inkPhysics

ANSWER BOOK

# Orbits and satellites

Gravitational fields · Year 13

AQA 3.7.2.4 · CIE 13.2 · OCR A 5.4.3

10 questions · 31 marks

NAVY EDITION

## SECTION A · Warm-up

**A1** The gravitational attraction between the planet and the satellite provides the centripetal force, acting towards the centre of the orbit. [2]

**A2** $T^2$ is proportional to $r^3$ ($T^2 \propto r^3$). [2]

**A3** It has a period of 24 hours (matching the Earth's rotation), lies in the equatorial plane, and orbits from west to east, so the satellite appears fixed above one point on the equator. [2]

## SECTION B · Standard

**B1** $GMm/r^2 = mv^2/r$, so $v = \sqrt{(GM/r)} = \sqrt{(6.67 \times 10^{-11} \times 6.0 \times 10^{24}/7.0 \times 10^6)} = 7561$ m $s^{-1}$. [4]

**B2** $T = 2\pi r/v = (2\pi \times 7.0 \times 10^6)/7561 = 5817$ s (about 97 minutes). [3]

**B3** $r = (GMT^2/4\pi^2)^{1/3} = ((6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 86400^2)/4\pi^2)^{1/3} = 4.23 \times 10^7$ m. [4]

**B4** A low orbit is at a few hundred kilometres, with a period of about 90 minutes, used for imaging and the space station. A geostationary orbit is far higher (about 36000 km), with a 24-hour period, used for communications and weather satellites that must stay above one point. [3]

## SECTION C · Stretch

**C1** $v = \sqrt{(GM/r)} = 7073$ m $s^{-1}$. (a) $KE = ½mv^2 = 1.25 \times 10^{10}$ J. (b) $PE = -GMm/r = -2.50 \times 10^{10}$ J. (c) Total = KE + PE = $-1.25 \times 10^{10}$ J. [4]

**C2** $r = (GMT^2/4\pi^2)^{1/3} = ((6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times (1.0 \times 10^5)^2)/4\pi^2)^{1/3} = 4.66 \times 10^7$ m. [4]

**C3** The plane of any orbit must pass through the centre of the Earth. To stay above a fixed point as the Earth turns, the satellite must circle in the equatorial plane; an orbit above another latitude would carry the satellite north and south of that point, so it could not appear stationary. [3]