SSD

1 Exercise

1.3

$$v_{\text{esc}} = \sqrt{\frac{2\mu_M}{r_M}} \Rightarrow \mu_M = \frac{v_{\text{esc}}^2}{2} r_M = 4.245 \cdot 10^4 \frac{km^3}{s^2}$$

$$g_{\text{Mars}} = \frac{\mu_M}{r_M^2} = 0.00368 \frac{km}{s^2}$$

1.6

1)

$$a = \sqrt[3]{\mu_S \frac{T^2}{4\pi^2}} = 178.25AU$$

2)

$$r_a = a(1+\varepsilon)$$

$$\varepsilon = \frac{r_a}{a} - 1 = \frac{350AU}{178.25AU} - 1 = 0.9635AU$$

3)

$$v_{\max} = \sqrt{\mu_S \left(\frac{2}{r_p} - \frac{1}{a}\right)} = 16.37 \frac{km}{2}$$

$$v_{\min} = \sqrt{\mu_S \left(\frac{2}{r_a} - \frac{1}{a}\right)} = 0.304 \frac{km}{2}$$

4 Exercise

4.1

1)

$$\sharp\text{Orbits} = \frac{18\text{days}}{\text{period}} = \frac{18 \cdot 14 \cdot 60}{103.267min} = 250.9998 \approx 250 \quad \text{[round to integer]}$$

2)

$$T = 2\pi\sqrt{\frac{a^3}{\mu_E}} \Rightarrow a = \sqrt[3]{\frac{T^2}{4\pi^2}\mu_E} = 7291.23km$$

$$h_a = a - r_E = 7291.23km - 6278km = 913.23km$$

3)

$$\Delta\Omega = \frac{T}{\tau_s} 2\pi = 1.233 \cdot 10^{-3} \frac{\text{rad}}{rev} = 0.07068 \frac{\text{deg}}{\text{rev}}$$

$$i = \arccos\left(\frac{\Delta\Omega a^2}{-3\pi J_2 r_E^2}\right) = 99.09^\circ$$

4.3

vars: $T = 205min, \varepsilon = 0.4, \nu = 60°$

$$e = \arccos\left(\frac{\varepsilon + \cos\nu}{1 + \cos\nu}\right)$$

$$\frac{2\pi}{T}\Delta t = e - \varepsilon \sin e \Rightarrow \Delta t = \frac{(e - \varepsilon \sin e) \cdot T}{2\pi} = 896.90s$$

8 Exercise

8.2

1) frame rate: $\frac{1000ms}{40ms} = 25$
   data rate for 1 second:

$$25 \cdot 5000 \text{ pixel} \cdot 11 \text{ bits} = 1357000 \text{ bits}$$

   data volume for the complete video stream

$$1357000 \text{ bit} \cdot 600s = 852000000 \text{ bit}s = 103125000 \text{ Byte} = 103 \text{ MB or } 98.3 \text{ MiB}$$

2) number of frames needed to transmit 103MB

$$\frac{103125000B}{500B} = 206250 \text{ frames}$$

   total amount of data to transfer

$$206250 \text{ frames} \cdot 512B = 105600000B$$

   needed data rate

$$\frac{105600000B \cdot 8}{60s \cdot 8} = 1760000\frac{\text{bit}}{s} = 1.76\frac{\text{Mbit}}{s} = 1.76\text{Mbps}$$

9 Exercise

9.1

1) mean motion $\left(\frac{\text{rev}}{\text{day}}\right) \rightarrow$ line 2

$$n = 14.59304284\frac{\text{rev}}{\text{day}}$$

   orbital period $T = \frac{24 \cdot 60\text{min}}{n} = 98.6772\text{min}$

$$a = \sqrt[3]{\frac{T^2}{4\pi^2}\mu_E} = 7073.56km$$

$$r_a = a(1 + \varepsilon) = 7086.60km$$

$$r_p = a(1 - \varepsilon) = 7060.52km$$

$$h_a = r_a - R_E = 708.60km$$

$$h_p = r_p - R_E = 682.52km$$

   TLE should not be older than 30 days $\rightarrow$ no good tracking possible

2) epoch $\rightarrow$ line 1

$$\underbrace{05}_{\text{year 2005}} \quad \underbrace{307}_{\text{day of year}} \quad \underbrace{06483461}_{\text{fraction of day (24h)}} \rightarrow \text{3. Nov 2005}$$

   time $t = 0.06483461 \cdot 86400s = 5601.71s$

$$\text{time is } \underbrace{01}_{h} : \underbrace{33}_{min} : \underbrace{21.71}_{s}$$

3)

$$\begin{aligned}\Delta\Omega &= \frac{-3\pi J_2 R_E^2}{a^2(1-\varepsilon^2)^2}\cos i \ \left(\frac{\text{rad}}{\text{rev}}\right) \\ &= \frac{-3\pi J_2 R_E^2}{a^2(1-\varepsilon^2)^2}\cos i \cdot n \ \left(\frac{\text{rad}}{\text{day}}\right) \\ &= 0.9875 \ \left(\frac{\text{deg}}{\text{day}}\right)\end{aligned}$$

if it is $\approx 1 \ \frac{\text{deg}}{\text{day}} \Rightarrow$ sun-sync orbit