

Worksheet 1 – GRAVITATIONAL FIELD AROUND THE EARTH

Task: Try to verify by calculation whether the gravitational force acts even in the state of weightlessness. In outer space, there is an international space station ISS in a state of weightlessness near the Earth, further from the Earth there are geostationary satellites (they are still above the same place on the Earth's surface), even further away is the Moon. At what distance will the attractive gravitational force of the Earth disappear?

2. At a height h above the surface of a spherical object (the Earth) with mass M_Z and radius R_Z , a gravitational force

$$F_g = \kappa \cdot \frac{M_Z \cdot m}{(R_Z + h)^2} \quad F_g = \kappa \cdot \frac{M_Z \cdot m}{(R_Z + h)^2} \quad \kappa = 6,67 \cdot 10^{-11} \text{ Nm}^2\text{kg}^{-2};$$

$$M_Z = 6 \cdot 10^{24} \text{ kg}; R_Z = 6,378 \cdot 10^6 \text{ m}.$$

acts on the object with mass m).

a) Calculate and compare the gravitational force acting on the object weighing 1 kg:

- on the surface of the Earth,
- at an altitude of 400 km at which the ISS is operating,
- at an altitude of 35 800 km in which geostationary satellites move,
- at a distance of the Moon, which is 380 thousand km.

b) Next, construct a graph of the dependence of this gravitational force on the distance from the Earth's surface from 0 km to 40,000 km. Use the prepared table with the distances of 2,000 km. (The graph can also be created in MS Excel or similar.) Estimate, according to the graph, how far the gravitational force of the Earth will be zero.

c) The ISS moves in a low orbit 400 km above the Earth's surface. What percentage is there a gravitational force less than on the surface? Why don't astronauts feel the gravitational force on the ISS?

d) Sketch a picture of the ISS trajectory at a scale of 1: 100,000,000 (the radius of the Earth will be 6.4 cm, the distance of the ISS trajectory from the Earth's surface is 4 mm).

Solution:

a)

1) Gravitational force acting on the object weighing 1 kg on the Earth's surface.

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It is N.

2) Gravitational force acting on the object weighing 1 kg at an altitude of 400 km above the Earth's surface.

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It is N.

3) Gravitational force acting on the object weighing 1 kg at an altitude of 38,500 km above the Earth's surface.

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It is N.

4) Gravitational force acting on the object weighing 1 kg at a distance of 380,000 km from the Earth's surface.

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It is N.

b) Complete the table and make a graph.

height [km]	0	2 000	4 000	6 000	8 000	10 000	12 000
force [N]							

height [km]	14 000	16 000	18 000	20 000	22 000	24 000	26 000
force [N]							

height [km]	28 000	30 000	32 000	34 000	36 000	38 000	40 000
force [N]							

**c) At ISS height, the gravitational force is % less than on the Earth's surface.
 Why don't astronauts feel the gravitational force on the ISS?**

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d) Sketch of the Earth and the trajectory of the ISS: