



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

NAVY SCREEN EDITION

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.
 $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ [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 $6.0 \times 10^{24} \text{ kg}$ 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. $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ [5]