HSC Physics – Module 5: Advanced Mechanics – Motion in Gravitational Fields Short Answer Question Solutions 5

41.

Criteria	Mark
• Correct substitution into a correct formula, yielding a correct answer • OR one error made with respect to units	2
• Correct substitution into a correct formula	1

$E_p = -G\frac{m_1 m_2}{r}$

$E_P = -\frac{6.67\times10^{-11}\times6.0\times10^{24}\times12}{40000\times10^3} = -1.2\times10^8$ J

42.

Criteria	Marks
• Uses formula correctly • Correct answer found • Units correct	2
• Correct substitution and units	1

43. (a)

Marking Criteria	Marks
• Correct answer with units	1

Mass will be the same on Alpha as it is on Earth i.e. $\frac{800}{9.8} = 80$ Kg (approx..)

(b)

Marking Criteria	Marks
• Correct answer	1

Weight will be $\frac{3.75}{9.8}\times 800 = 306N$

(c)

Marking Criteria	Marks
• Correct working and answer	2
• Partially correct working and answer	1

Use $g = \frac{GM}{r^2}$ for both Mars and Earth, then compare.

$r = \sqrt{\frac{GM}{g}}$

$\frac{r_{mars}}{r_{earth}} = \sqrt{(\frac{GM_{mars}}{g_{mars}} \div \frac{GM_{earth}}{g_{earth}})}$

$= \sqrt{\left(\frac{GM_{mars}}{g_{mars}} \times M_{mars}\right)}$

$= \sqrt{(\frac{9.8}{3.75} \times \frac{0.107358M_{earth}}{M_{earth}})}$

$= \sqrt{(\frac{0.107358}{\frac{3.75}{9.8}})}$

$r_{mars} = 0.53r_{earth}$

OR

Use $r_{mars} = \sqrt{\frac{GM_{mars}}{g_{mars}}}$

$= \sqrt{(\frac{(6.67\times10^{-11})(0.107358M_{earth})}{3.75})}$

$= 3.38 \times 10^6$ m

$r_{earth} = \sqrt{(\frac{GM_{earth}}{g_{earth}})}$

$= \sqrt{(\frac{(6.67\times10^{-11})(M_{earth})}{9.8})}$

$= 6.38 \times 10^6$ m

$r_{Mars} = 0.53r_{Earth}$

44. a) $\boldsymbol{T_T = 3T_R}$ $\qquad$ $\boldsymbol{r_T = 1.2 \times 10^6 km}$

$$\frac{T_T^2}{r_T^3} = \frac{T_R^2}{r_R^3}$$

$$\therefore r_R^3 = \frac{T_R^2}{3(T_R^2)^2} \times (1.2 \times 10^6)^3$$

$$\therefore r_R = 5.77 \times 10^8 m \text{ or } 5.77 \times 10^5 km$$

Criteria	Marks
Calculates correct answer with correct unit	2
Makes a single error in calculation or wrong unit	1

b)

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$T = \sqrt{\frac{(5.77\times10^8)^3 4\pi^2}{(6.67\times10^{-11})(5.68\times10^{26})}}$$

$$T = 4.47 \times 10^5$$

$$orbital\ velocity, v = \frac{2\pi r}{T}$$

$$v = \frac{2\pi(5.77\times10^8)}{4.47\times10^5}$$

$$v = 8103\ ms^{-1}$$

$$OR\ v = \sqrt{\frac{GM}{r}}$$

$$v = \left[\frac{(6.67\times10^{-11})(5.68\times10^{26})}{5.77\times10^8}\right]^{\frac{1}{2}}$$

$$v = 8103\ ms^{-1}$$

Criteria	Marks
Calculates correct answer using value of r from (a), with correct unit	2
Makes an error/wrong unit	1

c)

$m_c = 3m$ $\qquad$ $m_z = m$

$r_c = 3r$ $\qquad$ $r_z = 2r$

$g_c = \frac{Gm_c}{r_c^2}$ $\qquad$ $g_z = \frac{Gm_2}{r_z^2}$

$g_c = 1\ ms^{-1}$ $\qquad$ $g_z = \frac{G(m)}{(2r)^2}$

$$i.e.\frac{G(3m)}{(3r)^2} = 1 \qquad g_z = \frac{Gm}{4r^2}$$

$$\frac{GM}{3r^2} = 1 \qquad \therefore g_z = \frac{\left(\frac{Gm}{4\pi r^2}\right)}{\frac{Gm}{3r^2}} \times 1$$

$$\therefore g_z = 0.75\ ms^{-2}$$

Criteria	Marks
Calculates correct answer, with correct unit	2
Makes a single algebraic error, with correct unit	1

45.a)

Marking Criteria	Marks
Provides comprehensive definition of Newton's law of gravitation, referring to the masses of both objects and the inverse of the square of the distance.	2
Provides an answer which leaves out one of the dependencies from (a) OR writes the correct formula.	1

The gravitational force between two objects is proportional to the product of the masses of the objects and inversely proportional to the square of the distance between them.

b)

Marking Criteria	Marks
Accurately calculates the approximate mass of the sun.	2
Provide correct equation and substitution of values, but makes an error in the calculation.	1

a = GM/r2
M = ar2/G
M = 6 x 103 x (1.5 x 1011)2 ÷ 6.67 x 10-11 = 2.0 x 1036 kg

46.

Marking Criteria	Marks
Uses 1 kg mass to determine little g $g = G\frac{M_{Mars}}{R_{Mars}^2} = 6.67 \times 10^{-11} \times \frac{6.4 \times 10^{23}}{(3396.2 \times 10^3)^2} = 3.7\ m/s^2$	**2**
One error (e.g. no unit)	**1**

47. (a) Identifies the correct equation $\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ 1 mark

Correctly substitutes into the equation: i.e. $M = \frac{((6.0\times10^9)^3\times4\pi^2)}{(2.8\times10^5)^2\times6.67\times10^{-11}}$ 1 mark

Obtains the correct answer: 1.6 x 10^{30} kg 1 mark
(b) Correctly substitutes into the correct equation:
i.e. $F = \frac{6{,}67\times10^{-11}\times6.6\times10^{24}\times1.63\times10^{20}}{(6.0\times10^9)^2}$ 1 mark

Obtains the correct answer: 2.0 x 10^{25}N