InkPhysics

ANSWER BOOK

Gravitational potential

Gravitational fields · Year 13

AQA 3.7.2.3 · CIE 13.4 · OCR A 5.4.4

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The gravitational potential at a point is the work done per unit mass to bring a small test mass from infinity to that point. The zero of potential is taken at infinity. [2]

A2 $V = -GM/r = -(6.67 \times 10^{-11} \times 6.0 \times 10^{24})/(6.4 \times 10^{6}) = -6.25 \times 10^{7}$ J kg^{-1}. [2]

A3 The potential is zero at infinity, and gravity is attractive, so work must be done against nothing to remove a mass to infinity (energy is released as it falls in). The potential everywhere else is therefore below zero, i.e. negative. [2]

SECTION B · Standard

B1 $V = -GM/r = -(6.67 \times 10^{-11} \times 6.0 \times 10^{24})/(1.0 \times 10^{7}) = -4.00 \times 10^{7}$ J kg^{-1}. [3]

B2 $V_{surface} = -6.25 \times 10^{7}$ J kg^{-1}, $V_{final} = -3.13 \times 10^{7}$ J kg^{-1}. $\Delta V = 3.13 \times 10^{7}$ J kg^{-1}. Work $= m\Delta V = 500 \times 3.13 \times 10^{7} = 1.56 \times 10^{10}$ J. [4]

B3 $\tfrac{1}{2}mv^2 = GMm/r$, so $v = \sqrt{(2GM/r)} = \sqrt{(2 \times 6.67 \times 10^{-11} \times 6.0 \times 10^{24}/6.4 \times 10^{6})} = 1.12 \times 10^{4}$ m s^{-1} (about 11.2 km s^{-1}). [3]

B4 $|g| = \Delta V/\Delta r = (1.0 \times 10^{6})/(1.0 \times 10^{5}) = 10$ N kg^{-1}. [3]

SECTION C · Stretch

C1 $\Delta V = 0 - (-6.25 \times 10^{7}) = 6.25 \times 10^{7}$ J kg^{-1}. Energy $= m\Delta V = 1000 \times 6.25 \times 10^{7} = 6.25 \times 10^{10}$ J. [4]

C2 $V_1 = -5.72 \times 10^{7}$ J kg^{-1}, $V_2 = -2.86 \times 10^{7}$ J kg^{-1}. $\Delta V = V_2 - V_1 = 2.86 \times 10^{7}$ J kg^{-1}. [4]

C3 The field strength is the negative gradient of the potential–distance graph ($g = -\Delta V/\Delta r$). Equivalently, the change in potential is the area under the field strength–distance graph between two points. [3]