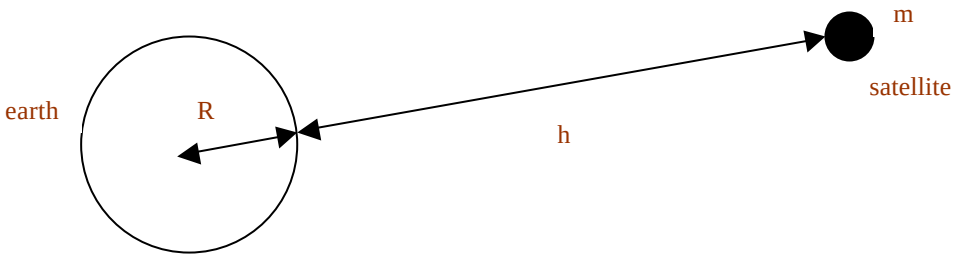
Dept. of Education and Science – Revised Sample Paper

Question 6.

Isaac Newton developed the theory of gravitation in the seventeenth century.
State Newton's law of universal gravitation.
What is the relationship between the gravitational constant G and the acceleration due to gravity g at the surface of the earth?
A satellite of mass *m* orbits the earth in a circular orbit at a constant height h above the surface of the earth.



Show that $T^2 = \frac{4\pi^2 (R+h)^3}{GM}$
where T is the period of the satellite, R is the radius of the earth, G is the gravitational constant and M is the Mass of the earth.

A communications satellite is usually in an orbit so that it appears stationary above a point on the earth's equator. What is the period of the communications satellite?

Calculate the height of the communications satellite above the surface of the earth.

State Newton's law of universal gravitation.

This states that there is an attractive force between any two particles of matter in the universe that is proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F = \frac{Gm_1m_2}{d^2}$$

What is the relationship between the gravitational constant G and the acceleration due to gravity g at the surface of the earth?

$$g = \frac{GM_E}{R^2}$$

Show that $T^2 = \frac{4\pi^2 (R+h)^3}{GM}$.

$$\frac{GMm}{(R+h)^2} = \frac{mv^2}{(R+h)} = \frac{m}{(R+h)} \times \left(\frac{2\pi(R+h)}{T} \right)^2 = \frac{4\pi^2 m(R+h)}{T^2}$$

$$So, \quad T^2 = \frac{4\pi^2 (R+h)^3}{GM}$$

A communications satellite is usually in an orbit so that it appears stationary above a point on the earth's equator. What is the period of the communications satellite?

The period is one day. T = 8.64 x 10^4 s

Calculate the height of the communications satellite above the surface of the earth.

$$T^2 = \frac{4\pi^2(R+h)^3}{GM}$$

$$(8.64\times10^4)^2 = \frac{4\pi^2(6.4\times10^6+h)^3}{6.7\times10^{-11}\times6.0\times10^{24}}$$

Solving for h gives

$$h = 3.6\times10^7\ m$$