БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ /
BELARUSIAN STATE UNIVERSITY

УТВЕРЖДАЮ / APPROVED

Проректор по учебной работе и образовательным инновациям Белорусского государственного университета/
Vice-rector for academic affairs and education innovations of Belarusian State University

_____О.Г.Прохоренко /Olesya G.Prakharenko

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ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ В ПРОФЕССИОНАЛЬНОЙ ДЕЯТЕЛЬНОСТИ/

INFORMATION TECHNOLOGIES IN PROFESSIONAL ACTIVITIES

Учебная программа учреждения образования по учебной дисциплине для специальности:
The program of the educational institution of the discipline for the speciality:

7-06-0532-03 Землеустройство, кадастры, геодезия и геоматика /
7-06-0532-03 Land Management, Cadastres, Geodesy and Geomatics

Профилизация / Profilization:

Управление геоданными с использованием интеллектуальных систем /
Geodata management using intelligent systems

2024

Учебная программа составлена на основе ОСВО 7-06-0532-03-2023 по специальности 7-06-0532-03 Землеустройство, кадастры, геодезия и геоматика, примерного учебного плана № 7-06-05-011/пр. от 18.01.2023, учебного плана БГУ № М47а-5.7-157/уч. от 29.03.2024

СОСТАВИТЕЛЬ:

О.А.Стрельченок, старший преподаватель кафедры почвоведения и геоинформационных систем факультета географии и геоинформатики Белорусского государственного университета

РЕЦЕНЗЕНТЫ:

В.А.Сипач, заместитель начальника отдела № 14 «Разработки технологий обработки и применения данных дистанционного зондирования Земли» Научно-инженерного республиканского унитарного предприятия «Геоинформационные системы»;

А.П.Безрученок, доцент кафедры экономической и социальной географии факультета географии и геоинформатики Белорусского государственного университета, кандидат географических наук, доцент

РЕКОМЕНДОВАНА К УТВЕРЖДЕНИЮ:

Кафедрой почвоведения и геоинформационных систем
(протокол № 12 от 19.04.2024);

Научно-методическим советом БГУ
(протокол № 7 от 30.04.2024)

Заведующий кафедрой _____ А.Н.Червань

ПОЯСНИТЕЛЬНАЯ ЗАПИСКА

Цели и задачи учебной дисциплины

Цель учебной дисциплины – систематизация и формирование знаний, умений и навыков использования современных информационных технологий обработки и представления геоданных в решении прикладных задач управления земельными ресурсами, и использования геоданных для решения экономических и управленческих задач.

Задачи учебной дисциплины:

1. Получение необходимых знаний и формирование навыков по использованию ГИС-приложений в различных областях профессиональной деятельности;

2. Овладение навыками применения операций геоинформационного анализа и средств обработки геоданных для решения комплексных задач в разных отраслях науки и производства;

3. Усвоение математического аппарата (математический анализ, статистика, методы машинного обучения), а также интеграция использования современных инструментов искусственного интеллекта (большие языковые модели) в процесс проектного обучения для решения актуальных гео-информационных и экономических задач;

4. Практическое применение накопленных знаний в реальных кейсах и проектах;

5. Формирование умений коллективной работы в решении комплексных практических задач

Место учебной дисциплины в системе подготовки специалиста с углубленным высшим образованием.

Учебная дисциплина относится **к модулю** «Современные информационные и образовательные технологии» государственного компонента.

Учебная программа составлена с учётом межпредметных связей с учебной дисциплиной «Программное геоинформационное обеспечение».

Требования к компетенциям

Освоение учебной дисциплины «Информационные технологии в профессиональной деятельности» должно обеспечить формирование следующей универсальной компетенции:

прогнозировать условия реализации профессиональной деятельности и решать профессиональные задачи в условиях неопределенности.

В результате освоения учебной дисциплины обучающийся должен:

знать:

основные ГИС-приложения, используемые организациями Республики Беларусь и в мире, их функциональные возможности;

основные операции ГИС-анализа, их назначение и особенности проведения; основные форматы пространственных данных, используемых в программных продуктах ГИС;

проблемные вопросы основных отраслей профессиональной деятельности и возможности ГИС по их решению; методы машинного обучения, статистического анализа данных, модели нейронных сетей, инструменты больших

языковых моделей, возможности их интеграции в ГИС анализ для повышения эффективности и качества решения геоинформационных и экономических задач.

уметь:

самостоятельно анализировать поставленные задачи и искать пути их решения; создавать структуру и определять свойства баз геоданных;

выполнять все виды пространственного анализа в основных ГИС - приложениях; представлять результаты геоинформационного анализа в виде правильно оформленных картографических продуктов;

иметь навык:

использования программных и технических средств геоинформационного анализа данных в различных областях профессиональной деятельности;

применения и интеграции современных ГИС систем с системами искусственного интеллекта (ИИ-агенты, большие языковые модели) для решения актуальных геоинформационных задач.

Структура учебной дисциплины

Дисциплина изучается в 1 семестре. Всего на изучение учебной дисциплины «Информационные технологии в профессиональной деятельности» отведено:

– для очной формы получения углубленного высшего образования – 96 часов, в том числе 48 аудиторных часов, из них: лабораторные занятия – 48 часов.

Трудоемкость учебной дисциплины составляет 3 зачетные единицы. Форма промежуточной аттестации – зачет.

EXPLANATORY NOTE

Aim and tasks of the discipline

Aim of the discipline – systematization and formation of the knowledge, skills and abilities for practical use of the modern information technologies in the processing and presenting geodata for solving applied problems of land resource management, and the use of geodata to solve economic and management problems.

Tasks of the discipline:

1. Obtaining the necessary knowledge and developing skills in using GIS applications in various areas of professional activity;
2. Mastering the skills of using geoinformation analysis operations and geodata processing tools to solve complex problems in

various branches of science and production;

3. Mastering the mathematical apparatus (mathematical analysis, statistics, machine learning methods), as well as integrating the use of modern artificial intelligence tools (large language models) into the process of project-based learning to solve current geoinformation and economic problems;
4. Practical application of accumulated knowledge in real cases and projects;
5. Formation of teamwork skills in solving complex

practical problems

Place of the academic discipline in the system of training a specialist with advanced higher education.

The academic discipline is part of the module «Modern information and educational technologies» of the state component.

Connections with other academic disciplines: «GIS software functionality», «Technologies for automated geodata processing», «Simulation and predictive data modeling in GIS».

Requirements for competences

Mastering of the academic discipline «Information technologies in professional activities» should provide the formation of the following universal competences*:*

to predict the conditions for the implementation of professional activities and solve professional problems under conditions of uncertainty.

As a result of mastering the academic discipline, the student is expected to:

know: the main GIS applications used by organizations of the Republic of Belarus and their functional capabilities; the main operations of GIS analysis, their purpose and features of implementation; the main formats of spatial data used in GIS software products; problematic issues of the main branches of professional activity and the capabilities of GIS for their solution; methods of machine learning, statistical data analysis, neural network models, tools of large language models, the possibilities of their integration into GIS analysis to improve the efficiency and quality of solving geoinformation and economic problems.

be able to: independently analyze the tasks set and look for ways to solve them; create a structure and determine the properties of geodatabases; perform all types of spatial analysis in the main GIS applications; present the results of geoinformation analysis in the form of correctly designed cartographic products;

have skills in: the use of software and hardware for geoinformation data analysis in various areas of professional activity; the application and integration of modern GIS systems with artificial intelligence systems (AI agents, large language models) to solve current geoinformation problems.

Structure of the academic discipline

The discipline is studied in the 1 semester. In total for the study of the discipline «Information technologies in professional activities» is allocated:

– for full-time advanced higher education – 96 hours, including 48 in-class hours, of them: laboratory classes – 48 hours.

The labor intensity of the discipline is 3 credit units.

Form of certification – end-of-term test.

CONTENT OF THE STUDY MATERIAL

Section 1 Introduction into modern information technologies, used in land management, geodesy, urban and rural development

Topic 1.1 Introduction into GIS, ArcGIS and mapping. IT in urban development.
Basics of GIS-mapping and land management. The sources of data for geo analysis. Representation of urbanized territories in GIS. Software products used in geo planning. Introduction in ArcGIS, its functionality. Implementation of urban planning solutions in GIS. Design and construction of a spatial database.

Topic 1.2 Information technologies in rural, agricultural and forestry development. Agricultural lands as an object of geoinformation mapping. Areas of IT and GIS use in agriculture. Software products used in agriculture. IT and GIS in forestry. Software products used in forestry. Features of IT and GIS use in land reclamation. Methods of statistical analysis, machine learning and forecasting using neural networks in geography and geomatics.

Topic 1.3 Information technologies in environmental protection and tourism.
Software products used in nature conservation activities and its use. Planning of ecological network in GIS. Tourist and recreational resources and features of their representation in GIS. Software products used in tourist and recreational activities. Features of using GIS in planning tourist routes.

Section 2 GIS and IT technologies in assessing the economic efficiency of projects

Topic 2.1 Mathematical methods of optimization for georesources planning.
Economic calculations and research, their essence and features of implementation. Methods of optimization of resource planning to achieve the target function (minimization of cost, maximum use of resources, constraints). Types of tasks and approach to solve it for optimization in geoinformatics area: optimal location of production, transport task, resources-locations assignment task.

Topic 2.2 IT tools for economical management and optimization.
GIS and other tools for economic analysis. ArcGIS functions for optimization of resource use and achievement of economic efficiency.

Section 3 Artificial Intelligence, LLM and Autonomous GIS: the next generation AI-powered GIS

Topic 3.1 AI-powered GIS (GeoAgent) and its application for solving spatial problems LLM as the reasoning core (DeepSeek, Grok) in management. Integration of LLM with RAG = Retrieval Augmented Generation. Autonomous AI-agent). GeoAgent to generate and execute geoprocessing workflow to perform spatial analysis.

TEACHING AND METHODOLOGICAL MAP OF THE DISCIPLINE

Full-time form of advanced higher education with the use of distance learning technologies (DLT)

Title of section, topic	Title of section, topic	In-class hours					Independent work	Form of control
		Lectures	Practical classes	Seminar classes	Laboratory classes	Other		
1	**Introduction into modern information technologies, used in land management, geodesy, urban and rural development**				**26**			
1.1	Introduction into GIS, ArcGIS and mapping. IT in urban development				10			Written reports on laboratory work. Personal interview
1.2	Information technologies in rural, agricultural and forestry development				8			Written reports on laboratory work. Personal interview
1.3	Information technologies in environmental protection and tourism				8			Written reports on laboratory work. Personal interview
2	**GIS and IT technologies in assessing the economic efficiency of projects**				**14**			
2.1	Mathematical methods of optimization for georesources planning				8			Written reports on laboratory work. Personal interview
2.2	IT tools for economical management and optimization				6			Written reports on laboratory work. Personal interview
3	**Artificial Intelligence, LLM and Autonomous GIS: the next generation AI-powered GIS**				**8**			
3.1	AI-powered GIS (GeoAgent) and its application for solving spatial problems				8			Written reports on laboratory work. Personal interview

INFORMATION AND METHODOLOGICAL PART

List of basic literature

1. Курлович, Д. М. ГИС в управлении земельными ресурсами = GIS for Land Resourse Management : учебно-методическое пособие для студ. учреждений высшего образования по спец. "география", "землеустройство, кадастры, геодезия и геоматика" / Д. М. Курлович ; БГУ. - Минск : БГУ, 2024. - 190 с. - URL: https://elib.bsu.by/handle/123456789/325904

List of additional literature

1. Toms, S. ArcPy and ArcGIS: automating ArcGIS for desktop and ArcGIS online with Python. ArcPy and ArcGIS / S. Toms, D. O'Beirne. – Birmingham Mumbai: Packt Publishing, 2017. – 251 p.

2. Zandbergen, P.A. Advanced Python Scripting for ArcGIS Pro / P.A. Zandbergen. – ESRI Press, 2020. – 290 p.

3. Zandbergen, P.A. Python scripting for ArcGIS / P.A. Zandbergen. – New York: ESRI Press, 2013. – 353 p.

4. Zandbergen, P.A. Python Scripting for ArcGIS Pro / P.A. Zandbergen. – ESRI Press, 2020. – 420 p.

5. Вестра, Э. Разработка геоприложений на языке Python / Э. Вестра. – Москва: Packt Publishing, 2017. – 448 с.

6. Хайнеман, Д. Алгоритмы. С примерами на Python / Д. Хайнеман. – Питер, 2021.

7. Conley, J. A Geographer's Guide to Computing Fundamentals: Python in ArcGIS Pro : Springer Textbooks in Earth Sciences, Geography and Environment. A Geographer's Guide to Computing Fundamentals / J. Conley. – Cham: Springer International Publishing, 2022.

8. Jordan, D.S. Applied geospatial data science with Python: take control of implementing, analyzing, and visualizing geospatial and spatial data with geopandas and more. Applied geospatial data science with Python / D.S. Jordan. – Birmingham: Packt Publishing, 2023.

9. McClain, B. Python for Geospatial Data Analysis / B. McClain. – O'Reilly Media, Inc., 2022.

10. Yang, C. Introduction to GIS programming and fundamentals with Python and ArcGIS / C. Yang. – Boca Raton, FL: Taylor & Francis, 2017. – 302 p.

11. Язык программирования Python / Г. Россум [и др.]; пер. с англ. – СПб.: АНО «Институт логики». Невский диалект, 2001. – 454 с.

12. Грекусис, Дж. Методы и практика пространственного анализа : с примерами решения ArcGIS, GeoDa и GeoDa Space / Джордж Грекусис ; [пер. с англ. А. Н. Киселева]. - Москва : ДМК Пресс, 2021. - 539 с.

List of recommended diagnostic tools and methodology for final mark formation

The object of diagnostics of students' competences is the knowledge and skills acquired as a result of studying the academic discipline. Identification of students' learning achievements is carried out by means of current and interim certification.

The following means of current certification can be used to diagnose competences: written reports on laboratory work, personal interview.

The form of interim certification in the discipline «Information technologies in professional activities» in accordance with the curriculum is end-of-term test.

Approximate list of laboratory classes

Laboratory class 1. Creating layers, identifying data types and attributes, assigning symbols to data and categories. Create a basemap, attribute table, data distribution, find railway tracks, find a place to build a school (Work with map of Shanghai)

Laboratory class 2. Introduction to Spatial Analysis: Map Projection, Basic Analysis Tools, Raster Tools, Spatial Statistics Toolbox. Using Spatial Autocorrelation to Identify Areas of High Unemployment. Checking Proximity to Transportation. (Use provided government health center locations in Ghana maps).

Laboratory class 3. Use spatial statistics: apply spatial autocorrelation to analyze spatial data (on the example of housing and rent in Greater Boston metro Area map).

Laboratory class 4. Analyze rainfalls using Interpolation (on the example of US map).

Laboratory class 5. To model the forecast of real estate prices depending on the location of objects on the map of the Grodno region using spatial statistics – regression analysis.

Laboratory class 6. To determine the best location for building a new international touristic & recreation center facility in Mogilev area.

Laboratory class 7. Identification of erosion zones in anti-erosion organization of the territory. Use map of EU country (Belgium)

Laboratory class 8. Using the previous task and data determining a place to build a new international touristic & recreation center facility in Mogilev area to practice network analyst in ArcGIS (create a network dataset, create a multimodal network dataset, finding the best route, finding the closest fire station, calculating service area and creating an OD cost matrix, creating a model for route analysis)

Laboratory class 9. Planning route for a bicycle trip in GIS using the example of several districts in Belarus Grodno region

Laboratory class 10. Using ModelBuilder in ArcGIS to model network analysis.

Description of innovative approaches and methods for teaching the discipline

When organizing the educational process, a combination of a case study method (case method) and project-based learning approach are used, which entails the following:

- student's acquisition of knowledge and skills necessary for solving practical problems;
- analyzing the situation by using professional knowledge, personal experience, additional literature and other sources.
- mastering students' skills of planning, self-organization and cooperation relevant for both educational and professional activities, including the creation of one's own product;
- acquiring skills to solve research, creative, social, business and communication problems.

Additionally, the method of group teaching is used, which is a form of organizing the educational and cognitive activity, involving different types of small groups working on both general and specific educational assignments and laboratory tasks.

Methodological recommendations for the organization of independent work

When studying the discipline «Information technologies in professional activities» it is recommended to use the following forms of independent work:

- search (selection) and review of literature and electronic sources on an individually specified problem of the academic discipline;
- fulfilment of homework;
- study of the material submitted for independent work;
- preparation for laboratory classes;
- research work;
- practice with GIS and other IT tools

The effectiveness of students' independent work is checked during the current and final control of knowledge.

Approximate list of questions for the exam/end-of-term test

1. What is GIS?
2. Possible types of GIS. Which GIS to use?
3. Comparison and difference between ArcGIS and QGIS.
4. Main functionality of GIS.
5. What are the possible most used layers in the GIS Maps?
6. Geospatial datatypes: vector and raster. What is this? What is the difference? Provide examples.

7. Vector data. Attribute table: description, structure, purpose, composition, GEOID, examples. Vector file's formats.
8. Vector data: symbolizing spatial data: purpose, principles, how to do?
9. Raster datatypes: origin, how to generate, symbolization, attribute table structure?
10. Raster file's formats. Georeferencing.
11. Tabular datatypes: purpose, how to use in geo tasks, formats.
12. Geodatabases: purpose, how to use, pros & cons
13. Spatial data: abstraction, resolution, size, scale. Where and how spatial data can be found (sources)?
14. Maps and data: metadata. What is metadata, examples?
15. Making good maps: main principles and approaches.
16. Three steps of map design process.
17. Vector and raster symbolization
18. Classification methods
19. Map layout design
20. Spatial analysis. What are the main useful types of spatial analysis and tools exist in ArcGIS?
21. Specialized tools of spatial analysis: please list ones and describe how and when to use.
22. Maps projection: what are they, why and how to use?
23. A Geographic Coordinate System (GCS) and Projected Coordinate System (PCS): principles, differences and characteristics. Mainly used GCS
24. Tips on selecting a PCS
25. Map projection: how to know the coordinate system of your data?
26. ArcGIS Analysis Toolbox: how and when to use?
27. Vector analysis: buffer. What is it, how to use?
28. Create and edit feature
29. Clip (Vectors): when, how and for what purpose to use?
30. Extract by mask/Clip Raster: what is it, purpose, how to use?
31. Contour: what is it, purpose, how to use?
32. Slope: what is it, purpose, how to use?
33. Spatial Statistics: spatial autocorrelation: what is it, what and how it measures? Distance models. Methods/models to define neighbors.
34. Point Pattern Analysis and Analyzers: what is it, purpose, how to use?
35. Spatial patterns analysis in data: what is it, purpose, how to use?
36. Spatial analysis: Mean, median, standard deviation ellipse, normal distribution, QQ plot, box plot. Outliers – how to detect, voroni map, histogram
37. Spatial autocorrelation – Moran's I: what is it, purpose, how to use?
38. Regression and Regression models: what is it, purpose, how to use?
39. Geostatistical Interpolation: what is it, purpose, how to use, types?
40. Network analysis tools: what is it, purpose, how to use, types?

ПРОТОКОЛ СОГЛАСОВАНИЯ УЧЕБНОЙ ПРОГРАММЫ УО

Название учебной дисциплины, с которой требуется согласование[1]	Название кафедры	Предложения об изменениях в содержании учебной программы учреждения высшего образования по учебной дисциплине[2]	Решение, принятое кафедрой, разработавшей учебную программу (с указанием даты и номера протокола)[3]
Дисциплина не требует согласования			

Заведующий кафедрой почвоведения
и геоинформационных систем,
кандидат сельскохозяйственных наук, доцент А.Н.Червань

19.04.2024

ДОПОЛНЕНИЯ И ИЗМЕНЕНИЯ К УЧЕБНОЙ ПРОГРАММЕ ПО ИЗУЧАЕМОЙ УЧЕБНОЙ ДИСЦИПЛИНЕ

на _____/_____ учебный год

№ п/п	Дополнения и изменения	Основание

Учебная программа пересмотрена и одобрена на заседании кафедры _____ (протокол № ____ от _____ 202_ г.)

Заведующий кафедрой

_____ _____

УТВЕРЖДАЮ
Декан факультета

_____ _____