



Optimal Design Methodology



Optimal Design Problem Definition

In **multi-stage** rocket design, basic **design** variables are **masses** within each stage.

Payload mass and ideal burnout **velocity** can either be **objective** function or **constraint**.



Optimal Design Problem Definition

In most cases, **objective** is to maximize, either \mathbf{m}_* for a given \mathbf{V}_* , or vice versa.

In all these **cases**, No. of stages is used as a **parameter**.



Optimal Design Method

Among the **many** techniques, **gradient** based methods are **useful** for problems that allow **differentiation**.

Typically, there is an **objective** function that is optimized, with respect to the **design** variables.



Optimal Design Description

Further, there are **constraints** that the solution needs to **satisfy**.

In the **present** case, either V_* can be taken as **objective** function & π_* **as constraint** or vice versa.



Optimal Solutions Concept

In **gradient** based methods, **partial** derivatives of objective **function**, with respect to design **variables**, are driven to **zero**, while satisfying the **constraint** exactly.

Thus, for an '**N**' stage vehicle having '**N**' design variables, we have '**N+1**' equations, for '**N**' **unknowns**.



Optimal Solutions Concept

It is **well** known that for **such** a system of **equations**, we can extract '**N**' solutions based on **least** squares method.

However, if an **exact** solution is **desired**, then we need to **add** one more **unknown**, to make the system **square**.



Summary

To **summarize**, optimal methods are **capable** of providing good solutions for the **stage-wise** payload ratios.

Further, we **note** that we can make use of **gradient-based** techniques to set up the applicable **solution** methodology.