Astronomy 11 Fall 1998 (S.T. Myers)

Equations for Midterm #2 Thu 12 November 1998

Constants

$c = 2.998 \times 10^5$ km/s

$\mathrm{h} = 6.626 \times 10^{-34}\,\mathrm{J\,s}$

$\mathrm{k} = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$

$\mathrm{m_p} = 1.67 \times 10^{-27}\,\mathrm{kg}$

$M_\odot = 2 \times 10^{30}$ kg

$L_\odot = 3.83 \times 10^{26}$ W

$M_\oplus = 5.98 \times 10^{24}$ kg

$g_\oplus = 9.807$ m/s^2

$1\,\mathrm{AU} = 1.496 \times 10^8\,\mathrm{km}$

$1\,\mathrm{radian} = 206265''$

$\mathrm{G} = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$

$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

$1\,\mathrm{eV} = 1.602 \times 10^{-19}\,\mathrm{J}$

$\mathrm{m_e} = 9.11 \times 10^{-31}\,\mathrm{kg}$

$R_\odot = 6.96 \times 10^5$ km

$T_\odot = 5770$ K

$R_\oplus = 6378$ km

Solar Constant $= 1370$ W/m^2

$1\text{Å} = 10^{10}\,\mathrm{m} = 10^{-4}\,\mu\mathrm{m}$

1 year $= 3.156 \times 10^7$ seconds $= 365.26$ days

Mechanics

$$\vec{v} = d\vec{r}/dt \qquad \vec{a} = d\vec{v}/dt$$

$$\vec{p} = m\vec{v} \qquad \vec{L} = \vec{r} \times \vec{p}$$

$$F_{cen} = \frac{mv^2}{r} \qquad F = \frac{Gm_1m_2}{r^2}$$

$$E = \frac{1}{2}\mu v^2 - \frac{GM\mu}{r} \qquad \frac{1}{S} = \frac{1}{P_{in}} - \frac{1}{P_{out}}$$

$$v_{circ} = \frac{2\pi a}{P} \qquad \mu = \frac{m_1m_2}{m_1+m_2}$$

$$M = m_1 + m_2 \qquad GM\,P^2 = 4\pi^2\,a^3$$

$$M\vec{R} = m_1\vec{r}_1 + m_2\vec{r}_2 = 0 \qquad M\vec{V} = m_1\vec{v}_1 + m_2\vec{v}_2 = 0$$

$$\vec{r} = \vec{r}_2 - \vec{r}_1 \qquad \vec{v} = \vec{v}_2 - \vec{v}_1$$

$$\vec{r}_1 = -\frac{\mu}{m_1}\vec{r} \qquad \vec{r}_2 = \frac{\mu}{m_2}\vec{r}$$

$$m_1r_1 = m_2r_2 \qquad m_1v_1 = m_2v_2$$

$$r_p = a(1-e) \qquad r_a = a(1+e)$$

$$H = rv_\theta \qquad L_{orb} = \mu v_p r_p = \mu v_a r_a$$

$$\frac{E}{\mu} = -\frac{GM}{2a} \qquad H^2 = GMa(1-e^2)$$

$$v_{circ}^2 = \frac{GM}{r} \qquad v_{esc}^2 = \frac{2GM}{r}$$

$$v_\theta^2 = \frac{GMa}{r^2}(1-e^2) \qquad v^2 = GM\left[\frac{2}{r} - \frac{1}{a}\right]$$

$$\vec{F}\cdot d\vec{r} = F_r dr + F_\theta r d\theta \qquad d\vec{r}/dt = (dr/dt, rd\theta/dt)$$

Radiation and Optics:

$$\nu = c/\lambda \qquad E = h\nu = hc/\lambda$$
$$F = L/4\pi r^2 \qquad F_{surf} = \sigma T^4$$
$$\lambda_{max} = \frac{2.9\,\mathrm{mm}}{(T/\,1\mathrm{K})} \qquad \theta_{res} = \frac{\lambda}{D}$$
$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad n = c/v \geq 1$$
$$y = f\,\theta \qquad P_{in} = F_{in} \cdot \pi D^2/4$$

Planetary Astrophysics

$$P_{abs} = \pi R^2\, F_{in}\,(1-A) \qquad P_{em} = 4\pi R^2\,\sigma\,T^4\,(1-G)$$
$$P_{ref} = \pi R^2\, F_{in}\, A \qquad F_{in} = \sigma\, T_{ss}^4 = L/4\pi r^2$$
$$T_{eq} = \frac{T_{ss}}{\sqrt{2}} \quad \text{(sphere)} \qquad T_{surf} = T_{eq}\left[\frac{1-A}{1-G}\right]^{1/4}$$
$$p = nkT = \frac{\rho kT}{a m_H} \qquad v_{rms}^2 = \frac{3kT}{m}$$
$$\frac{dP}{dr} = -\frac{GM(r)\rho(r)}{r^2} = -g\rho \qquad P_c \sim \frac{GM\bar{\rho}}{R}$$
$$M = \frac{4\pi}{3}\,\bar{\rho}\,R^3 \qquad T_c \sim \frac{\mu m_H}{k}\,\frac{P_c}{\bar{\rho}}$$
$$p = p_0\, e^{-h/H} \qquad H = \frac{kT}{mg}$$

Common Elements and Isotopes:

(Key: ${}^{mass}_{num}X$)

	${}^{1}_{1}\mathrm{H}$	${}^{4}_{2}\mathrm{He}$	${}^{12}_{6}\mathrm{C}$	${}^{14}_{7}\mathrm{N}$
	${}^{16}_{8}\mathrm{O}$	${}^{20}_{10}\mathrm{Ne}$	${}^{32}_{16}\mathrm{S}$	${}^{56}_{26}\mathrm{Fe}$

Mass of ${}^{1}\mathrm{H} = 1.67352 \times 10^{-27}$ kg

Representative Mean Densities:

	Water	Gas	Rock	Metal
$\bar{\rho}$ **(kg/m^3):**	1000	500 – 1700	∼3500	8000 – 10000

Solar System Data:

Planet	a **(AU)**	P **(days)**	e	$M/M_\oplus$	$R/R_\oplus$	**Albedo**
Mercury	0.387	87.96	0.206	0.056	0.38	0.06
Venus	0.723	224.70	0.007	0.815	0.95	0.76
Earth	1.0	365.26	0.017	1.0	1.0	0.40
Mars	1.524	686.98	0.093	0.107	0.53	0.16
Jupiter	5.203	4333	0.048	318	11.19	0.51
Saturn	9.54	10759	0.056	95	9.41	0.50
Uranus	19.18	30685	0.047	14.5	4.01	0.66
Neptune	30.06	60188	0.009	17.2	3.89	0.62
Pluto	39.44	90700	0.249	0.0018	0.18	0.50