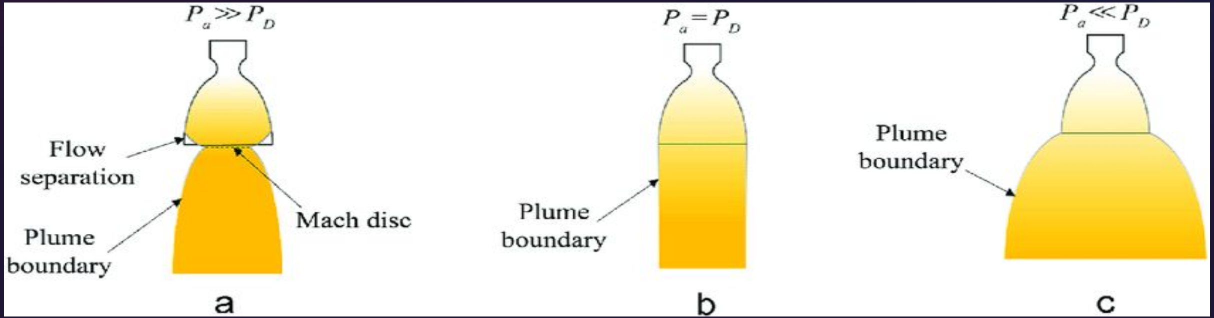


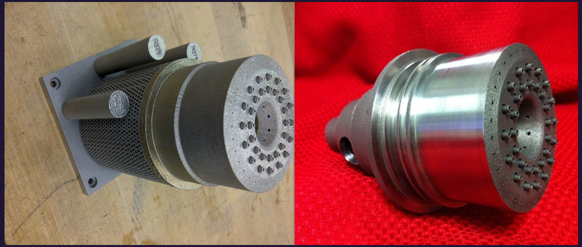
Figure 1.14

PARTS OF ROCKET ENGINE

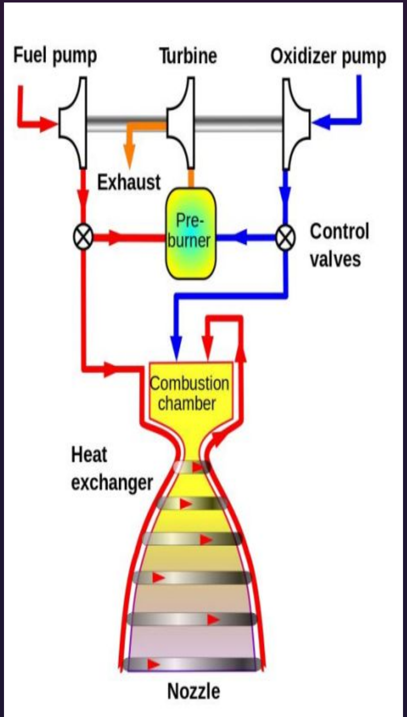
NOZZLE



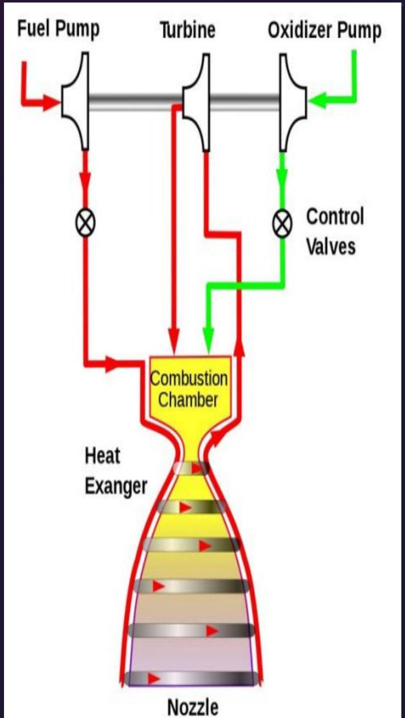
CHAMBER AND INJECTOR



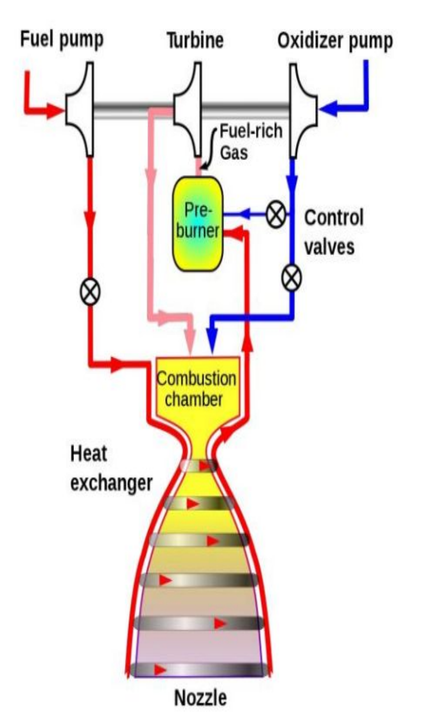
POWER CYCLES



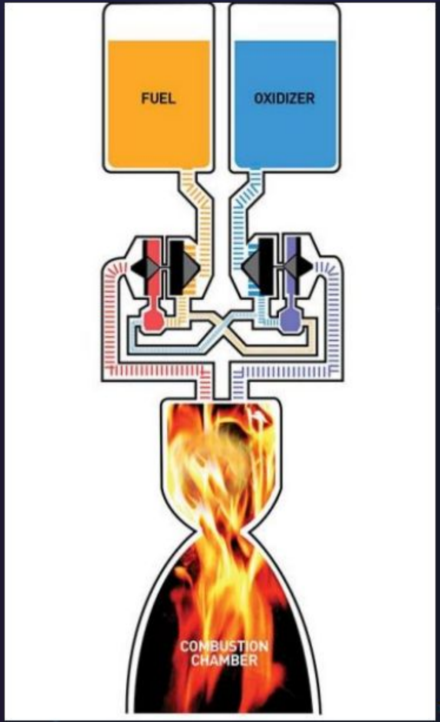
GAS GENERATOR CYCLES



EXPANDER CYCLE



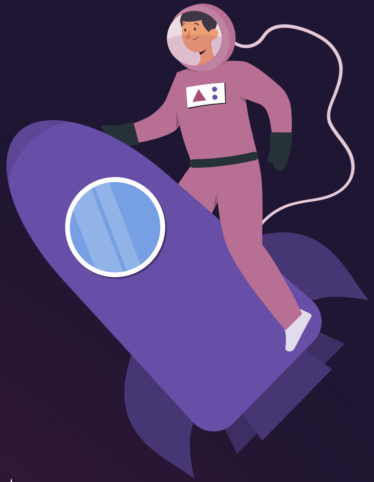
STAGED COMBUSTION



FULL FLOW STAGED COMBUSTION

TRAJECTORY PLANNING

So now how do you launch your rocket ?



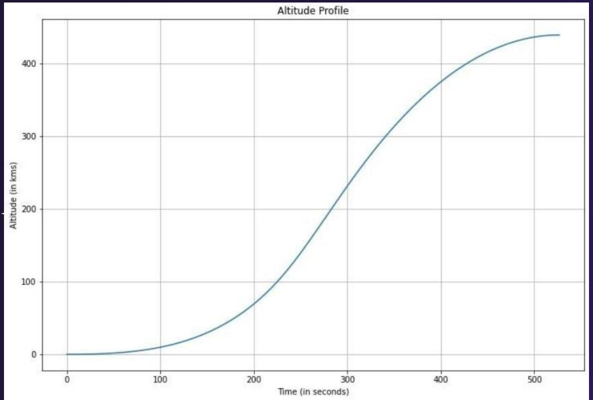
- Thrust at 5 different altitude
- Gravity turn altitude of start and end
- Cone Half Angle
- Rocket Radius
- Initial Wet Mass

$$\frac{d}{dt}r = r'$$
$$\frac{d}{dt}r' = -\frac{\mu}{r^2} + r\theta^2 + \frac{T(r)-D(r,r')}{m}cos(\alpha(r))$$
$$\frac{d}{dt}\theta = \theta'$$
$$\frac{d}{dt}\theta' = \frac{T(r)-D(r,r')}{r*m}sin(\alpha(r))$$
$$\frac{d}{dt}m = \frac{-T(r)}{I_{sp}*g_o}$$

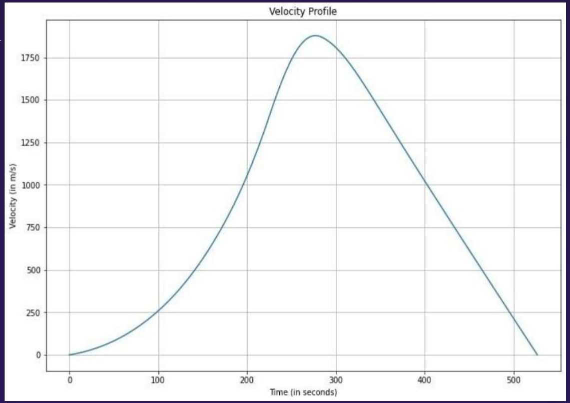
5 PARAMETERS

THE ROCKET EQUATIONS

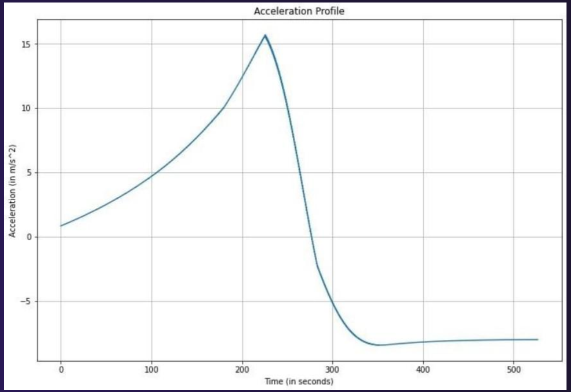
SOME OF THE GRAPHS OF AN IDEAL ROCKET...



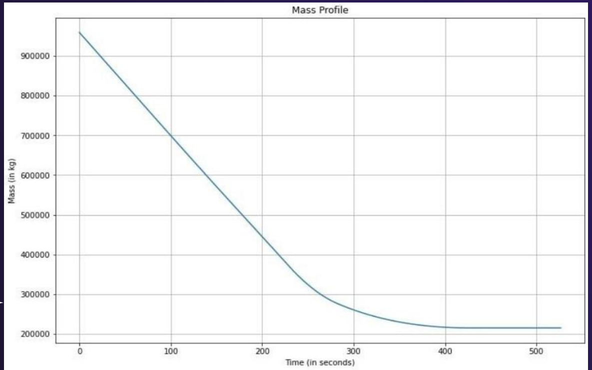
ALTITUDE VS TIME



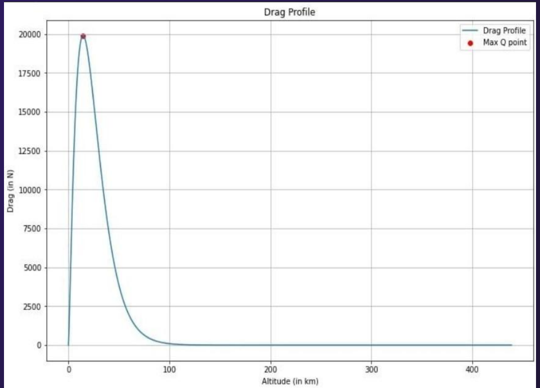
VELOCITY VS TIME



ACCELERATION VS TIME

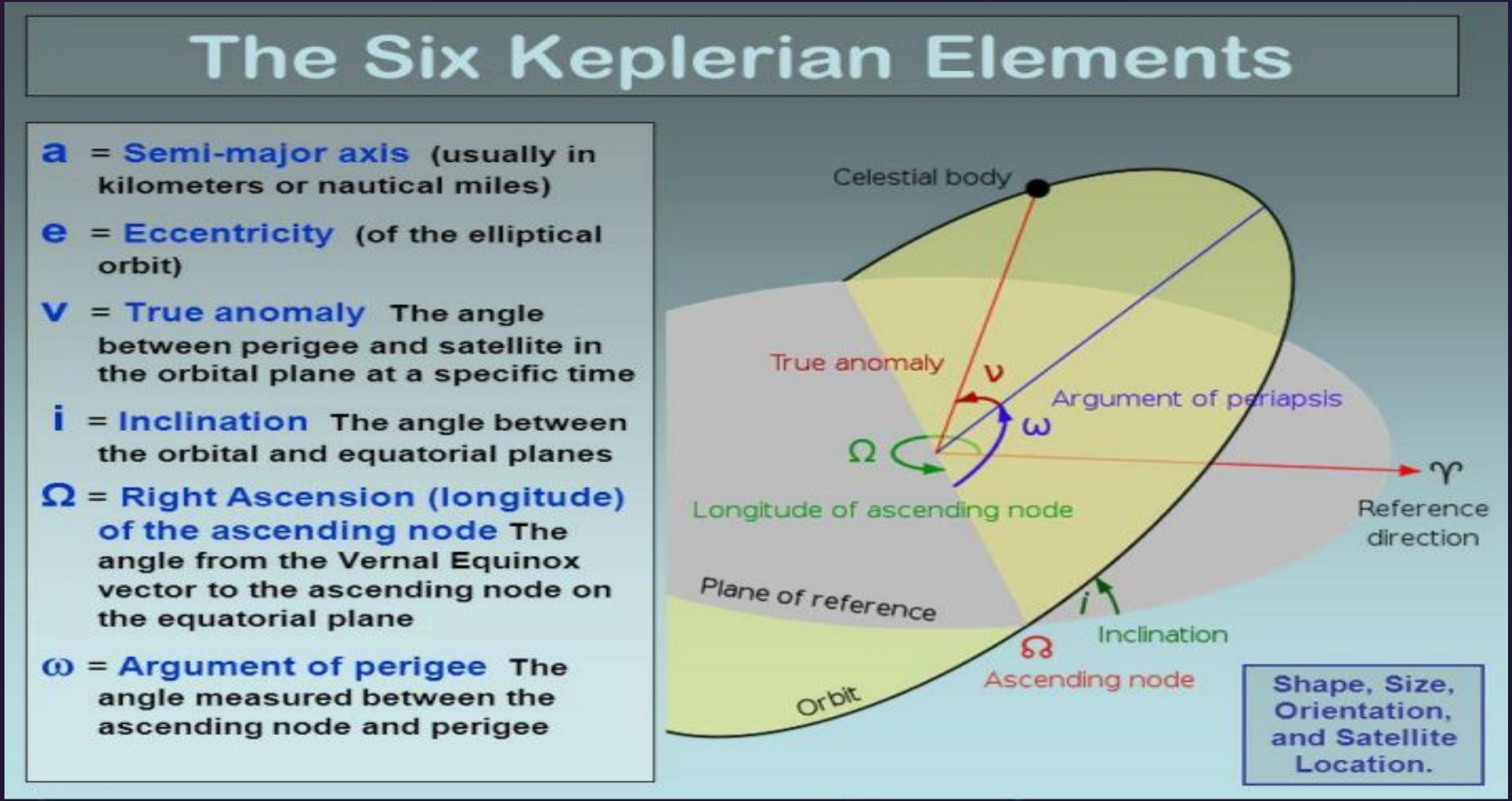


MASS VS TIME



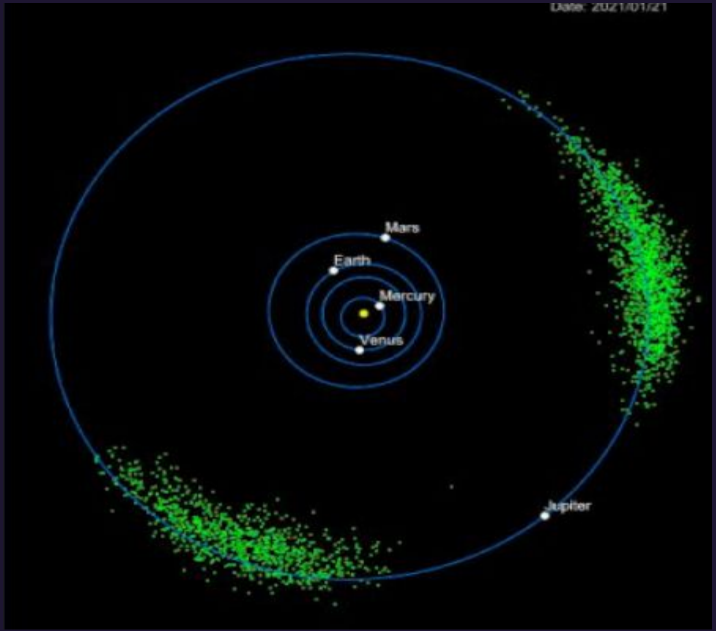
DRAG VS ALTITUDE

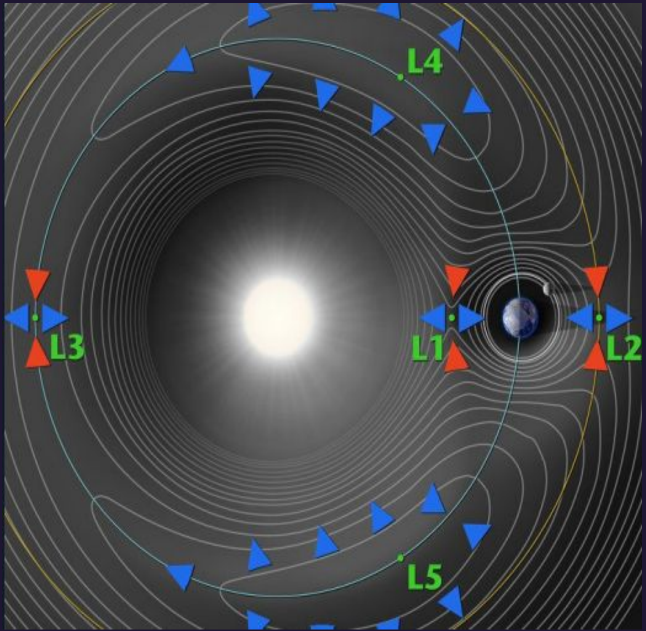
ORBITAL DYNAMICS



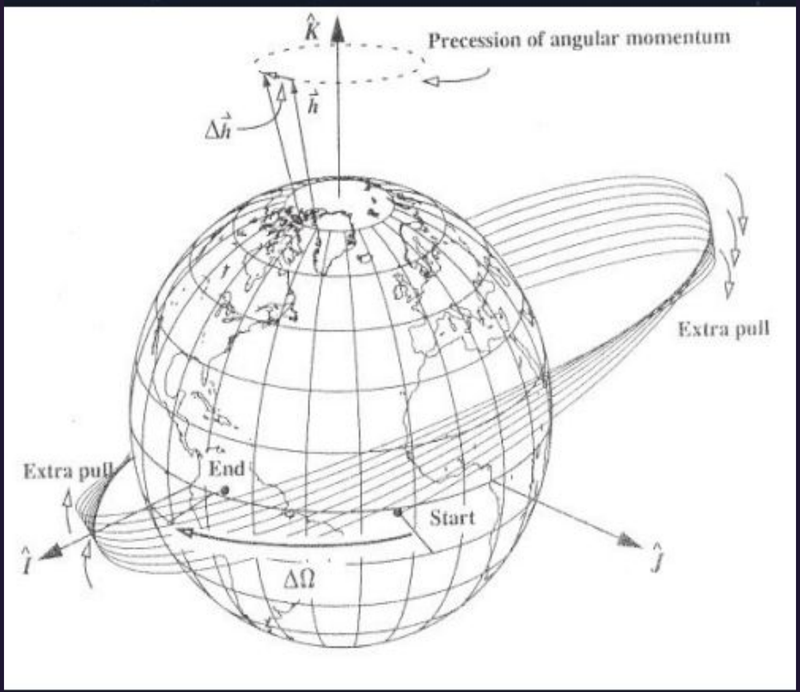
ORBITAL DYNAMICS

LAGRANGE POINTS

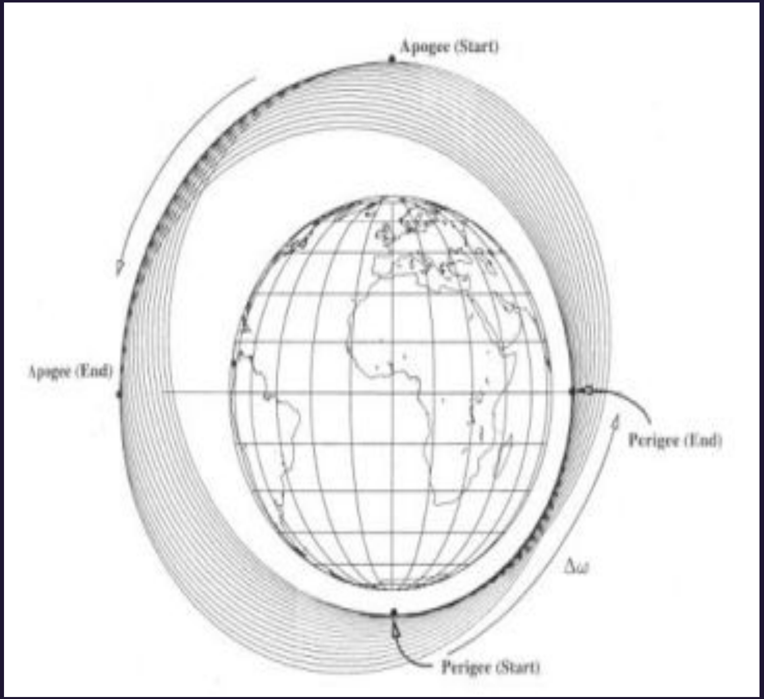




ORBITAL DYNAMICS

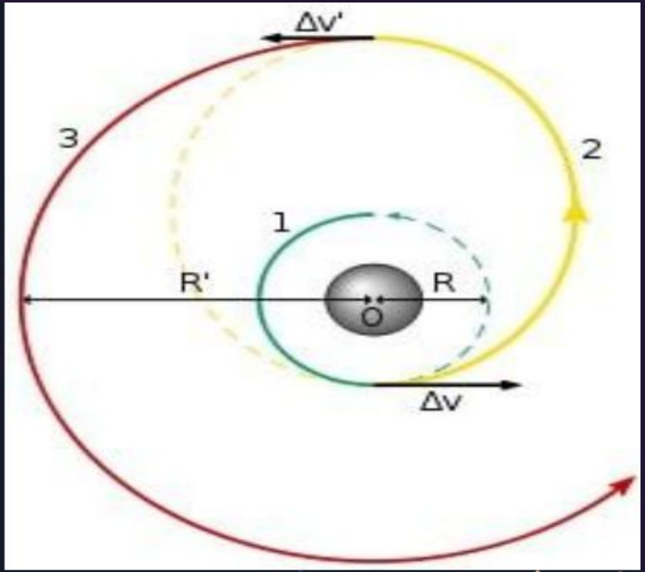


J2 NODAL REGRESSION

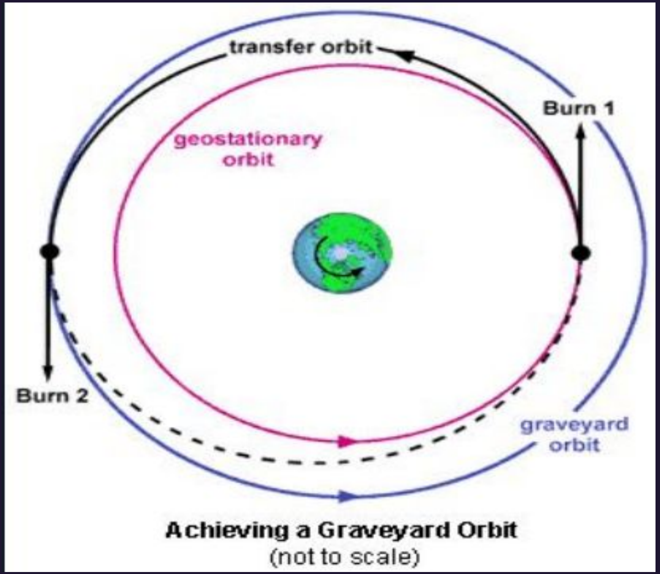


J2 APSIDAL ROTATION

ORBITAL DYNAMICS

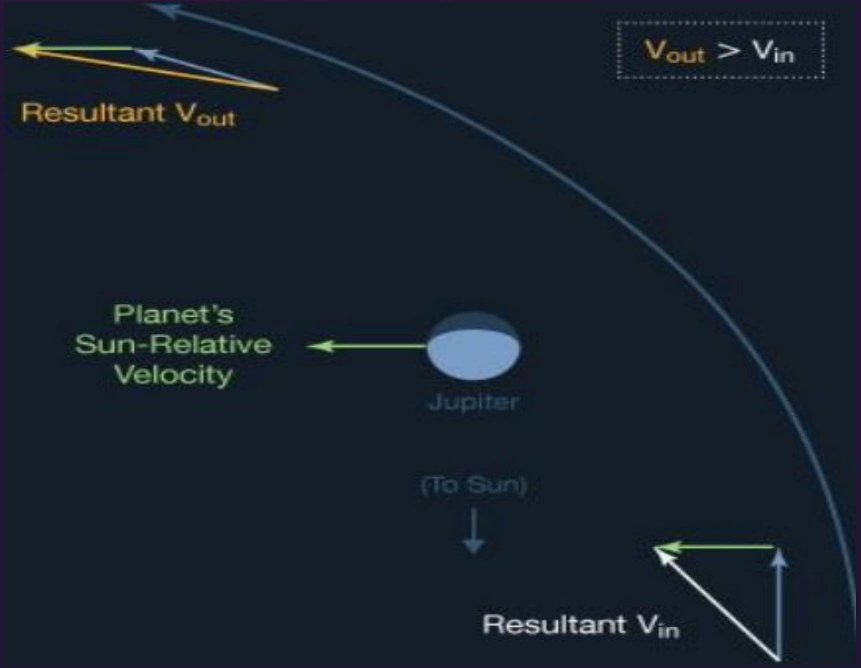


HOHMANN TRANSFER

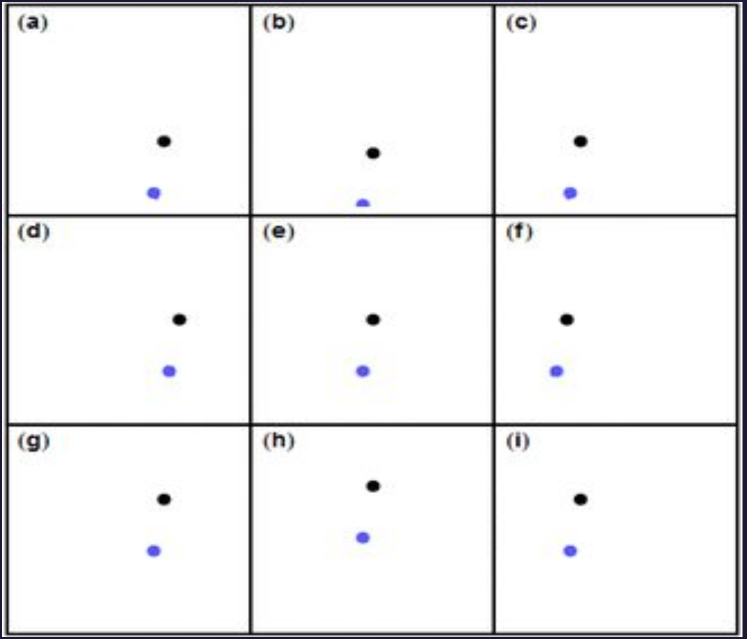


GRAVEYARD ORBIT

ORBITAL DYNAMICS

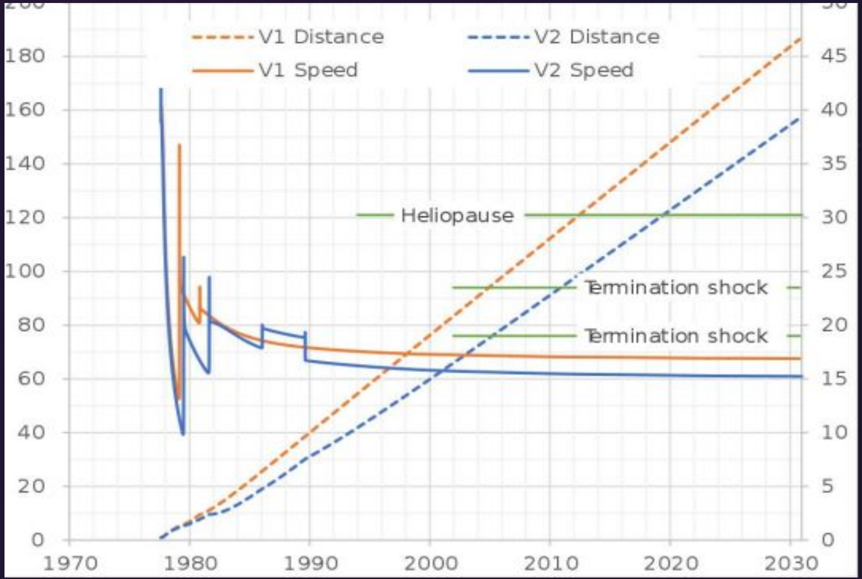


GRAVITATIONAL ASSIST

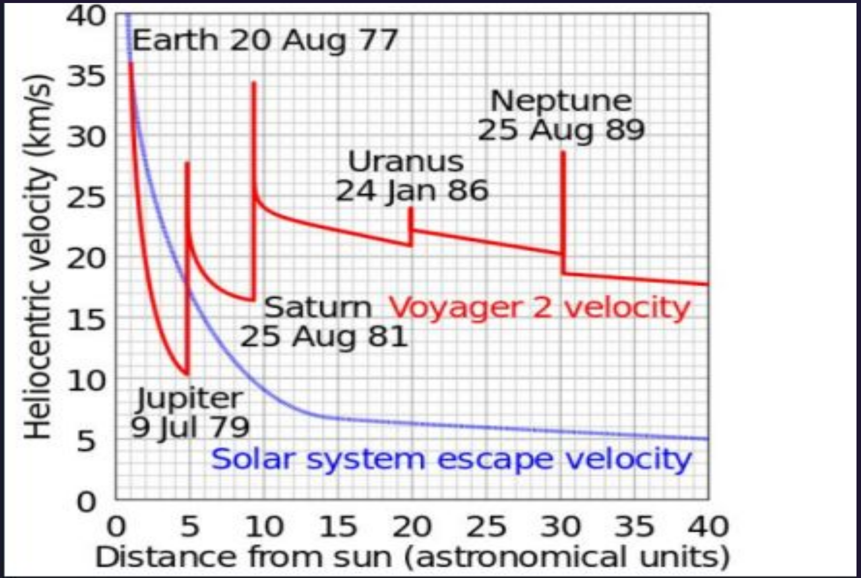


POSSIBLE OUTCOMES OF GRAVITATIONAL ASSIST

ORBITAL DYNAMICS

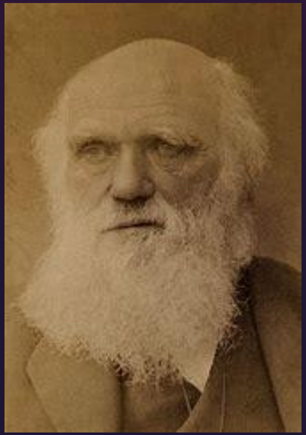


VOYAGER SPEED VS. DISTANCE FROM THE SUN



HELIOCENTRIC VELOCITY OF VOYAGER 2 VS. DISTANCE FROM THE SUN

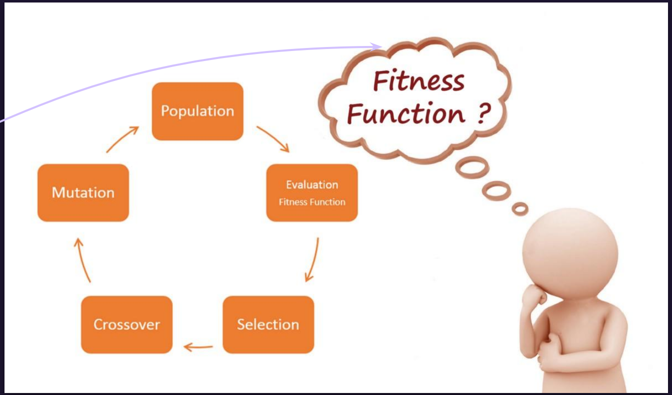
GENETIC ALGORITHM



Inspired by Charles Darwin's Theory of Natural Selection

Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on biologically inspired operators such as mutation, crossover and selection.

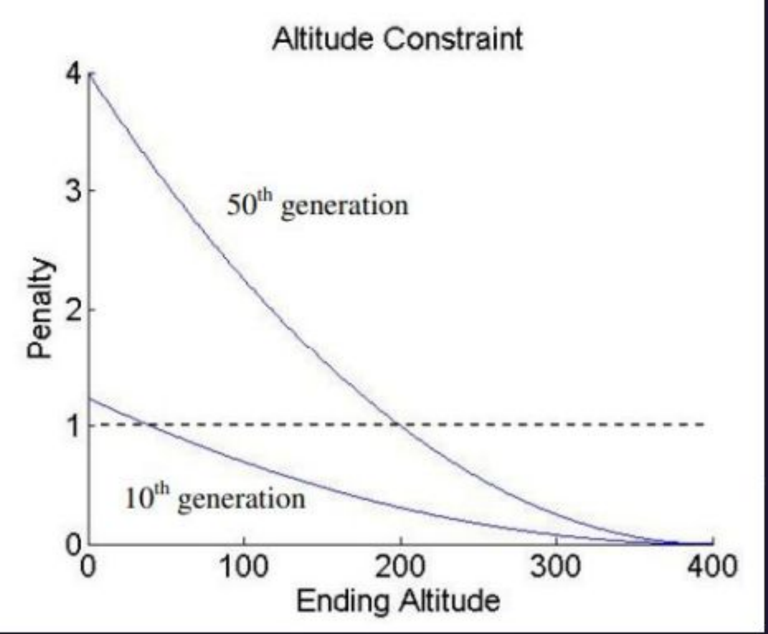
BUT ON WHAT BASIS??



APPLICATION OF MOGA TO SSTO ROCKETS

PENALTY : $p(A_{final}) = [abs(400-A_{final})/max\{1, 400-4*gen\}]^2$

FITNESS : $F = max\{1.0 - 0.01*n_{dom} - p(A_{final}), 0\}^2$



PARAMETERS RANGE

```
THRUST_VECTOR_RANGE = [
    [10.1e6, 10.3e6],
    [9.7e6, 9.9e6],
    [10.0e6, 10.2e6],
    [3.7e6, 3.9e6],
    [2e3, 4e3]
]
ANGLE_VECTOR_RANGE = [
    [350, 450],
    [320e3, 320e3]
]
CONE_HALF_ANGLE = [0.10, 0.15]
ROCKET_RADIUS = [3.8, 4.2]
TOTAL_MASS = [950e3 980e3]
```

APPLICATION OF MOGA TO SSTO ROCKETS

COST CALCULATION

ENGINE COST

$C_E = M_E * (C_{ESS} / M_{ESS})$

$C_{ESS} = 30$ million \$

$M_{ESS} = 3{,}500$ kg

STRUCTURAL COST

$C_S = M_S * (C_{Sss} / M_{Sss})$

$C_{Sss} = 75$ million \$

$M_{Sss} = 760{,}000$ kg

PROPELLANT COST

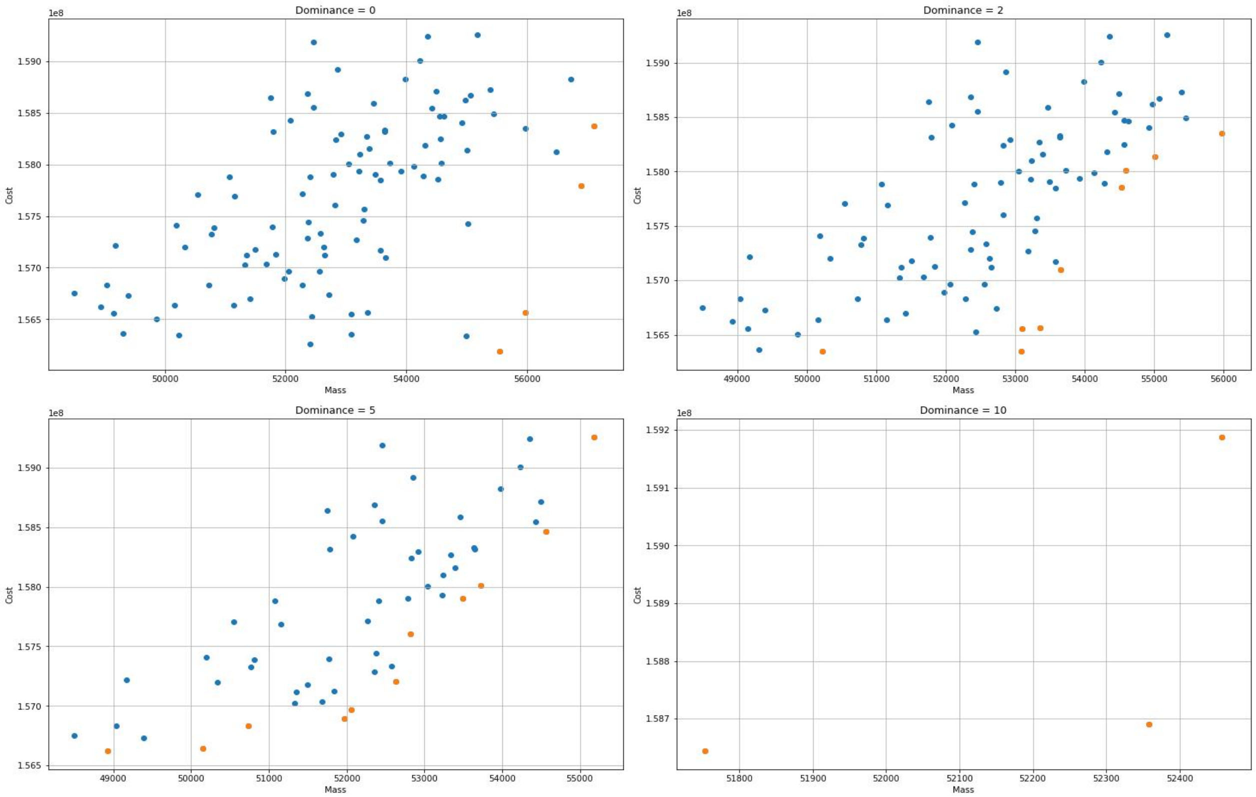
$C_P = (M_P * C_{O2} * (6/7)) + (M_P * C_{H2} * (1/7))$

$C_{O2} = 0.155$ \$/kg

$C_{H2} = 9.5$ \$/kg

ROCKET OPTIMIZATION USING PARETO FRONT AND DOMINANCE

We need to increase payload mass going into orbit while simultaneously minimizing the cost it takes to do so.

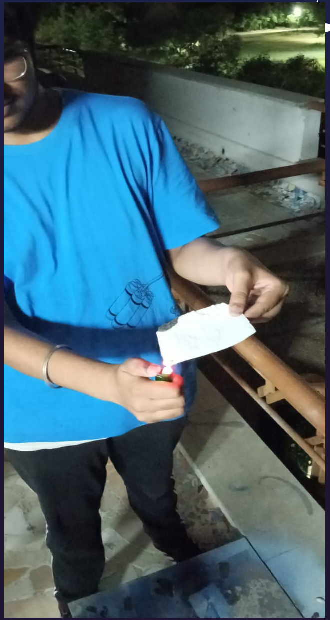
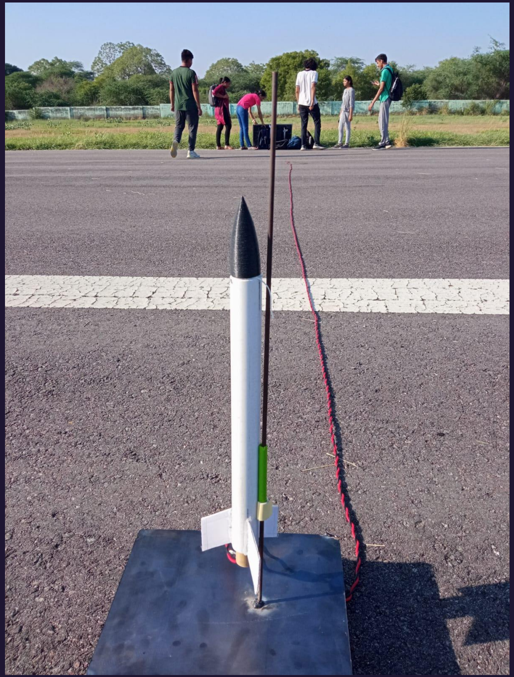


CONCLUSION

We calculated the Payload Mass, Total Cost and Mass to Cost Ratio of our fittest rocket and compared them with the actual properties of some mission and finally calculated the percentage error!

PROPERTY	CALCULATED VALUE	ACTUAL VALUE	PERCENTAGE ERROR
Payload Mass	52818.27 Kg	52100 Kg	1.38%
Total Cost	159.04 million $	157.3 million $	1.11%
M_p/C	332.11 Kg/M$	331.21 Kg/M$	0.27%





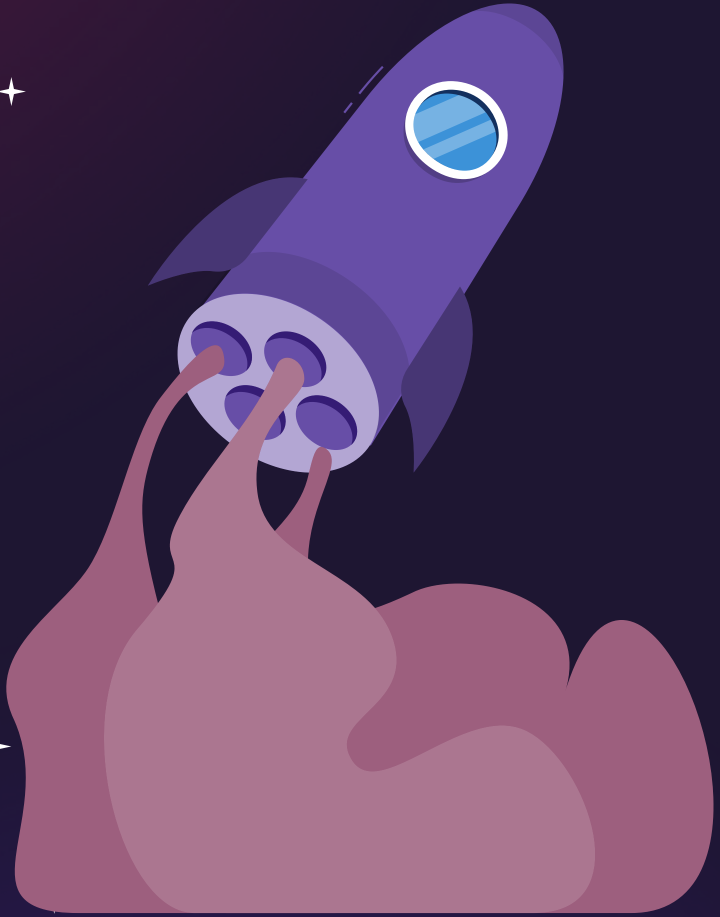






IITK

LAUNCHING OUR ROCKET



THANK YOU !!

COSMOS IS WITHIN US