3   A satellite of mass m orbits a planet of mass M and radius R_p. The radius of the orbit is R. The satellite and the planet may be considered to be point masses with their masses concentrated at their centres. They may be assumed to be isolated in space.

(a) (i) Derive an expression, in terms of M, m and R, for the kinetic energy of the satellite. Explain your working.

[2]

(ii) Show that, for the satellite in orbit, the ratio

$$\frac{\text{gravitational potential energy of satellite}}{\text{kinetic energy of satellite}}$$

is equal to −2.

[1]

(b) The variation with orbital radius R of the gravitational potential energy of the satellite is shown in Fig. 3.1.
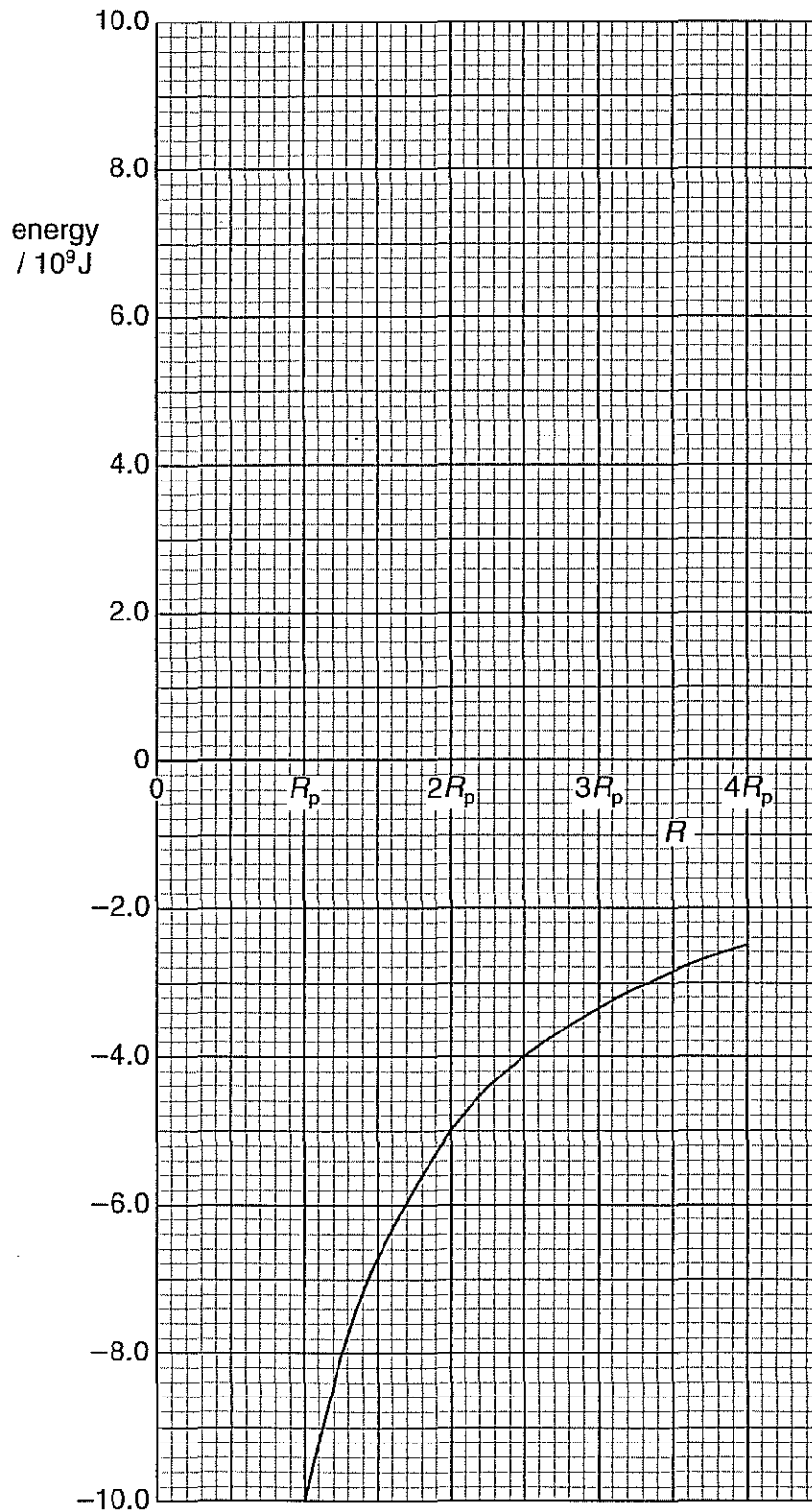

Fig. 3.1

(i) On Fig. 3.1, draw the variation with orbital radius of the kinetic energy of the satellite. Your line should extend from $R = 1.5R_p$ to $R = 4R_p$. [2]

(ii) The mass m of the satellite is 1600 kg.
The radius of the orbit of the satellite is changed from $R = 4R_p$ to $R = 2R_p$.
Use Fig. 3.1 to determine the change in orbital speed of the satellite.

change in speed = ... $m\,s^{-1}$ [5]