BLAST OFF!

Mid-Term Progress Report

ABOUT THE PROJECT

We aim to study and understand how and why rockets were invented, their structural aspects, the different kinds of launch vehicles (multi-stage/based on payload), how they're propelled by the engine, what sort of fuel-oxidiser combinations are used, orbital mechanics and so on.

TIMELINE

Session 1
History of Rockets

Session 2
Basic Structure of Rocket

Session 3
Dynamics and Staging

Session 4
Coordinate Systems

Session 5
SSTO and Heat Shield

Session 6
Traditional and Unconventional methods of propulsion

Session 7
Engines

WEEK 1

Contents of Session 1

01

Early attempts at rockets

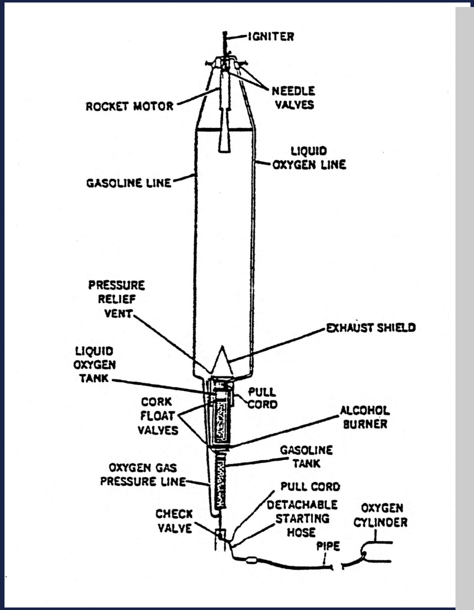
02

The Space Race

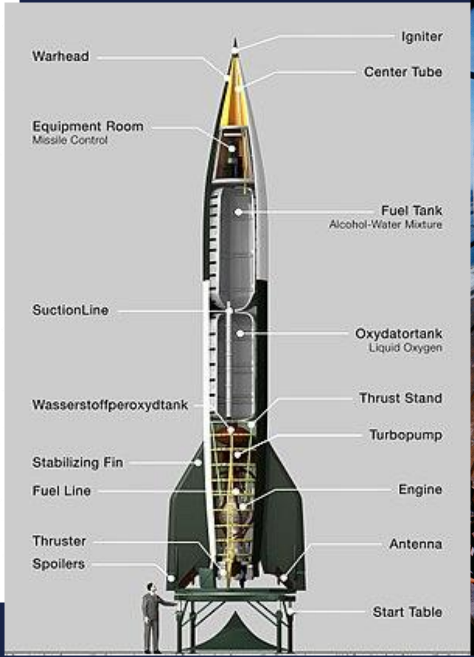
03

Modern era rockets

History of Rockets



Goddard's Rocket



V2 Rocket

Apollo 11

Starship

Contents of Session 2

01

Structural Anatomy of Rockets

02

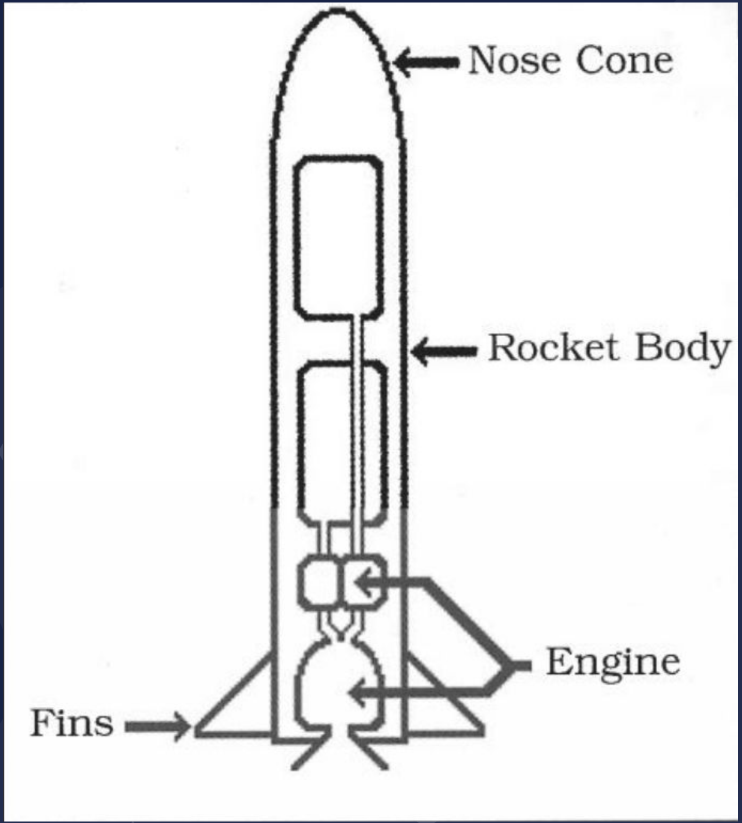
Fairings and stability

03

Dynamic Pressure

Structural System of Rockets

- Consists of payload, cylindrical body, fairings and control fins.
- Frame is made up of strong, but lightweight materials such as aluminum or titanium
- Thermal protection system used to protect from excessive heat caused due to friction.
- Fins are attached to the bottom for stability during the flight.
- Rocket boosters are made up of high density materials that have high strength and heat absorption capacity.

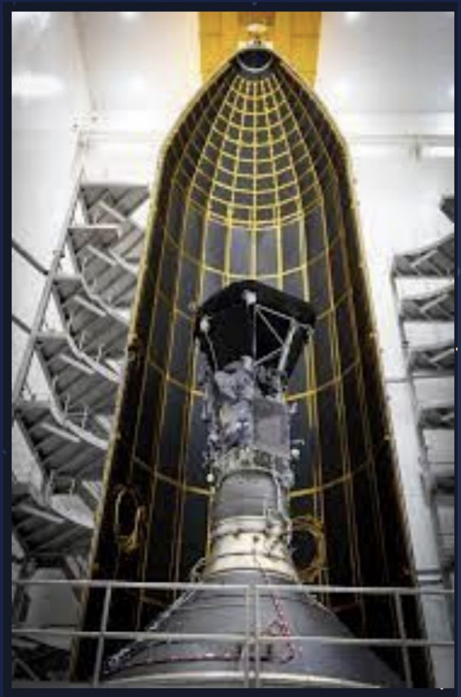


Rocket Fairings

- Enclosure of the uppermost stage of a rocket, i.e. the payload
- comprised of materials such as carbon fibre or ceramics like carbides.

- Protects the rocket and payload from noise and high frequency vibrations

- Fairing is typically a cone cylinder combination, due to aerodynamic considerations.



NASA’s Parker Solar Probe

First ever Reusable fairing by SPACEX

Dynamic Pressure and Max Q

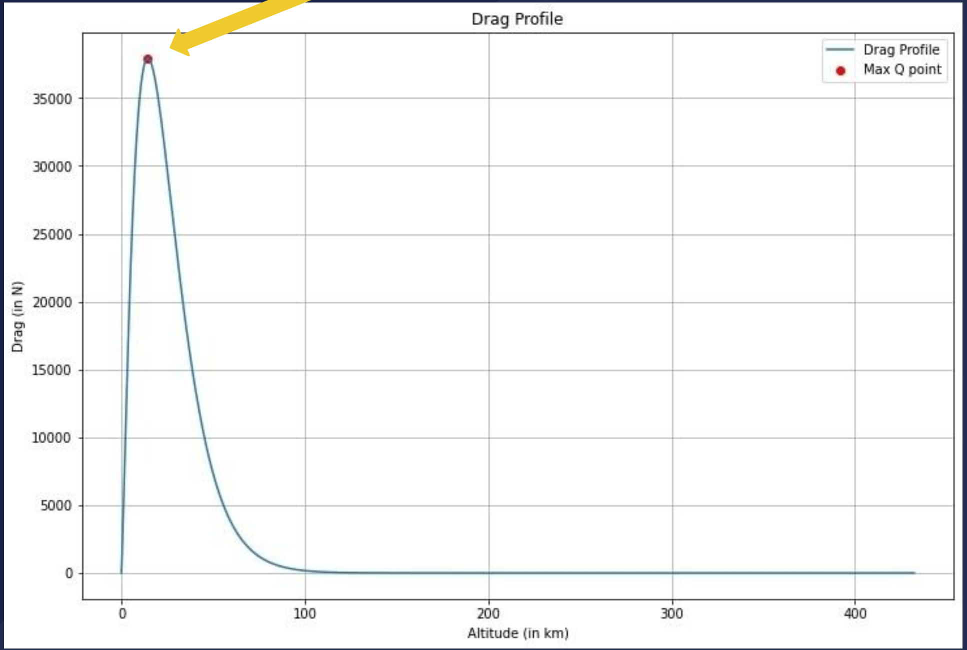
The Dynamic Pressure can be thought of as the kinetic energy density of the air with respect to the vehicle.

Dynamic pressure, q, is defined mathematically as

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

… where ρ is the local air density, and v is the vehicle's velocity

As rocket rises, the density of air decreases while speed increases thereby forming a maxima at a point called as MAXQ



WEEK 2

Contents of Session 3

01

A Primitive mathematical model

02

Specific Impulse

03

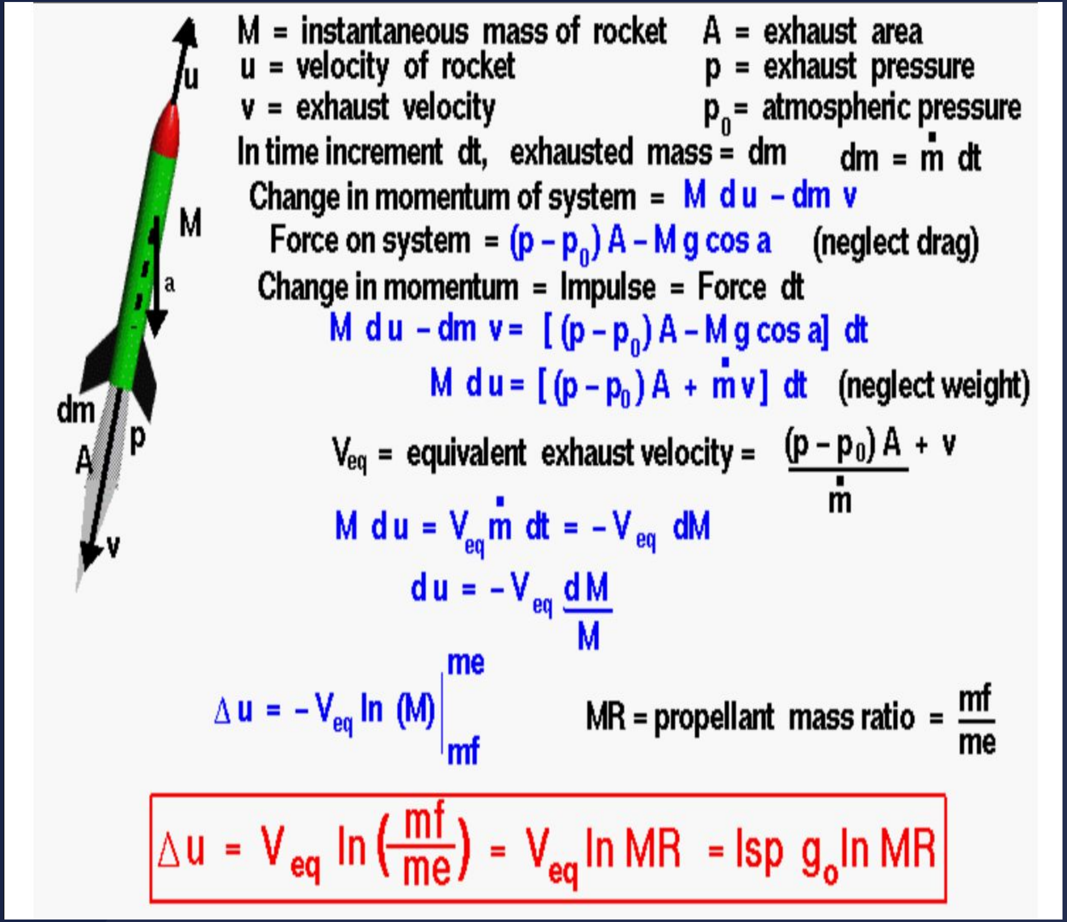
Staging - Series and Parallel

Mathematical model

Used the basic definition of linear momentum and its derivative and dynamics of variable mass system to analyse the dynamics of a rocket in a gravity free space.

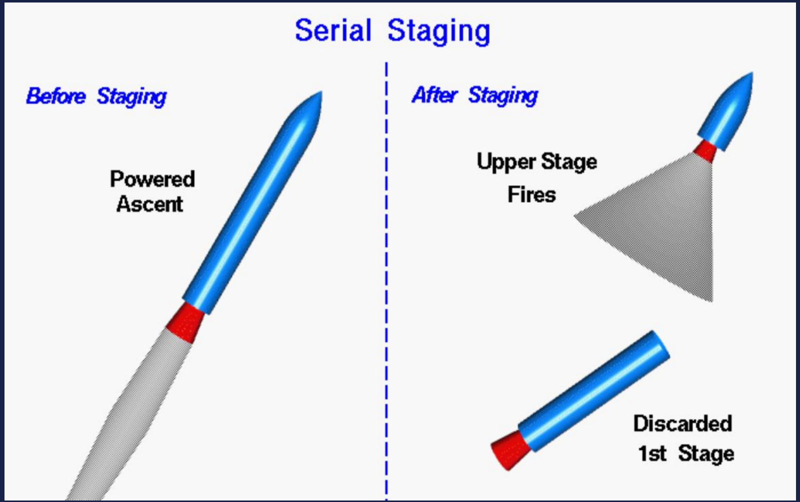
Specific Impulse

Learnt the meaning of specific impulse and understood what is its relevance, how it is a measure of the efficiency of a rocket system

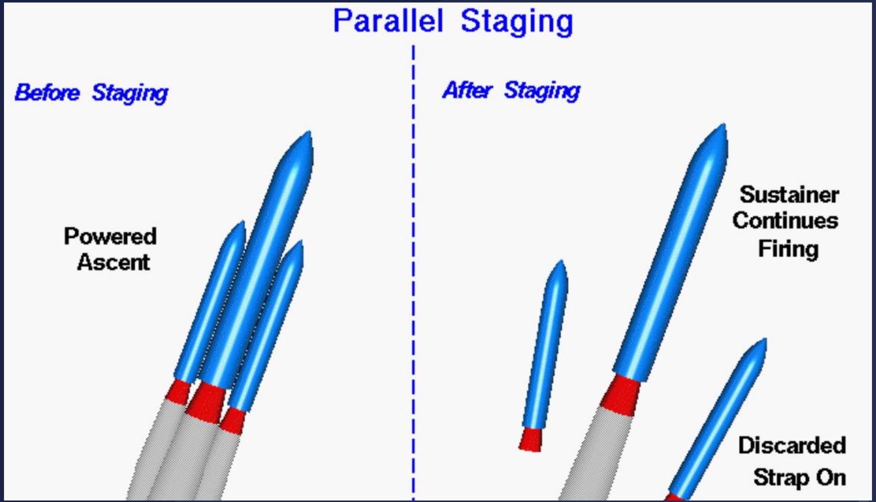


Staging - Series and Parallel

A process where different sections of the rocket fire and then detach so that the spaceship can penetrate the atmosphere and reach the space.



Serial Staging



Parallel Staging

Contents of Session 4

01

ALT-AZ Coordinate System

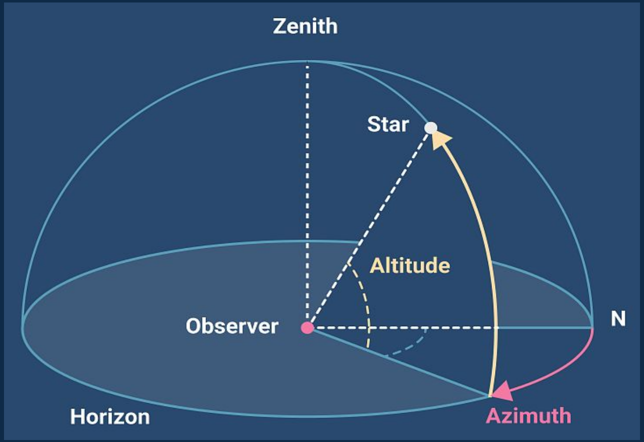
02

RA-DEC Coordinate System

COORDINATE SYSTEMS

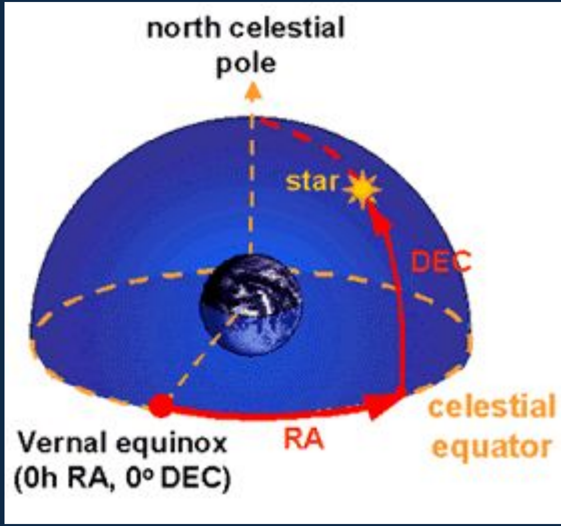
1) ALT-AZ

- The sky is considered as a dome around the observer.
- Altitude-The angular distance above the horizon
- Azimuth-The angular distance measured east from north and parallel to the horizon.



2) RA-DEC

- Right Ascension-Angle from the vernal equinox.
- Declination-angular distance above the celestial equator



Contents of Session 5

01

SSTO

02

Re-entry

03

Heat Shield

SSTO (single stage to orbit)

SSTO is stage in which vehicle reaches orbit from surface using only propellants and fluids without expending tanks , engines etc.

Calculations regarding SSTO

$$\Delta v = Isp \times g_o \times \ln[M_o/M_f]$$

$$\lambda(\text{structural Coeff}) = M_{rocket}/(M_{pay} + M_{rocket})$$

Isp =Specific Impulse

g_o= Standard Gravity

Mo = Initial Mass of Rocket

Mf = Final Mass of Rocket after reaching the orbit

Δv = Change in velocity

RE-ENTRY

Guided

Rocket lands at particular point with particular speed and can be controlled whale landing

Rocket lands in wide region and can't be controlled while its landing

Unguided

Heat Shield

Insulation Blanket

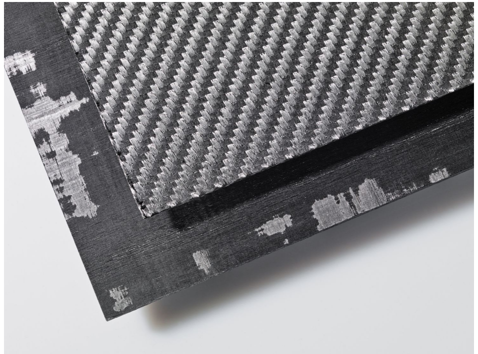
Used where heat is less than 649 degrees

Insulation tiles

Can withstand temp. Upto 1260 degrees

Reinforced Carbon

Used where temp >1260 degree



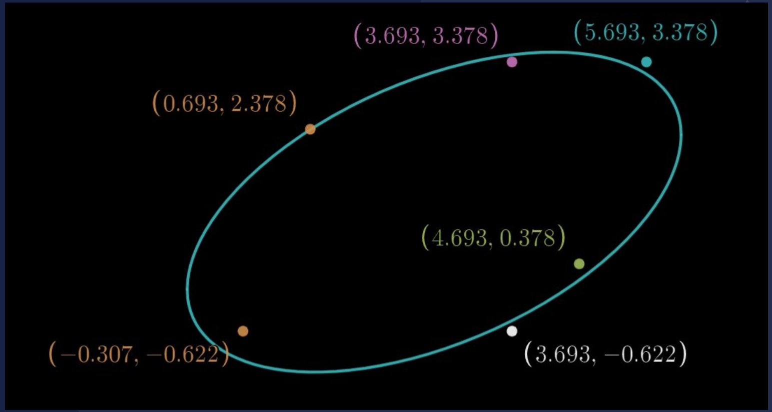
Regenerative cooling

Will be used in some advanced rockets like starship

ASSIGNMENT - I

Concepts Learnt:

1. Curve-Fitting using the method of least squares and used it to determine the best fit ellipse passing through given points.
2. Calculating the least distance of a star from earth using parametric coordinates of the trajectory
3. Calculated the velocity of a rocket at any general time t and determine the maximum altitude attained by the rocket
4. Employed the concepts of classical mechanics to solve one problem related with spaceships thrust and so on.



WEEK 3

Contents of Session 6

01

Liquid Propellants

02

Mono-propellants

03

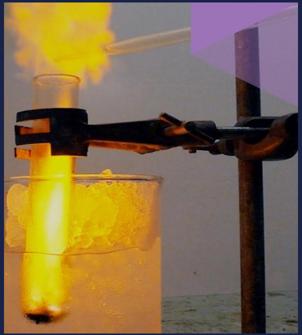
Solid Rocket Boosters(SRB)

IDEA OF PROPULSION

"Throw out as much as mass from the nozzle at maximum velocity possible"

High mass flow rate => High chamber pressure => High exhaust velocity.

LIQUID PROPELLANTS



PETROLEUM BASED

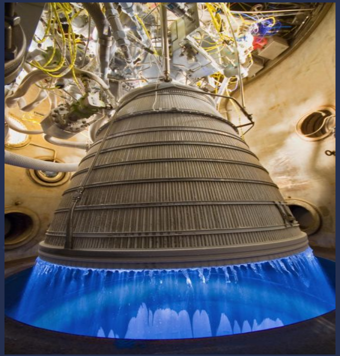
- ➢ Refined from crude oil and a mixture of hydrocarbons(RP1 widely used).
- ➢ used with an oxidiser.
- ➢ produce a Sooty Exhaust but is cheap.

HYPERGOLS

- ➢ ignite spontaneously on contact with each other and require no ignition source.
- ➢ easy start and restart capability make them ideal for spacecraft maneuvering systems.
- ➢Can be used as an igniter.

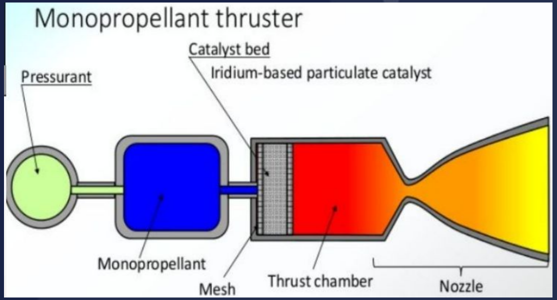
CRYOGENS

- ➢uses (LH2) as the fuel & (LO2) as the oxidizer
- ➢ environment friendly.
- ➢difficult to store over long periods.



MONOPROPELLANTS

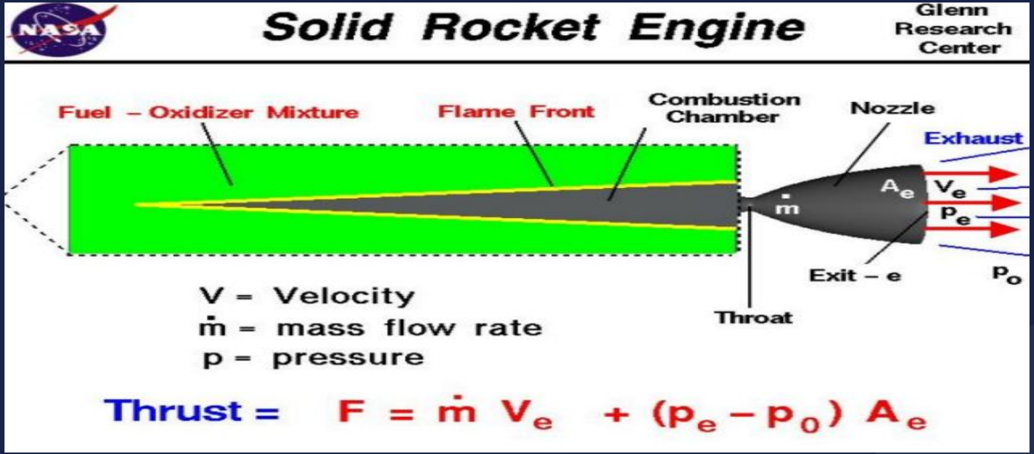
- ➢ Using single propellant which are pressure pumped.
- ➢ Simple in design(most reliable) .
- ➢ Will require Catalysis.
- ➢ Usually used in RCS.



SOLID PROPELLANTS

Used in gun powder rockets.

Solid Rocket Booster (SRB)



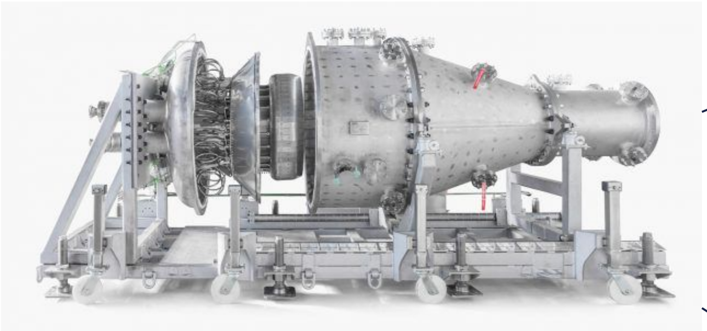
- ➢ SRB in Shuttle produced 12,000 kN of thrust.
- ➢ “DOUBLE” the power of a single F1 rocket engine
- ➢They can’t be switched off once they have been fired.

Contents of Session 7

Components

Nozzle

Outlet of the exhaust gases



Plumbing

It is the cycle of fuel in the engine to generate power

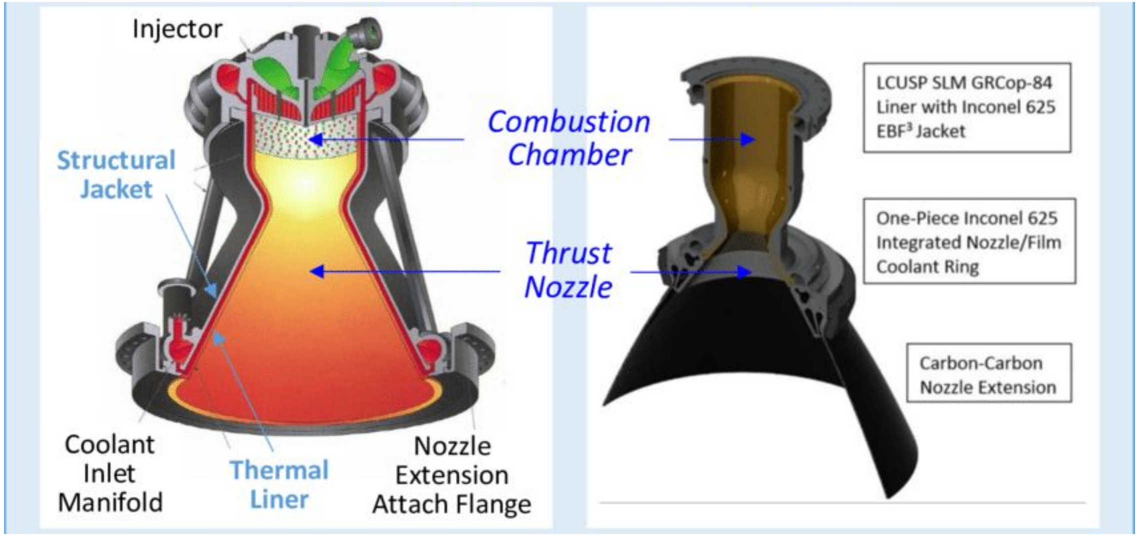
Turbopumps

The purpose of a turbopump is to produce a high-pressure fluid for feeding a combustion chamber or other use.

Combustion Chamber

As the name suggests!!

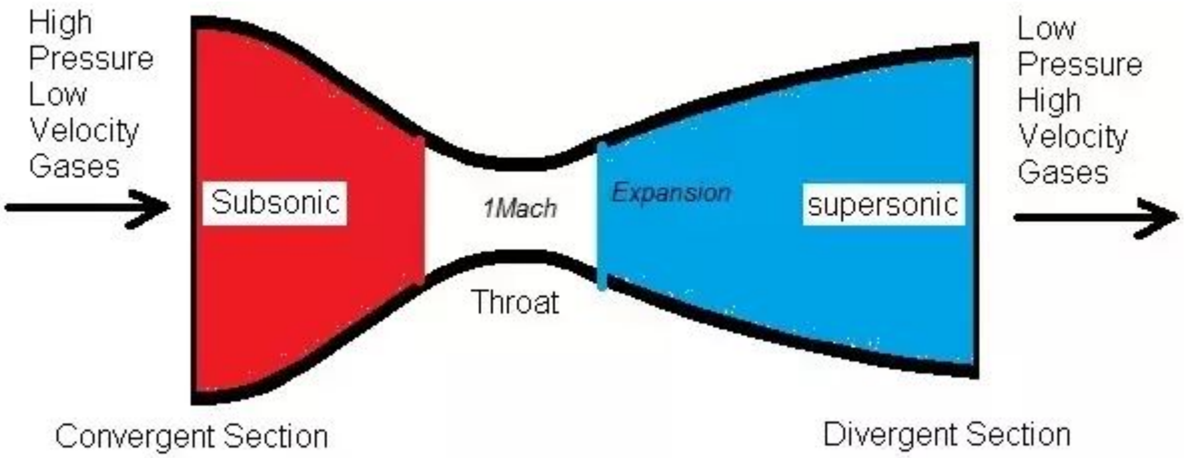
Combustion Chamber



It is the chamber where the combustion of the fuel takes place to produce the exhaust.

It has two parts → **Injector**, **Casing**

Nozzle



It is directly connected to the combustion chamber and the all the exhaust gases are expelled through this.

The velocity of exhaust gases increases although the area of nozzle increases

ASSIGNMENT - II

Concepts Learnt:

1. Relation between various parameters related to rocket like wet mass, payload mass, etc.
2. Calculating the displacement and velocity of the rocket at a general time
3. Solved problems related to SSTO t
4. Calculating the payload to fuel ratio which is necessary for optimisation and increasing the efficiency of the process

THANK YOU

“Cosmos is within us!”