InkPhysics

QUESTION WORKBOOK

Orbits and satellites

Gravitational fields · Year 13

AQA 3.7.2.4 · CIE 13.2.3, 13.2.4 · OCR A 5.4.3(a), 5.4.3(b), 5.4.3(c), 5.4.3(d), 5.4.3(e), 5.4.4(e)

19 questions · 53 marks

PRINT EDITION

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SECTION A · Warm-up

A1 A satellite moves in a circular orbit around a planet. State what provides the centripetal force on the satellite and give its direction. [2]

A2 State the relationship between the orbital period T and the orbital radius r for satellites orbiting the same planet. [1]

A3 State two features of a geostationary orbit. [2]

A4 A satellite is moved from a low circular orbit to a higher circular orbit around the same planet. State what happens to its orbital speed and to its orbital period. [2]

A5 Explain why the orbital speed of a satellite in a circular orbit does not depend on the satellite's mass. [1]

A6 Satellite B orbits a planet at four times the orbital radius of satellite A. Determine the ratio of B's orbital period to A's. [2]

SECTION B · Standard

B1 A satellite orbits a planet of mass 6.0×10^{24} kg in a circular orbit of radius 7.0×10^{6} m. Calculate the orbital speed of the satellite.
$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2} [3]

B2 A satellite travels at 7561 m s^{-1} in a circular orbit of radius 7.0×10^{6} m. Calculate its orbital period. [2]

B3 Calculate the radius of a geostationary orbit around a planet of mass 6.0×10^{24} kg that rotates with a period of 24 hours (86 400 s). [3]

B4 Compare a low Earth orbit with a geostationary orbit. Refer to altitude, period and one typical use of each. [3]

B5 By treating the gravitational force as the centripetal force, derive the relationship $T^2 = 4\pi^2 r^3/GM$ for a satellite in a circular orbit of radius r about a planet of mass M. [3]

B6 A moon of a distant planet orbits at a radius of 4.0×10^8 m with a period of 27 days. A second moon of the same planet orbits at a radius of 1.0×10^8 m. Determine the orbital period of the second moon, in days. [3]

B7 Show that the escape velocity from a point at distance r from a planet's centre is $\sqrt{2}$ times the speed of a satellite in a circular orbit of radius r. [3]

SECTION C · Stretch

C1 A satellite of mass 500 kg orbits a planet of mass 6.0×10^{24} kg in a circular orbit of radius 8.0×10^6 m. Calculate the kinetic energy, the gravitational potential energy and the total energy of the satellite. [4]

C2 A moon orbits a planet of mass 6.0×10^{24} kg with an orbital period of 1.0×10^{5} s. Determine the radius of its orbit. [3]

C3 Explain why a geostationary satellite must orbit directly above the equator. [3]

C4 An astronomer measures the orbits of four moons of a newly discovered planet:
moon W: $r = 1.0 \times 10^{8}$ m, $T = 2.0$ days
moon X: $r = 2.0 \times 10^{8}$ m, $T = 5.7$ days
moon Y: $r = 4.0 \times 10^{8}$ m, $T = 16.0$ days
moon Z: $r = 3.0 \times 10^{8}$ m, $T = 9.0$ days
The astronomer suspects that one measurement is wrong. Deduce which moon's data are inconsistent with the others. [4]

C5 A satellite in a low orbit experiences a small drag force from the outer atmosphere. Explain why the satellite's speed increases as a result of the drag, even though its total energy decreases. [4]

C6 A satellite of mass 600 kg is to be moved from a circular orbit of radius 9.0×10^6 m to a circular orbit of radius 1.8×10^7 m around a planet of mass 6.0×10^{24} kg. Calculate the minimum energy that must be supplied.
$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2} [5]