2 A planet of mass M and radius R is isolated in space.

Assume that all the mass of the planet is situated at its centre.

The planet has no atmosphere.

A satellite S of mass m orbits the planet at a height h above the surface of the planet, as shown in Fig. 2.1.

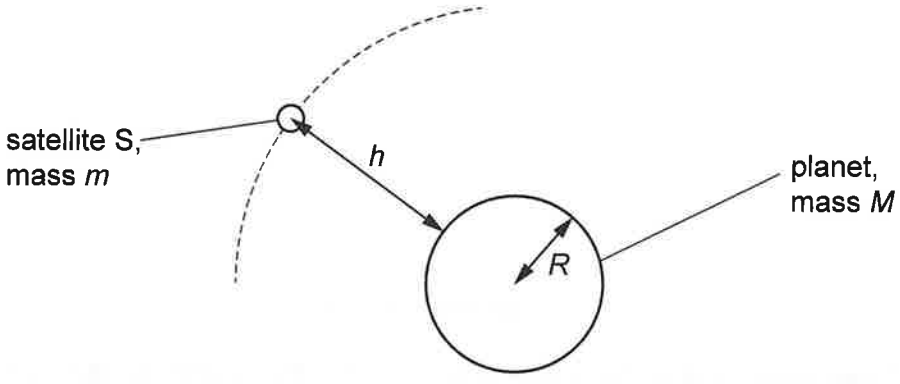

Fig. 2.1

(a) Show that the kinetic energy E_k of satellite S is given by the expression:

$$E_k = \frac{GMm}{2(R + h)}$$

where G is the gravitational constant.

[3]

(b) By considering the potential energy of satellite S and the expression in **(a)**, derive an expression for the total energy E_T of S in terms of G, M, m, R and h.

[3]

(c) The planet has a mass of 7.35×10^{22} kg and a radius of 1.74×10^{6} m.

Satellite S orbits at a height of 110 km above the surface of the planet.

Calculate the speed of S.

speed = ... $m\,s^{-1}$ [3]

(d) Another satellite P, also of mass m, is in orbit around the planet in **(a)** at a height above the surface that is less than 110 km.

State and explain how:

(i) the kinetic energy of P compares with that of S

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..... [2]

(ii) the total energy of P compares with that of S.

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..... [2]

[Total: 13]