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**Federal State Autonomous Educational Institution for Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA (RUDN University)
Patrice Lumumba
Institute of Environmental Engineering**

COURSE SYLLABUS

Physicochemical methods of waste testing

**Recommended by the Didactic Council for the Education Field for the specialization:
05.04.06 "Ecology and nature management"**

**The course instruction is implemented within the professional education programme of
higher education:**

«Integrated Solid Waste Management» (Network program with L.N. Gumilyov Eurasian National
University)

1. COURSE GOAL(s)

The course is designed to help students to obtain knowledge, skills and abilities in the field of application modern physical and chemical methods of research of waste components; theoretical foundations of modern physical and chemical methods used in environmental studies; general laboratory and special methods for the study of waste components (including hazardous and toxic substances); principles of operation of modern analytical equipment; the basics of setting up an experiment and processing research materials; features of sampling and qualitative and quantitative analysis of chemicals, bioorganic wastes, leachate components and landfill gas; routine research; programs for environmental monitoring of waste management facilities.

• 2. REQUIREMENTS FOR COURSE OUTCOMES

The course implementation is aimed at the development of the following competences:

Competence code	Competence descriptor	Competence formation indicators (within this course)
GC-1	Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy	GC-1.1 Knows how to solve problematic tasks and identify their components and relationships between them.
		GC-1.2 Able to search for solutions to a problematic task based on available and reliable sources of information.
		GC-1.3 Owns a strategy for solving a problem situation based on a systematic and interdisciplinary approach.
GC-6	Able to determine and implement the priorities of their own activities and ways to improve it based on self-assessment	GC-6.1 Able to analyze large amounts of information of professional content.
		GC-6.2 Able to analyze, synthesize and optimize solutions to the tasks.
GPC-3	Able to apply environmental research methods to solve research and applied tasks of professional activity	GPC-3.1 Knows how to identify and has the skills to solve problems, tasks of scientific research in the field of urban geography, environmental problems of cities.
		GPC-3.2 Owns modern methods for assessing geoecological information to solve theoretical and practical tasks of nature management
		GPC-3.3 Possesses the skills of predicting meteoroproc reactions, assessing the climatic potential of regions, assessing the objectivity of climate change scenarios.
		GPC-3.4 Uses modern databases, methods for obtaining and working with information of theoretical and empirical levels, GIS technologies.
		GPC-3.5 Oriented in the modern system of regulatory support for engineering and environmental surveys and environmental impact assessment of urban agglomerations.
GPC-4	Able to apply regulatory legal acts in the field of ecology	GPC-4.1 Models and predicts the behavior of natural and natural-technogenic ecosystems of varying degrees of complexity, finds ways to optimize them

	and nature management, norms of professional ethics	GPC-4.2 Knows the international practice of development and harmonization, as well as the application of environmental standards
		GPC-4.3 Has the skills to analyze the need for environmental protection measures based on the application of environmental standards, the skills to select and apply indicators for environmental expertise and forms of environmental control based on environmental standards.

As a result of course studying, the student must:

Know:

basic terminology related to physical and chemical research methods, classification of methods; basic theories and laws underlying physical and chemical methods; physical and chemical (including spectral) methods for solving professional problems in the field of laboratory analysis of samples of various origins; theory, practice and features of combining various methods for the analysis of pollution of biosphere objects; chemical and physico-chemical methods for solving professional problems in the field of determining the structure of bioorganic compounds; essence of physicochemical methods of analysis, features of their application in modern biological research.

Be able to:

apply methods of chemical analysis, instrumental methods of research and methods of operational analytical control; to calculate the results of quantitative analysis according to experimental data using the methods of normalization, external and internal standard and absolute calibration; interpret the results of the obtained experimental studies; independently analyze the information obtained as a result of laboratory research; use theoretical and applied knowledge of environmental safety in production activities.

Own:

methods for determining a rational scheme when choosing an algorithm for determining the composition and identification of compounds, depending on the nature of substances and their quantitative content; methods of systematic application of chemical reactions and instrumental studies of ecological monitoring of the biosphere; the skills of classifying simple and complex organic compounds and reactions in the study of the functional composition; methods of using the chemical and physical and mathematical apparatus necessary for professional activities; skills in working with bioorganic objects, taking into account the features of the analysis of polycomponent mixtures.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

Discipline *Physicochemical methods of waste testing* refers to the **Electives** (block 1 of the curriculum).

Within the higher education programme students also master other disciplines (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course.

Table 3.1

The list of the higher education programme components that contribute to the achievement of the expected learning outcomes

Competence code	Competence descriptor	Previous courses/modules, internships*	Subsequent courses/modules, internships*
GC-1	Able to carry out a critical analysis of problem situations	Undergraduate disciplines	-

	based on a systematic approach, develop an action strategy		
GC-6	Able to determine and implement the priorities of their own activities and ways to improve it based on self-assessment	Undergraduate disciplines	-
GPC-3	Able to apply environmental research methods to solve research and applied tasks of professional activity	Undergraduate disciplines	-
GPC-4	Able to apply regulatory legal acts in the field of ecology and nature management, norms of professional ethics	Undergraduate disciplines	-

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the discipline is 3 credit units.

Table 4.1. Types of academic activities during the period of the HE program(me) mastering

Types of academic activities	Total hours	Semester(s)			
		1	2	3	4
<i>Contact academic hours</i>	34			34	
Lectures	17			17	
Lab works					
Seminars (workshops/tutorials)	17			17	
<i>Self-study</i>	47			47	
<i>Evaluation and assessment (exam; pass/fail grading)</i>	27			27	
The total course workload	hours	108		108	
	credits	3		3	

5. COURSE CONTENT

Table 5.1. Course Modules and Contents

Title of Course Modules		Content	Types of academic activities
1.	Section 1. Classification of methods for monitoring and identifying of waste components	Chemical methods. Physical methods. Biological methods. The main fields of application of each group of methods.	L, S
2	Section 2. Methods of elemental analysis	Atomic adsorption analysis. Atomic emission analysis. X-ray fluorescence analysis. Neutron activation analysis. Method of mass-spectral analysis.	L, S
3	Section 3. Titrimetric methods of analysis	Types of titrimetric analysis. Titration types.	L, S
4	Section 4. Mass Spectrometry	Ionization methods: electron impact, chemical ionization, photoionization, field ionization, field desorption, fast	L, S

Title of Course Modules	Content	Types of academic activities	
	atom bombardment, matrix laser desorption ionization (MALDI), electrospray. Ion detectors: Faraday cup, secondary electron multiplier, multichannel amplifier. Mass analyzers: operating principles, resolution. Advantages and disadvantages. Analytical possibilities of mass spectrometry. Molecular, fragmentation and metastable ions. Combinations of a mass spectrometer with chromatographs. Examples of the use of mass spectrometry.		
5	Section 5. Chromatography	Chromatographic separation of a mixture of substances. Physical and chemical adsorption. adsorption-desorption equilibrium. Width and shape of the chromatographic peak. Resolution of the chromatographic column. The device and scheme of operation of the chromatograph. Dead time and retention time. Packed and capillary columns, their parameters. Optimal dimensions and resolution of the chromatographic column. Detectors.	L, S
6	Section 6. Radiospectroscopy	Magnetic moments of the electron and nuclei. NMR active nuclei. Spin in a constant magnetic field. Magnetic moment and Larmor precession. Absorption of energy of a high-frequency field. Spectroscopy of nuclear magnetic resonance. Chemical shift. Spin-spin interaction. Application of the NMR method. Spectroscopy of electron paramagnetic resonance. Hyperfine structure of the EPR spectrum. Structural and dynamic characteristics of a substance determined by EPR methods. Schematic diagram of an EPR spectrometer. Application of the EPR method.	L, S
7	Section 7. Optical spectroscopy	Classes of spectral devices. Dispersive elements of spectral instruments and their resolution. The passage of light through an absorbing medium. Absorption cross section, molar extinction coefficient. Law of Lambert-Bouguer-Beer. Spectra of absorption, emission and scattering. Luminescence and fluorescence. Spectral ranges and corresponding degrees of freedom in molecular systems. Rotational spectra and microwave spectroscopy. Vibrational spectra and infrared spectroscopy. Vibrations of polyatomic molecules. Electronic transitions and spectroscopy in the visible and ultraviolet ranges. Intensity of electronic-vibrational spectra: Franck-Condon principle. Spectroscopy of Raman scattering of light.	L, S
8	Section 8. Federal Law on production and consumption waste	Basic concepts. Legal regulation in the field of waste management. Requirements for waste disposal facilities. Requirements for the handling of hazardous waste. Requirements for the transport of hazardous waste. State cadastre of waste. Production control in the field of waste management.	L, S

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Classroom for Academic Activity Type	Classroom equipment	Specialized educational / laboratory equipment, software and materials for mastering the course (if necessary)
Lecture	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless Internet connection. Software: Microsoft Windows, MS Office / Office 365, MS Teams, Chrome (latest stable release), Skype. Microsoft Windows 7 corporate. License No. 5190227, date of issue March 16, 2010 MS Office 2007 Prof , License # 6842818, date of issue 09/07/2009
Seminars	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	
Computer Lab	Computer Lab for conducting classes, group and individual consultations, current control and intermediate certification, equipped with personal computers (in the amount of 12), a board (screen) and technical devices of multimedia presentations.	No
For Self-Study	Classroom for self-study (can be used for seminars and consultations), equipped with a set of devices includes laptop, stable wireless.	No

7. RECOMMENDED SOURCES FOR COURSE STUDIES

a) Main reading:

1. M.D. Kharlamova, A.I. Kurbatova. Modern technologies of waste management, recycling and environmental protection. Moscow, Peoples Friendship University of Russia, 2017 – 98 p.
2. D. Friedman. Waste Testing and Quality Assurance: Second Volume. ASTM International, 1990 – 459 p.
3. Test Methods for Evaluating Solid Waste: Physical/chemical Methods, Technical Update. U.S. EPA, 1982 – 23 p.

b) Additional reading:

1. L. Pawlowski. Physicochemical Methods for Water and Wastewater Treatment. – 1980. – 336 p.

Internet-based sources

1. ELS of RUDN University and third-party ELS, to which university students have access on the basis of concluded agreements:

- RUDN Electronic Library System - RUDN EBS <http://lib.rudn.ru/MegaPro/Web>
- ELS "University Library Online" <http://www.biblioclub.ru>
- EBS Yurayt <http://www.biblio-online.ru>
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" <http://e.lanbook.com/>
- EBS "Trinity Bridge"

2. Databases and search engines:

- electronic fund of legal and normative-technical documentation <http://docs.cntd.ru/>
- Yandex search engine [https:// www .yandex.ru/](https://www.yandex.ru/)
- Google search engine <https://www.google.ru/>
- abstract database SCOPUS [http:// www .elsevier.com/locate/scopus /](http://www.elsevier.com/locate/scopus/)

8. MID-TERM ASSESSMENT AND EVALUATION TOOLKIT

Evaluation materials and a point- rating system* for assessing the level of competence formation (part of competences) based on the results of mastering the discipline *Physicochemical methods of waste testing* are presented in the Appendix to this Work Program of the discipline.

DEVELOPER:

Associate Professor of
the ES&PQM

Department Position

Vasil'ev V.G.

Signature

Name, Surname

HEAD OF DEPARTMENT:

Director of ES&PQM Department

Position

Savenkova E.V.

Signature

Name, Surname

HEAD OF PROGRAMME:

Associate Professor of the
ES&PQM Department

Position

Popkova A.V.

Signature

Name, Surname

Department Environmental Safety and Product Quality Management
educational department to be specified

APPROVED

Department meeting protocol No _____,

Dated _____

day, month, year

Head of Educational Department

_____(Savenkova E.V.)

signature

ASSESSMENT TOOLKIT

for the course

Physicochemical methods of waste testing

course title

05.04.06 "Ecology and nature management"

field of studies / speciality code and title

«Integrated Solid Waste Management» (Network program with L.N. Gumilyov Eurasian National University)

higher education programme profile/specialisation title

master

graduate's qualification (degree)

Passport to Assessment Toolkit for Course Physicochemical methods of waste testing

Field of Studies / Speciality 05.04.06 "Ecology and nature management"

Course: Physicochemical methods of waste testing

Competences (competences in part) under assessment	Course module under assessment	Course topic under assessment	Tools to assess higher education programme mastering level									Points for topic	Points for module	
			Class work					Self-studies			Exam/Pass-fail assessment			
			Quiz	Test	Work with lecture materials	Work at the seminars	Lab work	Homework	Research essay/ Library research paper	Calculation and graphic work				Group work project
GC-1, CG-6, GPC-3, GPC-4	Module 1: Classification of methods for monitoring and identifying of waste components	Chemical methods. Physical methods. Biological methods. The main fields of application of each group of methods.			2	6		4					12	12
GPC-3	Module 2: Methods of elemental analysis	Basics of Elemental analysis			2	4		2					8	8

GPC-3	Module 3: Titrimetric methods of analysis	Basics of Titrimetric methods of analysis			2	4		2					8	8
GPC-3	Module 4: Mass Spectrometry	Basics of Mass spectrometry			2	4		2					8	8
GPC-3	Module 5: Chromatography	Basics of Chromatography			2	4		2					8	8
GPC-3	Module 6: Radiospectroscopy	Basics of Radiospectroscopy			2	4		2					8	8
GPC-3	Module 7: Optical spectroscopy	Basics of Optical spectroscopy			2	4		2					8	8
GC-1, GPC-4	Module 8: Federal Law on production and consumption waste	Basic concepts. Legal regulation in the field of waste management. Requirements for waste disposal facilities. Requirements for the handling of hazardous waste. Requirements for the transport of hazardous waste. State cadastre of waste. Production control in the field of waste management.			2	4		4					10	10
		TOTAL			16	34		20			10	20	70	70

QUESTION CARD No 1

QUESTION 1. Physical methods of analysis in environmental control and MSW monitoring programs.

QUESTION 2 The main methods of sample preparation in physical methods of analysis.

Developer _____ (Vasil'ev V.G.)
signature

Head of Educational Department _____ (Savenkova E.V.)
signature

day, month, year

Note * Practice case/task inclusion is subject to the teacher's discretion.

The set of exam question cards is complemented by the assessment criteria developed by the teacher and approved at the department meeting.

PROJECT WORK EXAMPLES

1. Pulp and paper industry waste: origin, regulations, control methods, disposal;
2. Glass industry waste: origin, regulations, control methods, disposal;
3. Tire industry waste: origin, regulations, control methods, disposal;
4. Waste from the metallurgical industry: origin, regulations, control methods, disposal;
5. PET production waste: origin, regulatory documents, control methods, disposal;
6. Textile industry waste: origin, regulations, control methods, disposal;
7. Timber processing waste: origin, regulatory documents, control methods, disposal;
8. Wastes of the oil refining industry: origin, regulations, control methods, disposal;
9. Aluminum industry waste: origin, regulations, control methods, disposal;
10. Waste of the coal industry: origin, regulations, methods of control, disposal;
11. Pharmaceutical industry waste: origin, regulations, control methods, disposal;
12. Waste production of meat products: origin, regulatory documents, control methods, disposal;
13. Waste production of dairy products: origin, regulatory documents, control methods, disposal;
14. Waste from leather and shoe industries: origin, regulations, control methods, disposal;
15. Waste of cement production: origin, regulatory documents, control methods, disposal;
16. Waste production of bread: origin, regulations, methods of control, disposal;
17. Waste from galvanic production: origin, regulatory documents, control methods, disposal;

18. Sugar production waste: origin, regulatory documents, control methods, disposal;
19. Flour production waste: origin, regulatory documents, control methods, disposal;
20. Grain production waste: origin, regulations, control methods, disposal.

QUESTIONS FOR SELF-STUDING

1. Chemical methods of environmental control.
2. Physical methods of environmental control.
3. Biological methods of environmental control.
4. Sample incineration methods.
5. Atomic absorption analysis.
6. X-ray fluorescence analysis.
7. Neutron activation analysis.
8. Mass spectral analysis method.
9. Ion detectors in MS.
10. Methods of ionization in MS.
11. Combination of MS with chromatography.
12. Principles of chromatography.
13. Types of chromatography.
14. Combination of chromatography with other methods.
15. Principle of NMR spectroscopy.
16. NMR identification of substances.
17. NMR in quantitative analysis.
18. Features of NMR in application to waste control.
19. Spectral methods of the optical range.
20. Vibrational spectra.
21. Spectroscopy of the Raman spectrum.
22. UV spectroscopy in the analysis of substances.
23. Features of the interaction of xenobiotics with abiotic components of the environment.
24. Features of the impact of pollutants on living organisms.
25. Ecological, physicochemical and toxicological features of priority persistent organic pollutants.
26. Waste of the 1st, 2nd, 3rd, 4th, 5th hazard class.
27. Federal classification catalog of waste.
28. Classification of waste by origin.

29. Classification of waste by hazardous properties;
30. Classification of waste according to the degree of harmful effects on the environment.

EXAMPLE OF HOMEWORK

Methods:

1. Cryoscopy, ebullioscopy
2. Optical microscopy
3. Refractometry
4. Polarimetry
5. Titrimetry
6. Electrophoresis, capillary electrophoresis
7. Spectrometry in the near infrared region
8. Spectrometry in the infrared region
9. Spectrophotometry in the ultraviolet and visible regions
10. Fluorimetry
11. Raman spectrometry
12. X-ray fluorescence spectrometry
13. Mass spectrometry
14. Chromatography
15. NMR spectroscopy
16. Atomic emission spectroscopy
17. Atomic absorption spectroscopy
18. X-ray powder diffractometry.

Place the numbers of the presented methods according to the following blocks of their use in the identification and quantitative determination of the content of elements, isotopes, ions, molecules:

1. Chemical (i.e. accompanied by a change in the composition of the analyte) methods.
2. Physical methods.
3. Measurement of molecular weight.
4. Measurement of magnetic properties.
5. Analysis of the atomic composition.
6. Establishment of the molecular formula.
7. Determination of functional groups of molecules.

Each method may correspond to more than one block. For the completeness of the answer, it is necessary to know both the basis of a particular phenomenon and method, as well as the measured characteristics and their relationship with the analyte data of interest.

Tentative list of assessment tools

No	Assessment tool	Brief features	Assessment tool representation in the kit
<i>Class work</i>			
1	Survey/Quiz	A tool of control, organised as a special conversation between a teacher and students on topics related to the course under study, and designed to clarify the amount of students' knowledge in a particular section, topic, problem, etc.	Questions on the course topics /modules
2	Test	A system of standardised tasks that allows the teacher to automate the procedure for measuring the student's level of knowledge and skills	Tests bank
3.	Colloquium	A tool for monitoring the acquisition and mastering of educational material on a topic, section or sections of a discipline, organised as a training session in the form of an interview among the teacher and students.	Questions on the course topics /modules
4	Control work	A tool of control organised as a classroom lesson, at which students need to independently demonstrate the acquisition and mastering of the educational material of the course topic, section, or sections.	Questions on the course topics /modules
5	Lab work	The system of practice tasks aimed at the students' practical skills formation	Practice tasks bank
6.	Round table, discussion, polemic, dispute, debate, (class work)	Evaluation tools that allow the teacher to engage students in the process of discussing controversial issues, problems and assess their ability to argue their own point of view.	List of themes for round tables, discussions, polemics, disputes, debates.
7	Business game and/or role play	Joint activities of a student group under the teacher's control to solve educational and professionally oriented tasks through the simulation of a real-world problem; this activity allows the teacher to assess the students' ability to analyse and solve typical professional challenges.	Topic (problem), concept, roles and expected results for each game
8.	Essay	A tool that allows the teacher to assess the student's ability to express in writing the	Themes for essays

		essence of the under study, to independently analyse this issue using the concepts and analytical tools of the relevant discipline, to draw conclusions that summarise his/her position on the issue under consideration.	
9.	Presentation (defence) of project/report/ Library research paper /briefs *	A tool for monitoring the students' ability to present the work results to the audience.	Themes for projects/reports/ Library research paper/ briefs
10	Pass/Fail assessment	A tool for checking the quality of students' performance of laboratory work, acquisition and mastering of the practice training and seminar educational material, successful completion of the advanced field internship and pre-graduate internship and fulfillment of all training assignments in the course of these internships in accordance with the approved programme.	Tasks examples
11	Exam	The evaluation of the student's work during the semester (year, the entire period of study, etc.); it is designed to identify the level, soundness and systematic nature of theoretical and practical knowledge gained by the student, formation of independent work skills, development of creative thinking, ability to synthesise the acquired knowledge and apply it to solve practice tasks.	Examples of tasks/questions/exam question cards
12	Internship and research and development (R&D) report	A form of written work that allows the student to generalise his/her knowledge, skills and abilities acquired during the introductory and advanced field internships, scientific and industrial internships and R&D activities.	
13	Case	A problem-solving task in which the student is asked to comprehend the real work-related (occupational) situation necessary to solve the problem.	Assignments to solve the case
14	Multi-level tasks and assignments with varying difficulty	The tasks and assignments differ in terms of the following levels: a) reproductive level allows the teacher to evaluate and diagnose the students' knowledge of factual material (basic concepts, algorithms, facts) and the students' ability to correctly use special terms and concepts, recognize objects of study within a certain section of the discipline, b) reconstructive level allows the teacher to evaluate and diagnose the students' abilities to synthesise, analyse, generalise factual and theoretical material and formulate specific	Set of multi-level tasks and assignments with varying difficulty

		conclusions, establish cause-and-effect relationships, c) creative level allows to evaluate and diagnose students' skills to integrate knowledge of various fields, argue their own point of view.	
<i>Self- studies</i>			
1	Calculation and graphic work	A tool for checking students' skills in applying the acquired knowledge according to a predetermined methodology in task solving or fulfilling assignments for a module or discipline as a whole.	Set of tasks for calculation and graphic work
2	Course work/project	A type of independent written work aimed at the creative development of general professional and specialised professional disciplines (modules) and the development of relevant professional competences	Course assignment themes
3	Project	The final "product" that results from planning and performance of educational and research tasks set; it allows the teacher to assess the students' ability to independently shape their knowledge in the course of solving practice tasks and problems, navigate in the information environment and the students' level of analytical, research skills, skills of practical and creative thinking; it can be implemented individually or by a group of students.	Themes for team-based or individual projects
4	Research essay (Library research paper)	The student's independent work in writing that summarises the results of the theoretical analysis of a certain scientific (educational and research) topic, where the author reveals the essence of the problem under study, considers different points of view, as well as argues his/her views on the material under consideration.	Themes for research essay (library research papers)
5	Reports, briefs	The product of the student's independent work, which is a public performance on the presentation of the results of solving a specific educational, practical, research or scientific topic.	Themes for reports, briefs
6	Essay and other creative assignments	A partially regulated assignment that has a non-standard solution and allows the teacher to diagnose students' skills in integrating knowledge from various fields and arguing their own point of view; it can be prepared individually or by a group of students.	Themes for team-based or individual creative assignments
7	Standard calculations	A tool to test skills in applying the acquired knowledge, according to a predetermined methodology, solving tasks or fulfilling	Set of tasks for standard calculations

		assignments for a module or discipline as a whole.	
8	Homework	<p>The tasks and assignments differ in terms of the following levels:</p> <p>a) reproductive level allows the teacher to evaluate and diagnose the students' knowledge of factual material (basic concepts, algorithms, facts) and the students' ability to correctly use special terms and concepts, recognize objects of study within a certain section of the discipline,</p> <p>b) reconstructive level allows the teacher to evaluate and diagnose the students' abilities to synthesise, analyse, generalise factual and theoretical material and formulate specific conclusions, establish cause-and-effect relationships,</p> <p>c) creative level allows the teacher to evaluate and diagnose students' skills to integrate knowledge of various fields, argue their own point of view.</p>	Set of multi-level tasks and assignments with varying difficulty

DEVELOPER:

Associate Professor of the
ES&PQM Department

Position

Vasil'ev V.G.

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HEAD OF DEPARTMENT:

Director of ES&PQM Department

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HEAD OF PROGRAMME:

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