# HSC Physics – Module 5: Advanced Mechanics – Motion in Gravitational Fields Short Answer Question Solutions 2

11. (a)

| Criteria | Marks |
|---|---|
| Arrow used to indicate the force acting from the satellite is towards the centre of the earth | 1 |

(b)

| Criteria | Marks |
|---|---|
| Correctly calculates the initial $E_p$ and final $E_p$ using the appropriate radii including units (-1.209 x $10^{14}$ J and 1.164 x $10^{14}$ J respectively AND the difference between the final and initial values (4.5 x $10^{12}$ J) | 3 |
| Calculates the initial $E_p$ and final $E_p$ and the difference between them but uses incorrect radii (including incorrect unit conversions) OR<br>Correctly calculates the initial $E_p$ and final $E_p$ using the appropriate radii including units but not the difference between them | 2 |
| Correctly calculate the initial $E_p$ and final $E_p$ | 1 |

12.
(a)

| Criteria | Marks |
|---|---|
| Correctly calculate the radius of the orbit of 55 cancri b (1.5 x $10^{10}$m) and the orbital velocity (7.42 x $10^4$ m $s^{-1}$) | 2 |
| Corerctly calculate the radius of orbit of 55 cancri b | 1 |

(b)

| Criteria | Marks |
|---|---|
| Correct calculation of the ratio using Kepler's law of periods (441.71:1) | 2 |
| Determines the period of 55 Cancri d (6493.21 days) | 1 |

13.

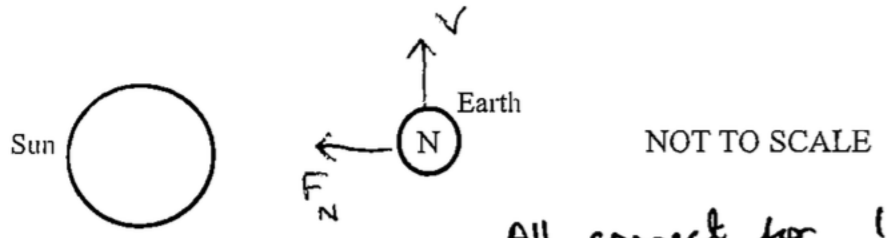
| Criteria | Marks |
|---|---|
| Uses an appropriate method to calculate a mass of 5.6x1026kg | 3 |
| Correctly method of calculation in kg but with one incorrect substitution OR<br>Correct answer with incorrect units. | 2 |
| Correctly method of calculation but with two incorrect substitutions. | 1 |

14. (a) 8.78m/$s^2$ 1 mark for correct number, 1 mark for correct unit

(b) $V = \left(\frac{Gm}{r}\right)^{\frac{1}{2}}$ 1 mark
= substitution line (no carry overs paid)
$= 7690$ m/s 1 mark for correct value and unit

(c) W= $E_{p_{final}} - E_{p_{initial}}$
$= -\frac{Gmm}{r_f} - -\frac{Gmm}{r_i}$ 1 mark
=substitution line 1 mark for correct answer and unit
$= 4.67 \times 10^9$ J

15. a)




All correct for 1 mark

(b) Show your working

$\frac{r^3}{T^2} = \frac{Gm}{4\pi^2}$ ← 1 mark correct equation

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

$= \frac{(6.67\times10^{-11}\times2\times10^{30}\times9.9452\times10^{14})}{4\pi^2}$

$r^3 = 3.360542 \times 10^{33}$

$r = 1.5 \times 10^{11}$m ← max 3 sig. figs (1 mark all correct)

$= 1.5 \times 10^{8}$km

16. V necessary to escape Earth's gravitational field 1 mark

$V = \sqrt{\frac{2GM}{r}}$

$= \sqrt{\frac{2\times6.67\times10^{-11}\times6\times10^{24}}{6.4\times10^{6}}}$ 1 mark

$=$ 11,183 ms$^{-1}$ 1 mark

17. (a) 1.44 x 10$^6$J

(b) -3.245 x 10$^6$J

(c) (a) + (b) $= \frac{-6.67\times10^{-11}\times1150\times1.1\times10^{20}}{r}$ (1 mark)

$r = 4.67 \times 10^6$ m (1 mark)

18. (a) $g = \frac{GM}{r^2} = 0.83$ m/s$^2$

(b) $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ (1 mark)

$T = 3.24 \times 10^4$ s (9 hours) (1 mark)

(c) $\frac{GMm}{r^2} = \frac{mv^2}{r}$ (or in words) (1 mark)

Hence $v = \sqrt{\frac{GM}{r}}$ which does not depend on the mass of the satellite. (1 mark)

19. (a)

| Marking Criteria | Marks |
|---|---|
| • Correct effect at both locations described | 2 |
| • Correct effect at either location described | 1 |

Sample answer:
Length of day shorter thus rotation of Earth speeds up. Centripetal acceleration of $v^2/r$ must be subtracted from 9.8 $ms^{-2}$ . Thus effective "g" near equator is less, say 9.7 $ms^{-2}$. No circular motion at south pole so no effect on value of "g". OR Faster v gives equatorial bulge so r increases so g is less and at pole r decreases so g increases.

(b)

| Marking Criteria | Marks |
|---|---|
| • Both changes described | 2 |
| • One change described or both changes (period and radius) identified | 1 |

Sample answer:
Earth rotates faster so the satellite must also travel faster and thus it will have a shorter period to match that of the Earth. It will do so if drops to a lower orbit where "g" is greater and the speed increases to compensate.

20.

| Marking Criteria | Marks |
|---|---|
| • response provided shows evidence of proper and thorough understanding of the concepts involved,<br>• presented in a logical manner<br>• appropriate energy formulae used correctly | 4 |
| • sound understanding of relevant factors and relationships evident<br>• appropriate energy formulae referred to | 3 |
| • basic understanding of the relevant factors and relationships evident,<br>• some appropriate formulae identified | 2 |
| • Some understanding of a relevant concept evident | 1 |

Sample answer:

For a spacecraft to escape Earth's gravitational field PE + KE = 0, EK= $1/2mv^2$ and gravitational potential energy, EP = $-Gm_1 m_2 /r$ . This solves to give escape velocity = root 2Gm/r. It needs to propel itself with sufficient fuel so that it can "climb up" to a potential energy of zero while still having kinetic energy and thus escape and not be drawn back by Earth's gravity.