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**Department of Software and Informatics Engineering**

**College of Engineering**

**University of Salahaddin-Erbil**

**Subject: Combinatorics and Graph Theory**

**Course Book: Second Year Students (First (Fall) Semester)**

**Lecturer's name: Lecturer Salar Jamal Atroshi**

**Academic Year: 2022-2023**

**Course Book**

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| **Course name** | **Combinatorics and Graph Theory** |
| **Lecturer in charge** | **Lecturer Salar Jamal Atroshi** |
| **Department/ College** | **Software and Informatics Engineering/ College of Engineering** |
| **Contact** | **Official E-mail:** **salar.atroshi@su.edu.krd****Personal E-mail:** **salar\_atroshi@yahoo.com** |
| **Time (in hours) per week**  | **Theory: 4 hours/week**  |
| **Office hours** | **Daily from 8:30 till 2:30 except the time of lectures.** |
| **Course code** | **SIE5136** |
| **Teacher's academic profile**  | I am working at Salahaddin University-Erbil/ College of Engineering /Software and Informatics Engineering Department as an academic staff member since 2003 till now. During these years I taught the students many subjects from different stages. Depending of my experience I think the criteria of a good instructor (lecturer) must include the ability to communicate with the students to know more details about them, because sometimes there are some students suffering from either economic problems or social problems which may lead to Psychological effects. Also I try to use the modern teaching tools to deliver the knowledge to the students. Finally, I believe that the Successful scientific march will be done, if there is cooperation between the lecturers and the students.  |
|  **Course overview:** This course examines classical and modern developments in graph theory and additive combinatorics, with a focus on topics and themes that connect the two subjects, the course also introduces students to current research topics and open problems. The course covers Graphs and Their Relatives, Special Types of Graphs, Graphs and Matrices, Graph Models and Distance, Properties of Trees, Spanning Trees, Counting Trees, Trails, Circuits, Paths, Cycles, Planarity, Colorings, Matchings, Ramsey Theory, Combinatorics. |
| **Course objective:**Our objectives of this course are: * To fill the gaps in modern problems of Discrete structures.
* To learn practical problem-solving skills, which can be later applied in algorithmic theory.
* To develop fundamental knowledge of combinatorics and complexity.
* To develop practical skills needed in modern logic.
* To give practical knowledge, which is needed in many courses theoretical informatics.
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| **Student's obligation****Attendance****Quizzes****Reports****Assignments** |
| **Forms of teaching**In the classroom, we will try the best to explain carefully the theoretical conceptual aspects of the subject, usually assuming that the students are familiar with a set of basic concepts on which the new material is based.After that, some more lecturing time is devoted to showing, with as much detail as possible, the solution to the selected problems or exercises. In addition, I am available during some scheduled office hours to assist students with their personal work.  |
|  **Assessment scheme**The following grade system is used for the evaluation of the module/course exam: The module/course exam is based on the summation of two categories of evaluations:**First: (40%)** of the mark is based on the academic semester effort which includes: -           Three examinations during the academic semester = 24%.-           Assignments = (6%).- Report and Seminar = (10%).**Second: (60%)** of the mark is based on final examination that is comprehensive for the whole of the study materials reviewed during the academic semester. |
| **Student learning outcome:**At the end of this course, students will be able to:* Define graph theoretic concepts, state and prove their properties.
* Describe graph theoretic algorithms and prove their correctness.
* Formulate problems in terms of graphs and apply the theorems and algorithms taught in the course to solve them.
* Define the various types of generating functions.
* State and prove the basic properties of generating functions.
* Use generating functions to solve a variety of combinatorial problems.
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| **Course Reading List and References‌:**1. “Combinatorics and Graph Theory 2nd Edition”, John M. Harris, Jeffry L. Hirst and Michael J. Mossinghoff, 2008.
2. “50 years of Combinatorics, Graph Theory, and Computing”,  [Fan Chung](https://www.routledge.com/search?author=Fan%20Chung), [Ron Graham](https://www.routledge.com/search?author=Ron%20Graham), [Frederick Hoffman](https://www.routledge.com/search?author=Frederick%20Hoffman), [Ronald C. Mullin](https://www.routledge.com/search?author=Ronald%20C.%20Mullin), [Leslie Hogben](https://www.routledge.com/search?author=Leslie%20Hogben) and [Douglas B. West](https://www.routledge.com/search?author=Douglas%20B.%20West), 2020.
3. “Introduction to Combinatorics, 2nd Edition”, [Martin J. Erickson](https://www.wiley.com/en-us/search?pq=%7Crelevance%7Cauthor%3AMartin+J.+Erickson), 2013.
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|  **The Topics:**

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| **Weeks** | **Descriptions** |
| Week 1 | Introduction |
| Weeks (2-3) | Concepts of graph theory |
| Week 4 | Graph representation |
| Week 5 | Planar graph |
| Weeks (6-7) | Spanning trees  |
| Week 8 | Counting Trees |
| Week 9 | Graph coloring |
| Week 10 | Matching in a graph |
| Weeks (11-12) | Principles of Combinatorics  |
| Week 12 | Binomial coefficients and Multinomial coefficients |
| Week 13 | The principle of inclusion and exclusion  |
| Weeks (14-15) | Generating Functions |

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| **Examinations:**Q1: From the Graph below:  ca b  1. Find the Order and the Size of the Graph.
2. Find Degree of the vertices a, b, c.

Solution:1. The Order of the Graph= 3

The Size of the Graph=61. The Degree of the a can be calculated by:

In degree of a=2Out degree of a=4The Total degree of a=6The Degree of the b can be calculated by:In degree of b=1Out degree of b=1The Total degree of b=2The Degree of the c can be calculated by:In degree of c=3Out degree of c=1The Total degree of c=4Q2: Count types of sequential representation.Solution:* Adjacency Matrix Representation.
* Incidence Matrix Representation.
* Circuit Matrix Representation.
* Cut Set Matrix Representation.
* Path Matrix Representation.

Q3: Represent the graph below using adjacency matrix:Solution:Q4: Find the minimum cost of the following spanning tree:  Solution: The minimum cost of the spanning tree is:  |