3 **(a)** The mass M of a spherical planet may be assumed to be a point mass at the centre of

the planet.

(i) A stone, of mass m travelling at speed v, is in a circular orbit of radius r about the planet, as illustrated in Fig. 3.1

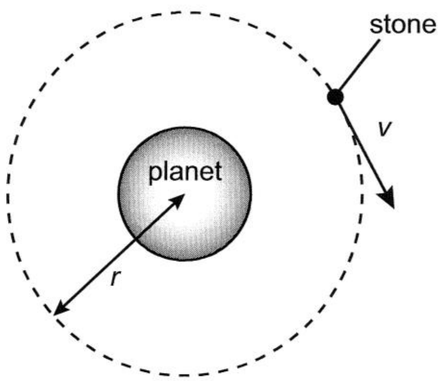

Fig. 3.1

Derive an expression, in term of r, M and the gravitational constant G, for the speed v. Explain your working.

[3]

(ii) A second stone, initially with negligible velocity at infinity, travels towards the planet. The stone does not hit the surface of the planet.

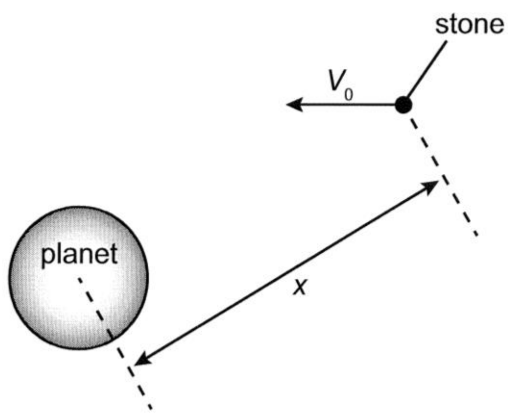

Fig. 3.2 (not to scale)

When the stone is at a distance x from the centre of the planet, its speed is V_0, as shown in Fig. 3.2.

Determine V_0 in terms of the gravitational constant G, the mass M of the planet, and x. Explain your working.

You may assume that gravitational attraction on the stone is due only to the planet.

[3]

(iii) Use your answer in **(ii)** and your expression in **(i)** to explain whether this stone could enter a circular orbit about the planet.

....

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....

....

.... [2]

(b) A charged point mass is situated in a vacuum. A proton travels directly towards the mass, as illustrated in Fig. 3.3.

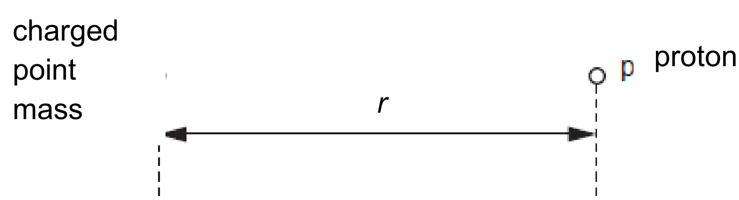

Fig. 3.3

When the separation of the mass and the proton is r, the electric potential energy of the system is U_P.

The variation with distance r of the electric potential energy U_P is shown in Fig. 3.4.

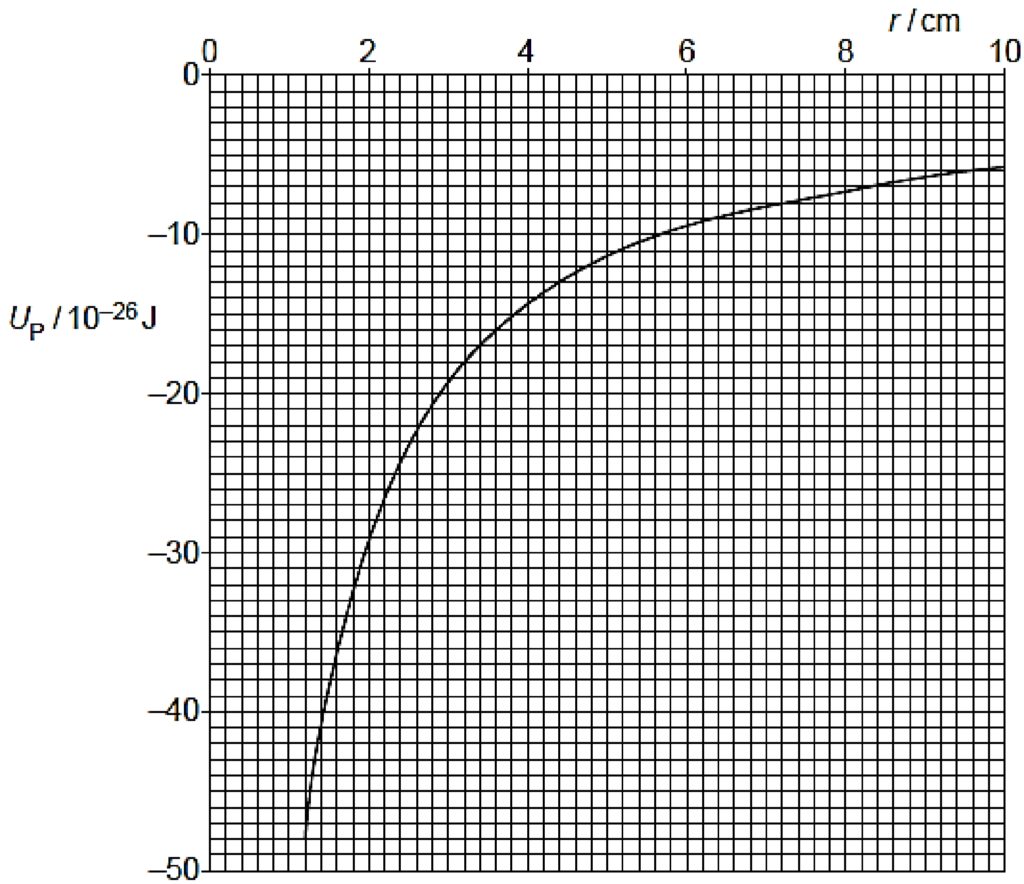

Fig. 3.4

Determine the electric field strength at a distance of 4.0 cm from the charged point mass.

field strength = …………………………….. V m^{-1} [3]