InkPhysics

ANSWER BOOK

Newton's law of gravitation

Gravitational fields · Year 13

AQA 3.7.2.1, 3.7.2.2 · CIE 13.2, 13.3 · OCR A 5.4.2

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The gravitational force between two point masses is attractive, proportional to the product of the masses and inversely proportional to the square of their separation: $F = GMm/r^2$. [2]

A2 $F = GMm/r^2 = (6.67 \times 10^{-11} \times 5.0 \times 5.0)/2.0^2 = 4.17 \times 10^{-10}$ N. [2]

A3 Gravitational field strength g is the gravitational force per unit mass on a test mass at that point: $g = F/m$. [2]

SECTION B · Standard

B1 $F = GMm/r^2 = (6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 7.3 \times 10^{22})/(3.8 \times 10^{8})^2 = 2.02 \times 10^{20}$ N. [4]

B2 $g = GM/r^2 = (6.67 \times 10^{-11} \times 6.0 \times 10^{24})/(6.4 \times 10^{6})^2 = 9.77$ N kg^{-1}. [3]

B3 $g = GM/r^2 = (6.67 \times 10^{-11} \times 6.0 \times 10^{24})/(1.28 \times 10^{7})^2 = 2.44$ N kg^{-1}. This is a quarter of the surface value, as expected from the inverse-square law (double the distance). [3]

B4 $g = GM/r^2 = 8.17$ N kg^{-1}. $F = mg = 500 \times 8.17 = 4084$ N. [3]

SECTION C · Stretch

C1 $g = GM/r^2 = (6.67 \times 10^{-11} \times 6.4 \times 10^{23})/(3.4 \times 10^{6})^2 = 3.69$ N kg^{-1}. [4]

C2 From $g = GM/r^2$: $M = gr^2/G = (9.81 \times (6.4 \times 10^{6})^2)/(6.67 \times 10^{-11}) = 6.02 \times 10^{24}$ kg. [4]

C3 The field spreads out over an ever larger area with distance, so its strength falls. From $g = GM/r^2$ it obeys an inverse-square law: doubling the distance from the centre reduces g to a quarter. [3]