

**PHYSICS 2: HSC COURSE 2<sup>nd</sup> edition (Andriessen et al)**

**Chapter 1: Earth's gravitational field (page 10)**

**WORKED SOLUTIONS**

**4.**

**Mercury:**

$$\begin{aligned}g &= G \frac{m_{\text{Mercury}}}{r_{\text{Mercury}}^2} \\&= \frac{(6.67 \times 10^{-11})(3.3 \times 10^{23})}{(2.44 \times 10^6)^2} \\&\approx 3.7 \text{ m s}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Weight} &= mg \\&= 80 \times 3.7 \\&\approx 296 \text{ N}\end{aligned}$$

**Venus:**

$$\begin{aligned}g &= G \frac{m_{\text{Venus}}}{r_{\text{Venus}}^2} \\&= \frac{(6.67 \times 10^{-11})(4.9 \times 10^{24})}{(6.05 \times 10^6)^2} \\&\approx 8.9 \text{ m s}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Weight} &= mg \\&= 80 \times 8.9 \\&\approx 712 \text{ N}\end{aligned}$$

**Io:**

$$\begin{aligned}g &= G \frac{m_{Io}}{r_{Io}^2} \\ &= \frac{(6.67 \times 10^{-11})(8.9 \times 10^{22})}{(1.815 \times 10^6)^2} \\ &\approx 1.8 \text{ m s}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Weight} &= mg \\ &= 80 \times 1.8 \\ &\approx 144 \text{ N}\end{aligned}$$

**Callisto:**

$$\begin{aligned}g &= G \frac{m_{Callisto}}{r_{Callisto}^2} \\ &= \frac{(6.67 \times 10^{-11})(1.1 \times 10^{23})}{(2.4 \times 10^6)^2} \\ &\approx 1.3 \text{ m s}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Weight} &= mg \\ &= 80 \times 1.3 \\ &\approx 104 \text{ N}\end{aligned}$$

Body	Mass (kg)	Radius (km)	$g$ on surface ( $\text{m s}^{-2}$ )	Weight of 80 kg person there (N)
Mercury	$3.3 \times 10^{23}$	2440	3.7	296
Venus	$4.9 \times 10^{24}$	6050	8.9	712
Io	$8.9 \times 10^{22}$	1815	1.8	144
Callisto	$1.1 \times 10^{23}$	2400	1.3	104

5.

(a) mass of Charon / mass of Pluto =  $1.9 \times 10^{21} / 1.27 \times 10^{22}$   
= 0.150

(b) radius of Charon / radius of Pluto =  $586 / 1137$   
= 0.515

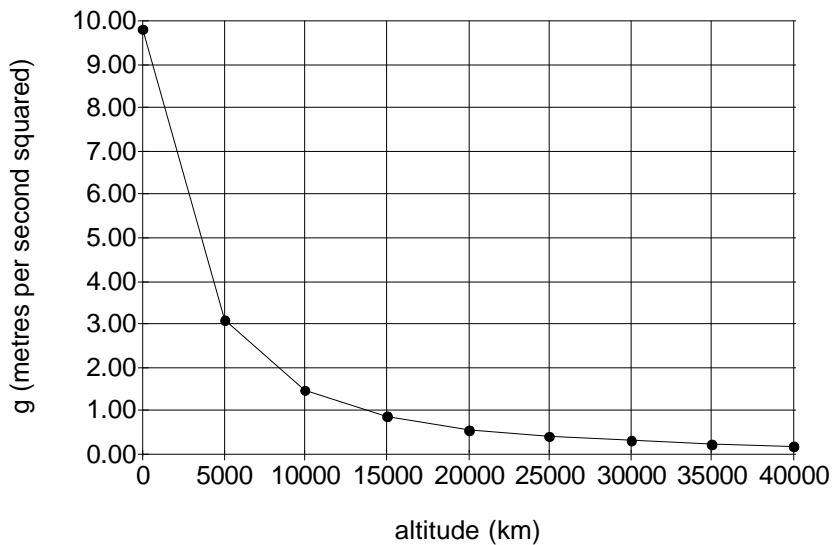
(c) density of Charon / density of Pluto =  $\frac{m_{Ch}}{\frac{4}{3}\pi r_{Ch}^3} / \frac{m_{Pl}}{\frac{4}{3}\pi r_{Pl}^3}$   
=  $\frac{1.9 \times 10^{21}}{(5.86 \times 10^5)^3} / \frac{1.27 \times 10^{22}}{(1.137 \times 10^6)^3}$   
= 9442 / 8640  
= 1.09

Given that the radius of Charon is not known precisely, this answer means that the density of Charon and Pluto is essentially the same – not an unexpected result.

(d) g on Charon / g on Pluto =  $G \frac{m_{Ch}}{r_{Ch}^2} / G \frac{m_{Pl}}{r_{Pl}^2}$   
=  $\frac{1.9 \times 10^{21}}{(5.86 \times 10^5)^2} / \frac{1.27 \times 10^{22}}{(1.137 \times 10^6)^2}$   
=  $5.53 \times 10^9 / 9.82 \times 10^9$   
= 0.56

7.

### g v altitude above Earth



11.

$$\begin{aligned} E_p &= -G \frac{m_E m_s}{r_E + \text{alt}} \\ &= -\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})(1000)}{(6.378 \times 10^6 + 4.00 \times 10^7)} \\ &= -8.59 \times 10^9 \text{ J} \end{aligned}$$

12.

(a)

$$\begin{aligned} E_p &= -G \frac{m_J m_C}{r} \\ &= -\frac{(6.67 \times 10^{-11})(1.9 \times 10^{27})(1.1 \times 10^{23})}{(1.88 \times 10^9)} \\ &= -7.4 \times 10^{30} \text{ J} \end{aligned}$$

(b)

$$\begin{aligned} E_p &= -G \frac{m_J m_S}{r} \\ E_p &= -\frac{(6.67 \times 10^{-11})(1.9 \times 10^{27})(1.99 \times 10^{30})}{(7.78 \times 10^{11})} \\ &= -3.24 \times 10^{35} \text{ J} \end{aligned}$$