Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

(N)ever the Same Phystech: History and Culture of MIPT from Ancient Times to the Present Day/(Не) тот Физтех: история и культура МФТИ с незапамятных в

Purpose of the course:

- to form a comprehensive understanding of the history and culture of MIPT as a special type of higher polytechnic school from its inception to the present in the context of scientific and technological development of the country, including the history of technological breakthroughs, the organization of scientific research and the socio-cultural history of higher education in the post-war, late Soviet and post-Soviet periods.

Tasks of the course:

1) to enable students to improve their knowledge and critical understanding of the history of MIPT, the key events, main stages and directions of the institute's development;

2) to encourage students to trace complex interconnections between the history of MIPT and the patterns, challenges and achievements of scientific and technical development of the USSR and post-Soviet Russia;

3) to enable students to develop a comprehensive understanding of the place and role of MIPT as a special type of higher polytechnic school within the higher education system of the late Soviet USSR and post-Soviet Russia;

4) to encourage students' interest and motivation to study the history of MIPT, to contribute to the formation of a sense of belonging to the culture of Phystech and identification with the community of phystechs;

5) to improve the ability to collect, analyse and summarise historical information, to familiarize students with conceptual and methodological tools of history and related social sciences as well as with various types of primary sources (archival documents, ego documents, periodicals, oral history, etc.);

6) to encourage the involvement of students in interdisciplinary social studies of MIPT, (post)-Soviet science and technology studies;

7) to encourage students' interest and participation in the projects of the History of Science and Technology group (Centre for Interdisciplinary Studies), the MIPT Museum, and the Phystech History Club;

8) to develop oral and written communication skills, presentation and discussion skills, critical thinking and general analytical skills.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- key events and personalities, main stages and directions of MIPT development in the context of scientific and technical development of the USSR and post-Soviet Russia;

- the place and role of MIPT as a special type of higher polytechnic school in the higher education system of the late Soviet USSR and post-Soviet Russia;

– basic approaches and terminology of the history of science and technology, socio-cultural history of higher education;

– main methods of empirical social and historical research.

be able to:

- identify, formulate and analyse the problems of the institute's history, establish cause-and-effect relationships between the trajectories of MIPT development, patterns of transformation of higher education and scientific and technical development of the USSR and post-Soviet Russia;

- present the results of analytical work on the selected topic orally and in writing;

- formulate, argue and defend their opinion on the given problem orally and in writing;

- evaluate and select the necessary data, analyse, systematize and summarize the necessary information;

- create and present creative products based on historical sources and historical research.

master:

- knowledge about key events and personalities, stages and trajectories of MIPT development in the context of scientific and technical development of the USSR and post-Soviet Russia;

- the main approaches and terminology of the history of science and technology, the socio-cultural history of higher education;

- the basics of empirical social and historical research methods;

- academic oral and written communication skills, presentation and discussion skills,

- critical thinking and general analytical skills.

Content of the course (training module), structured by topics (sections):

1. Introduction. Origins of MIPT. Basic approaches in the history and social sciences.

Higher education in the USSR in the pre-war period: separation of higher education and research, its specific features and limitations. Industrialisation and cultivation of a “new” Soviet engineer.

Pre-war initiatives to create a higher polytechnic school and their origins: international experience, ideas, institutions. The experience of A.F.Ioffe and the Leningrad Institute of Physics and Technology.

Social and cultural history of science and education. Approaches and methods. Structure and content of the course. Forms of control.

2. Main stages and trajectories of MIPT history in the context of scientific and technological development of Russia and USSR

The block “Main stages and trajectories of MIPT history in the context of scientific and technological development of Russia and USSR” incorporates several lectures, embracing the history of the institute from its launch as a faculty of Moscow State University to the contemporary development trends in 2010-2020s. This block includes the following topics: The post-war period: the first (1946) and second birth (1951) of MIPT; MIPT in the culture of the Cold War; "The Golden Age of Phystech": O.M.Belotserkovsky (1962-1987) and MIPT in late Soviet period; New hopes and challenges: the collapse of the USSR and early post-Soviet years; The transformation and revival of MIPT in the 2000s.

3. Key issues and phenomena of MIPT history and culture

The block “Key issues and phenomena of MIPT history and culture” is devoted to the the main aspects of intellectual and cultural life, including the following topics: Scientific schools at MIPT; Scientific school of L.D.Landau; (Inter)disciplinary extensions; «Raising» scientists and student science; Student life at Phystech; University with a “male” character; History of MIPT on campus: museum, archives, exhibitions; MIPT paper “For science”; MIPT history from below: memoirs and oral history.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Beam-Plasma Technologies. Part 1. Biomedical Applications/Пучково-плазменные технологии. Часть 1. Медико-биологические приложения

Purpose of the course:

To present students the basic concepts of plasma physics and plasma chemistry in the context of "Plasma medicine", "Plasma pharmacology" and "Plasma agriculture"; to acquaint students with beam-plasma techniques and equipment for bioactive compounds production and their biomedical applications.

Tasks of the course:

• Familiarization of students with known applications of non-equilibrium plasmas in technologies of:

- production of bioactive compounds for use as active agents of drugs;

- production of materials with increased biocompatibility;

- direct therapeutic effect on the human body;

- sterilization of various surfaces and tissues of the human body.

• Demonstration to students of beam-plasma systems that directly affect plasma on the tissues of the human body;

• Demonstration to students of the operation of beam-plasma systems in solving scientific problems related to technologies for production of bioactive compounds and medical materials;

• Developing students' skills in analyzing beam-plasma systems for their subsequent use in "Plasma medicine", "Plasma pharmacology" and "Plasma agriculture".

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• principles of operation and design of beam-plasma systems intended for the known and advanced biomedical technologies;

• methods of work on beam-plasma setups for technological purposes, features of their operation and maintenance;

• methods for measuring the main parameters characterizing the operation modes of beam-plasma setups;

• parameters and target characteristics of beam-plasma systems for biomedical purposes.

be able to:

• apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems for biomedical applications;

• perform calculations of the main parameters characterizing the operating modes of beam-plasma setups in solving practical biomedical problems;

• carry out preliminary design of beam-plasma setups designed to solve biomedical problems;

• perform physical and computer modeling of work processes in beam-plasma plasma-chemical reactors and setups for non-vacuum electron-beam processing of materials;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems for biomedical purposes.

master:

• the skills of mastering a large amount of interdisciplinary and special information;

• a culture of setting goals in the design and application of beam-plasma systems for biomedical application;

• skills of working on beam-plasma setups, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Fundamentals and applied aspects of nonequilibrium plasma usage for biology, pharmacology and medicine.

Introduction. Subject, goals and objectives of the course. Review of well-known fundamental and applied research on the subject of the course. Basic schematic solutions for low-temperature plasma generators and beam-plasma setups for biomedical technologies.

2. Selected principles of biology and medicine that underlie biomedical applications of non-equilibrium low-temperature plasmas.

Molecular bases of the organization of living systems. bioorganic molecules. Terminology used to describe biological objects and their functioning. Cells: organization and functions. Mechanisms of interaction between plasma and cells in vitro and in vivo.

3. Non-equilibrium plasma generators used in plasma medicine and for production of bioactive compounds and materials.

Gas-discharge plasma technical systems: glow discharges of various frequency ranges, discharges at atmospheric pressure. Dielectric barrier discharge. Electron-beam plasma generators. Hybrid plasma generators. Generators of flows of low-temperature non-equilibrium plasma.

4. Electron-beam and plasma technologies for sterilization of various surfaces and living tissues.

Plasma technologies as an alternative to traditional sterilization technologies. Non-thermal low-pressure plasma in the problems of surface sterilization. Inactivation of microorganisms in atmospheric pressure plasma. Factors determining the sterilizing effect of plasma exposure. Sterilization of living tissues of animals and humans. The problem of destruction of living tissues under plasma exposure. Sterilization of biological objects by fast electron flows. Prospects for the use of beam-plasma systems for the sterilization of biological objects.

5. Beam-plasma technologies for hematology.

Mechanisms of the effect of non-equilibrium plasma on the blood. Coagulation of blood under the influence of non-thermal plasmas. Plasma wound healing. Practical designs of plasma coagulators.

6. Beam-plasma technologies for dentistry and orthopedics.

Plasma modification of the biological properties of polymeric materials used in dentistry and orthopedics. Increasing the biocompatibility of polymeric and metallic materials. Plasma-stimulated processes to control cell and tissue regeneration. Plasma therapy of dental diseases. Beam-plasma technologies in the production of dental and bone implants.

7. Beam-plasma technologies for the treatment of skin diseases and surgery.

Inactivation of bacteria and fungi under the action of non-thermal plasma. Creation of ions directly on living tissue. Plasma therapy of skin ulcers. Treatment of oncological skin diseases. Plasma scalpel.

8. Beam-plasma technologies for pharmacology.

Beam-plasma technologies for obtaining inhibitors of human blood platelet aggregation. Manufacture of hemostatic agents. Obtaining bioactive complexes for targeted delivery of drugs to the area of therapeutic effect. Creation of plasma mixtures with "targeted delivery" to the cellular level. Hybrid materials based on plasma-modified peptides and polysaccharides. Bioactive complexes based on graphene.

9. Beam-plasma technologies for agriculture and veterinary medicine.

Methods for beam-plasma processing of natural organic raw materials (wood, chitin, chitosan) as a basis for obtaining bioactive materials for agriculture: plant growth stimulants, alternative herbicides, animal protection products, sorbents and enterosorbents. Technologies for improving the safety of agricultural products based on low-temperature plasma and electron beam processing.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Beam-Plasma Technologies. Part 1. Manufacturing Technologies/Пучково-плазменные технологии. Часть 1. Производственные технологии

Purpose of the course:

To acquaint students with the applications of electron-beam plasma in modern industrial technologies and the development trends of scientific research related to the use of plasma in various fields of industry.

Tasks of the course:

• Familiarization of students with known applications of electron-beam plasma in production technologies:

• Demonstration to students of the work of beam-plasma systems in solving problems of modifying materials and obtaining new materials by methods of beam-plasma impact on matter;

• Development of students' initial practical knowledge and skills when working with beam-plasma systems designed for materials processing technologies;

• Development of students' skills in designing beam-plasma systems in solving real technological problems, as well as in analyzing and optimizing workflows in such installations.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• principles of operation and design of beam-plasma installations intended for the implementation of known and advanced production technologies;

• methods of work on beam-plasma setups for technological purposes, features of their operation and maintenance;

• methods for measuring the main parameters characterizing the operation modes of beam-plasma industrial setups;

• parameters and target characteristics of beam-plasma systems for technological purposes.

be able to:

• apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems in the development of technological setups;

• perform calculations of the main parameters characterizing the operating modes of beam-plasma setups in solving practical technological and engineering problems;

• carry out preliminary design of beam-plasma setups designed to solve problems of thermal, chemical-thermal and plasma-chemical processing of various materials;

• perform physical and computer modeling of work processes in beam-plasma plasma-chemical reactors and setups for non-vacuum electron-beam processing of materials;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems for technological purposes.

master:

- the skills of mastering a large amount of interdisciplinary and special information;
- a culture of setting goals in the design and application of beam-plasma systems in industry;
- skills of working on beam-plasma setups, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Introduction to the subject. Basic schemes and technical solutions of beam-plasma setups for thermal, chemical-thermal and plasma-chemical processing of various materials.

Subject, goals and objectives of the course. Known industrial applications of electron-beam plasma. Basic schemes and technical solutions of beam-plasma setups for thermal, chemical-thermal and plasma-chemical processing of various materials. Ensuring the safety of industrial beam-plasma setups.

2. Control methods for installations that implement combined beam-plasma effects on matter.

Control of the accelerating voltage and current of the electron beam. Control of the energy release density in the working volume of beam-plasma installations. Control of pressure and component composition of the plasma-forming medium. Formation of the working zone in a beam-plasma installation during the processing of dispersed powders and liquids. Temperature control of materials when processing. Automatic maintenance of the specified modes during the materials processing.

3. Methods for measuring physical quantities characterizing work processes in technological beam-plasma installations for various purposes

Measurement of the temperature of materials during their beam-plasma processing. Measurement of heat flows in the working zone of the reactor, calorimetry of the reaction volume. Optical measurements as a source of information about the parameters of the reaction volume. Mass spectrometry of the reaction volume. Dosimetry of X-ray radiation in beam-plasma installations.

4. Technological processes of thermal and chemical-thermal treatment of materials in electron-beam plasma.

Heating of solids placed in an electron-beam plasma, phase transitions. Electron beam welding and cutting of materials outside of vacuum. Surface hardening of metals. Surface remelting and alloying. Thermal and chemical-thermal treatment of powders.

5. Technological processes of low-temperature plasma-stimulated synthesis of inorganic compounds.

Synthesis of nitrides and oxides of metals in electron-beam plasma. Mechanical and chemical properties of oxides and nitrides synthesized in electron-beam plasma. Biocompatibility of titanium oxides synthesized in electron-beam plasma. Synthesis of coatings on the surface of dispersed powders.

6. Technological processes of controlled destruction of macromolecular compounds in electron-beam plasma.

Obtaining low molecular weight compounds by controlled destruction of polysaccharides. Obtaining valuable water-soluble products from natural organic raw materials. Beam-plasma modification of proteins. Control of hydrophilic-hydrophobic properties of polymers and biopolymers by beam-plasma treatment. Technologies for the disposal of household and industrial waste based on the beam-plasma effect on the substance. Conversion of liquid and gaseous hydrocarbons in nonequilibrium plasma.

7. Generation of hybrid plasmas and technological processes of coating deposition in hybrid plasmas.

Obtaining single-layer and multilayer coatings in electron-beam plasma: various combinations of deposited materials and coating materials. Deposition of carbon coatings. Technique of hybrid plasma generation and features of the working processes organization in hybrid reactors. Deposition of coatings in hybrid plasma. 2D-coatings.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Beam-Plasma Technologies. Part 2. Aerospace Technologies/Пучково-плазменные технологии. Часть 2. Аэрокосмические технологии

Purpose of the course:

To acquaint students with the applications of electron-beam plasma in modern aerospace technologies and the development trends of scientific research related to the use of plasma in aerospace technologies

Tasks of the course:

• Familiarization of students with known applications of electron-beam plasma in aerospace technologies: active experiments in space, ionosphere and atmosphere of the Earth, plasma aerodynamics, modeling of space flight factors, etc.;

• Demonstration to students of the work of beam-plasma systems in solving scientific problems related to aerospace technologies;

• Development of students' initial practical knowledge and skills when working with beam-plasma systems intended for scientific research in the field of aerospace technologies;

• Development of students' skills in designing beam-plasma systems for their subsequent use in experiments related to aerospace technologies.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• principles of operation and design of beam-plasma setups intended for the implementation of known aerospace technologies;

• methods of work on beam-plasma setups used in scientific experiments on aerospace topics, features of operation and maintenance of such setups;

• methods for measuring the main parameters characterizing the modes of operation of beam-plasma setups;

• parameters and target characteristics of beam-plasma systems when they are used in industry.

be able to:

• apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems in the development of research setups;

• perform calculations of the main parameters characterizing the operating modes of beam-plasma installations in solving practical problems related to setting up scientific experiments;

• carry out preliminary design of beam-plasma installations intended for conducting experiments on aerospace topics;

• perform physical and computer modeling of work processes in beam-plasma experimental facilities;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems for various purposes.

master:

• the skills of mastering a large amount of interdisciplinary and special information;

• a culture of setting goals in the design and application of beam-plasma systems for scientific research;

• skills of working on beam-plasma setups, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Introduction to the subject. A review of well-known scientific research on aerospace applications of electron-beam plasma. Basic circuit solutions of beam-plasma installations intended for scientific research

The course subject and objectives. Known electron-beam plasma applications for scientific research on aerospace topics. Plasma aerodynamics, plasma-assisted combustion, simulation of space flight factors, aerosols in space. Synthesis of beam-plasma systems intended for ground testing of aerospace technologies. Principles of designing small-sized beam-plasma systems. System compatibility of electron-beam plasma generators. Ensuring the safety of beam-plasma installations for research purposes.

2. Control methods for electron-beam plasma experimental setups during experiments on aerospace topics

Control of the energy release density in the working volume of beam-plasma setups. Control of pressure and component composition of the plasma-forming medium in motionless beam-plasma formations and in flows of electron-beam plasma. Formation of the working zone in a beam-plasma installation. Gas temperature control in immobile beam-plasma formations and in electron-beam plasma flows. Temperature control of the model during the experiment. Automatic maintenance of the set modes during the experiment.

3. Methods to measure physical quantities characterizing stationary beam-plasma formations and beam plasma flows.

Measurement of gas temperature and models. Measurement of heat fluxes incident on the surface of the model. Optical and X-ray spectroscopy of electron-beam plasma. Measurement of the electron concentration in an electron-beam plasma. Mass spectrometry of plasma-forming media. Visualization of electron-beam plasma flows.

4. Generation of electron-beam plasma flows. Experiments in the field of plasma aerodynamics

Nozzle devices for electron-beam plasma generators. Combined devices: output window - gas nozzle. Influence of blowing on the thermal regimes of a model placed in a plasma flow. Aerodynamic characteristics of bodies of the simplest geometry in an electron-beam plasma flow. Phase transitions and plasma-chemical processes on the surface of a body in an electron-beam plasma flow.

5. Dispersion of liquids in an electron-beam plasma flows. Plasma-stimulated combustion of propellants

Dispersion of liquids in subsonic and supersonic electron-beam plasma flows. Formation of a combustible mixture in stationary beam-plasma formations and flows of electron-beam plasma. Ignition and combustion of gas and gas-liquid mixtures in an electron-beam plasma flow. Combustion of methane and propane in a free flow of electron-beam plasma and in a flow localized by the channel wall.

6. Simulation of space flight factors acting on spacecraft. Computational experiments

Calculation of particle fluxes falling on the surface of a spacecraft. Simulation of the impact of atomic oxygen plasma on the surface of an artificial satellite of the Earth. Influence of the own atmosphere of a spacecraft on the fluxes of particles falling on its surface. Modeling the influence of space flight factors on the mechanical, electrical and optical properties of spacecraft structural materials. Simulation of electrostatic charging of spacecraft.

7. Active plasma experiments in free space, ionosphere and atmosphere

Artificial aurora. Simulation of aerodynamic heating. Energy transportation. Microwave absorption in plasma clouds. On-board experiments.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Beam-Plasma Technologies. Part 2. Environmental Technologies/Пучково-плазменные технологии. Часть 2. Природоохранные технологии

Purpose of the course:

Demonstrate how basic principles of plasma physics and plasma chemistry are used in the environment saving at present and can be used in future.

Tasks of the course:

Familiarize students with known plasma-based approaches to development “green” technologies for industry, fossil and renewable resources usage, natural organic raw materials processing.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- fundamental concepts of applied plasma physics and plasma chemistry;

- methods for estimation of ecological characteristics of industrial setups of various types.

- principles of plasma chemical setups design

- modern problems of environment protection and “green” technologies

- typical designs of plasma generators applicable for “green” technologies.

be able to:

- estimate ecological efficiency of plasma-based techniques and equipment,

- use their knowledge to suggest technical decisions for environment savig technologies based on plasmas,

- to analyze advantages and disadvantages of beam-plasma technologies for environment protection and resource saving,

- estimate the by-side effects of the electron beams and plasmas application from the point of view of their action on environment.

master:

- skills of mastering a large volume information;

- skills of independent work in the laboratory and the Internet;

- culture of setting and modeling physical, chemical and environment problems;

- skills of competent multifactorial analysis of beam-plasma technologies.

Content of the course (training module), structured by topics (sections):

1. Introduction to the subject. General concepts of "green technologies"

Green economy. Green technologies. Estimation of ecological characteristics of industrial, power and medical technologies. Electron beam setups and electron-beam plasma chemical reactors. by-side effects of the electron beams and plasmas application from the point of view of their action on environment.

2. General concepts of "green technologies"

Principles of "Green chemistry" and "Green energy". Modern state of art of "Green technologies". Conventional approaches to diminish negative effect of industry, agriculture, power production and medicine on environment.

3. Fundamentals of plasma physics and plasma chemistry in context of "green technologies"

Plasma generation: thermal and non-thermal plasmas. Equilibrium and non-equilibrium plasma chemistry. Plasma catalysis. Electron-beam plasma generation at various pressures. Hybrid plasmas. Advantages and disadvantages of beam-plasma technologies in context of "green technologies". X-ray protection of electron-beam plasma setups.

4. Plasma chemistry in hydrogen production

General Features of Plasma-Assisted Production of Hydrogen. Plasma activation of gases techniques. Plasma processing methods for hydrogen production.

5. Plasma chemistry in conventional fuels burning

Plasma assisted combustion. Automobile and aircraft fuels ignition and burning stimulated by electric discharges and electron beams.

6. Plasma chemistry in fuels production

Syngas production in plasma chemical reactors. Plasma-assisted processes in biofuel production. Plasma-assisted coal gasification.

7. Plasma chemistry in cleaning of power and industrial plants gaseous exhausts

Exhausts cleaning from SO2 and NOx. EBARA-processes. Plasma-assisted mercaptans destruction. CO and CO2 conversion.

8. Plasma chemistry in hydrocarbons conversion

Methane conversion. GTL-processes. Schemes and designs of plasma chemical reactors for methane conversion and GTL processes.

9. Plasma chemistry in wastes recycling

Lignin recycling. Sawdust recycling. Plastics recycling. Syngas production from industrial and municipal wastes.

10. Plasma chemistry in water cleaning and disinfection

Plasma in liquids and solutions. Electron-beam plasma of aerosols. Active oxygen production in plasma chemical reactors.

11. Plasma chemistry in medical products disinfection and devices sterilization

Ozone production in plasmas. Surface sterilization by active oxygen, nitrogen oxides and X-ray radiation. Plasma generators for ozone, oxygen and nitrogen oxides production. Basic principles of the Plasma Medicine in the contexts of medical products disinfection and devices sterilization.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Chemistry of High Energies for Inorganic, Organic and Bio-Organic Matters/Химия высоких энергий неорганических, органических и биоорганических соедине

Purpose of the course:

• formation of scientific outlook on the matter transformations under ionizing radiation action and on high-energy chemistry place in advanced technologies;

• formation knowledge of high energy chemistry fundamental concepts and laws;

• ability development to use the acquired knowledge, skills and abilities in professional activity related to scientific research in plasma physics and chemistry, as well as to industrial and aerospace technologies based on plasmas.

Tasks of the course:

• formation of ideas about chemical phenomena occurring in matter under the influence of non-thermal energy;

• gaining knowledge about chemical reactions stimulated by ionizing radiation and high-energy particle flows;

• acquisition of the ability to use the general laws of chemistry in the analysis of phenomena related to high energy chemistry;

• mastery of methods and approaches to solving scientific and applied problems related to radiation technologies of inorganic, organic and bioorganic compounds.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• basic concepts of high energy chemistry;

• the mechanisms of processes in solid, liquid and gaseous substances initiated by the impact of various types of ionizing radiation и and high-energy particle flows;

• radiation-induced processes in the condensed phase and their influence on the change in the physicochemical properties of non-organic, organic and bio-organic compounds;

• theoretical foundations of technologies related to the ionizing radiation impact on substances and materials.

be able to:

• use the chemistry laws in the analysis of phenomena stimulated by ionizing radiation and high-energy particle flows, highlight the essence of phenomena, compare, generalize, draw conclusions;

• apply the basic laws of chemical thermodynamics and kinetics in solving professional problems of high energy chemistry;

• predict the possibility of chemical processes and describe their kinetics in solving professional problems;

• present data of experimental studies in the form of a completed study protocol.

master:

• methods of chemical processes analysis on the basis of thermodynamic calculations, determination of the main chemical reactions kinetic parameters;

• skills of self tuition with educational, scientific and reference literature; carry out research and draw generalizing conclusions;

• skills of safe work in a chemical laboratory and skills of practical work on setting up experiments in the field of high energy chemistry of non-jrganic, organic and bio-organic cjmpounds;

• skills in reporting on the results of the experiment.

Content of the course (training module), structured by topics (sections):

1. Basic concepts of high energy chemistry and radiation chemistry

The subject of study of high energy chemistry, the history of its development. Types of ionizing radiation. Specificity of various types of high-energy impact. Units of measurement: particle or quantum flux density, radiation intensity, absorbed dose, absorbed dose rate, radiation-chemical yield. Linear energy transfer. Local zones of excitation and ionization.

2. Interaction of ionizing radiation and fluxes of high-energy particles with matter

Primary processes of the ionizing radiation impact on matter. Time stages of radiation-chemical processes. Excitation and ionization. Pair recombination. Deactivation of excited states. Formation and transformations of primary ionic and radical products of radiolysis. Influence of the radiation type on the course of primary processes. Influence of the matter phase state on its radiolytic transformations: features of radiolysis of gaseous, liquid and solid substances.

3. Interaction of light radiation with matter

Photoinduced chemical transformations of matter: reactions of photodissociation and photosubstitution, photoisomerization and photorearrangement, radical reactions of excited molecules.

4. Radiation-chemical processes in gaseous substances

Composition and properties of the main primary and intermediate products of radiolysis in gaseous systems. Radiolysis of diatomic and triatomic gases. Radiolysis of ammonia.

Radiolysis of gaseous hydrocarbons: the most important reactions stimulated by ionization in gases, the influence of impurities. Initiation, continuation and termination of the reaction chain in hydrocarbons. Radiation-chemical oxidation of gaseous hydrocarbons.

5. Radiation chemistry of liquid systems

Formation, properties and reactions of primary products of pure water radiolysis, influence of dissolved oxygen. The main types of radical and redox reactions in aqueous and aqueous-organic systems.

Radiolysis of aqueous solutions of inorganic and organic compounds, features of radiolysis of concentrated solutions. Radiolysis of inorganic liquids: liquid ammonia, hydrazine. Radiolysis of organic liquids on the example of liquid hydrocarbons.

6. Radiation-chemical processes in solids

Peculiarities of radiolytic transformations in the solid phase. Radiolysis of glassy and crystalline substances. Low temperature radiolysis.

Radiation-stimulated heterogeneous processes: adsorption, catalysis, corrosion, dissolution.

7. Effect of ionizing radiation on polymers and biopolymers

Primary processes of radiolysis of polymers. Chemical and physico-chemical transformations of polymers during irradiation. Radiation crosslinking and destruction. The main intermediate (radical) and final products of such reactions.

radiation polymerization. radiation initiation. radical polymerization. Ionic polymerization. Co-polymerization. Solid state polymerization

Radiation and radiation-thermal transformation of natural macromolecular compounds: cellulose, hemicellulose, lignin, chitin.

8. Technological applications of radiation chemistry of polymers and biopolymers

Processes based on polymerization: curing of polymer coatings.

Processes based on radiation crosslinking of polymers: radiation vulcanization, radiation modification of cable insulation coatings, production of polymeric heat-shrinkable materials and radiation-crosslinked polyethylene foam.

Processes based on radiation degradation of polymers: modification of cellulose-containing waste for the production of feed additives, regeneration of rubbers based on butyl rubber, destruction of teflon, regulation of the molecular weight of polymers and biopolymers.

9. Sources of ionizing radiation and fluxes of high-energy particles in radiation chemistry and technology

Isotope sources: gamma installations, sources of alpha and beta radiation. Hardware sources: charged particle accelerators (straight-through, linear) x-ray tubes. Plasma generators. Electron-beam plasma generators. Dosimetry of ionizing radiation. Radiation protection.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Design and Maintenance of Beam-Plasma Systems/Проектирование и техническое обслуживание пучково-плазменных систем

Purpose of the course:

To acquaint students with the real beam-plasma systems applied in industrial and aerospace technologies. Basic principles of these systems design and safe maintenance are demonstrated in typical experiments related to plasma chemistry and plasma aerodynamics

Tasks of the course:

• Familiarization of students with known applications of electron-beam plasma in industrial and aerospace technologies:

• Demonstration to students of the work of beam-plasma systems for materials production and laboratory setups for plasma aerodynamic experiments

• Development of students' initial practical knowledge and skills when working with beam-plasma systems;

• Development of students' skills in designing main and supporting systems of beam-plasma setups including controlling their systems.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• principles of operation and design of beam-plasma setups used in typical industrial and aerospace technologies.

• methods of work on beam-plasma setups for various purposes, features of their operation and maintenance; principles for ensuring the reliability and safety of beam-plasma setups.

• methods for control the main parameters characterizing the operation modes of beam-plasma setups;

be able to:

• apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems;

• analyze the main parameters characterizing the operating modes of beam-plasma setups in solving practical technological and engineering problems;

• carry out preliminary design of beam-plasma setups for various experiments taking into account the features of the planned experiments;

• analyze possible danger under the electron-beam plasma generating setups operation and measures to avoid risks of any kind;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems for technological purposes.

master:

- the skills of mastering a large amount of interdisciplinary and special information;
- a culture of setting goals in the design and application of beam-plasma systems in industrial and aerospace technologies;
- skills of working on beam-plasma setups, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Basic circuit solutions of beam-plasma installations designed for industrial and aerospace technologies

Introduction. Subject, goals and objectives of the course. Technique of electron beams generation. Methods for injection of electron beams into dense gaseous media, injection windows. Electron guns, high voltage power supplies. Main systems and components of beam-plasma generators. Elements of internal equipment of plasma-chemical reactors. Ensuring the safety of beam-plasma installations.

2. Control methods for setups that realize combined beam-plasma effects on matter in gaseous, liquid and solid states.

Control of the accelerating voltage and current of the electron beam. Control of the energy release density in the working volume of beam-plasma installations. Control of pressure and component composition of the gaseous plasma-forming medium. Formation of the working zone containing dispersed powders and liquids in a beam-plasma setups Temperature control of the setup working volume. Automatic maintenance of the specified modes when the setup operates.

3. Methods for measuring physical quantities characterizing beam-plasma setups operation for various purposes.

Temperature measurements in beam-plasmas. Measurement of heat flows in the working zone of the reactor, calorimetry of the reaction volume. Optical measurements as a source of information about the parameters of the reaction volume. Mass spectrometry of the reaction volume. Dosimetry of X-ray radiation in beam-plasma setups.

4. Processes in beam plasmas generating setups responsible for effective and safe equipment operation.

Heating of solids contacting with electron-beam plasma, phase transitions. Plasma chemical processes in solids, liquids and gases. Radiation emission. Electrostatic effects.

5. Technological processes of low-temperature plasma-stimulated synthesis of inorganic compounds.

Synthesis of nitrides and oxides of metals in electron-beam plasma. Mechanical and chemical properties of oxides and nitrides synthesized in electron-beam plasma. Synthesis of coatings on the surface of dispersed powders.

6. Technological processes of controlled destruction of macromolecular compounds in electron-beam plasma.

Obtaining low molecular weight compounds by controlled destruction of polysaccharides. Obtaining valuable water-soluble products from natural organic raw materials. Beam-plasma modification of proteins. Control of hydrophilic-hydrophobic properties of polymers and biopolymers by beam-plasma treatment. Technologies for the disposal of household and industrial waste based on the beam-plasma effect on the substance. Conversion of liquid and gaseous hydrocarbons in non-equilibrium plasma.

7. Generation of hybrid plasmas and technological processes of coating deposition in hybrid plasmas.

Technique of generation of hybrid plasma generation and features of the organization of work processes in hybrid reactors. Hybrid plasma generation by joint action of electron beams and RF gas discharge. Deposition of coatings in hybrid plasma. Obtaining single-layer and multilayer coatings in hybrid plasma: various combinations of deposited materials and coating materials. Deposition of carbon coatings.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Digital Transformation: Social and Economic Challenges/Цифровая трансформация: социальные и экономические вызовы

Purpose of the course:

To familiarize students with contemporary processes of digital transformation, what consequences they might have and challenges they will lead to, to provide students theoretical tools for understanding these processes, and optimally reacting to challenges they arise.

Tasks of the course:

- To provide an overview of theoretical approaches to economic transformation;

- to work out framework for transition analysis;

- to introduce students into main social and economic challenges caused by digital transformation and what dramatic consequences they might lead to;

- to familiarize students with possible economic outcomes and to show what economic policy should be to overcome all problems, avoid disastrous scenarios and get use of all the bounties digital transformation can bring.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- Core approaches to economic transformation;

- criteria used to determine stages of economic development;

- key problems of traditional economic methodology being applied to digital economy analysis.

be able to:

- Analyze social and economic phenomena caused by digital transformation;

- analyze transitional dynamics and predict possible economic outcomes for world economy, national economy, and the student himself/herself;

- determine main social and economic challenges digital transformation arises;

- provide policy options for a changing world.

master:

- Tools for economic transition analysis;

- tools of critical economic thinking.

Content of the course (training module), structured by topics (sections):

1. Economic Transformation: Literature Survey

Various criteria of stage determination and approaches to transformation. Critique of postindustrialism. Resource scarcity and economic transformation. Vital resources and stages of development. Transitional dynamics and transformational crises. Digital economy and economics dead-end.

2. Economic Methodology: Are Our Tools Good Enough?

Resource scarcity and science without subject. Methods that we use and why they do not work anymore. Economic transformation: basic methodology.

3. Digital Economy: Challenges We Face

Resource scarcity, heterogeneity and foodchain structure of world economy. Great capital vs. labor (knowledge) battle. Monopolization and inequality. Global capital model failure. World without jobs. Challenges for science: areas of research.

4. Economic Policy in New World

Economic Policy Analysis: Are Our Tools Good Enough? Three Possible Outcomes: Capitalist (Disastrous), Revolutionary (Utopian), Regulatory (Second Best). New Challenges – New Policy. Economic Policy Mechanism

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Introduction to Plasma Physics. Electron Kinetics/Введение в физику плазмы. Электронная кинетика

Purpose of the course:

To provide students with basic principles of plasma physics, parameter characterizing plasmas, its manifestations in nature and applications in modern technologies.

Tasks of the course:

1. Students will gain preliminary understanding of the physical processes in plasma, the mechanisms of its production, physical phenomena in plasma interacting with solid bodies and aerosols. Student will also understand peculiarities of the electron-beam plasma in comparison with other plasmas.

2. Students will be able to offer the approaches to arrange experiments and computer simulations in the fields of plasma properties and plasma technologies.

3. Students will practice producing high quality graduate level academic essays on research topics suggested/agreed with Lecturer, making class presentations and carrying out research as

well as enhance their reading skills in English.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

The physical processes in plasma, the mechanisms of its production, physical phenomena in plasma interacting with solid bodies and aerosols. Student will also understand peculiarities of the electron-beam plasma in comparison with other plasmas.

be able to:

- To offer the approaches to arrange experiments and computer simulations in the fields of plasma properties and plasma technologies.

- To produce high quality graduate level academic essays on research topics suggested/agreed with Lecturer, making class presentations and carrying out research

master:

• skills of mastering a large amount of interdisciplinary and specialized information;

• the culture of setting problems in the field of plasma physics; the skills of estimating the parameters and properties of plasma systems.

Content of the course (training module), structured by topics (sections):

1. Plasma in nature and laboratory. Low-temperature plasma.

The definition of plasma. Examples of plasma in nature and laboratory plasmas. Space and ionosphere plasma. Ionization and electron-ion recombination. Ionization potential of atoms and molecules. Ways of gas ionization, plasma generated by external ionizers.

2. Basic plasma parameters. Ideal and non-ideal plasma.

Electrostatic energy in plasma. Debye shielding. Debye radius. Coupling parameter.

3. Dusty plasma.

Plasma containing solid dispersed particles. Plasma of aerosols. Dusty plasma as an example of non-ideal plasma. Ordered dust structures in plasma, plasma crystal.

4. Equilibrium and non-equilibrium plasma.

Conditions under which plasma is equilibrium. Equilibrium and non-equilibrium electron energy distributions.

5. Gas-discharge plasmas.

Glow DC-discharge. Plasma of RF- and MW-discharges. V-A characteristics of DC-discharge. Electrons mobility. Plasma conductivity.

6. Thermal plasma. Plasma of electric arc.

Ionization by gas heating. Electric arc. Plasma torch and plasmatrons. V-A characteristics of electric arc. Low- and high-temperature plasmas.

7. Electron-beam plasma. Peculiarities of the electron-beam plasma.

Plasma excited by electron beams. General characteristics of the electron-beam plasma. Beam parameters and medium characteristics responsible for the electron-beam plasma properties.

8. Electron beam propagation in vacuum. Electron optics.

Electron beams formation. Electrons acceleration by means of electrostatic and electromagnetic fields. Electron beam propagation in high vacuum. Space charge of electron beam. Purveyance. Electron optics. Electron beam deflection by means of electric and magnetic fields.

9. General description of the electrons scattering. Electron beam propagation in dense gas.

Particle collisions in plasma. Elastic and inelastic collisions in plasma. Electrons scattering in the electron-beam plasma. Single and multiple scattering. Cross sections for particle scattering (preliminary information).

10. Electron beams interaction with solids.

Motion of fast electrons in solids. Electrons scattering in solids. Electrons deceleration in solids, model of continuous deceleration. Bethe formula.

11. Electrostatic charging of bodies in the electron-beam plasma.

Electrons absorption by solids, electrostatic charge accumulation. Electrostatic charging of aerosols. Super-high charging of aerosol particles by electron beams. Differential charging of solids in the electron-beam plasma.

12. Plasma near a surface.

Interaction of plasma particles with surface of solids. Particles absorption and rebound. Solids heating in the electron-beam plasma. Plasma chemical processes near the surface. Peculiarities of plasma chemical processes in the electron-beam plasma.

13. General approaches to the electron-beam plasma simulation.

Simulation of elastic scattering. Simulation of electrons energy loss in collisions with atoms and molecules. Monte-Carlo technique to model electron beam propagation in dense media.

14. Radiation emission in the electron-beam plasma. X-ray radiation of the electron-beam plasma.

Mechanisms of optical radiation in plasmas. Spectra of plasma optical radiation. Bremsstrahlung in the electron-beam plasma.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Physics. Laws of Conservation in Mechanics and Aerodynamics/Физика. Законы сохранения в механике и аэродинамике

Purpose of the course:

Students master basic knowledge in the field of mechanics for further study of other branches of physics and in-depth study of the fundamental foundations of mechanics.

Tasks of the course:

Tasks of the Discipline:

• formation of students ' basic knowledge in the field of mechanics

• formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems

• * the formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processes

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

To know:

fundamental laws and concepts of mechanics, as well as the limits of their applicability:

 fundamentals of kinematics: radius-vector, velocity, tangential and normal acceleration, radius of curvature of the trajectory

 Newton's laws in inertial and non-inertial frames of reference

 laws of conservation of momentum, energy, momentum

 laws of motion of bodies in the gravitational field (Kepler's laws)

- laws rotational motion of a rigid body about a fixed axis and planar movement
- basis of the approximate theory of gyroscopes
- basic concepts of the theory of oscillations: the equation of harmonic oscillations and its solution, attenuation, q-factor of the oscillatory system
- basic concepts of the theory of elasticity and hydrodynamics
- fundamentals of special relativity: basic postulates, Lorentz transformations and their consequences, expressions for momentum and energy of relativistic particles

be able to:

Be able to:

- apply the studied General physical laws to solve specific problems of mechanics:
- record and solve the equations of motion of the particle and the particle system, including the reactive motion
- to apply the conservation laws to solutions of problems of dynamics of particles, systems of particles or rigid bodies
- apply conservation laws in the study of elastic and inelastic collisions of particles, including relativistic ones
- calculate the parameters of orbits when moving in the gravitational field for the two-body problem
- apply the laws of mechanics to different reference systems, including non-inertial ones
- calculate the moments of inertia of symmetric solids and apply to them the laws of rotational motion
- to count the oscillation periods of various mechanical systems with one degree-new freedom, including fluctuations in solids
- analyze physical problems, highlighting the essential and non-essential aspects of the phenomenon, and on the basis of the analysis to build a simplified theoretical model of physical phenomena;
- apply various mathematical tools for solving problems based on the formulated physical laws, and carry out the necessary analytical and numerical calculations;

master:

To be in command of:

The main methods for solving problems in mechanics;

Basic mathematical tools pertaining to the problems in mechanics.

Content of the course (training module), structured by topics (sections):

1. Introduction. Laws of conservation in classical mechanics. Examples

Main laws of conservation: mass, momentum, energy (kinetic and potential ones), angular momentum. Conditions for the conservation of these parameters.

2. Oscillations

Equation of oscillation and its derivation from the energy conservation law

3. Centre of inertia

Definition. Properties. Cjnsequences. Reduced mass. Application in solving the problems

4. Angular momentum

Conditions for the angular momentum conservation. Motion of a body with a fixed point. Celestial mechanics and laws of conservation. Giroscope

5. Collisions

Head-on collisions and non-head-on collisions. Absolutely elastic and absolutely inelastic collisions

6. Variable-mass systems. Jet propulsion

Meschersky equation. Tsiolkovsky equation. Jet engines. Airbreathing engines

7. Hydrostatics and hydrodynamics

Pascal law. Archimed law. Streamline and fluid tube. Bernoulli's law. Poiseuille formula. Stokes formula

8. Maxwell distribution

Maxwell distribution in one-, two- and three-dimensional cases. Characteristic velocities. Velocity of sound and Mach number.

9. Transport phenomena in gas

Molecule mean free path in gas. Number of collisions with wall. Diffusion. Viscosity. Thermal flux

10. Thermodynmics. Heat capacity

First law of thermodynamics. Work of gas. Internal energy. Heat capacity. Quasi-steady processe

11. Heat engines. Refrigerators

Cycles. Work in cycle. Carnot cycle. Efficiency

12. Enthropy and enthalpy

Second law of thermodynamics. Reversible and irreversible processes. Entropy. Gas flows and enthalpy

13. Determination of the bullet speed with the use of ballistic pendulum

The flight velocity of a pellet fired from a pneumatic gun is measured using the ballistic pendulum method. The velocities are calculated from the amplitude of deviation of ballistic and torsional pendulums using the laws of conservation of momentum, energy and angular momentum.

14. Investigation of a Free Gyroscope Precession

Laws of motion of a fast rotating axisymmetric top (i.e. a gyroscope) are studied. The top rotation speed is determined by the precession rate under the influence of constant torque. The moment of inertia of the top is determined by the method of comparison of the top torsional oscillation period with the period of reference body oscillation. The friction torque in the gyroscope axis is measured by the tilting rate of the gyroscope axis.

15. Investigation of the steady flow in the tube

Properties of stationary flow of liquids and gases are studied. Liquid flow rate is measured by Pitot and Venturi flowmeters. Gas viscosity is measured based on the dependence of gas flow rate on the pressure drop in the pipe section. The deviation from Poiseil law determines the critical value of Reynolds number corresponding to the transition from laminar flow to turbulent flow.

16. Determination of air viscosity by the velocity of the flow in thin tubes

Mutual diffusion of air and helium through a thin tube connecting two vessels is investigated. The concentrations of gases are measured by a thermistor sensor by the difference in thermal conductivity of gas mixture. The applicability of Fick law and the dependence of mutual diffusion coefficient on pressure are studied.

17. Determination of the solid bodies’ moment of inertia with the use of trafilerie suspension

Torsional oscillation periods of rigid bodies of different shape are measured with the aid of trifilar suspension. The measured periods are used to calculate the moments of inertia of the bodies, which are compared with those obtained by calculations based on geometric dimensions of the studied bodies. The additivity of inertia moments and the Huygens-Steiner theorem are checked experimentally.

18. Determination of the gravity acceleration with the use of reversible pendulum

Basic laws of oscillatory motion are investigated with a long rod-shaped physical pendulum and a revolving pendulum with movable loads. Pendulum oscillation periods are measured, and the dependence of the period on the amplitude of oscillation and attenuation is studied. The measured period of oscillation is used to calculate the acceleration of free fall with high accuracy.

19. Determination of the activation energy by the fluid viscosity temperature dependency

The viscosity coefficient of liquid as a function of temperature is measured by dropping the test balls in a vertical flask filled with glycerol. The Stokes formula for the viscosity of liquid is checked at a constant rate of falldown. The temperature dependence of viscosity determines the activation energy for the liquid molecules. The activation energy is compared to the bonding energy, evaporation heat and surface tension energy.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Plasma Chemistry/Химия плазмы

Purpose of the course:

To acquaint students with scientific and engineering principles concerning the physical and chemical foundations of plasma chemical, areas of plasma-chemical technological processes application; to develop skills and abilities to apply this knowledge when working in various fields of scientific and practical activities related to plasma chemistry.

Tasks of the course:

• To give students the necessary fundamental knowledge in the field of chemically active plasmas;

• To give students information about plasma-chemical technologies used in practice of functional materials production, coating deposition, in solving environmental problems, as well as promising plasma-chemical technologies based on the use of electron-beam plasma;

• Development of students' basic knowledge and initial practical skills when working with plasma chemical reactors of various types.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- general parameters of plasma chemical processes;
- kinetic and thermodynamic characteristics of plasma chemical reactions;
- features of processes in non-equilibrium plasmas;
- principles of operation and design of plasma-chemical reactors of various types;
- principles for calculating the main parameters characterizing the operating modes of plasma setups based on electron-beam plasma generators;
- plasma chemical reactors operation (beam-plasma reactors and hybrid-type reactors), features of their operation and maintenance;
- methods for measuring the main parameters characterizing the operating modes of plasma chemical reactors;

- basic parameters and target characteristics of plasma chemical reactors for technologies.

be able to:

- apply in practice the basic concepts used in the analysis and description of plasma-chemical processes in equilibrium and non-equilibrium plasmas;
- to predict the course of plasma-chemical transformations under various conditions, to choose the optimal method for obtaining products with the required properties and the required composition;
- to numerically estimate the key characteristics of plasma chemical processes and plasma-chemical reactors, as well as to numerically simulate plasma chemical processes in beam-plasma reactors, to optimize their operating regimes;
- to formulate the problem statement of the properties study for products of non-equilibrium plasma-chemical reactions;
- to determine (clarify) of obtaining products with desired properties by means of beam-plasma impact on mater;
- to master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of industrial plasma systems based on electron-beam plasma

master:

- skills of mastering a large amount of interdisciplinary and special information;
- culture of setting goals in the field of design and application of plasma chemical reactors;
- initial skills in working on beam-plasma reactors, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Introduction to plasma chemistry. Basic definitions and comments

Plasma as a state of matter. The main components of reactive plasma, the main mechanisms of plasma chemical processes: overview.

2. Mechanisms of plasma chemical reactions I: ionization.

Classification and types of ionization processes. Direct and stepwise ionization. Photo-ionization. Ionization under the action of high-energy electrons and in an electromagnetic field.

3. Mechanisms of plasma chemical reactions II: electron-ion recombination

Various mechanisms of electron-ion recombination. Plasma-chemical transformations and reactions involving positive and negative ions.

4. Mechanisms of plasma chemical reactions III: elementary processes involving excited atoms and molecules.

Processes involving excited atoms and molecules. Excited particles, resonant and metastable states. Dissociation of molecules under the influence of plasma, generation of radicals, radical plasma-chemical reactions. Reactive oxygen species, chlorine.

5. Examples of known plasma chemical processes

Ozone generation, nitrogen (II) oxide production, plasma-assisted etching of the material surface. Plasma catalysis, plasma-chemical fuel conversion and plasma-assisted hydrogen synthesis. Plasma-stimulated functionalization of carbon materials.

6. Plasma-chemical modification of (bio)organic polymers in gas discharge plasma

Plasma-stimulated polymers destruction, polymers oxidation under the plasma action, plasma-stimulated polymerization, copolymerization, functionalization and cross-linking of polymers. VUV-stimulated polymerization and degradation of polymers. Polymers aging as a result of plasma-chemical modification. Specific examples of plasma-chemical modification of synthetic and natural polymers, its effect on the physical and chemical resulting materials. Application of plasma-modified polymers in biology, medicine and technology.

7. Kinetics of reactions of polymers plasma chemical modification

Basic concepts, definitions, kinetic equations and mechanisms. Approaches to modeling and experimental study of plasma-chemical polymers modification kinetics.

8. Modification of various materials in the Electron-Beam Plasma: typical technological problems

Interaction of electron-beam plasma with proteins and polysaccharides. Synthesis of thin films and coatings in electron-beam plasma, surface functionalization of inorganic and organic materials in electron-beam plasma.

9. Mechanisms of material modification in Electron-Beam Plasma I: main acting factors

Main factors of the electron-beam plasma action on mater. Fast and secondary electrons, optical radiation, X-ray bremsstrahlung, active plasma particles. Mechanisms of interaction of these particles and radiations with (bio)organic molecules. Experimental approaches to differentiation of each factor effect on the material.

10. Mechanisms of materials modification in the Electron-Beam Plasma II: modification process control

Experimental and theoretical approaches to control the materials modification in the electron-beam plasma. Control of integral energy input, control of temperature distribution and fluxes of fast electrons and active plasma particles over the surface of samples of various geometry.

11. Main mechanisms of plasma interaction with living cells and tissues; application of gas discharge plasmas in biology and medicine

Basic information about the structure of the cell and the organization of body tissues. The main plasma-chemical factors affecting the structure and function of cells during treatment in plasma and the mechanisms of their action. The use of gas discharge plasmas for sterilization, inactivation of microorganisms, tissue engineering and cell technologies; stimulation of tissue regeneration. Plasma surgery, plasma-assisted coagulation, the use of gas-discharge plasma in dentistry and cosmetology. Plasma treatment of malignant cells.

12. Prospects of beam-plasma technologies for solving biological and medical problems

Technologies for bioactive peptides and oligosaccharides production. Biocompatible hybrid materials and coatings formation. Electron Beam Plasma for nanobiotechnologies and biosensors production. Beam Plasma modification and doping of carbon materials.

13. Prospects of low-temperature plasmas for green chemistry and environment saving agro technologies, gas cleaning

Plasma-chemical water and wastes treatment, plasma-assisted synthesis of phytostimulators and phytoprotectors. Application of plasma-chemical methods in the production of catalysts, processing of oil and oil products. Gas cleaning by gas discharge plasmas. Exhaust gases cleaning from hazardous and toxic pollutions by means of the electron beam plasma. EBARA-process.

14. Real plasma chemical reactors for industrial, agricultural and environment saving technologies

Plasma installations used for plasma chemical modification of various materials and solving biological and medical problems: plasma needle, plasma pencil, plasma torch, etc. Electron beam reactors for the production of bioactive compounds and materials.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Plasma Physics/Физика плазмы

Purpose of the course:

1. To provide students with knowledge and understanding of plasma physics fundamentals regarding properties of discharge and beam plasmas.

2. To develop critical analytical and debate skills enabling students to engage in independent analysis of plasma physical and related problems based on credible sources of information.

3. To enhance students' research, academic essay writing and presentation skills to graduate- level studies of the international standard.

Tasks of the course:

1. Students will gain solid understanding of the physical processes in plasma, the mechanisms of its production, transport and radiation phenomena in plasma media and peculiarities of discharge and electron-beam plasma.

2. Students will analyze case studies that highlight the basic plasma properties that could be used in modern plasma technologies.

3. Students will practice producing high quality graduate level academic essays on research topics suggested/agreed with Lecturer, making class presentations and carrying out research as

well as enhance their reading skills in English.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- general parameters of ideal and non-ideal plasmas processes;
- kinetics of elementary processes in equilibrium and non-equilibrium plasmas;
- features of processes in non-equilibrium plasmas;
- main transport plasma properties;
- fundamentals of thermodynamics and hydrodynamics of plasmas;
- principles for calculating the main plasma parameters;

- principles of plasma generation in a laboratory and plasma phenomena in nature;
- scientific basis of modern plasma technologies;
- Electron-Beam Plasma peculiarities and scientific principles of beam-plasma technologies.

be able to:

- apply in practice the basic concepts used in the analysis and description of plasma-physical processes in equilibrium and non-equilibrium plasmas;
- analyze plasma processes under various conditions of the plasma generation;
- numerically estimate the key characteristics of plasma generated by various ionizers, including the Electron-Beam generated plasma characteristics;
- analyze mechanisms of plasma-matter interaction and predict effect of plasma action on substances;
- to master new subject areas and theoretical approaches related to the analysis, design and application of Electron-Beam Plasma.

master:

- skills of mastering a large amount of interdisciplinary and special information;
- culture of setting goals in the field of design and application of plasma setups;
- initial skills in working on beam-plasma laboratory setups and in plasma physical experiments arrangement.

Content of the course (training module), structured by topics (sections):

1. Plasma in nature and laboratory

Examples of plasma in nature and laboratory plasmas. Space and ionosphere plasma. Atmospheric electricity. Gas discharge plasma. Plasma generated by external ionization. The definition of plasma. Plasma-like media.

2. Thermodynamics of plasma.

Thermodynamics of plasma. Principle of detailed balance. Thermodynamic approach to determine ionization degree and plasma composition. Saha equation.

3. Non-ideal plasma.

Non-ideal plasma. Debye shielding. Coupling parameter. Electrostatic energy in plasma. Equation of state for non-ideal plasma. System of equation to determine the composition of non-ideal plasma.

4. Hydrodynamics of plasma.

Hydrodynamics of plasma. Hydrodynamic description of fluid and plasma. Balance equations and transport coefficients. Relation between hydrodynamic description and thermodynamic description of plasma.

5. Plasma conductivity.

Plasma conductivity. Conductivity in steady electric field. The effect of magnetic field on plasma conductivity. Conductivity in sinusoidal electric field.

6. Transport phenomena in plasma.

Transport phenomena in plasma. Transport of particles, particle momentum and energy in plasma. Diffusion, mobility, viscosity and thermal conductivity of plasma.

7. Plasma permittivity.

Plasma permittivity. Conductivity current and polarization current. Plasma permittivity with and without collisions. Propagation of electromagnetic waves through plasma.

8. Ambipolar diffusion.

Ambipolar diffusion. Unipolar diffusion of electrons and ions in partially ionized plasma. Ambipolar electric field and ambipolar plasma diffusion. Ambipolar diffusion coefficient. Conditions that ambipolar diffusion occurs.

9. Particle collisions in plasma.

Particle collisions in plasma. Elastic and inelastic collisions in plasma. Two-body and three-body collisions. First-kind and second-kind collisions. Collisions and momentum and energy conservation laws.

10. Cross sections for particle scattering.

Cross sections for particle scattering. Definitions of differential and integral cross sections. Momentum transfer cross sections. Methods to measure and calculate cross sections.

11. Classical theory of scattering.

Classical theory of scattering. Scattering for model of rigid balls. Scattering theory for arbitrary interaction potential. Ion-neutral interaction. Resonant scattering of ions. Electron and ion scattering. Differential cross section for Coulomb interaction. Momentum cross section. Transport phenomena in fully ionized plasma.

12. Relaxation of electron momentum and energy.

Relaxation of electron momentum and energy. Relaxation of electron properties in collisions with ions and neutrals. Electron momentum relaxation frequency and characteristic length. Electron energy relaxation frequency and characteristic length.

13. Ionization and electron-ion recombination. Electron attachment and detachment.

Ionization and electron-ion recombination. Electron attachment and detachment. Electron-impact ionization of atoms and molecules. Step-wise electron-impact ionization. Ionization in collisions between neutrals. Photoionization. Dissociative, three-body and photo- electron-ion recombination. Electron attachment to molecules to form negative ions. Electron detachment from negative ions. Two-body and three-body ion-ion recombination.

14. Plasma decay.

Plasma decay. Plasma decay in diffusion regime. Decay under electron attachment. Recombination decay of plasma. Methods to determine attachment and recombination rates during plasma decay.

15. Non-equilibrium plasma.

Non-equilibrium plasma. Conditions that plasma is non-equilibrium. Non-equilibrium electron and ion energy distributions. Transport and rate coefficients in non-equilibrium plasma. Methods to calculate non-equilibrium electron and ion distributions.

16. Radiation in plasma.

Radiation in plasma. Bremsstrahlung radiation, radiation due to photorecombination and radiation in lines. Mechanisms of broadening of spectral lines: natural broadening, Doppler broadening, collisional broadening and broadening due to microscopic electric fields in plasma.

17. Properties of discharge plasma and electron-beam plasma.

Properties of discharge plasma and beam plasma. Glow discharge, arc, spark discharge, corona, streamer, leader, lightning discharge. Photoplasma, plasma generated by electron and ion beams. Similarities and difference between discharge plasma and beam plasma.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Plasma Technical Systems/Плазмотехнические системы

Purpose of the course:

To acquaint students with the principles of designing and real constructions of plasma technical systems in relation to the problems of developing industrial and aerospace technologies, as well as laboratory facilities.

Tasks of the course:

• Familiarization of students with well-known schemes and designs of devices generating low-temperature plasmas in laboratory and industrial conditions.

• Familiarization of students with the use of thermal and non-thermal plasma generators in science, engineering and technology;

• Development of students' initial practical knowledge and skills of working with plasma torches, and gas-discharge plasma sources electron-beam plasma generators;

• Development of students' initial skills in designing plasma systems in solving real technological problems.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• designs of low-temperature plasma generators of various types and for various purposes;

• methods for calculating working processes in thermal and non-thermal plasma generators;

• methods for studying the characteristics of thermal and non-thermal plasma generators;

• fundamentals of industrial and environmental safety in the operation of plasma technical systems for various purposes.

be able to:

• apply in practice the basic concepts used in the analysis and design of plasma technical systems for various purposes;

• carry out calculations of the characteristics of plasma technical systems during their design, as well as calculations related to the optimization of plasma technical systems in solving practical technological and engineering problems;

• carry out preliminary design of laboratory plasma technical systems;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of plasma technical systems for various purposes.

master:

• the skills of mastering a large amount of interdisciplinary and special information;

• the culture of setting goals in the field of design and application of plasma technology systems for technological purposes; skills in working on plasma setups, ensuring their reliable and safe operation.

Content of the course (training module), structured by topics (sections):

1. Introduction. Classification of plasma technical systems. Main parameters characterizing plasma technical systems.

Subject, goals and objectives of the course. Principles of classification of plasma technical systems according to the method of plasma generation and design solutions. Power and efficiency of plasma generators, temperature of the working fluid, pressure in the working volume, plasma flow velocity. Known applications of plasma technical systems of various types. Promising areas of plasma technical systems application.

2. Thermal plasma generators. Types, characteristics, designs, applications.

Electric arc plasma torches. Electrode systems and working chambers of electric arc plasma torches. Thermal protection of structural elements of electric arc plasma torches. microwave plasmatrons. Technical characteristics of known thermal plasma generators. Generators of supersonic thermal plasma flows. Thermogasdynamic testing of materials and products using electric arc plasma torches. Plasmatrons in production technologies.

3. Low pressure non-thermal plasma generators. Types, designs, characteristics, applications.

Gas-discharge generators of non-thermal low-pressure plasma: plasma-technical systems with a glow discharge of various frequency ranges. Electrode and non-electrode systems. Thermodynamic characteristics of low-pressure gas-discharge plasma. Examples of schemes and design solutions for setups with non-thermal low-pressure plasma. The principle of electron-beam plasma generation in gases of intermediate pressures.

4. Generators of non-thermal atmospheric pressure plasma.

Dielectric barrier discharge and plasma installations based on it. Plasma needle, plasma torch. Crown. High voltage sliding discharge. Ionization of gases by radiations of different frequency ranges and corpuscular streams. laser plasma. ECR plasma. Known schemes and design solutions for generators of non-thermal atmospheric pressure plasma and their applications in science, engineering and technology.

5. Combined plasma technical systems for technological applications.

The concept of hybrid plasma. Combined action of several ionizers of various types and their compatibility. Known schematic solutions for hybrid plasma generators.

6. Assessment of plasma technical systems reliability and safety.

Reliability of plasma technical systems of various types and principles of predicting failures during their operation. Regulations for the maintenance of plasma setups. Electrical safety of plasma technical systems. Prevention of the environment chemical pollution during the operation of plasma systems of various types and a comparative analysis of their environmental characteristics. Radiation and electromagnetic safety of plasma technical systems.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Program Orientation Course/Введение в специальность

Purpose of the course:

To acquaint students with the technique of electron-beam plasma generation, methods for studying its properties and with the electron-beam plasma main applications in industrial and aerospace technologies.

Tasks of the course:

• Demonstration to students of the operation of beam-plasma systems available at the Department of Logistics Systems and Technologies;

• Familiarization of students with the directions of proposed research and educational practices;

• Presentation of individual and group projects general ideas to be implemented during the study on the master's program “Beam-plasma systems and technologies.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- general information about principles of operation and designs of beam-plasma setups;

- basic methods of work on beam-plasma facilities, features of their operation and maintenance;

- methods for measuring the main parameters that characterize the operating modes of beam-plasma setups and properties of electron-beam plasma;

- main parameters and target characteristics of technological beam-plasma systems.

be able to:

- apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems;

- choose the optimal method for setting up experiments on beam-plasma facilities;

- numerically estimate in order of magnitude the beam-plasma key characteristics;

- formulate the problem statement of the experimental study of the properties of electron-beam plasma and its application in industrial and aerospace technologies;

- determine (clarify) methods for solving problems of experimental study of the properties of electron-beam plasma and its application in industrial and aerospace technologies;

- master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems.

master:

- the skills of mastering a large amount of interdisciplinary information;

- a culture of setting goals in the beam-plasma systems design and application;

- basic skills of working on beam-plasma facilities.

Content of the course (training module), structured by topics (sections):

1. The principle of electron-beam plasma generation, typical beam-plasma setups design

Introduction. Subject, goals and objectives of the course. Technique for generating electron beams. Methods for electron beams injection into dense gaseous media. Injection windows. Systems and components of beam-plasma setups. Concentrated electron beams propagation in a dense gaseous medium. Gas ionization and excitation by an electron beam

2. The main operation parameters of beam-plasma setups and methods for their measurement. Control methods for beam-plasma facilities

Electron guns characteristics, electron beams formation in vacuum. Control of the accelerating voltage and current of the. Faraday cups, collectors, probes, calorimetric methods for measuring the electron beam current. Injection windows characteristics. Coefficient of the electron beam transmission through the injection window and its dependence on the pressure of the plasma generating gas. Controlling the an electron beam energy release in a gas, the electron beam scanning after injection into a dense gas. Regulation and maintenance of the plasma generating gas pressure. Bremsstrahlung generation during the beam-plasma setups operation and methods for its measurement.

3. Methods used for measuring physical values characterizing the electron-beam plasma properties

Probe methods for diagnosing electron-beam plasma. Optical methods for diagnosing electron-beam plasma, optical spectrometers. Mass spectrometers. Temperature measurements in the electron-beam plasma. Pyrometry in beam-plasma setups.

4. Experiments arrangement to study the beam-plasma effect on matter

Heating of solids placed in an electron-beam plasma. Emission of optical and X-ray radiation by solid bodies in an electron-beam plasma. Plasma-chemical processes on the surface of a solid body in contact with an electron-beam plasma. Generation of electron-beam plasma in aerosols.

5. Experiments arrangement on the electron-beam plasma flows generation in relation to aerospace technologies

Generation of electron-beam plasma flows of air and gas mixtures. Measurement of the aerodynamic characteristics of bodies blown by an electron-beam plasma flow. Plasma-stimulated combustion. Aerosols in an electron-beam plasma flows.

6. Problems statement for system analysis and modeling of beam-plasma systems. Beam-plasma systems optimization

Compatibility of the main sub-systems of beam-plasma setups. Ensuring of beam-plasma setups reliable operation, technical maintenance of the main and auxiliary systems. Beam-plasma facilities radiation safety. System assessment of the beam-plasma facilities for various applicationas, efficiency criteria.

7. Discussion of the topics and content of individual and group projects to be carried out within the framework of educational practices

Projects related to the generation and study of the properties of an electron-beam plasmas of various media. Projects related to the study of properties modification and functionalization of various materials in electron-beam plasma. Projects on biomedical applications of electron-beam plasma. Projects related to the conversion of liquid and gaseous hydrocarbons in non-equilibrium plasmas.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Russian as a Foreign Language/Русский язык как иностранный

Purpose of the course:

The Russian as a foreign language (A2) course is aimed at the formation of intercultural professionally oriented communicative competence from the zero level to the elementary level (according to the European scale of foreign language proficiency levels) for solving social and communicative tasks in various areas of everyday, cultural, professional and scientific activities in the Russian language, as well as for further self-education.

Tasks of the course:

The tasks of the formation of intercultural, professionally oriented communicative competence consist of the gradual mastery by students of a set of competences, the main of which are:

– linguistic competence, i.e. the ability to adequately perceive and correctly use language units based on knowledge of phonological, grammatical, lexical, stylistic features of the studied language;

– sociolinguistic competence, i.e. the ability to adequately use realities, background knowledge, situationally conditioned forms of communication;

– sociocultural competence, i.e. the ability to consider during the communication speech and behavioral models adopted in the relevant culture;

– social competence, i.e. the ability to interact with communication partners, to make contact and maintain it, owning the necessary strategies;

– strategic competence, i.e. the ability to apply different strategies to maintain successful interaction in oral/written communication;

– discursive competence, i.e. the ability to understand and generate foreign language discourse considering cultural differences;

– general competence, including, along with knowledge about the country and the world, about the features of the language system, also the ability to expand and improve their own picture of the world, to be guided by the media sources of information;

– intercultural competence, i.e. the ability to achieve mutual understanding in intercultural contacts, using the entire set of skills to realize the communicative intention;

– compensatory competence, i.e. the ability to avoid misunderstandings, to overcome the communication barrier through the use of well-known speech and metalanguage means.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

– The main facts, realities, names, attractions, traditions of Russia;

– some achievements, discoveries, events in the field of Russian science, culture, politics, social life;

– basic phonetic, lexical-grammatical, stylistic features of the Russian language and its difference from the native language;

– the main differences in writing and speaking.

be able to:

– Generate adequate oral and written texts in a specific communication situation;

– to realize the communicative intention with the purpose of influencing the communication partner;

– adequately understand and interpret the meaning and intention of the author in the perception of oral and written authentic texts;

– identify similarities and differences in the systems of native and foreign languages;

– show tolerance, empathy, openness and friendliness when communicating with representatives of another culture.

master:

– Intercultural professionally oriented communicative competence in different types of speech activity at the level of A2;

– social and cultural competences for successful mutual understanding in terms of communication with representatives of another culture;

– various communication strategies;

– learning strategies for organizing the learning activities;

– strategies of reflection and self-evaluation for self-improvement of personal qualities and achievements;

– different methods of memorization and structuring digestible material;

– Internet technologies to select the optimal mode of obtaining information.

Content of the course (training module), structured by topics (sections):

1. My World

Communicative tasks. To talk about your everyday activity. To tell the time. To make an appointment. To talk about your family. To fill the registration form.

Vocabulary. Verbs describing everyday activity. Time. Parts of the day. Numbers 10-100. Events. Family. Registration form.

Grammar. 1st conjugation of verbs. 1 час, 2-4 часа, 5-20 часов. Consolidate conjugation of verbs. Possessive adjectives: мой/моя, твой/твоя.

Phonetics. Pronunciation of sounds: т, ть. Pronunciation of [ц], unstressed «я», «е». Pronunciation of [ж], [ш]. Devocalization of sound «ж» at the end of words.

2. Our Lesson

Communicative tasks. To understand your teacher’s instructions in Russian. To ask people if they have something. To indicate something. To set a meeting. To talk about your plans for a week.

Vocabulary. Verbs describing activities at the lesson. Personal things. Numbers 100-1000. Days of week. Events.

Grammar. Imperative form of verbs - читайте, слушайте etc. Construction “у меня есть”. Gender of nouns. Construction “У меня + событие”. Nouns in plural. Days of week.

Phonetics. Pronunciation of "о" in unstressed position. [ж], [ш]. Devocalization of sound «ж» at the end of words. Pronunciation of у, г.

3. In the City

Communicative tasks. To talk about your city. To ask where to go. To understand signs of a city. To buy a ticket for metro. To order in a restaurant. To refuse an offer. To say where you were yesterday.

Vocabulary. Places in town (parks, restaurants, museums etc.). Words for ordering in a café or buying a ticket for metro. Russian way to say “last/next week”.

Grammar. Endings of adjectives. Possessive pronouns. The prepositional case for locations. The past tense of the verb “to be”.

Phonetics. Devocalization “д” at the end of words and in front of voiced consonants. Practicing the phrase “к сожалению”. Words where “ч” is pronounced as [ш].

4. My Home

Communicative tasks. To describe your house. To call for a master to fix broken things at home. To explain location of things in the house. To talk about your free time and ways to rest at home.

Vocabulary. Furniture. Rooms. Verbs (to sleep, to want, to see, to watch, to hate). Parts of a house (wall, floor etc.). Outside the house (garden, forest). Verbs describing activities at home.

Grammar. Neuter gender nouns in plural. Masculine gender nouns in plural. Exceptions. The prepositional case, exceptions. The past tense. The accusative case for objects.

Phonetics. Pronunciation of the names of the rooms. Pronunciation of words with a change of stress in the prepositional case (в лесу, на полу, etc.). Pronunciation of [х]. Being surprised by the word “ух ты!”

5. Tasty Food

Communicative tasks. To explain what you need to buy. To talk about food preferences. To order and pay in a restaurant. To talk about recipes. To invite friends for dinner. To express admiration or criticism.

Vocabulary. Phrases for shopping. Phrases for restaurants. Phrases for inviting and accepting invitations.

Grammar. Personal pronouns with “нужно”, “надо”, “нравится”. The instrumental case after the preposition “с”. The future tense.

Phonetics. Pronunciation [ы], [и]. Devocalization of the voiced consonants at the end of words (б, д, в, з, ж, г). Intonation of admiration: “Как хорошо!”

6. Health

Communicative tasks. To talk to a doctor. To talk about health. To give recommendations. To talk about mood (I am sad, happy etc.). To agree/disagree.

Vocabulary. Parts of body. Health. Можно/нельзя. Emotions. Mood.

Grammar. Construction “у меня был”. Personal pronouns of with age, “можно”, “нельзя”. Short forms of adjectives.

Phonetics. Intonation of the interjection "ай!" when expressing pain. Pronunciation of ь, ъ.

7. People

Communicative tasks. To talk about people’s character. To describe appearance. To compare things. To buy clothes. To agree to do something.

Vocabulary. Adjectives. Describing a person. Adjectives. Appearance. Clothes. Colors. Size.

Grammar. Endings of adjectives. The comparative and superlative degree. The genitive case in possessive constructions. Endings of adjectives.

Phonetics. Pronunciation of [ш], [щ]. Combination «дж». Intonation of admiration urprise using the word “так”. Pronunciation of “ё” after the hushing sounds.

8. Transport

Communicative tasks. To talk with a taxi driver (price, address, etc.). To order a taxi. To cancel, reschedule or confirm a meeting. To talk about your trip. To describe cities.

Vocabulary. Transport. Dates. Verbs: перенести, отменить, подтвердить, прийти/приехать, уйти/уехать. The compass. Words for travelling.

Grammar. The prepositional case for transport. Ordinal numbers. The accusative case for directions with prepositions “в”, “на”.

Phonetics. Practicing the difference of pronunciation between "е" and "ё" in the conjugation of the verbs "идти", "ехать". Words where the letter "г" is pronounced as "в" (его, сегодня). Devocalization "з" in the preposition "из".

9. My Family

Communicative tasks. To talk about family. To accept the invitation. To talk about hobbies. To refuse the invitation. To ask and tell about biography.

Vocabulary. Family. Relatives. Activities during the holidays. Verb “уметь”. Verbs: пожениться, родиться, случиться, познакомиться.

Grammar. The genitive case. Possession. Reflexive verbs (the present tense). Заниматься + the instrumental case. Reflexive verbs (the past tense).

Phonetics. Devocalization of sound “ж” at the end of words. Pronunciation of тс, тьс = [ц]. Pronunciation of и = [ы] after ш, ж, ц.

10. Holidays

Communicative tasks. To congratulate with holidays. To tell about traditions. To sign postcards. To say wishes. To suggest the idea of gifts. To express surprise.

Vocabulary. Name of the holidays. Verbs: праздновать, поздравлять, прощаться, гулять. Wishes (happiness, love, luck, etc.). Gifts.

Grammar. Поздравлять + the instrumental case. The genitive case with the verb желать. The genitive case after prepositions.

Phonetics. Words with an unpronounceable "д". Words where г = [в]. Intonation of the phrase "Да ладно?!"

11. Shopping

Communicative tasks. To understand the information on the labels of cosmetic products. To buy groceries. To communicate in the store. To buy clothes.

Vocabulary. Body parts. Cosmetic. Stores. Numbers and time. Fruits and vegetables. Clothes, shoes, accessories. In the store.

Grammar. The genitive case. Plural. The genitive case with numbers. The genitive case.

Phonetics. Devocalization of "в" at the end of words. Devocalization of paired voiced consonants before voiceless consonants. The difference in pronunciation between "большой" and "больше".

12. Countries and Nationalities

Communicative tasks. To ask a person where he he is from. To talk about countries. To talk about the weather. To talk about the season. To talk about traditions and nationalities.

Vocabulary. Countries. Months. Weather. Season. Verbs (to love, to call, to speak). Traditions and nationalities.

Grammar. Months in the prepositional case (when?). 2nd conjugation of verbs. Nationalities.

Phonetics. Pronunciation of р, рь, ю. Pronunciation of the names of nationalities.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Selected Sections of Computer Science: Special Software/Избранные главы информатики: специальное программное обеспечение

Purpose of the course:

To provide students with preliminary knowledge and general understanding of physical phenomena computer simulation using PYTHON and FORTRAN (optionally) language and to enhance these knowledge in simulating the electron beam propagation in a dense medium by the Monte-Carlo technique.

Tasks of the course:

- Students will get a skill of programming on PYTHON and FORTRAN languages.
- Students will practice developing numerical codes using the Monte-Carlo technique.
- The course will help students to understand physical problem of the electron beam interaction with a dense medium and possibility to develop a code of numerical simulation of the beam propagation in a gas by the Monte-Carlo technique.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

- The numerical techniques for simulation of the electron beam propagation in a medium using the Monte-Carlo method.
- Basic information about the languages PYTHON and FORTRAN, especially the organization of code in PYTHON.
- Features of the object-oriented model in PYTHON.

be able to:

- To program on PYTHON and FORTRAN (optional) language.
- To develop numerical codes using Monte-Carlo technique.

master:

• To work with standard data structures in PYTHON, write functions in PYTHON, apply the functional features of the language, work with files using the PYTHON language.

• To numerically simulate the electron beams propagation in dense media typical for real beam-plasma systems and facilities.

Content of the course (training module), structured by topics (sections):

1. Principles of programming

Main principles of programming, structure of the code, compilation and linking processes, the shell of the code (Visual Studio, Developer Studio).

2. FORTRAN language learning

FORTRAN language learning: constants, variables, operators, arrays, types of the data, intrinsic functions, subroutines and functions, input and output data.

3. Programming on FORTRAN language

Developing of simple programs following the study of different aspects and items of FORTRAN.

4. Monte-Carlo technique

The idea and realization of Monte-Carlo technique to model the processes described by probability distribution functions. Modeling of the electron diffusion in noble gases.

5. Elastic and inelastic electron scattering on atoms and molecules

Differential and integral cross sections for electron interaction with atoms and molecules, elastic and inelastic processes. Classical and quantum approximations for the cross sections, comparison with experimental data.

6. Electron energy losses in collisions with atoms and molecules

Energy losing by electrons in collisions with atoms and molecules. Excitation and ionization of atom by electron impact. Secondary electrons. The models of continuous and discrete losses, Landau function.

7. Modeling of electron motion in a medium by Monte-Carlo technique

The features of the modeling of electron motion in a medium, each collision modeling and multi-scattering approximation, Moliere layers.

8. Modeling of electron energy losses in a medium by Monte-Carlo technique

Formulation of the probability functions for electron energy losses in a medium.

9. Numerical simulation of e-beam propagation in a medium

Development of the program for e-beam propagation in a medium by Monte-Carlo technique accounting for secondary electrons.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Selected Sections of General and Bioorganic Chemistry/Избранные главы общей и органической химии

Purpose of the course:

• formation of modern scientific ideas about the essence of chemical phenomena;

• creation of solid knowledge of fundamental concepts, laws, laws of general chemistry, chemical properties of elements and their compounds;

• formation of ideas about the place of chemistry in modern high-tech technologies and approaches to solving various particular problems of the physico-chemical direction;

• acquisition of the ability to use the acquired knowledge, skills and abilities in the field of professional activity related to plasma physics and chemistry, aerospace technologies and other fields.

Tasks of the course:

• formation of ideas about the main objects of chemistry and chemical processes, the relationship of composition, structure, properties and reactivity of chemicals;

• formation of knowledge of the basic laws of chemistry and chemical properties of elements and their compounds, the understanding and application of which will improve existing and develop new approaches in the field of aerospace technologies;

• formation of ideas about the relationship of chemical phenomena, the simplest methods of chemical research;

• obtaining knowledge based on specific ideas about the studied substances and their transformations, understanding the basics of chemistry;

• acquisition of the ability to analyze chemical phenomena, highlight their essence, compare, generalize, draw conclusions, use the laws of chemistry when comparing and analyzing various phenomena;

• formation of skills for solving problematic and situational tasks;

• acquisition of skills in the application of chemical laws to solve specific problems with quantitative calculations and the use of educational and reference literature;

• formation of practical skills in setting up and performing experimental work;

• formation of skills for studying scientific chemical literature.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• basic concepts of general chemistry;

• the structure of the Periodic system of elements of D.I. Mendeleev and the main characteristics of the element resulting from it;

• thermodynamic and kinetic patterns that determine the flow of chemical processes;

• methods for describing chemical equilibria;

• theoretical foundations of general chemistry, electronic structure of the atom, fundamentals of the theory of chemical bonding in compounds of different types;

• structure and chemical properties of the main classes of inorganic compounds;

• properties of water and aqueous solutions of strong and weak electrolytes, ways of expressing the concentration of substances in solutions;

• basic laws of chemical processes used in modern high-tech technologies and especially in the field of aerospace technologies;

• laboratory equipment of the experiment;

• safety precautions and rules of work in the chemical laboratory.

be able to:

• analyze chemical phenomena, highlight their essence, compare, generalize, draw conclusions, use the laws of chemistry in the study and comparison of various phenomena;

• apply the basic laws of chemical thermodynamics and kinetics in solving professional problems;

• predict the possibility of chemical processes and describe their kinetics;

• determine the chemical properties of elements and their compounds by the position of the element in the Periodic Table;

• find and use reference data of various physico-chemical quantities when solving chemical or related professional tasks;

• present experimental research data in the form of graphs, tables and a completed research protocol.

master:

• methods of chemical calculations, analysis of patterns of chemical processes based on thermodynamic calculations, determination of the main kinetic parameters of chemical reactions;

• skills of independent work with educational, scientific and reference literature; to search and make generalizing conclusions;

• skills of safe work in a chemical laboratory and skills of practical work on setting up an experiment;

• skills of making reports on the results of the experiment.

Content of the course (training module), structured by topics (sections):

1. Basic concepts and laws of general chemistry

The subject of chemistry. Substances are simple and complex. Chemical formulas, the concept of a mole. Relative atomic mass. The main types of chemical reactions, examples. Stoichiometry of chemical reactions.

2. The structure of the atom

Basic concepts of the electronic structure of the atom: quantum numbers and atomic orbitals, forms of atomic orbitals. Electronic configurations of atoms: rules for filling electronic shells.

3. Frequency of properties of elements and their compounds

Periodicity of properties of elements and their compounds: D.I. Mendeleev's periodic system of elements, the basic information contained in it, the relationship of the periodic system of elements with the structure of atoms. The periodicity of the physical properties of the elements: atomic and ionic radii, ionization energy of the atom and electron affinity. Electronegativity. Periodic classification of elements: metals, nonmetals, metalloids. Frequency of chemical properties of elements and their compounds: basic patterns. The concept of the degree of oxidation of elements, stable oxidation states.

4. Chemical bonding and structure of molecules

Types of chemical bonds: ionic, metallic, covalent. Mechanisms of formation and main characteristics (length, energy, bond angle, dipole moment of coupling). Specific properties of the covalent bond are saturation and directivity. The theory of repulsion of electron pairs of valence orbitals (OEPVO). Elements of the valence bond method: the concept of hybridization of atomic orbitals. Polar and nonpolar molecules, the dipole moment of the molecule.

Hydrogen bonding and intermolecular interactions.

Properties of substances and materials with different types of chemical bonds.

5. The main classes of inorganic compounds

There are four main classes of inorganic compounds: oxides, bases (hydroxides), acids, and salts.

6. The main classes of organic compounds

The main classes of organic compounds. Marginal and unsaturated hydrocarbons. The homological series of methane. Aromatic hydrocarbons. The main functional derivatives and their characteristic groups.

7. Chemical thermodynamics

Energy of chemical processes. I-th and II-th laws of thermodynamics, enthalpy of chemical reaction. Exo- and endothermic reactions. Thermochemical equations. The concept of entropy. Energy effects of chemical reactions. Hess's law and its application. Standard enthalpy of formation and combustion of chemical compounds. Thermal effects of chemical and physico-chemical processes (dissolution, phase transitions, etc.).

Spontaneous chemical processes, conditions of their occurrence. Isobaric-isothermal potential. The Gibbs equation. Factors determining the direction of chemical reactions, the influence of temperature. Reversible and irreversible reactions.

8. Chemical equilibrium

Equilibrium processes. The concept of chemical equilibrium, its criteria, chemical equilibrium in gaseous systems and solutions. Homogeneous and heterogeneous systems, equilibrium in heterogeneous systems. Isotherm of a chemical reaction. Chemical equilibrium constant. Chemical equilibrium shift: influence of concentration, temperature and pressure. The Le Chatelier principle.

9. Chemical kinetics

Kinetics of homogeneous reactions. The theory of the rate of chemical reactions: the concept of the rate of chemical reactions, the kinetic equation of a chemical reaction, the law of acting masses. Dependence of the chemical reaction rate on concentration. The rate constant of the chemical reaction, the order and the molecular nature of the chemical reaction. Methods for determining the order of a chemical reaction. Mechanisms of chemical reactions, simple and complex reactions (sequential, parallel). Kinetics of complex reactions.

The effect of temperature on the rate of chemical reactions. Arrhenius equation, its analysis. Activation energy, the rate of the limiting stage of a chemical reaction. Determination of activation energy based on experimental data.

Catalysts and catalysis. Homogeneous and heterogeneous catalysis.

10. Electrochemistry and redox reactions

Redox reactions (OVR). Conjugated oxidizer-reducing agent pairs. Redox properties of elements and their compounds depending on the position of the element in the periodic table. The most important oxidizing agents and reducing agents. Redox duality. Redox reactions in electrochemical systems. Galvanic cells. Standard redox potentials, methods of their determination. Thermodynamics in galvanic cells, the Nernst equation. Calculation of the EMF of a galvanic cell.

11. Organic polymers

Concepts of monomers and polymers. Polymerization reactions. Examples of polymers. The molecular weight of polymers. Basic properties of physico-chemical properties of polymers.

12. Biopolymers

Biopolymers and their natural raw materials sources.

Proteins: primary, secondary, tertiary and quaternary structure of proteins. Basic physical and chemical properties, research methods.

Carbohydrates: mono-, oligo- and polysaccharides. Cellulose, starch, chitin and chitosan, etc. Lignin. Structure, physico-chemical properties of polysaccharides. Methods of studying the structure and properties of polysaccharides, directions of practical use.

13. Chemical problems of processing products of renewable natural resources

Renewable natural resources, examples. Chemical approaches to the creation of new high-tech materials based on biopolymers. Chemical processing of cellulose and chitin: hydrolysis and problems of its waste disposal.

Alternative fuel sources. Synthetic liquid fuels and biofuels, methods and high-tech approaches to the production of biofuels.

14. Chemical problems of obtaining and converting energy in rocket technology

Rocket fuels: liquid rocket fuels, their chemical composition, main characteristics and related design features of rocket engines. The most common oxidizing agents and combustible. Solid and hybrid rocket fuels.

Autonomous chemical current sources for rocket technology, aviation and the submarine fleet. Fuel cells, types, device and principle of operation on the example of a hydrogen-oxygen fuel cell. Advantages and difficulties of using fuel cells. Modern batteries.

15. Chemical bases of creation of new functional materials

Basic concepts: Phase states of matter, phase equilibria and phase transitions. Solid solutions, alloys. Liquid crystals. Non-stoichiometric compounds.

Functional materials: systematics and classification by composition, structure and functional properties, principles of production and design, physical properties and practical applications. Structural materials and composites: distinctive features, basic quality criteria, mechanical properties. Hybrid materials: natural and artificial hybrid materials, the main approaches to obtaining and application areas. Nanomaterials: basic concepts, dimensional effects, reactivity, carbon nanomaterials (nanotubes, fullerenes, graphene), nanocatalysts, nanocomposites. Promising materials of aerospace engineering.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

Selected Sections of Higher Mathematics/Избранные главы высшей математики

Purpose of the course:

1. To provide students with knowledge in the fields of linear algebra, analytic geometry (special attention is given to problems that are to be encountered in further sections of the course).

2. To provide students with knowledge of calculus so that they can explore the behavior of functions of one or several variables, calculate integrals and multiple integrals and know the applications of calculus to field theory.

3. To study specific sections of ordinary differential equations and partial differential equations that are most relevant in beam-plasma systems modeling and analysis.

4. To get acquainted with basics of statistical analysis, regression and correlation analysis and hypothesis testing

Tasks of the course:

1. Students deepen their knowledge of analytic geometry and linear algebra.

2. Students obtain skills in calculus that are necessary for applications such as calculating area of a domain in the plane, calculating arc length, calculating surface area, calculating volume of the solid, finding work done on a charged particle moving through electric field, calculating field flow through the surface etc.

3. Students get to know basic types of differential equations used in plasma physics and ways of solving them.

4. Students can use methods of mathematical statistics in experimental data processing.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

Basic types of differential equations used in plasma physics and ways of solving them.

be able to:

To use calculus skills that are necessary for applications such as calculating area of a domain in the plane, calculating arc length, calculating surface area, calculating volume of the solid, finding work done on a charged particle moving through electric field, calculating field flow through the surface etc.

master:

Methods of mathematical statistics in experimental data processing.

Content of the course (training module), structured by topics (sections):

1. Vector algebra

Vectors. Dot product. Cross product. Linearly dependent and linearly independent vectors. Basis.

2. Elements of analytic geometry

Equations of lines and planes. Different problems concerning lines and planes (calculating distance between skew lines, volume of tetrahedron, constituting the equation of a plane passing through one line and parallel to the other etc).

3. Matrices and determinants

Operations with matrices. Inverse matrices. Degenerate and non-degenerate matrices. Determinant of a matrix, Its properties and ways of finding it.

4. Systems of linear equations

Homogeneous systems of linear equations. Using elementary row operations for solving systems of linear equations. Non-homogeneous systems of equations. Cramer's rule.

5. Linear operators. Eigenvectors

Linear operators and their matrices. Transformation matrix. Eigenvectors and eigenvalues. Diagonalization. Jordan form of a matrix.

6. Quadratic forms

Matrix of a quadratic form. Diagonalization. Positive and negative definite quadratic forms. Positive and negative semi-definite quadratic forms. Sylvester's criterion.

7. Taylor formula and Taylor series

Taylor and Maclaurin formulae, Taylor and Maclaurin series. Calculating limits using Taylor expansion and l'Hôpital's rule.

8. Graph sketching using derivatives

Maxima and minima of functions of one variable. Asymptotes. Convex and concave functions, inflection points. Sketching graphs using the first and second derivatives of a function.

9. Maxima and minima of functions of several variables. Conditional extrema

Functions of several variables. Partial derivatives. Taylor formula. Directional derivative. Gradient. Maxima and minima. Lagrange multipliers.

10. Methods of integration

Antiderivatives. Definite integrals. Integration by parts, integration by substitution. Integrating rational, irrational, trigonometric functions. Trigonometric substitutions.

11. Multiple integrals

Double integrals over rectangles and more general areas. Iterated integrals. Changing variables in double integrals. Polar coordinates. Triple integrals. Spherical and cylindrical coordinates.

12. Path integrals. Surface integrals

Vector fields. Path integrals. Green’s formula. Parametric surfaces. Surface area. Surface integrals. Divergence theorem. Stokes’ theorem.

13. Elements of ordinary differential equations

Linear ordinary differential equations. Systems of linear differential equations. Homogeneous and non-homogeneous systems of differential equations. Phase plane. Equilibrium. Types of equilibria in two-dimensional systems: node, saddle, focus. Lyapunov stability.

14. Elements of partial differential equations

Wave equation: derivation of the wave equation, general solution and Cauchy’s problem’s solution. Heat equation, solving heat equation using Fourier series. Diffusion equation. Continuity equation.

15. Elements of mathematical statistics

The normal distribution. The binomial distribution. The Poisson distribution. Confidence intervals. Chi-squared test. Regression and correlation.

Annotation

Major: 03.04.01 Прикладные математика и физика

specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии

System Analysis and Simulation of Beam-Plasma Systems/Системный анализ и моделирование пучково-плазменных систем

Purpose of the course:

To acquaint students with the methods of system analysis, modeling and design principles of beam-plasma systems in relation to industrial and aerospace technologies, as well as to laboratory facilities.

Tasks of the course:

• Familiarization of students with the known schematic solutions of beam-plasma systems;

• Familiarization of students with the principles of decomposition and synthesis of beam-plasma systems during their development;

• Development of students' initial practical knowledge and skills of physical and computer modeling of beam-plasma systems;

• Development of students' initial skills in designing beam-plasma systems in solving real technological problems.

List of the planned results of the course (training module)

As a result of studying the course the student should

know:

• principles of synthesis and decomposition of beam-plasma setups for various purposes;

• methods of system analysis and modeling of complex systems used in the calculation and design of beam-plasma installations for technological purposes, features of their operation and maintenance;

• principles of system compatibility as applied to the problems of designing beam-plasma modules intended for use in aerospace technologies;

• basic approaches to assessing the risks associated with the operation of beam-plasma installations for various purposes.

be able to:

• apply in practice the general methods of system analysis to design beam-plasma systems for various purposes;

• to carry out computational experiments related to the modeling of beam-plasma systems;

• perform calculations related to the optimization of beam-plasma setups in solving practical technological and engineering problems;

• carry out preliminary design of laboratory beam-plasma installations;

• master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems for various purposes.

master:

• the skills of a large amount of interdisciplinary and special information analysis;

• a culture of setting problems in the field of system analysis and modeling of beam-plasma systems for various purposes and skills in appropriate computational experiments.

Content of the course (training module), structured by topics (sections):

1. Introduction. Principles of beam-plasma systems synthesis and decomposition.

Subject, goals and objectives of the course. Beam-plasma facility as a complex system. General methods for the analysis of complex systems. target function. Principles of synthesis and decomposition of systems. Efficiency, reliability, robustness of complex technical systems. Principles of compatibility in the design of beam-plasma systems. Basic approaches to assessing the risks associated with the operation of beam-plasma installations for various purposes.

2. Basic physical models of processes used in calculating the beam-plasma systems parameters.

Models describing the emission of electrons and the formation of electron beams. Simulation of electron-kinetic processes during the propagation of an electron beam in vacuum. Physical models of electron beam propagation in a dense gaseous medium. Physical models and calculation formulas for the analysis of the processes of interaction of an electron beam with a solid body. Physical models of radiation generation when during the operation of beam-plasma facility. Physical models of secondary emission processes in the working volume of beam-plasma installations

3. Methods of computer simulation and optimization used in calculating the characteristics and design of beam-plasma systems

Monte Carlo method for modeling the propagation of an electron beam in a dense medium. Application software packages for simulation of electron-beam plasma generation in free and closed volume: DOZA and MolKin packages. Methods of multicriteria optimization in the design of beam-plasma systems.

4. Principles of compatibility in the design of beam-plasma systems.

The main and auxiliary systems of beam-plasma installations: electron injectors, electron beam formation systems, high-voltage power supplies, output windows, working chambers, vacuum systems, radiation protection, cooling systems. Joint functioning of the listed systems.

Optimization of weight and size characteristics of beam-plasma systems. Optimization of energy characteristics of beam-plasma systems. Ensuring safety and minimizing the harmful impact on the environment during the operation of beam-plasma systems.

5. Computational experiments on modeling beam-plasma systems for technological purposes.

Computer simulation of the plasma-chemical reactor for the metal nitrides and oxides synthesis as the example of the electron-beam plasma facility draft design.

6. Computational experiments on modeling beam-plasma systems for aerospace technologies.

Computer simulation of the plasma generation inside a closed container as an example of the draft design of the setup for experiments on aerospace applications of the electron-beam plasma.

7. Physical modeling of beam-plasma systems; verification of computer simulation methods for laboratory beam-plasma systems.

Physical experiments on temperature measurement in various zones of beam-plasma installations. Comparison of data obtained in physical experiments with the results of computer simulation.