Syllabus

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Title of the course: Adaptation course in discrete mathematics
Prerequisites: basic school-math knowledge
Course Type: elective course

The course topics follow those of the Data Science and Business Analytics' basic course but will also prove useful for Applied Mathematics and Informatics and Software Engineering students as well. The course is student oriented. It includes many problems from the very simple ones to the most intriguing.

Learning Objectives:

- To help our students follow the material of the Discrete Mathematics course by discussing its most important and challenging topics
- To teach our students the correct treatment of mathematical proof and mathematical definitions as well as the right logical reasoning behind proving statements and solving problems.

Learning Outcomes

- To master basic concepts and methods of Discrete Mathematics as far as these are necessary for studying more advanced courses and for the future professional life.
- To develop skills in formalizing and solving applied problems using the methods of Discrete Mathematics.

Course Plan:

1. Set theory. Operations with sets. Cardinality. Properties of operations with cardinalities. Countable and Uncountable Sets. The **inclusion–exclusion principle** for the cardinality of sets. How to prove the equivalence of sets?

2. Statements. Conditional Statements. Logical Equivalence.

3. Functions. Injections, surjections, bijections. Composition. Inverse functions. Relations of equivalence and order.

4. Type of proofs: mathematical induction, recursion, proof by counterexample, existence proofs.

5. Graphs. Types of graphs and their applications. Cycles. Spanning thee.

6. An Introduction to Probability Theory. Sample Space, Outcomes, Events, Probability. Random Variables and their Distributions. Conditional Probability and Independence. Expectation of a Random Variable. Variance, Standard Deviation, Chebyshev's Inequality. Law of Large Numbers. Central Limit Theorem.

7. Elementary generating functions. Generating functions of several variables. Pascal's triangle.

8. Computational theory. Divisibility and modular arithmetic. The Chinese remainder theorem. Euclid's algorithm. Applications of the theory of numbers. Diophantine equations. Fundamental theorem of arithmetic.

9. Decision trees. Method of proof for lower bounds. Boolean circuits and formulas. Basis and functionally complete basis.

Grading System

Final grade = mean (HW1, HW2, HW3, HW4, HW5)

Reading List

Required:

1. L. Lovasz, K. Vesztergombi. Discrete Mathematics. Lecture Notes, Yale University, 1999. http://www.cs.elte.hu/~lovasz/dmbook.ps

2. J. Anderson. Discrete Mathematics With Combinatroics. Prentice Hall; 2 edition 2003

3. Shen. Mathematical induction (C1) 3rd ed., Moscow: MCCME, 2007, 32 p. http://www.mccme.ru/free-books/shen/shen-induction.pdf (in Russian)

4. N. K. Vereshchagin, A. Shen. Introduction to the set theory. 4th ed., Moscow: MCCME, 2012, 112 c. http://www.mccme.ru/free-books/shen/shen-logicpart1-2.pdf (in Russian)

Optional:

5. R. Hammack. Book of Proof, Virginia Commonwealth University 2013, https://www.people.vcu.edu/~rhammack/BookOfProof/BookOfProof.pdf

6. Lando S.K. Introduction to discrete mathematics. MCNMO, 2012. - 272 p.

7. Gavrilov G.P., Sapozhenko A.A. Tasks and exercises in discrete mathematics: Textbook. manual for universities –M .: Fizmatlit, 2006.

8. Lando S.K. Lectures on generating functions. - Ed. 3-e.– M .: МЦНМО, 2007.

9. Harari F. Graph theory. – M .: URSS, 2003.

10. Donald Knuth, Ronald Graham, Oren Patashnik. Concrete math. Grounds of computer science. – M.: World; Binomial. Laboratory of Knowledge, 2006.

Methods of Instruction

Seminars.

Special Equipment and Software Support (if required)

None are required.