

# Astrodynamics Quick Reference Sheet: ASEN 3200

Orbital Period	$\mathbb{P} = 2\pi\sqrt{\frac{a^3}{\mu}}$	$\mathbb{P} = \frac{2\pi}{n}$	
Mean Motion	$n = \sqrt{\frac{\mu}{a^3}}$	$n = \frac{2\pi}{\mathbb{P}}$	
Specific Energy	$\mathcal{E} = \frac{v^2}{2} - \frac{\mu}{r}$	$\mathcal{E} = -\frac{\mu}{2a}$	
Semiparameter	$p = a(1 - e^2)$	$p = \frac{h^2}{\mu}$	$p = \frac{b^2}{a}$
Angular Momentum	$\vec{h} = \vec{r} \times \vec{v}$ $h = r^2\dot{\theta}$	$h = \sqrt{\mu p}$ $h = \sqrt{\mu a(1 - e^2)}$	$h = r_a v_a$ $h = r_p v_p$

**Table A.1** Astronomical data for the sun, the planets and the moon

Object	Radius (km)	Mass (kg)	Sidereal rotation period	Inclination of equator to orbit plane	Semimajor axis of orbit (km)	Orbit eccentricity	Inclination of orbit to the ecliptic plane	Orbit sidereal period
Sun	696 000	$1.989 \times 10^{30}$	25.38d	7.25°	–	–	–	–
Mercury	2440	$330.2 \times 10^{21}$	58.65d	0.01°	$57.91 \times 10^6$	0.2056	7.00°	87.97d
Venus	6052	$4.869 \times 10^{24}$	243d*	177.4°	$108.2 \times 10^6$	0.0067	3.39°	224.7d
Earth	6378	$5.974 \times 10^{24}$	23.9345h	23.45°	$149.6 \times 10^6$	0.0167	0.00°	365.256d
(Moon)	1737	$73.48 \times 10^{21}$	27.32d	6.68°	$384.4 \times 10^3$	0.0549	5.145°	27.322d
Mars	3396	$641.9 \times 10^{21}$	24.62h	25.19°	$227.9 \times 10^6$	0.0935	1.850°	1.881y
Jupiter	71 490	$1.899 \times 10^{27}$	9.925h	3.13°	$778.6 \times 10^6$	0.0489	1.304°	11.86y
Saturn	60 270	$568.5 \times 10^{24}$	10.66h	26.73°	$1.433 \times 10^9$	0.0565	2.485°	29.46y
Uranus	25 560	$86.83 \times 10^{24}$	17.24h*	97.77°	$2.872 \times 10^9$	0.0457	0.772°	84.01y
Neptune	24 760	$102.4 \times 10^{24}$	16.11h	28.32°	$4.495 \times 10^9$	0.0113	1.769°	164.8y
Pluto	1195	$12.5 \times 10^{21}$	6.387d*	122.5°	$5.870 \times 10^9$	0.2444	17.16°	247.7y

\* Retrograde

**Table A.2** Gravitational parameter ( $\mu$ ) and sphere of influence (SOI) radius for the sun, the planets and the moon

Celestial body	$\mu$ (km <sup>3</sup> /s <sup>2</sup> )	SOI radius (km)
Sun	132 712 000 000	–
Mercury	22 030	112 000
Venus	324 900	616 000
Earth	398 600	925 000
Earth's moon	4903	66 200
Mars	42 828	577 000
Jupiter	126 686 000	48 200 000
Saturn	37 931 000	54 800 000
Uranus	5 794 000	51 800 000
Neptune	6 835 100	86 600 000
Pluto	830	3 080 000

Semimajor axis	$a = \frac{1}{2} (r_a + r_p)$	$a = -\frac{\mu}{2\mathcal{E}}$	$a = \left( \mu \left( \frac{\mathbb{P}}{2\pi} \right)^2 \right)^{1/3}$
Eccentricity	$e = \frac{r_a - r_p}{r_a + r_p}$ $e = \left( 1 - \frac{r_p}{a} \right)$	$e = \sqrt{1 + \frac{2h^2\mathcal{E}}{\mu^2}}$ $e = \left( \frac{r_a}{a} - 1 \right)$	$\vec{e} = \frac{\vec{v} \times \vec{h}}{\mu} - \frac{\vec{r}}{r}$
Radius	$r = \frac{a(1 - e^2)}{1 + e \cos \theta}$	$r = \frac{h^2/\mu}{1 + e \cos \theta}$	$r = \frac{p}{1 + e \cos \theta}$ $r = a(1 - e \cos E)$
Periapsis Radius	$r_p = a(1 - e)$	$r_p = 2a - r_a$	$r_p = r_a \left( \frac{1 - e}{1 + e} \right)$
Apoapsis Radius	$r_a = a(1 + e)$	$r_a = 2a - r_p$	$r_a = r_p \left( \frac{1 + e}{1 - e} \right)$
Velocity	$v = \sqrt{\frac{2\mu}{r} - \frac{\mu}{a}}$	$v_{esc} = \sqrt{\frac{2\mu}{r}}$	$v_{circ} = \sqrt{\frac{\mu}{r}}$
Flight Path Angle	$\tan \gamma = \frac{e \sin \theta}{1 + e \cos \theta}$		
Time	$t - t_p = (E - e \sin E) \sqrt{\frac{a^3}{\mu}}$	$t - t_p = \frac{M}{n}$	$t - t_p = \left( \frac{E - e \sin E}{n} \right)$
Mean Anomaly	$M = n(t - t_p)$	$M = E - e \sin E$	$M = e \sinh H - H$
Eccentric Anomaly	$\tan \left( \frac{E}{2} \right) = \sqrt{\frac{(1 - e)}{(1 + e)}} \tan \left( \frac{\theta}{2} \right)$	$\cos E = \frac{e + \cos \theta}{1 + e \cos \theta}$	$\sin E = \frac{\sin \theta \sqrt{1 - e^2}}{1 + e \cos \theta}$
True Anomaly	$\tan \left( \frac{\theta}{2} \right) = \sqrt{\frac{(1 + e)}{(1 - e)}} \tan \left( \frac{E}{2} \right)$	$\cos \theta = \frac{\cos E - e}{1 - e \cos E}$	$\sin \theta = \frac{\sin E \sqrt{1 - e^2}}{1 - e \cos E}$
Hyperbolic Anomaly	$\tanh \left( \frac{H}{2} \right) = \sqrt{\frac{(e - 1)}{(e + 1)}} \tanh \left( \frac{\theta}{2} \right)$		

