DEPARTMENT OF AEROSPACE ENGINEERING

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Course	:	**19AST301 - Space Propulsion**			

UNIT I - FUNDAMENTALS OF ROCKET PROPULSION

Preliminary Performance Calculations

Figures of Merit	Units (SI)	Newtonian Physics	EP Application[9]	Definition
Thrust (F)	N	$F = \dot{m}_p v_e$	$F = \frac{\gamma \sqrt{\frac{2M}{e}} I_b \sqrt{V_b}}{1000}$	Total amount of force produced by a system or thruster.
Specific Impulse (I_{sp})	sec	$I_{sp} = \frac{F}{g_0 \dot{m}}$	$I_{sp} = \frac{\gamma \eta_m}{g_0} \sqrt{\frac{2eV_b}{M}}$	Measures propellant performance by quantifying the total impulse per unit mass of propellant.
System Change in Velocity (Δv)	m/s	$\Delta v = g_0 I_{sp} \ln\left(\frac{m_i}{m_f}\right)$		Quantifies system ability to change its velocity based on propellant performance and spacecraft mass.
Density Specific Impulse (I_d)	$\frac{\text{kg-s}}{\text{L}}$	$I_d = \rho I_{sp}$		Used to compare propellant performance for given I_{sp} and density. This is generally how well the propellant packages.
Total Impulse (I_t)	Ns	$I_t = \int_0^{t_b} F dt = F t_b$		Change in momentum given by integrating thrust over a given burn time. Quantifies total amount of force produced by the propellant.
Volumetric Impulse	$\frac{Ns}{L} \vee \frac{Ns}{U}$	$\frac{I_t}{V_{S/C}}$		This efficiency parameter used for SmallSat propulsion systems describes the amount of total impulse (Ns) a system imparts to a body per unit volume (U or L).
Propellant Mass Fraction†	None	$\zeta = \frac{m_p}{m_f}$		Quantifies the efficiency of a propulsion system to move a given mass (m_f).

Nomenclature:

F	Thrust, N	v_e	Combustion exit velocity at the nozzle, m/s
I_{sp}	Specific Impulse, s	t_b	Thruster burn time, s
Δv	Change in Velocity, m/s	m_i	Initial (wet) spacecraft mass, kg
I_d	Density Specific Impulse, (kg-s)/m^3	m_f	Final (dry) spacecraft mass, kg
I_t	Total Impulse, Ns	ρ	Density, kg/m^3
$V_{s/c}$	CubeSat Spacecraft Volume, U or L	g_0	Earth gravity acceleration, m/s^2
m_p	Propellant mass, kg	γ	Total Thrust Correction Factor
$\dot{m}_p$	Propellant mass flow rate, kg/s	M	Mass of planet, kg
I_b	Ion beam current, A	V_b	Effective beam voltage, Vdc
η_m	Thruster mass utilization efficiency	e	Ion Charge, A