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Research Article

Gigant Planets. Methodology For Determining The Physical Parameters Of Planets Using Mathematical Calculations Through Physical Formulas

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ABSTRACT

This article provides information about the characteristics of giant planets. it is also taught to rely on mathematical calculations of their physical parameters based on physical formulas. Since the integration of subjects is one of the directions of the search for new pedagogical solutions related to the unification of separate sections of different disciplines into a single whole. The introduction of new individual, advanced and pedagogical technologies into the educational process requires a change in the attitude of the teacher and the student to learning. An independent mental and cognitive activity is a means of personal development that can reveal its potential abilities.

Keywords: *planet, radius, diameter, orbit, eccentricity, ellipse, orbit length, mass, volume, area, axis, rotation period, day, year, density, lithosphere, mantle, core, atmosphere, molecular hydrogen, equator, crater, satellite, cosmic velocity, gravitational acceleration, Io, Ganymede, Europa, Callisto, Galileo, magnetosphere, ring, Huygens, Titan, magnetosphere, Herschel, 1781, telescope, methane, helium, green planet, Shakespeare, Halle, 1846, dark spot, Nereid Triton, distances, planetoid, Titius-Bode, Titius-Bode rule, Suns, Jupiter, Saturn, Uranus, Neptune.*

INTRODUCTION

In modern educational practice of higher educational institutions, the integration of subjects is one of the directions of the search for new pedagogical solutions related to the unification of separate sections of different disciplines into a single whole in order, firstly, to overcome the uniformity of learning goals and functions; secondly, to create a holistic view of their future profession among students (integration represents the purpose of learning here) and to provide a common space for the convergence of subject knowledge (integration represents a means of learning here). Higher education must learn to meet the challenges of the new era. Thanks to information technology conditions, new pedagogical technologies and active teaching methods are being introduced. One of the innovative technologies that contribute to the realization of creative abilities and the formation of the needs of the younger generation in self-education is the technology of inter-subject integration.. Here is an example of using knowledge of mathematics and physics in teaching an astronomy course. Astronomy, mathematics and physics, which grew out of the once unified science of nature - philosophy – have never lost touch with each other. As we know, mathematics, physics and their laws are studied in educational institutions earlier than astronomy. Let's consider the application of these laws using the example of studying the topic "Planet Giants" from the astronomy course.

METHODOLOGY

The planet Jupiter. The calm and strong golden visible luster gives the planet Jupiter grandeur and grandeur, especially under good conditions for observation. Therefore, apparently, she received the name Jupiter - that's how the Romans called the ancient Greek god Zeus - the lord of Heaven and Earth, gods and mortals. With his lightning bolts, he destroyed anyone who violated the order and legality established by him in the world. There fore, the ancient Greeks also called him the thunderer Zeus (called Mushtarii in the east).


The planet Jupiter

The distance from Earth to Jupiter is 3.68 astronomical units of length or 6.28•108 km. The mass of Jupiter is more than 318 times the mass of the Earth. Jupiter has an extended atmosphere (the height of the atmosphere reaches up to 6000 km.). The chemical composition of the atmosphere consists mainly of molecular hydrogen (H2). The amount of which is almost 74% (helium – 20%, methane - 5). Ammonia (NH4) has also been observed on Jupiter's clouds. Jupiter is located far from the Sun, because of this, the planet receives 27 times less solar energy than the Earth. Because energy is always inversely proportional to the square of the distance $\left(E = \frac{1}{R^2}\right)$. Average atmospheric temperature -145 °C.

General physical characteristics of Jupiter parameters

Values	**The value of the values**
The length of the orbit (circle)	$L = 2\pi \cdot r = L_E = 6{,}28 \cdot 778 \cdot 10^6\ km = 4{,}886 \cdot 10^9 km =$ $32{,}57\ a.$
The eccentricity of the planet	$e = 0{,}048$
Diameter and radius	$d\ = 142800\ km;\ r = 71400\ km.$
Volume	$V = 1310 \cdot V\ = 1310 \cdot 12{,}083 \cdot 10^{12}\ km^3 = 1{,}58 \cdot 10^{16}\ km^3$
The area of the planet	$S = 4\pi\Re^2 = 12{,}56 \cdot 71{,}4 \cdot 10^3\ km^2 = 64{,}03 \cdot 10^9\ km^2$
The mass of Jupiter	$m = 317{,}8 \cdot m\ = 317{,}8 \cdot 6 \cdot 10^{24}\ kg = 1{,}908 \cdot 10^{27}\ kg$
The average density of Jupiter	$\rho = \frac{\rho}{4{,}1} = \frac{5500\ \frac{kg}{m^3}}{4{,}1} = 1330\ \frac{kg}{m^3} = 1{,}33\ \frac{g}{sm^3}$
Acceleration of free fall	$g = 25{,}8\ \frac{m}{s^2}$
The period of Jupiter's rotation around the Sun	$T = 11{,}86\ ye \approx 12\ ye$
The period of Jupiter's rotation around its axis	$t = 9\ h\ 50\ m - 30s$
The orbital velocity of Jupiter	$\upsilon_{op} = 13{,}1\ \frac{km}{s}$

Cosmic velocities on the surface of the planet	$\upsilon_I = \sqrt{g\cdot R} = \sqrt{26{,}1\ \frac{м}{c^2}\cdot 71400000\ m} = 43100\ \frac{m}{s} \approx 43{,}1\ \frac{km}{s}$ $\upsilon_{II} = \sqrt{2\cdot g\cdot R} = \sqrt{2\cdot 26{,}1\ \frac{m}{s^2}\cdot 71400000\ m} = 60800\ \frac{m}{s} \approx 60{,}8\ \frac{km}{s}$

Jupiter has a strong magnetic field. Jupiter's magnetic field is 50 times larger than Earth's magnetic field:

$$B = 50\cdot B\ = 50\cdot 5\cdot 10^{-5}\ Tl = 2{,}5\cdot 10^{-3}\ Tl$$

The temperature in the atmosphere drops rapidly with altitude. From -113 C at a pressure of 1 atmosphere, to -160 C at a pressure of 0.03 atmosphere.

RESULTS

The temperature in the core reaches 30,000 K, and the pressure is more than 1 million bar. The high core temperature exists due to the Kelvin–Helmholtz mechanism, i.e. due to the slow gravitational compression of the planet. A phenomenon similar to the Earth's northern lights is observed in the polar clouds of Jupiter. The internal structure of Jupiter is completely unknown. Most likely, its bowels are in a liquid state, with the exception of a small stone core. The number of natural satellites of the planet is 17 (35). The four largest moons of Jupiter were discovered in 1610 by Galileo Galilei using his own telescope. These are: Io, Ganymede, Europa, Callisto. These natural satellites are often referred to as "gallium satellites". Ganymede is the largest of these natural satellites, with a diameter 1.5 times that of the moon, or 5,260 km.
The planet Saturn. Saturn is the second largest giant planet surrounded by beautiful rings. Saturn is named after the Roman god of agriculture.
The symbol of Saturn is a sickle. Saturn (called Zuhail in the east), one of the largest planets in the Solar system, is the sixth planet, in terms of distance from the Sun, and the last one that can be seen with the naked eye.
Saturn is located at the following distances from the Sun:

$$l = 1426000000\ km = 1{,}426\cdot 10^9 km \approx 9{,}5\ a.e$$


The planet Saturn

Saturn moves in an ellipse around the Sun. The orbit of motion is slightly different from the circle, the eccentricity is less than that of other planets:

$$e = 0{,}0558$$

The mass of the planet is 95 times the mass of the Earth, that is:

$$m = 95\cdot m\ = 95\cdot 6\cdot 10^{24}\ kg = 5{,}7\cdot 10^{26}\ kg$$

In other words, Saturn's mass is almost 120 times that of Venus.
Its size (diameter) It is also 9.5 times the size of the Earth, i.e.:

$$d = 120800\ km;\ r_{Saturn} = 60400\ km$$

Because Saturn rotates so fast on its axis, its size varies within $\frac{1}{10}$ part of your size. This shows that the equatorial and polar radii of the planet are different. The equatorial radius is 9.5 times the radius of the Earth, and the polar radius is 8.5 times:

$r = 8{,}5 \cdot r = 8{,}5 \cdot 6371\ km = 54150\ km$

Saturn's volume is 750 times the volume of the Earth:

$V = 750 \cdot V\ = 750 \cdot 1{,}2083 \cdot 10^{12}\ km^3 = 9{,}06 \cdot 10^{14}\ km^3$

Because the mass of the planet is so large, its gravitational pull is just as great, or 1.15 times the gravitational acceleration (g_{Earth}) of the Earth:

$g_{Земля} = 11{,}3\ \frac{m}{s^2}$

According to the value of the acceleration of gravity, an object with a mass of 800 N on Earth is equal to 900 N on Saturn.
Saturn orbits the Sun once every 29.5 Earth years (more precisely, 29 years, 5 months, 16 days). Hence the duration of 1 year on Saturn
Because Saturn is farther from the Sun than Jupiter, its orbital velocity is less:

$\upsilon_{op} = 9{,}6\ \frac{km}{s}$

We can also find this value as follows: The radius of the orbit, that is, the distance from the planet to the Sun.

$r_{op} = 1426000000\ km$

The length of the orbit

$l = 2 \cdot \pi \cdot r = 8955300000\ km$

This means that Saturn needs 8 billion 955 million to fly around the Sun once. This will cover a distance of 300,000 km.
From this,

$$\upsilon_{op} = \frac{l}{T} = \frac{8955300000\ km}{29{,}5} = \frac{8955300000\ km}{29{,}5 \cdot 365 \cdot 86400\ s} = 9{,}6\ \frac{km}{s}$$

Radar observations show that Saturn rotates around its axis very quickly. The period of one complete revolution around its axis, that is, the duration of 1 day of Saturn

$t = 10\ h\ 14\ m$

The inclination of the axis of rotation to the plane of the orbit is very small, about 26.5%. Therefore, there is no change of seasons on Saturn.
The average density of the planet is 8 times less than the average density of the Earth

$$\rho = \frac{\rho}{8} = \frac{5500\ \frac{kg}{m^3}}{8} = 690\ \frac{kg}{m^3} = 0{,}69\ \frac{g}{sm^3}$$

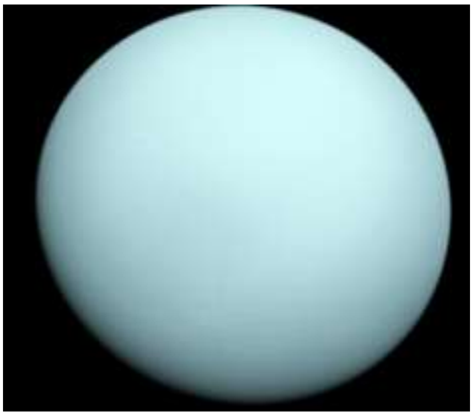
Saturn has the lowest density 0,69 $\frac{g}{sm^3}$. It rotates very fast, with a period of just over 10 hours and is therefore noticeably flattened. Clouds on Saturn are less noticeable than on Jupiter. Sometimes large-scale disturbances are noticeable. Saturn receives 92 times less heat from the Sun than the Earth receives from the Sun. The main reason for this is estimated to be the planet's distance from the Sun. The average annual temperature on the planet is 180C. Like Jupiter and Earth, this planet absorbs 55% of the light from the Sun and reflects 45%. In the inner layers of the planet, the temperature rises slowly with increasing depth. For example, at a depth equal to half the radius of the planet, the temperature is 10000° C, and the pressure is $3 \cdot 10^6$ atmosphere. At depth 0,7÷0,8 from the radius of the planet begins a layer of hydrogen in the metallic phase, and under this layer is the core. The mass of the core is 9 times the mass of the Earth, or 0.1 of the mass of the entire Saturn.
Based on the above, we can also find the cosmic velocities for the planet

$$\upsilon_I = \sqrt{g \cdot R} = \sqrt{11{,}3\ \frac{m}{s^2} \cdot 60400000\ mn} = 26125\ \frac{m}{s} \approx 26{,}1\ \frac{km}{s}$$

$$\upsilon_{II} = \sqrt{2 \cdot g \cdot R} = \sqrt{2 \cdot 11{,}3\ \frac{m}{s^2} \cdot 60400000\ m} = 36836\ \frac{m}{s} \approx 36{,}8\ \frac{km}{s}$$

The minimum speed of a spacecraft from our planet to Saturn should be 15,19 $\frac{km}{s}$. If we take into account that the distance from Earth to Saturn is 1,276,106 km, the spacecraft will travel 1,312,416 km in 1 day at a speed of 15.19 and reach the planet in 972.56 days or 2.66 years.

Because Saturn's mass is so large, it is covered by a thick layer of atmosphere. The atmosphere is similar to Jupiter's atmosphere with molecular hydrogen (H_2, 74%), with methane (CH_4,5%), with helium (He, 20%) and ammonia (NH_3). There are only a few around Saturn. The inner ring C has dimensions of 17,000 km, the average brightest B is 28,000 km and the outer A is 17,000 km. Rings A and B are separated by a Cassini slit. Spectral analysis data show that the ring particles are covered with ice and frost. Therefore, they have a high reflectivity. The largest particles of the rings have sizes from 1 to 15 meters
Saturn has many natural moons. According to new data, their number may range from 17 to 39. The largest satellite is Titan, with a diameter of 5,150 km (see appendices).
The planet Uranus. Uranus, one of the largest planets in the solar system, is the seventh closest planet to the Sun. Uranus is the first planet that cannot be seen with the naked eye, and which can only be seen with optical instruments. Uranus is the fourth largest giant planet in the solar system. The planet has a very beautiful greenish-bluish color. The reason for this lies in the composition of the planet's atmosphere and its temperature. At temperatures above -200 °C, a methane haze formed in the upper layers of the hydrogen-helium atmosphere of Uranus. Methane absorbs red rays well and reflects blue and green ones. That's why the planet has acquired a beautiful turquoise color. There are no noticeable disturbances in the atmosphere of Uranus.



The planet Uranus

The planet Uranus was discovered in 1781 by astronomer William Herschel. In 1977, the rings of Uranus were discovered. The images taken by Voyager 2 in 1986 confirmed their existence. Uranus is surrounded by eleven narrow rings located in the plane of the equator at a distance of 42 to 51.4 thousand km (or 1.65-2.02 radius) from the center of the planet.
The typical width of the rings is from 1 to 8 km, only the largest one varies from 22 to 93 km. The thickness of the rings does not exceed 1 km. The rings of Uranus are made up of fine dust and small solid dark particles.
The magnetic field of Uranium has one interesting feature. The axis of rotation of the planet almost lies in the plane of the orbit, and the magnetic field lines are twisted by the rotation of Uranus into a long corkscrew behind the planet.
The magnetic field strength is approximately equal to the Earth's magnetic field.
Uranus is located at the following distances from the Sun:

$$l = 2871000000 \quad km = 2,871 \cdot 10^9 \, km = 19,14 \quad \approx 19,1$$

Uranus moves in an ellipse around the Sun. The orbit of motion is slightly different from the circle, the eccentricity is less than that of Jupiter and Saturn:

$$e = 0,0471$$

By its mass, Uranium exceeds the mass of the Earth by 14.6 times:

$$m = 14,6 \cdot m = 14,6 \cdot 6 \cdot 10^{24} \ kg = 87,6 \cdot 10^{24} \ kg$$

Uranium Dimensions (diameter) It is also almost 4 times larger than Earth's, i.e.

$$d = 49600 \ km; \ r = 24800 \ km$$

And the volume of the planet is 57 times the volume of the Earth:

$$V = 57 \cdot V = 57 \cdot 1,2083 \cdot 10^{12} \ km^3 = 68,9 \cdot 10^{12} \ km^3$$

Since the mass of the planet is large enough, the gravitational force on it is just as great, or gravitational acceleration (g_{Earth}) Like the Earth

$$g_{Уран} = 9,62 \ \frac{m}{s^2}$$

Based on the magnitude of the acceleration of gravity, an object with a weight of 800 N on Earth is equal to 780 N on Uranus.
Uranus orbits the Sun once every 84.1 Earth years. Hence the duration of 1 year in Uranium

$T = 84{,}1 \quad \approx 84$

Because Uranus is farther from the Sun than Saturn, its orbital velocity is less:

$\upsilon_{op} = 6{,}8 \ \frac{km}{s}$

We can also find this value as follows:
The radius of the orbit, that is, the distance from the planet to the Sun.

$r = 2871000000 \ km = 2{,}871 \cdot 10^9 km = 19{,}14$

The length of the orbit

$l = 2 \cdot \pi \cdot r = 18029000000 \ km = 120{,}2 - a$

This means that Uranus will travel 18 billion 29 million kilometers to complete one circle around the Sun. From this,

$$\upsilon_{op} = \frac{l}{T} = \frac{18029000000 \ km}{84{,}1} = \frac{18029000000 \ km}{84{,}1 \cdot 365 \cdot 86400 \ s} = 6{,}8 \ \frac{km}{s}$$

Radar observations show that Uranus rotates very quickly around its axis. The period of one complete revolution around its axis, that is, the duration of one day of Uranium:

$t = 16 \ h \ 48 \ m = 1$

The inclination of the axis of rotation to the plane of the orbit is very small, about 82.5. This indicates that Uranus is tilted into orbit.
The average density of the planet is almost 3.5 times less than the average density of the Earth

$$\rho = \frac{\rho}{3{,}5} = \frac{5500 \ \frac{kg}{m^3}}{3{,}5} = 1410 \ \frac{kg}{m^3} = 1{,}41 \ \frac{g}{sm^3}$$

Because uranus is so massive, it is covered by a thick layer of atmosphere. The atmosphere consists of the same molecular hydrogen (H2-, 50%) as that of Jupiter and Saturn, with methane (CH_4-20%), with helium (He - 15%) и ammonia (NH_3-5%). The average annual temperature on the planet is -200C. Due to the high methane content in the planet's atmosphere, when the sun shines, it gives the atmosphere a green tint. That's why this planet is also called the Green Planet.
Based on the above, we can also find the cosmic velocities for the planet:

$$\upsilon_I = \sqrt{g \cdot R} = \sqrt{9{,}6 \ \frac{m}{s^2} \cdot 24800000 \ m} = 15430 \ \frac{m}{s} \approx 15{,}4 \ \frac{km}{s}$$

$$\upsilon_{II} = \sqrt{2 \cdot g \cdot R} = \sqrt{2 \cdot 9{,}6 \ \frac{m}{s^2} \cdot 24800000 \ m} = 21756 \ \frac{m}{s} \approx 21{,}8 \ \frac{km}{s}$$

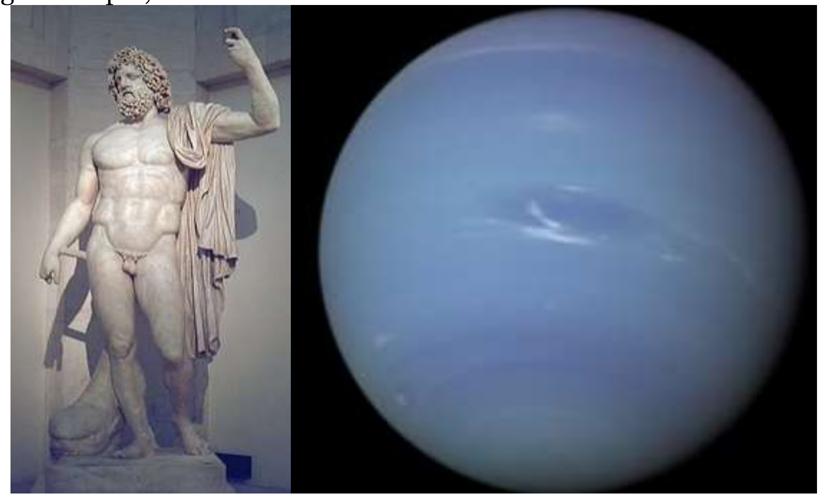
The minimum flight speed of a spacecraft from our planet to Uranus should be $15{,}88 \ \frac{km}{s}$. Considering that the distance from Earth to Uranus is $2721 \cdot 10^6$ The spacecraft will travel 1372000 km in 1 day at a speed of 15,88 $\frac{km}{s}$ and it will reach the planet in 1983.2 days or 5.43 years.

Uranus, like Saturn, is an orbiting planet. Uranium rings were first discovered in 1977 by the American Voyager spacecraft. A total of 10 rings were found in uranium. The width of the largest ring is 70 km, the rest is about 2.5 km. The thickness of the rings does not exceed 1 km. and they are made up of dust and solid particles. The planet Uranus has its own magnetic field. The magnetic field is 1.2 times weaker than the Earth's magnetic field

$$B = \frac{B}{1{,}2} = \frac{5 \cdot 10^{-5} \ Tl}{1{,}2} = 4{,}2 \cdot 10^{-5} \ Tl$$

The magnetic field is located at a distance equal to the radius of 18 planets, or 457,000 km. The planet has 15(21) natural satellites. According to an international agreement, all natural satellites are named after the heroes of Shakespeare's works. Physical data on all natural satellites of the planets are given in a separate appendix.
The planet Neptune. The last of the giant planets in the Solar System is Neptune. The eighth and farthest planet of the Solar system, Neptune, is named in honor of the god Neptune. Neptune is also commonly referred to as the planet found on the tip of a pen (pencil). This planet is named after the god of the seas and oceans. Neptune is the third largest giant planet in the solar system. It is located almost at the edge of the Solar system (30 AU from the Sun) and receives very little solar energy. But despite this, the planet is very active. Neptune's

photographs clearly show clouds appearing and disappearing in the planet's atmosphere. A remarkable detail of Neptune is also a large dark spot, similar in structure to



The planet Neptune

The planet was discovered in 1846 by an astronomer at the Halle Observatory in Berlin. The magnetic field strength of Neptune is 3 times less than that of Earth. Neptune is located at the following distances from the Sun:

$$l \ = 4499000000 \ km = 29{,}99 \ . \approx 30$$

Neptune moves in an ellipse around the Sun. The orbit of motion is slightly different from the circle, the eccentricity is much less than that of other planets: $e = 0{,}0085$

The mass of the planet is 17.2 times the mass of the Earth:

$$m = 17{,}2 \cdot m = 17{,}2 \cdot 6 \cdot 10^{24} \ kg = 103{,}2 \cdot 10^{24} \ kg$$

Its size (diameter) It is also 4 times larger than the earth's, i.e.

$$d = 50100 \ km; \ r_{нептун} = 25050 \ km$$

Its volume is 60 times the volume of the Earth:

$$V = 60 \cdot V \ = 60 \cdot 1{,}2083 \cdot 10^{12} \ km^3 = 72{,}5 \cdot 10^{12} \ km^3$$

Since the mass of the planet is large enough, its gravitational attraction is just as great, or 1.12 times the gravitational acceleration (Earth) of the Earth:

$$g = 11 \ \frac{m}{s^2}$$

According to the value of the acceleration of gravity, an object on Earth with a weight of 800 N on Neptune is 880 N.

Neptune orbits the Sun once every 165 Earth years. Hence the duration of 1 year on Neptune

$$T = 164 \quad 3280 \quad \approx 165$$

Because Neptune is located at great distances from the Sun, its orbital velocity is lower because of this:

$$\upsilon_{op} = 5{,}5 \ \frac{km}{s}$$

We can also find this value as follows:

The radius of the orbit, that is, the distance from the planet to the Sun

$$r = 4499000000 \ km = 30$$

The length of the orbit

$$l = 2 \cdot \pi \cdot r = 28254000000 \ km = 188{,}4$$

This means that Neptune will travel 28 billion 254 million kilometers to complete one orbit around the Sun. From this,

$$\upsilon = \frac{l}{T} = \frac{28254000000 \ km}{165} = \frac{28254000000 \ km}{165 \cdot 365 \cdot 86400 \ s} = 5{,}5 \ \frac{km}{s}$$

Radar observations show that Neptune rotates very quickly around its axis. The period of one complete revolution around its axis, that is, the duration of 1 day of Neptune

$t = 15\ h\ \ 48\ \ \min ute$

The average density of the planet is 3.5 times lower than the average density of the Earth

$$\rho = \frac{\rho}{3,5} = \frac{5500\ \frac{kg}{m^3}}{3,5} = 1600\ \frac{kg}{m^3} = 1,6\ \frac{g}{sm^3}$$

Because Neptune is so massive, it is covered by a thick layer of atmosphere, and the chemical composition of its atmosphere is similar to that of Uranus. The average annual temperature on the planet is -220C. Based on the above, we can also find the cosmic velocities for the planet:

$$\upsilon_I = \sqrt{g \cdot R} = \sqrt{11\ \frac{m}{s^2} \cdot 25050000\ m} = 16599\ \frac{m}{s} \approx 16,6\ \frac{km}{s}$$

$$\upsilon_{II} = \sqrt{2 \cdot g \cdot R} = \sqrt{2 \cdot 11\ \frac{m}{s^2} \cdot 25050000\ m} = 23405\ \frac{m}{s} \approx 23,4\ \frac{km}{s}$$

The minimum speed of a spacecraft from our planet to Neptune should be 16,14 $\frac{km}{s}$. If we take into account that the distance from Earth to Neptune is $4349 \cdot 10^6$ km, the spacecraft will travel 1394500 km in 1 day at a speed of 16,14 $\frac{km}{s}$ and it will reach the planet in 3118.88 days or 8.54 years. The number of natural satellites of the planet is 2 (8). The first and largest natural satellite of Neptune, Triton, was discovered in 1846 by astronomer Lascelles. The second natural satellite, Nereid, was discovered in 1949 by Kuiper.

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