

- 1 (a) State Newton's law of gravitation.

Gravitational Force is directly proportional to the product of two point masses and inversely proportional to the square of distance from their centres. [2]

- (b) A satellite is in a circular orbit around a planet. The radius of the orbit is R and the period of the orbit is T . The planet is a uniform sphere.

Use Newton's law of gravitation to show that R and T are related by

$$4\pi^2 R^3 = GMT^2$$

where M is the mass of the planet and G is the gravitational constant.

In orbit

$$F_c = F_g$$

$$mR\omega^2 = \frac{GmM}{R^2}$$

$$R^3\omega^2 = GM$$

$$R^3\left[\frac{2\pi}{T}\right]^2 = GM$$

$$\frac{R^3 4\pi^2}{T^2} = GM$$

$$4\pi^2 R^3 = T^2 GM$$

$$4\pi^2 R^3 = GMT^2$$

[2]

- (c) The Earth may be considered to be a uniform sphere of mass 5.98×10^{24} kg and radius 6.37×10^6 m.

A geostationary satellite is in orbit around the Earth.

Use the expression in (b) to determine the height of the satellite above the Earth's surface.

$$T^2 = \frac{4\pi^2}{GM} r^3$$

$$(24 \times 3600)^2 = \frac{4 \times (3.14)^2}{6.67 \times 10^{-11} \times 5.98 \times 10^{24}} \times r^3$$

$$r = 4.2 \times 10^7 \text{ m}$$

$$h = r - R$$

$$= 4.2 \times 10^7 - 6.37 \times 10^6$$

$$= 3.56 \times 10^7$$

height = 3.56×10^7 m [3]

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