2 A satellite S of mass m is in a stable circular orbit at an altitude of $2R$ above the surface of a planet of mass M and radius R, as shown in Fig. 2.1.

Assume the planet has no atmosphere and that all its mass is concentrated at its centre.

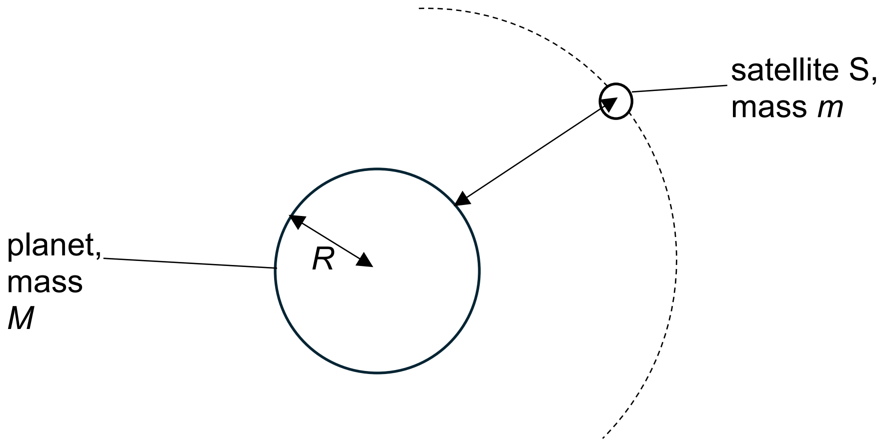


Fig. 2.1

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

$$E_k = \frac{GMm}{6R}$$

where G is the gravitational constant.

[2]

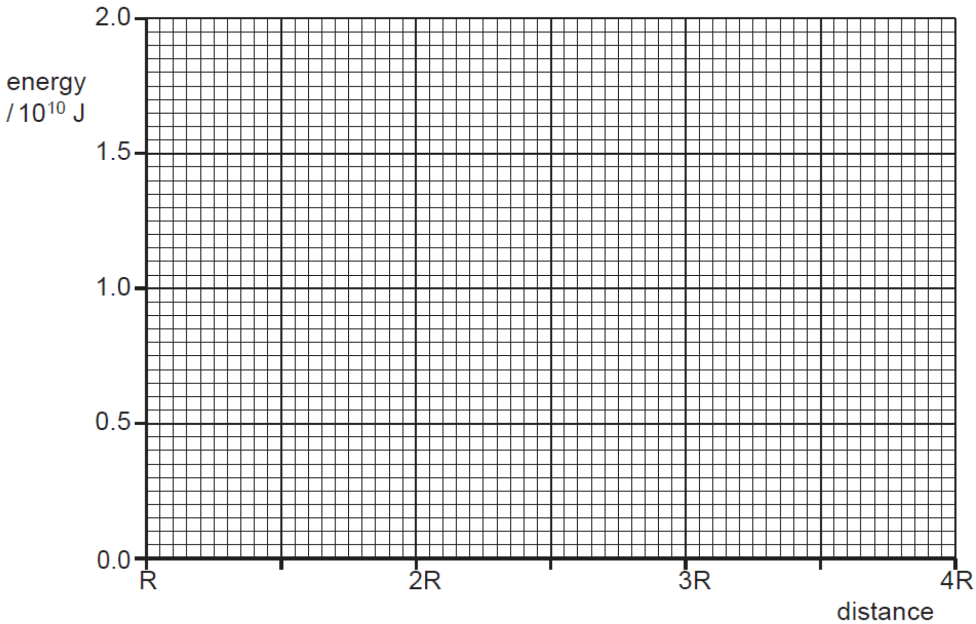
(b) The planet has mass 4.5×10^{24} kg and radius of 5.5×10^3 km. The satellite has a mass of 1500 kg.

Determine the total energy of satellite S in orbit.

total energy = ... J [2]

(c) A second satellite P is launched into orbits from the surface of the same planet with an initial kinetic energy of 2.0×10^{10} J. It rises to a distance of 4R from the centre of the planet.

On the axes provided in Fig 2.2, sketch a graph to show how the satellite's orbital kinetic energy varies with distance from the centre of the planet as it moves from R to 4R.



[2]

Fig 2.2

(d) A third satellite Q is to be launched vertically from the surface of the same planet. Determine the minimum speed that satellite Q must be given at the surface to escape the planet's gravitational field.

minimum speed = ... m s^{-1} [2]

[Total: 8]