2 **(a)** Derive the expression, in terms of the mass M of the Earth and its radius r, for the relationship between the gravitational constant G and the gravitational field strength g near the Earth's surface.

[1]

(b) Fig 2.1 is a graph of gravitational field strength g plotted against distance from the centre of the Earth.

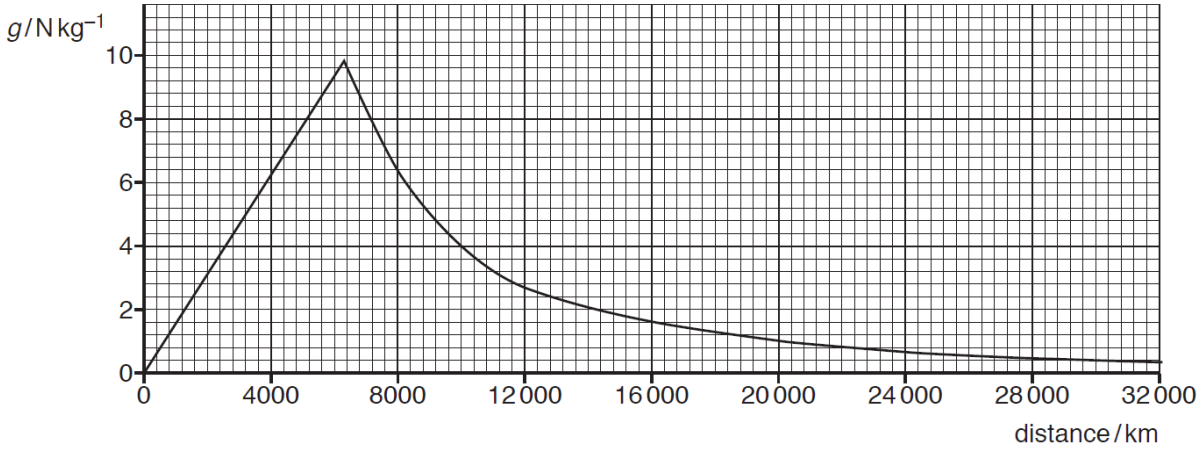

Fig. 2.1

(i) Use data from the graph to determine

1. the radius of the Earth,

radius of the Earth = ... km [1]

2. the gravitational force on a man-made satellite of mass 20000 kg at a distance of 8200 km from the centre of the Earth.

gravitational force = ... N [2]

(ii) Calculate the speed of the satellite in **(b)(i)2** for it to be circling the Earth at constant speed.

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

(c) **(i)** Define *gravitational potential*.

……

…… [1]

(ii) Use Fig. 2.1 to estimate the gravitational potential at a distance of 10 000 km from the centre of the Earth.

gravitational potential = ... J kg^{-1} [3]

(d) Fig. 2.2 represents a region of space near the surface of the Earth.

Fig. 2.2

(i) On Fig. 2.2, draw **five solid** lines, with arrows, to represent the gravitational field in this region. [2]

(ii) Add to Fig. 2.2, a dashed line that joins points of equal gravitational potential. [1]

(iii) Explain how the apparent inconsistency in the gravitational field strength represented in **(d)(i)** and in Fig. 2.1 can be resolved.

……..……..

……..……..

……..……..

……..……[1]

[Total: 15]