Rocket Equation: Delta-v, Exhaust Velocity and Burn Time

Ideal velocity change of a rocket stage from specific impulse and initial and propellant masses by Tsiolkovsky's equation, with mass flow and burn time for a thrust.

Method: Tsiolkovsky rocket equation

Input parameters

Unit system: SI

Parameter	Value	Unit
Specific impulse	311.00	s
Initial (wet) mass	25,000	kg
Propellant mass burned	19,000	kg
Thrust (for burn time)	450.00	kN

Calculated results

Parameter	Value	Unit
Ideal velocity change	4,352.5	m/s
Effective exhaust velocity I_sp g_0	3,049.9	m/s
Mass ratio	4.1667	
Propellant mass fraction	76.000	%
Propellant mass flow	147.55	kg/s
Burn time	128.77	s
Initial thrust-to-weight ratio	1.8355	

Notes for this case

- Ideal (Tsiolkovsky) Δv in free space: gravity and drag losses, typically 1.5–2 km/s for an ascent to orbit, must be added to the mission Δv budget.

Formula and method

$$\Delta v = I_{sp} g_0 \ln \frac{m_0}{m_0 - m_p}, \quad \dot{m} = \frac{F}{I_{sp} g_0}, \quad t_b = \frac{m_p}{\dot{m}}$$

Variables

I_{sp}	Specific impulse	s
m_0	Initial (wet) mass	kg
m_p	Propellant mass burned	kg
F	Thrust (for burn time)	N
Δv	Ideal velocity change	m/s
v_e	Effective exhaust velocity I_sp g_0	m/s
m_0/m_f	Mass ratio	-
m_p/m_0	Propellant mass fraction	-
$\dot{m}$	Propellant mass flow	kg/s
t_b	Burn time	s
$F/(m_0 g_0)$	Initial thrust-to-weight ratio	-

Method and standards

Ideal rocket equation.

Assumptions and limits

- Constant exhaust velocity; no external forces.

References

Tsiolkovsky rocket equation

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

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Reopens the calculator with the inputs of this report.