МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«САМАРСКИЙ НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
УНИВЕРСИТЕТ ИМЕНИ АКАДЕМИКА С.П. КОРОЛЕВА»
(САМАРСКИЙ УНИВЕРСИТЕТ)

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АНГЛИЙСКИЙ ЯЗЫК ДЛЯ СТУДЕНТОВ АЭРОКОСМИЧЕСКОГО ПРОФИЛЯ. КОММУНИКАТИВНАЯ КОМПЕТЕНТНОСТЬ БУДУЩЕГО ИНЖЕНЕРА

Рекомендовано редакционно-издательским советом федерального государственного автономного образовательного учреждения высшего образования «Самарский национальный исследовательский университет имени академика С.П. Королева» в качестве учебного пособия для обучающихся по основным образовательным программам высшего образования по направлениям подготовки 01.03.03, 01.04.03 Механика и математическое моделирование, 15.03.01 Машиностроение, 15.03.03, 15.04.03 Прикладная механика, 22.03.02, 22.04.02 Металлургия, 24.03.01, 24.04.01 Ракетные комплексы и космонавтика, 24.04.02 Системы управления движением и навигация и по специальности 24.05.01 Проектирование, производство и эксплуатация ракет и ракетно-космических комплексов

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ОГЛАВЛЕНИЕ

ВВЕДЕНИЕ

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Учебное пособие разработано на кафедре иностранных языков и русского как иностранного и предназначено для студентов 1 и 2 курсов института авиационной техники.

Module 1. HISTORY OF SPACECRAFT

Lead-In

1. Tick the words which are related to rockets to your mind. Give your reasons.

1) gunpowder
2) vacuum
3) gravity
4) firework
5) Newton
6) Sputnik
7) astrology
8) thrust
9) weapon
10) crew

2. How much do you know about the history of rockets? Who invented them first? What were they used for? Share the information.

3. Look at the picture below. Do you know what it is? How does it work? Try to explain.

Reading

1. Practice reading the following words.

spacecraft	['speɪskrɑːft]
aeolipile	[iː'ɔləpaɪl]
gunpowder	['gʌnˌpaudə]
mixture	['mɪksʧə]
propel	[prə'pel]
launch	[lɔːnʧ]
thrust	[θrʌst]
sphere	[sfɪə]
charcoal	['ʧɑːkəul]
saltpeter	[ˌsɔːlt'piːtə]
sulfur	['sʌlfə]
psychological	[ˌsaɪkə'lɔʤɪkəl]

2. Read and translate the text.

History of Spacecraft

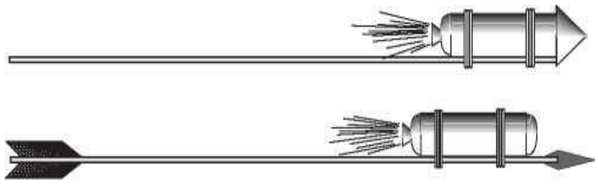
1. Rocket technology has been evolving for more than 2000 years. Today spacecraft are remarkable collections of human inventiveness that have their roots in science and technology of the past. They are natural results of thousands of years of experimentation and research on rockets and rocket propulsion.

2. One of the first devices that successfully used the principles essential to rocket flight was rocket-like device called an *aeolipile* (***Look at the picture in Lead-In***). The Greek, Hero of Alexandria, invented it. It used steam as a propulsive gas. Hero mounted a sphere on top of a water kettle. A fire below the kettle turned the water into steam, and the gas traveled through pipes to the sphere. Two L-shaped tubes on opposite sides of the sphere allowed the gas to escape, and in doing so gave thrust to the sphere that caused it to rotate.

3. Just when the first true rockets appeared is unclear. In the first century A.D. the Chinese reportedly had a simple form of gunpowder made from saltpeter, sulfur and charcoal dust. They used the gunpowder mostly for fireworks in religious and other festive celebrations. To create explosions during religious festivals, they filled bamboo tubes with the mixture and tossed them into fires.Perhaps some of those tubes failed to explode and propelled by the gases and sparks produced from the burning gunpowder.

4. The Chinese began experimenting with the gunpowder-filled tubes. At some point, they attached bamboo tubes to arrows and launched them. Soon they discovered that these gunpowder tubes could launch themselves just by the power produced from the escaping gas.

5. The date reporting the first use of true rockets was in 1232. At this time, the Chinese and the Mongols were at war with each other. During the battle of Kai-Keng the Chinese repelled the Mongol invaders by a barrage of “arrows of flying fire.” These fire-arrows were a simple form of a solid-propellant rocket. A tube capped at one end contained gunpowder. The other end was left open, and the tube was attached to a long stick. When the powder ignited, the rapid burning of the powder produced fire, smoke and gas that escaped out of the open end and produced thrust.



Fire arrows

6. The stick acted as a simple guidance system that kept the rocket headed in one general direction as it flew through the air. How effective these arrows of flying fire were as weapons of destruction is not clear, but their psychological effects on the Mongols must have been formidable.

7. Many records describe rocket experiments throughout the 13th to the 15th centuries. During the later part of the 17th century the great English scientist Sir Isaac Newton (1642-1727) laid the scientific foundations for modern rocketry. Newton organized his understanding of physical motion into three scientific laws. The laws explain how rockets work and why they are able to work in the vacuum of outer space. Newton’s laws soon began to have a practical impact on the design of rockets. In the 1720s researchers in the Netherlands, Germany and Russia started to use Newton's laws as tools in the rockets design.

You should remember the following words and phrases!	
spacecraft	космический аппарат
device	устройство, аппарат
to mount	монтировать, устанавливать
gunpowder	порох
mixture	смесь
to explode	взрывать, взрываться
to propel	толкать вперёд; двигать
to attach	прикреплять
to launch	запускать
to discover	обнаруживать, выяснять,
solid-propellant rocket	твердотопливная ракета
thrust	тяга
rocketry	ракетная техника
liftoff	старт ракеты
launch pad	стартовая площадка
to maintain	поддерживать, обслуживать

3. Match the synonyms and make up word combinations using the words from column B

A	B
1. propulsion	a. quick
2. remarkable	b. to utilize
3. device	c. to start
4. to invent	d. to light
5. to mount	e. mechanism
6. to use	f. strength
7. to launch	g. motion
8. power	h. to attach
9. rapid	i. to create
10. to ignite	j. outstanding

4. Read the text again and answer the questions.

1. Who developed the first rocket-like device?
2. What was its operational principle?
3. What provided propulsion of Chinese fireworks?
4. Were they used for celebrations or as weapons?
5. What produced thrust in "arrows of flying fire"?
6. Who laid the scientific foundation for rocketry?

5. Read and translate the text about Newton's Laws of Motion and put the words in brackets into Active or Passive Voice in Present or Past Simple.

The science of rocketry (1) ____________ (to begin) with the publishing of a book in 1687 by the great English scientist Sir Isaac Newton. His book *The Principia* described physical principles in nature. In *The Principia*, Newton stated three important scientific principles that (2) _________ (to govern) the motion of all objects, whether on the Earth or in space.

Here now, in simple form, are Newton's Laws of Motion.

The First Law of Motion reads as follows:

"An object remains still or moves with constant velocity unless it is acted upon by an unbalanced force."

This law (3) _______ (to call) often the Law of Inertia. The amount of inertia that object has is in proportion to the amount of force needed to slow this object down, to speed it up or to change its direction. In rocket flight, forces become balanced and unbalanced all the time. A rocket on the launch pad (4) ________ (to balance). The surface of the launch pad pushes the rocket up while gravity tries to pull it down. As the engines are ignited, the thrust from the rocket (5) ________ (to unbalance) the forces, and the rocket travels upward. Later, when the rocket runs out of fuel, it slows down, stops at the highest point of its flight, and then falls back to the Earth.

The Second Law of Motion reads as follows:

"Any change in motion of an object is in proportion to the force pressing on it and takes place in the direction of the straight line in which the pressing force acts."

Newton's Second Law gives a valuable means for measuring the forces of gravitation at any point of the Earth's surface. The ability of making such calculations is of great importance in planning the orbit of an artificial satellite.

The Third Law of Motion reads as follows:

"Whenever one object exerts a force on another, the second object exerts an equal and opposite force on the first object, or in other words, action and reaction are equal and opposite"

A rocket can lift off from a launch pad only when it (6) _______ (to expel) gas out of its engine. The rocket pushes on the gas, and the gas in turn pushes on the rocket. The action is the expelling of gas out of the engine. The reaction is the movement of the rocket in the opposite direction.

To enable a rocket to lift off from the launch pad, the action, or thrust, from the engine must be greater than the weight of the rocket. Only when the thrust is greater than the weight of the rocket, the forces become unbalanced and the rocket lifts off. In space where unbalanced force (7) ________ (to use) to maintain the orbit, even tiny thrusts will cause a change in the unbalanced force and result in the rocket changing speed or direction.

Newton's Laws of Motion are of great importance in dynamics of rockets. Artificial satellites, various spaceships, and orbital stations are travelling in space according to the Laws of Motion.

6. Match the words with their definitions.

1. gravitation	a) a substance made from a combination of different substances, or any combination of different things
2. steam	b) a special area from which spacecraft or missiles are sent into the sky
3. mixture	c) the force that attracts all objects towards one another
4. rocket	d) force that keeps something in the same position or moving in the same direction
5. launch pad	e) the action of a spacecraft or rocket leaving the ground
6. liftoff	f) the hot gas that is produced when water boils
7. inertia	g) a large cylinder-shaped object that moves very fast by forcing out burning gases used for space travel or as a weapon

Speaking

Imagine that you work as a museum guide at the museum of rocket history. Tell the visitors about the first rocket-like devices in detail. For more information use the Internet. Touch upon their design features, application, inventors.

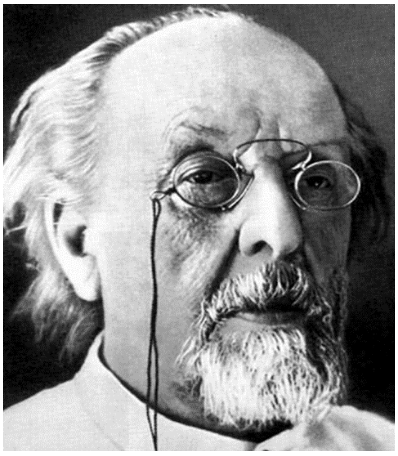
Module 2. FOUNDERS OF ROCKETRY

Lead-In

Look at the pictures. Do you know these people? Name them. What are they famous for?

a)

b)



c)

d)

Reading

1. Practice reading the following words.

conquer	['kɔŋkə]
astronautics	[ˌæstrə(u)'nɔːtɪks]
propellant	[prə'pelənt]
exhaust	[ɪg'zɔːst]
discard	['dɪskɑːd]
squadron	['skwɔdrən]
simultaneously	[ˌsɪməl'teɪnɪəslɪ]
supply	[sə'plaɪ]
refuel	[ˌriː'fjuːəl]
multistage	['mʌltɪsteɪʤ]

2. Read and translate the text.

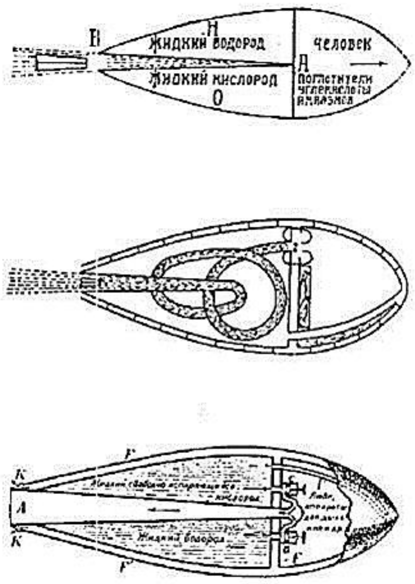
Founders of Rocketry

1. "Mankind will not remain on the Earth forever but it will penetrate beyond the atmosphere, timidly at first, and then will conquer all the space around the Sun". The outstanding Russian scientist K.E. Tsiolkovsky said these words at the beginning of the 20th century.

2. K. E. Tsiolkovsky, the founder of astronautics, was born in 1857. At the age of sixteen he was sent to Moscow to perfect his knowledge in mathematics, physics, mechanics and astronomy. Then he lived in Kaluga and taught physics and mathematics at school for 40 years.

3. K. E. Tsiolkovsky's contribution to rockets development is of great importance. In 1885 he began to work on the design of a spacecraft and suggested the rocket as the only vehicle for space travel. In a report he published in 1903, Tsiolkovsky proposed the use of liquid

propellants for rockets in order to achieve greater range and formulated the basic requirements for rocket propellants. Tsiolkovsky stated that only the exhaust velocity of escaping gases limited the speed and range of a rocket. The same year he introduced his famous formula, which determines the maximum speed for a single-stage rocket. For his ideas, careful research and great vision, Tsiolkovsky has been called the father of modern astronautics.



Tsiolkovsky Rocket Designs

4. Tsiolkovsky also suggested the idea of composite rockets or “space rocket trains”, as he called them in one of his works. They were of two types. The first type was like a railroad train with a locomotive positioned behind and pushing the carriages forward. Such a “space rocket train” is propelled initially by the lower rocket engine (first-stage rocket). As soon as the first-stage rocket runs out of its propellants, it is discarded and drops onto the Earth. Then, the engine of the second-stage rocket starts. By the moment all the stages have consumed their propellants the “space rocket train” attains a relatively high speed.

5. Another type of multistage rockets was named by Tsiolkovsky a space rocket squadron. All rockets within squadron are positioned like logs in a raft. At launch all the rocket engines begin operating simultaneously. As the propellants are being consumed, the half-empty tanks of the rockets in the central part of the squadron are filled with the rest of the propellant from the side rockets. Gradually, the side rockets are jettisoned and only the central rockets with refueled tanks keep on moving. Finally, the last central rocket remains using the last supply of the propellant.

6. Tsiolkovsky's theory of multistage rockets was one of the greatest contributions to the world's rocketry. His works on cosmonautics determined the possibility of flights in the solar system.

3. Read the text again and decide, whether the following statements are true or false.

1. K.E. Tsiolkovsky was the university professor and taught aerodynamics.

2. K.E. Tsiolkovsky suggested the jet engine as the only vehicle for space travel.

3. K.E. Tsiolkovsky suggested the use of liquid propellants for rockets in order to achieve greater range.

4. K.E. Tsiolkovsky also suggested the idea of composite rockets consisting of two rocket types –the first-stage rocket and the second-stage rocket.

5. In Tsiolkovsky's space rocket squadron the side rockets are used to refuel the central part of the rocket.

6. In Tsiolkovsky's space rocket squadron the central part of the squadron starts when the side rockets are jettisoned.

4. Match the synonyms.

A	B
1. composite	a. to start
2. to conquer	b. to attain
3. to perfect	c. to move
4. to jettison	d. to discharge
5. to propel	e. to overcome

6. to consume	f. to improve
7. to supply	g. to provide
8. to achieve	h. to use
9. to exhaust	i. to discard
10. to launch	j. compound

5. Match the words with their definitions.

1. range	a. to put more fuel into an aircraft, ship, etc., so that it can continue its journey
2. contribution	b. a machine that uses the energy from liquid fuel to produce movement
3. rocket	c. to provide something that is needed, often in large quantities and over a long period of time
4. propellant	d. the distance that a vehicle can travel without having to stop for more fuel
5. vehicle	e. an explosive substance that causes something to move forwards
6. exhaust	f. something that you do to help produce or achieve something together with other people, or to help make something successful
7. engine	g. a container that holds liquid or gas
8. to refuel	h. something used to transport people or goods
9. fuel tank	i. the waste gas from an engine
10. to supply	j. a large cylinder-shaped object that moves very fast by forcing out burning gases, used for space travel or as a weapon

You should remember the following words and phrases!	
astronautics	космонавтика
spacecraft	космический аппарат
liquid propellant	жидкое топливо
range	дальность, диапазон
exhaust velocity	скорость истечения, выхлопа
to discard	сбрасывать, отбрасывать
to consume	потреблять, расходовать
multistage rocket	многоступенчатая ракета
simultaneously	одновременно
to jettison	сбрасывать
to refuel	дозаправлять
rocketry	ракетная техника

6. Read the text on Robert H. Goddard and fill in the gaps (1-7) with the missing information (a-g). Translate the text into Russian.

a) lighter-than-air balloons

b) solid-propellant

c) parachute recovery systems

d) practical experiments

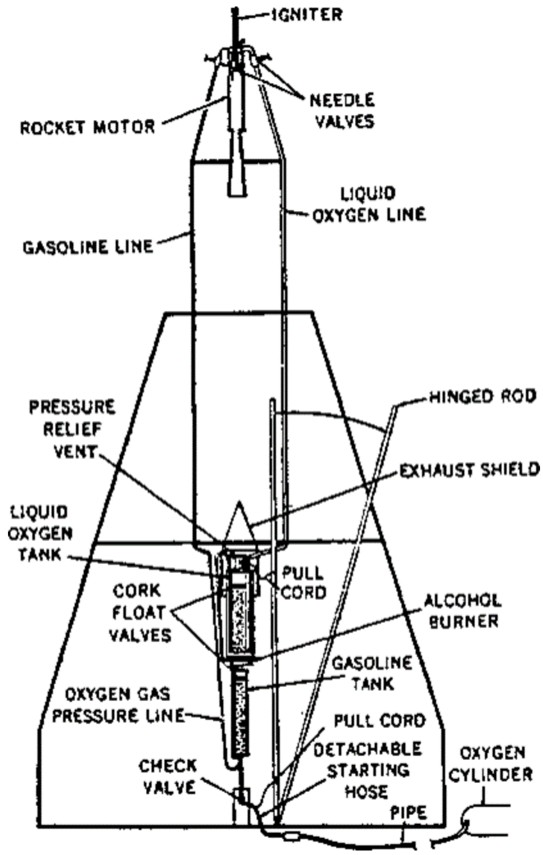
e) a gyroscope system

f) a liquid-propellant rocket

g) multistage rockets

Early in the 20th century, an American, Robert H. Goddard (1882-1945), conducted (1) __________ in rocketry. He had become interested in a way of achieving higher altitudes than were possible for (2) __________. Goddard reached several conclusions important to rocketry. From his tests, he stated that a rocket operates with greater *efficiency in a vacuum than in the air. Goddard also stated that (3) _____________ were the answer to achieving high altitudes, and that the velocity needed to escape Earth's gravity could be achieved in this way.*

Goddard's earliest experiments were with solid-propellant rockets. In 1915, he began to try various types of solid fuels and to measure the exhaust velocities of the burning gases.



While working on solid-propellant rockets, Goddard became convinced that a rocket could be propelled better by liquid fuel. No one had ever built a successful liquid-propellant rocket before. It was a much more difficult task than building (4) _________ rockets. Fuel and oxygen tanks, turbines and combustion chambers would be needed. In spite of the difficulties, Goddard achieved the first successful flight with (5) ____________ on March 16, 1926. (see the figure) Fueled by liquid oxygen and gasoline, the rocket flew for only two and a half seconds, climbed 12.5 meters and landed 56 meters away. By today's standards, the flight was unimpressive, but like the first powered airplane flight by the Wright brothers in 1903, Goddard's gasoline rocket became the forerunner of a new era in rocket flight.

Goddard's experiments in liquid-propellant rockets continued *for many years. His rockets grew bigger and flew higher. He developed (6) _________ for flight control and a payload compartment for scientific instruments. (7) _______________ returned the rockets and* *instruments safely to the ground. We call Goddard the father of modern rocketry for his achievements.*

Speaking

You are going to make a presentation for high school students. The topic of your presentation is "Outstanding scientists in the history of rocketry". Search the Internet for additional information.

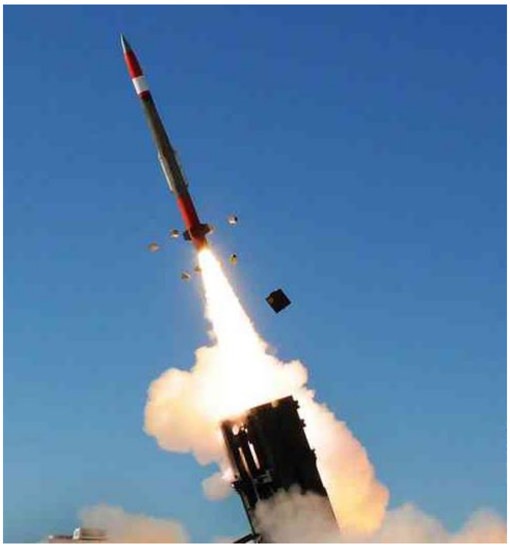
Module 3. ROCKET PRINCIPLES

Lead-In

1. Look at the pictures. What do you think of engines these spacecraft use? What are their operational principles?

a)

b)



c)

d)

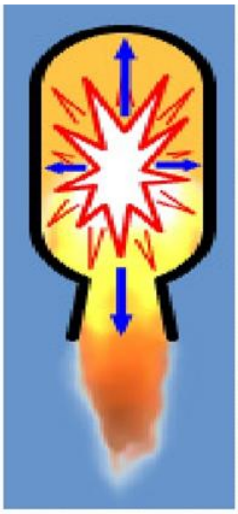
Reading

1. Practice reading the following words.

chamber	['ʧeɪmbə]
reliable	[rɪ'laɪəbl]
oxygen	['ɔksɪʤən]
hydrogen	['haɪdrəʤən]
insulation	[ˌɪnsjə'leɪʃən]
feature	['fiːʧə]
igniter	[ɪg'naɪtə]
throat	[θrəut]
turbine	['tɜːbaɪn]

2. Read and translate the text.

Rocket Principles

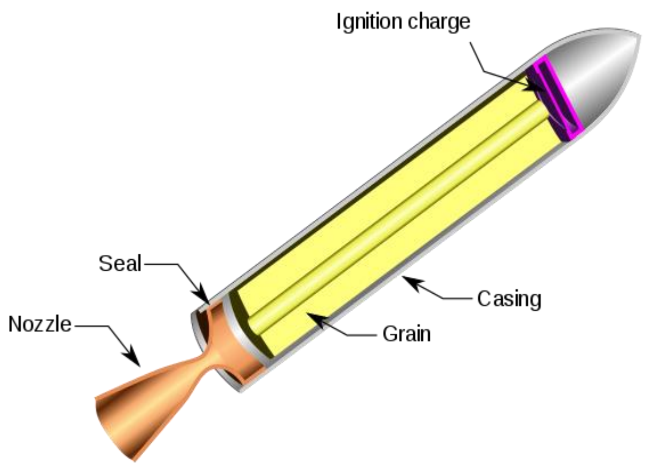


1. A rocket in its simplest form is a chamber enclosing gas under pressure. A small opening at one end of the chamber allows the gas to escape, and so provides a thrust that propels the rocket in the opposite direction. A good example of this is a balloon. Air inside a balloon is compressed by the balloon's rubber walls. The air pushes back so that the inward and outward pressing forces balance. When the nozzle is released, the air escapes through it, and the balloon is propelled in the opposite direction.

2. When we think of rockets, we rarely think of balloons. Instead, our attention is drawn to the giant vehicles that carry satellites into orbit and spacecraft to the Moon and planets. Nevertheless, there is a strong similarity between the two.

3. The first rockets ever built, the fire-arrows of the Chinese, were not very reliable. Many of them just exploded on launching. Others flew on erratic courses and landed in the wrong place. Today, rockets are much more reliable. They fly on precise courses and are capable of going fast enough to escape the gravitational pull of the Earth. Modern rockets are also more efficient today because we have an understanding of the scientific principles behind rocketry.

4. Most rockets today operate with either solid or liquid propellants. The word propellant means both fuel and oxidizer. The fuel is the chemical a rocket burns, but for burning to take place, an oxidizer (oxygen) must be present. Jet engines draw oxygen from the surrounding air. Rockets must carry oxygen with them into space, where there is no air.

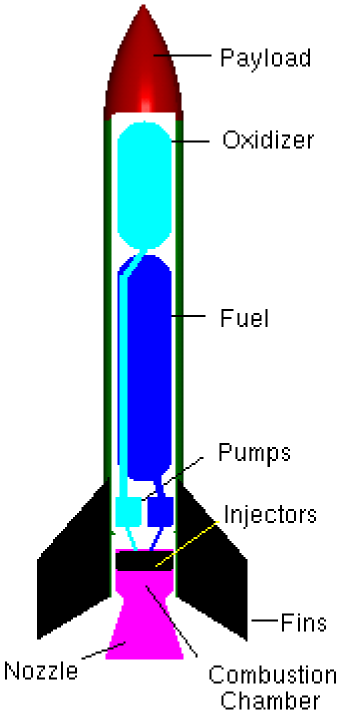


Solid propellant rocket

5. Solid rocket propellants contain both the fuel and oxidizer combined together in the chemical itself. Usually the fuel is a mixture of hydrogen compounds and oxygen compounds. Liquid propellants are kept in separate containers, one for the fuel and the other for the oxidizer. Just before firing, the fuel and oxidizer are mixed together in the engine.

6. A solid-propellant rocket has the simplest form of a motor. It has a nozzle, a case, insulation, propellant, and an igniter. The case of the motor is usually a relatively thin metal that is lined with insulation to keep the propellant from burning through. The propellant itself is packed inside the insulation layer.

7. Many solid-propellant rocket motors feature a hollow core that runs through the propellant. It is used to get higher thrust. The propellants burn from the inside out at a much higher rate sending mass out of the nozzle at a higher speed. These results are in greater thrust.



Liquid Propellant Rocket

8. The nozzle in a solid-propellant motor is an opening at the back of the rocket that permits the hot expanding gases to escape. The narrow part of the nozzle is a throat. Just beyond a throat is an exit cone. The purpose of the nozzle is to increase the acceleration of gases as they leave the rocket and thereby maximize the thrust. It does this by cutting down the opening through which the gases can escape.

9. The other main kind of a rocket engine is one that uses liquid propellants, which may be either pumped or fed into the engine by pressure. Liquid propellants have separate storage tanks—one for the fuel and one for the oxidizer. They also have a combustion chamber and a nozzle. The fuel of a liquid-propellant rocket is usually kerosene or liquid hydrogen; the oxidizer is usually liquid oxygen. They are mixed inside a combustion chamber. Here the propellants burn and reach high temperatures and pressures, and the expanding gas escapes through the nozzle at the lower end. To get the most power from the propellants, they must be mixed as completely as possible. Small injectors (nozzles) on the roof of the chamber spray and mix the propellants at the same time. As the chamber operates under high pressures, the propellants need to be forced inside. Modern liquid rockets use powerful, lightweight turbine pumps to take care of this job.

10. Thus, we have described the main parts and the operation of a solid-propellant motor and a liquid-propellant engine.

3. Answer the following questions.

1. What provides thrust of a rocket?
2. Were the first rockets reliable?
3. What does the word *propellant* mean?
4. What kind of fuel is used in modern rockets?
5. Why is an oxidizer required for space travelling?
6. What are the main components of a solid-propellant rocket?
7. Why do solid-propellant rockets have a hollow core?
8. What is the purpose of a rocket nozzle?
9. What is a combustion chamber intended for?
10. Why are the injectors used?

4. Give your own definitions for the words from the text.

1. ____________________________________ nozzle
2. ____________________________________ gravitational pull
3. ____________________________________ engine
4. ____________________________________ fuel
5. ____________________________________ compound
6. ____________________________________ combustion chamber

7. ______________________________ insulation

8. ______________________________ pump

You should remember the following words and phrases!	
pressure	давление, сжатие,
nozzle	сопло, форсунка
to escape	улетучиваться, истекать
reliable	надежный
to explode	взрываться
course	курс, направление
precise	точный
gravitational pull	гравитационное притяжение
to operate	работать, действовать
propellant	ракетное топливо
fuel	топливо
oxidizer	окислитель
case	кожух, корпус
insulation	изоляция
igniter	воспламенитель
to feature	отличать, характеризовать
rate	темп; скорость
throat	горловина сопла
combustion chamber	камера сгорания
injector	форсунка
to line	облицовывать
to pump	нагнетать

5. a) Match the synonyms

A	**B**
1. to propel	a. to enlarge
2. to compress	b. to work
3. to release	c. to force
4. to explode	d. to spread
5. to operate	e. to insulate
6. to combine	f. to free
7. to line	g. to squeeze
8. to increase	h. to move
9. to pump	i. to mix
10. to expand	j. to burst

b) Make up word combinations using verbs from B.

6. Read the text on thrust control and fill in the gaps (1-6) with the missing information (a-f). Translate the text into Russian.

a. combustion chamber

b. solid-propellant rockets

c. hollow core

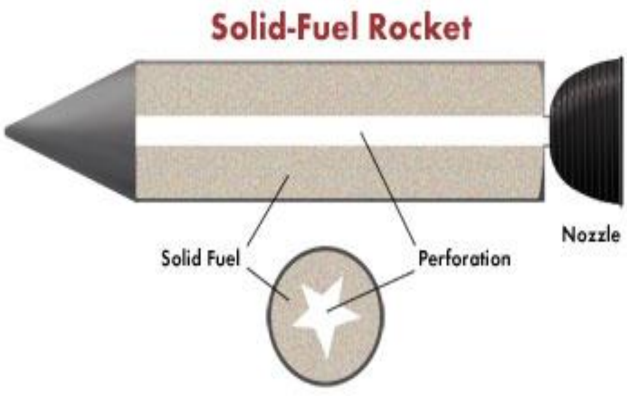
d. liquid-propellant engines

e. chamber pressure

f. engine thrust

Thrust Control

Controlling the thrust of an engine is very important to launch payloads into orbit. Thrusting for too short or too long period will cause a satellite to be placed in the wrong orbit. This could cause it to go too far into space to be useful or make the satellite fall back to the Earth. Thrusting in the wrong direction or at the wrong time will also result in a similar situation. A computer in the rocket's guidance system determines when that thrust is needed and turns the engine on or off appropriately. (1) ____________ do this by simply starting or stopping the flow of propellants into the (2) ____________. On more complicated flights, such as going to the Moon, the engines must be started and stopped several times. Some liquid-propellant engines control the amount of (3) ____________by varying the amount of propellant that enters the combustion chamber. Typically, the engine thrust varies for controlling the acceleration experienced by astronauts or to limit the aerodynamic forces on a vehicle. (4) ____________ are not as easy to control as liquid rockets. Once started, the propellants burn until they are gone. They are very difficult to stop or slow down part way into the burn. Some solid-fuel engines have hatches on their sides that can be cut loose by remote control to release the (5) ___________ and terminate thrust. The burn rate of solid propellants is carefully planned in advance.



The (6) __________ running the length of the propellants can be made into a star shape. At first, there is a very large surface available for burning, but as the points of the star burn away, the surface area is reduced. For a time, less of the propellant starts burning, and this reduces thrust.

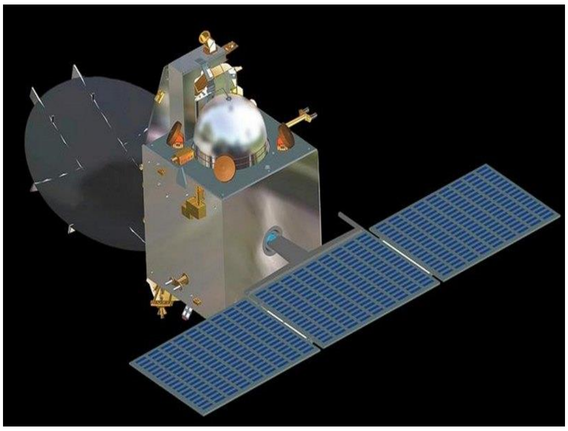
7. Translate the text in a written form.

A comparison of the advantages of a liquid-propellant or solid-propellant rocket depends entirely on application. The advantages of the liquid-propellant engine lie in its higher performance, its simple shutdown and restart capability, and the fact that it is easier to control. For example, the trust of a liquid-propellant rocket can be varied at will, by throttling the propellant flow, and the rocket can easily be controlled in flight by swiveling the relatively small engines.

The advantages of a solid-propellant rocket lie in its simplicity. It need not be fueled just prior to launching. It needs no pressure system or pumps to feed the propellants from the tanks into the combustion chamber, since the rocket's case combines the functions of both. The resulting simplification and speedup of launch preparations make the solid-propellant rocket especially attractive for military applications where quick response may be vital.

Speaking

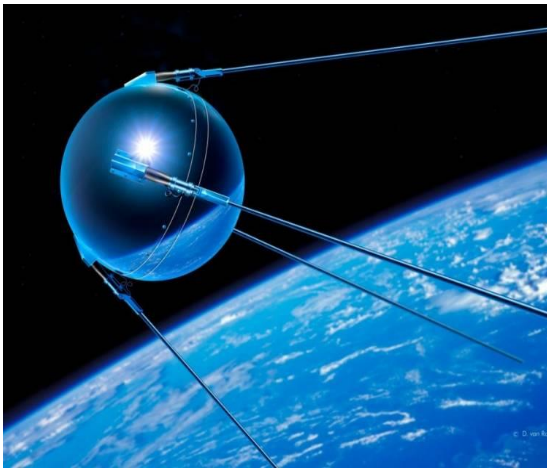
Look at the picture below. This space probe will be launched to the Mars. You are a member of the design team. Your task is to choose the launch vehicle to deliver it to the Martian orbit. Choose the rocket type and give your reasons. What type of rocket suits this purpose best of all? Discuss the task with your colleagues.



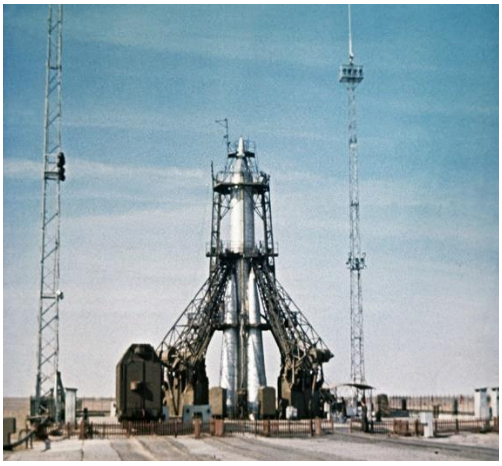
Module 4. THE FIRST SATELLITE

Lead-In

1. Look at the pictures. What do they show? How are the images connected? Share the ideas with your groupmates.



a)



b)

c)

d)

Reading

1. Practice reading the following words.

alloy	['ælɔɪ]
threshold	['θreʃəuld]
frequency	['friːkwənsɪ]
hemisphere	['hemɪsfɪə]
pressurized	[preʃəraɪzd]
nitrogen	['naɪtrəʤən]
titanium	[taɪ'teɪnɪəm]
broadcasting	['brɔːdkɑːstɪŋ]
authority	[ɔː'θɔrɪtɪ]

2. Match the English words with their Russian counterparts.

1. polished sphere	a. система отделения
2. space age	b. космическая эпоха
3. radio frequency	c. радиопередатчик
4. hermetically sealed	d. отполированная сфера
5. outer shell	e. частота радиоволн
6. to reflect sunlight	f. герметичный
7. radio transmitter	g. внешняя оболочка
8. separation system	h. отражать солнечный свет

3. Read and translate the text.

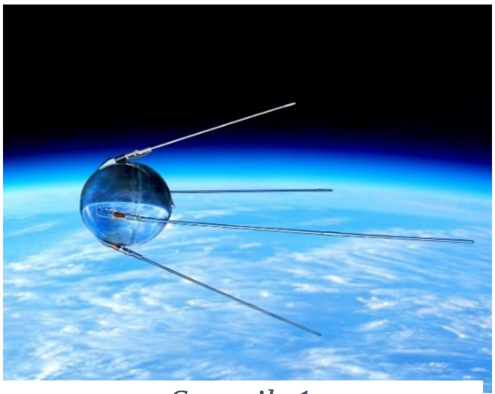
First Satellite – Sputnik 1

1. Sixty four years ago, the Soviet Union put the first artificial satellite into orbit and changed the world forever. Soviet authorities announced the success of Sputnik 1 several hours after its launch. Ra-

dio beeps from a highly polished aluminum-alloy sphere barely bigger than a ball signaled to the world, on the evening of 4 October, 1957, that humanity had crossed a monumental threshold. We had entered the space age.

2. The Soviet news agency TASS also released the radio frequencies on which the satellite was transmitting – 20.005 MHz and 40.01 MHz – along with broadcast timetables to enable radio enthusiasts around the world to tune in and marvel at its beep-beep-beeping. Sputnik 1 was described as the world's first artificial moon in news reports at the time, but it was a very small one. Its diameter was about 58 cm, and it weighed 83.6 kg.

3. The hemisphere of two millimeters thick connected by 36 bolts to which the antennas were attached had an additional external covering to help regulate the internal temperature. The two halves were hermetically sealed together and the satellite interior was pressurized to 1.3 atmospheres using nitrogen gas. Resin O-rings ensured sealed interface between hemispheres. The ventilator was designed to start whenever the internal temperature rose to more than 30°C, circulating the gas into the outer shell where it could cool. The aluminum alloy shell was strengthened with magnesium and titanium. It was highly polished so Sputnik would better reflect sunlight, enabling it to be more easily seen in the sky. It was visible with binoculars before sunrise and after sunset.



Sputnik-1

4. Most of the weight of the internal componentry came from three silver-zinc batteries. One powered a small ventilator, the others two simple radio transmitters. A one-Watt radio transmitter emitted signals lasting 0.4 seconds on the wavelength of 7 and 15 meters. If

the temperature onboard the satellite would exceed 50°C or fall below 0°C, or if the pressure inside fell below 0.35kg/cm², thermal and barometric switches would be activated changing the length of the radio signal sent by the satellite. Power supply to the radio transmitter and the thermal control system onboard the satellite would be activated by a remote switch. It would be activated by a sensor at the moment of separation of the launch vehicle and the satellite.

5. The top hemisphere carried two antennas with two beams each. One antenna had 2.4-meter beams, another 3.9 meter beams designed for broadcasting two different frequencies. A special spring mechanism was designed to deploy antennas to the angle of 35° toward the main axis of the container, immediately after the spacecraft had separated from the rocket. The paired configuration was angled to ensure Sputnik's broadcast signals would be heard on the ground no matter which way the satellite was oriented.

6. Sputnik 1 was launched into space atop a rocket which design was derived from the Soviet Union's development of the world's first intercontinental ballistic missile – the two-stage rocket R-7 'Semyorka'. A special transfer section was developed to connect the rocket with the satellite. A separation system was designed to jettison the payload fairing and the satellite from the core stage of the R-7 rocket.

7. Sputnik 1 transmitted for 21 days, until its batteries were depleted. The batteries exceeded expectations. Sputnik was powered by three silver-zinc batteries designed to operate for two weeks, but the satellite continued sending out radio signals for 21 days. It remained in space for 96 days, before it finally burnt up on re-entry into the Earth's atmosphere, on 4 January, 1958. In that time, travelling at a speed of about 29,000 km/h, it completed 1,400 orbits of the planet.

4. Choose the answer, which is the most corresponding to the text information:

1. Sputnik 1 was described as

- a huge sphere

- a cylinder-shaped object

- a small sphere.

2. Sputnik 1had an additional external covering

- to shield it from space trash

- to help regulate the internal temperature

- to strengthen the frame.

3. Sputnik 1 was highly polished

- to look well and impressive

- to absorb sunlight

- to reflect sunlight better.

4. Three silver-zinc batteries were used

- to provide power for satellite equipment

- to illuminate the satellite at night

- to signal on landing.

5. Two antennas were mounted at angles

- to balance forces acting on the satellite

- to control attitude

- to broadcast signals to be heard all over the world.

5. Match the synonyms.

1. launch	a. to exhaust
2. to connect	b. to discard
3. to deplete	c. cargo
4. to complete	d. start
5. to jettison	e. satellite
6. spacecraft	f. to finish
7. payload	g. to join

6. Match the words with their definitions.

1. sphere	a. the curved path through which objects in space move around a planet or star
2. to jettison	b. a device that produces electricity to provide power for radios, cars, etc.
3. satellite	c. an object shaped like a round ball
4.battery	d. a missile that is powered as it rises, but then falls without being controlled
5. to activate	e. to throw away or get rid of something that is not wanted or needed
6. ballistic missile	f. a structure made of metal rods or wires, often positioned on top of a building or vehicle, that receives or sends radio or television signals
7. orbit	g. a device sent up into space to travel around the Earth, used for collecting information or communicating by radio, television

8. alloy	h. a piece of curved or bent metal that can be pressed into a smaller space but then returns to its usual shape
9. spring	i. a metal that is made by mixing two or more metals, or a metal and another substance
10. antenna	j. to cause something to start working

7. Ask 10 questions of all possible types to the text.

You should remember the following words and phrases!	
alloy	сплав
threshold	порог
frequency	частота
to transmit	передавать
to seal	герметизировать
to pressurize	герметизировать
shell	оболочка
to strengthen	укреплять
to emit	испускать
to reflect	отражать
to exceed	превышать
to switch	включать
thermal control system	система термоконтроля
launch vehicle	ракета-носитель
spring	пружина
to work out	разрабатывать
to jettison	отделять
payload	полезная нагрузка
fairing	обтекатель

re-entry	возвращение в плотные слои атмосферы
transfer section	переходный отсек
preliminary design	эскизный проект
Vernier thruster	маневровый двигатель

8. Read the text and decide which words or word combinations, A, B or C best fits each space. There is an example (0) at the beginning.

The Government Decree of February 13, 1953 obliged (o) _______ a preliminary design of a two-stage ballistic rocket 170 t in mass with a separable warhead 3000 kg in mass capable (1) ________ to a range of 8000 km. In October 1953, the design assignment was changed: a fire charge mass was increased to 3000 kg (a total mass of the rocket warhead - to 5500kg) with a flight range remained unchanged, i. e. the design had to be modified radically.

It was decided to use steering Vernier thrusters (2) ________ finite thrust after the main engine has been shut down. In designing the Vernier thruster, many problems have been solved and new structures developed. These structures found application and further evolution.

The R-7 consisted of four boosters (3) ________ to a core stage. Fuel tanks of all stages also served as structural elements. Engines of all five stages were ignited from ground. Each stage accommodated a standardized four-chamber liquid-propellant (4) ________ of 80-90 tf thrust. A control system incorporated stabilization automatics ensuring normal and lateral stabilization, a velocity control system, and a *range and direction radio control system. On the core stage, a simultaneous fuel depletion system was provided because a lack of this system caused a large range loss.*

It was designed a launch complex for the R-7 in Tyuratam, Kazakhstan, known today as the Baikonur Cosmodrome. A massive ferroconcrete launch pad was built over a 45-meter deep flame pit. The rocket hung over an opening supported by four retractable trusses attached to load-bearing points at the top of each booster.

On start-up, (5) _______ flew by gravity, and the engines were (6) ______. The inflow of fuel turned the turbine blades, which began to pump hydrogen peroxide into the steam generators. Once the steam was produced, the turbo pump powered up to 8300 rpm. The supporting trusses held the rocket down until full take-off thrust was developed, about 10 seconds after ignition. During flight, a special system synchronized the fuel consumption of the four strap-on boosters to keep the rocket's weight in balance.

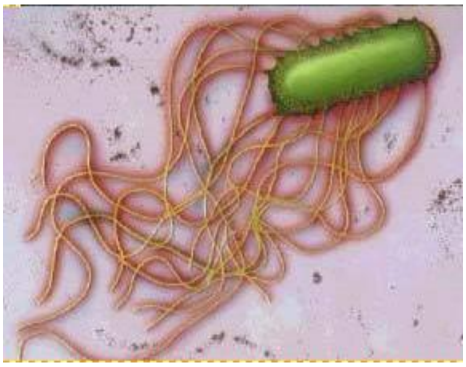
Radio telemetry systems used over 700 onboard sensors. A total of 6000(7) ________ per second were sent on 48 channels.

On October 4 and November 3, it placed the world's first (8) ________ Earth satellites into orbit.

0. A. to build	B. **to work out**	C. to buy
1. A. to be limited	B. to be started	C. to be launched
2. A. to generate	B. to stop	C. to evaluate
3. A. hinged	B. removed	C. attached
4. A. satellite	B. engine	C. fuel tank
5. A. fuel	B. air	C. water
6. A. compressed	B. ignited	C. released
7. A. measurements	B. items	C. kilometers
8. A. natural	B. huge	C. artificial

9. a) Look at these animals. What things in common do they have? Share the ideas.

a) a turtle



b) a bacterium

c) a rat

d) a dog

e) a rabbit

f) a snail

10. Translate the text in a written form.

First Animals in Space

Before the Soviet cosmonaut Yuri Gagarin became the first human in space in 1961, there were the animals. The first astronauts to break through Earth's atmosphere had no understanding of what they were doing.

First animals in space were carefully selected. They passed special training before the flight. It is interesting that taking dogs to participate in the flight the preference was given to outbred individuals, as they are more physically hardy.

Belka and Strelka

Orbital flight required healthy dogs weighing less than 6 kg and 35 cm in length, two to six years old. They were the most appropriate shorthaired animals to be fitted with sensors reading the information.

Before flying, the dogs were trained in the closed chambers, simulating the cabin of the spacecraft not to be afraid of loud noises and vibrations, eating, using the special device that supplied food in weightlessness.

Dogs were selected from a large number of applicants, but except for basic physical parameters, the coat color was also important. The advantage of the light coloured animals that it was easier to observe them through the monitors. Another important factor was their appeal, as in the case of success of the experiment they would have been presented to the public.

Although approximate duration of the flight of Belka and Strelka was one day, but in training and test, animals spent in the approximate flight conditions up to eight days.

During the flight, on-board life support system was working, and in weightlessness with the help of special devices, dogs were fed food and water. In general, the animals felt good, and only during the launch of the rocket heart palpitations were observed. This parameter returned to normal when the spacecraft reached the orbit.

Once made a successful exploration of space by animals, it became clear - people can also exceed the bounds of Earth's atmosphere wholesome and alive.

Speaking

Imagine that you work as a guide at the museum of space exploration history. Tell the visitors about the first animals in space in detail. For more information, use the Internet. The presentation is seen as desirable.

Module 5. THE FIRST MAN IN SPACE

Lead-In

1. Look at the pictures. Do you know these people? Name them. What are they famous for?

a)

b)

c)

d)

Reading

1. Practice reading the following words.

capsule	['kæpsjuːl]
thermal	['θɜːməl]
coating	['kəutıŋ]
reentry	[ˌriː'entrı]
injured	['ɪnʤəd]
failure	['feıljə]
occurrence	[ə'kʌrəns]
manual	['mænjuəl]

2. Match the English words with their Russian counterparts.

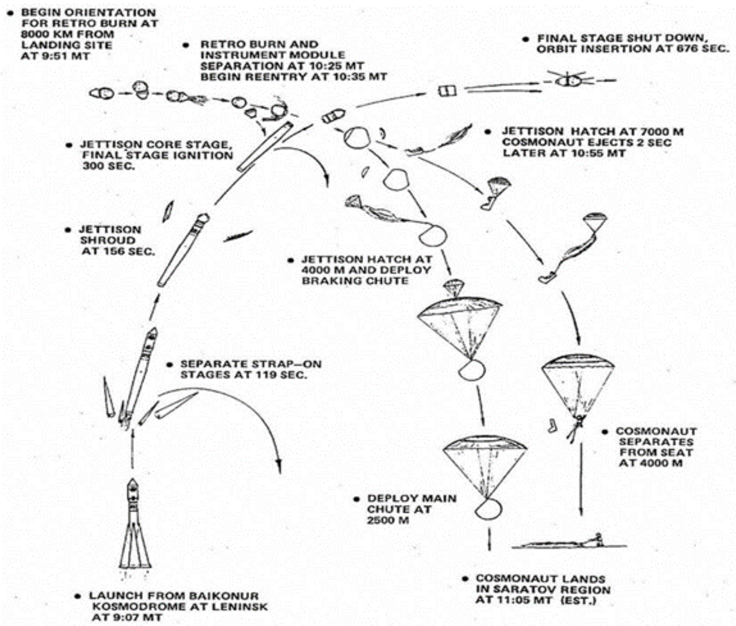
1. orbital spacecraft	a.отделение
2. common occurrence	b. жесткая посадка
3. reentry heat	c. сферическая отделяемая кабина
4. spherical capsule	d. траектория входа в плотные слои атмосферы
5. reentry	e. нагревание при возвращении в плотные слои атмосферы
6. rough landing	f. возвращение в плотные слои атмосферы
7. reentry path	g. орбитальный КА
8. detaching	h. обычное событие

3. Read and translate the text.

Vostok 1 Launch Vehicle

1. Soon after the success of the first Sputniks, Korolyov began working on the design of an orbital spacecraft that could be used as a

vehicle for the first human spaceflight missions. The spacecraft was called Vostok. Vostok had two sections - a spherical capsule in which the person was housed, and a conical module that contained the instruments needed for its flight. The spacecraft was large for the time, weighing 4.73 tons. The crew capsule was completely covered by a thermal coating to protect it during reentry. Vostok was designed so that the human aboard need not touch any control from launch to touchdown. The cosmonaut was ejected from it at an altitude of 7 km and was parachuted to the ground, while the spacecraft landed nearby with its own parachutes. The reason for this was that the Vostok descent module made an extremely rough landing that could have left a cosmonaut seriously injured.



Mission profile for VOSTOK-1

2. The Vostok capsule had limited thruster capability. The reentry path and orientation could not be controlled after the capsule had separated from the engine system. This meant that the capsule had to be protected from reentry heat on all sides, thus explaining the spherical design. Some control of the capsule reentry orientation was possible by way of positioning of the heavy equipment to offset the vehicle center of gravity, which also maximized the chance of the cosmonaut surviving g-forces while in a horizontal position. Even then, the cosmonaut experienced 8 to 9g.

3. The ejector seat also served as an escape mechanism in the event of a launch vehicle failure, which at this early phase of the space

program was a common occurrence. If an accident occurred in the first 40 seconds after liftoff, the cosmonaut would simply eject from the spacecraft and parachute to Earth. From 40 to 150 seconds into launch, ground controllers could issue a manual shutdown command to the booster. When the launch vehicle fell to a low enough altitude, the cosmonaut would eject. Higher altitude failures after shroud jettison would involve detaching the entire spacecraft from the booster.

4. There were five one-person Vostok missions. In August 1961, Gherman Titov at age 25 completed 17 orbits of Earth in Vostok 2. In August 1962, two Vostoks, 3 and 4, were orbited at the same time and came within 6.5 km of one another. This dual mission was repeated in June 1963;Valentina Tereshkova the first woman to fly in space was aboard the Vostok 6 spacecraft.

The monument at the site of the Gagarin's landing

4. Choose the answer, which is the most corresponding to the text information.

1. Vostok had two sections

- to house the person and the instruments

- to duplicate the equipment

- to house the person and the ejector seat

2. The crew capsule was covered by a thermal coating

- to protect it during launch

- to provide spherical shape

- to protect it during reentry

3. The cosmonaut landed

- in the descent module

- using parachute

- seriously injured

4. Capsule spherical design was chosen

- because of lack of free space onboard

- to protect from reentry heat on all sides

- to provide safe landing

5. Capsule's heavy equipment was positioned so to offset the vehicle center of gravity

- to protect the cosmonaut from high g-forces

- to save on heat insulating materials

- to save capsule weight

5. Match the synonyms.

1. capsule	a. cover
2. coating	b. landing
3. to house	c. malfunction
4. to eject	d. to discard
5. to experience	e. to escape
6. touchdown	f.compartment
7. injured	g. covering

8. shroud	h. to undergo
9. to detach	i. to contain
10. failure	j. damaged

6. Give your own definitions for the words from the text.

1.crew____

2.capsule____

3.thermal coating______________________________________

4. descent module_____________________________________

5. ejector seat____

6. parachute____

7. shroud____

7. Look at the text again and answer the questions.

1. What were the main components of Vostok 1?
2. Did the cosmonaut control the spacecraft?
3. Why was the crew capsule covered with the thermal coating?
4. Why did not the cosmonaut land in the descent module?
5. Why was the spherical design chosen?
6. What were the g-forces the cosmonaut experienced?
7. What was the ejector seat intended for?

You should remember the following words and word combinations	
thermal coating	теплоизоляционное покрытие
altitude	высота
to eject	отделять, катапультировать
descent module	спускаемый аппарат
thruster	маневровый двигатель
g-force	перегрузка
ejector seat	катапультируемое кресло
failure	отказ, несрабатывание
accident	катастрофа,авария
booster	ракета-носитель
shroud	обтекатель
to orbit	двигаться по орбите

8. Read the text and fill in the gaps using the words from the box. Watch out! There is an extra word!

applicants	lift-off	landed	launched	lasted
excellent results	ejected	skills	reached	required
flight	parachute	failure	reentered	

Yuri Gagarin was born in Klushino, a small village west of Moscow in the Soviet Union.

At the industrial school in Saratov where he learned to be a metalworker, he joined a flying club. He made his first solo (1) ________ in 1955.Gagarin's skills led him to the Orenburg Aviation School where he learned to fly MiGs aircraft.

But he really wanted to go to space. Yuri Gagarin was just one of 3,000 (2) _______ to be the first Soviet cosmonaut. Out of this large group of applicants, just 20 were chosen in 1960 to be the Soviet Union's first cosmonauts; Gagarin was one of the 20.

During the extensive physical and psychological testing required of the chosen cosmonaut trainees, Gagarin showed (3) _______. Later, Gagarin was chosen to be the first man into space because of professional (4) ______ .

Vostok 1, with Yuri Gagarin inside, was launched on schedule at 9:07 a.m. Moscow time. Just after (5)______, Gagarin called out "Poyekhali!" Although he was fully trained for the mission, no one knew if it was going to be a success or a (6) _______ .

Gagarin was (7)_____into space using an automated system. Gagarin did not control the spacecraft during his mission. He was not given the controls to the spacecraft because many scientists were worried about the psychological effects of being in space.

After entering space, Gagarin completed a single orbit around Earth. The Vostok 1's top speed (8) ______ 28,260 k/h. At the end of the orbit, Vostok 1 (9) ______ the Earth's atmosphere. When Vostok 1 was still about 7 km from the ground, Gagarin (10) ______ from the spacecraft and used a (11) _______ to land safely. Gagarin (12) ______ safely with his parachute about ten minutes after Vostok 1. His space travelling (13) ______ 108 minutes.

Nearly as soon as Gagarin's feet touched the ground back on Earth, he became an international hero. His success was known around the globe. He had accomplished what no other human being had ever done before. Yuri Gagarin's successful flight into space paved the way for all future space exploration.

9. Translate the text in a written form.

SPACECRAFT DESIGN PROCESS

The design and development of a spacecraft is an engineering process divided into identifiable phases. Spacecraft design and development typically include the following phases: *requirements definition, conceptual design, preliminary design, and detailed design.*

Spacecraft development begins by *defining needs or requirements* the system is to satisfy. For example, the need to gather and store weather images and data; to take photographic images and transmit the information in real time. The spacecraft mission will be a major determiner of the type orbit chosen for the spacecraft.

Next is the *conceptual design phase*, in which various system concepts which can satisfy the mission requirements are considered and subjected to analysis. The most proficient means to carry out the mission is selected and major risks, costs, and schedules are identified.

The *preliminary design phase* follows conceptual design, and may stretch over a couple of years. During this phase, variations of the concept chosen in the conceptual design phase are analyzed and refined. Subsystem and component level specifications are defined and major documents such as the interface control document are written.

The final phase is the *detailed design phase*, which can take four to five years. It is within this phase that the specific aspects of structural design are identified, such as finalizing the thickness of structures and load paths. The spacecraft design must accommodate everything that fits into the structure, including equipment, crew, provisions and payload. Design verification is an important part of this phase.

Verification involves tests of electronic circuit models, software and engineering models. Design and performance margin estimates are refined and test and evaluation plans finalized.

Module 6. SPACE ENVIRONMENT AND SPACECRAFT DESIGN

Lead-in

1. What do you know about space environment? What factors characterize it? How do they influence the spacecraft design? Discuss with your groupmates.

Reading

1. Practice reading the following words.

environment	[ɪn'vaɪərənmənt]
weightlessness	['weɪtləsnəs]
diaphragm	['daɪəfræm]
residual	[rɪ'zɪdjuəl]
pressurized	[preʃəraɪzd]
tenuous	['tenjuəs]
erosion	[ɪ'rəuʒən]
appropriate	[ə'prəuprɪət]

2. Match the English words with their Russian counterparts.

1. to pose a problem
2. rubber diaphragm
3. outlet valve
4. outgassing
5. oxygen erosion
6. to reach mission orbit
7. to recede at a rate

a. убывать со скоростью
b. выпускной клапан
c. ставить задачу
d. кислородная эрозия
e.образовать оксид
f. дегазирование
g. резиноваядиафрагма

8. to form oxides — h. достигнуть орбиты миссии

3. Read and translate the text.

Space Environment and Spacecraft Design

Microgravity

One aspect of space environment is microgravity. Once a spacecraft has reached its mission orbit, it falls free continuously in weightlessness. Microgravity can pose some problems for space engineers. One of them is how to make liquid rocket propellant enter a rocket engine when it is in a weightless state in fuel tanks. One common way to do this is to have a rubber diaphragm stretched across the middle of the fuel tank, with propellant on one side and a pressurized gas on the other. When a fuel outlet valve is opened, the diaphragm with gas pressure behind it squeezes fuel out of the tank and into the rocket engine.

Vacuum

A pure vacuum is a volume devoid of any material. Even in the Earth orbit at altitudes up to around 1000 km, there is a residual atmosphere, and even in space between the planets in the solar system, there is a material called the interplanetary medium. At about 800-km altitude in the Earth orbit, the atmospheric pressure is tiny, and at these low pressures materials suffer from an effect called outgassing. This is related to what happens to water when heated - the surface water molecules escape the body of the liquid, and if the process continues, all of the water will vaporize into gas. Similar things happen to metals in high vacuum, where the low pressure causes the surface atoms to outgas. For example, at temperatures of around 180°C, a surface composed of zinc will recede at a rate of around 1 mm per year. Thus, as long as the designer chooses the construction materials appropriately, outgassing will not be an issue as far as the strength of the structure is concerned.

A related problem for spacecraft is the effect of vacuum upon commonly used terrestrial lubricants. To overcome this problem, engineers have had to develop solid lubricant coatings for use in spacecraft bearings and mechanisms.

The Effects of the Earth's Atmosphere

Motion of a spacecraft in the low Earth orbit is affected by the atmosphere. The cause of this is air drag, which is a tiny force that acts in a direction opposite to the motion of the spacecraft. The density of the atmosphere falls steadily, from the breathable mix of oxygen and nitrogen at Earth's surface, to something approaching a vacuum at high altitude. However, the effects of air drag can be measured at altitudes up to about 1000 km. It is important to realize how tenuous the atmosphere is at high altitudes. For example, an atom of oxygen moving around at an altitude of 600 km will not find another atom to bump into for about 300 km, and at an altitude of 800 km this increases to over 1000 km.

The atmosphere also has direct effects on spacecraft and the materials used in their construction. Perhaps the best example of this is atomic oxygen erosion. The oxygen gives us life, but it is also aggressive in forming oxides such as rust. As you go up to orbital altitudes, the atmosphere is no longer shielded from solar ultraviolet radiation. This causes the O-bond to be broken, so that at the low Earth orbit altitudes single oxygen atoms move around and become the main atmospheric component. Atomic oxygen on the orbit has a similar erosive character, not only because of its chemical activity, but also because it hits spacecraft at around 8 km/ sec. Clearly, the spacecraft designer needs to be familiar with these environmental effects when choosing appropriate materials in the design.

4. Find the words with the following meaning in the text.

1. the region of space around the sun and planets of the solar system ____

2. the gradual destruction or diminution of something ____

3. to protect someone or something____

4. conditions in which a particular activity is carried on____

5. resistance to the passage of an object through the air____

6. a mixture of gases that surrounds any planet____

7. to turn something from a solid or liquid state into gas____

8. to release or give off (a substance) as a gas or vapor ____

5. Say, if the following statements are true or false. Correct the false ones.

1. Weightlessness prevents propellant from entering a rocket engine.

2. A pure vacuum exists at an altitude of about 400 kilometers.

3. Outgassing is a process of absorbing gases from the environment.

4. Outgassing is not a problem if materials for the spacecraft construction are chosen appropriately.

5. Solid lubricant coatings are used in spacecraft bearings and mechanisms to avoid outgassing.

6. Oxygen erosion is not possible in space because the atmosphere is tenuous at high altitudes.

6. Make up an abstract of the text.

7. Match the synonyms and make up word combinations using the words from column B

A	***B***
1. spacecraft	a. vacant
2. altitude	b. to leave
3. to squeeze	c. to form
4. to shield	d. height
5.steadily	e. to undergo
6. devoid	f. satellite
7. to suffer	g. to compress

8. to escape	h. to protect
9. to recede	i. permanently
10. to compose	f. to decrease

You should remember the following words and phrases!	
microgravity	микрогравитация
weightlessness	невесомость
diaphragm	диафрагма, мембрана
outlet valve	выходной клапан
residual	остаточный
to squeeze	выдавливать, выжимать
interplanetary medium	межпланетная среда
outgassing	дегазирование
to vaporize	испарять(ся)
coating	покрытие
bearing	подшипник, опора
air drag	аэродинамическое сопротивление
erosion	эрозия
rust	ржавчина
to shield	прикрывать, экранировать

8. Read the text on Space Debris and fill in the gaps (1-7) with the missing information (a-g). Translate the text into Russian.

a. high speeds

b. are negligible

c. natural and artificial

d. the threat

e. tenuous for drag

f. useful function

g. much greater

Space Debris

Space debris comes in two varieties: (1) _________. Natural space debris consists of the meteoroids that Earth encounters on its orbital journey around the Sun. It is estimated that around 100 metric tons of such material falls into Earth's atmosphere every day. Fortunately, the chances of an orbiting spacecraft encountering a large meteor (2) _________.

The threat to satellites posed by artificial debris is much greater. The chances of an impact with a 10-cm chunk of artificial debris is (3) ________ than the odds of encountering a meteoroid of similar size.

Artificial debris is useless lumps of man-made material in space that have ended up in orbit as a by-product of launching spacecraft. However, the junk we leave in space is generally more dangerous than our terrestrial garbage as it is moving at (4) ________ , posing a potentially lethal hazard to people and spacecraft in near-Earth orbits.

Any object larger than about 10 cm in Low Earth orbit (LEO) and larger than around 1m in geostationary Earth orbit (GEO) are tracked and catalogued.

Of the 9000 current catalogued objects, about 5% are operational spacecraft, but the majority have no (5) ________.

Peaks in debris density occur in orbital regions where there are lots of spacecraft. A good example of this are the peaks in debris density at altitudes of around 800 to 1000 km, where there are a large number of Earth observation satellites, and where the atmosphere is too (6) ________ to be effective in removing the resulting junk caused by operating these spacecraft.

Remember, however, that all of the large objects in orbit are catalogued and their orbits are known. So, using computer simulation, the spacecraft's operators are able to keep an eye on all 8000 or so LEO objects in the catalogue to see if any of them are predicted to make a close approach to their spacecraft. This is done routinely in operations rooms around the world. If an uncomfortably close encounter is predicted, the spacecraft's orbit is changed to reduce (7) _______.

9. Translate the text in a written form.

In orbit, spacecraft will need to survive the space environment and, in particular, to possess low-outgassing properties. Radiation and thermal cycling must not degrade thermal-control surfaces or joints in materials possessing different coefficient of expansion. The presence of atomic oxygen in low Earth orbits leads to the erosion/corrosion/oxidation of many material surfaces, and more coatings with good atomic oxygen durability need to be developed. The minimum altitude for an Earth-orbiting satellite is 200 km, and, once this altitude has been reached, appreciable changes can be produced in common engineering materials, whether they be metals, plastics, or ceramics. The vacuum in space is very high. Some polymers will decompose and some metals will tend to sublimate under vacuum. The rate at which the molecules or atoms leave a surface in vacuum will rise rapidly with an increase in temperature.

The actual temperature attained will differ from one spacecraft to another, the major temperature effect arising from the spacecraft's spin rate. Surfaces of non-spinning satellites exposed to direct solar radiation may be unable to dissipate thermal energy efficiently, and will reach higher temperatures than spinning satellites. Both active and passive thermal control systems are employed on satellites in order to restrict the oscillating temperature extremes. The active systems have made use of thermostatically controlled heaters. Passive systems involve the surface absorptance/emittance properties of material.

The events of sublimation and evaporation cause the release of metal atoms, which travel and are capable of recondensing on cooler surfaces. They are readily ionized and may be contributors to corona and arcing phenomena. These metallic ions may also cause the complete failure of a satellite mission by recondensing between slip rings, causing electrical short circuits, or recondensing on optical surfaces causing the loss of a specific wavelength transmission.

Speaking

1. You are going to make a presentation for the student's scientific conference. The topic of your presentation is "Ways of removing space debris from the Earth orbits". Search the Internet to find information on such projects.

2. Watch the videos, and extract as much information as you can from them. Share this information with your groupmates.

1. https://www.youtube.com/watch?v=j847hzLjrWQ

2. https://www.youtube.com/watch?v=JIg5t9RYdnM

Module 7. MULTISTAGE ROCKETS

Lead-in

1. What do you know about multistage rockets? What are the reasons for using them? Share the ideas with your groupmates.

Reading

1. Practice reading the following words.

multistage	['mʌltɪsteɪʤ]
vehicle	['viːɪkl]
optimize	['ɔptɪmaɪz]
scheme	[skiːm]
suit	[sjuːt]
bear	[beə]
accelerate	[ək'seləreɪt]
completion	[kəm'pliːʃn]

2. Match the keywords with their translations.

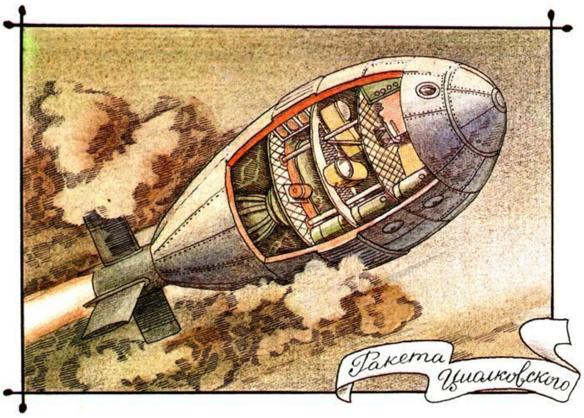
1. multistage liquid-fuel rocket	a. выработать топливо
2. to escape the Earth's gravitation	b. многоступенчатая ракета на жидком топливе
3. burnout time	c. доставлять полезную нагрузку
4. to deliver a payload	d. запускать разгонные блоки
5. to stack on top of each other	e. устанавливать один на другой

6. to run out of propellant	f. покинуть гравитационное поле Земли
7. to assist with lift-off	g. момент выгорания топлива
8. to fire boosters	h. содействовать при старте

3. Read and translate the text.

Multistage Rockets

1. The cosmonautics use of rockets was argued in the beginning of the 20th century by K.E. Tsiolkovsky, who is called the "father of astronautics." He pointed out that a rocket could operate in a vacuum and suggested that multistage liquid-fuel rockets could escape the Earth's gravitation.

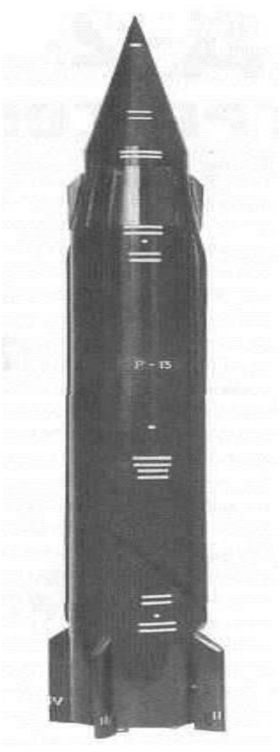


2. The main reason for multistage rockets is that once the fuel is burnt, the space and structure containing it and the motors themselves are useless and only add weight to the vehicle, which slows down its future acceleration. By dropping the stages, which are no longer useful, the rocket lightens itself. The thrust of future stages is able to provide more acceleration than if the earlier stage were still attached, large rocket would be capable of. When a stage drops off, the rest of the rocket is still traveling near the speed that the whole assembly reached at burnout time. This means that it needs less total fuel to reach a given velocity and/or altitude. Moreover, the velocity and altitude of the rocket after burnout can be easily modeled.

Another advantage is that each stage can use a different type of rocket motor each tuned for its particular operating conditions. Thus, the lower stage motors are designed for use at atmospheric pressure, while the upper stages can use motors suited to near vacuum conditions. Lower stages require more structure than upper as they need to bear their own weight plus that of the stages above them, optimizing the structure of each stage decreases the weight of the total vehicle and provides further advantage.

On the other hand, staging requires the vehicle to lift motors which are not being used until later, as well as making the entire rocket more complex and harder to construct. Nevertheless, the savings are so great that every rocket ever used to deliver a payload into orbit had staging of some sort.

3. A multistage rocket is a rocket that uses two or more stages, each of which contains its own engines and propellant.



Tandem rocket

4. A tandem is mounted on top of another stage. The result is effectively two or more rockets stacked on top of each other. Taken together these are called a launch vehicle.

Parallel staging rocket

By jettisoning stages when they run out of propellant, the mass of the remaining rocket is decreased. This staging allows the thrust of the remaining stages to accelerate easily the rocket to its final speed and height.

In tandem staging schemes, the first stage is at the bottom and is usually the largest, the second stage and subsequent upper stages are above it, usually decreasing in size.

5. A parallel stage is attached alongside another stage, they are attached next to each other. In parallel staging schemes, solid or liquid rocket boosters are used to assist with lift-off. In the typical case, the first stage and booster engines fire to propel the entire rocket upwards. When the boosters run out of fuel, they are detached from the rest of the rocket and fall away. This leaves a smaller rocket, with the second stage on the bottom, which then fires. Known in rocketry engineering as staging, this process is repeated until the final stage's motor burns to completion.

Two stage rockets are quite common, but rockets with as many as five separate stages have been successfully launched.

4. Look through the text again and match the given titles with the corresponding paragraphs. Watch out! There are some extra titles.

1. Multistage rocket definition
2. Parallel staging scheme
3. Comparison of tandem and parallel staging schemes
4. Multistage rocket operational principle
5. Tandem staging scheme
6. Innovative idea
7. Multistage rocket use

5. Choose the answer, which is the most corresponding to the text information:

1. In parallel staging schemes the upper stage

- is detached first;

- is launched into the desired orbit;

- runs out of fuel first.

2. In tandem staging schemes, the first stage

- is at the bottom and usually the smallest;

- is getting lighter when goes up;

- is jettisoned at the desired orbit.

3. Multistage rockets are used because

- they are very simple and cheap;

- they provide sufficient thrust to escape the Earth's gravitation;

- they are easy to construct.

4. Jettisoning is required

- to drop excess propellant;

- to simplify the structure of the launch vehicle;

- to get rid of unnecessary mass and to accelerate the upper stages.

5. Each stage of a multistage rocket

- is lighter than the previous one;

- is of the same design;

- is launched into the desired orbit.

6. The lower stage motors are designed

- to operate at the orbit;

- to operate at lower atmosphere;

- to house a reentry vehicle.

7. In parallel staging schemes

- stages are attached one by one;
- boosters are attached next to each other;
- boosters are used to control spacecraft attitude at the orbit.

6. Give your own definitions for the words from the text.

1. multistage rocket ______________________________________
2. burnout time ____
3. stage ____
4. booster ____
5. orbit ____
6. lift-off ____
7. launch vehicle ____
8. propellant ____
9. payload ____
10. acceleration ____

7. Work in pairs. Make up 5 "False" and 5 "True" statements and tell them to your partner. "False" statements should be corrected.

8. Find the synonyms of the following words from the text and make up your own word combinations with them.

1. to escape	a. following
2. to detach	b. to start
3. to launch	c. to exhaust
4. subsequent	d. unit
5. to run out	e. to run away
6. assembly	f. cause
7. reason	g. to jettison

9. Read the text and decide which word A, B, or C best fits each space. There is an example (0) at the beginning.

The Buran was a (0) ………orbiter capable of (1) ………different payloads into space and bringing cargoes back to the Earth. Its cargo compartment could be used for the reentry capsule Soyuz during manned space flights. In an (2) ………., the crew would get into the capsule for urgent evacuation.

The Energia-Buran was a cutting-edge space system that fundamentally differed from the (3) ………..in structural design. It was based on the multistage rocket design concept. This reusable launch vehicle had two-stage propulsion systems. This enabled Buran to be equipped with a very functional orbital maneuvering system. The spacecraft had its own orbital insertion and maneuvering engines. This made the launch (4) ………cleaner, since near-Earth space was not littered with spent rocket stages. The separated units either burned up in the atmosphere, or returned to Earth for overhaul, maintenance and repeated use.

The overall (5) ………. of the Energia's engines was 170 million horsepower. That was enough for missions to the Moon and beyond. However, the rocket was designed to fly only twice. The first time was during its initial test on May 15, 1987 and the second time, on November 15, 1988.

The orbital part of the flight was the most predictable for the designers and engineers. The spacecraft spent just 94 minutes in orbit, although it was capable of staying in space for up to 30 days.

Everybody (6) ………. about the landing, which was to be wholly computer-controlled for the first time. The seats in the Buran's cockpit were empty. Its success depended entirely on the performance of the onboard computer and the ground navigation systems.

The touchdown was far softer than the engineers had (7) ………. At that very moment the Buran went down in history as the first-ever orbiter to have accomplished a computer controlled landing.

0. A. <u>reusable</u>	B. expendable	C. combined
1. A. consuming	B. taking	C. delivering
2. A. emergency	B. common	C. unconventional
3. A. followers	B. predecessors	C. contemporary
4. A. ecologically	B. structurally	C. previously
5. A. weight	B. thrust	C. strength
6. A. worried	B. interested	C. believed
7. A. accelerated	B. known	C. anticipated

You should remember the following words and phrases!	
to escape	покидать
multistage rocket	многоступенчатая ракета
stage	ступень (ракеты)
acceleration	ускорение
to attach	подстыковывать; закреплять
burnout time	момент выгорания топлива
to bear	выдерживать нагрузку
staging	расположение ступеней
jettisoning	сбрасывание, разделение
to run out	выработать топливо
tandem staging	схема «тандем»
parallel staging	схема «пакет»
booster	разгонный блок
to detach	отсоединять
reusable	многоразовый
reentry capsule	спускаемый аппарат
overhaul	капремонт
maintenance	техобслуживание
touchdown	посадка, приземление
orbiter	орбитальный аппарат

Speaking

1. You are going to represent your research work on comparison of reusable space systems. The presentation is welcomed to support your report.

2. Go to https://www.youtube.com/watch?v=8dpkmUjJ8xU, watch the video and answer the following questions:

1. What was the height of the Saturn V rocket?

2. How many stages did it have?

3. Where was the actual spacecraft located?

4. What was the Command module intended for?

5. What was the purpose of the escape system?

6. What happened with the first stage after jettisoning?

7. When did the second stage shut up?

8. What height did the second stage shut up?

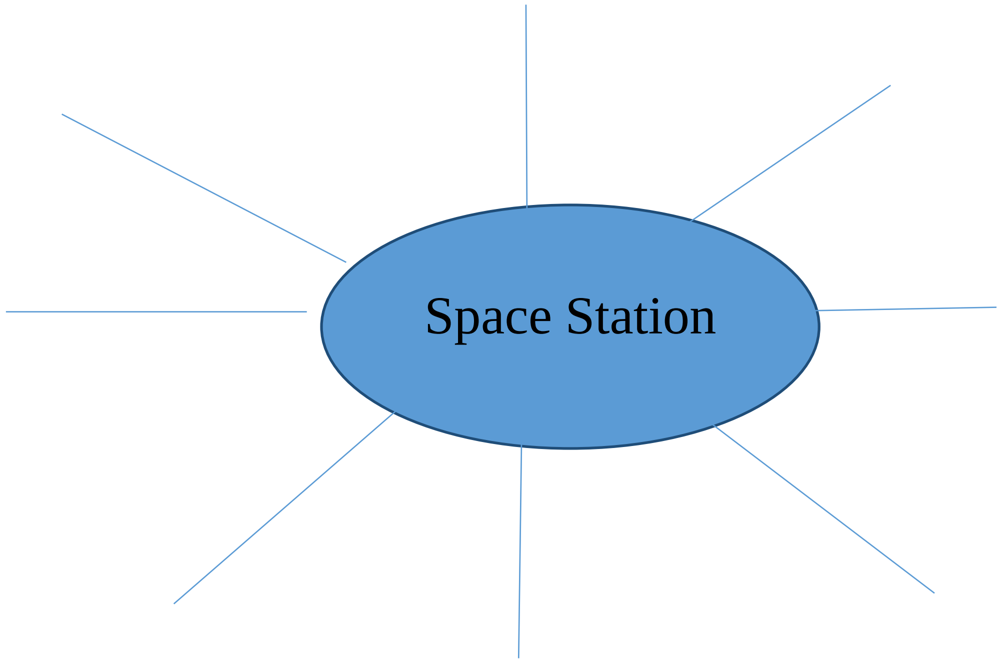
9. What was the function of the third stage?

10. What was the height of the parking orbit?

Module 8. The International Space Station-1

Lead-In

1. Brainstorm all possible terms related to the topic. Explain the reasons.



2. How much do you know about the history of space stations? Who constructed the first station? What were they used for? Share the information with your groupmates.

Reading

1. Practice reading the following words.

environment	[ɪn'vaɪərənmənt]
biology	[baɪ'ɔləʤɪ]
physics	['fɪzɪks]

astronomy	[ə'strɔnəmɪ]
meteorology	[ˌmiːtɪə'rɔləʤɪ]
measure	['meʒə]
canister	['kænɪstə]
cart	[kɑːt]
module	['mɔdjuːl]

2. Read and translate the text.

International Space Station

1. The International Space Station (ISS) is the ninth space station to be inhabited by crews following the Soviet and later Russian Salyut, Almaz, and Mir stations, as well as Skylab from the US.

International Space Station

The International Space Station is the largest orbiting laboratory ever built. The ISS serves as a microgravity and space environment research laboratory in which crew members conduct experiments in biology, human biology, physics, astronomy, meteorology, and other fields. The station is suited for the testing of spacecraft systems and equipment required for missions to the Moon and Mars. It is an international, technological, and political achievement. The five international partners include the space agencies of Russia, the United States, Canada, Europe, and Japan.

2. The first parts of the ISS were sent and assembled in orbit in 1998. Since the year 2000, the ISS has had crews living continuously

on board. Building and sustaining the ISS requires 80 launches on several kinds of rockets over a 12-year period.

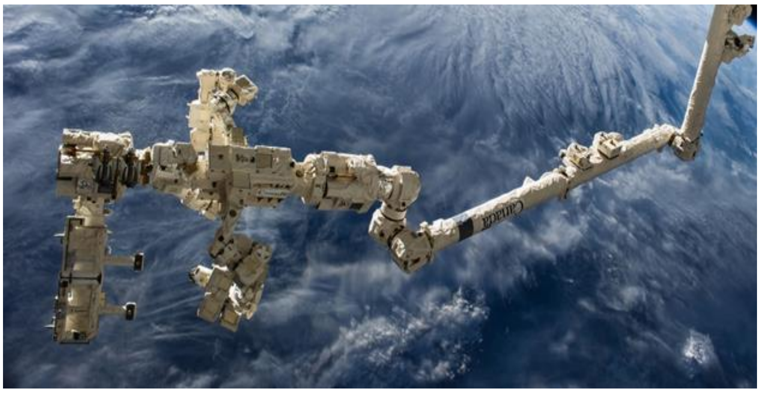
When fully complete, the ISS will weigh about 420,000 kilograms. It will measure 74 meters long by 110 meters wide. This is equivalent to a football field. The solar array surface area will be 2,500 square meters.

The ISS orbits between 370 and 460 kilometers above Earth's surface. Every 3 days, the ISS passes over the same place on Earth. It takes about 90 minutes for the ISS to circle Earth one time. The ISS orbits Earth 16 times per day. During the daylight periods, temperatures reach 200 ºC, while temperatures during the night periods drop to -200 ºC.

3. The components of the ISS include shapes like canisters, spheres, triangles, beams and wide flat panels. The modules are shaped like canisters and spheres. These are the areas where the astronauts live and work. Modular stations allow the mission to be changed over time, and new modules can be added or removed from the existing structure allowing greater flexibility.

The trusses are used to support the solar arrays and radiators. The solar arrays provide energy for the Station, they collect sunlight and convert this energy into electricity. Likewise, radiators are waffle-shaped panels used to get rid of extra heat that builds up in the Station.

The truss structures are made of triangle shapes for strength. They are covered in panels to shield the cables from impacts with space debris, radiation from the Sun and the harmful environment of space. In addition, the Integrated Truss Structure has a rail cart that can move back and forth along the trusses. Called the mobile transporter, the cart can act as a base for moving the Station's robotic arm when assembling parts of the Station.



Remote Manipulator System

4. The ISS also has a robotic arm known as the Remote Manipulator System Canadarm2. It is used to help construct the Station by grappling and moving modules or by moving astronauts into position to work on the Station. It is 17 meters long when fully extended and has seven motorized joints. These joints act like a shoulder, elbow, wrist and fingers. This arm is capable of handling large cargos to construct the ISS.

The movement of the robotic arm is controlled by the ISS's arm control unit. The hand controllers used by the astronauts tell the computer what the astronauts would like the arm to do. Built-in software examines the astronauts' commands and calculates which joints to move, in what direction to move them, how fast to move them, and to what angle to move. The astronaut watches three televisions to monitor the movement of the robotic arm.

3. These are the answers. What are the questions?

1. Nine habitable space stations.

2. In biology, human biology, physics, astronomy, meteorology, and other fields.

3. Space agencies of Russia, the United States, Canada, Europe, and Japan.

4. In 1988.

5. 420,000 kilograms.

6. About 90 minutes.

7. Solar arrays.

8. Remote Manipulator System.

4. Highlight the key words of each paragraph. Entitle each paragraph. Then make up an abstract for the text.

5. Match the synonyms.

1. movement	a. populated
2. to examine	b. to manipulate
3. joint	c. collision
4. to extend	d. medium
5. to handle	e. motion
6. harmful	f. junction
7. to shield	g. to protect
8. impact	h. to stretch
9. environment	j. damaging
10. inhabited	k. to check

6. Match the terms with their definitions.

1. joint	a. a device that sends out heat, often as part of a heating or cooling system
2. software	b. a place where two things are fastened together

3. truss	c. the instructions that control what a computer does; computer programs
4. solar panel	d. a frame supporting a part of the structure
5. controller	e. a piece of equipment that collects and uses the sun's energy to make electricity
6. radiator	f. a large vehicle that is used for carrying very large or heavy objects
7. built-in	g. a mechanical device that is operated by remote control
8. manipulator	h. a device used to operate or control a machine
9. transporter	i. included in something as a part of it, rather than being separate

7. a) Match the following words to make meaningful collocations. Use the dictionary if necessary.

A	B
control	array
fire	level
service	pressure
air	detection
sea	equipment
electrical	system
solar	module

b) Read the text about life support and thermal control systems and fill in the gaps with phrases from 7a).

Life Support and Thermal Control Systems

The critical systems are the atmosphere (1)_______, the water supply system, the food supply facilities, the sanitation and hygiene equipment, and (2) ________and the suppression equipment. The Russian Orbital Segment's life support systems are contained in the Zvezda (3)________.

The atmosphere on board the ISS is similar to the Earth's. Normal (4) _______ on the ISS is 101.3 kPa; the same as at (5) ______ on Earth. An Earth-like atmosphere offers benefits for crew comfort, and is much safer than a pure oxygen atmosphere, because of the increased risk of a fire.

The crew has a backup option in the form of bottled oxygen and Solid Fuel Oxygen Generation canisters, a chemical oxygen generator system. Carbon dioxide is removed from the air by the Vozdukh system in Zvezda. Other by-products of human metabolism are removed by activated charcoal filters.

The Thermal Control System maintains ISS temperatures within defined limits. The four components used in the Passive Thermal Control System are insulation, surface coatings, heaters, and heat pipes.

The Active Thermal Control System services point sources such as (6) ________ on cold plates as well as providing heat rejection for the crew cabin using pumps to move heat rejection fluids through the vehicle. The water-based internal cooling loops are used in controlling humidity and removing heat loads generated by the crew and electronic equipment. This heat is transferred to interface heat exchangers located on the exterior of the vehicle. There is a single independent Photo Voltaic Thermal Control System radiator for each of the four pairs of (7) _______ wings that use pumps to reject heat from the power generating equipment.

8. Read the text on the ISS solar arrays and fill in the gaps (1-6) with the missing information (a-f). Translate the text into Russian.

a. for delivery to space

b. source of energy

c. to charge

d. light to electricity

e. to generate

f. solar arrays

The ISS Solar Arrays

How do you get electricity 220 miles above Earth? No power cable is available for that job, so the best (1) __________ for a spacecraft is sunlight. Engineers have developed technologies to convert solar energy to electrical power.

(2) ________ that convert energy to electricity on the space station are made of thousands of solar cells. The solar cells are made from purified chunks of silicon. These cells directly convert (3) _________ using a process called photovoltaics.

Engineers developed a method of mounting solar arrays on a "blanket." The blanket can be folded (4) _________, and then deployed to its full size once in orbit. Once in orbit, ground controllers sent commands to deploy the blankets to their full size. Gimbals are used to rotate the arrays so that they face the sun to provide maximum power to the space station. Each of the eight solar arrays is 112 feet long by 39 feet wide.

Altogether, the four sets of arrays can (5) ________ 84 to 120 kilowatts of electricity. An active computer and monitor may use up to 270 watts. A small refrigerator uses about 725 watts.

The solar arrays produce more power than the station needs at one time for station systems and experiments. When the station is in sunlight, about 60 percent of the electricity that the solar arrays generate is used (6) ________ the station's batteries. At times, some or all of the solar arrays are in the shadow of Earth or the shadow of part of the station. This means that those arrays are not collecting sunlight. The batteries power the station when it is not in the sun. The solar arrays convert sunlight to direct current, or DC, power.

Solar Array Facts

•Together the arrays contain a total of 262,400 solar cells and cover an area of about 2,500 square meters -- more than half the area of a football field.

•A solar array's wingspan of 73 meters is longer than a Boeing 777's wingspan, which is 65 meters.

•The space station's electrical power system is connected by12.9 kilometers of wire.

You should remember the following words and phrases!	
inhabited	населённый
to conduct experiments	проводить эксперименты
to sustain	поддерживать
solar array	солнечная батарея
to convert	преобразовывать

to get rid of	избавитьсяот
to build up	накапливать
rail cart	рельсовая тележка
robotic arm	манипулятор
Remote Manipulator System	дистанционный манипулятор
to grapple	захватить
joint	соединение
software	программное обеспечение
to examine	проверять

Speaking

1. Go to https://www.youtube.com/watch?v=oLrOnEmy_GA, watch the video and answer the following questions:

1. When did ISS construction begin?

2. How many astronauts are usually onboard the station?

3. How much time does it take to orbit the Earth?

4. What must be done to prevent orbit altitude losing?

5. What are the main components of ISS?

6. What was the first module of the station? What was its purpose?

7. What launch vehicles were used to deliver payload to the station?

8. Why are docking modules required?

9. What is Canadarm? What is it intended for?

10. What modules are used for extra vehicular activity?

11. Why are radiators used at the station?

12. What is module Kupol intended for?

2. Go to, https://www.youtube.com/watch?v=K7NvsxcoDKo, watch the video and answer the following questions:

1. Which module provides good vision of the Earth and space?

2. What components of this module give the astronauts opportunity to watch the Earth and space?

3. What equipment is used to control Canadarm 2?

Module 9. THE INTERNATIONAL SPACE STATION - 2

Lead-In

1. Salyut 1, the first space station, was launched from the Soviet Union on April 19, 1971. Since that time, people have been using space stations for some purposes. Brainstorm practical applications of the International Space Station's facilities. Share the ideas with your groupmates.

Reading

1. Practice reading the following words.

unique	[juː'niːk]
airlock	['eəlɔk]
pressurized	[preʃəraɪzd]
deploy	[dɪ'plɔɪ]
hardware	['hɑːdweə]
cubic	['kjuːbɪk]

2. Before reading the text, match the English words with their Russian counterparts.

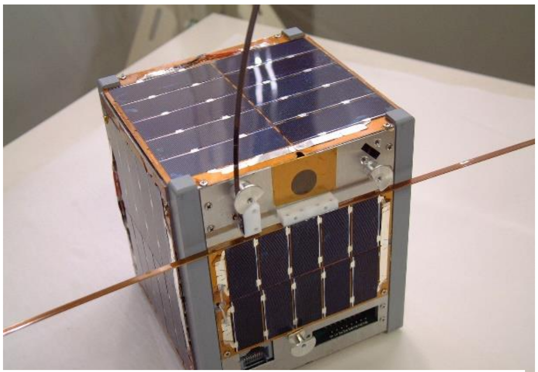
1. airlock — a. выскользнуть
2. to buffer — b. диагностика
3. check out — c. толкатель

4. to slide out — d. переходный шлюз

5. ejector — e. амортизировать

3. Read and translate the text.

Small Satellites



CubeSat

1. The International Space Station (ISS) offers a unique platform for access to low-Earth orbit (LEO) through its airlock working in coordination with the robotic arm.

This airlock allows small devices such as CubeSats to be deployed into LEO while making the trip up to space in the relative comfort of a pressurized cargo container. This can have many benefits in reducing the cost to small satellite operators.

2. Traditional satellites require complex systems and the resources of a dedicated launch vehicle to be launched into the orbit. However, with some help from the International Space Station, a new class of small satellites is changing the model for how we launch new technologies into space. They are classified into the following groups:

- Mini-satellites have full weight (together with fuel) from 100 kg to 500 kg.
- Micro-satellites have a full weight from 10 to 100 kg.
- Nano-satellites have weight from 1 kg to 10 kg. They are often designed for work in a group.

• Pico-satellites is the term for satellites with a weight from 100 g to 1 kg. These are usually designed for work in a group, sometimes with existence of larger satellite.

• Femto-satellites have weight of up to 100 g. Satellites of a poketsat format have a weight of several hundred or tens of grams and a size of several centimeters.

3. CubeSats, small, less than 50 centimeter cubic satellites, have an alternative way of being deployed. Satellites deployed from the space station are delivered by cargo spacecraft, where they are kept in a soft bag and buffered with packing material. An additional benefit to space station deployment of CubeSats is that after the CubeSats launch to space, astronauts aboard the orbiting station can perform quality checks on the hardware to ensure the small satellites are not damaged before deploying into space.

Satellite packed in a soft-sided bag

4. In order to launch a small satellite into the orbit, first the space station cargo supply spacecraft delivers the satellite in a Cargo Transfer Bag. The satellites are stored in Cargo Transfer Bags in the space station cabin until time for deployment. Following the final satellite checkout, the crew installs the satellite into the Small Satellite Orbital Deployer and places it on the airlock table. Then, after the airlock is sealed, it opens to allow the airlock table to slide out of the cabin of the space station. The Robotic Manipulator System approaches the airlock table and grapples the satellite ejector. Next, the Robotic Manipulator System moves the satellite in the ejector into position for de-

ployment into orbit. The Robotic Manipulator System holds the specified attitude aiming at the satellite's orbit. Finally, ground operators send the command to the ejector to release the satellite.

5. Modern small satellites differ rather significantly in functionality, despite the small size. They are widely used for a solution of problems of communication and telecasting. Now already up to 25% of geosynchronous spacecraft have a weight of less than 500 kg. And as a result of the use of the space station, potential developers of small satellites have increased their use of the space station deployers, and universities, companies and other non-traditional space users are finding affordable access to space.

4. Answer the following questions.

1. How are CubeSats delivered into LEO?
2. What is a CubeSat?
3. What are the advantages of a CubeSat?
4. What is a Cargo Transfer Bag intended for?
5. What provides a CubeSat deployment?

5. Match the antonyms and make up sentences using the words from column A.

A	***B***
1. to send	a. to deploy

2. to get away	b. to pressurize
3. to depressurize	c. to afford
4. to grip	d. to deliver
5. to fold	e. to approach
6. to get stuck	f. to release
7. to be unable	g. to slide out

6. Give your own definitions for the words from the text.

1. low-Earth orbit ____
2. space station ____
3. pressurized container ___________________________________
4. airlock ____
5. Cargo Transfer Bag ____________________________________
6. Robotic Manipulator ___________________________________
7. CubeSat ____

7. Fill in the gaps with the suitable derivative of the word given in the brackets.

1. The project is so complex, and we need greater __________ (to coordinate) between design teams.

2. Solar panels are manufactured _________ (to fold) to be delivered to the orbit in a special compartment.

3.__________ (to deploy) of spacecraft equipment is to be carefully calculated and tested on the ground to prevent failures at the orbit.

4. _________ (to eject) of small satellites is carried out after final satellite checkout.

5. Unmanned probe's missions try to prove __________(to exist) of exoplanets to get more data on our Universe.

6. ___________ (to function) of nano-satellites is limited by their size and specific equipment.

7. Robotic __________ (to equip) must be reliable to withstand extremely severe space environment.

8. Robotic Manipulator System carries out _________ (to maintain) of outer equipment of the ISS.

9. Small satellites reduce cost and __________ (complex) of a launch vehicle to operators.

10. ___________ (to pressurize) of a satellite is provided by an air-like nitrogen/oxygen mixture.

You should remember the following words and word combinations	
airlock	шлюзовая камера
robotic arm	манипулятор
to deploy	развёртывать, разворачивать
to buffer	амортизировать
hardware	аппаратное обеспечение,
checkout	проверка
to seal	герметизировать
to approach	приближаться, сближаться
to grapple	захватить, зацепить

ejector	толкатель
geosynchronous	геосинхронный

8. Read the text on scientific research at the ISS and fill in the gaps (1-8) with the missing information (a – h).

a) the psychophysiological aspect

b) regenerating

c) experiments

d) interplanetary spaceflights

e) equipment and software

f) reliable

g) vegetables

h) life support system

Scientific Research at the ISS

Some of the most important tasks in space biology include the creation of (1) ______and effectively functioning life support systems, and providing sustaining food sources for crewmembers. For long-term (2) ______________and planetary bases, the human (3) ____________and food production has to be based on (4) ____________the living environment from life support products through physical/chemical and biological processes. Greenhouses will most likely be designed for the cultivation of (5) _________, primarily greens and herbs. However, in order to implement these plans, plants must grow, develop, and reproduce in spaceflight with cultivation productivity similar to Earth. To address this need, a series of 17 Ras-teniya(6) _________were conducted using the Lada greenhouse on the Russian segment of the International Space Station. Multigenerational studies were carried out to culture genetically tagged dwarf pea plants in the Lada space greenhouse. For the first time in space research, four consecutive generations of genetically tagged pea line seeds were obtained in spaceflight.

The work done has great applied value because in the process of creating and operating the space greenhouse, cutting-edge (7) ____________ were developed, making it possible to grow plants automatically. This dual-purpose technology can also improve plant growth on Earth. (8) ____________of the interaction between humans and plants in a habitable pressurized volume was studied, and data were obtained on the safety of cultivating plant biomass on a space station for human consumption. These data are of great interest for design work to create productive greenhouses that are part of promising life support systems of any living complexes that are cut off from the Earth's biosphere.

9. Translate the text in a written form. Then make up an abstract for the text.

A technology of tiny elements studied on the International Space Station could have a big impact on everything from braking systems and robotics to earthquake-resistant bridges and buildings. Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions (InSPACE) is a set of experiments that gathered fundamental data about Magnetorheological (MR) fluids. They are a type of smart fluid that tends to self-assemble into shapes when exposed to magnetic fields. MR fluids change viscosity in a magnetic field and can even be made to change their arrangement at the nanoscale level, or one billionth of a meter. Such tiny distances are typical for molecules and atoms. When exposed to magnetic fields, MR fluids can quickly transition into a nearly solid state. When the magnetic field is removed, the

MR fluids return to a liquid state. This process produces useful viscoelastic properties that can be harnessed for a variety of mechanical devices, from robotic motions to strong braking and clutch mechanisms. The process of self-organization exhibited by MR fluids also could have long-ranging consequences for the design and manufacturing of a whole host of new nanomaterials and nanotechnologies.

Colloids are tiny particles suspended in a solution. They are critical to industrial processes as well as household products such as lotions, medications and detergents.

Microgravity slows down the movement of colloidal mixtures, allowing researchers to understand how they interact and how to control the tiny particles on the ground. You cannot do these experiments on Earth because the nanoparticles would settle out too quickly because of gravity. At first, the particles in the fluid form long, thin chains. As the magnetic field is applied, the magnetic dipoles in the particles cause these singular chains to grow parallel to the applied field. The chains parallel to each other interact and bond together over time.

By better understanding how these fluids “bundle” themselves into solid-like states in response to magnetic pulses, researchers have insight into phase separation. This may lead them to new nanomaterials from these tiny building blocks for use on Earth.

These models could be used to improve or develop active mechanical systems such as new brake systems, seat suspensions, stress transducers, robotics, rovers, airplane landing gears and vibration damping systems. It also has promise to engineer new nanomaterials for thermal barriers, energy harvesting and color displays. Thanks to the InSPACE series of investigations into tiny things, fundamental science could advance these systems and improve how we ride, drive, fly and live — in a big way.

Speaking

Imagine that you work as a guide at the museum of space exploration history. Tell the visitors about space stations ever built. For more information, use the Internet. The presentation is seen as desirable.

Module 10. LUNAR RESEARCH

Lead-in

1. What is the Moon? What do you know about Lunar missions? What are the reasons for Lunar exploration? Share the ideas with your groupmates.

Reading

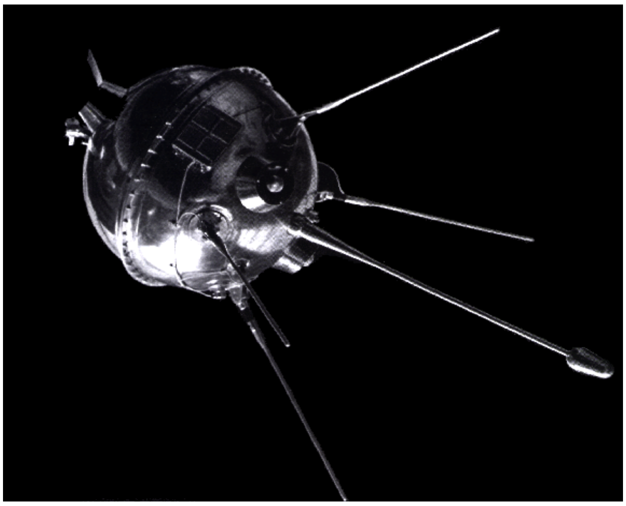
1. Practice reading the following words.

precise	[prɪ'saɪs]
escape	[ɪs'keɪp]
vision	['vɪʒn]
scintillation	[ˌsɪntɪ'leɪʃn]
ionizing	['aɪənaɪzɪŋ]
flux	[flʌks]
association	[əˌsəusɪ'eɪʃn]
observatory	[əb'zɜːvətrɪ]
path	[pãːθ]

2. Read and translate the text and make a list of unfamiliar words. Compare them with your partner. In pairs, try to guess the meaning of these words.

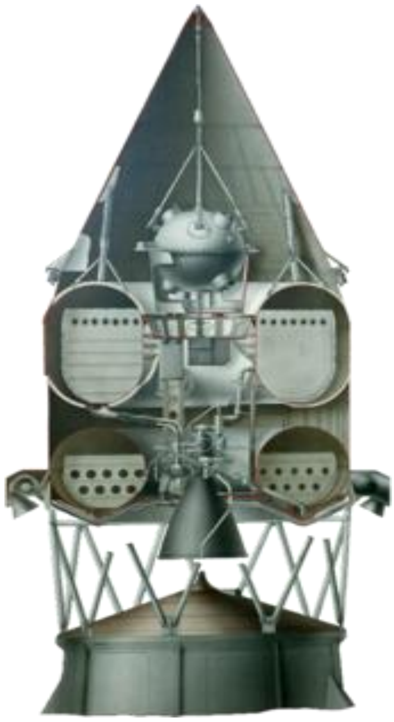
Moon Exploration

1. Luna 2 was the sixth of the Soviet Union's Luna program spacecraft launched to the Moon. The spacecraft was launched on 12 September 1959. It followed a direct path to the Moon. Once the vehicle reached the Earth's escape velocity (11.2 km/s), the upper stage was detached allowing the probe to travel on its path to the Moon. The probe started transmitting information back to the Earth using three different transmitters. These transmitters provided precise information on its course.



Luna 2

2. On 13 September 1959, it impacted the Moon's surface (at about 3.3 km/s) east of Mare Imbrium near the craters Aristides, Archimedes, and Autolycus. To be able to provide a vision from the Earth on 13 September, Luna 2 released a vapour cloud that expanded to a 650-kilometre diameter and it was seen by observatories. This vapour cloud also acted as an experiment to see how the sodium gas would act in a vacuum and zero gravity. It was the first spacecraft to reach the surface of the Moon, and the first human-made object to make contact with another celestial body.



Upper stage of Lunar rocket

3. Luna 2 carried five different types of instruments to conduct various tests. The scintillation counters were used to measure any ion-

izing radiation and Cherenkov radiation detectors to measure electromagnetic radiation caused by charged particles. The primary scientific purpose of a Geiger Counter carried on Luna 2 was to determine an electron spectrum of the Van Allen radiation belt. The last instrument on Luna 2 was a three-component fluxgate magnetometer. The probe's instrumentation was powered by silver-zinc and mercury-oxide batteries.

4. The spacecraft also carried Soviet pennants which were located on the probe and on the Luna 2 rocket. The two sphere-shaped pennants in the probe had surfaces covered by 72 pentagonal elements in pattern similar to an association football. In the center, it was an explosive charge designed to shatter the sphere, sending pentagonal shields in all directions.

5.The radiation detectors and magnetometer were searching for Lunar magnetic and radiation fields similar to the Van Allen radiation belt around the Earth, sending information about once every minute until its last transmission which came about 55 km away from the lunar surface. It was not able to detect any type of radiation belts around the Moon at or beyond the limits of its magnetometer's sensitivity, although. Using ion traps on board, the satellite made the first direct measurement of solar wind flux from outside the Earth's magnetosphere.

3. Match the terms on the left with the definitions and explanations on the right.

1. path	a. a piece of equipment for broadcasting radio or television signals
2. Moon	b. an electronic device for measuring the level of radioactivity

3. transmitter	c. the speed at which a rocket must travel in order to get into space
4. probe	d. the round object that moves in the sky around the Earth and can be seen at night
5. detector	e. a space from which most or all of the matter has been removed, or where there is little or no matter
6. solar wind	f. an emanation from the Sun's corona consisting of a flow of charged particles that interacts with the magnetic field of the Earth and other planetary bodies
7.Geiger counter	g. the round object that moves in the sky around the Earth and can be seen at night
8. magnetometer	h. a device used to find particular substances or things, or measure their level
9. escape velocity	i. a device used for measuring intensity of a magnetic field
10. vacuum	j. a route or track between one place and another, or the direction in which something is moving

4. Choose the answer, which is the most corresponding to the text information:

1. Luna 2 was launched

- to do some measurements around the Moon

- to research asteroids

- to get lunar soil samples

2. Luna 2 used three transmitters

- to get more information

- to provide precise information

- to be well heard by the observers of all countries

3. Sodium gas was expanded

- to prove Luna 2 visited the Moon
- to provide additional atmosphere
- to carry out experiments

4. Radiation detectors and magnetometer were used

- to measure Van Allen belt magnetic and radiation fields
- to measure Earth's magnetic and radiation fields
- to measure lunar magnetic and radiation fields

5. Solar wind flux was measured by

- radiation detectors and a magnetometer
- scintillation counters
- ion traps.

5. Ask 10 questions to the text.

6. Give opposites to the words from the text.

1. to find	5. inaccurate
2. to receive	6. to capture
3. to hide	7. to compress
4. to join	8. to result in

7. Read the text and decide which word combinations best fit each space.

1. communications session

2. the total distance

3. pressurized containers

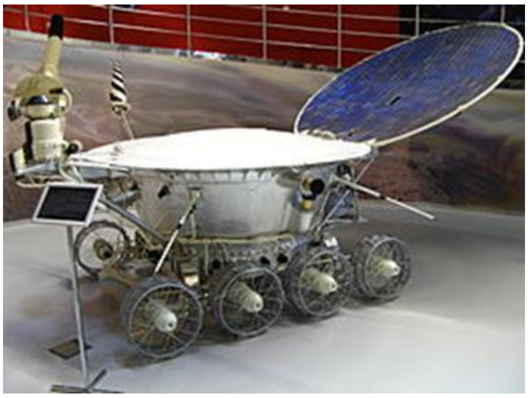
4. the lunar soil

5. was equipped

6. by a solar cell array

Lunokhod 1- the First on the Moon

Lunokhod 1 was the first robotic lunar rover landed on the Moon by the Soviet Union as part of its Lunokhod program. An amazing spacecraft gently settled to the lunar surface on 17 November 1970. It carried the first successful robotic lunar rover - Lunokhod 1. For the next ten months the rover was driven by operators in the Soviet Union, with (a) __________ traveled more than 10 km.



Lunokhod 1

Lunokhod 1 was formed of a tub-like compartment with a large convex lid on eight independently powered wheels. Its length was 2.3 meters. Lunokhod 1 (b) _________ with a cone-shaped antenna, a highly directional helical antenna, four television cameras, and special extendable devices to test (c) ________ for soil density and mechanical properties. An X-ray spectrometer, an X-ray telescope, cosmic ray detectors, and a laser device were also included. The vehicle was powered by batteries, which were recharged during a lunar day (d) ___________ mounted on the underside of the lid. To be *able to work in a vacuum, special fluoride-based lubricant was used for the mechanical parts, and electric motors were enclosed in (e)_________. During lunar nights, the lid was closed, and a polonium-210 radioisotope heater unit kept the internal components at operating temperature.*

The lander had dual ramps from which the payload, Lunokhod 1, could descend to the lunar surface. The rover would run during the lunar day, stopping occasionally to recharge its batteries via solar panels. At night, the rover hibernated until the next sunrise, heated by the radioactive source. Lunokhod 1 was intended to operate through three lunar days (approximately three Earth months), but actually operated for eleven lunar days (322 days).

Controllers finished the last (f) __________ with Lunokhod 1 on September 14, 1971. During its 322 Earth days of operations, Lunokhod 1 travelled 10,540 meters and returned more than 20,000 TV images and 206 high-resolution panoramas. In addition, it performed 25 lunar soil analyses with its x-ray fluorescence spectrometer and used its penetrometer at 500 different locations.

8. Make up an abstract of the text **'Lunokhod 1- the First on the Moon'.**

You should remember the following words and phrases!	
path	курс; траектория
escape velocity	вторая космическая скорость,
to expand	расширяться; увеличиваться в объёме
celestial body	небесное тело
scintillation counter	счётчик вспышек
to cause	послужить причиной, вызывать
fluxgate magnetometer	феррозондовый магнитометр

ion trap	ионная ловушка
solar wind	солнечный ветер
mechanical properties	механические свойства
to recharge	перезаряжать

9. a) What do you know about the first humans on the Moon? Who were they? What were their purposes? What did they do there? Share the information with your groupmates.

b) Read the text and make sure, if your predictions are correct.

Apollo 11 Mission

On July 16th, 1969 the historic Apollo 11 mission took off from the Kennedy Space Center in Florida. The crew consisted of Neil Armstrong as the Commander, Michael Collins as the Command Module Pilot, and Edwin "Buzz" Aldrin as the Lunar Module Pilot.

On July 19th Apollo 11 passed behind the Moon and fired its service propulsion engine to enter lunar orbit. On the following day, the Lunar Module Eagle separated from the Command Module Columbia, and Armstrong and Aldrin commenced their lunar descent.

Taking manual control of the Lunar Module, Armstrong brought them down to a landing spot in the Sea of Tranquility, and then announced their arrival by saying: "Houston, Tranquility Base here. The Eagle has landed." After conducting post-landing checks and depressurizing the cabin, Armstrong and Aldrin began descending the ladder to the lunar surface.

When he reached the bottom of the ladder, Armstrong said: "I'm going to step off the Lunar Excursion Module now". He then set his left boot on the surface of the Moon at 2:56 UTC July 21st, 1969, and spoke the famous words “That’s one small step for a man, one giant leap for mankind.”

About 20 minutes after the first step, Aldrin joined Armstrong on the surface, and the two men began conducting planned surface operations. In so doing, they became the first and second humans to set foot on the Moon.

For the next two and a half hours, Aldrin and Armstrong took notes, pictures and made holes to get moon rock. They did many experiments, for example the collecting of moon rocks and dust. An American flag was set up and photographed on the moon.

After finishing their work, Armstrong and Aldrin returned to the Eagle and slept for seven hours before leaving. While preparing to leave, Aldrin broke the circuit breaker in the engine starter. Armstrong used a pen to bridge the circuit and stop them from being stuck on the moon. Aldrin and Armstrong left many things on the Moon: an American flag, a few experiments, a golden feather, a logo of Apollo 1 and some bronze coins honoring Yuri Gagarin and Vladimir Komarov. He also left a sign on the Moon, with a message from the human race. The sign reads:

‘Here men from the planet Earth first set foot upon the Moon, July 1969 A.D. We came in peace for all mankind’.

On July 24, three astronauts returned to the Earth and were immediately placed into quarantine in case they brought back some disease from the Moon. They stayed in quarantine for three weeks. When they got out, the men were heroes around the world.

10. Answer the following questions.

1. What spacecraft delivered the crew to the lunar orbit?

2. What module descended on the lunar surface?

3. When did they touch down the Moon?

3. Which of the crewmembers stepped on the lunar surface?

4. Who stayed in the orbit? Why?

5. How long did they stay on the Moon?

6. What did they do on the lunar surface?

7. Did they leave anything on the Moon?

8. Why were they placed into quarantine?

Speaking

1. Go to https://www.youtube.com/watch?v=OCjhCL2iqlQ, watch the video "Apollo 11's journey to the Moon" and describe the main stages of Apollo 11 Mission.

2. You are going to make a presentation for the student scientific conference. The topic of your presentation is "Lunar Research". Search the Internet for additional information. This video would help you: https://www.youtube.com/watch?v=oX8-IXdABuc

Module 11. ENGINES OF THE FUTURE

Lead-In

1. What power plants are used for spacecraft traveling?

Brainstorm at least three reasons why people might need to develop spacecraft propulsions operating other principles.

Reading

1. Practice reading the following words.

chemical	['kemɪkl]
apply	[ə'plaɪ]
wire	['waɪə]
coil	[kɔɪl]
exhaust	[ɪg'zɔːst]
neutralize	['njuːtrəlaɪz]
ionization	['aɪənaɪz'eɪʃn]
chaotic	[keɪ'ɔtɪk]

2. Match the English words with their Russian counterparts.

1. working fluid	a. тормозящее поле
2. wire coil	b. ионный пучок
3. electric current	c. рабочая жидкость
4. retarding field	d. соленоид
5. ion beam	e. электрический ток

Electric Propulsion

1. Chemical rockets use the energy stored in propellants to create a hot gas which then becomes the working fluid in a heat engine and is expelled generating thrust. There is, however, a fundamental limitation which results from combining the functions of working fluid and energy source: no more energy can be put into the rocket than is contained in the propellant flowing into the engine. More ambitious programs – manned missions to the Mars, for example, - would require a very large mass of propellant. Moreover, all the necessary propellant would need to be raised to the Earth orbit.

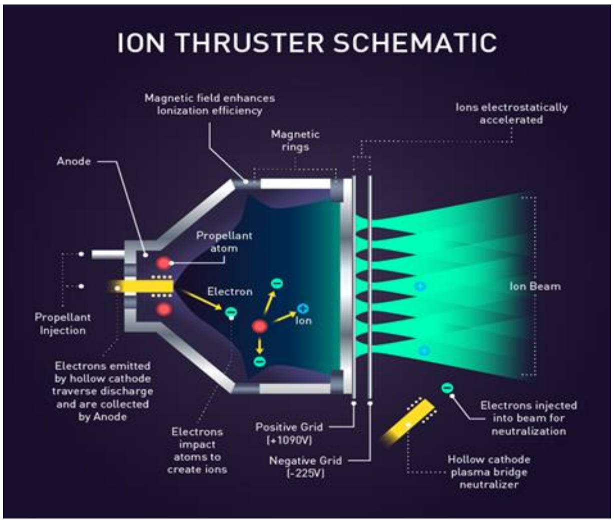
2. The concept of electric propulsion is one of the ways out. The basic principle of electric propulsion is to apply electrical energy to the propellant from an external power source. The simplest way is to heat the propellant with a hot wire coil through which an electric current passes. More energy can be delivered from the electric current if an arc is struck through the propellant which generates high temperatures and produces high exhaust velocity.

Electric power can come from a battery, solar panels or an onboard nuclear or solar generator.

Ion Thrusters

3. This is the simplest concept: propellant is ionized and then enters a region of strong electric field, where the positive ions are accelerated. Passing through a grid, they leave the engine as a high-velocity exhaust stream. The electrons do not leave, and so the exhaust is positively charged. Ultimately, this would result in a retarding field developing between the spacecraft and the exhaust, and so an electron current is discharged into the exhaust to neutralize the spacecraft. The electrons carry little momentum, and so this does not affect the thrust.

4. The propellant enters the ionization chamber in the form of neutral gas molecules. There is a radial electric field across the chamber, and electrons are released from the cathode. The electrons are accelerated by the radial field, and reach energies of several tens of electron volts, which is enough to ionize the neutral propellant atoms by collision. The ionization becomes efficient, and the number of ions produced is maximized.



There is no need for a nozzle to generate thrust because the motion of the ion beam is ordered and not chaotic. The thrust is transferred through the body of the thruster to the spacecraft.

3. Answer the following questions.

1. Where is energy derived from in chemical rockets?

2. What are the limitations of chemical rockets?

3. What is the basic principle of electric propulsion?

4. What generates high temperatures and produces high exhaust velocity in electric propulsions?

5. What accelerates electrons in an ion thruster?

6. Why is it required to accelerate electrons?

7. What provides thrust of an ion thruster?

8. Is a nozzle required to generate thrust? Why?

4. Highlight the key words of each paragraph. Entitle each paragraph. Next, make up an abstract for the text.

5. Find the words in the text with the following meaning.

1. to form an ion ____

2.negative electrode in a piece of electrical equipment ________

3. the force that keeps an object moving ____________________

4. carefully arranged or controlled _________________________

5. an explosive substance that causes something to move forwards____

6. an atom that has an electrical charge because it has added or lost one or more electrons ___________________________________

7. a narrow piece attached to the end of a tube so that the air that comes out can be directed in a particular way_____________________

8. a structure made from horizontal and vertical lines crossing each other to form squares_____________________________________

9. the area surrounding an object with an electrical charge where positive and negative particles are reacting with each other __________

10. the waste gas from an engine or the pipe the gas flows through ____

6. Match the synonyms.

A	***B***
1. fluid	a. quicken
2. propellant	b. discharge

3. chamber	c. confused
4. chaotic	d. unite
5.current	e. room
6. expel	f. liquid
7. combine	g. stream
8. accelerate	h. fuel

7. Translate the following word combinations:

1. ускорять поток ионов
2. ускорять рабочую жидкость
3. выталкивать горячий газ
4. столкновение нейтральных атомов
5. упорядоченный луч
6. создавать тягу
7. электрическая дуга
8. приводить к столкновению
9. проходить через решетку
10. пропускать электрический ток

You should remember the following words!	
working fluid	рабочая жидкость
grid	решетка
exhaust	выхлоп, выхлопной
charged	заряженный

to result in	приводить к
retarding field	тормозящее поле
momentum	импульс
ionization chamber	ионизационная камера
collision	столкновение
arc	дуга
coil	соленоид

8. Read the text and decide which word combinations best fit each space.

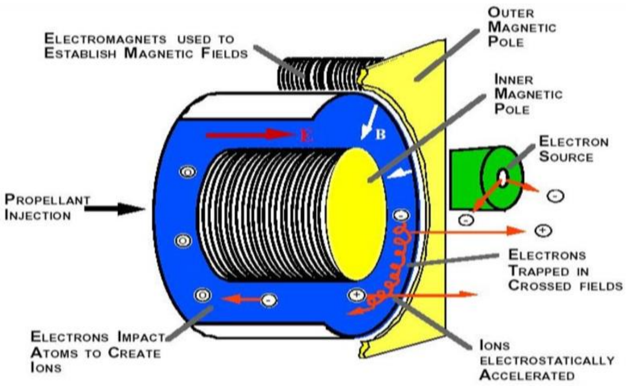
1. a maximum speed
2. a positive charge
3. the same principle
4. in a vacuum of outer space
5. to propel the rocket forward
6. a negative charge
7. typically xenon or krypton
8. currently in use
9. a significant amount

Plasma Thrusters

1. In this type of rocket, a combination of electric and magnetic fields are used to break down the atoms and molecules of a propellant gas into a collection of particles that have either (a)__________ (ions) or (b)__________ (electrons). In other words, the propellant gas becomes a plasma.

2. In configurations of this engine, an electric field is applied to eject the ions out the back of the engine, which provide thrust to the spacecraft in the opposite direction. A spaceship could theoretically reach a speed 198,000 kph. These rockets are to work (c) _________since the density of air near the Earth's surface slows down the acceleration of the ions in the plasma needed to create thrust, so we can't actually use them for lift-off from Earth. However, some of these plasma engines have been operating in space since 1971. They are typically used for upkeep of the International Space Station and satellites, as well as the main source for propulsion into deep space.

3. All plasma rockets operate on (d) __________: electric fields and magnetic fields work side by side to first transform a gas – (e) _________ – into plasma and then accelerate the ions in the plasma out of the engine at over 72,400 kph, creating a thrust in the direction of desired travel.



Hall thruster

4. *Hall* thrusters are plasma engines that are (f) _________regularly in space. In this device, electric and magnetic fields are set up in a perpendicular fashion in the chamber. When electricity is sent through these fields, the electrons begin to rush around super-fast in circles. As the propellant gas injects into the device, the high-speed electrons knock electrons off the atoms in the gas, creating a plasma consisting of free electrons carrying negative charges and now positively charged atoms (ions) of the propellant. These ions exhaust of the back of the engine and create thrust needed (g) __________ . While the two processes of ionization and acceleration of the ions happen in steps, they occur within the same space in this

engine. *Hall* thrusters can generate (h) __________ of thrust, so they can go incredibly fast.

5. A plasma rocket uses much less fuel than these conventional engines – 100 million times less fuel. It is so fuel-efficient that you can go from the Earth's orbit to the Moon's orbit with just about 113 liters of gas. Plasma rockets accelerate gradually and can reach (i) __________ of 55 kilometers per second over 23 days, which is four times faster than any chemical rocket. Less time spent traveling means less risk of the ship experiencing mechanical failures and astronauts being exposed to solar radiation, bone loss and muscle atrophy.

9. Ask questions to which the following statements could be answers.

1. A collection of particles that have either a positive charge (ions) or a negative charge (electrons).

2. Because the density of air near the Earth's surface slows down the acceleration of the ions in the plasma needed to create thrust.

3. To upkeep of the International Space Station and satellites, as well as the main source for propulsion into deep space.

4. Typically xenon or krypton.

5. Ion exhausts.

6. They use much less fuel than conventional engines.

7. About 113 liters of gas.

8. 55 kilometers per second.

9. Less risk of the ship experiencing mechanical failures and astronauts being exposed to solar radiation, bone loss and muscle atrophy.

10. Do you know principles of sailing? What are they? Discuss the following points:

- ***Necessary conditions***
- ***Devices required***
- ***Advantages and disadvantages***

11. Do you think sailing principles could be used to travel into deep space? What provides thrust in this case? Share the ideas with your partners. Then read the text "Solar Sails" and make sure whether your predictions were true.

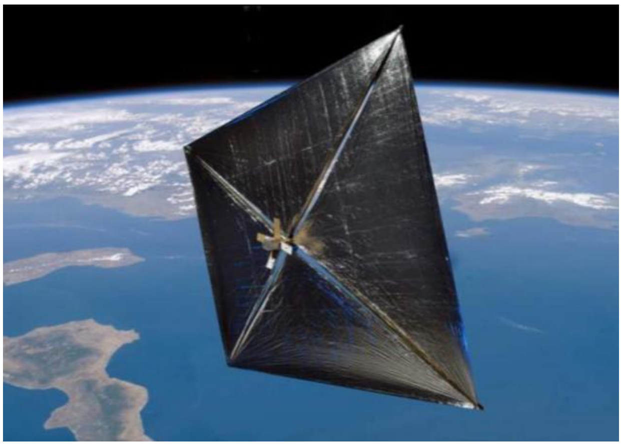
Solar Sails

1. Our journeys to space have been limited by the power of chemical rocket engines and the amount of rocket fuel that a space-craft can carry. Today, the weight of a rocket at launch is approxi-mately 95 percent fuel.

2. Nearly 400 years ago, Johannes Kepler proposed the idea of exploring the galaxy using sails. Through his observation that comet tails were blown around by some kind of solar breeze, he believed sails could capture that wind to propel spacecraft the way winds moved ships on the oceans. Scientists have discovered that sunlight exerts enough force to move objects.

3. A solar sail-powered spacecraft does not need traditional propellant for power, because its propellant is sunlight and the sun is its engine. Light is composed of electromagnetic radiation that exerts force on objects it comes in contact with. Researchers have found that at 1 astronomical unit, which is the distance from the Sun to the Earth, equal to 150 million km, sunlight can produce about 1.4 kilowatts of power. Eventually, the continuous force

of the sunlight on a solar sail could propel a spacecraft to speeds five times faster than traditional rockets.



Solar sail

4. Materials used to manufacture solar sails must be highly reflective and able to tolerate extreme temperatures. The giant sails being tested today are made of very lightweight, reflective material that is upwards of 100 times thinner than an average sheet of stationery.

5. The reflective nature of the sails is the key. As photons (light particles) bounce off the reflective material, they gently push the sail along by transferring momentum to the sail. Because there are so many photons from sunlight, and because they are constantly hitting the sail, there is a constant pressure exerted on the sail that produces a constant acceleration of a spacecraft. Although the force on a solar-sail spacecraft is less than a conventional chemical rocket, the solar-sail spacecraft constantly accelerates over time and achieves a greater velocity.

6. With just sunlight as power, a solar sail would never be launched directly from the ground. The second spacecraft is needed to launch a solar sail, which would then be deployed in space. Another possible way to launch a solar sail would be with microwave or laser beams provided by a satellite or other spacecraft. These energy beams could be directed at the sail to launch it into space and provide a secondary power source during its journey.

7. Once launched, the sails are deployed using an inflatable boom system that is triggered by a built-in deployment mechanism.

As it continues to be pushed by sunlight, a solar sail-propelled vehicle will build up speeds that rocket powered vehicles would never be able to achieve. Such a vehicle would eventuallytravel at about 90 km/sec, which would be more than 324,000 kph. That speed is about 10 times faster than the spacecraft orbital speed of 8 km/sec. Solar sail technology will eventually play a key role in long-distance missions.

By adding a laser or magnetic beam transmitter, it could push speeds to 30,000 km/sec, which is one-tenth the speed of light. At those speeds, interstellar travel would be an almost certainty.

12. Decide if these statements are true or false. Correct the false ones.

1. Today, the weight of a payload is approximately 15 percent of a rocket at launch.

2. Sunlight is a propellant for a solar sail.

3. Solar sail could be launched directly from the ground because it is light.

4. Constant acceleration of a spacecraft is provided by photons constantly hitting the sail.

5. Materials for solar sails should be extremely lightweight, temperature resistant and highly reflective.

6. Solar sails are launched, folded and deployed using a built-in deployment mechanism in space.

7. A solar sail could be launched with microwave or laser beams provided by a satellite or other spacecraft.

8. Solar sails could reach the speed exceeding speed of light.

9. Solar sails are made of reflective materials for consistent reception of radio signal from the ground control center.

10. Solar sails are accelerated by constant pressure of hitting photons from sunlight.

13. Make up an abstract for the text.

14. Match the words in A with the words in B to make collocations and translate them.

A	***B***
chemical	unit
electromagnetic	mechanism
astronomical	radiation
reflective	speed
constant	vehicle
deployment	missions
sail-propelled	travel
orbital	engines
long-distance	acceleration
interstellar	material

15. Using the suffixes from the right column, form adjectives and adverbs from the words in the left.

electromagnet	-ly
tradition	-able
constant	-ly
direct	-al
deploy	-ly
inflate	-ed
eventual	-al
orbit	-ic

Speaking

1. Watch the video at https://yandex.ru/video/preview/?filmId=7002753291096696449&reqid=1586341102178003-1406327103605470650039666-sas1-7569-V&suggest_reqid=626189228140697819411502793332446&text=solar+sails and answer the following questions:

1. What are the disadvantages of modern rocket propellant?

2. What is the initial speed of a solar sail by the end of the first day?

3. What would the solar sail speed be by the end of the first year of travelling?

4. What would the solar sail speed be in three years of traveling?

5. What would provide this speed increase?

6. What are the prospects of using solar sails?

Module 12. EXTRAVEHICULAR ACTIVITY

Lead-In

1. What do you know about extravehicular activity (EVA)? Try to give a definition of EVA. Why is extravehicular activity required? Share the ideas with your groupmates.

2. Discuss the hazards of spacewalks with your groupmates.

3. Look at the pictures of different suits for various purposes (a spacesuit, a diving-suit, an anti-g suit, etc.). What similarities and differences do they have? What are the reasons?

a)

b)

c)

d)

Reading

1. Match the phrases with their Russian equivalents.

1. extravehicular activity	a) правила техники безопасности
2. safety procedures	b) шлюз с регулируемым давлением
3. pressure-controlled airlock	c) непредвиденное о обстоятельств
4. spacesuit	d) деятельность в открытом космосе
5. contingency	e)космический скафандр

2. Practice reading the following words.

extravehicular	['ekstrəvɪ'hɪkjulə]
exterior	[ɪk'stɪərɪə]
procedure	[prə'siːʤə]
spacesuit	['speɪssjuːt]
ensure	[ɪn'ʃuə]
environment	[ɪn'vaɪərənmənt]
technique	[tek'niːk]
contingency	[kən'tɪnʤənsɪ]
mature	[mə'ʧuə]
cadence	['keɪdəns]
hatch	[hæʧ]

3. Read the text and make sure whether your predictions were true.

Extravehicular Activity

1. Extravehicular activity (EVA) is any activity done by an astronaut outside a spacecraft beyond the Earth's atmosphere. Extravehicular activity requires astronauts to exit the relative safety of their spacecraft to perform work on its exterior. The process adheres to strict safety procedures, requires extensive safety equipment, and is only performed when it is absolutely necessary. Spacewalks are dangerous, physically demanding, and rare.

2. The process of doing a spacewalk is not just physically challenging due to the pressurized resistance of the spacesuit, it is also

mentally demanding - astronauts have to focus on the work they are doing as well as their safety, a vast number of potential tools, interacting with the crew and with the team in the mission control center, all while the clock is ticking.

3. There are many different reasons for spacewalking - everything from installing a new piece of equipment or removing a broken piece of apparatus, to deploying experiments, to surveying for damage - but the operational components of a spacewalk are all the same regardless of the task.

4. In the International Space Station, astronauts must exit the space center through the pressure-controlled airlock. Before opening a hatch, the air pressure of the airlock - the space between the hatches - is equalized with that of the environment beyond the next hatch to open. A gradual pressure transition minimizes air temperature fluctuations, decreases stresses on air seals, and allows safe verification of a pressure spacesuit.

Once in space, there are systems in place to ensure its efficiency and safety:

•During a spacewalk, astronauts are supported by the crew inside the Station, who help to remind them where they are in the procedure or setting for the tools they are using.

•If an astronaut is the lead spacewalker, he is also responsible for keeping track of what the other astronaut is doing outside, as well as the cadence, safety, and completion of the entire extravehicular activity.

5. Before an astronaut does a spacewalk there are years of training on spacesuit systems, in virtual reality simulators, in vacuum

chambers, and simulating weightlessness under water. The most important of these training environments is underwater because the environment on the Earth that best simulates the weightlessness of spacewalking is under water.

6. The main aim of training is to invent, develop and perfect entire EVAs, and hone the individual skills needed.

Astronauts spend hundreds of hours training under water, learning how to operate and maneuver in their spacesuits, learning how to think in three dimensions, and developing new techniques for spacewalking. During training, astronauts practice skills to monitor the health of their suits, get used to the cadence of hot sunrises and icy, dark sunsets every 46 minutes, and prepare for the physically demanding experience of spacewalking, as the pressurized, stiff spacesuit resists every motion.

7. EVA remained the preferred method for many tasks because of its efficiency and its ability to respond to unexpected failures and contingencies. Designing and certifying a robot to perform tasks beyond known requirements is extremely costly and not yet mature enough to replace humans.

4. Look at the text again and discuss these questions.

1. What is extravehicular activity?

2. What are the purposes of spacewalks?

3. What difficulties are connected with the extravehicular activity?

4. Why is the pressure-controlled airlock required?

5. Is an astronaut absolutely autonomous outside of the station or supported by the crew inside the station?

6. Why are the years of training on spacesuit systems necessary?

7. What devices are used to train an astronaut for the extravehicular activity?

5. Give your own definitions for the words from the text.

1. spacesuit ____

2. pressure-controlled airlock ____________________________

3. vacuum chamber ___________________________________

4. contingency _______________________________________

5. robot ____

6. hatch ____

7. safety procedure ___________________________________

6. Match the adjectives with their definitions.

1. extensive	a. to have control and authority over something and the duty of taking care of it
2. dangerous	b. surprising or strange things are likely to happen
3. challenging	c. thing or activity could harm you
4. gradual	d. belonging to or intended for one person
5. responsible	e. happening slowly over a long period of time
6. individual	f. firm or hard
7. unexpected	g. having a great range
8. stiff	h. difficult, in a way that tests your ability

7. In the text find the synonyms of the following words and make up your own word combinations with them.

1. hatch	a. demand
2. requirement	b. trainer
3. dimension	c. breakdown
4. skill	d. work
5. simulator	e. severe
6. damage	f. ability
7. strict	g. measurement
8. activity	h. gate

8. Highlight the key words of each paragraph. Entitle each paragraph. Then make up an abstract for the text.

9. Read the text* "Russian Spacesuit "Orlan-MKS" – an Engineering Masterpiece"** ***and fill in the gaps (1-6) with the missing information (a-f). Translate the text into Russian.

a) personal spacecraft

b) the emergency life support system

c) sharp temperature drop

d) a multilayered design

e) manufacturing

f) orbit-based spacesuit

Russian Spacesuit “Orlan-MKS” – an Engineering Masterpiece

Modern Russian spacesuit “Orlan-MKS” starts its prehistory from the Soviet lunar developments when the first semi rigid spacesuit “Krechet” was developed. It became a basis for creating space “clothes” for our astronauts.

Then “Orlan” was developed. “Orlan” is the only (1)______________. It is able to operate at an orbit for five years without returning to the Earth for maintenance and repair. Its preparation for going up into space is carried out onboard the ISS. It is able to withstand out-of-limit loads, vacuum, radiation, highest solar emission, and great temperature drops. Today the most reliable in the world spacesuit “Orlan-MKS” is used at the ISS. Its (2) ______________ takes about 1.5 years. Its overall cost is about 11 million dollars, and 70% of it accounts for life-support and control systems.

Modern “Orlan-MKS” is a result of more than 60 years of innovation, it is like a (3)______________ , and an astronaut enters it using a hatch at the back of the spacesuit. Its weight is 110 kg, and an astronaut can work autonomously out of the space station for 8 hours.

The spacesuit is based on a semi-rigid structure. Its body and a helmet are made of aluminium alloy as a unified rigid body, envelopes of arms and legs are manufactured of soft materials. “Orlan-MKS” has (4) ________________ with an impressive total of 11 layers that combine heating, cooling and a pressurization systems.

To allow maximum mobility at overpressure the spacesuit is fitted with pressure bearings and hinges.

Autonomous life-support system is housed in a backpack. A backpack unit provides astronauts with oxygen, carbon-dioxide removal, electrical power, a water-cooling system and communication.

Orlan-MKS

It should be taken into account possibility of hit by small particles of dust or rock that move at high speeds (micrometeoroids) or orbiting debris from satellites or spacecraft. That is why the spacesuit has the main and backup containments to protect an astronaut. All other systems are also duplicated, and it is the great advantage of "Orlan-MKS". If depressurization happens, (5) ________________ will activate maintaining pressure inside the spacesuit for 30 minutes. This time is enough to return to the ISS.

"Orlan-MKS" features excellent repairability, its components such as segments of arms, legs and gloves are easily replaced.

Another distinctive feature of "Orlan-MKS" is its versatility, astronauts 165-190 cm height can use it, and its size is adjusted onboard the Station by means of special devices. But gloves are shaped to astronaut's hands, they are used only two times because of their intensive use and wear.

To communicate with the ISS and mission control center "Orlan-MKS" uses its outer envelope made of fabric with built-in special waveguides as an antenna. Spacesuits of new generation are provided with unique automatic thermal control system. It is like climate control equipment in a car. Vacuum-shield thermal insulation fabric allows an astronaut to feel comfortably in conditions of (6) _____________ from +150 to -120 Celsius degree.

Computer hardware and software have also improved greatly. In case of emergency, the computer emits an alarm signal to the astronaut and proposes some solutions of the problem.

The spacesuit is being improved continuously. In comparison with the previous ones it can be applied not 15 but 20 times for spacewalks, it is much more economically efficient. To operate in outer space is a hard work, but extravehicular activity can be easier due to state-of-the-art and exceptionally reliable Russian spacesuits "Orlan-MKS".

10. Choose the answer, which is the most corresponding to the text information.

1. Spacesuits are used

- to provide comfortable conditions for an astronaut inside a spacecraft

- to protect an astronaut from severe conditions of outer space when spacewalking

- to allow an astronaut to travel far from the ISS

2. A spacesuit is fitted with pressure bearings and hinges

- to avoid overpressure

- to adjust the size of a spacesuit

- to allow maximum mobility

3. To protect an astronaut from hit by micrometeoroids a spacesuit

- has main and backup containments

- is fitted with special traps around a spacesuit

- is manufactured of very stiff metal

4. An astronaut communicates with the Station and mission control center

- by means of antennas at the top of the helmet

- with built-in special wave guides as an antenna

- using remote control board

5. Automatic thermal control system

- protects an astronaut from sharp temperature drops

- gives an astronaut good vision

- provides microgravity condition during a spacewalk

6. If something is going wrong during extravehicular activity

- the computer emits an alarm signal to the astronaut and proposes some solutions

- another astronaut would come and help

- an astronaut would stay in outer space forever

You should remember the following words and phrases!	
extravehicular activity	
pressure-controlled airlock	
hatch	
vacuum chamber	
safety procedures	
experience	
contingency	
mission control center	
maintenance	
emergency	
backup	
life support system	
pressure bearing	

Speaking

1. Watch the video:

https://www.youtube.com/watch?time_continue=8&v=mDtpVZVtPP8&feature=emb_title

Try to elicit as much information from the video as you can and tell your groupmates about the Manned Maneuvering Unit. Take a look at its purposes and advantages.

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