

7.3.2 Gravitational potential

Gravitational potential (V) at a point in a gravitational field is defined as:

“the work done in moving a unit mass from infinity to that point”



The only difference between gravitational potential and gravitational potential energy (E_{gp}) is that gravitational potential is the work done per unit mass (i.e. It is the gravitational potential energy a 1kg mass would have at that point.)

$$V = \frac{E_{gp}}{m}$$

where m is the mass in kg

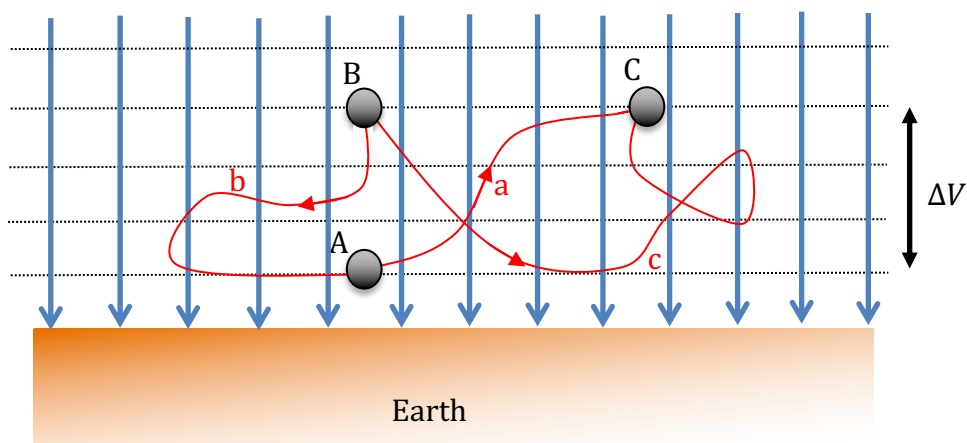
(1) What are the units for gravitational potential?

If we move a mass (m) from one position to another and there is a change in the gravitational potential (ΔV), then the change in gravitational potential energy is:

$$\Delta E_{gp} = m\Delta V$$

Uniform fields

In section 7.3.1 we saw that close the Earth’s surface we can take the gravitational field to be (to a close approximation) uniform.



The dotted lines are called ‘equipotential’ lines. There is no change in gravitational potential along these lines.

(2) Would the change in gravitational potential energy be positive or negative when moving a mass from A to B?

The change in gravitational potential in moving from one point to another in a gravitational field is only dependent on the starting potential and the final potential and not on the path taken.

(3)  Explain what changes (if any) occur to the gravitational potential energy of a mass moved along paths a, b, c, in the diagram above.

Radial fields

We saw in section 7.3.1 that the gravitational potential energy of a mass in a radial gravitational field is given by:

$$E_{gp} = - \frac{GMm}{r}$$

where G =the gravitational constant= $6.67 \times 10^{-11} \text{m}^3 \text{kg}^{-1} \text{s}^{-2}$, and r =distance between the centre of mass of M and m

(4)  Using the equation at the top, write an expression for V , for a radial field.

(5)  Work out the gravitational potential at the surface of the Earth.
(radius of the Earth = 6400km, mass of Earth = $6.0 \times 10^{24} \text{kg}$)

(6)  A geostationary orbit is found at a radius of 42000km. What is the gravitational potential at this position?

(7)  What is the minimum energy required to launch 1kg to a geostationary orbit?

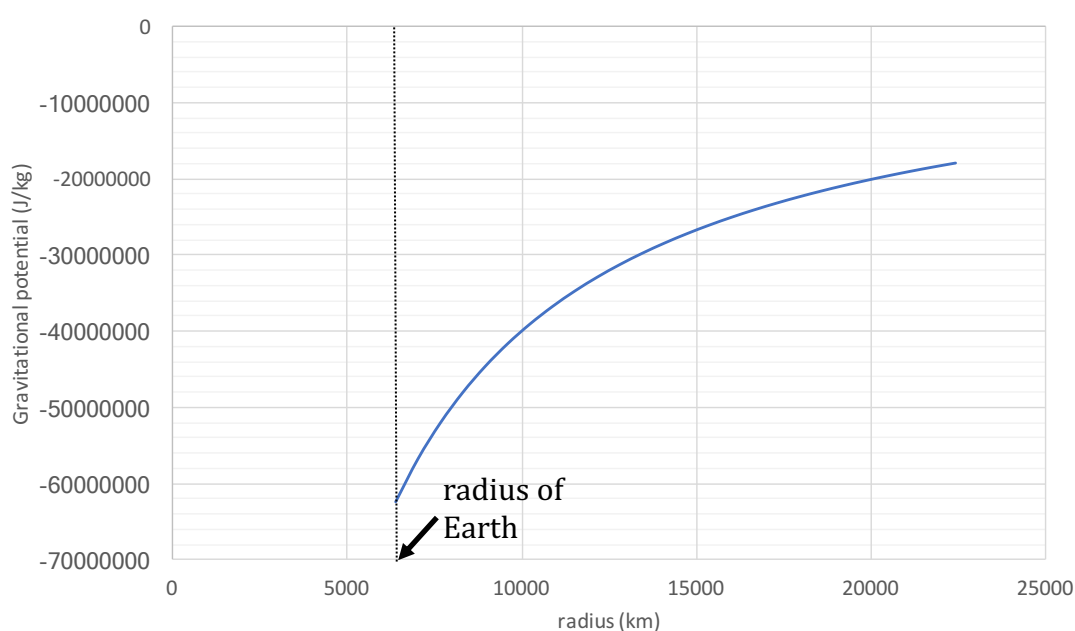
Gravitational field strength and gravitational potential

Gravitational field strength (g) is the gradient of the gravitational potential (V) versus radius (r) graph. Mathematically:

$$g = -\frac{\Delta V}{\Delta r}$$

Note: g is a vector quantity and V is a scalar quantity.

Consider the V versus r graph for the Earth:



The graph shows how the gravitational potential increases as you move away from the Earth's surface. The Earth's surface is at 6400km.

(8) Draw a tangent to the curve at 10000km and find the gradient.

(9) What is the gravitational field strength at 3600km above the Earth's surface?
(Note: r on the graph is in km)