Answers and Hints to Exercise Questions in "Solar System Dynamics"
(Last Updated: 1 September 2006)

Chapter 7

Q7.1 Note that $\mu_1 = m_1/(m_\mathrm{s} + m_2)$ and $\mu_2 = m_2/(m_\mathrm{s} + m_1)$ where m_s is the mass of the star. See error listing.

Q7.2 The precession rate of Saturn due to Jupiter is 2.6×10^{-3} °y^{-1} using this method. The formula for g_- given in Q7.1 is identical to that derived in Q6.3. The precession rate of Venus due to Earth is 6.9×10^{-4} °y^{-1} usingthis method. The precession rate of the lunar orbit due to the Sun is 5.53×10^{-2} °d^{-1} using this method; this gives a precessional period of 17.8 y. The precession rate due to the Earth's J_2 is 5.88×10^{-6} °d^{-1}; this is much smaller than the solar effect.

Q7.3 The rate is $\dot{\varpi} = \frac{1}{4}(m'/M)n\alpha\left\{(2\alpha D + \alpha^2 D^2)b_{1/2}^{(0)} + (e'/e)(2 - 2\alpha D - \alpha^2 D^2)b_{1/2}^{(1)}\cos(\varpi' - \varpi)\right\}$. (i) When $\varpi' = \varpi$, $\dot{\varpi} = 1.447°$/century. (ii) When $\varpi' = \varpi + 180°$, $\dot{\varpi} = 2.220°$/century.

Q7.4 Using the secular theory for Jupiter and Saturn alone gives $e_\mathrm{forced} = 0.0350$, $\varpi_\mathrm{forced} = 9.40°$, $e_\mathrm{free} = 0.0452$, $\varpi_\mathrm{forced} = 122.54°$, $I_\mathrm{forced} = 1.150°$, $\Omega_\mathrm{forced} = 96.55°$, $I_\mathrm{free} = 2.091$, $\Omega_\mathrm{forced} = 300.34°$. Using Brouwer & van Woerkom's secular theory gives $e_\mathrm{forced} = 0.0371$, $\varpi_\mathrm{forced} = 6.28°$, $e_\mathrm{free} = 0.0479$, $\varpi_\mathrm{forced} = 123.85°$, $I_\mathrm{forced} = 1.149°$, $\Omega_\mathrm{forced} = 96.02°$, $I_\mathrm{free} = 2.086$, $\Omega_\mathrm{forced} = 300.08°$.

Q7.5 For a density of 1.2 g cm^{-3} the minimum separation varies from 57.8 km for a zero mass F ring, to 162.2 km for an F ring mass equal to three times that of Prometheus. The separation is less than 70 km when $0 \le m < 0.4$ where m is measured in units of a Prometheus mass. For a density of 0.6 g cm^{-3} the minimum separation varies from 79.5 km for a zero mass F ring to 132.5 km for an F ring mass equal to three times that of Prometheus. The separation is never less than 70 km.

Q7.6 The eccentricity–pericentre eigenfrequencies, g_i (in degrees per day) and the associated locations in semi-major axes (in km) where $A = g_i$ are $g_1 = 1.00184$ (187488, 237296, 238739, 292761, 296549, 374945, 379850, 523206, 530872, 1186250, 1257440, 1480710, 1481490, 3556240, 3566360), $g_2 = 0.417727$ (241742, 290962, 298218, 373313, 381449, 520975, 533089, 1166710, 1276970, 1480490, 1481710, 3553470, 3569130), $g_3 = 0.198099$ (305715, 370258, 384213, 517838, 536160, 1141710, 1301890, 1480190, 1482010, 3549920, 3572680), $g_4 = 0.0842694$ (397518, 510745, 542585, 1098550, 1344560, 1479590, 1482600, 3543850), $g_5 = 0.0275128$ (574249, 1000210, 1436770, 1476800, 1485110, 353070, 3591890), $g_6 = 0.0188353$ (618933, 944487, 1491350, 3524270, 3598320), $g_7 = 0.00137212$ (2145640, 3414930, 3704710), $g_8 = 0.000152186$ (4161030). The inclination–node eigenfrequencies, f_i (in degrees per day) and the associated locations in semi-major axes (in km) where $B = f_i$ are $f_1 = -0.999287$ (187491, 237294, 238740, 292758, 296552, 374942, 379853, 523201, 530877, 1186210, 1257490, 1480710, 1481490, 3556240, 3566360), $f_2 = -0.417079$ (241745, 290958, 298222, 373309, 381453, 520970, 533094, 1166670, 1277010, 1480490, 1481710, 3553460, 3569140), $f_3 = -0.197899$ (305721, 370253, 384217, 517833, 536165, 1141670, 1301930, 1480190, 1482010, 3549920, 3572680), $f_4 = -0.0842182$ (397524, 510739, 542591, 1098510, 1344590, 1479590, 1482600, 3543840), $f_5 = -0.0275047$ (574257, 1000170, 1436800, 1476800, 1485110, 353070, 35918900), $f_6 = -0.0188356$ (618899, 944493, 1491350, 3524270, 3598320), $f_7 = -0.00137098$ (2146000, 3414860, 3704780), $f_8 = -0.00015199$ (4161600).