Combinatorics

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Yufei Zhao

yufeiz@mit.edu

A Taste of Algebraic Combinatorics

Problem: (St. Petersburg) Students in a school go for ice cream in groups of at least two. After $k > 1$ groups have gone, every two students have gone together exactly once. Prove that the number of students in the school is at most k.

Solution. Let there be n students. Note if some student went for ice cream only once, then everyone else has to have gone with that student, due to the constraint that every pair of student have gone together exactly once. Furthermore, since each group consists of two students, no other groups can be formed. However, $k > 1$, so this situation cannot occur. Therefore, every student went for ice cream at least twice.

Let us construct **incidence vectors** $\mathbf{v}_i \in \mathbb{R}^k, 1 \leq i \leq n$, representing the students. That is, the j-th component of $\mathbf{v}_i$ is 1 if student i went with the j-th group, and 0 otherwise.

The condition that every two students have gone together exactly once translates into the dot product $\mathbf{v}_i \cdot \mathbf{v}_j = 1$ for $i \neq j$. The condition that every student went for ice cream at least twice translates into $|\mathbf{v}_i|^2 \geq 2$.

We want to prove that $n \leq k$. Suppose otherwise. Then $\{\mathbf{v}_1, \ldots, \mathbf{v}_n\}$ consists of at least $k + 1$ vectors in $\mathbb{R}^k$, so they must be linearly dependent. It follows that there are real numbers $\alpha_1, \ldots, \alpha_n$, not all zero, such that

$$\alpha_1 \mathbf{v}_1 + \cdots + \alpha_n \mathbf{v}_n = 0.$$

Let us square the above expression (i.e., taking the dot product with itself). We get

$$0 = \sum_{i=1}^{n} \alpha_i^2 |\mathbf{v}_i|^2 + 2\sum_{i<j} \alpha_i \alpha_j \mathbf{v}_i \cdot \mathbf{v}_j = \sum_{i=1}^{n} \alpha_i^2 |\mathbf{v}_i|^2 + 2\sum_{i<j} \alpha_i \alpha_j = \sum_{i=1}^{n} \alpha_i^2 \left(|v_i|^2 - 1\right) + \left(\sum_{i=1}^{n} \alpha_i\right)^2.$$

However, the RHS expression is positive, since $|\mathbf{v}_i|^2 \geq 2$ and some α_i is nonzero. Contradiction. □

If you know a little bit of linear algebra, try the following problem.

1. (Crux 3037) There are 2007 senators in a senate. Each senator has enemies within the senate. Prove that there is a non-empty subset K of senators such that for every senator in the senate, the number of enemies of that senator in the set K is an even number.

Poset Quickies

Definition. A *partially ordered set* (or *poset* for short) P is a set, also denoted P, together with a binary relation denoted $\leq$ satisfying the following axioms:

[Combinatorics Problems And Solutions](#)

Robert Geretschlager

Combinatorics Problems And Solutions:

Combinatorics Problems and Solutions J Richard Hollos,Stefan Hollos,2024-04-20 This book will help you learn combinatorics in the most effective way possible through problem solving It contains 263 combinatorics problems with detailed solutions Combinatorics is the part of mathematics that involves counting It is therefore an essential part of anyone s mathematical toolkit The applications of combinatorics include probability cryptography error correcting games music and visual art In this new edition we have expanded the introductory section by more than twice the original size and the number of problems has grown by over 30% There are new sections on the pigeon hole principle and integer partitions with accompanying problems Many of the new problems are application oriented There are also new combinatorial geometry problems Someone with no prior exposure to combinatorics will find enough introductory material to quickly get a grasp of what combinatorics is all about and acquire the confidence to start tackling problems   **Problems & Solutions in Theoretical & Mathematical Physics: Introductory level** W.-H. Steeb,2003 This book is a collection of problems with detailed solutions which will prove valuable to students and research workers in mathematics physics engineering and other sciences The topics range in difficulty from elementary to advanced level Almost all the problems are solved in detail and most of them are self contained All relevant definitions are given Students can learn important principles and strategies required for problem solving Teachers will find this text useful as a supplement since important concepts and techniques are developed through the problems The material has been tested in the author s lectures given around the world The book is divided into two volumes Volume I presents the introductory problems for undergraduate and advanced undergraduate students In Volume II the more advanced problems together with detailed solutions are collected to meet the needs of graduate students and researchers The problems included cover most of the new fields in theoretical and mathematical physics such as Lax representation Backlund transformation soliton equations Lie algebra valued differential forms the Hirota technique the Painleve test the Bethe ansatz the Yang Baxter relation chaos fractals complexity etc

Combinatorial Problems and Exercises László Lovász,2007 The main purpose of this book is to provide help in learning existing techniques in combinatorics The most effective way of learning such techniques is to solve exercises and problems This book presents all the material in the form of problems and series of problems apart from some general comments at the beginning of each chapter In the second part a hint is given for each exercise which contains the main idea necessary for the solution but allows the reader to practice theechniques by completing the proof In the third part a full solution is provided for each problem This book will be useful to those students who intend to start research in graph theory combinatorics or their applications and for those researchers who feel that combinatorial techniques mightelp them with their work in other branches of mathematics computer science management science electrical engineering and so on For background only the elements of linear algebra group theory probability and calculus are needed   Combinatorics II

<u>Problems and Solutions</u> Stefan Hollos,J. Richard Hollos,2016-11-01 This book deals mainly with pattern counting problems It is a continuation of our previous combinatorics problem book There are 80 problems with detailed solutions including 70 figures many of which are examples of patterns The book will teach you powerful methods for counting patterns These methods should be in the toolbox of every combinatorialist It also provides the means to generate patterns with programs that can be downloaded from the book s web page at abrazol com The book starts with patterns that can be described by regular expressions and finite automata It shows how to get generating functions for families of patterns from a regular expression or it s corresponding finite automaton It then looks at pattern counting problems that involve equivalence under symmetry For example how many unique necklaces can one construct using beads of 3 different colors if a rotated necklace is considered the same as the original These problems are surprisingly easy to answer using a method called Polya s theory of counting This method and its more general form called Burnside s theorem are covered There are many worked out problems that show how to use these methods Included are problems that find the number of unique ways to color the Platonic solids   <u>Combinatorics Problems and Solutions</u> Stefan Hollos,J. Richard Hollos,2013-02-14 Introduction Problems Exercises   *The Discrete Math Workbook* Sergei Kurgalin,Sergei Borzunov,2020-08-12 This practically focused study guide introduces the fundamentals of discrete mathematics through an extensive set of classroom tested problems Each chapter presents a concise introduction to the relevant theory followed by a detailed account of common challenges and methods for overcoming these The reader is then encouraged to practice solving such problems for themselves by tackling a varied selection of questions and assignments of different levels of complexity This updated second edition now covers the design and analysis of algorithms using Python and features more than 50 new problems complete with solutions Topics and features provides a substantial collection of problems and examples of varying levels of difficulty suitable for both laboratory practical training and self study offers detailed solutions to each problem applying commonly used methods and computational schemes introduces the fundamentals of mathematical logic the theory of algorithms Boolean algebra graph theory sets relations functions and combinatorics presents more advanced material on the design and analysis of algorithms including Turing machines asymptotic analysis and parallel algorithms includes reference lists of trigonometric and finite summation formulae in an appendix together with basic rules for differential and integral calculus This hands on workbook is an invaluable resource for undergraduate students of computer science informatics and electronic engineering Suitable for use in a one or two semester course on discrete mathematics the text emphasizes the skills required to develop and implement an algorithm in a specific programming language   **Teaching Mathematics in Grades 6 - 12** Randall E. Groth,2012-08-10 A journey into the vibrant and intriguing world of mathematics education Teaching Mathematics in Grades 6 12 explores how research in mathematics education can inform teaching practice in grades 6 12 The author shows secondary mathematics teachers the value of being a researcher in the classroom by constantly experimenting with methods

for developing students mathematical thinking and then connecting this research to practices that enhance students understanding of the material The chapters in Part I introduce secondary teachers to the field of mathematics education with cross cutting issues that apply to teaching and learning in all mathematics content areas The chapters in Part II are devoted to specific mathematics content strands and describe how students think about mathematical concepts The goal of the text is to have secondary math teachers gain a deeper understanding of the types of mathematical knowledge their students bring to grade 6 12 classrooms and how students thinking may develop in response to different teaching strategies **Fuzzy Learning and Applications** Marco Russo,Lakhmi C. Jain,2024-04-26 With low computational complexity and relatively short development time Fuzzy Logic is an indispensable tool for engineering applications The field is growing at an unprecedented rate and there is a need for a book that describes essential tools applications examples and perspectives in the field of fuzzy learning The editors of Fuzzy Learni **Theory and Problems of Combinatorics** C. Vasudev,2005 Combinatorics Is The Mathematics Of Counting Selecting And Arranging Objects Combinatorics Include The Theory Of Permutations And Combinations These Topics Have An Enormous Range Of Applications In Pure And Applied Mathematics And Computer Science These Are Processes By Which We Organize Sets So That We Can Interpret And Apply The Data They Contain Generally Speaking Combinatorial Questions Ask Whether A Subset Of A Given Set Can Be Chosen And Arranged In A Way That Conforms With Certain Constraints And If So In How Many Ways It Can Be Done Applications Of Combinatorics Play A Major Role In The Analysis Of Algorithms For Example It Is Often Necessary In Such Analysis To Count The Average Number Of Times That A Particular Portion Of An Algorithm Is Executed Over All Possible Data Sets This Topic Also Includes Solution Of Difference Equations Differences Are Required For Analysis Of Algorithmic Complexity And Since Computers Are Frequently Used In The Numerical Solution Of Differential Equations Via Their Discretized Versions Which Are Difference Equations It Also Deals With Questions About Configurations Of Sets Families Of Finite Sets That Overlap According To Some Prescribed Numerical Or Geometrical Conditions Skill In Using Combinatorial Techniques Is Needed In Almost Every Discipline Where Mathematics Is Applied Salient Features Over 1000 Problems Are Used To Illustrate Concepts Related To Different Topics And Introduce Applications Over 1000 Exercises In The Text With Many Different Types Of Questions Posed Precise Mathematical Language Is Used Without Excessive Formalism And Abstraction Precise Mathematical Language Is Used Without Excessive Formalism And Abstraction Problem Sets Are Started Clearly And Unambiguously And All Are Carefully Graded For Various Levels Of Difficulty **Problem Solving in School Mathematics** ,1980 **Basic Discrete Mathematics: Logic, Set Theory, And Probability** Richard Kohar,2016-06-15 This lively introductory text exposes the student in the humanities to the world of discrete mathematics A problem solving based approach grounded in the ideas of George P lya are at the heart of this book Students learn to handle and solve new problems on their own A straightforward clear writing style and well crafted examples with diagrams invite the students to develop into precise and critical thinkers

Particular attention has been given to the material that some students find challenging such as proofs This book illustrates how to spot invalid arguments to enumerate possibilities and to construct probabilities It also presents case studies to students about the possible detrimental effects of ignoring these basic principles The book is invaluable for a discrete and finite mathematics course at the freshman undergraduate level or for self study since there are full solutions to the exercises in an appendix Written with clarity humor and relevant real world examples Basic Discrete Mathematics is a wonderful introduction to discrete mathematical reasoning Arthur Benjamin Professor of Mathematics at Harvey Mudd College and author of The Magic of Math   Instructor's Solutions Manual Bradley W. Jackson,1990   **Informatics in Schools. Fundamentals of Computer Science and Software Engineering** Sergei N. Pozdniakov,Valentina Dagienė,2018-10-10 This book constitutes the proceedings of the 11th International Conference on Informatics in Schools Situation Evolution and Perspectives ISSEP 2018 held in St Petersburg Russia in October 2018 The 29 full papers presented in this volume were carefully reviewed and selected from 74 submissions They were organized in topical sections named role of programming and algorithmics in informatics for pupils of all ages national concepts of teaching informatics teacher education in informatics contests and competitions in informatics socio psychological aspects of teaching informatics and computer tools in teaching and studying informatics   **Engaging Young Students In Mathematics Through Competitions - World Perspectives And Practices: Volume Ii - Mathematics Competitions And How They Relate To Research, Teaching And Motivation** Robert Geretschlager,2020-04-15 The two volumes of Engaging Young Students in Mathematics through Competitions present a wide scope of aspects relating to mathematics competitions and their meaning in the world of mathematical research teaching and entertainment Volume II contains background information on connections between the mathematics of competitions and the organization of such competitions their interplay with research teaching and more It will be of interest to anyone involved with mathematics competitions at any level be they researchers competition participants teachers or theoretical educators The various chapters were written by the participants of the 8th Congress of the World Federation of National Mathematics Competitions in Austria in 2018   **On Students' Conceptualizations of Combinatories** Christopher Eugene Smith,2007   *Mathematical Olympiads' Correspondence Program (1995-96)* Edward Barbeau,Bruce Shawyer,Peter Ivan Booth,John Grant McLoughlin,Canadian Mathematical Society,1997   **Discrete Mathematics Across the Curriculum, K-12** Margaret J. Kenney,Christian R. Hirsch,1991 Discrete mathematics is the branch of mathematics that deals with arrangements of distinct objects It includes a wide variety of topics and techniques that arise in everyday life such as how to find the best route from one city to another where the objects are cities arranged on a map It also includes how to count the number of different combinations of toppings for pizzas how best to schedule a list of tasks to be done and how computers store and retrieve arrangements of information on a screen   **Linear Programming in Single- & Multiple-objective Systems** James P. Ignizio,1982   McGraw-Hill's GMAT James Hasik,Stacey

Rudnick,Ryan Hackney,2006-04-01 IF YOU WANT a Fast more efficient prep for the new GMAT b Secret strategies of test prep professionals c Ways to score in the high 600s or better d Addmission to a top ranked business school e All of the above THEN YOU NEED McGRAW HILL S GMAT Before you apply to today s top business schools you need to develop a solid set of strategies that will raise your GMAT score and your chances for success This all in one guide from the nation s leading test preparation experts covers the full range of subjects you ll encounter on the GMAT including math syntax and logic with a special emphasis on the crucial quantitative questions You ll learn how the new computerized exams are administered and scored and get the preparation tools test taking techniques and high scoring secrets of professional tutors Unique features to suite every student s needs include 6 complete sample exams with fully explained answers In depth coverage of the most important quantitative subjects analytical writing and verbal skills Specialized training for the toughest questions such as combinatorics Boolean mathematics and parallel reasoning Invaluable advice on the rest of the admissions process from preparing a winning application to getting into the very best schools   Cahiers de Linguistique Théorique Et Appliquée ,1983

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