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## Annotation

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

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

### **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: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Chinese/Китайский язык**

#### **Purpose of the course:**

The formation and development of intercultural, professionally-oriented communicative competence of students at the elementary level to solve communicative problems in the professional, business, socio-cultural and academic spheres, as well as for the development of professional and personal qualities of bachelor graduates.

#### **Tasks of the course:**

Achieving the elementary level of intercultural professionally-oriented communicative competence in the course of studying the discipline "Chinese language" requires to solve a number of tasks which consist in the consistent mastering a set of sub-competencies. The main of the latter are:

- linguistic competence: the ability to understand other people's speech and express oneself in Chinese;
- sociocultural competence: the ability to take into account in communication speech and non-speech behavior adopted in China;
- social competence: ability to interact with communication partners using the relevant strategies;
- discursive competence: knowledge of the rules for building oral and written discourse messages, the ability to build such messages and understand their meaning in the speech of other people;
- strategic competence: the ability to use the most effective strategies in solving communicative problems;
- subject competence: knowledge of subject information when organizing one's own utterance or understanding of the utterance of other people;
- compensatory competence: the ability to overcome the communication barrier through the use of well-known speech and meta-language means;
- pragmatic competence: the ability to choose the most effective and expedient way of expressing thoughts, depending on the conditions of the communicative act and the task.

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

As a result of studying the course the student should

**know:**

- Basic facts, realities, names, sights, and traditions of China;
- historical, social, political and cultural events in China;
- phonetic, lexical and grammatical, stylistic features of the Chinese language and its difference from the native language;
- main features of written and oral forms of communication.

**be able to:**

- Generate adequate oral and written texts in the context of a specific communication situation;
- realize the communicative intention with the aim 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, first foreign (second foreign) and Chinese 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 elementary level;
- sociocultural competence for successful understanding in the conditions of communication with representatives of another culture;
- various communication strategies;
- learning strategies for organizing their learning activities;
- strategies of reflection and self-esteem to self-improve personal qualities and achievements;
- different methods of memorization and structuring of digestible material;
- Internet technologies to select an optimal mode of obtaining information;
- presentation technologies for providing information.

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

1. Introductory-phonetic and introductory-hieroglyphic course. Meeting Chinese colleagues, fellow students, neighbours.

Introduction into the basics of Chinese pronunciation (putonghua) and the basic rules of calligraphy and hieroglyphics.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To read words, word combinations and phrases both written in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To compose phrases, including everyday life phrases, according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. Participate in a dialogue-inquiry and dialogue-incident to action. To take part in the role-playing game “Meet the Chinese colleagues”.

Pronunciation: The sound-letter standard for recording Chinese words is pinyin, following the basic requirements for pronouncing Chinese sounds and distinguishing all Chinese sounds by ear. Following the rules of the tone system of the Chinese language, the main types of intonation of Chinese sentences.

Vocabulary: phrases of greeting and farewell, fixed expressions, courtesy phrases. Names of the countries, cities in China and the world. Common last names, social roles, educational supplies.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structures (word order, topic and comment (subject and predicate, inverted object etc.). A sentence with a quality predicate, quality adjective in the commentary position. Negative sentence form with quality predicate, quality adjective in the commentary position. Sentences with a linking verb是shì, the position of the negation 不bù in a sentence with a linking verb是shì, interrogative sentences with particles吗ma, 吧ba, 呢ne. Attribute in the possessive meaning. Particle的de. Order of attributes in a Chinese sentence. Personal pronouns in Chinese, their functions and usage. Demonstrative and interrogative pronouns in Chinese. Interrogative sentences with interrogative pronouns. Word order in an interrogative sentence with an interrogative pronoun. A sentence with a verb predicate (action verb in the commentary position). Adverbs也yěand都dōu, their place in a sentence with regard to the predicate. The combination of the adverb都dōu with the negation不bù.

Writing: basic rules of calligraphy. The basics of hieroglyphics, mastering graphemes and hieroglyphs in accordance with the lexical and grammatical material studied. Writing short written statements according to the communicative task.

## 2. Getting to know the university campus, orientation in the city.

Buildings inside the campus, the insides of the building, different institutions and their location relative to each other, orientation in space and in cardinal directions. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incident

to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard etc. To describe the university campus, ways to get to one's destination. To take part in the role-playing tour around the campus. To talk about locations and movement directions.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases. Date, time, time of day, days of the week, postpositions (locatives) to specify spatial relationships.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory, and their structure schemes. Sentences of presence and possession with the verb 有 yǒu. Location indications with verbs 在 是 Postpositions (“adverbs of place”) specifying spatial relationships (前边 qiánbiān, 后边 hòubiān, 上边 shàngbiān etc.), in the function of a subject, an object and an attribute. Sentences of location (verb 在 zài, verb 有 yǒu, linker 是 shì).

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

### 3. Everyday life at work and at home, telling the exact time, plans for the nearest future.

Discussing the daily timetable, class schedule, plans for the nearest future, appointing a meeting. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incident to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard etc. To talk about the past experience in the everyday and professional life. To tell the exact time, the beginning and the ending of events, class schedule, plans for the nearest future.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, telling the exact time, days of the week, part of the day, adverbs of time today, tomorrow, yesterday, counting from 1 to 100, address, phone number.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Adverbial modifier of time; ways to specify time and date. Ordering adverbial modifiers of time in a sentence. Special question to the adverbial modifier of time. The verb 有 and the negation 没有. Interrogative words 几 and 多少, phrasal particles 吧 and 呢.

Writing: basic rules of calligraphy. The basics of hieroglyphics, mastering graphemes and hieroglyphs in accordance with the lexical and grammatical material studied. Writing small written statements according to the communicative task.

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4. Talking about address, phone number, travel route. Shopping. Family. The weather.

Talking to the shop assistant, discussing the planned purchase, its price and quantity. Talking about the family members and pets. Discussing seasons and the weather in Russia and China, the air temperature. Discussing preferences.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incident to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk and reason within the topic studied and give examples and arguments. To describe events, to state facts and what one has read/heard. To construct mini-dialogs with the shop assistant about the planned purchase, its price and quantity. To make dialogs about the family members. To discuss climate peculiarities of China and the speaker's country, the weather in different seasons, temperature conditions.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases, purchase, goods, shops, money, counting words for different objects, money, family members. Family members and pets. Seasons of the year, the weather, natural phenomena.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Interrogative words 几 and 多少. Numerals 二 and 两. Using counting words depending on the noun.



Quality predicate and special question to a quality predicate with the interrogative word 怎么样.

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

5. Talking about present moment of action. Daily and weekly class schedule, plans for tomorrow.

Discussing free time, home tasks, present actions. Discussing plans for the nearest future, at first and then. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incident to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard. To discuss present actions, to talk about the class schedule and about what happens every day, every week etc. To discuss planned actions for the nearest future and their sequence.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases. Time expressions from ... till ..., present moment, every day, days of the week, at first, then, institutions and purposes to visit those.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes.

Adverbs of present tense 现在 and 正在, expressions 每...都, time period expression 从...到, 先...然后... .

Modal verb 打算, talking about the purpose of a trip using a serial verb construction 去商店买东西. Adverb 一起. General question with an affirmative-negative predicate.

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in according to the communicative task.

6. Discussing the product before purchasing, friend's birthday, choosing a present, talking about preferences.

Talking about choosing the color of the clothes, about preferences. Discussing a purchase, its benefits and drawbacks. Choosing a birthday present for a friend, discussing different options and people's preferences. Using the acquired knowledge and skills in speech.

Communicative tasks: to perceive by ear and reproduce words, word combinations, phrases according to the pronunciation norm of the Chinese language. To understand the main content of various authentic pragmatic and journalistic audio and video texts on relevant topics. To extract the necessary/requested information from various audio and video texts on the relevant topics. To read words, word combinations, phrases and small texts, written both in pinyin and in hieroglyphs, according to the pronunciation norm of the Chinese language. To read authentic texts of various styles using various reading strategies/types in accordance with the communicative task. To compose phrases and short texts according to the lexical and grammatical norms of the Chinese language. To use courtesy phrases. To participate in a dialogue-inquiry and dialogue-incident to action, to make a dialogue-exchange of views and a combined dialogue, including elements of different types of dialogues. To talk, to reason within the studied topics and problems, and give examples and arguments. To describe events, to state facts and what one has read/heard. To discuss a product before purchase, its benefits and drawbacks. To discuss a present for a friend and help with the choice. To give advice and arguments.

Pronunciation: meeting the basic requirements for pronouncing Chinese sounds and differentiating all of Chinese sounds by ear. Following the rules of the Chinese language tone system. The main types of intonation of Chinese sentences, the melody and rhythm of Chinese sentences of different types, phrasal accent.

Vocabulary: fixed expressions, courtesy phrases, colors and shades, properties of objects, expression "a little..." (有点儿...), vocabulary related to birthdays.

Grammar: the main communicative types of sentences - narrative (affirmative/negative), interrogative (general and special question), imperative, exclamatory and their structure schemes. Attributive construction with the 的, adverb 有点儿... and adverb 挺, alternative question with the conjunction 还是, attribute with the "prefix" 可 (可送的, 可看的, 可去的).

Writing: mastering graphemes and hieroglyphs according to the lexical and grammatical material studied. Writing messages or written statements in accordance with the communicative task.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**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

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**English Language. Drug discovery/Английский язык в фармакологии**

### **Purpose of the course:**

Basics of new drug development; methods used in the identification of target molecules; application of various technologies and methods in the development of new drugs; methods of modeling and optimization of new drugs; basics of drug quality control and compliance with safety and efficacy standards; developing an understanding of the main stages and processes involved in the development of new drugs; developing skills in analytical processing of a large array of information on the topic of specialization; mastering the practical skills necessary for the development of new drugs; developing the skills necessary for the development of new drugs.

### **Tasks of the course:**

Develop lexical skills to understand and use specific terminology in the field of drug development; study grammar structures for working with scientific literature and understanding the basic processes related to drug development; develop listening skills and understanding of speech by scientific specialists in the field of drug development; activate skills of active reading of scientific articles, drug development reports, and solving tasks related to drug development; familiarize oneself with specific tasks related to drug development and the requirements imposed on the drug development process; develop teamwork and project management skills in the field of drug development; apply information technologies and scientific resources for obtaining and processing data on drug development; familiarize oneself with the basic principles of drug development regulation in different countries and regions; develop the ability to solve communicative tasks in various situations of intercultural communication using language means; conduct interpersonal and professional communication in a foreign language taking into account cultural differences.

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

As a result of studying the course the student should

#### **know:**

- The interconnection, influence, and interaction of language and culture.
- The role of language as an integral part of culture in a person's life, their behavior, and communication with speakers of other languages and different cultures, national identity.
- Understanding of the cultural-anthropological view of human beings, their lifestyle, ideas, views, customs, value systems, and perception of the world, both their own and that of others.

- The influence of culture through language on human behavior, their perception of the world and life in general.
- The history of the emergence, development stages, and methods of teaching intercultural communication.
- The concept of "culture," its role in the communication process, as well as its relation to such concepts as "socialization," "enculturation," "acculturation," "assimilation," "behavior," "language," "identity," and "global citizenship."
- The influence of various social transformations on the change of cultural identity.
- The peculiarities of perceiving other cultures, the reasons for prejudices and stereotypes in intercultural interaction.
- Mechanisms for forming intercultural tolerance and dialogue of cultures.
- Types, forms, models, and structural components of intercultural communication.
- Norms and styles of intercultural communication.
- Mental characteristics and national customs of representatives of different cultures, cultural standards on ethnic, political, and economic levels.
- The linguistic worldview of speakers of a foreign language and the features of their worldview.
- Ethical and moral norms of behavior in a cross-cultural environment.
- Language norms of oral communication culture, ethical and moral norms of behavior, accepted in the country of the studied language; stereotypes and ways to overcome them; etiquette norms of the countries of the studied language.
- Methods of systemic and critical analysis; methods of developing strategies for identifying and solving problem situations.
- The stages of the project life cycle; stages of project development and implementation; methods of project development and management.
- Methods of team formation; methods of effective team management; basic leadership theories and leadership styles.
- Rules and regularities of personal and business oral and written communication; modern communication technologies in Russian and foreign languages; existing professional communities for professional interaction.
- Regularities and features of socio-historical development of different cultures; peculiarities of intercultural diversity in society; rules and technologies of effective intercultural interaction.
- Methods of self-assessment, self-control, and self-development.

**be able to:**

- Apply methods for studying cultural systems and intercultural situations.
- Perceive, analyze, interpret, and compare cultural facts.
- Determine the role of basic cultural concepts in intercultural communication.

- Find adequate solutions in different intercultural communication situations.
- Analyze the peculiarities of intercultural communication in a collective.
- Reflect on the orientation system of their own culture.
- Recognize and correctly interpret nonverbal signals during intercultural communication.
- Create a communicative portrait of a representative of another linguistic culture.
- Reveal the significance of concepts and actions in an intercultural situation.
- Analyze similarities and differences in communication behavior from the positions of interacting cultures.
- Adequately realize their communicative intention in communication with representatives of other lingual cultures.
- Adapt to different linguistic and non-linguistic norms of behavior when encountering another culture.
- Determine the reasons for communication failures and apply methods to overcome them.
- Take the position of a partner in intercultural communication and identify possible conflicts as being rooted in the values and norms of their culture.
- Successfully overcome barriers and conflicts in communication and achieve mutual understanding.
- Reveal the connection and influence of language and culture.
- Tolerantly relate to representatives of other cultures and languages.
- Analyze the main stages and regularities of the historical development of society to form a civil position.
- Respectfully and carefully treat historical heritage and cultural traditions.
- Use models of social situations, typical scripts of interaction of participants in intercultural communication.
- Be guided by the principles of cultural relativism and ethical norms, presupposing the rejection of ethnocentrism and respect for the uniqueness of the foreign language culture and value orientations of the foreign community.
- Overcome the influence of stereotypes and carry out intercultural dialogue in general and professional communication.
- Model possible communication situations among representatives of different cultures and societies.
- Apply methods of a systemic approach and critical analysis of problem situations; develop a strategy of actions, make specific decisions for its implementation.
- Develop a project considering analysis of alternative implementation options, determine target stages, main work directions; explain the goals and formulate tasks related to the preparation and implementation of the project; manage the project at all stages of its life cycle.

- Develop a plan of group and organizational communication for the preparation and implementation of the project; formulate tasks for team members to achieve the set goal; develop a team strategy; apply effective leadership styles to lead the team to achieve the set goal.
- Apply communicative technologies, methods, and ways of business communication for academic and professional interaction in practice.
- Determine the theoretical and practical significance of the cultural and linguistic factor during the interaction of various philosophical and scientific traditions.
- Understand and tolerantly perceive the intercultural diversity of society; analyze and consider the diversity of cultures in the process of intercultural interaction.
- Solve tasks of personal and professional development, determine and implement priorities for improving one's own activities; apply self-assessment and self-control methodologies.

**master:**

- Norms of etiquette and behavior when communicating with representatives of a foreign culture.
- Principles of tolerance in resolving intercultural conflicts.
- Methods of communicative research, the ability to apply acquired knowledge in scientific research, oral and written communication.
- Communicative strategies and tactics characteristic of other cultures.
- Skills of correct intercultural communication, independent analysis of intercultural conflicts in communicating with representatives of other cultures and methods of their resolution.
- Ability to correctly interpret specific manifestations of verbal and non-verbal communicative behavior in different cultures.
- Communication skills in oral and written forms in Russian and foreign languages for solving tasks of interpersonal and intercultural interaction.
- Skills oriented towards ethical and moral norms of behavior accepted in the cross-cultural society.
- Necessary interactional and contextual knowledge that allows overcoming the influence of stereotypes and adapting to changing conditions when interacting with representatives of different cultures.
- Methodology of systemic and critical analysis of problem situations; methods of goal setting, determining ways to achieve it, and developing action strategies.
- Methods of project development and management; methods for evaluating the need for resources and project effectiveness.
- Ability to analyze, design, and organize interpersonal, group, and organizational communications within a team to achieve the set goal; methods of organization and team management.
- Methodology of interpersonal business communication in Russian and foreign languages, using professional language forms, means, and modern communication technologies.
- Methods and skills of effective intercultural interaction.



- Technologies and skills for managing one's cognitive activities and their improvement based on self-assessment, self-control, and lifelong learning principles.

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

#### 1. Topic 1. Deep Learning in Drug Discovery

Integration of deep learning methods into the process of drug discovery. Deep learning algorithms for processing large arrays of genetic and molecular data. Virtual screening. Predictive modeling. Efficiency and safety in drug development. Personalized medicine. Analyzing large sets of genomic and clinical data to identify patterns and relationships. Alternative in silico methods. Identification of novel specific inhibitors. New chemical class drugs for cancer therapy.

Communicative tasks: communicate orally and in writing: explain and discuss Drug Discovery in the context of scientific disciplines such as biology, chemistry, and pharmacology; hypothesize and form judgments based on a large body of scientific literature; discuss relationships and patterns; translate scientific texts with respect to cultural context and genre and style; transform scientific texts in oral and written communication; participate in a simulation of a scientific conference.

#### 2. Topic 2. Design and Synthesis

Design and synthesis of promising innovative compounds as key components of Drug Discovery. Chemical structure of drug candidate. Study of factors such as solubility, stability and bioavailability. In vitro and in vivo experiments and human clinical trials. High-throughput screening. Computer modeling. Optimization of the synthesis process taking into account factors such as yield, purity and reproducibility. Drugs for the treatment of inflammation and inflammatory diseases. Combinations of creative thinking, scientific knowledge and technical expertise. Communicative tasks: communicate orally and in writing: explain the concept of resistance and its mechanisms; discuss technological advances and automation; discuss the development and synthesis of new drugs; analyze methods of testing a large number of compounds for their potential therapeutic effects; translate scientific texts in oral and written communication; predict the properties of new drug candidates before they are synthesized; translate scientific texts with respect to cultural context and genre and style; analyze and synthesize scientific literature.

#### 3. Topic 3. Design and Optimization

Design and optimization in drug development: maximizing efficacy and minimizing side effects. Molecular targeting. Computational modeling and genomic analysis. Chemical structure. Pharmacokinetics. Toxicity. Optimization of toxicity by structural modifications. Clinical trials. Determination of efficacy, safety and optimal dosing regimen of the drug. Communicative tasks: communicate orally and in writing: describe the molecular target, chemical structure, pharmacokinetics, toxicity and clinical efficacy of drug candidates; discuss any potential safety issues; describe the development cycles of vaccines and antiviral agents; translate scientific texts taking into account cultural context and genre and style; transform scientific texts in oral and written communication.

#### 4. Topic 4. Biological Investigation

Biological mechanisms that contribute to the development of a particular disease or condition. Key proteins or enzymes involved in the disease process. High-throughput screening. Rational drug design. Preclinical trials. Clinical trials. Virtual screening. Coping with SARS-CoV-2 and the health problems that accompany COVID-19. Communicative tasks: communicate orally and in writing: describe sequential biological studies; describe types of screening; transform scientific texts in oral and written communication; translate scientific texts taking into account cultural context and genre and style.

#### 5. Topic 5. Bio-AI revolution

Artificial Intelligence (AI) and Machine Learning (ML) technologies and their application in the field of biology to solve complex problems. Recent advances in biotechnology and how they are contributing to the development of AI systems that can be used in drug discovery, gene editing, and other areas of biology. The impact of these technologies on advancing research and discovery in medicine and health care, including precision medicine, personalized therapies, disease diagnosis and prevention. The ethical and social implications of the Bio-AI revolution, including issues related to privacy, data ownership, and the potential for misuse or unintended consequences. How to evaluate and interpret biological data, such as genomic and proteomic data, using AI and ML to make predictions and model biological systems. Communicative tasks: communicate orally and in writing: effectively communicate ideas, opinions, and conclusions using scientific language and terminology; conduct extensive research and extract information from scientific literature, scientific databases, and other sources to support their work; collaborative learning and interdisciplinary problem solving skills.

#### 6. Topic 6. Trends in Drug Discovery

Recent advances in drug discovery, including high-throughput screening, computational drug design, and network pharmacology. Novel drug targets, including those based on genomics, epigenomics and proteomics, as well as recent advances in personalized medicine and precision medicine. Advanced drug delivery systems, including liposomal formulations, nanoparticle-based systems and drug-eluting implants. Advanced drug design and optimization techniques including combinatorial chemistry, fragment-based drug design and biomimetic drug design. Regulatory framework for pharmaceutical development, including intellectual property rights, FDA approval and clinical trials. Novel pharmaceutical and biotechnology research, including vaccines, biologics, and biosimilars. Communication Objectives: communicate orally and in writing: analyze and evaluate recent trends and advances in drug discovery and their impact on health care, society, and the environment; acquire the technical skills necessary to work with scientific and technical data, including data mining, statistical analysis, and data visualization; effectively communicate research results and solve critical problems using innovative technologies and methodologies.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**English Language. Intercultural Communication/Английский язык. Межкультурная коммуникация**

### **Purpose of the course:**

Formation of cultural and linguistic competence as a basis for a respectful intercultural attitude towards spiritual, national, and other values of other countries and nations; development of graduate students' cultural sensitivity, the ability to correctly interpret specific manifestations of communicative behavior in different situations; intercultural contacts, practical skills and abilities in communicating with representatives of other cultures, the ability to correctly interpret specific manifestations of communicative behavior and tolerant attitude to them; mastering intercultural interaction up to the necessary and sufficient level to solve communicative and social problems in different cultural, everyday, academic and professional tasks, in communication with representatives of other cultures.

### **Tasks of the course:**

To form the learner's ability to solve communicative tasks by language means in various situations of intercultural communication, to interact on the interpersonal and professional level in a foreign language, considering the peculiarities of the culture of the language being studied, as well as the ability to overcome intercultural differences in situations of everyday, social and professional communication; to develop the ability to reflect on one's own and other cultures, which initially prepares one to have a respectful attitude to cultural manifestations of the target language; to expand the knowledge on the corresponding culture for deep understanding of diachronic and synchronic relations between one's own and the culture of the target language; to acquire new insights into the conditions of socialization and enculturation in one's own and other cultures, social stratification, and sociocultural forms of interaction in shared cultures.

To achieve the goals and objectives of mastering the discipline, students must master a foreign language professional communicative competence, including:

**Ethnographic competence:** the ability to understand the country of the studied language, its history and culture, everyday life, prominent representatives, traditions and manners; the ability to compare the history, culture, customs of their own and other cultures, understanding of cultural specificity and the ability to explain the causes and origins of a particular cultural characteristic.

**Linguistic competence:** the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people's statements.

Subject-professional competence: the ability to operate with knowledge in real world communication with representatives of the studied culture, showing empathy as the ability to understand the norms, values and motives of behavior of representatives of another culture.

Communicative competence: the ability to establish and maintain contacts with representatives of different age, social and other groups of both their own and other cultures, the ability to be a mediator between their own and other cultures.

Pragmatic competence: the ability to choose the most effective and expedient way of expressing thoughts, depending on the conditions of the communicative act and the task set.

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

As a result of studying the course the student should

#### **know:**

- interrelation, mutual influence and interaction of language and culture;
- the role of language as an organic part of culture in human life, behavior and communication with speakers of other languages and other cultures, national individuality and identity of peoples;
- the concept of a cultural and anthropological view of a person, his/her way of life, ideas, attitudes, customs, system of values, perception of the world - his/her own and others';
- the influence of culture through language on human behavior, worldview and life in general;
- the history of emergence, development stages and teaching methods of intercultural communication;
- the meaning of the concept of "culture", its role in the communication process, as well as the relationship with such concepts as "socialization", "inculturation", "acculturation", "assimilation", "behavior", "language", "identity", "global citizenship";
- the impact of various social transformations on cultural identity changes;
- the specifics of how other cultures are perceived, the causes of prejudice and stereotypes in intercultural encounters;

- mechanisms of forming intercultural tolerance and dialogue of cultures;
- types, kinds, forms, models, structural components of intercultural communication;
- the norms and styles of intercultural communication;
- features of mentality and national customs of different cultures, cultural standards of ethnic, political and economic plans;
- linguistic worldview of native speakers of foreign languages, their distinctive features of outlook and understanding of the world;
- ethical and moral norms of behavior in a culturally different environment;
- language standards of oral communication culture, ethical and moral norms of behavior adopted in the country of the studied language; stereotypes and ways to overcome them; norms of etiquette in the country of the studied language;
- methods of systematic and critical analysis; methods of developing an action strategy for identifying and solving a conflict situation;
- stages of the project life cycle; stages of project development and implementation; methods of project development and management;
- team building techniques; methods of effective team management; basic leadership theories and leadership styles;
- rules and patterns of personal and business oral and written communication; modern communication technologies in Russian and foreign languages; existing professional communities for professional interaction;
- regularities and peculiarities of social and historical development of different cultures; peculiarities of intercultural society diversity; rules and methods of effective intercultural interaction;
- methods of self-assessment, self-control and self-development

**be able to:**

- apply the techniques of studying cultural systems and intercultural situations;
- perceive, analyze, interpret and compare cultural facts;
- determine the role of basic cultural concepts in intercultural communication;
- find adequate solutions in various intercultural communicative situations;
- analyze the peculiarities of intercultural communication in a team;
- reflect on the reference system of one's own culture;
- recognize and correctly interpret nonverbal signals in the process of intercultural communication;
- compose a communicative portrait of a representative of another linguistic culture;
- discover the meanings of concepts and actions in an intercultural situation;

- analyze coincidences and differences in communicative behavior from the perspective of the cultures in contact;
- adequately implement one' s communicative intentions when communicating with representatives of other linguistic cultures;
- switch when encountering another culture based not only on linguistic, but also on non-linguistic norms of behavior;
- identify the causes of communicative problems and apply ways to overcome them;
- take the position of a partner in intercultural communication and identify possible conflicts as conditioned by the values and norms of one' s culture;
- successfully overcome barriers and conflicts in communication and achieve mutual understanding;
- reveal the relationship and mutual influence of language and culture;
- be tolerant of other cultures and languages;
- analyze the main stages and regularities of the historical development of society to form their civic position;
- respect and preserve the historical heritage and cultural traditions;
- use models of social situations, typical scenarios of interaction of participants of intercultural communication;
- guide the principles of cultural relativism and ethical norms, which imply rejection of ethnocentrism and respect for the diversity of foreign language culture and value orientations of foreign-language societies;
- overcome the influence of stereotypes and carry out intercultural dialogue in general and professional lines of communication;
- model possible communicative situations between representatives of different cultures and societies;
- apply methods of systematic approach and critical analysis of problem situations; develop action strategies, make concrete decisions to implement them;
- develop a project taking into account the analysis of alternative options for its implementation, determine the target stages, the main directions of work; explain the goals and formulate tasks related to the preparation and implementation of the project; manage the project at all stages of its life cycle;
- develop a plan of collective and organizational communications in preparation and implementation of the project; formulate tasks for team members to achieve the set goal; develop a team strategy); apply effective styles of team leadership to achieve the set goal;
- apply communicative technologies, methods and ways of business communication in practice for academic and professional interaction;
- determine theoretical and practical significance of cultural and linguistic factors in the interaction of different philosophical and academic traditions;

- understand and tolerate intercultural diversity of society; analyze and take into account the diversity of cultures in the process of intercultural interaction;
- solve the problems of personal and professional development, determine and implement the priorities of improvement of own activity; apply the methods of self-assessment and self-control.

**master:**

- norms of etiquette and behavior when communicating with representatives of other cultures;
- principles of tolerance in resolving intercultural conflicts;
- methods of communicative research, the ability to apply the acquired knowledge in research activities, oral and written communication;
- communicative strategies and tactics characteristic of other cultures;
- skills for proper intercultural communication, independent analysis of intercultural conflicts in the process of communication with representatives of other cultures and ways to resolve them;
- the ability to correctly interpret specific manifestations of verbal and nonverbal communicative behavior across cultures;
- oral and written communication skills in Russian and foreign languages to solve interpersonal and intercultural communication issues;
- skills of operating with a focus on ethical and moral norms of behavior accepted in a foreign cultural society;
- the necessary interactive and contextual knowledge, allowing to overcome the influence of stereotypes and adapt to changing conditions in contact with representatives of different cultures
- methodology of systematic and critical analysis of problematic situations; methods of setting a goal, determining the ways to achieve it, developing action strategies
- methods of project development and management; methods of resource and project efficiency evaluation;
- the ability to analyze, design and organize interpersonal, collaborative and organizational communication in a team to achieve an objective; methods of organization and management of the team;
- methods of interpersonal business communication in Russian and foreign languages, with the use of professional language forms, tools, and modern communication technologies;
- methods and skills of effective intercultural interaction;
- technologies and skills for managing one's own cognitive activity and improving it on the basis of self-assessment, self-control and principles of lifelong learning.

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

1. Topic 1. Culture and language

The fundamental principles of intercultural communication and dialogue of cultures. Cultural worldview: an understanding of the values, norms, and morals of one's own culture and those of others. Types of relations between cultures. Linguistic system. The communicative function of language. Various forms of language communication. Human speech as a means of transmitting and receiving the bulk of vital information. The correlation between human speech and the language system as a whole. The meaning of language in peoples' cultures. Language as a unique means of storing and passing information, as well as controlling human behavior. The relationship between language, culture and communication. Language culture, language personality communication, identity, stereotypes of consciousness, world pictures, etc.

Communicative tasks: to carry out communication in oral and written forms: explaining the values and ethical norms of one's own culture and those of other cultures; discussing the characteristics and types of relationships between cultures; discussing the importance of taking into account the differences in the means of communication and the communication styles of other cultures; expressing hypotheses and one's own perspective on the interaction between language and culture.

## 2. Topic 2. Typology of cultures

The fundamental principles of intercultural communication and dialogue of cultures. Cultural worldview: an understanding of the values, norms, and morals of one's own culture and those of others. Types of relations between cultures. Parametric model of culture by G. Hofstede. Theory of cultural standards by A. Thomas. Differentiation of cultures by R. Lewis and F. Trompenaars. Perceptual stereotypes, prejudices and their functions, importance for intercultural communication. Tolerance in intercultural communication.

Communicative tasks: to carry out communication in oral and written forms: explaining the differences in various types of cultures; discussing the specifics of cultural standards, models, concepts; describing the values, norms, and morals of one's own culture and those of other peoples; analyzing coincidences and differences in communicative behavior from the perspective of contacting cultures; taking the partner's position in intercultural communication and identifying possible conflicts as conditioned by values and norms of his/her culture; discussing possible problems in communication with the representative of another culture and ways to resolve them in case analysis.

## 3. Topic 3. The essence and types of intercultural communication

Existing cultural differences between different people. Overcoming intercultural differences as the main goal of interpersonal communication. Cognitive, social and communication styles of intercultural communication. Verbal and nonverbal communication. Forms and methods of verbal and nonverbal communication. Paraverbal communication. National and cultural characteristics of verbal and nonverbal communicative behavior in different cultures.

Communicative tasks: to carry out communication in oral and written forms: describing events, concepts (space, time, personality, life, etc.) in terms of one's own and other cultures; discussing means of verbal and nonverbal intercultural communication; finding similarities and differences in ways of intercultural communication, typical for foreign and one's own cultures; modeling features of communicative behavior of representatives of one's own and other cultures in a role play.



#### 4. Topic 4. Intercultural scientific communication

Forms of academic and intercultural communication: oral, written, formal, informal. Academic communication: intercultural aspect. Intercultural academic communication and the problems of translation. Academic text as a subject-sign model in a monocultural and intercultural environment. Difficulties and contradictions that occur in the perception and understanding of foreign-language texts.

Communicative tasks: to carry out communication in oral and written forms: describing similarities and differences in foreign-language and native-language academic communication; using cultural standards in situations of oral and written intercultural academic communication; transforming academic texts (from oral to written, from formal to colloquial, etc.); translating academic texts with regard to cultural context and genre type affiliation.

#### 5. Topic 5. International academic mobility

Academic mobility as a means of intercultural communication. The importance of intercultural communication for academic mobility. Features of social and academic adaptation in the context of academic mobility. Intercultural communication and communicative competence in the process of academic mobility.

Communicative tasks: to carry out communication in oral and written forms: discussing the benefits of international academic mobility; giving examples of academic mobility in foreign-language and native-language cultures; solving issues related to cultural adaptation in an international academic environment; participating in a role play on typical situations of international academic mobility.

#### 6. Topic 6. Intercultural communication in business

Etiquette and business communication features in different countries. General principles of business etiquette. National principles of business negotiations. Comparing the etiquette of business negotiations. European and Asian communication styles. General features of business etiquette in Asian countries. The influence of different cultural factors on business development of companies planning to enter foreign markets. Communication strategies for achieving mutual understanding in international business. Working with Chinese partners. Knowledge of cultural characteristics as a competitive advantage. Participating in international projects and programs. Working in an international team.

Communicative tasks: to carry out communication in oral and written forms: describing corporate cultures, norms of business etiquette and behavior accepted in the native and foreign countries; solving common problem situations in intercultural business communications; using effective interpersonal communication strategies in intercultural business communications; writing a business e-mail to a foreign partner taking into account his/her cultural affiliation; negotiating with representatives of another linguistic culture.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**English Language. Leadership in Science, Industry and Academia/Английский язык. Лидерство в науке, индустрии и образовании**

### **Purpose of the course:**

Formation and development of social, business, cultural and professionally-oriented communicative competencies in accordance with the Common European Framework of Reference for solving communicative tasks in the socio-cultural, academic and professional-business spheres of activity, as well as for the development of professional and personal qualities of master's graduates.

### **Tasks of the course:**

To form the learner's ability to solve communicative tasks by language means in various situations of intercultural communication, to interact on the interpersonal and professional level in a foreign language, considering the peculiarities of the culture of the language being studied, as well as the ability to overcome intercultural differences in situations of social and professional communication. To achieve the goals and objectives of studying the course, students are to master a foreign language general professional communicative competence, including:

Linguistic competence: the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people's statements.

Pragmatic competence: the ability to choose the most effective and expedient way of expressing thoughts, depending on the conditions of the communicative act and the task set.

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

As a result of studying the course the student should

#### **know:**

- methods of system and critical analysis;
- methods of developing an action strategy to identify and solve a problem situation;
- stages of the project life cycle;
- stages of project development and implementation; methods of project development and management;
- methods of forming teams;
- methods of effective team management, characteristics of communicative behavior in the process of intercultural communication;
- basic leadership theories and leadership styles;
- rules and patterns of personal and business foreign language oral and written communication;
- modern communication technologies in Russian and foreign languages, culturally determined features of communication in the process of intercultural communication;
- existing professional communities for professional interaction;
- patterns and features of socio-historical development of various cultures;
- features of the intercultural diversity of society;
- rules and technologies of effective intercultural interaction; methods of self-assessment, self-control and self-development.

#### **be able to:**

apply methods of a system approach and critical analysis of problem situations;

- to search for solutions to the problem situation and develop a strategy of actions to achieve the goal, to make certain decisions for its implementation, using the skills of foreign language oral and written speech;
- to assess the impact of the decisions taken on the external environment of the planned activity and the relationships of the participants in this activity;
- to develop a project considering the analysis of alternative options for its implementation, to determine the target stages, the main directions of work;
- formulate goals and objectives, relevance, significance related to the preparation and implementation of the project, expected outcomes and possible areas of their application, using the skills of foreign language oral and written speech;

- manage the project at all stages of its life cycle;
- organize and coordinate work with due account for the diversity of the project participants' cultures;
- develop a plan of group and organizational communications during the preparation and implementation of the project;
- formulate tasks for team members to achieve the goal; develop a team strategy using the skills of foreign language oral and written speech;
- apply effective team leadership styles to achieve the set goal;
- exchange business information in oral and written forms in the language being studied;
- to present the results of academic, scientific and professional activities at various events, including international;
- to put into practice communication technologies, methods and patterns of business communication for academic and professional interaction;
- to identify the specifics of the philosophical and scientific traditions of the main world cultures, to understand and tolerate the intercultural diversity of the society;
- analyze and consider the diversity of cultures in the process of intercultural interaction;
- to solve the tasks of personal and professional development, to determine and implement priorities for improving the own activities;
- apply methods of self-assessment and self-control; apply methodologies of improving and preserv health in the process of life.

**master:**

- methodology of system and critical analysis of problem situations;
- methods of setting goals, determining ways to achieve it, developing strategies for actions using foreign language oral and written speech skills;
- methods of project development and management, forecasting the results of activities using the skills of foreign language oral and written speech;
- methods of assessing the need for resources and the effectiveness of the project using the skills of foreign language oral and written speech;
- ability to analyze, design and organize interpersonal, group and organizational communications in a team to achieve a goal;
- methods of organizing and managing a team, applying the skills of intercultural interaction in the language being studied;
- methodology of interpersonal business communication in the language being studied, using professional language forms, means and modern communication technologies for academic, scientific and professional interaction;
- methods and skills of effective intercultural interaction;

- skills necessary for writing translation and editing various academic texts (abstracts, essays, reviews, articles, etc.);
- ability to determine theoretical and practical significance of the cultural and linguistic factor in the interaction of various philosophical and scientific traditions;
- technologies and skills to manage the own cognitive activity and improve it based on self-assessment, self-control and principles of self-education throughout life.

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

1. Topic 1. The new reality of the leadership concept
  
2. Topic 2. The phenomenon of scientific leadership in the modern world
  
3. Topic 3. Leadership in academia, science and industry
  
4. Topic 4. Scientific, educational and scientific-technical projects

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**English Language. Modern Combinatorics/Английский язык. Комбинаторика**

### **Purpose of the course:**

Study of the history of mathematics; development of master's students' foreign language competence for successful interaction in the field of the studied science, ability to correctly interpret specific manifestations of communicative behavior in different situations of professional context; practical skills and abilities in communicating oral and written discourse; development of creative and analytical thinking for the implementation of projects in the field of mathematics and computer science; refraction of English language skills to the study and application of knowledge in a specific field of mathematics and computer science; development of the skills of master's students in the field of mathematics and computer science

### **Tasks of the course:**

To develop the learner's ability to solve communicative tasks in various situations of professional and general cultural interaction by linguistic means, to carry out interpersonal and professional communication in a foreign language taking into account the peculiarities of the culture of the studied language, as well as the ability to overcome intercultural differences in situations of social and professional communication; to develop the ability to accumulate subject knowledge and operate them in foreign-language communication; to expand the knowledge and skills of the learner in the foreign language.

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

As a result of studying the course the student should

#### **know:**

- the relationship, mutual influence and interaction of language and culture;
- the role of language as an organic part of culture in human life, behavior and communication with speakers of other languages and other cultures, national identity and identity of peoples;
- an idea of cultural and anthropological view of person, their way of life, ideas, views, customs, value system, perception of the world - their own and others';
- the influence of culture through language on human behavior, his worldview and life in general;
- the history of emergence , stages of development and methods of teaching intercultural communication;

- the content of the concept of "culture", its role in the communication process, as well as its relation to such concepts as "socialization", "enculturation", "acculturation", "assimilation", "behavior", "language", "identity", "global citizenship";
- the influence of various social transformations on the change of cultural identity;
- peculiarities of perception of other cultures, causes of prejudices and stereotypes in intercultural interaction;
- mechanisms of formation of intercultural tolerance and dialog of cultures;
- types, kinds, forms, models, structural components of intercultural communication;
- norms and styles of intercultural communication;
- mental peculiarities and national customs of representatives of different cultures, cultural standards of ethnic, political and economic plan;
- the linguistic picture of the world of speakers of a foreign language culture, the peculiarities of their worldview and understanding of the world;
- ethical and moral norms of behavior in a foreign cultural environment;
- language norms of oral communication culture, ethical and moral norms of behavior accepted in the country of the studied language; stereotypes and ways to overcome them; etiquette norms of the countries of the studied language;
- methods of systematic and critical analysis; methods of developing an action strategy for identifying and solving a problem situation;
- stages of the project life cycle; stages of project development and realization; methods of project development and management;
- methods of team building; methods of effective team leadership; basic leadership theories and leadership styles;
- rules and regularities of personal and business oral and written communication; modern communicative technologies in Russian and foreign languages; existing professional communities for professional interaction;
- regularities and peculiarities of socio-historical development of different cultures; peculiarities of intercultural diversity of society; rules and technologies of effective intercultural interaction;
- methods of self-assessment, self-control and self-development.

**be able to:**

- apply methods of studying cultural systems and intercultural situations;
- perceive, analyze, interpret and compare cultural facts;
- determine the role of basic cultural concepts in intercultural communication;
- find adequate solutions in various situations of intercultural communication;
- analyze the peculiarities of intercultural communication in a team;

- reflect the orientation system of one's own culture;
- recognize and correctly interpret non-verbal signals in the process of intercultural communication;
- compose a communicative portrait of a representative of a different linguoculture;
- reveal the meaning of concepts and actions in an intercultural situation;
- analyze coincidences and differences in communicative behavior from the perspective of the cultures in contact;
- adequately realize their communicative intention in communication with representatives of other linguocultures;
- switch when meeting with another culture to other not only linguistic but also non-linguistic norms of behavior;
- identify the causes of communicative failures and apply ways of overcoming them;
- take the position of a partner in intercultural communication and identify a possible conflict as conditioned by the values and norms of his/her culture;
- successfully overcome barriers and conflicts in communication and reach mutual understanding;
- reveal the interrelation and mutual influence of language and culture;
- show tolerance to the representatives of other cultures and languages;
- analyze the main stages and regularities of the historical development of society to form a civic position;
- respect and cherish historical heritage and cultural traditions;
- use models of social situations, typical scenarios of interaction between participants of intercultural communication;
- be guided by the principles of cultural relativism and ethical norms, which imply the rejection of ethnocentrism and respect for the uniqueness of foreign-language culture and value orientations of foreign-language society;
- overcome the influence of stereotypes and carry out intercultural dialog in general and professional spheres of communication;
- model possible situations of communication between representatives of different cultures and societies;
- apply methods of systematic approach and critical analysis of problem situations; develop a strategy of action, make concrete decisions for its realization;
- develop a project taking into account the analysis of alternative variants of its implementation, define target stages, main directions of work; explain the goals and formulate tasks related to the preparation and implementation of the project; manage the project at all stages of its life cycle;
- develop a plan of group and organizational communications in preparation and implementation of the project; formulate tasks for team members to achieve the set goal; develop a team strategy); apply effective styles of team leadership to achieve the set goal;



- to apply in practice communicative technologies, methods and ways of business communication for academic and professional interaction;
- determine the theoretical and practical significance of the cultural and linguistic factor in the interaction of different philosophical and scientific traditions;
- understand and tolerantly perceive the intercultural diversity of society; analyze and take into account the diversity of cultures in the process of intercultural interaction;
- to solve the problems of personal and professional development, to determine and realize priorities of improving one's own activity; to apply methods of self-assessment and self-control.

**master:**

- norms of etiquette and behavior when communicating with representatives of a foreign language culture;
- principles of tolerance in resolving intercultural contradictions;
- methods of communicative research, the ability to apply the acquired knowledge in research activities, oral and written communication;
- communicative strategies and tactics characteristic of other cultures;
- skills of correct intercultural communication, independent analysis of intercultural conflicts in the process of communication with representatives of other cultures and ways to resolve them;
- norms of etiquette and behavior when communicating with representatives of a foreign language culture;
- principles of tolerance in resolving intercultural contradictions;
- methods of communicative research, ability to apply the acquired knowledge in research activities, oral and written communication;
- communicative strategies and tactics characteristic of other cultures;
- skills of correct intercultural communication, independent analysis of intercultural conflicts in the process of communication with representatives of other cultures and ways of their resolution;
- skills of correct interpretation of specific manifestations of verbal and non-verbal communicative behavior in different cultures;
- communication skills in oral and written forms in Russian and foreign languages to solve problems of interpersonal and intercultural interaction;
- skills of activity with orientation on ethical and moral norms of behavior accepted in a foreign cultural society;
- the necessary interactive and contextual knowledge to overcome the influence of stereotypes and adapt to changing conditions in contact with representatives of different cultures;
- methodology of systematic and critical analysis of problem situations; methods of setting a goal, determining ways to achieve it, and developing strategies of action;

- methods of project development and management; methods of assessing the need for resources and project efficiency;
- the ability to analyze, design and organize interpersonal, group and organizational communications in a team to achieve the goal; methods of organization and team management;
- methods of interpersonal business communication in Russian and foreign languages, using professional language forms, means and modern communication technologies;
- methods and skills of effective intercultural interaction;
- technologies and skills to manage and improve their cognitive activity on the basis of self-assessment, self-control and principles of self-education throughout life.

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

#### 1. 1. Topic 1. Mathematics as a science

History of development of mathematics as a science. Outstanding scientists and fundamental discoveries. Connection of mathematics with other sciences. Basic arithmetic operations. The concept of number. History of numbers. Numerical systems. Axioms. Logic and proofs. Definitions. Variety of theories.

Communicative tasks: to reason about the development of mathematics as a science; to make reports on outstanding discoveries in mathematics and computer science; to participate in a role-playing game on the theme "Outstanding mathematicians of different epochs"; to exchange opinions on the relationship between mathematics and other sciences; to participate in debates on the theme of the discovery or invention of mathematics; to operate with basic mathematical concepts; to analyze different number systems; to participate in a conversation on the theme of the evolution of number as a basic mathematical component.

#### 2. Topic 2: Scientific discoveries and achievements in mathematics and computer science

Scientific and technological revolution. The contradictory nature of scientific and technological progress. Development of information technologies. Natural sciences in the second half of XX - early XXI century. New approaches to explaining the world. Game theory of John von Neumann. Jordaan's theory of sets. Theory of algorithms. Graphical processing units (GPUs). Machine learning stored procedure in databases (PL/Python).

Communicative tasks: to participate in a discussion on the topic of scientific and technological revolution; to build logical statements about the contradictions of scientific and technological progress; to tell about scientific discoveries in the field of mathematics and computer science; to analyze new approaches to explaining the world; to search for necessary information on the topic; to find and offer a combinatorial problem for the group to solve.

#### 3. Topic 3: Fundamentals of Combinatorics

History of combinatorics. Possible and impossible in combinatorics. Basic concepts of combinatorics. Permutation. Enumeration of combinations. The concept of factorial. Binomial

coefficient. Partitioning problems. Formulas. Placements. Principle of inclusion and exclusion. Pigeonhole principle.

Communicative tasks: discuss and operate with the basic concepts of combinatorics; solve cases/problems on combinatorics of different types and explain their solution; in small groups exchange opinions about the possibility of applying one or another approach when solving combinatorial problems; express a reasoned opinion when solving a logic puzzle on the example of TED Talk Riddles; summarize the main ideas of a scientific article.

#### 4. 4. Topic4: Combinatorics and graph theory

Basic concepts of graph theory. Eulerian graphs. Hamiltonian graphs. Shortest paths. Trees. Planar graphs. Coloring of graphs. Dimensions of graphs. Combinatorial objects and methods of combining and permutation. Network theory, connectivity, optimization.

Communicative tasks: participate in a conversation on graph theory, give a proof of theorems on graph theory, describe the construction of the Eulerian cycle; in small groups discuss and propose a solution to the letter carrier's problem for different types of graphs; formulate in combinatorial terms problems related to discrete objects; apply basic algorithms of discrete optimization; speak out about possible ways of decoding ciphers, solving other problems of information theory.

#### 5. Topic 5: Scope of combinatorics

Relation of combinatorics to other sciences. Game theory. Probability theory. Cryptography. Complexity analysis of various algorithms. Statistical physics. Number of combinations. Sets. Formation of ordered sets.

Communicative tasks: discuss solutions to typical combinatorial problems; participate in brainstorming and make an oral report on the topic "Scope of Combinatorics"; exchange opinions on the possibility of expanding the scope of combinatorics; in small groups discuss the cultural value of combinatorics in different countries of the world and present their point of view to the group; participate in a role-play on solving combinatorial problems in everyday life; compare combinatorial methods used in various industries, identify and discuss in small groups

#### 6. 6. Topic 6: Derivative functions

Fibonacci numbers, definition and notation. Golden Ratio. Catalan numbers, recurrence and explicit formulas. Applications: correct bracket sequences, number of triangulations of a convex polygon, number of ways to connect points on a circle by non-intersecting chords.

Communicative tasks: to explain in an argumentative manner the significance of Fibonacci numbers and the golden section in various spheres of human life (cybernetics, computer science, engineering, architecture, art, biology); to participate in the discussion of the topic; to formulate questions on the essence of the discussed problem.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**English Language. Modern State of Artificial Intelligence/Английский язык.  
Современное состояние искусственного интеллекта**

### **Purpose of the course:**

The study of the main directions of development and the state of artificial intelligence at the present stage as a promising section of data science: methods of intelligent analysis of big data, machine learning methods, methods of presentation and primary data processing, opportunities, advantages and limitations of AI technologies in their use, the use of artificial intelligence methods in scientific research and other areas of human activity, terminology of the AI sphere in Russian and English.

### **Tasks of the course:**

To form the ability of the student to solve communicative tasks by language means in various situations of professional intercultural communication, to carry out interpersonal and professional communication in a foreign language, taking into account the peculiarities of the culture of the language being studied and the sphere of professional activity of the student, as well as the ability to overcome intercultural differences in situations of social and professional communication; to teach proficiency in specialized vocabulary, to understand and describe situations of artificial intelligence application in various fields of knowledge, such as: public administration, education, healthcare, science, transport, industry, commerce; to be aware of the need to use and develop AI, to be ready to implement the developments of fundamental science in a specific product created on the basis of information technology; freely use terminology related to the field of AI in both Russian and English.

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

As a result of studying the course the student should

#### **know:**

- methods of system and critical analysis;
- methods of developing an action strategy to identify and solve a problem situation;
- stages of the project life cycle;
- stages of project development and implementation; methods of project development and management;
- methods of forming teams;

- methods of effective team management, characteristics of communicative behavior in the process of intercultural communication;
- basic leadership theories and leadership styles;
- rules and patterns of personal and business foreign language oral and written communication;
- modern communication technologies in Russian and foreign languages, culturally determined features of communication in the process of intercultural communication;
- existing professional communities for professional interaction;
- patterns and features of socio-historical development of various cultures;
- features of the intercultural diversity of society;
- rules and technologies of effective intercultural interaction; methods of self-assessment, self-control and self-development.

**be able to:**

- apply methods of a system approach and critical analysis of problem situations;
- to search for solutions to the problem situation and develop a strategy of actions to achieve the goal, to make certain decisions for its implementation, using the skills of foreign language oral and written speech;
- to assess the impact of the decisions taken on the external environment of the planned activity and the relationships of the participants in this activity;
- to develop a project considering the analysis of alternative options for its implementation, to determine the target stages, the main directions of work;
- formulate goals and objectives, relevance, significance related to the preparation and implementation of the project, expected outcomes and possible areas of their application, using the skills of foreign language oral and written speech;
- manage the project at all stages of its life cycle;
- organize and coordinate work with due account for the diversity of the project participants' cultures;
- develop a plan of group and organizational communications during the preparation and implementation of the project;
- formulate tasks for team members to achieve the goal; develop a team strategy using the skills of foreign language oral and written speech;
- apply effective team leadership styles to achieve the set goal;
- exchange business information in oral and written forms in the language being studied;
- to present the results of academic, scientific and professional activities at various events, including international;
- to put into practice communication technologies, methods and patterns of business communication for academic and professional interaction;

- to identify the specifics of the philosophical and scientific traditions of the main world cultures, to understand and tolerate the intercultural diversity of the society;
- analyze and consider the diversity of cultures in the process of intercultural interaction;
- to solve the tasks of personal and professional development, to determine and implement priorities for improving the own activities;
- apply methods of self-assessment and self-control; apply methodologies of improving and preserve health in the process of life.

**master:**

- methodology of system and critical analysis of problem situations;
- methods of setting goals, determining ways to achieve it, developing strategies for actions using foreign language oral and written speech skills;
- methods of project development and management, forecasting the results of activities using the skills of foreign language oral and written speech;
- methods of assessing the need for resources and the effectiveness of the project using the skills of foreign language oral and written speech;
- ability to analyze, design and organize interpersonal, group and organizational communications in a team to achieve a goal;
- methods of organizing and managing a team, applying the skills of intercultural interaction in the language being studied;
- methodology of interpersonal business communication in the language being studied, using professional language forms, means and modern communication technologies for academic, scientific and professional interaction;
- methods and skills of effective intercultural interaction;
- skills necessary for writing translation and editing various academic texts (abstracts, essays, reviews, articles, etc.);
- ability to determine theoretical and practical significance of the cultural and linguistic factor in the interaction of various philosophical and scientific traditions;
- technologies and skills to manage the own cognitive activity and improve it based on self-assessment, self-control and principles of self-education throughout life.

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

1. Topic 1. Artificial intelligence as science and technology

The history of the term "artificial intelligence (AI)". AI science as part of the computer science complex. AI-based technologies in the computer technologies system. AI and interdisciplinary research. Two directions of AI: pure (descending) and dirty (ascending). Three waves of AI. Directions of AI.

Communicative tasks: to carry out communication in oral and written forms: to explain ethical principles; and to discuss the of AI development trends and its role in interdisciplinary research.

## 2. Topic 2. Approaches to building artificial intelligence

Intuitive approach and Turing test. Symbolic and logical approaches. Agent approach, MAS and swarm intelligence. A hybrid approach. Strong (general) and weak (applied) AI.

Communicative tasks: to carry out communication in oral and written forms: to explain differences in approaches; to discuss the features of approaches to building AI; to analyze the development of approaches, situational cases.

## 3. Topic 3. Key challenges and threats of the development of artificial intelligence systems

Some successful projects that implement AI capabilities. The Philosophy of Artificial Intelligence (Chinese Room). The possibility or impossibility of modeling human thinking as one of the philosophical problems in the field of AI. Concerns: complete dependence on computers, unpredictability, the use of AI for military purposes, social risks, existential risks, errors in AI systems

Communicative tasks: to carry out communication in oral and written forms: to describe the origins of artificial intelligence, the main provisions of its philosophy; to model the features of the development of artificial intelligence in the essay "How artificial intelligence will change our lives.

## 4. Topic 4. Applied fields of activity for artificial intelligence

Expert systems and DSS. Pattern recognition. Chatbots. Creation. Autonomous cars. Robots and avatars. The AI Effect.

Communicative tasks: to carry out communication in oral and written forms: to describe the areas of practical application of artificial intelligence; to transform scientific texts (from oral to written, from scientific and journalistic style to conversational, etc.); to translate scientific texts taking into account the professional context and genre-style affiliation.

## 5. Topic 5. Spheres of life and artificial intelligence: a map of the application of AI technologies

Artificial intelligence and public administration. Artificial intelligence and security. Artificial intelligence and transport. Artificial intelligence and industry. Artificial intelligence and education. Artificial intelligence and science. Artificial intelligence and healthcare. Artificial intelligence and culture. Artificial intelligence and the development of new industries.

Communicative tasks: to carry out communication in oral and written forms: to discuss the use of artificial intelligence in various sectors of the economy and scientific knowledge; to give examples of the possibilities of using artificial intelligence in various branches of scientific knowledge.

## 6. Topic 6. Current state and prospects of artificial intelligence development

Related technologies. Artificial intelligence and quantum technologies. Artificial intelligence and nanotechnology. Development of artificial neural network (INS) technologies. Processing of natural languages. Machine translation systems. Machine learning.

Communicative tasks: to carry out communication in oral and written forms: to describe related technologies; to solve situational cases; to write a business email to a foreign partner, taking into account his cultural affiliation; to negotiate with representatives of another linguistic culture.



## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **German for Scientific Purposes/Немецкий язык для научных целей**

#### **Purpose of the course:**

Formation and development of social, business, intercultural and professionally-oriented communicative competencies for solving communicative tasks in the socio-cultural, academic and professional-business spheres of activity, as well as for the development of professional and personal qualities of a graduate.

#### **Tasks of the course:**

To form the learner's ability to solve communicative tasks by language means in various situations in the academic and professional sphere, to acquire knowledge in a wide range of fields of science, to make an in-depth analysis of information and to form his opinion both orally and in writing.

To achieve the goals and objectives of mastering the discipline, students must master a foreign language professional communicative competence, including:

Linguistic competence: the ability to correctly construct grammatical forms and syntactic constructions in accordance with the norms of the studied language.

Sociolinguistic competence: the ability to use and transform language forms in accordance with the situation of foreign-language communication.

Sociocultural competence: the ability to consider verbal and non-verbal behavior of the studied language country in communication.

Social competence: the ability to interact with communication partners, possession of appropriate strategies.

Discursive competence: the ability to understand and achieve coherence of individual statements in meaningful communicative models.

Strategic competence: the ability to use the most effective strategies in solving communicative tasks.

Object competence: knowledge of meaningful information when organizing one's own statement or understanding other people's statements.

Domain expertise: the ability to operate with knowledge in conditions of real communication with the studied culture representatives, manifestation of empathy as the ability to understand the norms, values and motives of behavior of another culture representatives.

Communicative competence: the ability to establish and forge contacts with representatives of various age, social and other groups of native and other linguistic cultures, the ability to be a mediator between the own and foreign-language cultures.

Pragmatic competence: the ability to choose the most effective and expedient way of expressing thoughts, depending on the conditions of the communicative act and the task set.

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

As a result of studying the course the student should

#### **know:**

- features of speech activities in German;
- the main phonetic, lexical and grammatical phenomena and structures used in oral and written speech when communicating in German, their difference from the native language for the reasoned and logical construction of statements that allow the application of the studied language in everyday, academic, scientific, business and professional communication;
- features of foreign-language academic communication, techniques for extracting and delivering foreign-language information for academic purposes;
- fundamentals of organizing written communication, types of written communicative tasks and functions of written communication tools;
- specifics of using verbal and non-verbal means in situations of foreign-language communication;
- types and features of written texts and oral presentations, general content of complex texts on abstract and specific topics, features of foreign-language texts, universal patterns of structural organization of the text, including highly specialized texts;
- rules of using various technical means for the purpose of searching and extracting foreign-language information, basic rules of determining the relevance and reliability of foreign-language sources, analysis and synthesis of information;
- world achievements, discoveries, events from the field of history, culture, politics, social life;
- general forms of teamwork organization; special aspects of behavior and interests of other participants; fundamentals of strategic planning of the team to achieve the goal;
- standard types of communicative tasks, goals and objectives of business negotiations, socio-cultural features of business negotiations, their communicative-pragmatic and genre features;
- vocabulary and terminology for academic, scientific and professional communication.

#### **be able to:**

- understand and use language tools in all types of speech activities in German;
- conduct discussions in German in various spheres of communication: everyday life, socio-cultural, socio-political, professional;

- verbally implement a communicative intention in order to influence a communication partner to start, conduct/maintain and finish a dialogue-asking about what he saw, read, dialogue-exchanging opinions and observing the norms of speech etiquette, if necessary using strategies to restore a failure in the communication process (re-questioning, paraphrasing, etc.);
- extract general and detailed information when reading authentic scientific and scientific-journalistic German-language texts;
- provide information based on the read text in the form of a prepared monologue (presentation on the proposed topic);
- understand monologue and dialogue statements in direct communication and in audio/video recordings;
- understand communicative intentions of the received written and oral messages;
- expand the proposed argument in the form of illustrations, details, explanations;
- use modern information technologies for professional activity, business communication and self-development;
- convey in Russian the content of German-language scientific and scientific-journalistic texts in the field of professional activity;
- select literature on the topic, compile a bilingual glossary, translate and review special literature, prepare scientific reports and presentations based on the read special literature, explain the own point of view and tell about plans;
- carry out oral and written foreign language communication in accordance with the student's field of professional activity;
- use the techniques and principles of building public speech for the report;
- recognize and differentiate linguistic and speech phenomena, distinguish basic and secondary information when reading texts and listening to speech, use standard means of oral and written communication in interpersonal communication; apply adequate communicative means in standard interaction situations on professionally oriented topics;
- use graphic editors, create easily perceived visual materials;
- describe graphical information (circular histogram, table, column and line graphs); write a short article on a given topic;
- write a summary, a review, a short article-advice on the proposed topic;
- abstract and annotate foreign-language professional texts;
- present research results in a written and oral form;
- apply information and communication technologies in communication and speech activity in a foreign language;
- identify and formulate problems that arise in the process of learning a foreign language; evaluate the student's capabilities, the realism and adequacy of the planned ways and ways to achieve the planned goals.

**master:**

- intercultural professionally oriented communicative competence in different types of speech activity;
- various communication strategies: educational strategies for organizing educational activities; strategies of reflection and self-assessment in order to improve personal qualities and achievements; strategies for perception, analysis, creation of oral and written texts of various types; Internet technologies for choosing the optimal mode of obtaining information; different methods of memorizing and structuring the acquired material;
- presentation technologies for information communication;
- method of searching and analyzing information from various sources in the professional field;
- skills of annotating and abstracting original scientific and scientific-journalistic articles;
- methods of assessing and self-assessing the results of foreign language learning activities;
- methods of identifying and realizing individual language capabilities, personal and professionally significant qualities in order to improve them;
- the ability to understand the speech of native speakers at a fast rate and respond adequately considering cultural norms of international communication;
- the ability to create clear, logical monologue and dialogue statements in various situations of everyday and professional communication, using the necessary set of communication tools;
- techniques of public speech and business and professional discourse in German.

**Content of the course (training module), structured by topics (sections):****1. Topic 1. Flexible skills**

Social and emotional intelligence. Personal and social skills. A relationship with the self. Skills and abilities to recognize emotions, understand the intentions, motivation and desires of other people and their own, managing emotions in order to solve practical problems. Inner harmony. Self-understanding. Self-regulation. Motivation. Empathy. Creativity. Sociability. Corporationism. Criticism. Key characteristics of a successful person. Success of the individual. Overcoming difficulties.

Communicative tasks: to carry out communication in oral and written forms: to build logical statements about personal and social skills, to describe various situations using illustrations; to use aphorisms in communication and be able to interpret them; to discourse upon ways of achieving success, possibilities of developing internal potential, life prospects, life meaningfulness, formation of responsibility assumed voluntarily; to talk about ways of self-improvement.

**2. Topic 2. Communication in the modern world**

Communication in society. Culture of communication based on common values: honesty, respect, mutual trust. Types and forms of communication. Means of communication. Social network.

Communicative tasks: to carry out communication in oral and written forms: to search, receive, transmit and exchange information, to apply in practice various types of information messages: statements, texts, images, sound messages, signals, signs, forum messages, conducting discussions, expressing one's own opinion, reviewing texts, description of illustrations; reasoned essay.

### 3. Topic 3. Ecology, nature, society

Modern environmental problems. Interaction of nature and society. Environmental protection. Biosphere and humans. Ecological consciousness.

Communicative tasks: to carry out communication in oral and written forms: to exchange opinions on the role of ecology and modern humans' attitude to nature; to discourse upon the dependence of public health on environmental factors; to discuss the impact of environmental factors on the generation of the future; to make descriptive essays on the subject; to draw conclusions, formulate an opinion on the role of society in the preservation of natural habitats on the planet.

### 4. Topic 4. Social and ethical issues in science, industry, and consumption

Globalization of consumption and social consequences. Science for sustainable development. Production and consumption. Conscious consumption. Principles and strategies of minimalism. Consumer culture. Consumption as a new form of control in society.

Communicative tasks: to carry out communication in oral and written forms: to discuss the problems of consumption globalization to meet the needs of the individual, society, the state; to express a reasoned opinion about the role of science and the impact of economic development on consumer attitudes to the world; to discuss socio-ethical issues and social consequences of consumerism.

### 5. Topic 5. The New Digital World

Global technological processes related to digitalization. Digital technologies – the Internet of Things. The digital world of science and business. Immersion in the digital world. Safe gadgets. Young hackers. The influence of the digital world on the perception of modern life.

Communicative tasks: to carry out communication in oral and written forms: to be able to search for the necessary information on the topic; to prepare reports on the topic; to express their own judgments about the advantages, limitations and prospects of using digital technologies, and their capabilities; to participate in a group discussion; to exchange opinions on technological innovations for solving various problems using technical means of the digital world; to compose essay-reasoning on the proposed topic.

### 6. Topic 6. Industry 4.0: on the way to "digital" production

Integration and cooperation with the use of digital technologies and increased flexibility in the organization of work. Transformation of economic sectors and types of activities and its impact on employment. Creating new markets and new forms of work through digital platforms. Problems

related to big information data. Relation between the use of human and machine labor (devaluation of experience, individual support). Possibility of flexible working conditions in terms of time and location. Profound changes in the structures of organizations.

Communicative tasks: to carry out communication in oral and written forms: to discuss flexibility in the organization of work in the context of the Work 4.0 concept; to talk about transformation of economic sectors and its impact on employment and activities in the world of labor; to recognize needs and interests of the interlocutor and base on them in the process of dialogue; to make messages about the creation of new markets and new forms of work through digital platforms; to express the own point of view, to speak constructively about the relationship between the use of human and machine labor; to make messages about the choice of a strategy for flexible working conditions; to be able to justify the chosen strategy; to prepare a report on the proposed topic.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Introduction to Quantum Metrology/Основы квантовой метрологии**

#### **Purpose of the course:**

Provide students with knowledge of basics of the quantum metrology.

#### **Tasks of the course:**

Widen the scope of students in the field of quantum mechanics, introduce the physical platforms used for quantum sensors.

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

As a result of studying the course the student should

##### **know:**

the foundations of quantum metrology and magnetometry, the physical platforms on which quantum calculators and sensors are implemented, the implementation of algorithms and measurements with them.

##### **be able to:**

explain the basic processes in quantum metrology and in the way quantum sensors work, estimate quantum sensor performance.

##### **master:**

the mathematical apparatus of quantum mechanics, especially related to quantum computing and measurement.

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

##### **1. Physical platforms**

Physical platforms: cold atoms, cold ions, artificial atoms, photons. Main physical platforms on which optical clocks, atomic interferometers and gravimeters are based. Methods for obtaining

and preparing particles, n.o. laser cooling, pumping and polarization processes. The advantages and disadvantages of various platforms in a specific application.

## 2. Quantum logic operations

Basic operations performed on atoms (ions, photons) to prepare and read states. The method of quantum logic, which uses a sparing ion to read the internal state of a "clock" ion.

## 3. Optical clocks

Principles of operation of optical clocks. Existing clocks on single and ensembles of ions, on neutral atoms in lattices, nuclear transitions. Systematic shifts and errors of optical clocks. Stability and accuracy of optical clocks.

## 4. Atomic interferometers, gravimeters

The principles of operation of atomic interferometers and gravimeters. Atomic ensembles used for gravimetry. Sensitivity to various external fields and methods of their measurement. The achievable performance of interferometers and gravimeters. Limiting factors.

## 5. Non-classical states in quantum metrology

Examples of using nonclassical states of light or atomic ensembles to improve the characteristics of quantum sensors. Using squeezed states to overcome the standard quantum noise limit.

## 6. Magnetometry

Color centers in diamond (nitrogen-vacancy, silicon-vacancy), NV center ground state, spin optical polarization and readout. DC magnetometer operation principles, error estimation for NV-based magnetometer. Superconducting quantum interference device(SQUID). DC-SQUID, RF-SQUID magnetometers. Magnetometer error estimation. Rubidium vapor cell magnetometer.

## 7. Thermometry in nanoscale

Living cell thermometry via color centers in nanodiamonds. Measurement principle and error estimation.

## 8. Nuclear magnetic resonance gyroscope

8. Gyroscope based on Xenon nuclear spin ensemble. Operation principle, continuous induced precession regime. Measurement errors and precision limits.

## 9. Electrometry

9. Electrometry with Rydberg atoms. Electrometry with color centers in diamond. Measurement errors and precision limits.

## 10. Methods of sensitivity improvement

Methods of sensitivity improvement. Quantum error correction. Non-demolition measurement.



## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**Labs in Quantum Photonics and Cryptography/Лабораторный практикум по квантовой фотонике и криптографии (РКЦ)**

### **Purpose of the course:**

To familiarize students with state-of-the-art laboratory instrumentation and standard operating procedures in quantum photonics and cryptography.

### **Tasks of the course:**

- To develop practical skills of use of modern tools and device of quantum data processing based on photonics;
- to reinforce the theoretical knowledge acquired on preceding lectures.

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

As a result of studying the course the student should

#### **know:**

Practical aspects of operating with photon emitters and detectors, fiber-optic interferometers, state-of-the-art instrumentation and computer system of the photonic lab.

#### **be able to:**

- Use modern instruments and data processing systems of the photonic lab;
- apply theoretical knowledge on quantum data processing to handle practical task.

#### **master:**

Basic skills to work in a photonic lab.

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

1. Lab #1. Single-photon detector.

Measurements of basic characteristics of a single-photon avalanche diode: quantum efficiency, linearity and maximum count speed, dead time of detection, post-pulses, and jitter.

2. Lab #2. Single-photon interferometry with fiber optics.

Obtaining light interference in a fiber-optic interferometer. Stabilization of the interferometer. Young's experiment (interference pattern from single photons).

3. Lab #3. Single-photon reflectometry and plug-and-play interferometer scheme.

An optical time-domain reflectometer (OTDR) for fiber-optic communication systems. Identification of components and measurement of their characteristics using a reflectogram. Switching to photon counting mode to increase sensitivity.

4. Lab #4. Fiber-optic quantum key distribution system.

Setting up and running a quantum key distribution system using autocompensation fiber-optic circuit. Testing its main characteristics.

5. Lab #5. Quantum-optical random number generator.

Setup and run of a hardware random number generator based on the phase of spontaneous emission of a semiconductor laser diode. Checking the correctness of its operation mode, reception and statistical testing of the resulting output sequence.

6. Lab #6. Bright-light control of a single-photon detector.

Demonstration of the blinding of a single-photon avalanche diode and of its classical control using bright light. Measurement of characteristics of single-photon avalanche diode under attack on the quantum key transfer system. Testing of a possible solution.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

**Machine Learning for Quantum and Statistical Physics/Машинное обучение для квантовой и статистической физики (РКЦ)**

### **Purpose of the course:**

to give a brief introduction to the methods of modern deep machine learning, to give an overview of the existing approaches of machine learning tools utilization for experimental quantum physics and statistical physics.

### **Tasks of the course:**

provide to students with the necessary knowledge and skills for independent interdisciplinary research at the intersection of machine learning and physics.

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

As a result of studying the course the student should

#### **know:**

the basic methods of deep machine learning and existing methods of their application for research in the field of modern quantum technologies.

#### **be able to:**

select appropriate machine learning tools for experimental and theoretical research in the field of quantum physics and statistical physics, navigate in modern research at the intersection of quantum technology and machine learning.

#### **master:**

basic technologies and algorithms of deep machine learning, and methods for using them as tools for research in various fields of quantum physics and statistical physics.

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

1. Introduction.

Introductory lecture. Overview of modern methods of machine learning. Course overview.

## 2. Linear classification and fully-connected neural networks.

Linear classification, optimization objective, gradient descent, deep neural networks, forward and back propagation. Methods of automatic differentiation.

## 3. Diagnosing quality of trained models.

Diagnosing quality of trained models. Quality metrics of training, diagnosing overfitting and underfitting. Regularization.

## 4. Convolutional neural networks.

Convolutional neural networks. Examples of convolutions, stride, pooling, padding. Examples of convolutional neural network architectures.

## 5. Recurrent neural networks.

Recurrent neural networks. Different types of recurrent architectures. Backward propagation. Gradient vanishing and explosion. Gated Recurrent Unit (GRU), Long Short Term Memory (LSTM). Bidirectional recurrent networks.

## 6. Boltzmann machines for statistical physics.

Boltzmann machines for problems of statistical physics. Description of the Boltzmann machine, definition, problem statement, optimization functional, gradient derivation and gradient descent. Utilization for classification and statistical physics tasks.

## 7. Boltzmann machines for quantum state tomography.

Boltzmann machines for quantum state tomography. Tomography of pure and mixed quantum states. Maximum Likelihood Method. Utilization of Boltzmann machines for tomography. Comparison of methods.

## 8. Sampling methods

Two sampling algorithms from an arbitrary distribution are discussed: the Gibbs algorithm and Metropolis algorithm. These algorithms are used to train a Boltzmann machine.

## 9. Variational autoregressive neural networks for statistical physics.

Variational autoregressive neural networks for statistical physics and many-body physics. Problem statement, optimization objective derivation, method of model training, overview of possible neural network architectures. Possible applications for other tasks.

## 10. Overview of recent advance.

Overview of recent advance in machine learning.

## 11. Final project.

Presentation of the independent research projects of students.

## **Annotation**

**Major: 12.04.03 Фотоника и оптоинформатика**

**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Physics of Quantum Fluids/Физика квантовых жидкостей (РКЦ)**

#### **Purpose of the course:**

Provide students with the basic knowledge of ultracold quantum systems, which are one of the main topics of research around the world and at RQC.

#### **Tasks of the course:**

Provide understanding of the main results obtained in the physics of ultracold quantum systems.

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

As a result of studying the course the student should

#### **know:**

Primary concepts of the physics of ultracold quantum systems: Bose-Einstein condensation, Superfluidity in Bose and Fermi systems etc.

#### **be able to:**

solve a large variety of problems related to the physics of ultracold quantum systems.

#### **master:**

mathematical techniques that are necessarily for solving these problems.

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

1. Key quantities. Elastic and inelastic interaction between atoms.

Key quantities. Elastic interaction between atoms. Weakly interacting regime. Two-body scattering problem. Inelastic collisions

2. Bose-Einstein condensation in an ideal gas.

Second quantization. Thermodynamics of an ideal Fermi gas. Particle and hole excitations.

### 3. Weakly interacting Bose gas. Gross-Pitaevskii equation.

Gross-Pitaevskii equation for the condensate wavefunction. Density-phase representation. Collapsing condensates. Stable condensates. Healing length. Bose-Einstein condensation in an external harmonic potential.

### 4. Dynamics of Bose-Einstein condensates.

Exact scaling approach for a two-dimensional evolution of a trapped condensate. Scaling approach for evolving 3D trapped condensates. Fundamental frequencies of oscillating condensates.

### 5. Elementary excitations of a Bose-condensed gas.

Bogoliubov transformation. Excitation spectrum of a uniform condensate. Non-condensed fraction. One-body density matrix and long range order. Quantum fluctuations of the density and phase. Quantum fluctuations and ground state energy.

### 6. Bose-condensed gas at a finite temperature. Superfluidity in Bose systems.

Non-condensed fraction and the one-body density matrix at finite temperatures. Landau criterion of superfluidity. Superfluid and normal density. Beliaev damping of elementary excitations. Landau damping. Small parameter of the theory at finite temperatures.

### 7. Vortices in Bose-condensed gases.

Vortices in rotating and non-rotating superfluids. Circulation. Gross-Pitaevskii equation for the vortex state. Excitations of the vortex state. Fundamental modes. Kelvin modes and vortex contrast.

### 8. Ideal Fermi gas. Thermodynamics and excitations.

Second quantization. Thermodynamics of an ideal Fermi gas. Particle and hole excitations

### 9. Repulsively interacting Fermi gas. Landau's Fermi liquid theory.

Weakly interacting Fermi gas with repulsion between particles. Quasiparticles in Landau's Fermi liquid theory. Hydrodynamic regime. Collisionless regime. Zero sound.

### 10. Attractively interacting Fermi gas. Superfluid pairing.

Cooper problem. BCS approach. Gapped single-particle excitations. Order parameter and transition temperature.

### 11. Superfluidity in Fermi gases.

Landau criterion in Fermi gases. Superfluid current. Bogoliubov-Anderson sound. Superfluid and normal density. Thermodynamic quantities near  $T_c$ .

### 12. Ginzburg-Landau approach. Vortices in Fermi gases.

Landau-Ginzburg functional. Critical fluctuations. Vortex state. Vortices near  $T_c$

### 13. Strongly interacting Fermi gases.

Anomalously large scattering length. Fano-Feshbach resonance. BCS-BEC crossover. Description of the strongly interacting regime. Unitarity limit.

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**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Quantum Information Processing/Обработка квантовой информации (РКЦ)**

#### **Purpose of the course:**

to acquaint students with the basics of quantum information processing theory, necessary for starting their own research activities.

#### **Tasks of the course:**

give a general idea of the formalization of information concept from the view point of the probability theory;

introduce the basic ideas of classical information processing;

introduce the formalism of positive operator-valued measures;

introduce the basic concepts of quantum information transfer;

introduce the basic algorithms of quantum computing, as well as modern algorithms of quantum machine learning.

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

As a result of studying the course the student should

##### **know:**

the basic concepts of quantum and classical information theory and the fundamental differences between quantum and classical information theory;

principles for constructing quantum algorithms and the functioning of quantum computers;

basic approaches to the transmission of information through quantum channels.

##### **be able to:**

calculate the entropy characteristics for classical probability distributions and quantum states;

perform operations on bra- and ket- vectors;

purify mixed quantum states;

calculate quantum states of the qubit register after applying a given set of quantum gates;  
construct elementary quantum algorithms;  
to design the simplest quantum communication protocols.

**master:**

the mathematical apparatus of classical and quantum information theory;  
formalism of the quantum channels description.

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

1. Review of the foundations of quantum mechanics formalism for finite-dimensional spaces

Review of the foundations of quantum mechanics formalism for finite-dimensional spaces. Hilbert spaces, bra and ket vectors, unitary, Hermitian, semi-positive operator. Matrix multiplication, trace, eigen values and eigen vectors. Calculation of mean values of the observables. Pure and mixed states, tensor product and partial trace.

2. Quantum measurement and quantum evolution

Quantum measurement and quantum evolution. Quantum measurements and quantum evolution. Formalism of positive operator-valued measures. Naimark's theorem. Completely positive trace-preserving mappings. Representations of quantum channels in terms of Kraus operators. Stinespring representation.

3. Quantum entanglement

Quantum entanglement. The concept of quantum entanglement of pure and mixed states. Measures of quantum entanglement and witnesses of quantum entanglement. The use of entangled states in the protocol of quantum teleportation and super-dense coding.

4. Quantum information theory

Quantum information theory. Foundations of classical information theory. Generalization of classical information theory to quantum states. Information transmission through quantum channels, Holevo bound.

5. Universal quantum computing

Universal quantum computing. Basic quantum gates, universal set of quantum gates, Solovay-Kitaev theorem. Principles of constructing quantum algorithms. Deutsch's, Deutsch-Jozsa's, Simon's, Shor's, Grover's algorithms. Demonstration of "quantum supremacy".

6. Variational and adiabatic quantum computing

Variational and adiabatic quantum computing. The principle of constructing variational quantum algorithms. Examples of using variational quantum algorithms. Using variational algorithms for quantum simulation. The principle of constructing adiabatic quantum algorithms. The relationship between variational and adiabatic algorithms.



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**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Quantum Communications/Квантовая связь (РКЦ)**

#### **Purpose of the course:**

to provide insights into modern applications of quantum mechanics to long-distance communication.

#### **Tasks of the course:**

to give the students proper background for work and research in the field of photonic quantum technologies, especially of long-distance communication.

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

As a result of studying the course the student should

##### **know:**

theoretical basis of quantum communications and its common applications to date.

##### **be able to:**

understand recent advances in quantum communications and cryptography.

##### **master:**

basic ideas and techniques of analysis of quantum communication systems.

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

##### **1. Introduction**

History of cryptography. Quantum cryptography. Demonstration that measurement changes a quantum state. Key distribution networks. Course overview. Sources of photons and coherent states. (Vadim)

##### **2. Components of quantum- optical systems**

Transmission of light in free space and optical fiber. Beamsplitters, polarizers, attenuators, wavelength filters, isolators and circulators. Modulators of polarization, phase, and intensity. Interferometers in single-photon regime. Photodetectors and power meters. Single-photon detectors. Integrated optics. (Vadim)

### 3. Basics of quantum optics

Qubits. Dual- and single-rail qubits. How to encode states of light to make qubits. Discrete variables vs. continuous variables. Bloch sphere. Phase coding of single photon. (Yury)

### 4. Measurement in quantum mechanics

How to measure qubit. Measurement of non-orthogonal states. How to make annihilation operator with measurement. Application examples: quantum random number generator, interaction-free detection. (Yury)

### 5. Quantum key distribution (QKD)

BB84 protocol and post-processing. Intercept-resend attack. How to realise QKD protocols on physical level. How qubits are prepared and measured in experiment. Free-space and fiber realisations. Using entanglement in experimental QKD. Decoy-state protocol. Differential-phase-coding protocol. (Yury)

### 6. Applications of QKD

Main applications of QKD and how they work. Quantum key generation rate in experiments. Limits on QKD distance. Quantum networks. Trusted repeaters. Satellite QKD and its challenges. (Yury)

### 7. Quantum superposition

Pure and mixed states. Transition from pure states to mixed states and vice versa. Double-slit interference and quantum erasure. Quantum ensembles and density matrix. (Denis)

### 8. Quantum measurements

Measurement-induced transformations. Quantum Zeno paradox. Projective measurements. Generalized measurements and POVM. Examples of optical schemes for generalized quantum measurements. Accessible information. Holevo bound. (Denis)

### 9. Entangled states

Bell basis. Correlations of entangled states. Remote state preparation. Entangled photons. Heralded sources of single photons. “Ghost” imaging and “ghost” interference. Superluminal communication and the “no-cloning” theorem. (Denis)

### 10. Security of BB84 protocol

Equivalence of prepare-and-measure and entanglement-based QKD. Decoy state QKD. Detection of eavesdropping attempts. Intercept-resend attack. Optimal attack. Bell inequality. Examples of Bell's inequality violation. (Denis)

### 11. Bell measurement with linear optics

Bell measurement with linear optics. Quantum teleportation. (Denis)

## 12. Security and threat model of QKD

The use of quantum random number generator in QKD. The need to trust the manufacturer. Processing double-clicks. Optical Trojan-horse attack and countermeasures to it. (Vadim)

## 13. Paper seminar on quantum teleportation; Detector control attack

J.-G. Ren et al., “Ground-to-satellite quantum teleportation,” *Nature* 549, 70 (2017). Detector control attack and countermeasures to it. (Vadim)

## 14. Paper seminar on twin-field QKD; Countermeasures against imperfections and certification

M. Lucamarini et al., “Overcoming the rate–distance limit of quantum key distribution without quantum repeaters,” *Nature* 557, 400 (2018). Types of countermeasures against imperfections. Distinguishability of source states. Certification of cryptographic tools. (Vadim)

## 15. Discussion and question-and-answer session

Discussion and question-and-answer session. (all lecturers)

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### **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 "e" 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 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.



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**specialization: Photonics, Quantum Technologies & 2D Materials/Фотоника, квантовые технологии и двумерные материалы**

### **Solid-State Quantum Computing/Твердотельные квантовые вычисления**

#### **Purpose of the course:**

To introduce students to one of the main directions of the development of quantum technologies – quantum computing, in particular, solid-state quantum computing.

#### **Tasks of the course:**

teach students to navigate the basic physical platforms and algorithms for processing and transmitting quantum information.

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

As a result of studying the course the student should

##### **know:**

the basic concept of quantum information processing;

experimental implementations of qubits;

existing solid-state quantum platforms;

theoretical proposals for as yet unexplored types of qubits, using, for example, electrons on the surface of superfluid helium, impurity spins in fullerenes, and others;

realizations of superconducting quantum circuits.

##### **be able to:**

solve a broad spectrum of problems related to physical foundations of solid-state quantum computing.

##### **master:**

approaches to create the simplest one- or two-qubit schemes, such as semiconductor quantum dots, diamond vacancies, solid-state impurity spins, and other quantum two-level systems;

basic principles of functioning of various types of superconducting qubits, decoherence mechanisms, and strategies for increasing the coherence of superconducting qubits.

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

1. Introduction: Basics of quantum computing

A general introduction to quantum computing. Physical limitations of existing classical computing platforms.

2. Microscopic qubits

Microscopic qubits: Atoms, Ions, Photons.

3. Condensed matter qubits

Solid-state qubits: semiconductor quantum dots, impurity spins, NV centers, impurity spins in fullerenes, electrons on the surface of liquid helium. The simplest one-or two-qubit schemes.

4. Superconductivity and Josephson junctions

The main focus of the course will be on superconductors. Therefore, we will devote a separate lecture to the basics of superconductivity and Josephson transitions..

5. Phase and flux qubits

With this lecture, we will begin to discuss superconducting quantum circuits in detail. Such schemes are currently used in existing quantum computers. In this lecture, we will discuss phase and flow qubits.

6. Charge qubit

The first type of superconducting qubit experimentally demonstrated in 1999 was charge qubits. We will discuss these pioneering experiments and talk about the problem of charge noise limiting the coherence time of such qubits.

7. Qubit readout and circuit QED

Quantum electrodynamics of circuits (circuit QED), the Janes-Cummings model, and qubit readout.

8. Transmon qubit

Transmons are currently the most widely used superconducting qubits in quantum processors. We will discuss the advantages of transmons, as well as their limitations and disadvantages.

9. Fluxonium, superinductance, g-flux qubit

The fluxonium is the result of the evolution of the streaming qubit and opens up new perspectives for the construction of quantum circuits. The most important element in such schemes is superinductivity, the properties of which we will discuss.

10. Qubit manipulation and gates

In this lecture, we will talk about manipulating the quantum states of qubits, about one- and two-qubit gates, and about tools for controlling the interaction between qubits.

## 11. Decoherence, two-level defects

We will talk about the sources of losses and the causes of dephasing of qubits, various decoherence mechanisms, and strategies for increasing the coherence of superconducting qubits.

## 12. Qubit readout electronics

Manipulating superconducting qubits requires the generation of short microwave pulses with precisely specified amplitude and phase. Qubit measurement involves amplifying weak microwave signals using parametric and low-noise cryogenic amplifiers. We will discuss the details of how practical schemes work.

## 13. Quantum processors, simulators, error correction

Quantum processors are divided into devices for executing universal quantum protocols and quantum simulators. We will discuss the advantages and practical limitations of different approaches. The second part of the lecture will be devoted to practical methods of error correction in quantum computing.