

Equations

Total Impulse Thrust force integrated over the time of application.

$$I_t = \int_0^t F dt \quad (1)$$

Specific Impulse: Thrust per unit propellant ‘weight’ flow rate.

$$I_S = \frac{\int_0^t F dt}{g_0 \int_0^t \dot{m} dt} = \frac{I_t}{w} \quad (2)$$

Total Propellant Weight:

$$w = m_p g_0 \quad (3)$$

Weight Flow Rate:

$$\dot{w} = \dot{m}_p g_0 \quad (4)$$

Effectice Exhaust Velocity: An average or mass-equivalent velocity at which propellant is being ejected from the nozzle.

$$c = I_S g_0 = \frac{F}{\dot{m}} = v_2 + (p_2 - p_3) \frac{A_2}{\dot{m}} \quad (5)$$

Characteristic Velocity: Compares relative performance of different chemical rocket propulsion systems. Essentially independent of nozzle characteristics. Can be related to the efficiency of the combustion process.

$$c = I_S g_0 = \frac{F}{\dot{m}} = v_2 + (p_2 - p_3) \frac{A_2}{\dot{m}} \quad (6)$$

Mass Ratio: Ratio of the final mass over the initial mass.

$$\mathbf{MR} = \frac{m_f}{m_0} \quad (7)$$

Propellant Mass Fractio: Ratio of the usefull propellant mass to the intitial mass.

$$\zeta = \frac{m_p}{m_0} = \frac{(m_0 - m_f)}{m_0} = \frac{m_p}{(m_p + m_f)} \quad (8)$$

Impulse-to-Weight Ratio: The total impulse divided by the initial propellant-loaded vehicle sea-level weight.

$$\frac{I_t}{w_o} = \frac{I_t}{(m_f + m_p)g_0} = \frac{I_S}{\frac{m_f}{m_p} + 1} \quad (9)$$

Thrust: Momentum and pressure thrust.

$$F = \dot{m} v_2 + (p_2 - p_3) A_2 \quad (10)$$

Symbols

I_t	Total Impulse	N · s
I_S	Specific Impulse	s
m_p	Total Effective Propellant Mass	kg
w	Effectice Propellant Weight	N
\dot{m}	Total Mass Flow Rate	kg / s
\dot{w}	Weight Flow Rate	N / s
g_0	Earth's Average Gravity	kg / s ²
c	Effectice Exhaust Velocity	m / s
MR	Mass Ratio	Unitless
m_f	Final Mass	kg
m_0	Initial Mass	kg
ζ	Propellant Mass Fraction	Unitless
I_t / w_0	Impulse-to-Weight Ratio	s
F	Thrust	N
v_2	Nozzle Exit Velocity	m / s ²
p_2	Nozzle Exit Pressure	Pa
p_3	Ambient Pressure	Pa
A_2	Nozzle Exit Area	m ²
c^*	Characteristic Velocity	m / s
p_1	Chamber Pressure	Pa
A_t	Throat Area	m ²