Gravitational Fields

Fields · 4 questions · step-by-step answers at the end

Name: Date: Score: / 4

USEFUL EQUATIONS

$F = GMm / r^2$ $g = GM / r^2$ $\varphi = -GM / r$ $T^2 = (4\pi^2 / GM)r^3$ $v_{esc} = \sqrt{(2GM / R)}$

Questions

Show your working in the space under each question.

1. At what height above Earth's surface is g one quarter of its surface value?

2. Find the gravitational potential at Earth's surface and the escape velocity. (M = 5.97×10^{24} kg, R = 6.37×10^{6} m)

3. Find g at the surface of Mars (M = 6.42×10^{23} kg, R = 3.39×10^{6} m).

4. How does the orbital speed change if the orbital radius doubles?

Step-by-step answers

Gravitational Fields

1. $g \propto 1/r^2$, so $r = 2R$: a height of **one Earth radius** (6.4×10^6 m).

2. 1. $\varphi = -GM/R = -(6.67 \times 10^{-11})(5.97 \times 10^{24})/(6.37 \times 10^6) = \mathbf{-6.25 \times 10^7\ J\ kg^{-1}}$.
2. To escape, the kinetic energy per kg must equal 6.25×10^7 J: $\frac{1}{2}v^2 = GM/R$.
3. $v = \sqrt{(2 \times 6.25 \times 10^7)} = \mathbf{1.12 \times 10^4\ m\ s^{-1}}$ (11.2 km s^{-1}).
Answer: $\mathbf{-6.25 \times 10^7\ J\ kg^{-1}}$; $\mathbf{11.2\ km\ s^{-1}}$

3. $g = GM/R^2 = (6.67 \times 10^{-11} \times 6.42 \times 10^{23})/(3.39 \times 10^6)^2 = \mathbf{3.7\ N\ kg^{-1}}$.

4. $v = \sqrt{(GM/r)}$, so it falls by a factor of $\mathbf{\sqrt{2}}$.