7 **(a)** Define the *gravitational potential* at a point.

……

……

…….. [2]

(b) The Earth may be considered to be an isolated sphere of radius R with its mass concentrated at its centre.

The variation of the gravitational potential ϕ with distance x from the centre of the Earth is shown in Fig. 7.1.

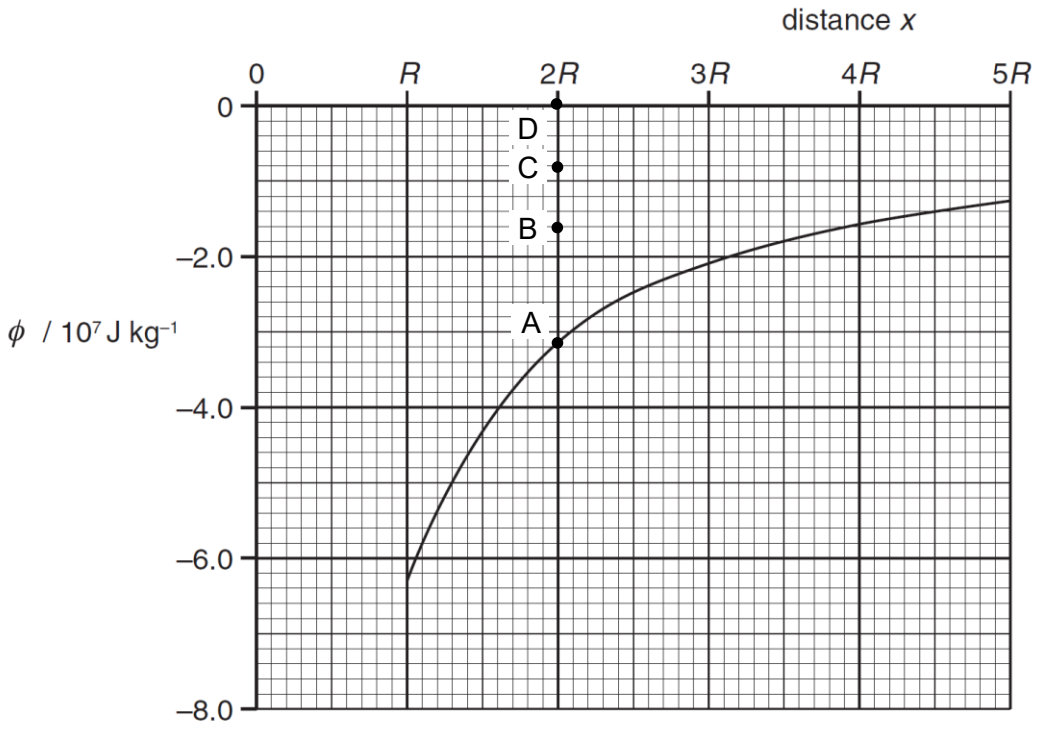


Fig. 7.1

The radius R of the Earth is 6.4×10^6 m.

(i) Using Fig. 7.1, determine the gravitational field strength at the point $2R$ above the surface of the Earth. Explain your working.

gravitational field strength = …….. N kg^{-1} [3]

(ii) At a certain distance $x = 2R$, the total energy of a space capsule (i.e. the sum of its gravitational potential energy and its kinetic energy) may be represented by one of the 4 points A, B, C and D.

Which point (or points) could represent the total energy of the space capsule

1. if it were momentarily at rest at the top of its trajectory,

2. if it were falling towards the Earth,

3. if it were moving away from the Earth, with sufficient energy to reach an infinite distance,

4. if it is moving in a circular orbit around Earth.

In each case, briefly explain how you arrived at your answer.

1. ……

……

…… [2]

2. ……

……

……

…… [3]

3. ……

……

…… [2]

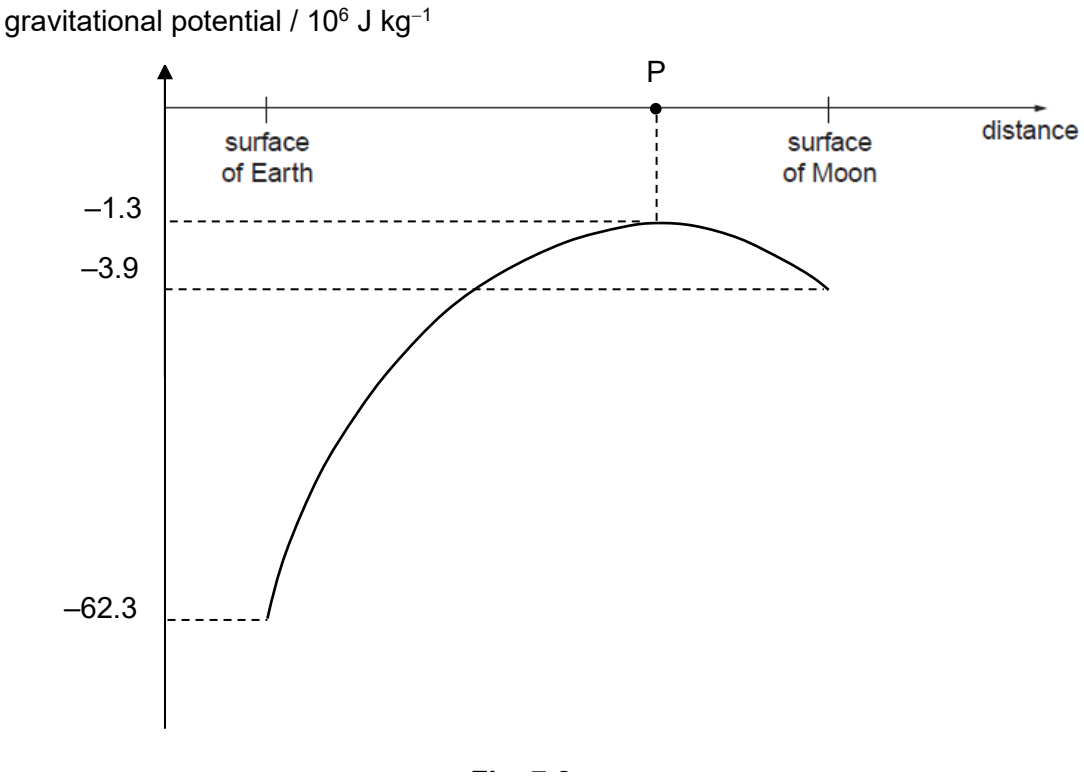
4. ……

……

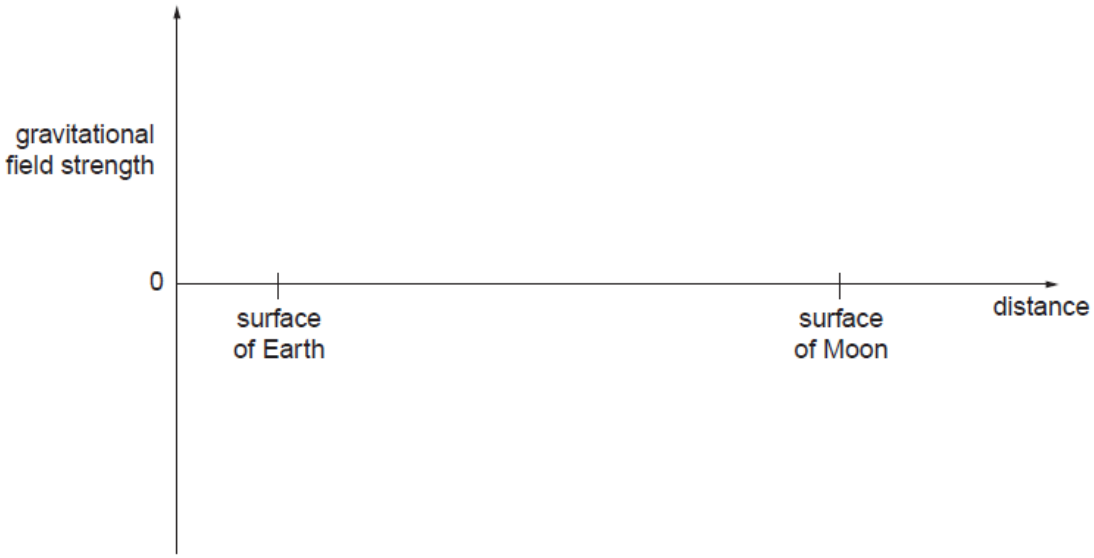
…… [2]

(c) In practice, the Earth is not isolated and the gravitational field around Earth is affected by other celestial bodies such as the Moon.

Fig. 7.2, which is not to scale, shows how the gravitational potential between the surface of the Earth and the surface of the Moon varies along the line joining the centres. At the point P, the gravitational potential is a maximum.



(i) On the axes of Fig. 7.3, sketch a graph to show the variation of the gravitational field strength with distance between the surface of the Earth and the surface of the Moon.



[3]

(ii) Using Fig. 7.2, find the minimum energy needed to send a 4.0 kg object from the surface of Earth to the surface of the Moon.

minimum energy = ... J [3]

[Total: 20]

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