Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Applied Mathematics and Informatics
A.M. Raygorodskiy

Work program of the course (training module)

course: Software Development and Data Engineering/Разработка ПО и системы хранения данных
major: Applied Mathematics and Informatics
specialization: Contemporary Combinatorics/Современная комбинаторика
"Pusk" Online and Supplementary Education Centre
Chair of Discrete Mathematics
term: 1
qualification: Master

Semester, form of interim assessment: 2 (spring) - Grading test

Academic hours: 45 AH in total, including:
lectures: 15 AH.
seminars: 30 AH.
laboratory practical: 0 AH.

Independent work: 45 AH.

In total: 90 AH, credits in total: 2

Author of the program: R.G. Neychev, professor

The program was discussed at the Chair of Discrete Mathematics 05.12.2022

Annotation

This course focuses on the fundamentals of software engineering. Proper design is an important part of any project. This course covers the basics of the Python programming language, basic concepts and language constructs. Along with this, this course provides tools for using Python programming language in complex projects. You will gain insight into the correct design of the code, maintaining the codebase and integrating your applications with others.

1. Study objective

Purpose of the course

- Learn how to write effective and readable code
- Learn Software Development best practices
- Gain essential experience with Python
- Get used to testing and documenting the code
- Get ready to implement the Machine Learning and Deep Learning techniques

Tasks of the course

- Software Development
- Python
- Testing
- Working with different environments

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
UC-1 Use a systematic approach to critically analyze a problem, and develop an action plan	UC-1.1 Systematically analyze the problem situation, identify its components and the relations between them
	UC-1.3 Develop a step-by-step strategy for achieving a goal, foresee the result of each step, evaluate the overall impact on the planned activity and its participants
UC-2 Able to manage a project through all stages of its life cycle	UC-2.1 Set an objective within a defined scientific problem; formulate the agenda, relevance, significance (scientific, practical, methodological or other depending on the project type), forecast the expected results and possible areas of their application
	UC-2.2 Forecast the project outcomes, plan necessary steps to achieve the outcomes, chart the project schedule and monitoring plan
	UC-2.3 Organize and coordinate the work of project stakeholders, provide the team with necessary resources
UC-6 Determine priorities and ways to improve performance through self-assessment	UC-6.1 Achieve personal growth and professional development, determine priorities and ways to improve performance

Gen.Pro.C-1 Address current challenges in fundamental and applied mathematics	Gen.Pro.C-1.1 Apply fundamental scientific knowledge, new scientific principles, and research methods in applied mathematics and computer science
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional tasks
Gen.Pro.C-2 Iimprove upon and implement new mathematical methods in applied problem solving	Gen.Pro.C-2.2 Assess the relevance and practical importance of applied mathematical research in professional settings
Gen.Pro.C-4 Combine and adapt current information and communications technologies (ICTs) to meet professional challenges	Gen.Pro.C-4.1 Use ICTs to search and analyze professional information, highlight, structure, format, and present it in the form of analytical reviews with sound conclusions and recommendations

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

As a result of studying the course the student should:

know:

- idea of the structure, functioning of the visual analyzer;
- understanding of psychophysiological and information models of binocular vision;
- principles of video interface functioning in relation to VR / AR systems.

be able to:

- principles of functioning and methodology for the development of distributed systems in relation to the tasks of creating VR / AR systems;
- the structure and principles of functioning of existing and future graphics API.

master:

- methodology for the development of software for all links of VR / AR systems (including the graphics core, virtual environment control subsystems, video interface, etc.);
- an object-oriented methodology for designing and developing software code for the entire range of tasks for creating VR / AR systems.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Objects, values and types	3	6		9
2	PEP8, Style guides	3	6		9
3	Functional programming elements	3	6		9
4	Scopes and Namespaces	3	6		9
5	Classes: Declaration, Inheritance, attributes, instances, instance variables, private section	3	6		9
AH in total		15	30		45
Exam preparation		0 AH.			
Total complexity		90 AH., credits in total 2			

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

Semester: 2 (Spring)

1. Objects, values and types

Flow control statements: if, for, while Python Data structures Multi-threading: Process Pool, Thread Pool, threading module, multiprocessing

2. PEP8, Style guides

Complex condition Functions: Declaration, Signature, Call by assignment, Call Stack, Closures, Recursions

3. Functional programming elements

Modules: imports, module search path, standard modules, dir() Packages: __init__.py, __all__, dotted imports

4. Scopes and Namespaces

Compilation and interpretation strategies (AOT, JIT) How to speed up the python code: numba, cython, joblib, dask, c++ extensions Data Science toolbox overview

5. Classes: Declaration, Inheritance, attributes, instances, instance variables, private section

Iterators, Generators, Generator Expressions, Context Managers, Decorators Exceptions: Built-In Exceptions, handling exception, raise exception, custom exceptions Standard Library, inspect Logging

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

A standard classroom.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

1. От хранения данных к управлению информацией [Текст]/[ред.: Г. Сомасундарам (Сому), А. Шривастава] , -СПб., Питер, 2010

Additional literature

1. Основы математического и программного обеспечения систем 3D-визуализации индуцированного виртуального окружения [Текст] : учеб. пособие для вузов / В. О. Афанасьев, С. В. Клименко ; М-во образования и науки РФ ; Моск. физ.-техн. ин-т (гос. ун-т), Фак. высоких технологий и инноваций .— М. : МФТИ, 2014 .— 241 с.

7. List of web resources that are necessary for the course (training module) mastering

http://dm.fizteh.ru/

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

Multimedia technologies can be employed during lectures and practical lessons, including presentations.

9. Guidelines for students to master the course

successful completion of the course requires intense independent work of the student. The course program contains the minimum required time for a student to work on a topic.

Independent work includes:

- elaboration of educational material (based on lecture notes, educational and scientific literature), preparation of answers to questions intended for independent study, proof of individual statements, properties;
- preparation for practical training, several individual homework assignments.

Interim control of knowledge is carried out in the form of written questionnaires on theory. In addition, in the course of mastering the course, the student must complete a project containing several interrelated tasks with their subsequent protection.

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Informatics
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term:	1
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Semester, form of interim assessment: 2 (spring) - Grading test

Author: R.G. Neychev, professor

1. Competencies formed during the process of studying the course

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2. Competency assessment indicators

As a result of studying the course the student should:

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3. List of typical control tasks used to evaluate knowledge and skills

1. What is the difference between mutable and immutable objects in python? What are the benefits for using mutable or immutable types? What is “call by assignment” ?
2. What is closure in python? When can we use it?
3. What is a decorator in python? How to implement your own decorator? (Decorator with parameters)
4. What is a context manager in python? Usage
5. Generators and iterators in python? Implementation, Usage
6. Class Inheritance, mro, mixins
7. GIL
8. Multiprocessing vs. Multithreading, what is the difference
9. How can we make private attributes in class?
10. Class Interface for creating hashable objects.

4. Evaluation criteria

Questions for the exam

1. Prove that if m, n are two coprime integers of different parity, then the numbers m2 - n2 and 2mn are also coprime.
2. Write and prove the general formula for the number of different representations of a given integer n as the sum of two squares. (Representatives that are not obtained from each other by changing signs and the order of the terms are considered different.)
3. Based on the obtained formula, derive the lower bound for the maximum number of equal distances among the given n points on the plane using a regular rectangular lattice.
4. Build a regular pentagon using a compass and a ruler.
5. Build a regular 15-gon using a compass and a ruler.
6. You are given a single segment. It is required to construct using a compass and a ruler a segment of length x satisfying the equation
7. Based on the previous task, prove that a regular heptagon cannot be built using a compass and a ruler.
8. Prove that trisection of the angle is impossible.
9. Describe all possible combinations of the amounts of black and white balls in the ballot box, so that if two balls are randomly fished in a sample without returning, the probability of fishing two white balls is exactly 0.5.
10. Consider the relation on the sides a, b, c of the triangle, in which a triangle with vertices at the bases of the bisectors is isosceles. Assuming that the sides converging on side c of the large triangle are equal, reduce this relation to the following
11. In what follows, we consider the cube defined by the first of the three equations (refusing the requirement that a, b, c be sides of a triangle). Show that the resulting cube is indecomposable, that is, the polynomial that defines it does not factor.
12. In addition to this, show that our cube is nonsingular, that is, there is not a single point on its projectivization at which each direction is tangent (or the same thing at which all three first partial derivatives of the polynomial defining it degenerate).

Exam ticket examples

Ticket number 1

1. Write and prove the general formula for the number of different representations of a given integer n as the sum of two squares.
2. Prove that trisection of the angle is impossible.

Ticket number 2

1. Consider the relationship on the sides a, b, c of the triangle, in which a triangle with vertices at the bases of the bisectors is isosceles.
2. Describe all kinds of combinations of the numbers of black and white balls in the ballot box, so that if two balls are randomly fished in the sample without returning, the probability of fishing two white balls is exactly 0.5.

Assessment “excellent (10)” is given to a student who has displayed comprehensive, systematic and deep knowledge of the educational program material, has independently performed all the tasks stipulated by the program, has deeply studied the basic and additional literature recommended by the program, has been actively working in the classroom, and understands the basic scientific concepts on studied discipline, who showed creativity and scientific approach in understanding and presenting educational program material, whose answer is characterized by using rich and adequate terms, and by the consistent and logical presentation of the material;

Assessment “excellent (9)” is given to a student who has displayed comprehensive, systematic knowledge of the educational program material, has independently performed all the tasks provided by the program, has deeply mastered the basic literature and is familiar with the additional literature recommended by the program, has been actively working in the classroom, has shown the systematic nature of knowledge on discipline sufficient for further study, as well as the ability to amplify it on one’s own, whose answer is distinguished by the accuracy of the terms used, and the presentation of the material in it is consistent and logical;

Assessment “excellent (8)” is given to a student who has displayed complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently performed all the tasks stipulated by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (7)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in the answer, has independently performed all the tasks provided by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (6)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently carried out the main tasks stipulated by the program, studied the basic literature recommended by the program, showed systematic character of his knowledge of the discipline, which is sufficient for further study;

Assessment “good (5)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, mastered the basic literature recommended by the program, made some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors by himself;

Assessment “satisfactory (4)” is given to a student who has discovered knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, learned the main literature but allowed some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors under the guidance of a teacher;

Assessment “satisfactory (3)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, not showed activity in the classroom, independently fulfilled the main tasks envisaged by the program, but allowed errors in their implementation and in the answer during the test, but possessing necessary knowledge for elimination under the guidance of the teacher of the most essential errors;

Assessment “unsatisfactory (2)” is given to a student who showed gaps in knowledge or lack of knowledge on a significant part of the basic educational program material, who has not performed independently the main tasks demanded by the program, made fundamental errors in the fulfillment of the tasks stipulated by the program, who is not able to continue his studies or start professional activities without additional training in the discipline in question;

Assessment “unsatisfactory (1)” is given to a student when there is no answer (refusal to answer), or when the submitted answer does not correspond at all to the essence of the questions contained in the task.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

During examination the student are allowed to use the program of the discipline.