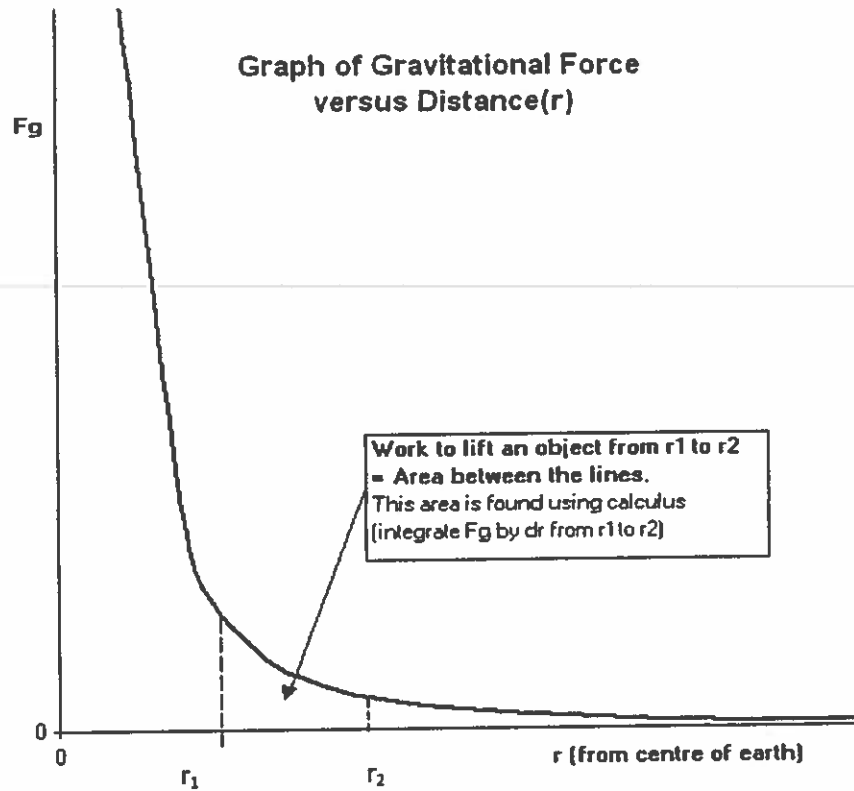
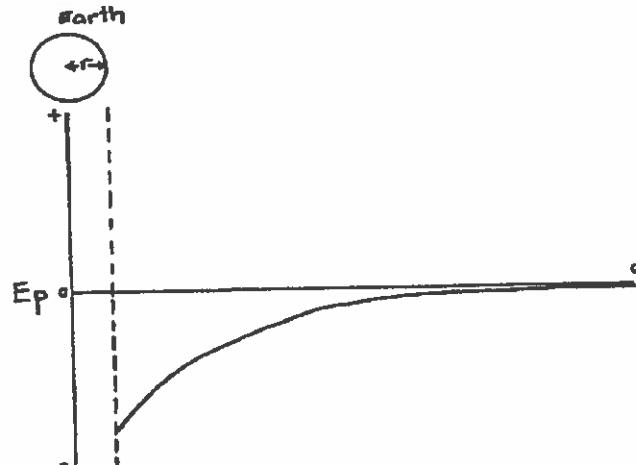


Gravitational Potential Energy not on Earth



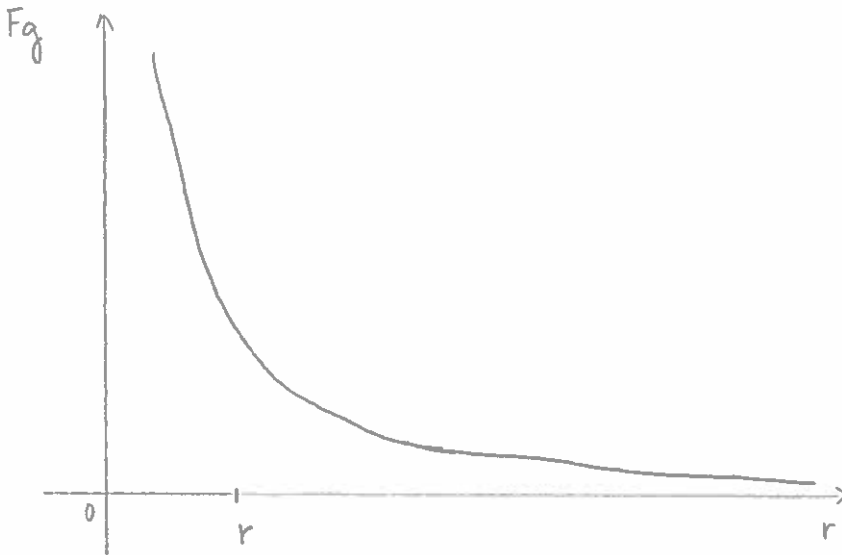
- A graph of the  $E_p = GPE$  surrounding a planet:



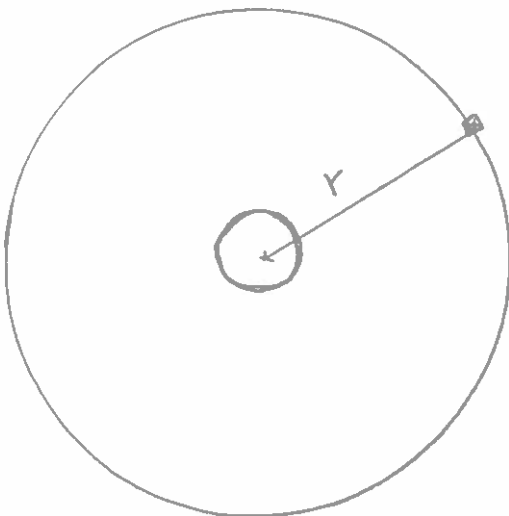
- When lifting an object against a gravitational field, e.g. launching a rocket, work is done on the object, that is, energy is transferred to the object. The object's gravitational potential energy,  $E_p = GPE$ , that is, the energy it has due to its position within the gravitational field, increases as a result.
- When an object moves toward the source of the gravitational field, such as when dropping a stone, energy due to position in a field is transformed into kinetic energy (the stone speeds up).

- Hence the position of lowest  $E_p = \text{GPE}$  in the gravitational field surrounding a planet is at the surface of the planet.
- An object only has zero  $E_p = \text{GPE}$  when it is no longer within the gravitational field, that is, a very large distance away. (Mathematically, distance must be infinite.) We say: **gravitational potential energy relative to zero at infinity.**

Example 1. Which of the indicated areas of the graph represent the work needed to send an object from separation distance  $r$  to infinity?



Example 2: State the expression for the total energy of the orbiting satellite shown below?



**Example 3.** A  $2.0 \times 10^3$  kg satellite is in a circular orbit around the earth. The satellite has a speed of  $3.6 \times 10^3$  m/s at an orbital radius of  $3.1 \times 10^7$  m. What is the total energy of this orbiting satellite?

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**Example 4.** A  $5.2 \times 10^4$  kg rocket is initially at rest on the surface of the earth. If  $3.0 \times 10^{11}$  J of work is done on this rocket, what maximum altitude  $h$  will the rocket reach? (Assume the rocket's mass does not change.)

Example 5. How much work is required to move a 560-kg satellite from altitude  $3.0 \times 10^6$  m above Earth to  $4.0 \times 10^7$  m above Earth?

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