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ФИО: Ястребов Олег Александрович  
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**Federal State Autonomous Educational Institution of Higher Education  
Peoples' Friendship University of Russia named after Patrice Lumumba  
RUDN University**

**Academy of Engineering**

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educational division (faculty/institute/academy) as higher education programme developer

## **COURSE SYLLABUS**

**Methods for oil production intensification and enhanced oil recovery / Методы  
интенсификации добычи нефти и повышения нефтеотдачи пластов**

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course title

**Recommended by the Didactic Council for the Education Field of:**

**21.04.01 Oil and Gas Engineering**

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field of studies / speciality code and title

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

**Oil and Gas Engineering / Технологии добычи и транспортировки нефти и газа**

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higher education programme profile/specialisation title

## 1. COURSE GOAL(s)

The discipline «Methods for oil production intensification and enhanced oil recovery / Методы интенсификации добычи нефти и повышения нефтеотдачи пластов» is included in the curriculum of the master's programme "Oil and Gas Engineering / Технологии добычи и транспортировки нефти и газа" within the field of study 21.04.01 "Oil and Gas Engineering" and is studied in the 3rd semester of master 2. The discipline is delivered by the Department of Mineral Developing and Oil & Gas Engineering. It consists of 6 sections and 13 topics and is aimed at studying the field experience of applying various technologies and methods of production enhancement, acquiring practical skills in solving specific design tasks related to selecting the method for well stimulation, and mastering the methodology of field analysis of the effectiveness of implementing various geological and technical measures.

The goal of the discipline is to provide students with knowledge, skills, competencies, and practical experience in the field of advanced reservoir stimulation methods for increasing oil flow rates from wells, technologies for implementing these methods, as well as techniques that affect well productivity or injection capability, which characterize the stages of competency formation and ensure the achievement of the planned learning outcomes of the educational programme.

## 2. REQUIREMENTS FOR LEARNING OUTCOMES

The course "Methods for oil production intensification and enhanced oil recovery / Методы интенсификации добычи нефти и повышения нефтеотдачи пластов" is designed for students to acquire following competences (competences in part):

*Table 2.1. List of competences that students acquire during the course*

Competence code	Competence descriptor	Competence formation indicators (within this course)
PC-3	Able to manage the system for monitoring the technical condition and technical diagnostics at the facilities and plants of the oil and gas complex	PC-3.1 Knows the principles, physical foundations, technical support of technical control and diagnostic methods, modern developments in the field of strength of materials, fracture mechanics, materials technology and materials science; design features, manufacturing technology, operation and repair of the control object, types and types of defects, probable zones of their formation, taking into account the loads acting on the object and other factors, principles, physical foundations, technical support for the types and methods of technical control and diagnostics; principles of construction, functional diagrams and rules for operating equipment for a given method of control, rules for selecting and checking the quality of used consumable flaw detection materials; control systems used to check objects (products) of a certain type; metrological support; standards, calculation methods and other applicable regulatory documents and rules for assessing the technical condition; harmful environmental factors of this control method and ways to prevent their impact on the environment and humans; principles of planning and organization of work of technical control and diagnostic units, current state and prospects for the development of

Competence code	Competence descriptor	Competence formation indicators (within this course)
		<p>technical control and diagnostic methods; rules for electrical safety and fire safety, rules for the construction and safe operation of facilities</p> <p>PC-3.2 Can determine the methods, equipment, technologies and techniques to be used for specific types of objects; perform control operations, evaluate and identify the results of control and testing, issue conclusions on the results of technical control and diagnostics; organize, conduct and manage calculations and experimental work to assess the technical condition</p> <p>PC-3.3 Has the skills to perform verification calculations, taking into account the identified defects; assessment of the mutual influence of various defects on the technical condition of the control object; determining the need for additional research in order to clarify the determining parameters of the technical condition; development of measures to reduce operational risks based on risk analysis, minimization of operational risks</p>
PC-5	Capable of applying the basic principles of rational use of natural resources and environmental protection	<p>PC-5.1 Knows the legal and methodological framework of the procedure for conducting environmental impact assessment EIA and environmental expert activities for use in professional activities; fundamentals of the theory and normative legal acts of the integrated development and rational use of natural resources and environmental protection; the procedure for conducting a geological examination of projects, regulatory documents for compiling an environmental passport</p> <p>PC-5.2 Can assess the state of the environment when conducting complex geological and geographical studies; use mechanisms for the rational use of natural resources and environmental protection; apply regulatory and methodological documents to assess and prevent environmental damage at production facilities</p> <p>PC-5.3 Has the methodology of rational use of natural resources and environmental protection; a system of methods (EIA) and conducting state environmental expertise for successful research and production activities; skills and knowledge to assess environmental damage at production facilities, modern methods for eliminating the consequences and preventing environmental damage at production facilities</p>
PC-6	Able to organize, manage, and carry out quality control of the main types of work in the development of oil and gas fields, transportation and processing of oil and gas	<p>PC-6.1 Knows:</p> <p>The main types of applied systems for assessing the quality of geological types of work in the development of oil and gas fields, transportation and processing of oil and gas; ISO-9001 quality system, GKZ regulations and classification of oil and gas reserves</p> <p>Requirements of regulatory legal acts of the Russian Federation, local regulations, administrative documents and technical documentation in the field of hydrocarbon production</p> <p>Technological processes of hydrocarbon production</p> <p>Purpose, device and principle of operation of equipment for the extraction of hydrocarbon raw materials</p> <p>Physical and chemical properties of hydrocarbon raw</p>

Competence code	Competence descriptor	Competence formation indicators (within this course)
		<p>materials, chemical reagents, the procedure and rules for their disposal</p> <p>Technological modes, well operation parameters</p> <p>Standards for technological losses of hydrocarbon raw materials during production in accordance with the accepted scheme and development technology</p> <p>The influence of various processes occurring in the reservoir on the productivity factor of a production well</p> <p>The procedure for measuring the productivity factor of a production well</p> <p>Methods for calculating the productivity factor and skin effect according to well surveys with recording the pressure recovery curve</p> <p>Purpose, device and principle of operation of equipment for mechanized production of hydrocarbon raw materials</p> <p>Standards, specifications, guidelines for the development and execution of technical documentation</p> <p>Types of emergencies during well operation, their causes and methods of prevention and elimination</p> <p>Structure, interaction of means of an automated process control system, telemechanics, automatic control systems for hydrocarbon production equipment, ways to control them</p> <p>Requirements for labor protection, industrial, fire and environmental safety</p> <p>PC-6.2 Can:</p> <p>Organize and conduct quality control of work in the development of oil and gas fields, transportation and processing of oil and gas at different stages of the study of specific objects</p> <p>Evaluate the residual life of hydrocarbon production equipment</p> <p>Analyze inflow characteristics in a vertical, horizontal or multilateral well</p> <p>Predict the change in the inflow characteristics from the reservoir to the well, taking into account the reservoir operation mode</p> <p>Develop operating instructions for hydrocarbon production equipment</p> <p>Control the operation of equipment for artificial lift of hydrocarbons</p> <p>Identify wells operating with deviations from the planned regime</p> <p>Conduct emergency drills with subordinate personnel according to the action plan for localization and elimination of accidents and incidents at hydrocarbon production facilities</p> <p>PC-6.3 Has:</p> <p>The methodology for assessing the quality of all types of work in the development of oil and gas fields, transportation and processing of oil and gas at different stages of the study of specific objects</p> <p>Skills for organizing and monitoring the implementation of plans and tasks for the extraction of hydrocarbons</p> <p>Skills for operational management of production and</p>

Competence code	Competence descriptor	Competence formation indicators (within this course)
		monitoring compliance with hydrocarbon production technology Skills for monitoring compliance with the specified operating mode of well equipment, piping, oil and gas field pipelines, prefabricated pipelines, gas pipelines, pipelines, inhibitor pipelines in accordance with the requirements of the technological regulations of the installation, operating instructions and passports of equipment manufacturers Skills to analyze the dynamics of hydrocarbon production. Organization of providing jobs with up-to-date technological documentation Skills in organizing monitoring and control of the operation of the field and wells Skills of control and management of work on the preparation and maintenance of technical documentation of the unit Skills of control and management in the direction of compliance with the requirements of labor protection, industrial, fire and environmental safety in the unit Skills to control and manage the preparation of reports on the production of hydrocarbons

### 3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course refers to the elective component of (B1) block of the higher educational programme curriculum.

*Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results*

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
PC-3	Able to manage the system for monitoring the technical condition and technical diagnostics at the facilities and plants of the oil and gas complex	Advanced oil and gas processing equipment and product quality management; Fundamentals of construction and operation of pipeline transport; Machinery and equipment for field development and transportation of hydrocarbons; Technological practice (educational); Technological practice (industrial)	Diagnostics of oil and petroleum products main pipeline facilities; Pre-graduation Practical Training; Final State Examination
PC-5	Capable of applying the basic principles of rational use of natural resources and environmental protection	Machinery and equipment for field development and transportation of hydrocarbons; Modern stream in oil and gas processing in Russia; Technologies for developing prospective hydrocarbon reserves; Technological	Final State Examination

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
		practice (educational); Technological practice (industrial)	
PC-6	Able to organize, manage, and carry out quality control of the main types of work in the development of oil and gas fields, transportation and processing of oil and gas	Machinery and equipment for field development and transportation of hydrocarbons; Modern aspects of geological and geophysical research in the oil and gas industry	Improving the efficiency of the production process and operation of equipment for the extraction of hydrocarbons; Well Repair and Water Breakthrough Control Technologies; Pre-graduation Practical Training; Final State Examination

\* To be filled in according to the competence matrix of the higher education programme

#### 4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course "Methods for oil production intensification and enhanced oil recovery / Методы интенсификации добычи нефти и повышения нефтеотдачи пластов" is 5 credits.

Table 4.1 Types of academic activities during the period of the HE programme mastering

Type of study work		TOTAL, acc.hrs.	Semester(s) 3
<i>Contact academic hours, acc .</i>		54	54
including:			
Lectures		18	18
Laboratory work			
Seminars (workshops/tutorials)		36	36
<i>Self-study (ies), academic hours</i>		99	99
<i>Evaluation and assessment (exam or pass/fail grading)</i>		27	27
<b>The course total workload</b>		acc.hrs.	<b>180</b>
		Credits	<b>5</b>

#### 5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

Course module title		Course topic title		Course module contents (topics)	Academic activities types
1	Well Productivity Management	1.1	Objectives of managing well productivity and injectivity.	Ensuring planned flow rates for production wells and maintaining target injectivity for injection wells. Minimizing production losses. Extending the mean time between repairs (MTBR). Economic criteria: cost-effectiveness of treatments.	LC, S
		1.2	Methods for stimulating production and injection wells.	Classification: mechanical (bottomhole cleaning, pump replacement), physico-chemical (acid treatments, surfactants), thermal, wave methods. Hydraulic	LC, S

				fracturing (HF), hydro-sandblast perforation. Application for production and injection wells.	
		1.3	Differences between enhanced oil recovery methods and well productivity management techniques.	Productivity management – influencing the near-wellbore zone (NWBZ) to restore/increase flow rate. Enhanced Oil Recovery (EOR) methods – influencing the entire reservoir to alter fluid and rock properties (waterflooding, polymer flooding, gas flooding). Scale, cost, duration of effect.	LC, S
2	Processes Occurring in the Near-Wellbore Zone (NWBZ)	2.1	Causes of declining well productivity and injectivity.	Plugging (pore clogging) by mechanical particles, paraffins, asphaltenes, salts, corrosion products, mud cake. Clay swelling. Salt precipitation (CaCO <sub>3</sub> , CaSO <sub>4</sub> , BaSO <sub>4</sub> ). Formation of emulsions and gas hydrates.	LC, S
		2.2	Processes occurring in the NWBZ during field development.	Changes in phase permeability. Reservoir deformation (porosity reduction under drawdown). Induced (uncontrolled) hydraulic fracturing. Sand production. Formation of mechanical impurity accumulation zones. Evolution of the NWBZ over time.	LC, S
3	Acid Treatments of Wells	3.1	Types of acid treatments, their advantages, disadvantages, and applicability.	Hydrochloric acid (HCl) – for carbonates. Mud acid (HCl+HF) – for clastics. Foamed acids, gelled acids, emulsified acids. Advantages: simplicity, low cost. Disadvantages: corrosion, secondary precipitates, shallow penetration. Applicability for carbonate, clastic, and fractured reservoirs.	LC, S
		3.2	Field pilot implementation and evaluation of acid treatment effectiveness.	Selection of candidate wells. Determination of volume, concentration, and process parameters (pressure, injection rate). Effectiveness criteria: increase in oil flow rate or injectivity, duration of effect, unit cost per ton of oil. Well testing before/after (pressure buildup tests, injectivity tests).	LC, S
4	Hydraulic Fracturing	4.1	Types of hydraulic fracturing, their advantages, disadvantages, and applicability.	Proppant HF (classical), acid HF (for carbonates), high-rate HF (without proppant), multistage HF (MSHF) for horizontal wells. Advantages: deep penetration, high production increase. Disadvantages: high cost, risk of fracture height growth out of zone. Applicability: low-permeability reservoirs, well "revitalization."	LC, S
		4.2	Field pilot implementation and evaluation of hydraulic fracturing effectiveness.	Selection of wells based on geological and technical criteria. Design (proppant volume, carrier fluid injection rate). Mini-frac for stress assessment. Monitoring (microseismic, tracers). Economic evaluation: success factor, incremental recovery factor, payback period.	LC, S
5	Other Technologies for Enhancing Well	5.1	Horizontal wells as a method for enhancing	Increasing drainage area through wellbore length. Reducing drawdown on the reservoir. Application in low-	LC, S

	Productivity and Injectivity		well productivity and injectivity.	permeability reservoirs, fractured rocks, gas caps. Combination with MSHF. Disadvantages: high drilling cost, complex workover.	
		5.2	Wave stimulation of the reservoir.	Acoustic, shock-wave, and ultrasonic treatment of the NWBZ. Mechanism: destruction of colloidal structures, demulsification, viscosity reduction. Vibroseismic surface stimulation. Advantages: reagent-free, environmentally friendly. Disadvantages: limited radius of action, unproven effectiveness.	LC, S
		5.3	Thermal methods of oil production stimulation.	Steam stimulation (cyclic steam treatments), electric thermal heaters (cable, induction), thermogasochemical stimulation (TGCS). Injection of heat carriers (steam, hot water). Application for high-viscosity and waxy oils, removal of asphaltene-resin-paraffin deposits (ARPD).	LC, S
6	Enhanced Oil Recovery Methods	6.1	Causes of residual oil saturation. Classification of enhanced oil recovery methods. Field pilot implementation.	Residual oil: capillary traps, "dead" pores, unswept zones. Classification of EOR methods: hydrodynamic (waterflooding), physico-chemical (polymer, micellar, alkaline), gas (CO <sub>2</sub> , nitrogen, flue gases), thermal (SAGD, in-situ combustion), microbiological. Implementation stages: laboratory tests, pilot area, commercial application. Evaluation: sweep efficiency, displacement efficiency, recovery factor.	LC, S

\* - to be filled in only for **full**-time training: *LC* - lectures; *LW* - lab work; *S* - seminars.

## 6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

*Table 6.1. Classroom equipment and technology support requirements*

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
Lecture	A lecture hall for lecture-type classes, equipped with a set of specialised furniture; board (screen) and technical means of multimedia presentations.	
Seminar	A classroom for conducting seminars, group and individual consultations, current and mid-term assessment; equipped with a set of specialised furniture and technical means for multimedia presentations.	
Self-studies	A classroom for independent work of students (can be used for seminars and consultations), equipped with a set of specialised furniture and computers with access to the electronic information and educational environment.	

\* The premises for students' self-studies are subject to **MANDATORY** mention

## 7. RESOURCES RECOMMENDED FOR COURSE STUDY

### *Main readings:*

1. Antoniadi, D. G., Gaponenko, A. M., Vartumyan, G. T., Streltsova, Yu. G. Modern technologies for enhancing high-viscosity oil production and evaluation of their application efficiency. – Moscow; Vologda: Infra-Engineering, 2019. – 421 p.
2. Fedin, L. M., Fedin, K. L., Fedin, A. K. Fundamentals of enhanced oil recovery of heavy oil [Electronic resource]. – Simferopol: Dolia, 2013. – 111 p.

### *Additional(optional) reading (sources):*

3. Oparin, V. N., Simonov, B. F., et al. Geomechanical and technical foundations of enhanced oil recovery using vibrowave technologies: monograph / edited by V. V. Ivashin. – Novosibirsk: Nauka, 2010. – 404 p.

### *Internet sources*

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:
  - RUDN Electronic Library System (RUDN ELS) <http://lib.rudn.ru/MegaPro/Web>
  - EL "University Library Online" <http://www.biblioclub.ru>
  - EL "Yurayt" <http://www.biblio-online.ru>
  - EL "Student Consultant" [www.studentlibrary.ru](http://www.studentlibrary.ru)
  - EL "Lan" <http://e.lanbook.com/>
2. Databases and search engines:
  - electronic foundation of legal and normative-technical documentation <http://docs.cntd.ru/>
  - Yandex search engine <https://www.yandex.ru/>
  - Google search engine <https://www.google.ru/>
  - Scopus abstract database <http://www.elsevierscience.ru/products/scopus/>

### *Training toolkit for self- studies to master the course \*:*

1. The set of lectures on the course «Methods for oil production intensification and enhanced oil recovery / Методы интенсификации добычи нефти и повышения нефтеотдачи пластов».
2. Guidelines for students on the development of the course "Methods for oil production intensification and enhanced oil recovery / Методы интенсификации добычи нефти и повышения нефтеотдачи пластов".

\*The training toolkit and guidelines for the course are placed on the course page in the university telecommunication training and information system under the set procedure.

**DEVELOPERS:**

Associate Professor of the Department of Mineral  
Developing and Oil&Gas Engineering

Tcharo H.

---

position, department

name and surname

**HEAD OF EDUCATIONAL DEPARTMENT:**

Mineral Developing and Oil&Gas Engineering

Kotelnikov A.E.

---

name of department

name and surname

**HEAD****OF HIGHER EDUCATION PROGRAMME:**

Professor of the Department of Mineral Developing and  
Oil&Gas Engineering

Kapustin V.M.

---

position, department

name and surname