Question	Answer	Marks
1	A	1
2 a	$v = \sqrt{16 \times 9.8\,\text{m s}^{-2} \times 0.4\,\text{m}}$ $= 7.9\,\text{m s}^{-2}$	1 1
2 b	$f = \dfrac{v}{2\pi r}$ = 3.2 revolutions per second	1 1
3	Orbital period in seconds = 6.18×10^5 s $M = \dfrac{4\pi^2 \times (1.07 \times 10^9)^8}{6.67 \times 10^{-11} \times (6.18 \times 10^5)^2}$ $= 1.9 \times 10^{27}$ kg	1 1 1
4	$\dfrac{g_{\text{Earth}} \times r_{\text{Earth}}^2}{\text{mass}_{\text{Earth}}} = \dfrac{g_{\text{Mars}} \times r_{\text{Mars}}^2}{\text{mass}_{\text{Mars}}}$ $g_{\text{Mars}} = \dfrac{g_{\text{Earth}} \times r_{\text{Earth}}^2 \times \text{mass}_{\text{Mars}}}{\text{mass}_{\text{Earth}} \times r_{\text{Mars}}^2}$ $= \dfrac{9.8 \times 1^2 \times 0.11}{1 \times 0.53^2}$ $= 3.8\,\text{N kg}^{-1}$	1 1 1 1
5 a	The area between the line and the x-axis from 0×10^6 m to 20×10^6 m.	1
5 b	$800\,\text{kg} \times 4.7 \times 10^7\,\text{J kg}^{-1}$ $= 3.8 \times 10^{10}$ J	1 1
5 c	gr^2 will be a constant negative value for data pairs if relationship correct. One mark for each correctly calculated value of gr^2.	4
6 a	Potential energy = $\dfrac{-6.67 \times 10^{-11} \times 7.4 \times 10^{22} \times 25}{1.7 \times 10^6}$ $= -7.3 \times 10^7$ J	1 1
6 b	Assuming that the potential energy of the rock relative to the Moon is zero when the rock is at a great distance from the Moon, loss in E_p as it approaches the Moon = gain in E_k. Therefore, E_k gain = $+7.3 \times 10^7$ J.	1 1 1
7 a	Arrow from satellite towards the centre of the planet.	1
7 b	There is no force in the direction of motion so no linear acceleration. However, the velocity is changing because the direction of motion is changing. Acceleration is rate of change of velocity.	1 1
7 c	Circle between surface of planet and orbit of satellite, centred on the planet.	1
7 d i	Potential energy of satellite of mass 290 kg $= \dfrac{-6.67 \times 10^{-11} \times 6.6 \times 10^{23} \times 290}{7.0 \times 10^6}$ $= -1.8 \times 10^9$ J.	1 1
7 d ii	$v = \sqrt{\dfrac{GM}{r}}$ $= 2.5 \times 10^3\,\text{m s}^{-1}$	1 1
7 d iii	$E_k = \dfrac{1}{2} \times 290\,\text{kg} \times (2.5 \times 10^3\,\text{m s}^{-1})^2$ $= 9 \times 10^8$ J (1 s.f.)	1 1

7 d iv	Total energy = kinetic energy + potential energy $= 9 \times 10^8 + (-1.8 \times 10^9) = -9 \times 10^8$ J	1 1
7 e	E_p will be twice the magnitude; velocity will be the same; E_k will be twice the magnitude; total energy will be twice the magnitude.	1 mark for each 2 correct.
8 a i	Arrow (from comet) tangential to orbit.	1
8 a ii	Arrow (from comet) at right angles to arrow *A*.	1
8 b i	$\frac{E_k}{m} = \frac{v^2}{2}$ $= 1.49\ \text{J kg}^{-1}$	1 1
8 b ii	$\frac{E_{total}}{m} = \frac{E_k}{m} + \frac{E_p}{m}$ $\frac{E_{total}}{m} = 1.5 \times 10^9\ \text{J kg}^{-1} + \frac{-6.67 \times 10^{-11}\,\text{J Kg}^{-2}\,\text{m} \times 2.00 \times 10^{30}\,\text{Kg}}{8.82 \times 10^{10}\,\text{m}}$ $\frac{E_{total}}{m} = -1.247\ldots \times 10^7\ \text{J kg}^{-1} \approx -20\ \text{MJ kg}^{-1}$	1 1
8 b iii	$\frac{E_{total}}{m} = \frac{E_k}{m} + \frac{E_p}{m}$ $-1.247\ldots \times 10^7\ \text{J kg}^{-1} = \frac{v^2}{2} + \frac{-GM}{r}$ $v = \sqrt{2\left(-1.247\ldots \times 10^7 - \frac{-6.67 \times 10^{-11} \times 2.00 \times 10^{30}}{5.3 \times 10^{12}}\right)}$ $= 5.0 \times 10^3\ \text{m s}^{-1}$ (2 s.f.)	1 1 1