2 In July 2015, the New Horizons space probe made its closest approach of Pluto.

Charon is one of the moons of Pluto. Data, including the radius r and period of rotation about the axis T, are given for Pluto and Charon in Table 2.1.

Table 2.1

	r/km	mass/kg	T/days
Pluto	1.20×10^3	1.31×10^{22}	6.36
Charon	0.600×10^3	1.52×10^{21}	6.36

When viewed from above, Pluto and Charon rotate in the same direction about their axes.

(a) (i) The orbital speed of Charon is $0.200\,\text{km}\,\text{s}^{-1}$ and its orbital radius is 1.75×10^4 km. Show that the period of the orbit of Charon around Pluto is 6.36 days.

[2]

(ii) A space probe on the surface of Pluto is able to observe Charon over a time of several days.

Suggest what the space probe observes as a result of

1. the period of rotation of Pluto about its axis equalling the orbital period of Charon,

.....

.....

2. equal periods of rotation about their axes for both Pluto and Charon.

.....

.....

[2]

(b) Pluto may be considered to be an isolated sphere with its mass concentrated at its centre.

Use data from Table 2.1 to determine the gravitational field strength g_P on the surface of Pluto.

g_P = ... $N\,kg^{-1}$ [2]

(c) **(i)** A rock of mass M, initially at rest at infinity, falls towards Pluto. There is negligible resistance to the motion of the rock from Pluto's atmosphere.

Show that the speed v of the rock as it hits the surface of Pluto is given by the expression

$$v = \sqrt{2g_P r}$$

where r is the radius of Pluto.

[3]

(ii) As a result of bombardment of Pluto by a meteor, a rock is ejected from the surface.

Use information from Table 2.1 and **(b)** to calculate the minimum initial speed of the rock so that it eventually reaches infinity.

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