ASTR120
Homework 5 −Solutions

Ch. 12, Prob. 39.
To determine the angular resolution of the image, we can use the small angle formula:

$$\alpha = \frac{206265\, d}{D}$$

In this case, d is the finest detail the image shows and D is the distance the camera is from the object. So:

$$\alpha = \frac{206265\,(100)}{7.2 \times 10^5} = 28.6 \text{ arcsec}$$

Ch. 13, Prob. 42.
a. For this part of the problem, we will use Newton's version of Kepler's third law:

$$P^2 = \frac{4\pi^2}{G\,(M_1 + M_2)}\, a^3, \text{ where P is 117 min.} = 7020 \text{ sec and } M_1 + M_2 = M_{Mars}$$

$$7020^2 = \frac{4\pi^2}{G\,(6.42 \times 10^{23})}\, a^3, \quad a = 3.77 \times 10^6 \text{ m}$$

b. Since a is calculated from the center of Mars, the height of MGS above the surface of Mars is just $a - R_{Mars} = 3.77 \times 10^6 - 3.40 \times 10^6 = 3.7 \times 10^5$ m

c. The orbit of the MGS crosses both the north and south poles. This way, the entire planet can be imaged as the planet rotates underneath the satellite.

Ch. 13, Prob. 49.
a. The sky is not black. Any picture you see of astronauts in space shows the 'sky' to be black

b. The haziness near the horizon of the photo indicates an atmosphere as well. On Earth, we can see individual clouds as well as the sky itself

c. Wind-blown sand dunes are present, which suggest an atmosphere.

Ch. 14, Prob. 42.
Total mass of hydrogen: $M_H = 0.75\, M_{Jupiter}$
Total mass of helium: $M_{He} = 0.25\, M_{Jupiter}$
mass of hydrogen atom: $m_H = 1.67 \times 10^{-27}$ kg
mass of helium atom: $m_{He} = 4\, m_H = 6.68 \times 10^{-27}$ kg

Number of hydrogen atoms: $N_H = \frac{M_H}{m_H} = \frac{0.75 \times 1.899 \times 10^{27}}{1.67 \times 10^{-27}} = 8.53 \times 10^{53}$

Number of helium atoms: $N_{He} = \frac{M_{He}}{m_{He}} = \frac{0.25 \times 1.899 \times 10^{27}}{6.68 \times 10^{-27}} = 7.11 \times 10^{52}$

Ch. 14, Prob. 48.
For this problem, we will need Newton's Law of Universal Gravitation:

$$F = \frac{GMm}{r^2}$$

In this case, M is the mass of Jupiter, m the mass of *Galileo*, and R the radius of the planet. Here we're assuming that the top of Jupiter's cloud deck is what we can see and measure, so the distance from the top of the clouds to the center of Jupiter is just our measured value of Jupiter's radius.

$$F = \frac{GMm}{r^2} = \frac{6.67 \times 10^{-11}\,(1.899 \times 10^{27})\,(339)}{(7.15 \times 10^7)^2} = 8.4 \text{ kN}$$

Alternatively, we can compare the surface gravity, since $m = \frac{F}{a} = \text{constant}$.

$$\frac{F_J}{F_E} = \frac{g_J}{g_E}$$

We're given $F_E = 3.32$ kN. We can find $g_J = 2.36\, g_E$ in the text. So:

$$F_J = \frac{g_J}{g_E} F_E = \frac{2.36\, g_E}{g_E} 3.32 = 7.8 \text{ kN}$$

The difference in the two methods may be due to different assumptions.

Ch. 14, Prob. 49.

$$\rho = \frac{\text{mass}}{\text{volume}}$$

From section 14 – 6, we learned that Jupiter's core probably has 2.6 % of Jupiter's mass, and has a radius of 1.1×10^7 m. The core should be spherical, so:

$$\rho_{core} = \frac{(0.026)\,(1.899 \times 10^{27})}{\frac{4}{3}\pi\,(5.6 \times 10^4)^3} = 7.1 \times 10^4 \text{ kg m}^{-3}$$

This density is much larger than the density of the Earth ($5,500$ kg m^{-3}) or its iron core ($13,000$ kg m^{-3}), a testament to the crushing pressure at the center of Jupiter.

Ch. 15, Prob. 49.

a. If moved to Earth's orbit, the molecules in Titan's atomsphere will heat up. Their thermal velocity will likely exceed Titan's escape velocity. Titan would no longer have an atmosphere

b. Titan is bigger than the Moon. So if it were to orbit the Earth, solar eclipses would happen more often.

Ch. 16, Prob. 32.

a. $\frac{B_{Pluto,\,peri}}{B_{Earth}} = \left(\frac{D_{Earth}}{D_{Pluto,\,peri}}\right)^2 = \left(\frac{1 \text{ AU}}{29.6 \text{ AU}}\right)^2 = 1.14 \times 10^{-3}$

b. $\frac{B_{Pluto,\,aph}}{B_{Earth}} = \left(\frac{D_{Earth}}{D_{Pluto,\,aph}}\right)^2 = \left(\frac{1 \text{ AU}}{49.4 \text{ AU}}\right)^2 = 4.10 \times 10^{-4}$

c. $\frac{B_{Pluto,\,peri}}{B_{Pluto,\,aph}} = \left(\frac{D_{Pluto,\,aph}}{D_{Pluto,\,peri}}\right)^2 = \left(\frac{49.4 \text{ AU}}{29.6 \text{ AU}}\right)^2 = 2.79$

Extra Cedit

a. From Figure 14 – 14, we find that $R_{A,\,outer} = 1.37 \times 10^8$ m and $R_{B,\,inner} = 9.2 \times 10^7$ m.
Using Newton's version of Kepler's third law, we find:

$$P_{A,\,outer}^2 = \frac{4\pi^2}{G\,(M_{Saturn} + M_{Ring\,particle})} a_{A,\,outer}^3 = \frac{4\pi^2\,(1.37 \times 10^8)^3}{(6.67 \times 10^{-11})\,(5.685 \times 10^{26})}$$

$$= 2.68 \times 10^9$$

$$P_{A,\,outer} = 5.17 \times 10^4 \text{ s} = 14.4 \text{ hr}$$

$$P_{B,\,inner}^2 = \frac{4\pi^2}{G\,(M_{Saturn} + M_{Ring\,particle})} a_{B,\,inner}^3 = \frac{4\pi^2\,(9.2 \times 10^7)^3}{(6.67 \times 10^{-11})\,(5.685 \times 10^{26})}$$

$$= 8.11 \times 10^8$$

$$P_{B,\,inner} = 2.85 \times 10^4 \text{ s} = 7.91 \text{ hr}$$

b. The rotational period of Saturn is 10.23 hours. This is in between the orbital periods of the outer A ring and the inner B ring. Since the inner B ring's orbital period is faster than the rotational period, it will appear to move a head of you. The outer A ring's orbital period is slower than Saturn's rotational period, so it will appear to move in the opposite direction as the B ring.