

Discrete Structure and Combinatorics

מבנים בדידים וקומבינטוריקה

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- **Course number** : 20211061
- **Mandatory**
- **Credits** : 5
- **Course Site**: <http://www.cs.bgu.ac.il/~dsc192>
- **Prerequisites**:
 - 201.1.0201 Introduction to Logic and Set Theory

Course Objectives

The main objectives of the course are

- To introduce topics and techniques of discrete methods and combinatorial analysis.
- To introduce a large variety of applications and, through some of them, the algorithmic approach to the solution of problems.
- To develop mathematical maturity.
- To present a survey of essential topics for computer science students who will encounter some of them again in more advanced courses.

Course Requirements

1. 30 x 2-hour lectures
2. 15 x 2-hour exercise sessions
3. 8 theoretical homework assignments (about 6-8 hours per assignment); submission in pairs
4. 7 online quizzes
5. Midterm exam
6. Final exam

The weight of the homework assignments is 8%. The grade for the homework assignments component is the average of the 5 highest grades among the grades for assignments 1-7. The weight of the online quizzes is 2%.

The weight of the midterm exam is 20%.

The weight of the final exam is 70%. A grade of at least 56 in the final exam is a necessary condition for passing the course.

Detailed Syllabus

Combinatorics

1. The rules of sum and product
2. The pigeon-hole principal (increasing/decreasing monotone sequence)
3. Basic counting problems (selection with/without repetitions, when the order is relevant or not, multisets, permutations)
4. The binomial coefficients (the binomial theorem, algebraic vs. combinatorial proof, Pascal's identity, Pascal's triangle, Catalan numbers)
5. Multinomial coefficients
6. The principle of inclusion and exclusion

Recurrences

1. Fibonacci numbers
2. The substitution method
3. Linear recurrences (mostly homogenous recurrences, the characteristic polynomial/equation)

Introduction to Graph Theory

1. Basic terms (directed/undirected graph, degree, path, cycle, metric, connectivity, connected components, subgraph)
2. Family of graphs (clique, independent set, regular graph, bipartite graph, tree, spanning tree)
3. Planar graphs
4. Graph coloring (mostly coloring of planar graphs)
5. Paths/tours (Euler path/tour, Hamiltonian cycle, the travelling salesperson problem)
6. Extremal graph theory (Ramsey, Turan)
7. Matchings in graphs.

Discrete Probability – An Introduction

1. Discrete probability spaces (sample space, uniform distribution, event, independent events, principal of inclusion and exclusion, complement event)
2. Independence and conditional probability
3. Random variable, expectation
4. Distribution of a random variable
5. Variance, Markov and Chebyshev inequalities
6. Applications of probability in combinatorics (the birthday paradox, the probabilistic method – a lower bound for Ramsey numbers)

References

Textbooks

- מתמטיקה בדידה, נתי ליניאל ומיכל פרנס, נ. בן-צבי מפעלי דפוס בע"מ, מהדורה שניה, 2005.
- **Discrete and combinatorial mathematics: An applied introduction**, Ralph P. Grimaldi, Pearson, 5th Edition, 2004.