Two-body problem expressions

$$\frac{\mathrm{d}^2\boldsymbol{r}}{\mathrm{d}t^2} = -\frac{\mu}{r^3}\boldsymbol{r}; \qquad \xi = \frac{v^2}{2} - \frac{\mu}{r} = -\frac{\mu}{2a}; \qquad \boldsymbol{h} = \boldsymbol{r} \times \boldsymbol{v}; \qquad \boldsymbol{e} = \frac{\boldsymbol{v} \times \boldsymbol{h}}{\mu} - \frac{\boldsymbol{r}}{r}$$

$$p = \frac{h^2}{\mu} = a(1-e^2); \qquad r = \frac{p}{1+e\cos\theta} = a(1-e\cos E); \qquad v_r = \dot{r} = \frac{\mu}{h}e\sin\theta; \qquad v_\theta = r\dot{\theta} = \frac{\mu}{h}(1+e\cos\theta)$$

$$M_e = E - e\sin E; \qquad M_p = \frac{1}{2}\tan\frac{\theta}{2} + \frac{1}{6}\tan^3\frac{\theta}{2}; \qquad M_h = e\sinh H - H$$

$$n_e = \sqrt{\mu/a^3}; \qquad n_p = \sqrt{\mu/p^3}; \qquad n_h = \sqrt{-\mu/a^3}$$

$$\sin E = \frac{\sqrt{1-e^2}\sin\theta}{1+e\cos\theta}; \qquad \cos E = \frac{e+\cos\theta}{1+e\cos\theta}; \qquad \sin\theta = \frac{\sqrt{1-e^2}\sin E}{1-e\cos E}; \qquad \cos\theta = \frac{\cos E - e}{1-e\cos E}$$

$$\sinh H = \frac{\sqrt{e^2-1}\sin\theta}{1+e\cos\theta}; \qquad \cosh H = \frac{e+\cos\theta}{1+e\cos\theta}; \qquad \sin\theta = -\frac{\sqrt{e^2-1}\sinh H}{1-e\cosh H}; \qquad \cos\theta = \frac{\cosh H - e}{1-e\cosh H}$$

Circular restricted three-body problem expressions

$$\mu^* = \frac{m_2}{m_1+m_2}; \qquad \rho_1^2 = (x+\mu^*)^2 + y^2 + z^2; \qquad \rho_2^2 = (x+\mu^*-1)^2 + y^2 + z^2$$

$$U = -\frac{1-\mu^*}{\rho_1} - \frac{\mu^*}{\rho_2} - \frac{1}{2}(x^2+y^2); \qquad \ddot{x} - 2\dot{y} = -\frac{\partial U}{\partial x}; \qquad \ddot{y} + 2\dot{x} = -\frac{\partial U}{\partial y}; \qquad \ddot{z} = -\frac{\partial U}{\partial z}$$

Spacecraft design expressions

$$\frac{E_b}{N_0} \geqslant \frac{PG_tL_sG_r}{N_0R}; \qquad L_s = \frac{\lambda^2}{(4\pi r)^2}; \qquad N_0 = (kT_S); \qquad G = \frac{4\pi A_r}{\lambda^2}$$

$$F = \dot{m}I_{sp}; \qquad \Delta V = I_{sp}\ln\left(\frac{M_0}{M_f}\right)$$

Physical constants

Name	Value	Units
Gravitational constant G	$6.67260 \cdot 10^{-11}$	$\mathrm{m^3kg^{-1}s^{-2}}$
Boltzmann constant k	$1.38 \cdot 10^{-23}$	$\mathrm{m^2kg/(s^2K)}$
Stefan-Boltzmann constant σ	$5.67 \cdot 10^{-8}$	$\mathrm{W/(m^2K^4)}$
Speed of light in vacuum c	$299.79 \cdot 10^6$	m/s

Celestial body data

Orbital and physical properties of celestial bodies have been obtained from NASA's JPL Horizons database. a is the semi-major axis with respect to the Sun (planets) or Earth (Moon) at epoch J2000.0; R is the mean body radius; $\mu = GM$ is the gravitational parameter; ω_s is the sidereal rotation of the body about its axis.

Body	a [10^6 km]	R [km]	μ [10^5 km^3/s^2]	ω_s [10^{-6} rad/s]
Sun, ☉	-	695700	1327120	N/A
Mercury, ☿	57.909	2440.0	0.220318	1.24001
Venus, ♀	108.21	6051.8	3.24859	-0.29924
Earth, ⊕	149.67	6371.0	3.98600	72.921
Moon, ☾	0.38475	1737.5	0.0490280	2.6617
Mars, ♂	227.94	3389.9	0.428284	70.882
Jupiter, ♃	778.56	69911	1266.87	175.85