InkPhysics

QUESTION WORKBOOK

Newton's law of gravitation

Gravitational fields · Year 13

AQA 3.7.2.1, 3.7.2.2 · CIE 13.1.1, 13.2.1, 13.2.2, 13.3.1, 13.3.2
OCR A 5.4.1(b), 5.4.1(d), 5.4.2(a), 5.4.2(b), 5.4.2(c)

19 questions · 53 marks

PRINT EDITION

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SECTION A · Warm-up

A1 State Newton's law of gravitation for two point masses. [2]

A2 Two point masses, each of mass 5.0 kg, are 2.0 m apart. Calculate the gravitational force between them.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [2]

A3 Define gravitational field strength and write down the equation relating it to the force on a mass. [2]

A4 The Earth pulls a student of mass 60 kg with a gravitational force of 590 N. State the magnitude of the gravitational force the student exerts on the Earth, and explain why the Earth's resulting motion is negligible. [2]

A5 The gravitational field strength at the Earth's surface is 9.8 N kg^{-1}. Without using values of G or the Earth's mass, determine the field strength at a point 3 Earth radii from the Earth's centre. [2]

A6 State what is meant by a point mass, and explain why Newton's law of gravitation can be applied to spherical planets. [2]

SECTION B · Standard

B1 A planet of mass 6.0×10^{24} kg and its moon of mass 7.3×10^{22} kg are separated by a distance of 3.8×10^{8} m. Calculate the gravitational force between them. [2]

B2 A planet has a mass of 6.0×10^{24} kg and a radius of 6.4×10^{6} m. Calculate the gravitational field strength at its surface. [2]

B3 For the same planet, calculate the gravitational field strength at a distance of 1.28×10^7 m from its centre. Comment on how your value compares with the surface value. [3]

B4 A satellite of mass 500 kg orbits the planet at a distance of 7.0×10^6 m from its centre. Calculate the gravitational field strength at this distance and hence the gravitational force on the satellite. [3]

B5 Two snooker balls, each of mass 74 g, rest with their centres 6.0 cm apart. Calculate the gravitational force each ball exerts on the other, and suggest why this force has no noticeable effect.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [3]

B6 A planet of mass 6.4×10^{23} kg orbits a star of mass 2.0×10^{30} kg at a distance of 2.3×10^{11} m. Calculate the gravitational force of the star on the planet, and the acceleration of the planet.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [4]

B7 The gravitational field strength at a point above a planet of mass 6.4×10^{23} kg is 1.0 N kg^{-1}. Determine the distance of this point from the planet's centre.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [3]

SECTION C · Stretch

C1 Mars has a mass of 6.4×10^{23} kg and a radius of 3.4×10^{6} m. Show that the gravitational field strength at the surface of Mars is approximately 3.7 N kg^{-1}. [3]

C2 The gravitational field strength at the surface of a planet of radius 6.4×10^6 m is 9.81 N kg^{-1}. Determine the mass of the planet. [3]

C3 Explain why the gravitational field strength of a planet decreases with distance from its centre, and state the mathematical form of this decrease. [3]

C4 A magazine article describes two newly discovered planets orbiting another star:
planet K: mass 3.0×10^{25} kg, radius 1.6×10^7 m
planet L: mass 8.9×10^{24} kg, radius 7.7×10^6 m
The article claims that both planets have a surface gravitational field strength greater than the Earth's value of 9.8 N kg^{-1}. Deduce whether the claim is correct.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [4]

C5 Estimate the gravitational force of attraction between two people sitting 1.0 m apart, and estimate how many orders of magnitude smaller this is than your weight.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [3]

C6 A crewed space laboratory orbits 4.2×10^5 m above the surface of a planet of mass 6.0×10^{24} kg and radius 6.4×10^6 m. Show that the gravitational field strength at this altitude is about 8.6 N kg^{-1}, and explain why the crew float inside the laboratory even though g there is far from zero. [5]