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HISTORY OF SCIENCE AND TECHNOLOGY

Synopsis of lectures

Recommended by the Methodical Council of the Igor Sikorsky Kyiv Polytechnic Institute
as a study aid for bachelor's applicants
on the educational programs "System Analysis and Management", "System Analysis of the
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The textbook "History of Science and Technology" outlines the key aspects of the development of
scientific knowledge and technological innovations from ancient times to the present. The material
contains thematic sections that cover important milestones in the development of science and
technology, attention is paid to the impact of scientific achievements on society and the state. The
manual is proposed for bachelor's degree holders in the specialty 124 Systems Analysis and will
also be useful for specialists in other technical fields.

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Introduction

In today's rapidly developing world, technologies are constantly improving, business paradigms are changing, and approaches to education, science, and culture continue to evolve. This guide is designed to provide users with a deeper understanding of the key aspects of today's innovations and their applications in various areas of life.

We live in the age of information, where knowledge and information become the main engines of social and economic development. The acceleration of scientific and technological progress requires us not only to understand modern technologies, but also to be able to think critically and adapt to constant changes.

In this guide, we'll cover various aspects of today's technology and innovation landscape, including the Internet of Things, artificial intelligence, blockchain, quantum computing, 3D printing, and many other topics. We will explore how these technologies affect various industries - from manufacturing to healthcare, from education to finance - and consider the potential opportunities and challenges associated with their implementation.

In addition to the technical aspect, we will also consider the social, ethical and economic dimensions of innovation. It is important to understand how technology affects work, privacy, security and social justice, and how it can contribute to sustainable development and solutions to global challenges.

This guide is intended for a wide audience: from students and teachers to industry specialists and a wide range of readers interested in modern technologies and innovations. We strive to provide a clear and accessible presentation of material that will allow everyone to immerse themselves in the world of modern technologies and consider their impact on our future.

Thematic plan

1. Introduction. Theoretical and methodological foundations of "History of Science and Technology"
2. Accumulation of knowledge, technique and technology in prehistoric times and the age of ancient civilizations
3. Technique of the Middle Ages. Scientific knowledge of the XVI-XVIII centuries.
4. Development of technology and scientific knowledge in the mid-18th - 70s of the 19th century.
5. New discoveries in physical, mathematical and natural sciences on the border of the 19th and 20th centuries.
6. The development of technology at the beginning of the 20th century. and during the First World War
7. World science and technology in the 1920s-1940s
8. Development of science and technology in the second half of the 20th - at the beginning of the 21st century.
9. The main trends and prospects for the development of science in the 21st century

Lecture 1. Introduction. Theoretical and methodological foundations of "History of Science and Technology"

1. Subject, goal, task of the course.
2. Methodology of history of science research
3. Overview of basic concepts
4. Periodization of the history of science and technology

Subject, goal, task of the course

The history of science and technology is an integral part of the general cultural and intellectual heritage of mankind. It explores the development of scientific ideas and technological innovations throughout different eras and cultures. The importance of this field of research lies not only in preserving the historical memory of scientific and technical achievements, but also in understanding how new ideas and inventions affected society, culture, economy and politics. Studying the history of science and technology allows us to better understand how scientific knowledge and technological capabilities have shaped our world, and how social, cultural, and economic conditions have facilitated scientific discovery and technological innovation.

The methodology of research in the history of science covers a wide range of approaches and techniques. Historians of science use both quantitative and qualitative research methods, including analysis of primary and secondary sources, interviews with scientists and engineers, and historical reconstruction of scientific experiments and technological processes. Particular attention is paid to contextual analysis in order to understand how scientific ideas arose and developed in specific historical circumstances. This includes consideration of social, cultural, economic, and political factors that may have influenced the development of science and technology.

The history of science and technology also deals with the analysis of how scientific ideas have been accepted, modified or rejected by different cultures and societies. This allows us to understand how science and technology shape and were shaped by social values and expectations. An important part of this process is the study

of scientific communication and public perception of science, as well as the role of scientists and engineers in society.

The history of science and technology is a fundamental component of general cultural and professional education. It plays a key role in understanding both the scientific and technological principles that have shaped our modern world. By studying the history of science, we understand the development of scientific ideas from simple observations to complex theories. Similarly, the history of technology reveals how technological inventions and innovations have changed human work, lifestyles, and human interactions. In addition, understanding the historical context allows us to appreciate the social, economic, and ethical aspects of science and technology.

Methodology of history of science research

The research methodology of the history of science combines approaches from various disciplines, including philosophy, sociology, and history. The main task is the analysis of scientific ideas, techniques, experiments and tools in their historical and cultural context. This requires not only the study of primary sources, such as scientific papers, patents, and the correspondence of scientists, but also the critical analysis of secondary sources that interpret historical events. Historians of science use a variety of research methods, including the diachronic approach, which follows the development of scientific ideas over time, and the synchronic approach, which analyzes scientific concepts within a specific historical period.

The study of the history of science also includes the analysis of changes in the methodology of scientific research. It helps to understand the emergence and changes of various scientific paradigms under the influence of new data, tools and theoretical approaches. In addition, the study of the historical development of laboratory practices, experimental methods and scientific institutions allows a better understanding of the influence of these elements on the production of scientific knowledge.

The analysis of the history of science is not limited to the study of positive achievements and successes. It also includes an examination of scientific errors and dead ends that provide valuable lessons for modern science and technology. This allows

scientists and engineers to better understand the risks associated with scientific research and contributes to the development of a more responsible approach to scientific research and technological innovation.

Also, an important aspect of the study of the history of science is the study of the influence of social, political and cultural factors on the development of science and technology. The history of science shows how scientific ideas and technologies were formed under the influence of economic interests, political ideologies and cultural norms. This understanding helps to reveal the complexity of scientific research and to emphasize the importance of interdisciplinary approaches in solving modern scientific and technological problems.

In conclusion, the history of science and technology not only allows a better understanding of the past, but also contributes to the formation of a reasonable approach to future scientific discoveries and technological innovations. It provides important tools for analyzing and understanding how science and technology interact with social, cultural and ethical aspects of human life, and how this interaction affects the development of human civilization.

Overview of basic concepts

The history of science and technology is a discipline that studies the development of scientific knowledge and technological innovations over time. She examines how various scientific ideas, discoveries, and technological inventions have influenced society and culture. It also includes the analysis of interactions between science, technology, and other aspects of human endeavor, such as politics, economics, religion, and the arts.

4 industrial revolutions

The term "4 industrial revolutions" refers to four significant periods of technological and industrial development:

1. The first industrial revolution (late 18th - early 19th centuries) was associated with the development of steam engines and the mechanization of production.

2. The second industrial revolution (late 19th - early 20th centuries) is characterized by electrification, mass production and development of steel.
3. The third industrial revolution (1970s) was marked by the emergence of digital technologies, computerization and automation of production.
4. The fourth industrial revolution (21st century) is focused on the integration of physical, digital and biological technologies, which leads to the transformation of the economy and society.

The scientific revolution is a period of sharp and fundamental changes in the way of thinking and views of the world in the scientific community. The most famous example is the Copernican revolution, when the astronomical model of the world went from geocentric to heliocentric, which changed the understanding of the universe.

Technological progress refers to the process of improving technologies and their application in various spheres of human activity. This includes the development of new tools, production methods and materials that increase efficiency, reduce costs and create new opportunities for societal development. Technological progress not only affects economic growth and living standards, but also changes the cultural and social aspects of everyday life.

A scientific discovery is a process or event that leads to a new understanding of natural phenomena, laws, or principles. Discoveries can change existing knowledge or create the basis for new scientific research. They are usually associated with critical observations and experimental data that disprove or extend existing theories. Scientific discoveries, such as the structure of DNA or the laws of quantum mechanics, have a profound impact on science and technology.

An engineering invention is the creation of a new or improvement of an existing technical solution, product or process. Inventions embody the application of scientific knowledge for practical purposes and often become the basis for new technologies and industrial applications. Notable engineering inventions include the steam engine, the transistor, the Internet, and the cell phone, each of which has had a significant impact on the development of the modern world.

Patent and intellectual property rights

A patent is a form of intellectual property protection that gives the inventor the exclusive right to use, manufacture, sell or import the invention for a certain period of time. Patenting stimulates innovation because it allows inventors to profit materially from their inventions while ensuring the dissemination of new knowledge. Intellectual property law includes not only patents, but also copyrights, trademarks, and trade secrets, each of which has different terms and limitations for the protection and use of an intellectual product.

Periodization of the history of science and technology

Periodization of the history of science and technology is an attempt to systematize and structure a significant amount of information about the development of scientific knowledge and technological achievements over time. It helps historians, researchers and students better understand the evolution of scientific ideas and technological innovations, their impact on society and culture. Here are the main periods in the history of science and technology:

1. The prehistoric period and the ancient world - this period covers the time from the emergence of man to the beginning of written history. It is characterized by the appearance of the first tools, gathering, hunting, and the beginnings of agriculture. At this time, the foundations of mathematics, astronomy and medicine were laid in ancient civilizations such as Mesopotamia, Egypt, India and China.
2. Classical Period (Antiquity and Middle Ages) – This period covers the development of scientific knowledge and technology in ancient Greece and Rome, as well as in medieval Europe and the Islamic world. Antiquity brought fundamental ideas in astronomy, mathematics, physics, and medicine, and the Middle Ages were marked by the preservation, translation, and expansion of this knowledge, as well as the development of universities.
3. Renaissance and Scientific Revolution (15th - 17th centuries) - this period is marked by a renewed interest in ancient knowledge, but with a new critical approach and methodology. The development of printing contributed to the wide

spread of knowledge. The scientific revolution of the 17th century led to radical changes in physics, astronomy, mathematics and chemistry, laying the foundations of modern science.

4. Industrial Revolutions (18th – 20th centuries) – Begun in England at the end of the 18th century, the Industrial Revolutions brought with them significant technological changes that affected all aspects of life.

Different scholars have proposed different approaches to dividing the history of science and technology into periods, each of which reflects certain historical, cultural, and technological changes. Let's look at a few key approaches.

1. Thomas Kuhn and the concept of scientific revolutions

Thomas Kuhn in his book "The Structure of Scientific Revolutions" first introduced the concept of "paradigm" and developed a model of periodization of scientific development. He argued that science develops through a sequence of periods of normal science, scientific crises, scientific revolutions, and normal science again. Every scientific revolution leads to a paradigm shift, that is, the basic concepts, theories, and methods used in science.

2. Herbert Butterfield and the emergence of the scientific revolution

Herbert Butterfield, in his work "The Origin of Modern Science", focuses on the period from 1300 to 1800 years, which he considers crucial for the development of modern science. He claims that this time was marked by profound changes in the way of human thinking and approaches to natural science, which laid the foundation for the scientific method.

3. Georges Sarton and the contribution of civilizations

Georges Sarton, one of the founders of the academic discipline of the history of science, proposed dividing the history of science based on the contributions of different civilizations. He divided the history of science into "ages" or periods named after prominent scientists and cultures. This allowed him to emphasize the importance of the cultural context in the development of scientific knowledge.

4. A.R. Hall and the role of technological transformations

A.R. Hall examined the history of technology through the lens of major technological transformations, such as the invention of the wheel, the emergence of the printing press, the development of the steam engine, and the emergence of digital services.

Control questions for the topic:

1. What are the main subject, purpose and tasks of the "History of Science and Technology" course?
2. What are the key principles of the methodology of history of science research? Give examples of how these principles are applied in research.
3. What basic concepts are used in the course "History of Science and Technology"? Give their brief definitions.
4. Justify the need to study the history of science and technology. What is the significance of this course for understanding modern scientific and technical achievements?
5. How does the history of science influence the development of modern scientific methods and approaches?
6. What periodization of the history of science and technology is used in the course? Describe the characteristics of each period.
7. What changes in science and technology were the most significant in each of the historical periods?
8. Explain the relationship between the development of science and technical progress. Give examples that demonstrate this relationship.

Lecture 2. Accumulation of knowledge, technique and technology in prehistoric times and the age of ancient civilizations

1. The discovery of fire by man and the invention of various means of its extraction. Invention and use of the bow and arrow
2. The emergence of agriculture based on complex tools
3. The beginning of the use of metals in the production process. Origin and development of mining in ancient times
4. Features of construction in the countries of the East (Egypt, China, India, Japan)
5. Military equipment of ancient times
6. Mathematical and natural knowledge of ancient civilizations

The discovery of fire by man and the invention of various means of its extraction. The invention and use of the bow and arrow

The discovery of fire played a critical role in the development of human civilization. This not only provided warmth in cold weather and protection from predators, but also made cooking possible, which in turn improved nutrition and promoted physical development. Fire also encouraged social interaction as people gathered around fires, sharing knowledge and telling stories.

Primitive people used several methods of obtaining fire, which was a huge step in the development of human civilization. One of the oldest methods is rubbing wood against wood. A person would rotate the wand between the palms of their hands, pressing it against dry wood, which would cause heat and eventually sparks that could ignite dry grass or leaves. This method required effort and time, but was quite effective in conditions where other means were unavailable.

Another common method was the use of flint and marcasite (or flint and steel in later periods). When these materials hit each other, sparks were formed that could ignite the flammable material. This method was faster and more efficient compared to the

friction method and is considered one of the most revolutionary discoveries in human history.

There are also known methods when sunlight and a magnifying glass or other transparent objects capable of concentrating light on a small area were used to produce fire, which led to the ignition of dry materials. However, this method could only be used on sunny days.

The invention of ways to make fire changed the lives of early humans, allowing them to cook food, keep warm in cold weather, scare off wild animals, and develop new tools. Fire became a symbol of progress and the basis for the further development of civilization.

The bow and arrow are among the earliest known weapon systems and have greatly influenced hunting and warfare methods. Their development allowed people to more efficiently obtain food and defend themselves from enemies or predators from a distance, without the need to get close to danger. Bows and arrows are considered important innovations in ancient technology, as they demonstrate the use of different materials (wood, stone, feathers) and techniques (molding, gluing, knitting).

The development of bow weapons led to significant social and technological changes. Bows provided a new strategic advantage in warfare and forced societies to adapt to new forms of warfare. In addition, they contributed to the development of various crafts, including archery and arrow-making, which became an important part of ancient economies.

Overall, fire and the bow and arrow not only greatly influenced the daily lives of people in ancient times, but also caused key social and cultural changes. With the use of fire and bow weapons, people gained greater ability to control their environment and ensure their own safety, which in turn contributed to the development of more stable and organized forms of society.

Fire allowed humans to colonize new territories, including colder climates, and provided light that expanded the possibilities for activity after sunset. In addition, the use of fire for cooking made foods more digestible and safe, contributing to better health and population growth.

The bow and arrow, on the other hand, changed the dynamics of hunting, allowing humans to forage more efficiently and increase their chances of survival. This technology also had a profound effect on intertribal relations and military conflicts, as groups with more advanced bow technology had a strategic advantage.

It is also necessary to consider that the making of bows and arrows required certain knowledge and skills, including the selection of suitable materials, an understanding of the principles of mechanics and the ability to use various tools. This indicates a significant level of technical knowledge and cultural development in those times.

In addition, the development of these technologies contributed to the growth of trade as people exchanged knowledge, materials and finished goods. The invention of fire and the development of bow and arrow weapons were steps that not only provided immediate practical benefits, but also contributed to cultural and technological development, which became the foundation for further advances in science and technology.

The emergence of agriculture based on complex tools

The emergence of agriculture is one of the most important events in human history, which initiated the Neolithic revolution and changed human societies from nomadic hunter-gatherers to settled agrarian communities. The transition to agriculture required the development and use of sophisticated tools to cultivate the land, sow seeds, tend crops, and harvest crops.

In the ancient world, agriculture was a key activity that provided the basis for the development of civilizations. With the advent of sophisticated tools, the efficiency of farming increased significantly, allowing for increased yields and supporting a growing population.

One of the earliest tools used to cultivate the land was a wooden plow. Its design gradually became more complicated: at first it was a simple stick for loosening the soil, which later turned into more complex designs with metal tips for better penetration into the ground.

The development of metallurgy contributed to the creation of iron axes, sickles, and other tools that made tillage and harvesting more efficient. Iron sickles made it possible to quickly harvest grain crops, and heavy iron plows effectively cultivated the soil, preparing it for sowing.

Another important invention was the irrigation system, which made it possible to control the supply of water to the fields, which was especially important for agriculture in arid regions. Systems of canals, reservoirs, and dams helped store and distribute water resources, greatly increasing productivity.

The development of traction power also played an important role: the use of animals (bulls, horses) to pull plows and other agricultural machines increased labor productivity.

These tools and techniques became the foundation for the further development of agriculture, laying the foundation for the agrarian civilizations of the ancient world. They not only ensured an increase in productivity, but also contributed to socio-economic development, forming the foundations of social structure and culture.

Agriculture caused profound changes in social structure and daily life. The creation of stable sources of food allowed the population to grow and settlements to expand. The first settlements and cities appeared, which later turned into city-states and empires. The development of agriculture also led to division of labor, specialization, and social stratification, as some members of society engaged in farming, others in crafts, trade, or administration.

Agriculture also stimulated technological development. The requirements for storing and handling products led to the invention of various types of storage, such as silos and barns, as well as preservation methods including drying, smoking and salting. The development of agriculture influenced the development of other fields, such as pottery, textile production and metallurgy, which were necessary for the manufacture of tools and equipment.

In addition to technical innovations, agriculture has brought about changes in resource management and land use. Irrigation and water supply systems have become vital to maintaining stable crops, especially in arid regions. This led to the development

of hydraulics and water engineering, including the construction of canals, dams and reservoirs.

The development of agriculture also contributed to the formation of cultural and religious aspects of society. The cyclic nature of agricultural work, dependence on natural cycles and weather conditions led to the development of calendars and astronomical knowledge. In many cultures, agriculture was closely related to religious beliefs and practices, reflected in fertility gods, rituals for blessing crops, and celebrating harvest festivals.

Finally, the emergence of agriculture as the dominant form of economic activity caused changes in the landscape and environment. The clearing of land for agricultural purposes has affected forests, flora and fauna, and contributed to the growth of human impact on the environment. Thus, agriculture not only provided the basis for the development of civilization, but also became a catalyst for profound social, cultural, technological and environmental changes in human society.

The beginning of the use of metals in the production process

The use of metals became a turning point in the development of technology and technology of ancient civilizations. The transition from stone to metal tools significantly expanded man's capabilities in the production and processing of materials. In the ancient world, copper, bronze and iron played a key role in the development of civilizations, becoming the basis for the transition from the Stone Age to the ages of metals. Each of these metals had its own unique characteristics and methods of processing, which influenced their use by people and the transition from one to another.

Copper was one of the first metals that people began to actively use. It is a soft, ductile metal with high thermal and electrical conductivity. Copper was extracted from ore by smelting in clay furnaces. It was used to make jewelry, tools, and weapons. However, the softness of copper limited its use in the production of tools and weapons, which required greater strength.

The development of bronze technology, which consisted in alloying copper with tin (and sometimes other additives), was a significant advance. Bronze was stronger

than copper, better held the sharpness of cutting edges and had greater resistance to corrosion. The Bronze Age is characterized by the flourishing of crafts, in particular, the manufacture of weapons, tools, dishes and art products. Bronze casting methods made it possible to create complex shapes and products.

The transition to the Iron Age was due to the development of iron processing technology, which, although it required higher temperatures for processing than copper or bronze but provided much stronger products. Iron was widely used in the manufacture of tools, weapons, and also in construction. Iron processing included smelting from ore, forging and tempering, which made it possible to obtain products of different hardness and strength.

The transition from the use of copper to bronze, and then to iron, was associated with the search for materials that could better meet the needs of the development of society in tools, weapons and other objects of use. Each new stage in the development of metallurgy contributed to the expansion of the capabilities of mankind, leading to changes in the social system, military affairs, agriculture and culture.

Mining arose as a response to the growing need for metal resources. Initially, metal mining was carried out on the surface of the earth or at a shallow depth, where copper ores were easily available. However, over time, as the need for the metal grew, deeper mines began to be developed. The development of mining required considerable effort and innovation, including the creation of specialized equipment for ore extraction, transportation, ventilation and mine drainage.

Mining advanced significantly during the Bronze Age, when new types of ores were needed to produce bronze (an alloy of copper and tin). This encouraged the search and development of new deposits, as well as the development of trade between different territories and cultures. During the Bronze Age, the technologies of mining and metallurgy reached a high level of development, which made it possible to create a variety of tools, weapons and artistic products.

The development of mining and metallurgy contributed to changes in the social structure, economy and culture of ancient societies. Mining regions that had large reserves of metals often turned into centers of political power and economic prosperity.

At the same time, the development of the mining industry required a significant labor force and specialized knowledge, which led to the emergence of new professions and social roles, as well as to the strengthening of social stratification.

In addition, the development of mining and metallurgy affected trade routes and communications between different regions and cultures. Metals became important trade goods, which stimulated the creation of new trade routes and increased cultural exchange. Thus, the Bronze Age was marked by intense contacts between Egypt, Mesopotamia, Anatolia and other regions.

However, the exploitation of metals and the development of mining also had their negative consequences. Intensive metal mining led to the degradation of landscapes, depletion of natural resources and environmental pollution. In addition, mining activities were often associated with brutal labor and the use of slave labor.

Despite these challenges, the use of metals and the development of mining have been crucial factors in the progress of human civilization. They not only provided materials for the production of tools, weapons and other objects, but also stimulated technological innovation, social and cultural change, contributing to the development of art, science and architecture.

Features of construction in the countries of the East (Egypt, China, India, Japan)

Building techniques and architectural styles varied considerably among the ancient civilizations of the East, reflecting unique cultural traditions, climatic conditions, and available materials.

Ancient Egypt was famous for its monumental buildings, especially the pyramids, which served as the eternal dwellings of the pharaohs in the afterlife. The Egyptians used limestone, sandstone and granite quarried along the Nile. Engineers and builders of Egypt achieved great success in masonry, able to create precise geometric shapes and raise huge blocks to significant heights without modern equipment.

The construction of the pyramids in Egypt, especially the Great Pyramid of Giza, is one of the greatest achievements of ancient civilizations. These monumental structures were built as tombs for the pharaohs, demonstrating the power and religious beliefs of the Egyptians. According to generally accepted theories, the pyramids were built with the help of a large number of workers who used stone cut in quarries and transported it to the construction site. Construction techniques included the creation of clay and wooden skates, as well as the use of ramps to lift heavy stone blocks. Although the exact methods and tools used in construction remain a subject of research, the engineering genius and organization that went into creating these structures is still impressive today. The pyramids testify to the high level of mathematical and astronomical knowledge of the ancient Egyptians.

In China, architecture developed with an emphasis on harmony with nature and symmetry. A feature of Chinese architecture is the use of wood as the main building material, as well as complex roof systems that amaze with their beauty and complexity. The construction of the Great Wall of China, which was supposed to protect the empire from attack, is a great achievement of engineering thought, demonstrating the use of various materials and adaptation to different landscapes.

In ancient China, architectural development reached a high level of craftsmanship, especially through the use of plank construction and the use of brackets. The plank method made it possible to connect wooden beams without the use of nails, creating strong and flexible structures that could withstand seismic loads.

A particularly important technique was the use of brackets — complex wooden joints that acted as elements distributing the load between the pillars and the roof. These structures not only increased the stability of the building, but also allowed for the creation of elegant architectural forms with wide projecting roofs.

Brackets also played an aesthetic role, as they were delicately carved and often decorated with ornaments. Such designs demonstrated the high level of craftsmanship of ancient Chinese craftsmen and their deep understanding of materials.

Indian architecture is known for its complexity and variety, from majestic temples to intricate reservoirs. Different building materials were used in India,

including stone, brick and wood, depending on the region. The peculiarity of Indian construction is its ornamentation and the use of pillars, domes and arches, as well as the embodiment of religious and symbolic motifs in the design.

Mohenjo Daro, located in modern Pakistan, is one of the greatest architectural wonders of the ancient world. This city flourished around 2600-1900 BC. in the era of the Indus civilization, impresses with its expanded planning structure and advanced engineering thought. Mohenjo-Daro had a well-planned network of streets that intersected at right angles and an advanced system of water supply and sewage, indicating a high level of organization of urban life.

One of the most significant finds is a large bath, which was probably used for ritual rites. Mohenjo-Daro's sewage system, consisting of paved channels under the streets, is a testament to the engineering genius of its inhabitants. The buildings were built of burnt bricks, which ensured their long-term stability.

This ancient metropolis demonstrates an exceptional level of urban planning and social organization, making Mohenjo-Daro not only an archaeological site, but also a testament to the high level of development of the ancient Indus Valley Civilization.

Japanese architecture is characterized by minimalism, functionality and a close connection with the natural environment. Traditional Japanese houses were built in a minimalist style, with an emphasis on functionality and the use of natural light. Japanese houses were often built with variable weather conditions such as earthquakes in mind, leading to the development of lightweight, flexible structures that could withstand seismic vibrations.

Traditional Japanese architecture is also characterized by the use of sliding doors (fusuma and shoji), which allows for easy changes in the internal layout of the space. Interiors are often simple and elegant, with an emphasis on natural materials such as wood, straw and paper. These features contribute to a calm, balanced atmosphere that reflects the Japanese understanding of beauty and nature.

Military equipment of ancient times

The military techniques and strategies of the ancient world were diverse and innovative, especially in the field of siege technology. The siege weapons of ancient times were designed to breach or besiege defensive structures, including city walls, fortresses, and castles.

One of the earliest forms of siege weapons was the catapult. It was used to launch heavy projectiles, such as stones or combustible materials, over long distances. Catapults varied in size and design, but most operated on the principle of lever and tension. These machines could cause serious damage to defense structures or enemy troops.

A ballista was similar to a large bow or crossbow and was used to launch arrows or darts. These siege weapons were essential for accurate fire on enemy soldiers or for vulnerable parts of defensive structures. Ballistae had great accuracy and significant penetration power, which made them indispensable during sieges.

A siege ram was a massive structure, usually made of wood, designed to break down a city's gates or walls. Rams were often equipped with a metal or iron tip and used mass and inertia to inflict maximum damage. In addition to their primary function, battering rams could also act as protection for troops approaching enemy walls.

Siege towers were tall, movable structures that allowed attackers to be level with the top of defensive walls or fortresses. They were equipped with ladders or bridges, which allowed soldiers to quickly and directly attack defensive positions. Siege towers helped overcome key defensive obstacles and contributed to the success of the siege.

Warships of the ancient world played a key role in naval battles and sieges. From Egyptian and Phoenician watercraft to Greek triremes and Roman warships, these vessels were designed to dominate the seas and support military operations.

Greek triremes were fast and maneuverable rowing ships equipped with three rows of oars on each side. These ships had a carved protruding nose, which was used to pierce enemy ships. They could also carry light infantry units for boarding.

The Romans adapted the Greek design of the trireme, developing their own multi-tiered warships such as the quinqueremes. They had a large capacity and were

able to carry more soldiers and equipment. Roman ships could also be equipped with a corvus - a boarding bridge that allowed soldiers to quickly board enemy ships.

Phoenician and Egyptian ships, mainly merchant ships, could also be equipped for fighting. They were longer and wider than triremes, with a large cargo capacity that allowed them to carry large numbers of troops or siege equipment.

Warships of the ancient world were used not only to directly engage enemy fleets, but also to lay siege to coastal cities, control trade routes, and support land forces. They could make surprise attacks, intercept enemy ships and transport troops over long distances.

Mathematical and natural knowledge of ancient civilizations

Ancient civilizations made a significant contribution to the development of mathematical and natural knowledge. Their methods of obtaining scientific knowledge and specific discoveries formed the basis of many modern scientific disciplines.

Ancient peoples used a variety of methods to study the natural world, which included observation, experimentation, and logical reasoning. They studied astronomy, geometry, mechanics and medicine using the tools and knowledge available to them.

Observation and Recording - Ancient astronomers such as the Babylonians and Egyptians made careful observations of the celestial bodies, which allowed them to create complex calendars and develop systems of timekeeping.

Practical Application – In many fields, such as engineering and medicine, ancient peoples used empirical methods to solve practical problems. For example, land management and irrigation techniques were developed in Babylon and Egypt.

Logical Reasoning and Mathematical Calculations – The Greeks made significant contributions to the development of deductive reasoning and mathematical logic, especially in geometry and philosophy.

The achievements of ancient civilizations in the fields of mathematics and natural sciences can be illustrated by the following examples:

Eratosthenes and Measuring the Circumference of the Earth - Eratosthenes of Cyrene, living in the 3rd century BC, used observations of the sun and geometric

calculations to determine the circumference of the Earth with astonishing accuracy. He compared the angle of the sun's rays in two different cities - Alexandria and Syene (now Aswan) - and used the difference to estimate the total circumference of the planet.

Babylonian Mathematics – The Babylonians, who flourished around 2000 BC, developed a complex system of arithmetic and algebra, and had advanced knowledge of geometry. They used the hexadecimal number system, which is the basis for the modern division of time into hours, minutes and seconds, as well as angles in degrees.

Greek Geometry - The Greeks, especially Euclid, who lived in the 3rd century BC, made a significant contribution to the development of geometry. Euclid's Elements is one of the most influential mathematical works of all time, formalizing the axioms and theorems that form the basis of modern geometry.

Indian Mathematics - Indian scientists made significant contributions to the development of mathematics, including the introduction of zero as a number and the development of the decimal number system. The great mathematician Aryabhata worked on algebra, trigonometry and astronomy. His work included the calculation of the value of π with great accuracy, as well as methods for calculating the ecliptic of the sun and moon.

Chinese natural science - Chinese scientists made numerous discoveries in the field of natural science, including meteorology, geology, and medicine. They developed early forms of seismographs to determine the direction of earthquakes and developed extensive herbaria.

Control questions for the topic:

1. What historical evidence and archaeological findings support the discovery and use of fire by ancient people? Describe the fire-making methods known in ancient times.
2. What was the significance of the invention of the bow and arrow for the development of primitive societies? How did this affect hunting, warfare, and social structures?

3. Describe the process of the emergence of agriculture and the role of complex tools in this process. How did society change with the transition from gathering to agriculture?
4. Tell about the beginning of the use of metals in the production process and its influence on the development of civilizations.
5. Describe the features of architecture and construction in the ancient civilizations of the East (Egypt, China, India, Japan). What technologies and materials were used?
6. What types of military equipment were distributed in the ancient world? Give examples of the use of military equipment in historical battles.
7. How did mathematical and natural knowledge develop in ancient civilizations? Give examples of important achievements.
8. How did the change in technology and the accumulation of scientific knowledge in ancient civilizations affect the further development of mankind?

Lecture 3. Technique of the Middle Ages. Scientific knowledge of the XV-XVI centuries.

1. Medieval workshops and their influence on the development of production.
Features of the emergence of manufacturing production.
2. Scientific and technical achievements of the countries of the Middle and Far East during the Middle Ages.
3. Development of natural science during the Late Middle Ages. The beginning of book printing.
4. Blast furnace production in the XIV-XVI centuries.
5. A water wheel is a manufacturing engine.
6. Prominent scientists of the Middle Ages: N. Copernicus, J. Bruno, G. Galileo , J. Kepler

Medieval workshops and their influence on the development of production

Medieval workshops were the foundation of craft production and had a significant impact on economic life in Medieval Europe. They served not only as a place for the manufacture of goods, but also as centers of learning and knowledge transfer, and played an important role in the development of local economies.

The production process in the workshops was closely connected with the system of apprenticeship and apprenticeship. Young apprentices began their studies under the guidance of an experienced master, learning the intricacies of the craft and gradually acquiring the necessary skills. After years of study and completion of qualifying work, a student could become an apprentice, and then a full-fledged master and a member of the workshop.

Production of goods in workshops was carried out manually and was very time-consuming. This contributed to the high quality and individuality of the products, but at the same time limited the number of products that could be created. Each shop specialized in a particular craft, such as blacksmithing, weaving, goldsmithing,

leatherwork, or stonemasonry, which ensured a high level of knowledge and skill in each specific field.

In the medieval workshop, the production process had a clearly defined structure and stages, the responsibility for which lay entirely with the craftsman. He not only managed production but was also a guarantor of product quality. The first stage consisted in the selection of materials that the master or his students purchased from the local market or received from suppliers. This was followed by the process of processing raw materials to the desired form or state. This could include smelting metal, working wood, or mixing ingredients to make paints.

Then the craftsman or skilled craftsmen began the main production, forming the final product. They used specialized tools and techniques that were passed down from generation to generation. At this stage, the master had to directly monitor the quality of work and compliance with workshop standards.

The last stage included finishing the product, checking it for compliance with quality standards and, if necessary, marking the workshop or the master's personal mark. The finished product was then sold on the local market, through the workshop bench or to customers.

The workshops had a significant influence on the monopolization of production in medieval cities. They set rules and standards for the production of goods, controlled prices and regulated competition. Guild membership conferred the exclusive right to manufacture and sell certain goods in a specific area, effectively limiting production to guild members. This protected the interests of the craftsmen, but also limited competition and innovation.

The guild system also provided support to its members, including financial assistance in case of illness or inability to work, as well as pension contributions and funeral expenses. This created a strong social network among the artisans, strengthening their economic and social position in the urban community.

However, the monopolization of production through the guild system also had its drawbacks. High entry requirements and strict regulations could limit market entry

for new entrants, inhibiting innovation and productivity. It could also lead to higher prices for consumers due to limited competition and controlled prices.

Despite this, the workshops significantly contributed to the development of local economies and production processes. They ensured the standardization of products, maintained the high quality of goods and contributed to the development of crafts and skills that were passed down from generation to generation. The guild system also encouraged the development of urban culture and identity, which was particularly important in the context of the Middle Ages, when cities began to acquire more autonomy and political power.

Features of the emergence of manufacturing production

Manufacturing production in Europe, which originated between the 15th and 18th centuries, laid the foundation of the capitalist economy. It was characterized by the concentration of production in the hands of entrepreneurs who invested capital in the means of production and hired workers. This approach made it possible to significantly increase the volume and efficiency of production compared to home or artisanal methods.

The first manufactories arose in Italy, Flanders, and later their number increased in England, France, the Netherlands and Germany. England became a pioneer of the industrial revolution, where thanks to the development of manufactories, the prerequisites were created for a large-scale transition to factory production. This geographical spread of manufactures contributed not only to the development of capitalism, but also to the strengthening of the economic positions of these regions.

Manufacturing marked a departure from the feudal economy based on land ownership and serfdom and laid the foundations for the modern economic system, where capital, investment and market competition play a key role.

Manufacturing marked an important stage in the development of industry, playing a key role in the transition from artisan shops to industrial production. Manufactories were characterized by a more pronounced division of labor, the use of innovations in the production process, and an increase in the scale of production.

The division of labor in manufactories was much more pronounced than in traditional craft workshops. In factories, the work process was divided into smaller operations, which allowed workers to specialize in the performance of a certain task. This contributed to increased efficiency and productivity, as each employee became an expert in their specific field.

Manufactories introduced a number of innovations in the production process, including the improvement of tools and mechanisms, the introduction of new technologies and the use of more efficient materials. This not only improved product quality, but also reduced production costs. The introduction of water and windmills, which provided energy for various production processes, was a significant breakthrough during this period.

Three types of manufactories: centralized, scattered, mixed

Centralized factories, also known as factory factories, were characterized by the concentration of all stages of the production process under one roof. This type of production allowed the owners to have better control over product quality, production costs and the work process in general. Centralization facilitated an effective division of labor as workers could specialize in specific tasks, which in turn increased productivity and optimized production cycles. The use of machines and other technical means became more efficient due to centralization.

Dispersed manufactories (or home production) consisted in the fact that the various stages of production were distributed among many workers who worked separately from each other, often at home. This system was common, for example, in the textile industry, where workers made products according to orders, receiving materials and instructions from entrepreneurs or merchants. Although this type of production provided flexibility and the ability to produce in rural areas, it had low productivity and made it difficult to control product quality.

Mixed manufactories combined elements of both centralized and distributed production systems. In such a model, some stages of production could be concentrated in one place, while others - distributed among different workers or groups of workers. This approach made it possible to take advantage of both systems: centralization helped

increase production efficiency and quality control, while distributed production provided flexibility and the ability to use labor.

Scientific and technical achievements of the countries of the Middle and Far East during the Middle Ages

The Middle Ages in the countries of the Middle and Far East was a period of significant scientific and technical achievements. At this time, the Muslim world and China made a great contribution to the development of fundamental knowledge and engineering.

During the Golden Age of Islam, scientists in the Muslim world made revolutionary breakthroughs in many fields of knowledge, including mathematics, astronomy, medicine, chemistry, and engineering. Centralized power, a favorable cultural atmosphere, and the attraction of knowledge from all conquered territories allowed Islamic scholars to collect, preserve, and expand the knowledge of ancient Greek, Persian, and Indian cultures.

In the Middle Ages, Arab universities played a key role in the preservation and development of scientific knowledge. Centers of learning such as Al- Qaraouin in Fez (Morocco), founded in 859, and Al- Azhar in Cairo (Egypt), founded in 972, became places where scholars from different parts of the world gathered.

Arab universities not only preserved and improved the knowledge of the ancient world, but also actively contributed to its dissemination through translations into Arabic of the works of Greek, Persian and Indian scientists. This set the stage for the Renaissance in Europe, when through translations from Arabic into Latin, Europeans gained access to the lost knowledge of antiquity and to new ideas.

Muslim scientists of the Middle Ages made a significant contribution to world science, their research and inventions influenced numerous fields of knowledge. Al- Khwarizmi, for example, is considered the father of algebra. His works on mathematics formed the basis of this science and were actively used in Europe, stimulating its development in the Renaissance. His introduction of the algorithm concept became fundamental for modern computer science.

Ibn Sina (Avicenna), an outstanding Persian scientist, the author of the "Canon of Medical Science", influenced the development of medicine not only in the Islamic world, but also in Europe, where his works remained the main medical textbooks for many centuries.

Al-Biruni, one of the greatest scientists of his time, made significant contributions to astronomy and geography. His research included accurate astronomical observations and calculations, as well as detailed geographical descriptions of various regions. He also experimented with cartography, improving methods of measuring distances and angles.

In the field of engineering, Muslim scholars made significant contributions, developing complex water systems for irrigation and drinking water supply that were critical to agrarian societies. The development of clocks and other mechanical devices demonstrated a high level of technical skill and innovative thinking.

These scholars and their innovations were extremely important, not only enriching scientific and technological development in the Muslim world, but also promoting cultural and scientific exchange between East and West.

In China, where Confucianism influenced all aspects of life, including education and government, this period was also a time of great technical innovation. Confucian thought, with its emphasis on the stability, order, and harmony of nature, contributed to the development of fields such as agronomy, engineering, and architecture.

One of the most famous Chinese innovations of this era is the invention of gunpowder, which changed the conduct of warfare around the world. The Chinese also developed a printing press with moving elements, which greatly accelerated the spread of knowledge. Other significant inventions included the water wheel, which was used to irrigate fields and mills, and paper, which made possible the widespread dissemination of written information.

Gunpowder was invented around the 9th century. Initially, it was used in medicine, but over time, its potential for military purposes was realized. Gunpowder is the basis for the manufacture of explosives and projectiles, which radically changed the course of warfare, and later global history.

The compass, invented in the 11th century as a tool for divination, soon became indispensable in navigation. Its use enabled sailors to navigate sea voyages regardless of the weather and time of day, contributing to the development of sea trade and the exploration of new lands.

A seismograph invented in 132 AD by the scientist Zhang Heng, was designed to detect and indicate the direction of distant earthquakes. This device, which was far ahead of its time based on the principle of operation, testifies to the deep understanding of natural phenomena by Chinese scientists.

In engineering, China was noted for large-scale projects such as the Grand Canal, which promoted trade and economic growth, and irrigation and water management systems that increased agricultural productivity. China's bridges, roads and fortifications, including the Great Wall of China, also testify to a high level of engineering thought and planning.

Confucianism contributed to the development of administrative and engineering systems that supported the stability and efficiency of the state. Confucian scholars such as Zhu Xi promoted educational and administrative reforms, which in turn positively influenced technical and engineering advances.

The influence of these cultural and philosophical traditions on the scientific and technical achievements of the Middle and Far East in the Middle Ages cannot be underestimated. They provided the ideological framework and social context in which new ideas and technologies could develop, influencing the further development of world science and engineering.

Development of natural science during the Late Middle Ages

The late Middle Ages was a period of significant changes in the development of natural science, when classical knowledge was reinterpreted and integrated with new research methods. Christianity and the development of universities played a significant role in the formation of scientific thought of that time.

Christianity exerted a significant influence on the development of the natural sciences in the Middle Ages, providing the intellectual context in which many scientists

conducted their research. The Church supported the study of the natural world as a means of better understanding God's creation. However, there were certain limitations: studies that contradicted biblical texts or church doctrines were often criticized or banned.

Universities became important centers for the study of natural sciences in the Late Middle Ages. They provided a structured environment for learning and debate, allowing scholars to meet, discuss and compare ideas. Oxford, Paris, Bologna and other university cities became important centers of scientific progress, where such disciplines as medicine, mathematics, astronomy and philosophy developed.

Alchemy in the Late Middle Ages was considered not only a mystical practice, but also a serious scientific pursuit. Alchemists had an ambitious goal - to turn base metals into gold, to find the elixir of life that could grant eternal life, and to reveal the hidden secrets of nature. At first glance, these tasks may seem naive or unattainable, but they prompted alchemists to deeply explore the material world.

In pursuit of their goals, alchemists developed and used a variety of laboratory instruments and techniques, many of which became the foundation for modern chemistry. They conducted complex experiments on distillation, sublimation, crystallization and filtration, systematized recipes and techniques that were passed down from generation to generation.

This experimental approach, despite its focus on obtaining mythical results, made a significant contribution to the development of the scientific research method. Alchemy also stimulated interest in the study of minerals, plants, and animals, contributing to the development of natural philosophy, which was later transformed into natural science.

Although modern science rejects alchemy as a pseudoscience because of its mystical and speculative aspects, its contribution to the development of scientific knowledge and methodology cannot be ignored. Through the research of alchemists who sought to understand and control natural processes, the foundation for modern chemistry and pharmaceuticals was laid.

Roger Bacon, an English philosopher and scientist, is one of the key figures in the development of the scientific method in the Late Middle Ages. He emphasized the importance of observation, experiment, and mathematical analysis in the study of the natural world. Bacon believed that a deeper understanding of the universe and God's laws can be gained through a systematic study of nature. His approach laid the foundations for the empirical scientific method that would come to dominate European science during the Renaissance and Enlightenment.

Bacon is also known for his work on optics, as well as research in other branches of science, including mechanics and astronomy. He called for the reform of scientific education and the adoption of an integral approach to knowledge that unites various scientific disciplines. An important aspect of his philosophy was the conviction that knowledge should serve practical purposes and contribute to the improvement of human life.

In general, the development of natural science in the Late Middle Ages was closely related to the religious, philosophical and cultural changes taking place in the society of that time. Christianity, on the one hand, provided an ideological basis for the study of nature, but on the other hand, it could limit the areas of research that contradicted the dogmas of faith. Nevertheless, this period laid the groundwork for more systematic and experimental approaches to science that would later lead to significant discoveries and technological innovations.

The beginning of book printing

The beginning of book printing became one of the most significant events in world history, which radically changed the distribution of knowledge and information. This process began in China, developed in Europe thanks to Gutenberg and was reflected in Eastern Europe, in particular in the work of Ivan Fedorov.

China is the birthplace of book printing. Already in the 7th century, wooden boards were used here for printing texts. However, a major breakthrough was the invention of movable elements made of ceramics around 1040 BC Shenem during the Song Dynasty. This technology made it possible to significantly increase the speed and

volume of production of printed materials. However, due to the large number of characters, movable type did not become very popular in China compared to block printing.

In Europe, the revolution in book printing took place in the 15th century thanks to Johannes Gutenberg, who invented the printing method using movable metal letters. This happened around 1440 in Mainz, Germany. Gutenberg's press significantly reduced the cost of producing books and made them available to a wider range of readers. Gutenberg's most famous work is the 42-line Bible, which was completed around 1455. This event marks the beginning of mass book publishing in Europe and is an important moment in the development of the Renaissance, the Reformation and the Scientific Revolution.

Ivan Fedorov, who is considered one of the founders of book printing in Eastern Europe, in particular in Ukraine, made a significant contribution to the development of book printing. One of the most famous works that were printed by Ivan Fedorov on the territory of modern Ukraine is "The Apostle" - the first known printed book in Russia. It was printed in Lviv in 1574. "Apostol" is a collection of liturgical texts of the New Testament, which are read in the church during the year. This book had great religious and cultural significance, contributing to the spread of the Orthodox faith and the Church Slavonic language.

Another significant work of Ivan Fedorov is "Primer", which was also printed in Lviv in 1574. This study guide was intended for teaching literacy and the basics of the Orthodox faith. It included the alphabet, prayers, alphabet texts and other educational materials aimed at facilitating the process of learning to read and write.

These publications of Ivan Fedorov had a significant impact on cultural and religious life in Ukraine, contributing to the spread of literature, education and Christianity. They also played a key role in the development of Ukrainian printing and culture in general, marking the beginning of a new era in the information space of the region.

Blast furnace production in the XIV-XVI centuries.

Blast furnace production, which developed in the XIV-XVI centuries, became a significant breakthrough in the metallurgical industry and had a huge impact on the development of production and technology in the Middle Ages.

Blast furnace production first appeared in China, where it was developed as early as the eighth century, but its main spread in Europe occurred between the 14th and 16th centuries. In Europe, such regions as Lorraine (modern Belgium and France), Germany, Sweden and England became centers of blast furnace production. These geographic regions had large reserves of iron ore and wood needed to produce pig iron.

Blast furnace production in the late Middle Ages became an important technological breakthrough, which marked the transition from manual production of iron to its mass production. The process involved producing pig iron from iron ore in a large furnace known as a blast furnace.

In the first stage, iron ore, along with auxiliary materials such as limestone (which acted as a flux to remove impurities) and coke or charcoal (as fuel), was charged into a blast furnace. An important innovation was the use of coke, which made it possible to reach higher temperatures compared to traditional charcoal.

Then the fuel was ignited, and with the help of blowing - special mechanisms for supplying air - the necessary temperature was maintained in the furnace, which promoted chemical reactions between the ore and the flux. As a result of these reactions at higher temperatures, iron was separated from impurities, turning into liquid cast iron, which collected at the bottom of the furnace.

The final stage was the release of liquid iron and slag through special holes. Cast iron could be used as an end product or further processed into steel products. Slag, a by-product of the process, was used in construction as a component of building materials.

This technological process not only increased the production of iron, but also improved its quality.

The appearance of cast iron as the main product of blast furnace production significantly changed metallurgy and production processes. Cast iron had greater

strength and hardness compared to traditionally produced iron, making it an ideal material for the production of weapons, armor, tools, and building materials. The development of blast furnace production also contributed to an increase in the volume of metal production, a decrease in the cost of products, and the development of new technologies.

The growth of cast iron production led to the development of new methods of its processing, in particular puddling and rolling, which made it possible to obtain softer and more flexible forms of iron suitable for a wider range of applications. It also further contributed to the development of engineering structures such as bridges and railways, which were made possible by the use of strong and reliable metal.

The development of blast furnace production also had a significant socio-economic impact. It contributed to the growth of urbanization, as new cities and communities were formed around metallurgical centers. In addition, the demand for coal as the main fuel for blast furnaces contributed to the development of the mining industry.

However, on the other hand, intensive use of natural resources such as wood and coal has led to environmental problems, including deforestation and air pollution. Also, this period was accompanied by social changes, as traditional artisanal methods of production gradually took a back seat to large-scale industrial production.

A water wheel is a manufacturing engine

During the Middle Ages, the water wheel became one of the most important inventions that significantly changed the landscape of manufacturing production. The use of water wheels made it possible to mechanize many processes that were previously performed manually and significantly increase labor productivity.

Water wheels can be classified according to the place and method of their installation: horizontal and vertical. Horizontal wheels (turbines) are located directly in the water flow, which drives them. Vertical wheels are divided into bottom and top pressure wheels depending on how the water is supplied to the wheel: through the top or directly below it.

The efficiency of water wheels was quite low compared to modern standards and usually did not exceed 20-30%. However, in those days it was a significant achievement, as it allowed to automate production and increase its scale.

Traditionally, waterwheels were made of wood, although some parts could be made of metal, especially in areas subject to the most wear and tear, such as the wheel axle and bearings. The choice of materials was often determined by local conditions and the availability of resources.

Water wheels were used in various branches of manufacturing production. The most common use was in milling, where wheels were used to grind grain into flour. It was a living room for agriculture, which was the basis of the medieval economy.

In addition to mills, water wheels were used in the textile industry, where they powered looms and wool processing machines. In the mining industry, water wheels were used to drive pumps that pumped water out of mines, as well as to ventilate mine workings. In the sawmill industry, they helped automate the process of sawing wood.

In addition, water wheels were used to power the smith's hammers in the forge, greatly simplifying the process of working with metals and allowing the creation of large-scale metal products such as weapons, armor, and various tools.

The efficiency of water wheels, their ability to work without interruption, and the low cost of operation (since the main "fuel" was water) made them indispensable in many aspects of medieval production. However, the development of water wheels and their use required appropriate infrastructure, such as the construction of dams, canals and reservoirs, which in turn contributed to the development of hydraulic engineering.

The introduction of waterwheels not only promoted industrial development, but also catalyzed social change, as increased production and labor efficiency required more skilled labor and led to urban population growth. Thus, the water wheel became one of the key elements of the industrial development of the Middle Ages, laying the foundation for future technological innovations.

Prominent scientists of the Middle Ages

The Middle Ages and Early Modern Times were a period of significant scientific discoveries and intellectual changes that set the stage for the Scientific Revolution. Scientists such as Nicolaus Copernicus, Giordano Bruno, Galileo Galilei, and Johannes Kepler made fundamental contributions that changed the understanding of astronomy, physics, and mathematics.

Leonardo da Vinci, known as one of the greatest geniuses of the Renaissance, made significant contributions not only in the field of art, but also in science and engineering. His boundless curiosity about nature and the human body, combined with deep knowledge in various fields, allowed him to create projects that were several centuries ahead of their time.

Leonardo da Vinci left behind numerous drawings and records that demonstrate his engineering ideas and inventions. He designed flying machines based on observations of birds and principles of aerodynamics, including the ornithopter, a machine that imitates the wings of a bird. Leonardo also developed concepts for the parachute, helicopter, and light-powered aircraft.

In the field of military equipment, he created drawings of various types of artillery, multi-barreled guns, and also designed fortifications and fortifications. At the same time, Leonardo invented various mechanisms for raising water that could be used in agriculture and construction.

Da Vinci also worked on civil engineering projects, including sewerage systems for cities, bridges with innovative designs, and the design of the ideal city based on the principles of health and hygiene.

One of his most famous works is the Vitruvian Man, a drawing illustrating the proportions of the human body based on the works of the ancient Roman architect Vitruvius. This work symbolizes the synthesis of art and science and is an example of harmony and measure in nature. It also reflects da Vinci's ideas about man as a microcosm that reflects the structure of the entire universe.

Nicolaus Copernicus (1473–1543) is known primarily for his theory of the heliocentric world system, which opposed the generally accepted at that time Ptolemy's

geocentric system. In his work "On the Rotation of the Celestial Spheres", Copernicus proposed the idea that the Sun is at the center of the universe, and the Earth and other planets revolve around it. This theory became an important step in the development of astronomy and natural science in general, because it required the rejection of old ideas and the adoption of a new worldview.

Giordano Bruno (1548–1600) was an Italian philosopher who supported and developed the Copernican system. He argued that the universe is unlimited and contains an infinite number of worlds revolving around their suns. Bruno also disputed the Aristotelian concept of fixed stars fixed in a sphere. His ideas were radical for the time and contributed to the further development of astronomical thought, but also led to his persecution and execution.

Galileo Galilei (1564–1642) is often called the "father of modern astronomy" due to his methodical observations and scientific discoveries. Using a telescope, he discovered the four largest moons of Jupiter (known as the Galilean moons), the phases of Venus, and mountains on the Moon, confirming Copernicus' heliocentric model. Galileo also made important discoveries in the field of physics: he studied the motion of objects and formulated the laws of inertia, which were later developed into Newtonian mechanics. His methods of experimental research and mathematical analysis became the foundation for modern scientific methodology.

Johannes Kepler (1571–1630) made significant contributions to astronomy by developing the three laws of planetary motion that describe the orbits of the planets around the Sun. These laws became an important step in the development of astronomy, because they not only confirmed the heliocentric system of Copernicus, but also provided an accurate mathematical description of the motion of the planets. Kepler also worked on optics and made important contributions to the development of telescopic lenses, which improved the quality of astronomical observations.

Kepler, like Galileo, used mathematics as a language to describe natural phenomena, which strengthened the scientific revolution and contributed to the transition from Aristotelian to a new, more empirical and mathematical scientific paradigm.

These scientists not only made a huge contribution to the science of their time, but also laid the foundations for future generations of scientists, significantly changing the understanding of the natural world. Their discoveries and research methods influenced many fields of knowledge and continue to inspire scientific research to this day.

Control questions for the topic:

1. How did medieval workshops influence the development of production and socio-economic structures in the Middle Ages? Describe the main characteristics of the workshop system.
2. What were the peculiarities of the emergence of manufacturing production compared to workshop production? How did the manufactory differ from traditional workshops?
3. Describe the scientific and technical achievements of the countries of the Middle and Far East during the Middle Ages. What influence did they have on world history?
4. What factors contributed to the development of natural science in the Late Middle Ages? Give examples of specific achievements or discoveries of this period.
5. What was the importance of book printing for the development of science and culture? What changes did it make in the dissemination of knowledge?
6. Describe the role of blast furnace production in the development of the metallurgical industry of the XIV-XVI centuries. How did it affect the economy and technical development?
7. What role did the water wheel play in manufacturing? What were the technical and economic consequences of its use?
8. Describe the contributions of prominent scientists of the Middle Ages, such as Nicolaus Copernicus, Giordano Bruno, Galileo Galilei, and Johannes Kepler, to the development of the scientific worldview. How did their theories and discoveries affect the further development of science?

Lecture 4. Development of technology and scientific knowledge in the mid-18th - 19th century.

1. Industrial revolution in England. Invention of the steam engine.
2. The emergence of mechanical engineering.
3. Technological revolution in transport.
4. Creation of classical natural science.
5. Development of the metallurgical industry.
6. Technical revolution in means of communication.

Industrial revolution in England

The Industrial Revolution in England in the 18th century was the result of a number of favorable factors that combined to create the conditions for radical changes in production and society. First, population growth increased the demand for goods and services while providing labor for factories and manufactures. Second, the geographical location of England and its colonial settlements provided access to raw materials and sales markets. Third, technological innovation, especially in the textile industry and metallurgy, greatly increased productivity. In addition, the development of the transport system, in particular railways, revolutionized the distribution of goods and raw materials.

Belgium became the second country after England to start the Industrial Revolution, thanks to its coal reserves and strategic geographical location. Belgium quickly adapted English technology and production methods, especially in textiles and metallurgy.

France developed somewhat more slowly due to the social and political upheavals of the late 18th and early 19th centuries. However, improvements in agriculture, railway construction and the development of mechanical engineering marked the beginning of French industrialization.

Germany began its path to industrialization by merging small states into a single country. The focus on heavy industry, chemical industry and exports contributed to the rapid industrial development of the country.

The United States of America adapted and developed British technology, becoming a leader in some industries, including steel and automobiles, thanks to its natural resources and entrepreneurship.

The Industrial Revolution led to a shift from manual labor to machine-based production, which increased the speed and scale of production. For the first time in history, goods began to be produced so quickly and massively that they became available to a wide range of consumers, not just the elite. England's economy underwent significant changes: incomes and national wealth rose, but so did the gap between rich and poor.

The industrial revolution caused profound social changes. The migration of labor from rural areas to cities has caused urbanization and changes in lifestyles. Working conditions in early factories were brutal and dangerous, causing growing discontent among workers. At the same time, a working class was formed, which began to organize strikes and trade unions, demanding better working conditions and higher wages.

A reaction to these changes was Luddism, a movement that arose in the early 19th century among English workers who protested against mechanization, which they believed threatened their work and well-being. Luddites, named after the mythical leader Ned Ludd, carried out attacks on factories, destroying machines that they considered the cause of their impoverishment. These actions were among the first examples of industrial protest and class struggle triggered by technological change.

Luddite movement testified to deep social discontent caused by rapid changes in production processes. The government's response to the actions of the Luddites was decisive and harsh - the destruction of cars was made a capital crime, and many Luddites were arrested, convicted or even executed.

The first industrial revolution brought with it profound social, economic and technological changes. Economically, it caused a significant increase in production and

productivity, thanks to the introduction of machinery that replaced manual labor. This led to a decrease in the cost of goods and an increase in consumption.

Socially, the coup created a new class of workers who moved from the countryside to the cities in search of factory work, which in turn led to urbanization and the growth of urban settlements. However, working conditions were often harsh, with low pay and long hours, creating social tension and prompting the birth of a labor movement and demands for reform.

Technologically, the revolution ushered in an era of innovation that continues to this day. The invention of the steam engine, the mechanical loom, and other technologies radically changed production processes. It also contributed to the development of transport - railways and steamships, which revolutionized trade and movement.

Overall, the first industrial revolution ushered in the modernization of society despite the challenges it created, paving the way for further technological and social innovation.

Invention of the steam engine

The development of the steam engine began with the work of Thomas Severy and Thomas Newcomen in the 17th and early 18th centuries. Thomas Severy, an English inventor, in 1698 patented the first machine that used steam to pump water out of flooded mines. Although his machine was imperfect and had limited efficiency, it laid the foundation for further developments.

Thomas Newcomen improved Severy's concept by creating his "atmospheric engine" in 1712. This engine was already more efficient and was widely used for pumping water from mines, becoming the first steam engine in practical use. However, both machines were limited by atmospheric pressure and had a high level of fuel consumption, which limited their use.

A revolutionary breakthrough in the development of steam engines occurred with the appearance of James Watt, a Scottish inventor. In the 1760s, while working to repair a model of the Newcomen engine, Watt realized that significant energy losses

occurred due to the cooling of the cylinder on each cycle. Watt made significant improvements to the design, including a separate condenser that kept heat inside the cylinder and, as a result, greatly increased the machine's efficiency.

In 1781, Watt developed a double-acting steam engine, which allowed the machine to work more evenly and with less steam consumption. His inventions, including the introduction of the centrifugal governor and parallel motion, standardized production and increased the potential of steam engines in various industries.

The basic principle of a steam engine is to use steam under pressure to create mechanical motion. The steam produced in the boiler is fed into the cylinder, where it expands and does work by pushing the piston. In Watt's engines, this expansion of steam occurred on one side of the cylinder and then on the other, allowing the piston to move back and forth. This piston motion is converted into rotary motion by a system of connecting rods and wheels, allowing the energy to be used for various purposes, such as powering looms, pumps, or mills.

A separate condenser, which Watt introduced into the design, made the process more efficient, as it reduced the energy losses that occurred when cooling the cylinder. In addition, it made it possible to reduce fuel consumption and make the engine more economical and efficient.

James Watt's steam engine became a key element of the First Industrial Revolution. Its widespread adoption contributed to the mechanization of production, especially in the textile industry, where looms could now operate much faster and more efficiently. Later, steam engines were used in mines to pump water, in the metallurgical industry to blow blast furnaces, and in many other industries.

In the metallurgical industry, steam engines were used to power blast furnaces and forge hammers, which made it possible to significantly increase the volume of steel and iron production. This, in turn, contributed to the development of mechanical engineering, as it became possible to manufacture larger and more powerful machines.

The transportation industry was also revolutionized by the steam engine. Steam locomotives and steamships radically changed approaches to the transportation of goods and passengers, significantly reducing travel time and increasing the volume of

transportation. This, in turn, had a huge impact on the development of international trade and the expansion of markets, a significant increase in production capacity, urbanization and social changes.

Agriculture also benefited from the use of the steam engine as it was used to power agricultural machinery such as tractors and combines, greatly increasing labor productivity and yields.

Thus, the invention and development of the steam engine had a profound impact on industrial production, the economy and society as a whole, ushering in an era of mass industrialization and technological progress.

The emergence of mechanical engineering

Mechanical engineering as a branch arose in response to the growing needs of the first industrial revolution. Early models of machines were aimed at automating and increasing the productivity of manual labor. One of the first and most famous examples was Richard Arkwright's water frame, which revolutionized the textile industry by allowing cotton to be drawn and spun automatically. This led to a significant increase in production and a decrease in the cost of fabrics.

Another important early invention is James Watt's steam engine, which found wide application in mechanical engineering, paving the way for the further development of various mechanical machines for various industries.

The development of mechanical engineering was closely related to scientific and technical innovations and the growing needs for mass production. The advent of milling, turning and drilling machines made it possible to automate the production of parts with high precision, which was impossible for manual processing.

The development of mechanical engineering was also closely related to the improvement of materials, in particular the production of high-quality steel, which made it possible to manufacture more durable and reliable machines. This, in turn, led to the standardization of components and the growth of mass production.

The influence of mechanical engineering on other branches of industry was profound and multifaceted. In the textile industry, machines made it possible to

significantly increase production volumes and reduce the cost of products. In mining, mechanization contributed to more efficient extraction of resources and improved working conditions. In metallurgy, improved machines and technologies made it possible to improve the quality of metal and simplify its processing.

Also, the impact of mechanical engineering was felt in agriculture, where such mechanisms as planters, harvesters and tractors appeared, which made it possible to mechanize harvesting and other agricultural work, significantly increasing productivity and reducing the physical burden on farmers.

The growth of mechanical engineering also contributed to the development of the transport industry. Railroads, steamships, and later automobiles and airplanes changed the face of transportation, making transportation faster, cheaper, and more accessible. This, in turn, opened the way for the globalization of trade and the convergence of different parts of the world.

All this led to significant social changes, stimulating migration from rural areas to cities, urbanization and the formation of a new social class - industrial workers. On the other hand, machine building also contributed to increased labor conflicts and social inequality, as many workers faced harsh working conditions, low pay, and job losses due to mechanization.

Thus, the emergence and development of mechanical engineering became a catalyst for the first industrial changes, which provided the foundation for the modern industrial economy, but also caused a number of serious social challenges, the consequences of which are still felt today.

Technological revolution in transport

Trains became a symbol of the industrial revolution and changed the face of transportation in the 19th century. One of the first steam locomotives, George Stephenson's "Rocket", demonstrated its superiority at the Rainhill Race in 1829, reaching a speed of almost 47 km/h. This success paved the way for the widespread use of steam locomotives in railway transport. The "Rocket" had a highly efficient

boiler, a multi-cylinder engine and used coal as fuel, which allowed it to generate significant power.

Other early steam locomotives, such as the Locomotive and Puffing Billy, also made significant contributions to the development of rail transport, increasing the speed of freight and passenger transport and reducing the cost of transport.

The steamboat was another important form of transportation that emerged during the Industrial Revolution. Robert Fulton's *Claremont*, launched in 1807, was the first successful steamship to make a commercial voyage on New York's Hudson River. This opened the way for the steamship industry and contributed to the development of river and sea transportation.

Steamships such as the *Great Britain* improved intercontinental travel by making it faster, more reliable, and more cost-effective. These ships could travel long distances without the need to refuel, reducing the travel time between Europe and America.

Although steam cars were not as widely used as steamships and trains, they too played a role in the development of transportation. Early models, such as Nicolas Joseph Cunho's car, showed the possibilities of using steam for individual transport. However, due to their large mass, limited range and long preparation time, steam cars did not become as common as steam locomotives and steamships. However, they contributed to further research and development of transport technologies, laying the foundation for the future automotive industry.

The technological revolution in transport had a profound effect on the economy and industry. Trains and steamships provided much faster and cheaper transportation of raw materials, goods and passengers, which contributed to the expansion of markets, the growth of trade and urbanization. This, in turn, stimulated the development of new industries, increased production volumes, and increased economic efficiency.

Railroads contributed to the intensification of the coal industry, as the need for coal as a fuel for steam locomotives increased dramatically. Also, the railways stimulated the development of the metallurgical industry due to the need for iron and steel for the construction of railway tracks and wagons.

Steamships played a key role in the development of maritime trade and international transport, reducing the cost and time of shipping goods between continents. This contributed to the globalization of the world economy, the growth of exports and imports, as well as the strengthening of economic ties between countries.

All of these changes have had significant social consequences, including mass labor migration, changes in lifestyles and work, and the formation of new social classes. The introduction of new transport technologies became one of the defining characteristics of the first industrial revolution, which had far-reaching consequences for the development of the modern world.

Creation of classical natural science

The first industrial revolution was a time of colossal changes not only in industry and technology, but also in science. This period marked the birth and development of classical natural science, with special emphasis on mathematics, physics, chemistry, biology, and mechanics.

Mathematics was fundamental for the development of other sciences. Leonard Euler, who lived and worked in the 18th century, made significant contributions to the development of mathematical analysis, number theory and other branches of mathematics. His work laid the foundation for modern mathematical analysis and influenced many other branches of science.

In the field of physics, a significant contribution was made by Isaac Newton, whose laws of motion and the universal law of universal gravitation became the basis of classical mechanics. His work "Mathematical Foundations of Natural Philosophy" laid out the foundations of physics, which remain important to this day.

In chemistry, Antoine Lavoisier, often called the father of modern chemistry, made revolutionary contributions by formulating the law of conservation of mass and creating the first systematic chemical nomenclature. His research changed the understanding of chemical reactions and formed the basis of chemical science.

In biology, Carl Linnaeus developed a system of classification of living organisms that helped organize and standardize natural knowledge. His work in the field of systematics became the basis for modern biological classification.

In mechanics Jean le Rond D'Alembert and Leonhard Euler made significant contributions to the development of the theory of dynamics and fluids, laying the foundations for hydrodynamics and the theory of elasticity.

This period was also characterized by the first beginnings of interdisciplinary research and the strengthening of the scientific method of research, which allowed the development of natural science based on empirical data and logical analysis. The development of experimental methodology, in particular in laboratory research, significantly increased the accuracy of scientific conclusions and contributed to further progress in all fields of science.

An important characteristic of this era was the creation and gradual introduction into scientific circulation of the scientific method as the main tool for the development of knowledge. It highlights the shift from speculative philosophy to a more grounded, experimental science based on observation, hypothesis, experiment, and deduction.

The development of classical natural science during this period not only expanded the boundaries of human knowledge about the surrounding world, but also laid the foundation for further technological innovations that would shape the industrial revolution and modern scientific and technological progress.

All these achievements of classical natural science had a profound impact on the economy and industry, stimulating the development of new production technologies, improving materials and processes, as well as improving methods of management and labor organization. They also contributed to the growth of general education and raising the cultural level of society, laying the foundations for the modernization of many aspects of human life.

The development of the metallurgical industry in the days of the first industrial revolution

The Industrial Revolution led to a rapid increase in the demand for iron and steel, which were essential materials for building cars, railroads, bridges, factories, and other infrastructure. Iron became critical to the development of transportation, especially after the invention of the steam locomotive and the widespread introduction of railroads, which connected distant regions and facilitated the development of domestic and international trade.

The development of metallurgy was closely related to technological innovations. In search of ways to increase production and improve metal quality, engineers and metallurgists developed new methods and processes. One such innovation was the puddling process, which made it possible to obtain higher quality iron by oxidizing carbon and other impurities in iron ore.

The Bessemer process, developed by Henry Bessemer in the middle of the 19th century, had a great influence on the development of the metallurgical industry. This method involved blowing air through molten iron to oxidize unwanted elements such as carbon, manganese and sulphur, turning iron into steel faster and cheaper than ever before. The Bessemer process revolutionized steelmaking and enabled the mass production of steel, which was critical to industrial growth.

Later, the Martin process, developed by Pierre-Emile Martin, improved steel production by allowing more precise control over the chemical composition and temperature of the melt. This method used an open flame to heat the metal and produced large volumes of higher quality steel.

The impact of the development of the metallurgical industry on the economy and industry was enormous. The mass production of steel by the Bessemer and Marten processes contributed to a decrease in the cost and increase in the availability of this important building material. This, in turn, gave impetus to the development of other branches of industry, in particular the construction industry, mechanical engineering, transport and railway construction.

The increase in the production and quality of steel also had a significant impact on the military industry, allowing the creation of stronger and more reliable weapons and armor. This changed the nature of warfare, making the country's production capacity an important factor.

In addition, the development of metallurgy contributed to job growth and labor migration, especially to urban industrial areas, leading to urbanization and significant social change. At the same time, it also led to the growth of the working class and increased social consciousness, which later became the basis for labor movements and social reforms.

Thus, the development of the metallurgical industry in the days of the first industrial revolution became a catalyst for general technological and economic progress, changing not only the industrial landscape, but also society as a whole.

Technical revolution in means of communication

The technical revolution in means of communication began with the invention and development of the telegraph. The Schilling telegraph is one of the first practical electromagnetic telegraphs, developed by the Russian inventor and diplomat Pavel Lvovich Schilling in 1832. Schilling's invention had a significant impact on the development of telegraph technology and communications.

The shilling telegraph was the basis for further developments in this field. He used a system of eight wires that corresponded to the eight sectors of the compass. Each combination of wires created a specific letter or symbol that allowed messages to be transmitted over a distance.

Schilling's telegraph was that it was one of the first to use the principle of electromagnetism to control the arrow indicating the letters. This principle became the basis for the further development of electromagnetic telegraphs, in particular the telegraph of Samuel Morse.

The first experiments with the electric telegraph began in the early 19th century, but the key moment was the development by Samuel Morse and Alfred Weil in the 1830s of a practical system known as the Morse system. The Morse telegraph used a

code of short and long signals (dots and dashes), which allowed messages to be transmitted over long distances using electrical impulses along a conductor.

Other important developments included the pneumatic telegraph, which used compressed air to transmit messages through tubes, and the optical telegraph, a signaling system that transmitted messages using visual cues (such as via towers with interchangeable panels or semaphores).

The history of the development of the telegraph infrastructure began with the creation of the first lines that connected important cities and industrial centers. This required a lot of investment and coordination, as telegraph poles had to be installed and wires laid over long distances. In many countries, this process has been taken over by state institutions in order to ensure national security and promote economic development.

The creation of the telegraph network was accompanied by technological challenges, in particular, the need to overcome long distances and ensure signal stability. The development of relay stations that amplified the signal made it possible to transmit messages over significant distances without loss of quality.

The development of the telegraph infrastructure contributed to the growth of the economy, as it improved communication between different regions of the country and international partners. This simplified trade, facilitated the rapid dissemination of financial information, and increased the efficiency of management. In addition, the telegraph allowed governments to respond more quickly to crises and coordinate military operations.

Over time, telegraph networks became more extensive, covering not only large cities, but also remote regions. This made it possible to integrate national economies and contributed to the creation of a single information space. International telegraph lines, such as the transatlantic telegraph cable, connected different parts of the world, making instant global communication possible.

Alexander's invention of the telephone was a revolutionary step in the means of communication. Graham Bell in 1876, which made it possible to transmit voice over long distances. The telephone transformed personal and business communication, as

for the first time people were able to discuss matters instantly regardless of distance between them. Elisha Gray also worked on a similar device and filed for a patent on the same day as Bell, leading to a long patent battle.

The operating principle of Bell's telephone was based on the use of electromagnetism. When a person spoke into a microphone, the sound waves caused the microphone membrane to vibrate. These fluctuations, in turn, affected the strength of the electric current passing through the microphone. An electrical signal modulated by the user's voice was transmitted over wires to the interlocutor's telephone. There it reached the receiver, where the electromagnet converted electrical signals back into sound vibrations, which were reproduced by the receiver membrane in the form of sound.

This simple but ingenious mechanism for converting sound into an electrical signal and back made possible direct voice communication between people over long distances, laying the foundation for the entire future telecommunications industry.

New communication technologies had a profound impact on economics and politics. The telegraph enabled the instantaneous transmission of information over long distances, which was especially important for business, financial markets, and government structures. This contributed to the faster development of trade, improved inventory management and more efficient allocation of resources.

The telephone, in turn, made communications even more flexible and personal, contributing to the development of business operations, improved cooperation and quick resolution of problems. It also changed social mores as people became more accessible to each other. In the political sphere, telephone lines made it possible to respond more quickly to crisis situations and coordinate actions at different levels of government.

The influence of these innovations on the development of journalism and mass media was also important. The telegraph and telephone made it possible to collect and distribute news at an unprecedented speed, contributing to the formation of a globalized information space.

The influence of the telegraph and telephone on the economy and society was so great that these inventions can be compared to the influence of the Internet in the modern world. They have significantly reduced communication time and costs, contributing to greater integration of world economies, political systems, and cultures.

Control questions for the topic:

1. What were the main factors that contributed to the beginning of the industrial revolution in England?
2. What was the significance of the invention of the steam engine for the development of industry? Give examples of the impact of the steam engine on various industries.
3. How did the emergence of mechanical engineering affect the technical progress and economic development of society?
4. Describe the technological revolution in transportation that occurred during the first industrial revolution. How have the methods of transporting goods and passengers changed?
5. What achievements in the field of natural science were characteristic of the period of the first industrial revolution? Give examples of important discoveries.
6. Describe the development of the metallurgical industry during the first industrial revolution. How have the methods of production and processing of metals changed?
7. What was the impact of the technical revolution in the means of communication on society and the economy?
8. How did the changes brought about by the first industrial revolution affect people's daily lives? Give examples of specific changes in life, work, transport or communications.

Lecture 5. New discoveries in the physical, mathematical and natural sciences at the turn of the XIX-XX centuries.

1. Fundamental discoveries in physics.
2. Development of mathematics.
3. Chemistry is at the forefront of scientific and technological progress.
4. Emergence of new branches of mechanics.
5. New trends in the development of astronomy at the end of the 19th century.
6. The invention of the internal combustion engine and its significance

Fundamental discoveries in physics of the second half of the 19th and early 20th centuries.

The second half of the 19th and the beginning of the 20th centuries was a period of intensive research and discoveries in physics, which radically changed the understanding of natural phenomena and laid the foundation for modern physics.

This period is marked by significant discoveries in the field of electricity. James Clerk Maxwell formulated his famous equations of electromagnetism, which describe the relationship between electric and magnetic fields and predict the existence of electromagnetic waves. These equations became the foundation for understanding radio waves, microwaves, and other forms of electromagnetic radiation.

The development of wave theory is associated with the works of Heinrich Hertz, who experimentally demonstrated the existence of electromagnetic waves, thus confirming Maxwell's predictions. These discoveries formed the basis of the development of wireless communication.

In 1895, Wilhelm Röntgen, experimenting with cathode-ray tubes, accidentally discovered a new type of rays, which he called "X-rays" or "x-rays". These rays had a unique ability to penetrate through various objects, including tissues of the human body, which made it possible to obtain images of bones and other internal structures. The discovery of the X-ray became revolutionary in medicine, as it opened the way to the development of radiology as an important field of diagnosis and treatment.

A less well-known, but equally important contribution to the study of x-rays was made by the Ukrainian and Austrian physicist Ivan Pului. Independently of Röntgen, he conducted research on cathode ray tubes and in 1890 developed his own version of the tube that could emit x-rays. Pului conducted a series of experiments that greatly deepened the understanding of the properties of these rays, although his work did not receive such wide international recognition as Röntgen's research.

At the turn of the 19th and 20th centuries, the world witnessed revolutionary discoveries in the field of atomic physics, which radically changed the understanding of the nature of matter. The experiments and theoretical explorations of this period laid the foundation for the development of modern physics and its practical applications.

In 1897, Joseph John Thomson discovered the electron, the first subatomic particle, which was the first step in developing a model of the structure of the atom. Thomson proposed a "raisin pudding" model where electrons were distributed in a positively charged "dough".

Ernest Rutherford, studying the scattering of alpha particles, developed a new atomic model that for the first time presented the atom as a miniature solar system with a nucleus in the center and electrons orbiting around it. This research not only helped clarify the structure of the atom, but also laid the foundation for further discoveries in nuclear physics.

Antoine Henri Becquerel, while studying the fluorescence of uranium salts, accidentally discovered radioactivity - the spontaneous emission of particles from atoms. Maria Sklodowska -Curie together with her husband Pierre Curie systematized these phenomena, discovered new radioactive elements - radium and polonium, and established that radioactivity is an attribute of atoms of certain elements.

The development of atomic physics and the study of radioactivity were not only of theoretical importance. They found wide application in medicine, in particular in radiotherapy for the treatment of cancer, in industry and energy, laying the foundation for the use of nuclear energy. These studies also contributed to the development of quantum mechanics, a new branch of physics that studies the behavior of matter and energy at the atomic and subatomic levels.

So, the discoveries of the late 19th and early 20th centuries played a key role in shaping the modern scientific picture of the world, allowing humanity to better understand the fundamental principles of nature and find new ways of applying them.

The development of mathematics in the second half of the 19th and early 20th centuries

The second half of the 19th and the beginning of the 20th centuries was marked by deep changes in mathematics, which can be described as a transition from the classical period of development to the modern one. This time is characterized by a significant expansion of research areas, generalization and abstraction of mathematical theories, which took place under the influence of the growing needs of applied sciences and technologies.

This period was marked by significant discoveries made by scientists from different countries. Bernhard Riemann, Georg Cantor, and Richard Dedekind made significant contributions to the development of set theory, topology, and number theory. Henri Poincaré's work in the field of differential equations and topology had a significant impact on the development of modern mathematics.

The creation of non-Euclidean geometry in the 19th century was one of the most revolutionary events in mathematics, which radically changed approaches to understanding space and its properties. Traditionally, geometry was based on Euclid's axioms, which were considered absolute and irrefutable. However, the inventions of Nikolai Lobachevsky, Janos Boyayem and Carl Gauss showed that there are alternative geometric systems that do not obey Euclidean postulates, in particular the fifth postulate about parallel lines.

Lobachevsky and Boyai developed the concept of hyperbolic geometry, where more than one line parallel to the given line can be drawn through a point outside a given line. Such ideas were radically different from the Euclidean vision, where only one parallel line can be drawn through a point outside a straight line.

These discoveries not only expanded the mathematical arsenal, but also prompted philosophical reflections on the properties of space and the nature of the

universe. Non-Euclidean geometry played a key role in the development of Albert Einstein's theory of relativity, where hyperbolic geometry became the basis for describing the structure of space-time.

The discovery of non-Euclidean geometry also changed approaches to mathematics education and research, emphasizing the importance of open-mindedness and a willingness to rethink and test existing theories. It stimulated the development of other branches of mathematics, such as topology and algebraic geometry, emphasizing the deep connection between abstract mathematical concepts and physical reality.

Thus, non-Euclidean geometry became a symbol of the transition from the classical understanding of mathematics to a more flexible and comprehensive approach, allowing mathematics to evolve and adapt to the new challenges of modernity.

The development of mathematics contributed to its application in other scientific fields, such as physics, chemistry and biology. Abstract mathematical concepts and methods made it possible to formulate and solve complex scientific problems, increasing the accuracy and efficiency of research. Especially significant was the use of mathematical analysis in theoretical physics, which made it possible to formulate and test physical theories with unprecedented accuracy.

Thus, mathematical methods have become an integral part of quantum mechanics and the theory of relativity, providing tools for describing phenomena at the atomic and subatomic levels, as well as for studying the structure of space-time. The introduction of complex numbers, matrices and operators significantly expanded the possibilities of mathematical modeling of physical processes.

The development of statistics and probability made important contributions to data processing and experimental physics, allowing better understanding and interpretation of the results of measurements and observations. It has also found applications in other sciences, such as biology, where statistical methods are used to analyze genetic data and environmental studies.

In the 19th century, mathematics became a compulsory university subject, reflecting the growing recognition of its importance to scientific and technological

progress. This period was a time of intensive development of mathematical knowledge, including the formulation of probability theory, analytical geometry, differential and integral calculus. The inclusion of mathematics in university curricula was a response to the need for qualified professionals able to apply mathematical methods in science, engineering and new, rapidly developing industries.

Education during this period underwent reforms aimed at increasing the general level of education and developing critical thinking. Mathematics, as a discipline that develops logical thinking and analytical skills, was considered ideal for achieving these goals. The study of mathematics not only stimulated students' intellectual development, but also provided them with tools for future research and innovation.

Also, the 19th century witnessed the establishment of many specialized mathematical societies and journals, which facilitated the exchange of ideas and cooperation between mathematicians from different countries. The establishment of mathematics as a compulsory discipline in higher education institutions emphasized its central role in the academic community and in the training of the future generation of scientists and engineers.

During this period, mathematics proved its ability not only to describe and solve specific scientific and technical problems, but also to generate new theories and concepts that formed the basis of further discoveries. Mathematics has become the universal language of science, capable of uniting various disciplines and providing means for a deeper understanding of complex natural phenomena.

Chemistry is at the forefront of scientific and technological progress

The second half of the 19th and the beginning of the 20th centuries became a period of significant discoveries in the field of chemistry, which affected various areas of scientific and technological progress. This time is characterized not only by the increase in the number of discoveries, but also by the intensification of interdisciplinary research.

The development of chemistry during this period took place in close interaction with other scientific fields, in particular with physics, biology and mathematics. This

has led to the emergence of new interdisciplinary fields such as physical chemistry, chemical thermodynamics, and biochemistry, which have expanded the scope for understanding and using chemical processes in various fields.

Stanislav Cannizzaro, an outstanding Italian chemist of the 19th century, made a revolutionary contribution to the development of chemistry, which had far-reaching consequences for the scientific community. At the Karlsruhe Congress of Chemists in 1860, he presented his breakthrough ideas that helped solve the age-old problem of standardizing atomic weights and molecular formulas. Until then, chemists used different methods to determine atomic weights, which led to confusion and misunderstandings.

Cannizzaro proposed the use of the Avogadro hypothesis as a basis for determining atomic weights, thereby unifying the approach to chemical research. He argued that molecules of elements are made up of a definite number of atoms, and this can be used to accurately determine the atomic weights of elements. His technique allowed scientists to more accurately determine the chemical composition of substances and contributed to the standardization of chemical nomenclature.

This contribution of Cannizzaro not only improved the accuracy of chemical research, but also provided the basis for further discoveries in chemistry. The standardization of the language of chemistry greatly facilitated the exchange of knowledge between chemists from different countries, promoting international cooperation and progress in scientific research. The implementation of his methods in scientific practice contributed to the unification of educational programs in chemistry, raising the level of chemical education and research.

Cannizzaro, thus, played a key role in the formation of modern chemistry as a science. His work demonstrates how one timely and influential discovery can dramatically change the direction of an entire field of knowledge, laying the foundation for its future development.

Chemical discoveries of this period had a huge impact on the development of industry. The invention of artificial dyes, such as aniline dyes, revolutionized the textile

industry. Ammonia synthesis by the Haber -Bosch method played a key role in the production of fertilizers, which contributed to the agricultural revolution.

The development of new medicines, including synthetic drugs and vaccines, has changed approaches to the treatment and prevention of disease, increasing the quality and length of people's lives. In the field of materials science, the discovery of new polymers and plastics changed industrial production, providing materials that excelled in lightness, durability and flexibility of application. This gave impetus to the development of the aviation, automotive and packaging industries.

The chemical industry has become key in the creation of new types of fuel, lubricants, explosives and other chemicals necessary for the modern economy and defense industry. The discovery and use of liquid crystals, synthetic rubber and other synthetic materials have become important elements in the development of modern technologies.

All these discoveries and developments in chemistry not only contributed to technical progress and the expansion of industrial production, but also had a great social impact, in particular in improving the quality of life, developing medicine and protecting the environment. Chemistry, like never before, has become a universal language that unites different fields of knowledge and promotes the development of interdisciplinary research.

Emergence of new branches of mechanics

The end of the 19th and the beginning of the 20th centuries were marked by significant changes in the field of mechanics, which were reflected in the emergence of new directions and concepts that radically changed our understanding of natural phenomena.

During this period, classical mechanics continued to develop, introducing new approaches and methodologies. The following industries appeared:

Analytical mechanics - especially important were the works of Joseph Louis Lagrange and William Rowan Hamilton, who laid the foundation of analytical mechanics. They introduced new formalisms, such as the Lagrangian and the

Hamiltonian , which made it possible to describe dynamical systems more abstractly and generally.

Statistical Mechanics – The development of statistical mechanics, particularly the work of Ludwig Boltzmann and James Clerk Maxwell, laid the foundation for understanding the macroscopic properties of matter through the interactions of their microscopic components.

Theory of Elasticity - This branch expanded due to the work of Augustin Louis Cauchy and Simeon Poisson, who investigated the behavior of solid bodies under the action of external forces.

Hydrodynamics, the study of the movement of liquids and gases, also underwent major changes with the development of Osborne's work Reynolds, which influenced the understanding of turbulence and fluid flows.

Aerodynamics - at the dawn of the 20th century, such scientists as Nikolai Zhukovsky and Ludwig Prandtl made a significant contribution to the development of aerodynamics. Zhukovsky, often called the father of Russian aviation, developed the theory of the infinite span wing, which helped to understand lift. Prandtl, a German scientist, introduced the concepts of boundary layer and laminar flow, which were crucial to the understanding of aerodynamic drag and the control of air flows.

The transition to the 20th century was marked by one of the biggest revolutions in physics - the emergence of quantum mechanics. Works by Max Planck, Albert Einstein, Niels Bohr, Werner Heisenberg and Erwin Schrödinger was exposed to the shortcomings of classical physics in explaining the behavior of atoms and subatomic particles.

Quantum mechanics introduced the concepts of quanta, wave -corpuscular dualism, the uncertainty principle, and the superposition of states, radically changing our understanding of nature at the microscopic level. These concepts turned out to be key to explaining phenomena that were previously considered incomprehensible, such as the structure of the atom, chemical bonds, and the behavior of electrons in solids.

Quantum mechanics has also played a crucial role in the development of new technologies, including semiconductors, lasers, and quantum computers, laying the foundation for modern electronics and information technology.

The impact of these changes on the physical picture of the world was profound. Classical mechanics, although still important for the description of macroscopic systems, is now supplemented by quantum mechanics for the analysis of the microcosm. This prompted physicists to search for new theoretical approaches that combine these two pictures into a single coherent theory.

Thus, the period of the second half of the 19th and the beginning of the 20th centuries became a time of intensive development of mechanics and rethinking of the basic principles on which it is based, opening new ways for further research in physics and other scientific disciplines.

New trends in the development of astronomy at the end of the 19th century

The end of the 19th century was a period of significant progress in astronomy, which was caused by the emergence of new research methods, the improvement of telescopic technology and the development of astrophysics as a separate branch of science.

One of the revolutionary innovations in astronomy was the use of spectrography, which allowed scientists to divide the light coming from stars and other cosmic objects into a spectrum and analyze its composition. This opened the way to determining the chemical composition, temperature, motion and other characteristics of celestial bodies at a great distance from Earth. Spectroscopic studies also contributed to the discovery of dark absorption lines in the spectra of stars, which provided important information about the composition of the atmospheres of these stars.

Astrophysics, as a branch of astronomy dealing with physical processes in the universe, began to stand out as a separate direction at the end of the 19th century. Scientists began to use physical and chemical principles to explain astronomical phenomena such as stellar spectra, the evolution of stars, and the structure of galaxies.

Improvements in optical technologies and telescope designs have greatly expanded the possibilities of astronomical observations. Large refractors and reflectors appeared, which made it possible to observe distant stars and galaxies with unprecedented detail. The development of astronomical observatories, equipped with the latest equipment and instruments, such as photographic plates for recording data, contributed to the collection of a huge amount of new information about the universe.

The development of astronomy also contributed to the creation of detailed maps of the starry sky, which included the positions, movements and other characteristics of stars and celestial objects. This became possible thanks to accurate observations and the use of photographic equipment, which made it possible to capture images of the sky on plates and analyze them with great accuracy. The creation of star catalogs and star maps became an important tool for astronomers that facilitated further research and discovery.

These maps not only provided a vast amount of information about the location and movement of the stars, but also allowed scientists to discover new celestial objects such as binary stars, variable stars, asteroids and distant galaxies. In addition, these maps have played a key role in studying the structure of our galaxy and understanding the scale of the universe.

The creation of time zones in the 19th century was a response to the need for time unification in the context of growing globalization and the development of railway transport. Until then, the time in different cities was determined locally based on solar time, which led to confusion and complicated travel planning and commercial activities.

The problem became especially urgent with the development of railway networks, when the need for precise coordination of train movements required greater standardization of time. Canadian railway engineer Sandford Fleming proposed dividing the globe into 24 time zones, each of which would have the same standard time, differing by one hour from neighboring zones. This system was first presented at the International Meridian Congress of 1884 in Washington, where the choice of the Prime Meridian passing through Greenwich in London was also agreed upon.

The introduction of time zones greatly simplified logistics and made it possible to accurately plan events on an international scale. It was also important for the development of international trade and the economy, because it made it possible to coordinate more effectively the activities of companies operating in different time zones.

Thus, the creation of time zones in the 19th century became a key step on the way to the creation of a modern globalized time management system, contributing to the further integration of the world community and the simplification of international communication and interaction.

Thanks to all these achievements, astronomy at the end of the 19th and the beginning of the 20th century experienced a period of rapid development, expanding our knowledge of the universe and its constituent parts. New research methods, the development of astrophysics, improvements in telescope technology and observatory infrastructure, and the creation of detailed maps of the starry sky played a crucial role in this progress, laying the foundation for further discoveries in astronomy.

The invention of the internal combustion engine and its significance

The invention of the internal combustion engine (ICE) marked a new era in the world of technology and engineering, which significantly influenced the development of transport, industry and agriculture.

Jean Joseph Etienne Lenoir, a Belgian -French engineer, developed the first commercially successful internal combustion engine in 1860. Its engine ran on illuminating gas and was quite simple in design. Lenoir's engine was a two-stroke, and although it had low efficiency and high fuel consumption, it was the first step towards the development of more efficient systems.

The next major breakthrough in the development of internal combustion engines was made by the German engineer Nikolaus August Otto. In 1876, he developed the first efficient four-stroke engine, which became known as the Otto cycle. The Otto cycle consists of four main phases: intake, compression, stroke and exhaust. This

principle greatly increased engine efficiency compared to previous models and became the basis for most modern gasoline engines.

Rudolf Diesel, a German engineer, in 1897 developed the engine that bears his name. The difference between a diesel engine is the way fuel is ignited: it does not occur from a spark, as in gasoline engines, but from the high temperature created as a result of air compression in the cylinder. This provides higher efficiency and better efficiency compared to gasoline engines.

The internal combustion engine (ICE) is the backbone of modern vehicles, from cars to airplanes. Its principle of operation consists in converting the chemical energy of the fuel into mechanical energy through the combustion process inside the engine cylinder. The main components of an internal combustion engine include cylinders, pistons, a crankshaft and a gas distribution system.

In a four-stroke engine, each cycle consists of four main phases: intake, compression, stroke and exhaust. During the intake stroke, the intake valve opens and the fuel-air mixture enters the cylinder while the piston moves down. Next comes the compression stroke, when both valves are closed and the piston moves up, compressing the mixture, which increases its temperature and pressure.

The working stroke begins with a spark from the spark plug, which ignites the mixture, causing it to burn rapidly. The sudden increase in gas pressure pushes the piston down, which is the only stroke that directly produces useful work. Finally, in the exhaust stroke, the exhaust valve opens, and the piston, moving up, pushes the exhaust gases out of the cylinder.

The movement of the piston through these four strokes is transmitted to the crankshaft, which converts the reciprocating motion of the piston into a rotary one, which can then be used to drive the wheels of a car or other mechanisms.

The efficiency of internal combustion engines largely depends on the optimization of these processes, as well as on the improvement of materials and component designs. The development of technologies, such as direct fuel injection and turbocharging, allows to increase the power of engines, reduce fuel consumption and reduce emissions of harmful substances.

Internal combustion engines catalyzed a technological revolution in transportation, enabling the mass production of automobiles, the development of aviation, and shipping. Their use has fueled globalization and economic growth by allowing people and goods to move more quickly and efficiently.

In addition, diesel engines influenced agricultural machinery, easing heavy manual labor and increasing productivity. In industry, internal combustion engines are used as energy sources for various machines and mechanisms.

However, on the other hand, ICEs have also caused a number of environmental and social problems, including air pollution from exhaust gases and dependence on fossil fuels. This caused the need to find alternative sources of energy and cleaner technologies.

In sum, the invention and development of the internal combustion engine had a profound impact on the development of modern civilization, shaping the technical landscape of the modern world and creating new challenges for humanity.

Control questions for the topic:

1. What were the fundamental discoveries in physics in the second half of the 19th and early 20th centuries? Describe the significance of at least two of them for the development of modern science.
2. How did the development of mathematics in the specified period affect other fields of science? Give examples of specific mathematical theories or concepts that have emerged and their applications.
3. Why is chemistry at the forefront of scientific and technological progress in the second half of the 19th and early 20th centuries? Give examples of key discoveries and their impact on industry.
4. Describe the emergence of new branches of mechanics during this period. How did they contribute to the development of technology?
5. What new trends in astronomy were discovered at the end of the 19th century? What is their significance for the further development of this science?

6. What was the significance of the invention of the internal combustion engine for the development of transport and industry? Describe the implications of this invention.
7. How did discoveries in physics, mathematics, chemistry, and other sciences affect industrialization and society as a whole?
8. What were the main challenges and limitations for scientists in the research of the second half of the 19th - beginning of the 20th century?

Lecture 6. Development of technology at the beginning of the 20th century. and during the First World War

1. Electricity is the basis of industrial development.
2. Application of new technologies in mechanical engineering.
3. Features of the creation of the oil industry.
4. O. Lilienthal. Aviation development in the first decades of the 20th century.
5. The beginning of the creation and use of artificial materials.
6. New equipment on the fields of the First World War.

Electricity is the basis of industrial development

The end of the 19th and the beginning of the 20th century became a time of revolutionary changes in the development of technology, especially in electricity, which played a key role in the development of industry.

Thomas Edison, one of the most famous inventors of the time, made a significant contribution to the development of electrical engineering. His developments, in particular, the incandescent light bulb, became a catalyst for the development of electric lighting and the widespread use of electricity in everyday life and industry.

Nikola Tesla, another outstanding inventor and engineer, made fundamental contributions to the development of power transmission systems. He developed the concept of alternating current and polyphase systems, which became the basis for modern electrical networks.

The war of currents, which took place at the end of the 19th century, became a symbolic clash between two technological philosophies in electricity, represented by Thomas Edison on the one hand and Nikola Tesla and George Westinghouse on the other. Edison, founder of the Edison company Electric Light Company, strongly defended the use of direct current (DC) for electrification, citing safety and reliability. Instead, Tesla and Westinghouse believed that alternating current (AC) was the future because it allowed electricity to be efficiently transmitted over long distances without significant loss of power.

The struggle reached its climax when both sides launched active marketing campaigns aimed at discrediting the opponent. Edison even conducted public demonstrations of the dangers of alternating current by electrocuting animals. However, the advantages of alternating current, especially its ability to transform to high or low voltages for power transmission and distribution, eventually proved decisive.

The turning point was the adoption of alternating current to generate electricity at Niagara Falls, a project of great symbolic and practical importance. This not only demonstrated the technical superiority of AC, but also laid the foundation for the rapid development of power grids around the world.

As a result, alternating current became the standard for the generation, transmission and distribution of electricity, which contributed to mass electrification and further technological progress. The war of currents not only determined the direction of electric power development, but also emphasized the importance of innovation and openness to new ideas in scientific and technical research.

The development of polyphase alternating current systems contributed to the emergence of two-phase and three-phase asynchronous motors. These motors became the foundation for the development of industrial equipment because they were more efficient, reliable and easier to use compared to DC motors.

The first hydroelectric plants became an important source of electricity, demonstrating the possibility of generating electricity from renewable sources. The creation of the first large hydroelectric plant on the Niagara River in 1895 became a symbol of a new era in energy, providing cheap and efficient electricity for industrial production and the needs of the population.

The process of electrification, which began in the United States and Europe, radically changed industrial society. The establishment of electric grids and stations contributed to the growth of industrial enterprises, as electricity became widely available and efficient. This allowed factories to run longer and with greater productivity, and also encouraged the development of new industries such as electrical engineering and consumer electronics manufacturing.

Electrification also had a profound effect on people's daily lives, as it improved living conditions by providing lighting, heating, and electrical appliances that made households more comfortable and functional. In urban planning and transportation, electrification led to the development of electric trams, subways and underground railways, which ensured more efficient and faster mobility of the urban population.

Electrification also transformed agriculture by providing means for irrigation, ventilation, and mechanization that increased yields and productivity. It helped end rural isolation by providing access to information and modern technology.

The basis of industrial development and economic growth during this period was closely related to electrification. It not only contributed to the expansion of existing industries, but also encouraged the creation of new ones, emphasizing the role of electricity as the basis of modern technological progress.

Application of new technologies in mechanical engineering

The end of the 19th and the beginning of the 20th centuries became a period of significant progress in mechanical engineering, marking an era of technological innovation and the emergence of new branches of this industry.

The development of technologies and inventions of this period contributed to the emergence of completely new branches of mechanical engineering. In particular, the development of the automotive industry and aviation became possible thanks to progress in the design of internal combustion engines and improvements in materials science. These new industries required the development of specialized equipment and tools, which stimulated the further development of the machine-building industry.

The period from 1850 to 1918 was a time of intensive development of mechanical engineering, and completely new branches appeared, which became a response to the growing needs of industrialization and technological progress. This time covers the end of the industrial revolution and the beginning of the era of mass production, which contributed to the emergence of new types of machines and equipment.

One of the key new branches was electrical engineering. The invention of alternators and transformers paved the way for large-scale power generation and distribution. This contributed to the creation of electric motors, which began to be used in industry to drive various mechanisms, replacing steam engines and manual labor.

The automotive industry has also undergone tremendous development. Karl Benz, Gottlieb Daimler, and other pioneers ushered in an era of automobile manufacturing that eventually led to the mass production of automobiles in the 20th century. The production of automobiles required the development of specialized machines for stamping, welding, and assembly.

Heavy engineering and shipbuilding also underwent significant changes, adapting to new materials such as steel and new technologies, including welding and the use of steam turbines. This made it possible to build larger, faster and more efficient ships.

British engineer Joseph Whitworth made a significant contribution to the standardization of screw connections, introducing the gauge system in 1841. This system established uniform standards for threads, which helped to simplify the production and maintenance of machines, and also facilitated the interchangeability of parts. Whitworth's standardization formed the basis of modern international standards.

Standardization became a key factor in the development of mechanical engineering, as it allowed mass production of components and reduced costs. The introduction of uniform standards for sizes, shapes and materials made it possible to automate production processes and improve product quality.

One of the most important innovations in mechanical engineering was Henry Ford's introduction of linear assembly line production in 1913. This radically changed the approach to production, allowing to significantly increase the speed and reduce the cost of assembling cars. The Ford assembly line became a symbol of industrial efficiency and the embodiment of the principles of mass production.

The application of new technologies and methods in mechanical engineering has radically changed production processes. Mass production, supported by standardization and assembly lines, made it possible to quickly and efficiently

manufacture a large number of homogeneous products. This, in turn, reduced the cost of goods, making them more accessible to the masses, and contributed to rapid technological development.

The development of mechanical engineering also contributed to the globalization of production chains. Components and assemblies for machines and mechanisms began to be produced in different countries and then assembled in others, which required international coordination and logistics.

Thus, the development of new technologies in mechanical engineering not only contributed to industrial progress, but also significantly influenced the social structure, economy and culture of modern society, setting new directions for future development.

Features of the creation of the oil industry

The development of the oil industry at the end of the 19th and the beginning of the 20th centuries became one of the key moments of the industrial revolution, causing significant changes in the energy, transport and chemical industries.

With the development of technology and the increase in the need for energy, the need for oil products has also increased. Oil became necessary for the operation of internal combustion engines used in cars, airplanes and other vehicles, and also became the basis for the development of the chemical industry, including the production of plastics, fertilizers and pharmaceuticals.

The first methods of oil extraction were relatively simple and limited to the natural release of oil to the surface where it could be easily collected. However, with the growth of industrial demand for oil and its derivatives, such methods quickly became insufficient. There was a need to develop technologies capable of providing more intensive and deep oil production.

A breakthrough in this direction was the drilling of wells, a technique that made it possible to reach oil deposits at significant depths. The first successful commercial well was drilled by Edwin Drake in 1859 near Titusville, Pennsylvania, USA, laying the foundation for the modern oil industry. The drilling method required the use of

heavy drilling equipment and special techniques to reach oil reservoirs located at depths of several hundreds or even thousands of meters underground.

With the development of drilling technologies, rotary drilling was introduced, which provided faster and more efficient penetration through hard rock. It also contributed to the development of additional methods, such as hydraulic fracturing and horizontal drilling, which made it possible to significantly increase the productivity of wells.

In addition, secondary and tertiary recovery techniques have been developed to improve the efficiency of oil recovery, which involve injecting water or gas into the formation to maintain pressure and increase the displacement of oil to the well.

Thus, the development of oil extraction technologies not only responded to the growing demand for this valuable resource, but also contributed to technological progress, stimulating innovation in engineering and natural resource management.

Exploration of oil fields became possible thanks to the use of geological and geophysical methods, which made it possible to more accurately determine the location of oil deposits. This led to the discovery of large oil fields in various parts of the world.

One of the first countries where intensive oil production began was the United States, where a field was discovered in Pennsylvania in the middle of the 19th century. Almost at the same time, oil production began in the Caspian region of the Russian Empire and in Carpathia, which at that time belonged to Austria- Hungary. These regions quickly became important centers of the oil industry.

To simplify the trade and transportation of oil, a standard volume - a barrel - was adopted. The establishment of a barrel as an international standard for measuring oil volumes contributed to the unification and facilitation of trade in this raw material on the world market. A standard barrel has a volume of approximately 159 liters or 42 US gallons. This volume has become a convenient unit for transporting, storing and selling oil.

The use of the standard barrel also made it possible to improve logistics in the oil industry, optimize production and ensure greater transparency in the oil market.

This influenced the formation of prices for oil products and contributed to the globalization of the oil industry.

The development of the oil industry at the end of the 19th and the beginning of the 20th century had a significant impact on production processes in other industries. Oil has become a key source of energy not only for transport, but also for industrial production, heating, lighting and other needs. The invention and introduction of new technologies for extraction, processing and use of oil contributed to technological progress and economic growth.

In addition, the oil industry stimulated the development of the chemical industry, because many chemicals and materials began to be obtained from oil, which later found wide use in pharmaceuticals, agriculture, construction, and the production of plastics.

Thus, the creation of the oil industry not only provided the world with a necessary source of energy, but also laid the foundation for further innovation and technological development, playing a decisive role in the formation of modern industrial society.

Otto Lilienthal and the development of aviation in the first decades of the 20th century

Otto Lilienthal was one of the first pioneers of aviation, whose research and experiments with flying self-built gliders laid the foundation for modern aerodynamics. At the end of the 19th century, Lilienthal developed a number of gliders and made more than 2,000 flights, demonstrating the possibility of controlled human gliding in the air. His works on aerodynamic theory, in particular research on wing profiles, became the foundation for the development of future aircraft.

Brothers Orville and Wilbur The Wrights developed the ideas of Lilienthal and other predecessors, creating the world's first manned aircraft that could take off, fly and land under pilot control. On December 17, 1903, in Kitty Hawk, North Carolina, they made the world's first controlled flight of an internal combustion engine airplane.

France quickly became a leader in the development of aviation after the Wright brothers. Louis Blériot, Henri Farman, and other French pilots and designers developed

a variety of model aircraft that demonstrated various aspects of flight and construction. Bleriot's flight across the English Channel in 1909 in his plane "Bleriot XI" is famous.

One of the first aviation schools in Europe was founded at the Kyiv Polytechnic Institute at the beginning of the 20th century. Important research in the field of aerodynamics was conducted here, new aircraft designs were developed, and students and teachers could immerse themselves more deeply in the theory and practice of flight.

One of the key figures in the early history of the Aviation School of KPI was Fyodor Artemovich De Lone, known as an aviation designer and theoretician. He was one of the pioneers in studying the aerodynamic characteristics of aircraft wings and bodies. De Launay's work helped lay the theoretical foundation for the further development of aviation and aircraft design.

Another prominent figure associated with this school was Count Oleksandr Kudashev, who made one of the first controlled flights in the Russian Empire on a motorized aircraft in 1910. His experiments greatly contributed to the understanding of the practical aspects of flight and gave impetus to the development of aircraft design in the Russian Empire.

One of the most famous graduates and teachers of the KPI School of Aviation was Ihor Sikorsky, who later became one of the world's most prominent aircraft designers. In his early years at KPI, Sikorsky focused on the creation of helicopters and heavier-than-air vehicles, particularly airplanes. His work at KPI, research and experiments with aerodynamics and engines greatly influenced his later achievements in the design of airplanes and helicopters.

Airships, these massive airships, became a symbol of aviation progress in the late 19th and early 20th centuries. They fall into two main categories: soft-framed, known as blimps, and rigid-framed, the most famous of which were the designs developed by Ferdinand von Zeppelin. Rigid airships had a metal frame covered with fabric, which made them stronger and able to carry much larger loads than their soft counterparts. This allowed them to make long flights, carrying passengers and cargo over considerable distances.

The use of hydrogen gave airships the lift they needed, although helium was later found to be a safer alternative gas due to its non-flammability. Engines installed on airships provided them with maneuverability and the ability to move independently, unlike balloons, which could only move according to the direction of the wind.

For military purposes, airships were used for reconnaissance, bombing, and even as platforms for early detection of enemy aircraft. During the First World War, they played a significant role in aerial operations, providing strategic advantages through their ability to stay in the air for long periods of time and conduct surveillance over large areas.

The development of aviation technology in the first decades of the 20th century opened new opportunities for research, travel and military strategy. It has influenced technological developments, geopolitics and cultural exchanges, laying the groundwork for today's globalized era.

The beginning of the creation and use of artificial materials

The development of the chemical industry in the late 19th and early 20th centuries was marked by significant achievements in the creation and use of artificial materials. These innovations not only changed production processes, but also had a huge impact on the economy, industry and people's daily lives.

One of these breakthroughs was the invention and development of polymers - large molecules formed by chemically joining smaller molecules into chains.

The first artificial polymer that found practical use was celluloid, invented in the 1860s. This material, obtained by treating cellulose with nitrate and camphor, was used in the production of photographic film, billiard balls and various household items. Celluloid opened the era of plastics and demonstrated the potential of artificial materials to replace natural ones.

At the beginning of the 20th century, Bakelite was developed - the first synthetic polymer obtained from phenol and formaldehyde. Invented by Leo Bakeland in 1907, Bakelite was distinguished by its high strength, heat resistance and electrical insulating

properties, which made it an ideal material for the electrical industry, as well as for the production of household goods.

The development of polymer science and technology in the first half of the 20th century contributed to the creation of a wide range of synthetic polymers, including nylon, polyethylene, polystyrene and many others, which found applications in textiles, packaging, construction and the automotive industry.

The invention of man-made polymers radically changed the material world, offering alternatives to natural materials, expanding the possibilities of design and production, and opening new horizons for scientific research and technological development.

Another significant achievement was the development of technologies for the production of artificial rubber and rubber, which were important for the automotive industry, the production of shoes, insulating materials and many other products. The creation of synthetic rubber made it possible to reduce dependence on natural sources of rubber, especially in the conditions of world wars and economic crises.

The development of electrolysis methods led to innovations in the production of metals, in particular aluminum and magnesium. These lightweight yet strong materials have opened up new opportunities for aircraft construction, the transportation industry, and modern construction.

The creation and introduction of artificial materials had a profound impact on the economy and industry. It contributed to the development of new industries, the creation of new jobs and the emergence of new markets. Lowering the cost of production and improving the quality of products thanks to the use of artificial materials allowed companies to increase production volumes and expand the range of products.

In addition, the emergence of new materials contributed to the globalization of production chains. Businesses were able to move production to countries with lower production costs while taking advantage of new materials, which affected international trade and economic relations.

At the same time, the development of artificial materials also posed new challenges to society, in particular regarding environmental issues and waste disposal. The problem of recycling and destruction of plastic products has become urgent due to their high resistance to natural decomposition.

Thus, the creation and application of artificial materials has defined many aspects of modern industry and economy, opening new horizons for the development of technology and at the same time posing new challenges to humanity.

New equipment on the fields of the First World War

The First World War was a period of significant technological innovations in military affairs, which changed the nature of warfare and the strategy of war. The features of these innovations are closely related to the positional nature of the war, which prompted the development and implementation of new equipment.

The First World War was characterized by long-term positional battles, especially on the Western Front. This required new approaches to warfare and the use of equipment capable of operating effectively in trench warfare.

Machine guns, which before the war were considered auxiliary weapons, turned out to be extremely effective in positional battles, defending trenches from infantry assaults. The development of artillery also played an important role, especially through the use of heavy artillery and chemical munitions, which greatly increased its destructive power and influence on the course of hostilities.

The development of tanks in the First World War was a response to the stalemate on the fronts, where positional battles in trenches and wire fences led to huge losses and little progress. The British Army, eager to find a way to overcome this stagnation, invested in the development of armored vehicles capable of withstanding small arms fire and overcoming obstacles on the battlefield.

The first tanks put into action during the Battle of the Somme in 1916, although they were at an early stage of development and had a number of technical shortcomings, showed considerable potential. They could move over the ground

plowed by artillery, crossed trenches and wire obstacles, becoming mobile fortifications that could bring infantry closer to enemy lines under the protection of armor.

Despite the mixed results of the first combat applications, the experience of the Battle of the Somme showed the importance of tanks in breaking defensive lines. This stimulated further technological improvements, including improved armor, weaponry, and increased mobility. In the following years, tanks became much more efficient and reliable, playing a key role in many combat operations.

After the end of the First World War, the tank became a decisive element of modern military doctrines, symbolizing a new era in the conduct of hostilities. They demonstrated a new approach to warfare - maneuver warfare, where mobility and firepower took precedence over static defense. The evolution of tanks not only changed the course of combat, but also forever changed the principles of designing military equipment, influencing the development of mechanized troops around the world.

The First World War caused significant changes in naval military construction, where new classes of warships appeared, adapted to the changed requirements of warfare at sea. Battleships of the "Dreadnought" class radically changed the perception of sea battles due to their technical characteristics, in particular, the presence of powerful single-caliber artillery, which allowed accurate fire at long distances. These ships had significant firepower and armor protection, which made them a dominant force at sea and forced other countries to rethink their naval strategies.

Submarines, or submarines, contributed to the strategic restructuring of naval warfare. In particular, Germany's use of submarines for indiscriminate torpedo blockade of Allied trade routes demonstrated their effectiveness as a means of naval warfare. These vessels could sneak up on enemy ships, using their torpedoes without warning, making them a formidable threat to even the largest warships and merchant ships.

The development of these new classes of ships not only changed the strategy of warfare at sea, but also stimulated technological progress, prompting improvements in shipbuilding, artillery, and torpedo systems. Naval forces around the world had to adapt

to new conditions of combat, which influenced the development of naval strategy in the following decades.

Aviation on the battlefields of the First World War played a key role that radically changed the conduct of military operations. Airplanes, which were originally used for reconnaissance and adjusting artillery fire, quickly evolved into powerful tools of warfare. The transition from small machine guns to integrated airborne weapons transformed aircraft into fighters capable of aerial combat and the destruction of enemy targets on the ground.

The development of bomber aviation made it possible to hit targets located far behind the front line, which made aircraft indispensable for strategic offensive operations. Aerial bombardment for the first time in military history introduced an element of unpredictability into the enemy's plans, creating additional psychological pressure.

The advent of air combat stimulated the development of new tactics and techniques of combat piloting, and also prompted the creation of specialized fighters optimized for air combat. The emergence of aviation aces such as Manfred von Richthofen added a romantic aura to aviation, but the brutal reality of air combat required great skill and bravery from pilots.

Military conflicts also accelerated the development of anti-aircraft defenses, including anti-aircraft guns and war balloons. These means were intended to protect military and civilian objects from air attacks.

Thus, aviation not only changed the face of the First World War, but also laid the foundations for the future development of military aviation, opening new horizons in the technique and tactics of warfare.

Thus, the First World War became a period of significant technical innovations, which not only influenced the course of the war, but also forever changed the nature of the conduct of hostilities. The new machinery and technology introduced during the conflict laid the foundations for modern military technology and strategy.

Control questions for the topic:

1. What was the importance of electricity for the development of industry at the turn of the 19th and 20th centuries? Give examples of the impact of electrification on industrial processes.
2. How has the application of new technologies in mechanical engineering changed production processes and products? Give specific examples of such technologies.
3. Describe the features of the creation of the oil industry at the beginning of the 20th century. What impact did it have on the economy and the development of other industries?
4. What contribution did O. Lilienthal make to the development of aviation in the first decades of the 20th century? Describe its achievements and significance for future aircraft construction.
5. How did the beginning of the creation and use of artificial materials affect industry and everyday life? Give examples of such materials and their applications.
6. What role did new technology play on the battlefields of World War I? Describe the impact of technological innovation on the course of military operations.
7. What were the main trends in the development of engineering and technology at the end of the 19th - at the beginning of the 20th century? Give examples and explain their impact on society.
8. Evaluate the impact of the development of technology during this period on the change in the working and living conditions of ordinary people. How has society changed with the advent of new production technologies and materials?

Lecture 7. World science and technology in the 1920s-1940s

1. Nuclear physics in the 1920s-1940s.
2. The influence of the development of the electric power industry on the production of electrical equipment.
3. Development of non-ferrous metallurgy in the 1920s-1940s.
4. The beginning of the era of television.
5. Creation of jet aircraft.
6. Creation and use of rockets on solid and liquid fuel.

Nuclear physics in the 1920s-1940s.

The period of 1920-1940 was a time of significant breakthroughs in nuclear physics, which laid the foundation for further developments in this area and had important scientific and military consequences.

This period is characterized by intensive research into the atomic nucleus, which was prompted by discoveries made at the turn of the century. Scientists such as Ernest Rutherford advanced understanding of the structure of the atom and its nucleus by discovering protons and conceptualizing neutrons. These discoveries changed approaches to the study of the atom and its energetic properties.

The development of particle accelerator technology has played a key role in nuclear physics. The Cockcroft-Walton accelerator, created in 1932, made it possible for the first time to artificially split atomic nuclei, confirming the ideas proposed by Rutherford. This opened new avenues for experiments with nuclear reactions and the study of the structure of matter.

The understanding of nuclear processes and the role of uranium-235 in nuclear chain reactions opened a new era in scientific research and technological innovation. The discovery of uranium-235, an isotope capable of sustaining a self-sustaining nuclear reaction, laid the groundwork for both peaceful nuclear power and nuclear weapons, radically changing global politics and security strategies.

Enrico Fermi, one of the leading scientists in this field, made an unparalleled contribution to the development of nuclear physics. His research on slow neutrons and the construction of the world's first nuclear reactor, which was called the "Chicago woodshed", opened the way for the use of nuclear energy. This experiment confirmed the possibility of a controlled nuclear reaction and was a critical step towards the creation of a nuclear reactor used for power generation and scientific research.

Fermi and his colleagues showed that with the help of moderation, or slowing down of neutrons, it is possible to significantly increase the probability of a nuclear reaction of uranium, which opened up new opportunities for the development of nuclear technology. These discoveries not only contributed to the development of nuclear power plants, which became an important part of the world's energy infrastructure, but also laid the foundation for the creation of nuclear weapons, which had profound geopolitical consequences in the future.

The Manhattan Project, a large-scale research program initiated in the United States to develop an atomic bomb, was the culmination of the efforts of scientists from around the world. Involving leading physicists of the day, including Enrico Fermi, Robert Oppenheimer, and other prominent scientists, the Manhattan Project demonstrated the power of nuclear energy not only as a source of limitless possibilities, but also as a means of untold destruction.

The launch of the world's first nuclear reactor under the leadership of Enrico Fermi in December 1942 at the University of Chicago opened a new era in atomic energy research. The experiment, known as the Chicago "woodhouse", not only confirmed the possibility of maintaining a self-sustaining chain reaction, but also allowed scientists to better understand the principles of control and management of nuclear reactions.

These breakthrough studies became the foundation for the further development of nuclear reactors, which were used not only in the production of nuclear weapons, but also in peaceful atomic energy. The development of nuclear power plants made it possible to use nuclear energy to produce electricity, which was an important step towards meeting the growing energy needs of mankind.

The use of atomic bombs against Japan at the end of World War II demonstrated the terrible destructive power of nuclear weapons and ushered in the nuclear era in international relations. It also prompted the development of international treaties and agreements on the non-proliferation of nuclear weapons and the limitation of nuclear arsenals in order to prevent nuclear war.

In the period 1920-1940 in the Soviet Union, in particular in Kharkiv, research in the field of nuclear physics was also actively developed. Kharkiv became one of the leading centers of nuclear research in the USSR, thanks in particular to the work of the Kharkiv Physical and Technical Institute (KhPTI), founded in 1928.

KhFTI scientists, among whom were outstanding physicists Lev Landau (who later won the Nobel Prize), Oleksandr Leypunskyi, Igor Kurchatov and many others, conducted fundamental research in the field of quantum mechanics, nuclear physics and solid state physics. They studied the properties of neutrons, nuclear reactions and the possibilities of practical use of nuclear energy.

One of the key developments of Soviet scientists during this period was the creation of a cyclotron - an accelerator of charged particles. Although the first Soviet cyclotron was built in Leningrad, the research conducted in Kharkiv significantly influenced its development and subsequent use in nuclear experiments.

The work of the Kharkiv Physical and Technical Institute was of great importance for the further development of the nuclear program of the Soviet Union, in particular within the framework of the project to create an atomic bomb. Research conducted in Kharkiv helped lay the foundations for the development of Soviet atomic science and technology.

Research in nuclear physics in the first half of the 20th century had a revolutionary impact on world science and technology, paving the way for the development of nuclear energy, which became a new, powerful source of energy. These discoveries also laid the foundation for nuclear medicine, greatly expanding the possibilities of diagnosis and treatment of many diseases. However, along with the positive aspects, nuclear research has led to an arms race and a nuclear threat, putting global security at risk. Ultimately, the understanding of nuclear processes led to

international cooperation and regulation of the use of nuclear technology, emphasizing the need for responsibility and an ethical approach in scientific research.

The impact of the development of the electric power industry on the production of electrical equipment in the 1920s-1940s

The development of the electric power industry in the 1920s-1940s had a profound impact on industry and everyday life, determining the direction of development of electrical equipment production.

During this period, numerous power plants were established, including hydroelectric, thermal and nuclear power plants, which contributed to the increase in electricity production and to meet the growing needs of industry and the population. This, in turn, spurred technological development and improved production efficiency.

The expansion of the electricity transmission infrastructure was critically important for the development of the electric power industry. The construction of high-voltage transmission networks made it possible to transport electricity over long distances from the sources of its production to consumers, which ensured access to electricity in wider regions.

The expansion of the electricity transmission infrastructure became a decisive step in the development of the electric power industry. The construction of networks of high-voltage transmission lines that could transport electricity over long distances with minimal losses made it possible to expand access to electricity. This has facilitated the integration of regional energy systems, creating larger and more reliable grids.

An important aspect of this period was the improvement of technologies for the production and transmission of electricity. The introduction of new control and automation methods has helped increase the efficiency of power plants and transmission systems, minimizing energy losses and optimizing their operation.

Expanding access to electricity contributed to the emergence and popularization of the first electrical appliances in households in the United States and Europe. Electric light bulbs, refrigerators, washing machines, vacuum cleaners and other appliances

have become commonplace in many homes, radically changing people's daily lives and lifestyles.

The development of electricity in the 1920s and 1940s not only transformed industrial production, but also laid the foundation for the modernization of society. This time was marked by the creation of new types of power plants, including thermal, hydroelectric and, on a smaller scale, the first attempts at using atomic energy. The construction of these facilities ensured a significant increase in electricity production, which was necessary to meet the growing needs of industry and the population.

The period of construction of the electricity transmission infrastructure was especially important, which included the deployment of a large network of high-voltage lines, which made it possible to transmit electricity over long distances from the places of its production to industrial centers and urban agglomerations. The development of transformer substations, switches, relays and other elements of the transmission system ensured more efficient and safer distribution of electrical energy.

In the 1920s and 1940s, technological innovations in the power industry contributed to a revolution in the field of household electrical equipment, which had a profound impact on society. Wide access to electricity opened the door to mass production and use of electrical appliances that made life much more convenient and efficient. Refrigerators became not only a symbol of technological progress, but also changed the way products are stored, prolonging their freshness and preservation. Washing machines freed the owners from the time-consuming process of washing by hand, raising the hygienic standard and providing more free time.

Vacuum cleaners transformed the cleaning process by providing deeper and more efficient cleaning, and radios connected people to the world by providing access to news, music and entertainment regardless of their location. These innovations not only improved the quality of life, but also changed social norms, stimulating cultural change and bringing society together through shared interests and information.

The production of household electrical appliances has also contributed to the development of new industries, creating thousands of jobs and contributing to economic growth. Companies such as General Electric in the US and Siemens in

Europe, became leaders in manufacturing and innovation, introducing new technologies that made electrical appliances more affordable and efficient.

In parallel with the growing popularity of household electrical equipment, safety standards also developed. Innovations in electrical safety and product standardization ensured consumer protection by ensuring that electrical appliances were not only convenient to use, but also safe.

In general, the development of electric power and electrical equipment in the interwar period not only contributed to industrial growth and urbanization, but also provided the basis for further technological progress in the second half of the 20th century, affecting all spheres of life in society.

Development of non-ferrous metallurgy in the 1920s-1940s.

In the period 1920-1940, non-ferrous metallurgy underwent significant transformations that affected the economy and industry globally. Nonferrous metals such as copper, aluminum, zinc, lead, and tin have become essential to the development of many industries, from electrical engineering to automotive.

Copper, due to its excellent conductive properties, has become an indispensable material in the production of electrical wires and components, which allowed to expand the electricity supply infrastructure and contribute to the electrification of cities and industrial facilities.

Aluminum, on the other hand, has become a key material in the aerospace and automotive industries due to its lightness and strength. Its use in the production of aircraft allowed to reduce the weight of aircraft, increase their efficiency and flight range, while in the automotive industry, aluminum contributed to the creation of lighter and more economical vehicles.

Lead, used in the production of storage batteries, has played an important role in the development of the automotive industry and energy storage systems, providing a reliable power source for a variety of technologies. Zinc, due to its anti-corrosion properties, has been used to protect metal structures and products from corrosion, extending their service life and efficiency.

The development of industries related to the extraction and processing of non-ferrous metals not only contributed to technological progress, but also stimulated economic growth, creating new jobs and expanding opportunities for engineering and design. The use of these metals in various industries has shown their importance both in achieving technical progress and in improving the quality of life of people, providing the basis for further innovations in various areas of the modern world.

In the years 1920-1940, non-ferrous metallurgy experienced a period of significant technological breakthroughs, which made it possible to solve long-standing production problems and reduce the cost of non-ferrous metals, in particular aluminum. The Bayer process, pioneered to obtain alumina from bauxite, and the Hall -Eru process, which allowed the electrolytic production of pure aluminum, radically changed the industry. These innovations not only made aluminum easier to produce, but also made it much cheaper and more readily available for mass use in aircraft, automobiles, and consumer goods.

Improvements in flotation methods, a technology that allows you to effectively separate valuable minerals from junk rock, have contributed to a significant increase in the production of copper, lead, zinc and other metals. This not only increased the efficiency of mining, but also ensured a more stable supply of raw materials for various industries.

The development of technologies in non-ferrous metallurgy had a huge impact on the economy and industrial development in general. The decrease in the cost of non-ferrous metals made possible the mass production of electrical cables, vehicles, building materials and other products that were inaccessible to the general population before these innovations. In addition, improvements in the extraction and processing of metals contributed to the development of new engineering and construction solutions, opening the door to further innovations in construction, aviation and other high-tech sectors of the economy.

The development of non-ferrous metallurgy also had a reverse side - increasing damage to the environment. Mining and processing of non-ferrous metals has led to

large-scale pollution of air, water and soil, including toxic emissions, heavy metals and other harmful substances.

During this period, the United States, Canada, the USSR, and some European countries, such as Germany and Great Britain, became world leaders in the production of non-ferrous metals. These countries have invested significant resources in the development of the mining industry and metallurgical production, introducing the latest technologies and methods. This not only contributed to the increase in production volumes, but also stimulated scientific research and engineering development in this field.

The development of non-ferrous metallurgy in these countries was also closely related to the military industry, especially in the context of the preparation and conduct of the Second World War. The demand for non-ferrous metals has increased significantly due to their use in the production of weapons, military equipment and ammunition.

Overall, the development of non-ferrous metallurgy in the 1920s and 1940s was crucial to industrial growth, technological development, and military power. At the same time, it emphasized the need to develop effective methods of environmental protection and reduce the negative impact of industrial production on nature.

The beginning of the era of television

The period 1920-1940 was marked by significant steps in the development of television, which became a new era in mass communication and entertainment. Advances in hardware, major engineering inventions, and the first television broadcasts changed the way people received information and entertainment.

The first research in the field of television focused on the creation of a reliable system of image transmission over a distance. Inventors such as John Logie Baird in Britain and Vladimir Zworykin in the US made huge contributions to the development of electronic components such as the iconoscope (the first television camera) and the kinescope (television screen).

In the years 1920-1940, engineers and scientists took a huge step forward in the development of television technology, laying the foundation for the mass distribution of television in the following decades. The development of the scanning system, a key component of television technology, made it possible to transmit motion images with extreme precision and smoothness. This system used electronic signals to control the movement of an electron beam in a cathode ray tube, scanning the image line by line, creating the illusion of a moving image on the screen.

The creation of the electron beam tube, the invention of which is attributed to the German physicist Karl Ferdinand Braun, was another important milestone in the history of television. It converted electrical signals into visual images, effectively displaying them on a screen. The cathode ray tube was the heart of early televisions, enabling the display of dynamic images and eventually the transmission of live television broadcasts.

These innovations made it possible to create working prototypes of televisions, which were eventually improved and adapted for mass production.

One of the first major public broadcasts was television coverage of the 1936 Olympic Games in Berlin, Germany. This was accomplished with the help of the German Television Service, established under the leadership of Ferdinand Braun. The broadcast demonstrated the potential of television as a means of mass information.

In Great Britain, the BBC (British Broadcasting Corporation) began regular television broadcasts in 1936, using a system developed by John Logie Bird. This marked the beginning of regular television broadcasting available to the general public.

Television also developed rapidly in the Soviet Union. In 1931, the first remote image transmission in the USSR was carried out. The development of Soviet television gained momentum in the 1930s, when the first television stations were founded, and in 1934 an experimental television station was launched in Moscow. Soviet engineers worked to improve television equipment, including cameras and receivers, and to expand the television broadcast network.

The first telecasts in the USSR were educational and propaganda in nature, demonstrating the achievements and successes of the Soviet people. Despite the

technical and ideological challenges, by the end of the 1930s, the foundations for the further development of the television industry were established in the USSR.

Thus, the period 1920-1940 was the time of birth and development of television as an important means of communication and entertainment. The development of technology, the creation of infrastructure and the growth of the production of television equipment laid the foundation for the mass distribution of television in the following decades.

Creation of jet aviation (1920-1940)

In the period between 1920 and 1940, the foundations of jet aviation were laid, which was a significant step forward in the development of aircraft construction. An important breakthrough in this field was the creation of turbojet engines, which made it possible to significantly increase the speed and efficiency of aircraft compared to traditional piston engines.

The basis for the development of jet aviation was the creation of the turbojet engine, which was achieved thanks to the work of such engineers as Frank Whittle in Great Britain and Hans von Oheim in Germany. These engines work on the principle of drawing in air with the front blades of the compressor, compressing it, mixing it with fuel and then burning it, and then ejecting hot gases from the back, which creates thrust and sets the aircraft in motion.

In the Soviet Union, an important contribution to the development of jet engines was made by the engineer Arkhip Lyulka, who developed several projects of turbojet engines and became one of the pioneers in this field. Lyulka's work laid the foundation for the creation of the first Soviet jet aircraft.

Germany took a leading position in this field, successfully developing and launching the Messerschmidt Me-262, the world's first mass-produced jet fighter. This aircraft had exceptional flying characteristics, including high speed and maneuverability, which made it significantly more efficient than most Allied piston aircraft. The Messerschmidt Me-262 was armed with powerful machine guns and missiles capable of inflicting serious damage on enemy aircraft and ground targets.

In Great Britain, the development of jet aviation also achieved significant success with the production of the Gloucester Meteor, the British RAF's first operational jet aircraft. The Gloucester Meteor entered service in 1944 and played an important role in anti-aircraft defense against German B-1s and other threats. Although the Meteor did not have the high speed figures of the Me-262, it was a reliable and efficient aircraft, which allowed the British to gain valuable experience in the use of jet aircraft.

In the USSR, interest in jet aviation has been manifested since the end of the 1930s, when the first experimental developments in this area began. Although World War II slowed down some of these projects, it also demonstrated the need for faster and more maneuverable aircraft capable of competing with the best designs of both allies and enemies. Among the early developments were designs that did not reach mass production, but pioneered experience that became extremely valuable in the post-war period.

After the war, Soviet designers, including Artem Mikoyan and Mykhailo Gurevich, intensified work on jet aircraft, creating a number of fighters, including the MiG series .

The development of jet aviation in the USSR was also boosted by the interception and study of Western technology, which allowed Soviet engineers to make faster progress in designing their own jet aircraft. In addition, great emphasis was placed on the training of qualified engineers and pilots able to effectively use the advantages of new technology.

It is important to note that the development of jet aviation was not limited to the creation of military aircraft. It also contributed to advances in civil aviation, where the principles of jet propulsion were used to create faster and more efficient passenger aircraft.

Thus, the development of jet aviation in the 1920s and 1940s was of great importance not only for military strategy and technology, but also for civil aviation, opening new horizons in passenger and cargo transportation and setting new standards in the aviation industry.

Creation and use of rockets on solid and liquid fuel

The period between 1920 and 1940 was a time of important discoveries and innovations in the field of rocketry, which laid the foundation for the further development of space research and military technology.

Konstantin Tsiolkovsky, a Russian and Soviet scientist, is often considered the father of theoretical astronautics. In his works, he outlined the basic principles of using rockets for space travel and first proposed the idea of a multi-stage rocket. His pioneering theoretical developments played a key role in the development of rocket technology.

Robert Goddard, an American scientist and engineer, made a significant contribution to the development of practical rocketry. He created and launched the world's first liquid-fueled rocket in 1926. His innovations, including the use of the de Laval nozzle and flight control systems, became the foundation for modern rocketry.

During the 1930s, active development of missile technologies was carried out in Germany, which found its embodiment in the famous series of FAU missiles. Wernher von Braun, a prominent German and later American rocket engineer, led the team that developed the V-2 rocket, the first long-range combat missile used in World War II. This was the first ever use of ballistic missiles for military purposes.

Solid rockets are simpler in design and more reliable than liquid rockets, but they are less flexible to control and usually have less thrust. Liquid rockets, in contrast, require more complex control and fuel systems, but provide greater thrust and maneuverability in flight. This allows for more precise control of speed and direction, which is critical for military applications and space flight.

The development of liquid-fueled rockets, in particular, made it possible to reach higher altitudes and speeds that were impossible for solid-fueled rockets of the time. Nevertheless, solid-fuel rockets continued to be developed and found use for military and research purposes due to their simplicity and reliability.

Both types of rockets played an important role in the development of rocket technology and were of great importance for further progress in space research. Thanks

to these technologies, the foundations were laid for future advances in astronautics, including interplanetary flight and space exploration.

The development of rocket technology in the 1920s and 1940s showed the importance of integrating scientific knowledge, engineering art and production capabilities, which later became the basis for the creation of increasingly complex and powerful missile systems that changed the face of the modern world.

Control questions for the topic:

1. What key advances in nuclear physics were made in the 1920s and 1940s? Describe the main studies and their authors.
2. How did the development of electric power affect the production of electrical equipment in the period between the two world wars? Give examples of specific inventions or technologies.
3. Describe the main trends and achievements in non-ferrous metallurgy in the 1920s-1940s. What impact did it have on other industries?
4. What was the significance of the beginning of the era of television for culture and society? What technological innovations have become possible thanks to the development of television?
5. How did the creation of jet aircraft change the aviation industry and military strategy? Describe the key models of jet aircraft and their designers.
6. What was the importance of the research and development of rockets on solid and liquid fuel for the further development of space technology and military applications?
7. How did the changes in science and technology of the 1920s and 1940s affect people's everyday lives? Give examples of specific inventions or technologies.
8. Evaluate the impact of the development of scientific research and technological innovations of this period on the further development of society. What challenges and problems have arisen as a result of these changes?

Lecture 8. Development of science and technology in the second half of the 20th - at the beginning of the 21st century.

1. Development of electric power industry. Alternative energy.
2. Stages of development of computer technology, digital technologies. (Hardware part)
3. Stages of development of computer technology, digital technologies. (Software part)
4. New directions of transport development.
5. Academician S. Lebedev and his contribution to modern science.
6. "Space Race"

Development of electric power industry and alternative energy in the second half of the 20th - at the beginning of the 21st century.

The development of electric power in the second half of the 20th century and the beginning of the 21st century was marked by significant technological changes, among which the introduction of nuclear power plants and the development of renewable energy sources played a major role.

Nuclear power plants (NPPs) became a significant source of electricity in the second half of the 20th century. Nuclear power plants (NPP) produce electricity using nuclear reactions, which distinguishes them from traditional thermal power plants that use coal, gas or oil. The core of the NPP's work is a nuclear reactor, where the controlled fission of uranium or plutonium atoms takes place. During this process, a large amount of heat is released, which is used to heat the water. The water is turned into high-pressure steam, which is then sent to a turbine, causing it to spin. The rotation of the turbine generates an electric current with the help of a generator.

A key element of NPP safety is the cooling system, which prevents the reactor from overheating. The cooling system removes heat from the reactor and maintains the temperature at a safe level. In some cases, large water tanks or special cooling towers are used.

After the steam has done its work in the turbine, it cools and condenses back into water in the condenser, where it can be used again for heating. This cyclical process allows efficient production of electricity, minimizing the consumption of resources.

NPPs have a high level of energy efficiency and are capable of producing large amounts of electricity, which makes them an important part of the energy infrastructure of many countries. At the same time, they require complex safety measures and careful waste management.

However, the development of nuclear energy was also accompanied by serious challenges, especially after accidents at nuclear power plants such as Chernobyl (1986, Ukraine) and Fukushima (2011, Japan). These events highlighted the potential risks of using nuclear power and prompted the search for safer and more sustainable energy sources.

Renewable energy sources play a key role in the global transition to a more sustainable energy system, which reduces dependence on fossil fuels and contributes to the fight against climate change. Solar energy is one of the fastest growing sectors, thanks to the rapid drop in the cost of solar panels and the improvement of their efficiency. This allows not only large solar farms, but also private households to invest in their own power generation systems, reducing their carbon footprint and reducing energy costs.

Wind energy also shows significant potential, especially in regions with high wind potential. The development of offshore wind farms allows the use of strong sea winds, ensuring stable energy production. At the same time, wind turbines are becoming more and more efficient and cost-effective, making wind power one of the fastest ways to decarbonize the energy sector.

Hydropower, which has long served as a reliable source of renewable energy, continues to be an important part of the energy mix of many countries. Despite the environmental and social challenges associated with building large dams, new technologies such as small hydropower and the use of low-impact reservoirs offer more sustainable solutions for power generation.

Bioenergy, which involves the production of energy from biomass, is becoming more widespread due to its ability to convert organic waste into useful energy. This not only promotes waste disposal, but also ensures the production of heat and electricity with minimal impact on the environment.

Geothermal energy, although geographically limited, offers a stable and reliable source of energy for heating and electricity generation. Using the Earth's natural heat can significantly reduce dependence on fossil fuels, especially in regions with high geothermal activity.

The use of these and other renewable energy sources is increasing every year as they help reduce dependence on fossil fuels and reduce carbon dioxide emissions. However, the transition to renewable energy also requires significant investments in new technologies and infrastructure, as well as the development of efficient energy storage systems to overcome its intermittency .

The development of renewable energy sources is of great importance not only for ecology, but also for the economy and security of states, as it allows countries to become more energy independent and resistant to external shocks in energy markets.

Stages of development of computer technology and digital technologies (Hardware part)

The development of computer technology in the second half of the 20th - at the beginning of the 21st century. can be divided into several key stages, each characterized by significant technological breakthroughs and changes in the use and capabilities of computing machines.

Four generations of computers and their features

1. The first generation (1940s - early 1960s) were large, often room-filling machines that used electronic lamps. They had limited computing power and used magnetic drums to store data. Examples include ENIAC and UNIVAC.
2. Second Generation (early 1960s - late 1960s) – This generation of computers used semiconductor transistors instead of electronic tubes, making them more

reliable, smaller, and more efficient. Memory on magnetic cores replaced magnetic drums. Examples include the IBM 7094 and the PDP-8.

3. The third generation (late 1960s - 1970s) - these systems used integrated circuits, which made it possible to further reduce the size and cost of computers, as well as significantly increase their performance. This generation introduced the concepts of operating systems and higher-level programming. IBM System /360 is one of the famous representatives of this generation.
4. The fourth generation (1980s - present) - the development of microprocessors marked the beginning of the fourth generation. Personal computers became widely available, and the integration of all major computer components on a single microchip greatly increased performance and functionality. Examples include the IBM PC, Apple Macintosh, and others.

Gordon Moore, co-founder of Intel, observed in 1965 that the number of transistors on a microchip doubled approximately every two years, leading to a rapid increase in computing power while reducing the size and cost of microchips . This observation, known as Moore's Law, became fundamental to the development of computer technology, predicting rapid growth in microprocessor performance and spurring innovation in manufacturing and design.

With the appearance of the fourth generation of computers, new technological companies appeared on the market, which contributed to the rapid development and distribution of personal computers. Companies such as Apple, IBM, Microsoft, Intel, and many others have played a key role in the development of the computer industry. They invested significant resources in research and development, which led to new microprocessor architectures, improved software, and expanded computer functionality.

This period was also marked by the development of network technologies and the Internet, which, together with the development of computer technology, created the basis for the global information age. The development of wireless technologies, mobile devices and cloud computing have become a logical continuation and development of computer equipment and digital technologies.

ARM, the architecture behind much of today's mobile devices, was developed in the 1980s by Acorn Computers. It has become popular due to its energy efficiency and high performance, which makes it ideal for mobile phones, tablets and other portable devices. Due to its advantages, ARM quickly became the standard in the mobile industry.

Over the years, ARM Holdings has developed numerous versions of the architecture, each offering improvements in speed, power efficiency, and data processing capabilities. This constant improvement has allowed the ARM architecture to maintain its dominance in mobile and embedded systems.

One of the key moments in ARM's history was the adoption of its architecture by major technology companies such as Apple, Samsung , and Qualcomm for use in their devices. This not only ensured the widespread adoption of ARM, but also contributed to innovations in microprocessor design.

Today, ARM continues to be at the forefront of technological development, offering solutions that meet the needs of high-speed data processing, artificial intelligence and the Internet of Things, thanks to its flexibility and adaptability to the new challenges of the digital era.

In general, the development of computer technology and digital technologies in the second half of the 20th - at the beginning of the 21st century. changed the modern world, causing radical changes in the economy, culture and everyday life of people.

Stages of development of computer equipment and digital technologies (Software part)

Software development in the second half of the 20th century and the beginning of the 21st century went through several key stages that changed approaches to programming, interaction with computers, and their use in everyday life.

The development of programming languages began with machine code and assembly languages, which required a deep understanding of computer architecture. In the 1950s, the first high-level languages such as FORTRAN and COBOL were developed, allowing programmers to write code that was hardware-independent. In the

following decades, such languages as C, Java, Python appeared, which simplified the development of programs and expanded the possibilities of programming.

High-level programming languages allow programmers to write code that is easier to read and understand, and that focuses more on the logic of the program than on the hardware features of the computer. In contrast, low-level languages such as assembly provide almost direct hardware control and efficiency but require a more detailed understanding of how the computer works and are more difficult to develop and maintain.

The evolution of operating systems (OS) is fundamental to the development of information technologies. It started with UNIX, which became the basis for many modern operating systems due to its modularity and multitasking. MS-DOS, launched in the 1980s, made personal computers more accessible to a wide range of users, but was limited to a text-based interface and single-tasking.

A revolutionary step was the introduction of the graphical user interface (GUI) in systems such as Apple's Mac OS and Microsoft's Windows. This greatly simplified the interaction of users with computers, making them intuitive and easy to use. Modern versions of Windows and Mac OS continue to develop these ideas, offering powerful tools for work and entertainment, support for a wide range of software and a high level of user experience.

Linux, on the other hand, offered an open and flexible approach to OS development. Its modularity and customization have made it a popular choice among developers, system administrators, and tech-savvy users. Linux is the basis of many server systems, cloud computing and even the Android mobile OS.

The development of operating systems reflects the general progress in the field of computer technology, adapting to the growing needs of users and constantly changing hardware. Operating systems have become not just a means of managing computer resources, but also a platform for innovation and development of new software, playing a central role in today's digital world.

The emergence of the Internet launched a real revolution in the field of digital technologies, making the global information network an integral part of the everyday

life of billions of people. Beginning as an ARPANET scientific project designed to share data between universities and research laboratories, the Internet has evolved into a comprehensive network that integrates a variety of technologies, platforms, and services.

Developments in web technologies, including markup and style languages such as HTML and CSS, as well as JavaScript programming, have made the web more interactive and user -friendly. The introduction of protocols such as HTTP for the transfer of hypertext documents and FTP for file transfer made it easier to share information and access content, fueling the growth of websites and online services.

Thanks to these innovations, the Internet has become the basis for the development of e-commerce, digital marketplaces, social networks and many other platforms that allow users not only to consume content, but also to actively interact by exchanging knowledge, opinions and products. It has not only transformed consumer habits and business models, but also fostered new forms of communication and communities, making the Internet a key element of today's digital culture.

Thus, the Internet is not only a technological infrastructure, but also a catalyst for social change and innovation that continuously evolves and adapts to the needs of users and the market, opening up new opportunities for global interaction and creativity.

The development of the Internet also led to the emergence of cloud technologies and big data, which made it possible to store, process and analyze huge amounts of information in real time. This has opened new opportunities for scientific research, education, medicine and many other fields.

In general, the stages of development of computer technology and digital technologies have significantly influenced society and culture, changing the way people live, how they interact with information and with each other. The modern world is becoming increasingly digital, which requires constant development and adaptation to new technologies.

New directions of transport development (second half of the 20th - beginning of the 21st century)

In the second half of the 20th century and the beginning of the 21st century, the world witnessed significant innovations in the field of transport that changed the way people and goods move.

The introduction of high-speed trains has radically changed the landscape of rail transport, providing a fast, comfortable and efficient way to travel between cities and countries. After the successful launch of the Shinkansen in Japan, which set new standards for passenger transportation with its impressive speed and punctuality, other countries sought to develop their own high-speed rail systems.

In France, TGV (Train à Grande Vitesse) ushered in a new era in European rail transport, connecting cities such as Paris and Lyon in record time. The launch of the TGV catalysed the development of similar systems in neighboring countries, including Germany with its Intercity -Express (ICE) and Italy with the Frecciarossa, enabling the creation of an extensive high-speed rail network across Europe.

China, on the other hand, has made a huge leap in the development of its high-speed railway, investing billions of dollars in the construction of one of the largest networks in the world, which today covers thousands of kilometers and provides connections between the main cities and regions of the country at speeds exceeding 300 km/h.

The development of high-speed rail not only contributed to economic growth and reduced travel times, but also became an important factor in improving the environmental sustainability of transport infrastructure, providing a cleaner and more efficient alternative to road and air transport.

The development of jet aviation ushered in a new era in passenger transportation, allowing aircraft to carry more passengers over greater distances at significantly higher speeds than was possible with turboprop aircraft. De Havilland The Comet, as the first jet passenger aircraft, marked the beginning of this revolution, although it faced serious reliability problems that led to catastrophic accidents. However, the success of the

Boeing 707 and Douglas DC-8 restored confidence in jet aviation, setting new standards of safety and comfort for intercontinental flights.

The launch of these aircraft contributed to globalization by reducing the isolation of remote regions and making international travel more accessible to a wide range of people. It also started a competition between aircraft manufacturers to create even more efficient, safe and economical jet aircraft, which led to the development of wide-body aircraft like the Boeing 747, which further increased the volume and lowered the cost of air travel.

Today, jet aircraft continue to dominate the aviation industry, and their continuous technological improvement focuses on increasing fuel efficiency, reducing emissions and improving passenger comfort, ensuring continuous progress in the field of commercial air travel.

The resurgence of interest in electric vehicles in today's world has been fueled by the global need to reduce carbon dioxide emissions and reduce dependence on fossil fuels. The development and commercialization of electric vehicles became possible thanks to significant breakthroughs in battery technology, which not only increased the energy efficiency and range of cars, but also reduced charging times.

Tesla Motors, founded by Elon Musk, played a key role in the popularization of electric cars, offering the market high-performance cars that can compete with traditional gasoline cars not only in terms of characteristics, but also in terms of design and comfort. Models like Tesla Model S, demonstrate that electric vehicles can provide impressive dynamic performance and a long range on a single charge.

Tesla is being followed by other automakers that are also investing significant resources in the development of electric vehicles. This has led to the expansion of the electric car market, where consumers have a choice among a wide range of models from economy to premium class. Governments in many countries are supporting this movement by offering tax breaks and subsidies for the purchase of electric vehicles, as well as investing in the development of charging station infrastructure.

Thus, electric vehicles are becoming more accessible and practical for a wide range of users, promising to significantly change the future of road transport and make it more environmentally sustainable.

Hyperloop is a new concept of transportation that involves the movement of capsules with passengers or cargo along a low-pressure pipeline over long distances at speeds close to the speed of sound. The idea, originally proposed by Elon Musk in 2013, aims to revolutionize travel times between major cities. Although the hyperloop is still in the development and testing stages, several companies, including Hyperloop Transportation Technologies and Virgin Hyperloop, are actively working on the implementation of this technology. They conduct experiments to check the safety, efficiency and economic feasibility of this type of transport.

These new directions of transport development reflect global efforts to improve the efficiency, environmental friendliness and accessibility of transport systems. They have the potential to radically change the ways in which we move, and to influence urban planning, the global economy and the environment. The development of transport technologies continues to be an important factor in creating a sustainable and efficient future.

Academician Sergey Lebedev and his contribution to modern science

Serhiy Oleksiyovych Lebedev (1902-1974) is an outstanding Ukrainian and Soviet scientist and designer, whose work significantly influenced the development of computer technology not only in the USSR, but throughout the world. His research and development opened up new possibilities for the use of computing machines for scientific and engineering purposes.

Serhiy Lebedev was born on July 2, 1902 in Nizhyn, Chernihiv Oblast. He graduated from the Leningrad Polytechnic Institute in 1928 and worked at various scientific institutes doing research in the field of electrical engineering and electronics.

In 1939, Lebedev moved to Kyiv, where he headed the laboratory at the Institute of Electrical Engineering of the Academy of Sciences of the Ukrainian SSR. There he

began his first research in the field of computing. It was in Kyiv that he laid the foundations for the creation of the first Soviet computer.

Under the leadership of Lebedev, the first electronic calculator in the USSR was created - MERM (Small Electronic Calculator), which was launched in 1951. MERM was not only the first Soviet computer, but also one of the first in Europe, which marked the beginning of a new era in Soviet computer science and automation.

The creation of MERM under the leadership of Sergey Lebedev was a real breakthrough in Soviet science and technology. The development of this machine began in the conditions of post-war shortages and limited resources, but thanks to the innovative approach and perseverance of the team of scientists, it was possible to create a full-fledged computing device. MERM ensured the performance of a wide range of computing operations and became the basis for the further development of computing technology in the USSR.

Work on MERM was an important step in the development of domestic electronics and programming. The machine became a living testimony of the potential of electronic computing machines in an era when much of the calculations were performed manually or with the help of electromechanical devices. MERM has made it possible to solve complex scientific problems, contributing to progress in such areas as nuclear physics, astronomy and engineering.

The success of MERM marked the beginning of the active development of computer technology in the USSR, stimulating the creation of new computer models that later found application in various areas of economics and scientific research. Thus, the initiative of Lebedev and his team not only opened a new page in the history of Soviet science, but also made a significant contribution to the global development of informatics and computer technologies.

The creation of VEOM-6 became an important stage in the development of computer technology in the USSR, demonstrating the significant achievements of Soviet scientists in the field of computer engineering and programming. This machine was designed based on the experience gained during the development and operation of the MERM, but with significantly greater computing power and functionality. VEOM-

6 used electronic components that were modern for that time, which made it possible to increase its performance and reliability.

Due to its characteristics, VEOM-6 has found wide application in various fields of science and industry. The machine was used to perform complex scientific calculations, process large data sets, and design new technologies and materials. Its effectiveness in solving problems of high complexity contributed to progress in atomic energy, space research and other important fields.

The work of Lebedev and his team on VEOM-6 confirmed the position of the USSR in the development of computing technology. This project not only provided the scientific and technological basis for the further development of computers, but also contributed to the formation of a professional community of specialists in the field of computer science in the country, laying the foundations for innovation and research in this field for many years to come.

The "Elbrus" system appeared as a result of the desire of Serhiy Lebedev and his team to create a highly efficient computer system that could meet the growing needs for processing large data sets and performing complex scientific calculations. The development of " Elbrus " marked a significant step forward in the construction of computer architecture, offering solutions that optimized computing processes and improved overall system performance.

"Elbrus" was distinguished by the use of parallel data processing and high reliability, which made it ideal for use in critical areas, in particular, in the defense industry and space research. The system demonstrated exceptional capabilities in solving problems related to the modeling of complex scientific phenomena, design automation, and management of large databases.

The Space Race (1950s-1970s and the modern stage)

The space race became one of the most significant features of the Cold War, symbolizing the struggle for technological and political dominance between the US and the USSR. In the 1950s and 1970s, this competition spurred both countries to make significant advances in space exploration and technology development.

The space race began with the launch of the USSR's first artificial Earth satellite - " Sputnik " in 1957, which became a huge shock and challenge for the United States. In response, the US accelerated its space program, leading to the launch of its first satellite, Explorer 1, in 1958. The USSR's next major step was sending Yuri Gagarin into space in 1961, making him the first person to orbit the Earth. The USA's response was quick - in 1969, as part of the Apollo 11 mission, astronauts Neil Armstrong and Buzz Aldrin made the first landing on the moon.

This event was not only a significant achievement in human history, but also confirmed the possibilities and potential of space exploration. In parallel with manned missions, both countries have developed and launched a number of unmanned spacecraft to explore other planets of the solar system and outer space in general.

During the space race, numerous new technologies were developed that found applications not only in the aerospace industry, but also in everyday life, including satellite television, GPS navigation, improved materials, and medical technology. The space race also contributed to the development of the scientific and engineering potential of both countries, laying the foundation for further space exploration and discovery.

The end of the space race ushered in a period of cooperation in space, including joint missions and international projects such as the International Space Station, which became a symbol of the possibilities of international partnership in space exploration.

In the 21st century, the space race took on a new dimension, including not only national but also private initiatives. China, India, the European Space Agency and other countries have greatly expanded their participation in space exploration, launching their own satellites, missions to the moon and Mars.

Private companies such as SpaceX, Blue have a significant influence on the modern space race Origin, and Virgin Galactic. These companies were founded by famous entrepreneurs Elon Musk, Jeff Bezos, and Richard Branson, respectively, are developing the latest space technologies, such as reusable rockets, spaceships for tourist travel, and ambitious plans to colonize Mars.

SpaceX made history with the successful launch and return of the first reusable rocket, revolutionizing the cost of spaceflight. The company is also engaged in the development of Starship, a spacecraft intended for flights to Mars and other distant space missions. SpaceX already plays a key role in delivering cargo and crew to the International Space Station.

Blue Origin focuses on developing rockets and spacecraft for space tourism, offering short flights beyond the Earth's atmosphere. Although the company is moving more slowly than SpaceX, its goals and ambitions for a permanent human presence in space are also far-reaching.

Virgin Galactic develops space planes for subspace tourist flights, giving people the opportunity to experience weightlessness and see the curvature of the Earth. Their VSS Unity has already completed several successful test flights.

In general, the new stage of the space race is characterized not only by the competition of states, but also by the active participation of the private sector, which leads to the rapid development of technologies, the reduction of the cost of space flights and opens up new opportunities for space exploration. This not only promotes scientific and technological progress, but also opens up new horizons for the future of mankind in space.

Control questions for the topic:

1. Describe the main achievements and trends in the development of electric power in the second half of the 20th - at the beginning of the 21st century. What role did alternative energy sources play?
2. What were the main stages of the development of computer technology from the point of view of the hardware part in the specified period? Give examples of significant inventions or technological innovations.
3. What major changes occurred in the development of software (software part) from the second half of the 20th century to the beginning of the 21st century?

4. Describe the new directions of transport development that appeared in the second half of the 20th - at the beginning of the 21st century. How have these changes affected everyday life and the economy?
5. What contribution did Academician S. Lebedev make to the development of modern science? Describe his key achievements and impact on the scientific community.
6. What were the key moments and achievements in the "space race" in the second half of the 20th century? How did it affect the development of science and technology?
7. How have approaches to energy production and consumption changed with the development of alternative energy sources? What are the challenges and prospects facing the modern energy industry?
8. What technological breakthroughs and innovations in the field of computer technology had the greatest impact on the development of society and the economy in the late 20th and early 21st centuries?

Lecture 9. The main trends and prospects for the development of science in the 21st century

1. Big date
2. Internet of things
3. Augmented Reality (AR)
4. Quantum computing
5. Blockchain
6. 3D printing

Big Date

As part of the fourth industrial revolution, known as Industry 4.0, the concept of Big Data plays a key role, providing enterprises with new opportunities to analyze large volumes of data to make informed decisions and optimize processes.

Big Data refers to data sets that are so voluminous, fast-moving, or complex that traditional data processing methods are insufficient. It includes structured data (for example, from databases) and unstructured data (texts, videos, images). Big Data processing requires the use of powerful computing systems, machine learning algorithms and other analytical tools.

Big Data is often described using the four Vs: Volume, Velocity , Variety , and Veracity . Volume refers to the scale of data, Velocity refers to the speed at which it is received and processed, Variety refers to the different types and sources of data, and Value refers to its usefulness and reliability.

The use of Big Data continues to expand, covering an increasing number of sectors of the economy and spheres of life. In retail, big data analysis allows companies to better understand consumer behavior, optimize product assortment, and personalize marketing offers, thereby increasing sales and customer loyalty. In the field of transport, big data helps analyze traffic patterns, improve urban transport management and optimize logistics.

Big Data also has a significant impact in the field of energy, where the analysis of large volumes of data is used to forecast energy consumption, optimize resource allocation, and improve production efficiency. In education, data analytics helps identify and analyze trends in learning, adapt educational programs to student needs, and improve learning outcomes.

In addition, big data plays a key role in the development of Artificial Intelligence and machine learning, providing algorithms with the necessary amount of information to train and improve the accuracy of their predictions. This facilitates the development of intelligent systems capable of performing complex tasks, from automatic language translation and natural language processing to pattern recognition and autonomous driving.

Thus, the use of Big Data opens up new opportunities for innovation and efficiency in a wide range of industries, while at the same time creating challenges related to data protection, privacy and ethical issues.

The problem of privacy and data protection in the context of Big Data is particularly acute, because the volumes of collected information arrays are unprecedentedly large, and they may contain very sensitive data about people's personal lives. The risk not only of data loss due to hacker attacks, but also of their improper use by third parties without the consent of the owners is increasing. This creates the need to develop complex data protection mechanisms and ensure their confidentiality at all stages of processing.

The risk of "garbage data" indicates the importance of verification and validation of the information being processed. The quality of the input data directly affects the reliability of the conclusions obtained as a result of the analysis, which makes it necessary to thoroughly clean the data and critically evaluate it.

Ethical considerations cover a wide range of issues, from determining the limits of what is permissible in data collection to the management and use of analytical results. Issues of privacy, ownership of data and their commercial use arise, which requires the development of clear rules and regulations.

Technical challenges associated with Big Data processing include the need to use powerful computing resources, efficient analysis algorithms, and storage of large amounts of information. The development of data storage and processing technologies, such as cloud services and distributed ledger technologies, help to solve these problems, but at the same time they create new challenges in the field of information security.

In conclusion, Big Data is a powerful tool in the context of Industry 4.0, which, if used correctly, can significantly improve productivity, efficiency and innovation in various sectors. However, to ensure its positive impact, it is necessary to solve the challenges and threats associated with it.

Internet of things

The Internet of Things (IoT) plays a key role in the fourth industrial revolution, connecting physical objects with the Internet and enabling their interaction and data exchange. IoT covers a wide range of devices, from consumer gadgets to industrial equipment.

The Internet of Things (IoT) is one of the most promising areas of modern technology development, which is based on the integration of physical objects into the digital world with the help of built-in sensors, microprocessors and wireless communication. The main purpose of IoT is to collect, exchange and analyze data from the environment to improve people's quality of life, production efficiency and resource management.

RFID labels (Radio-Frequency Identification) are used for automatic identification and tracking of objects. These miniature devices can store a unique identifier and other information about the object to which they are attached, allowing data to be easily read from a distance without direct contact.

Smart sensors collect various types of information, from temperature and humidity to motion and lighting, and can automatically transmit the collected data for analysis. The use of such sensors in intelligent homes and in production allows to significantly increase comfort, safety and efficiency of energy consumption.

Intelligent weather stations and thermostats automate the collection of data on weather conditions and indoor temperature regulation, respectively. This allows not only to optimize living and working conditions, but also to increase the energy efficiency of buildings.

Smart watches and other similar devices collect data on the wearer's physical state, such as heart rate, activity and sleep quality, providing valuable information for monitoring health and improving training efficiency.

Real-time data processing platforms analyze information received from IoT devices to make operational decisions, predict events and optimize processes. These systems can integrate with cloud services, providing scalability, flexibility and availability of data processing.

In the home segment, IoT includes smart home systems that allow users to control lighting, temperature, security, and other home functions using smartphones or other devices. This promotes convenience, energy efficiency and safety.

Industrial IoT (IIoT) uses similar technologies to optimize manufacturing processes, increase productivity and reduce costs. IIoT includes smart factories where machines and equipment collect and share data to monitor production processes, predict maintenance and prevent failures.

IoT use cases cover a wide range of sectors. In agriculture, IoT enables precise control of irrigation and fertilizers depending on soil and weather conditions. In medicine, smart devices can monitor patients' vital signs and send data to doctors in real time. In logistics and transportation, IoT facilitates route optimization, cargo monitoring, and warehouse inventory management, ensuring more efficient use of resources and increased customer satisfaction.

Despite the numerous advantages, IoT carries certain risks and challenges. From a security perspective, the increasing number of connected devices creates more potential entry points for cyberattacks. Without proper protection, these devices can become easy targets for hackers who can steal personal data, disrupt systems or even use them to launch DDoS attacks.

Data privacy is also a significant concern, as IoT devices collect vast amounts of data about users' personal lives and behaviors. This raises the question of who owns this data and how it is used.

Technical challenges, such as incompatibility of standards and protocols, also complicate the integration and use of IoT in different sectors. In addition, there is a risk of network congestion due to the large amount of data being transferred and processed.

Despite the challenges, the potential of IoT within Industry 4.0 is extraordinary. The development of technologies and the introduction of new security standards can help minimize risks and maximize the opportunities provided by the Internet of Things to increase efficiency, ensure sustainability and create innovative solutions in various areas of life.

Augmented Reality (AR)

Augmented reality (AR) is one of the key technologies within Industry 4.0, as it changes the way people interact with the digital world by superimposing virtual objects on the real environment. This technology has a wide range of applications in various industries, including manufacturing, education, healthcare and entertainment.

AR uses cameras, sensors, microprocessors and displays to project virtual information onto the real world. The technology can be implemented through smartphones, specialized glasses (for example, Microsoft HoloLens or Google Glass) or through projectors. AR systems can use marker, markerless, or projection approaches.

Marker AR requires the use of special markers – usually QR codes or special images – that serve as landmarks for placing virtual elements in the physical world. This allows you to precisely determine the location of virtual objects and ensure their correct integration with real objects.

Markerless AR, on the other hand, offers more flexibility because it does not require any external features or markers. Using computer vision and artificial intelligence algorithms, markerless AR can analyze the environment through a mobile device's camera, recognize surfaces, objects, and even estimate the depth of a scene.

This allows virtual objects to be superimposed directly on the real environment with a high degree of accuracy and realism, expanding the possibilities of using AR in navigation, games, education and marketing.

Projection AR opens up new horizons for interacting with virtual content by projecting light images onto physical surfaces. This method does not require screens or special glasses and can be used to create interactive installations, navigation systems in public places, as well as for educational and entertainment activities. Projection AR provides a direct display of information on surfaces, creating the effect of the presence of virtual objects in the real world.

In industry, AR can be used to visualize complex processes, train personnel, support repairs and maintenance. For example, engineers can use AR to view schematics in real time while working on a machine or for virtual prototyping.

In medicine, AR can be used to visualize a patient's anatomy during surgery or to teach students, allowing them to "see" under the skin without real interventions.

In education, AR can make the learning process more interactive and understandable, allowing students to visualize complex concepts and historical events as if they were actually happening in front of them.

In retail, AR can be used to enhance the shopping experience by allowing customers to "try on" clothes or "see" how furniture will look in their home before purchasing.

Despite its multiple benefits, AR also comes with risks and challenges. Data privacy and security are significant concerns, as AR can collect large amounts of personal information through cameras and sensors. This requires developers and manufacturers to implement strict data protection and privacy measures.

In addition, there are concerns about "information overload", where users are exposed to too much virtual information, which can lead to reduced attention and distraction in the real world, especially during tasks that require high concentration.

Technical limitations such as display quality, battery life, and data processing speed limitations can also affect the effectiveness and quality of using AR.

Finally, there is a risk of dependence on technology and loss of real social connections, as people may become more focused on the virtual world, separating themselves from real life.

Despite these challenges, the potential of AR within Industry 4.0 is enormous, offering new opportunities for innovation and improvement in various fields of activity. It is important that the development and implementation of AR is accompanied by careful consideration of ethical, social and technical issues in order to maximize its benefits and minimize potential risks.

Quantum computing

Quantum computing represents a revolutionary breakthrough in computing that uses quantum phenomena such as superposition and entanglement to process information orders of magnitude faster than is possible with classical computing.

Quantum computers use the quantum properties of qubits to calculate tasks beyond the reach of the most powerful conventional machines. Qubit (qubit , QUantum Bit) — quantum bit — is an elementary unit of quantum information.

A qubit, unlike a classical bit, which can only be in one of two states (0 or 1), has the ability to be in both states simultaneously thanks to the phenomenon of quantum superposition. This phenomenon allows quantum computers to perform several calculations at the same time, which significantly increases their computing power compared to traditional computers. This ability of qubits provides an advantage in tasks that need to process large amounts of data or perform complex calculations, such as factoring large numbers, optimization and modeling chemical reactions.

In addition to superposition, qubits also use the principle of quantum entanglement, which allows the state of one qubit to influence the state of another, regardless of the distance between them. This phenomenon becomes the basis for quantum teleportation and quantum communication, opening up new opportunities for the development of quantum networks and secure communication technologies.

Thanks to these principles, quantum computers have the potential to revolutionize many fields, from cryptography and optimization to modeling chemical

reactions, that would be beyond the reach of classical computers. For example, they can find applications in the development of new materials and drugs by performing precise simulations of molecular structure, which require computing power not available to traditional systems.

Despite the great potential, the development of quantum computing faces technical challenges, such as the need to keep qubits in a stable quantum state, which requires extremely low temperatures, and the difficulty in accurately measuring qubit states without destroying them. The development of algorithms that effectively take advantage of quantum computing is also a subject of active research.

Specialized programming languages for quantum computing, such as Microsoft's Q# and IBM's Qiskit, are fundamental tools for development and research in quantum technology. Q#, developed by Microsoft, is part of the Quantum Development Kit, which provides an integrated environment for creating quantum algorithms, simulating quantum operations, and testing them on classical computers. The language includes unique constructs specific to quantum computing, such as quantum gates and entanglement, allowing developers to efficiently manipulate qubit states.

Qiskit, developed by IBM, is open source software designed to work with quantum computers on the IBM Quantum Experience. It allows users to easily design experiments, run them on real quantum computing systems via the cloud or on-premises simulators, and analyze the results. Qiskit provides powerful tools for building and optimizing quantum algorithms, facilitating research in quantum computing.

Both programming languages aim to provide developers with tools to work efficiently with quantum computing, allowing them to develop new quantum algorithms and implement them in a variety of applications. This includes everything from cryptography and optimization to quantum chemistry and materials science. The development of these languages and related tools opens up new opportunities for researchers and developers to deepen the understanding of the quantum world and develop the quantum technologies of the future.

Companies like IBM, Google, and D- Wave have already developed working quantum computers. For example, IBM Q System One is one of the first commercially available quantum computers. Google also announced the achievement of quantum supremacy with their Sycamore processor.

Quantum computing has the potential to revolutionize many industries, including cryptography (developing new encryption methods), pharmaceuticals (rapid modeling of molecules), finance (optimizing portfolios), and logistics (solving the traveling salesman problem).

Quantum computing carries a number of potential threats and challenges. One of the biggest threats is the ability of quantum computers to break current cryptographic standards, which could lead to major problems with the security of data and communications. In addition, quantum computing can create new types of cyber threats for which modern security systems are not prepared. There is also the risk of concentrating technological power in the hands of a limited number of actors, which can lead to an imbalance of power and control. Finally, the rapid development of quantum technologies may outpace the development of ethical norms and legal frameworks, potentially leading to unresolved social and legal issues.

Quantum computing represents a major advance in computing and has the potential to radically change the Industry 4.0 landscape. This technology promises to significantly speed up data processing and solving tasks that are now considered too difficult for classical computers. The introduction of quantum computing could lead to breakthroughs in materials science, logistics, drug manufacturing and artificial intelligence, making manufacturing processes more efficient, accurate and economical.

In particular, quantum computing can help develop new materials, optimize supply chains, improve machine learning methods, and accelerate the development of new drugs. However, realizing this potential requires overcoming technical and theoretical challenges, as well as ensuring the security of quantum data.

Thus, quantum computing should become an important component of Industry 4.0, offering new opportunities for innovation and efficiency in various industrial sectors.

Blockchain

Blockchain is one of the key technologies underlying Industry 4.0, offering new approaches to guarantee security, transparency and decentralization in data processing and transactions.

Blockchain is a distributed database that provides the ability to maintain a high level of security and transparency for the storage of digital records. Blockchain technology uses sequential blocks of data connected using cryptography. Each block contains a unique hash (information encrypted according to a certain algorithm - a digital fingerprint of the transaction) of the previous block, transactions made during the time period, and its own hash. This creates a chain of blocks (blockchain), where it is impossible to change information in one block without changes in all subsequent blocks, which ensures immutability and traceability of information.

Decentralization is a key feature of blockchain, as copies of the database are stored on many computers in the network. This reduces the risks of centralized systems such as data manipulation or a single point of failure. Consensus algorithms such as Proof are used to confirm transactions and add new blocks to the chain of Work or Proof of Stake, which ensures data consistency across the network.

Blockchain has a wide range of applications, from financial transactions, as in the case of cryptocurrencies such as Bitcoin, to smart contracts on platforms such as Ethereum, which allows automating the execution of contractual agreements without intermediaries. This technology opens up new possibilities for creating transparent and secure voting systems, delivery systems, digital identification and much more.

The concept of blockchain was first introduced in 2008 by an individual or group under the pseudonym Satoshi Nakamoto as a technological basis for cryptocurrency Bitcoin. Since then, blockchain has found applications in many other areas outside of cryptocurrencies.

Cryptocurrencies such as Bitcoin and Ethereum are especially famous for using blockchain. They use blockchain to provide security and transparency to transactions. However, the potential of blockchain is much broader and includes decentralized

databases, smart contracts, and other applications where reliability and traceability are required.

Blockchain finds applications in supply chains to ensure transparency and traceability of goods, in financial services to improve the efficiency and security of transactions, in the identification and authentication of individuals, in voting to ensure the integrity of elections, and in many other areas.

Despite its many advantages, blockchain also carries certain risks. One of the main challenges is scalability: blockchains can have trouble processing large numbers of transactions quickly. There are also privacy issues: although the blockchain ensures the anonymity of transactions, the full transparency of all transactions may reveal personal information in the case of de-anonymization of addresses or in other specific situations. Additionally, storing large amounts of data on the blockchain can be a challenge in terms of efficiency and cost.

Energy consumption is another critical issue, especially for blockchains using the Proof consensus mechanism of Work, as in the case of Bitcoin . It requires a lot of computing resources and consumes a lot of electricity, which puts environmental sustainability at risk.

Security threats such as a 51% attack (where one group of miners controls the majority of the network's computing power) and the possibility of tampering with smart contracts through code errors or design flaws are also important risk factors.

In addition, legal uncertainty and lack of standards can make it difficult to integrate blockchain technologies into traditional business processes and regulatory frameworks, creating additional barriers to their adoption and implementation.

Despite these challenges, the potential of blockchain to strengthen security, increase transparency and streamline processes in many industries remains significant. It is important to develop and apply these technologies responsibly, taking into account all potential risks and challenges.

3D Printing

3D printing, or additive manufacturing, is one of the key technologies of Industry 4.0, which allows creating physical objects layer by layer from digital models. This technology is revolutionizing manufacturing processes, design, medicine, and other industries.

The main components of 3D printing include 3D printers, consumables (plastic, metal, ceramic, etc.), and modeling software. The printing process begins with the creation of a digital 3D model of the object, which is then converted into a series of horizontal layers and sent to the 3D printer.

Types of technology:

1. FDM (Fused Deposition Modeling) is one of the most common technologies, due to its availability and ease of use. The material, usually a thermoplastic, is heated to its melting point and pushed through an extruder, layer by layer, allowing for the production of strong and functional parts from a wide range of plastics.
2. SLA (Stereolithography) uses precise UV light to cause polymerization in liquid resin, creating highly detailed and smooth models. This technology is ideal for prototyping, jewelry, and components that require high precision and surface quality.
3. SLS (Selective Laser Sintering) allows you to create strong and durable objects using a laser for sintering powder materials. This technology is suitable for the production of functional parts, complex mechanisms, as well as for the production of products based on metal, ceramics or high-strength plastics without the need for the use of supporting structures.
4. DMLS (Direct Metal Laser Sintering) is similar to SLS, but specializes in the production of high-quality metal parts. This technology is used in aviation, automotive, medicine and other industries where precise, strong and durable metal components are required.

3D printing is used in many industries. In medicine, this technology allows for the creation of customized implants and prostheses, as well as models of organs for

preparation for surgical operations. In the aerospace industry, 3D printing is used to create lightweight and strong components. In the automotive industry, it allows rapid creation of prototypes and custom spare parts. In construction - for the creation of building components and even entire buildings.

Despite the many benefits, 3D printing also has potential risks. This includes infringement of intellectual property because the ability to copy and reproduce facilities may lead to unauthorized production and distribution of protected goods. This puts copyrights and patents at risk, requiring new approaches to intellectual property protection.

Product safety is also an important issue, as poorly manufactured parts from a 3D printer can have flaws that are hidden from view. This is especially critical in the automotive and aerospace industries, where the reliability of every part can be a safety issue.

Environmental impact is another aspect that needs attention. Although 3D printing can reduce waste compared to traditional manufacturing, the use of some materials, such as plastic, can contribute to pollution. In addition, the need for energy to operate 3D printers requires consideration of the impact on the environment.

privacy and security are also important, as digital models used in 3D printing may contain sensitive information. Unauthorized access to this data could lead to the leakage of important technology or personal information.

Given these challenges, it is important to develop and implement policies and mechanisms that enforce the safe and responsible use of 3D printing. This includes the development of quality standards for 3D printed products, regulatory regulation for the use and disposal of materials, and measures to protect intellectual property and data. With these measures in mind, 3D printing can continue to be a powerful tool in the Industry 4.0 era, offering new opportunities for innovation and development in many sectors.

Control questions for the topic:

1. What are the main characteristics and challenges associated with "Big Data" in the context of Industry 4.0? Describe how companies can use big data to improve their operations.
2. What is the importance of the Internet of Things (IoT) for Industry 4.0? Give examples of how IoT can be used in manufacturing processes.
3. Describe how augmented reality (AR) can be used in various industries. What are the advantages and disadvantages of AR compared to traditional methods?
4. How can quantum computing affect the development of technology and data processing? What are the potential benefits and challenges of using quantum computers?
5. How can blockchain be used in industry beyond cryptocurrencies? Provide examples of blockchain applications that demonstrate its potential for security and transparency.
6. What is the place of 3D printing in Industry 4.0? Describe how 3D printing affects manufacturing processes and product development.
7. What are the main challenges and risks associated with the implementation of Industry 4.0 technologies in traditional industrial processes?
8. How do the various components of Industry 4.0 interact with each other, and what strategies should companies develop to effectively integrate these technologies into their operations?

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Електронне мережеве навчальне видання

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ІСТОРІЯ НАУКИ І ТЕХНІКИ

КОНСПЕКТ ЛЕКЦІЙ

Навчальний посібник

(Англійською мовою)

У навчальному посібнику «Історія науки і техніки» викладено ключові аспекти розвитку наукових знань та технологічних інновацій з давнини до сучасності. Матеріал містить тематичні розділи, які охоплюють важливі віхи у розвитку науки та техніки, приділено увагу впливу наукових здобутків на суспільство та державу. Посібник запропоновано для здобувачів ступеня бакалавра за спеціальністю 124 Системний аналіз і буде також корисним для фахівців інших технічних галузей.

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і розповсюджувачів видавничої продукції ДК № 5354 від 25.05.2017 р.