

## 3

## Determinants

## 3.1 SOLUTIONS

**Notes:** Some exercises in this section provide practice in computing determinants, while others allow the student to discover the properties of determinants which will be studied in the next section. Determinants are developed through the cofactor expansion, which is given in Theorem 1. Exercises 33–36 in this section provide the first step in the inductive proof of Theorem 3 in the next section.

1. Expanding along the first row:

$$\begin{vmatrix} 3 & 0 & 4 \\ 2 & 3 & 2 \\ 0 & 5 & -1 \end{vmatrix} = 3 \begin{vmatrix} 3 & 2 \\ 5 & -1 \end{vmatrix} - 0 \begin{vmatrix} 2 & 2 \\ 0 & -1 \end{vmatrix} + 4 \begin{vmatrix} 2 & 3 \\ 0 & 5 \end{vmatrix} = 3(-13) + 4(10) = 1$$

Expanding along the second column:

$$\begin{vmatrix} 3 & 0 & 4 \\ 2 & 3 & 2 \\ 0 & 5 & -1 \end{vmatrix} = (-1)^{1+2} \cdot 0 \begin{vmatrix} 2 & 2 \\ 0 & -1 \end{vmatrix} + (-1)^{2+2} \cdot 3 \begin{vmatrix} 3 & 4 \\ 0 & -1 \end{vmatrix} + (-1)^{3+2} \cdot 5 \begin{vmatrix} 3 & 4 \\ 2 & 2 \end{vmatrix} = 3(-3) - 5(-2) = 1$$

2. Expanding along the first row:

$$\begin{vmatrix} 0 & 5 & 1 \\ 4 & -3 & 0 \\ 2 & 4 & 1 \end{vmatrix} = 0 \begin{vmatrix} -3 & 0 \\ 4 & 1 \end{vmatrix} - 5 \begin{vmatrix} 4 & 0 \\ 2 & 1 \end{vmatrix} + 1 \begin{vmatrix} 4 & -3 \\ 2 & 4 \end{vmatrix} = -5(4) + 1(22) = 2$$

Expanding along the second column:

$$\begin{vmatrix} 0 & 5 & 1 \\ 4 & -3 & 0 \\ 2 & 4 & 1 \end{vmatrix} = (-1)^{1+2} \cdot 5 \begin{vmatrix} 4 & 0 \\ 2 & 1 \end{vmatrix} + (-1)^{2+2} \cdot (-3) \begin{vmatrix} 0 & 1 \\ 2 & 1 \end{vmatrix} + (-1)^{3+2} \cdot 4 \begin{vmatrix} 0 & 1 \\ 4 & 0 \end{vmatrix} = -5(4) - 3(-2) - 4(-4) = 2$$

3. Expanding along the first row:

$$\begin{vmatrix} 2 & -4 & 3 \\ 3 & 1 & 2 \\ 1 & 4 & -1 \end{vmatrix} = 2 \begin{vmatrix} 1 & 2 \\ 4 & -1 \end{vmatrix} - (-4) \begin{vmatrix} 3 & 2 \\ 1 & -1 \end{vmatrix} + 3 \begin{vmatrix} 3 & 1 \\ 1 & 4 \end{vmatrix} = 2(-9) + 4(-5) + (3)(11) = -5$$

# Linear Algebra 4th Edition Problem 20 Section 14

**Klaus Fritzsche, Hans Grauert**



## Linear Algebra 4th Edition Problem 20 Section 14:

Elementary Linear Algebra, Students Solutions Manual Stephen Andrilli, David Hecker, 2010-03-13 Elementary Linear Algebra Students Solutions Manual *Elementary Linear Algebra, Students Solutions Manual (e-only)* Stephen Andrilli, David Hecker, 2010-04-24 Combinatorial Convexity and Algebraic Geometry Günter Ewald, 2012-12-06 The aim of this book is to provide an introduction for students and nonspecialists to a fascinating relation between combinatorial geometry and algebraic geometry as it has developed during the last two decades This relation is known as the theory of toric varieties or sometimes as torus embeddings Chapters I IV provide a self contained introduction to the theory of convex polytopes and polyhedral sets and can be used independently of any applications to algebraic geometry Chapter V forms a link between the first and second part of the book Though its material belongs to combinatorial convexity its definitions and theorems are motivated by toric varieties Often they simply translate algebraic geometric facts into combinatorial language Chapters VI VIII introduce toric varieties in an elementary way but one which may not for specialists be the most elegant In considering toric varieties many of the general notions of algebraic geometry occur and they can be dealt with in a concrete way Therefore Part 2 of the book may also serve as an introduction to algebraic geometry and preparation for farther reaching texts about this field The prerequisites for both parts of the book are standard facts in linear algebra including some facts on rings and fields and calculus Assuming those all proofs in Chapters I VII are complete with one exception IV Theorem 5.1 In Chapter VIII we use a few additional prerequisites with references from appropriate texts **A Course in Arithmetic** J-P. Serre, 2012-12-06 This book is divided into two parts The first one is purely algebraic Its objective is the classification of quadratic forms over the field of rational numbers Hasse Minkowski theorem It is achieved in Chapter IV The first three chapters contain some preliminaries quadratic reciprocity law  $p$ -adic fields Hilbert symbols Chapter V applies the preceding results to integral quadratic forms of discriminant  $\neq 0$  These forms occur in various questions modular functions differential topology finite groups The second part Chapters VI and VII uses analytic methods holomorphic functions Chapter VI gives the proof of the theorem on arithmetic progressions due to Dirichlet this theorem is used at a critical point in the first part Chapter III no 2.2 Chapter VII deals with modular forms and in particular with theta functions Some of the quadratic forms of Chapter V reappear here The two parts correspond to lectures given in 1962 and 1964 to second year students at the Ecole Normale Supérieure A redaction of these lectures in the form of duplicated notes was made by J. J. Sansuc Chapters I IV and J. P. Ramis and G. Ruget Chapters VI VII They were very useful to me I extend here my gratitude to their authors *Theory of Complex Functions* Reinhold Remmert, 2012-12-06 A lively and vivid look at the material from function theory including the residue calculus supported by examples and practice exercises throughout There is also ample discussion of the historical evolution of the theory biographical sketches of important contributors and citations in the original language with their English translation from their classical works Yet the book is far from being a mere history of

function theory and even experts will find a few new or long forgotten gems here. Destined to accompany students making their way into this classical area of mathematics, the book offers quick access to the essential results for exam preparation. Teachers and interested mathematicians in finance industry and science will profit from reading this again and again and will refer back to it with pleasure.

*Compact Lie Groups* Mark R. Sepanski, 2007-04-05 Blending algebra, analysis and topology, the study of compact Lie groups is one of the most beautiful areas of mathematics and a key stepping stone to the theory of general Lie groups. Assuming no prior knowledge of Lie groups, this book covers the structure and representation theory of compact Lie groups. Included is the construction of the Spin groups, Schur Orthogonality, the Peter Weyl Theorem, the Plancherel Theorem, the Maximal Torus Theorem, the Commutator Theorem, the Weyl Integration and Character Formulas, the Highest Weight Classification, and the Borel-Weil Theorem. The necessary Lie algebra theory is also developed in the text with a streamlined approach focusing on linear Lie groups. Key Features are: Provides an approach that minimizes advanced prerequisites; Self-contained and systematic exposition requiring no previous exposure to Lie theory; Advances quickly to the Peter Weyl Theorem and its corresponding Fourier theory; Streamlined Lie algebra discussion reduces the differential geometry prerequisite and allows a more rapid transition to the classification and construction of representations; Exercises sprinkled throughout. This beginning graduate level text, aimed primarily at Lie Groups courses and related topics, assumes familiarity with elementary concepts from group theory, analysis, and manifold theory. Students, research mathematicians, and physicists interested in Lie theory will find this text very useful.

**Principles of Random Walk** Frank Spitzer, 2001 More than 100 pages of examples and problems illustrate and clarify the presentation. **BOOK JACKET**

**A Course in p-adic Analysis** Alain M. Robert, 2013-04-17 Kurt Hensel (1861-1941) discovered the p-adic numbers around the turn of the century. These exotic numbers, or so they appeared at first, are now well established in the mathematical world and used more and more by physicists as well. This book offers a self-contained presentation of basic p-adic analysis. The author is especially interested in the analytical topics in this field. Some of the features which are not treated in other introductory p-adic analysis texts are: topological models of p-adic spaces inside Euclidean space; a construction of spherically complete fields; a p-adic mean value theorem and some consequences; a special case of Hasse-Winkel's functional equation lemma; a remainder formula for the Mahler expansion; and most importantly, a treatment of analytic elements.

**The Arithmetic of Dynamical Systems** J.H. Silverman, 2010-05-05 This book is designed to provide a path for the reader into an amalgamation of two venerable areas of mathematics: Dynamical Systems and Number Theory. Many of the motivating theorems and conjectures in the new subject of Arithmetic Dynamics may be viewed as the transposition of classical results in the theory of Diophantine equations to the setting of discrete dynamical systems, especially to the iteration theory of maps on the projective line and other algebraic varieties. Although there is no precise dictionary connecting the two areas, the reader will gain a flavor of the correspondence from the following associations: Diophantine Equations, Dynamical Systems, rational and integral rational and

integral points on varieties points in orbits torsion points on periodic and preperiodic abelian varieties points of rational maps

There are a variety of topics covered in this volume but inevitably the choice reflects the author's tastes and interests. Many related areas that also fall under the heading of arithmetic or algebraic dynamics have been omitted in order to keep the book to a manageable length. A brief list of some of these omitted topics may be found in the introduction. Online Resources: The reader will find additional material, references, and errata at <http://www.math.brown.edu/~jhs/ADSHome.html>.

**Acknowledgments**

The author has consulted a great many sources in writing this book. Every attempt has been made to give proper attribution for all but the most standard results.

**Iteration of Rational Functions** Alan F. Beardon, 2000-09-27 This book focuses on complex analytic dynamics which dates from 1916 and is currently attracting considerable interest. The text provides a comprehensive, well-organized treatment of the foundations of the theory of iteration of rational functions of a complex variable. The coverage extends from early memoirs of Fatou and Julia to important recent results and methods of Sullivan and Shishikura. Many details of the proofs have not appeared in print before.

**Introduction to Elliptic Curves and Modular Forms** Neal I. Koblitz, 2012-12-06 This textbook covers the basic properties of elliptic curves and modular forms with emphasis on certain connections with number theory. The ancient congruent number problem is the central motivating example for most of the book. My purpose is to make the subject accessible to those who find it hard to read more advanced or more algebraically oriented treatments. At the same time I want to introduce topics which are at the forefront of current research. Down-to-earth examples are given in the text and exercises with the aim of making the material readable and interesting to mathematicians in fields far removed from the subject of the book. With numerous exercises and answers included, the textbook is also intended for graduate students who have completed the standard first-year courses in real and complex analysis and algebra. Such students would learn applications of techniques from those courses thereby solidifying their understanding of some basic tools used throughout mathematics. Graduate students wanting to work in number theory or algebraic geometry would get a motivational example-oriented introduction. In addition, advanced undergraduates could use the book for independent study projects, senior theses, and seminar work.

**Modular Functions and Dirichlet Series in Number Theory** Tom M. Apostol, 2012-12-06 This is the second volume of a 2-volume textbook which evolved from a course Mathematics 160 offered at the California Institute of Technology during the last 25 years. The second volume presupposes a background in number theory comparable to that provided in the first volume together with a knowledge of the basic concepts of complex analysis. Most of the present volume is devoted to elliptic functions and modular functions with some of their number-theoretic applications. Among the major topics treated are Rademacher's convergent series for the partition function, Lehner's congruences for the Fourier coefficients of the modular function  $j(\tau)$  and Hecke's theory of entire forms with multiplicative Fourier coefficients. The last chapter gives an account of Bohr's theory of equivalence of general Dirichlet series. Both volumes of this work emphasize classical aspects of a subject which in recent years has undergone a

great deal of modern development It is hoped that these volumes will help the nonspecialist become acquainted with an important and fascinating part of mathematics and at the same time will provide some of the background that belongs to the repertory of every specialist in the field This volume like the first is dedicated to the students who have taken this course and have gone on to make notable contributions to number theory and other parts of mathematics T M A January 1976 The first volume is in the Springer Verlag series Undergraduate Texts in Mathematics under the title Introduction to Analytic Number Theory

**Galois Theory** Jean-Pierre Escofier, 2000-12-21 This book offers the fundamentals of Galois Theory including a set of copious well chosen exercises that form an important part of the presentation The pace is gentle and incorporates interesting historical material including aspects on the life of Galois Computed examples recent developments and extensions of results into other related areas round out the presentation

**An Introduction to the Theory of Groups** Joseph J. Rotman, 2012-12-06 Anyone who has studied abstract algebra and linear algebra as an undergraduate can understand this book The first six chapters provide material for a first course while the rest of the book covers more advanced topics This revised edition retains the clarity of presentation that was the hallmark of the previous editions From the reviews Rotman has given us a very readable and valuable text and has shown us many beautiful vistas along his chosen route

**MATHEMATICAL REVIEWS**

**From Holomorphic Functions to Complex Manifolds** Klaus Fritzsche, Hans Grauert, 2012-12-06 The aim of this book is to give an understandable introduction to the theory of complex manifolds With very few exceptions we give complete proofs Many examples and figures along with quite a few exercises are included Our intent is to familiarize the reader with the most important branches and methods in complex analysis of several variables and to do this as simply as possible Therefore the abstract concepts involved with sheaves coherence and higher dimensional cohomology are avoided Only elementary methods such as power series holomorphic vector bundles and one dimensional co cycles are used Nevertheless deep results can be proved for example the Remmert Stein theorem for analytic sets finiteness theorems for spaces of cross sections in holomorphic vector bundles and the solution of the Levi problem The first chapter deals with holomorphic functions defined in open sub sets of the space  $\mathbb{C}^n$  Many of the well known properties of holomorphic functions of one variable such as the Cauchy integral formula or the maximum principle can be applied directly to obtain corresponding properties of holomorphic functions of several variables Furthermore certain properties of differentiable functions of several variables such as the implicit and inverse function theorems extend easily to holomorphic functions

Lectures on Discrete Geometry Jiri Matousek, 2013-12-01 Discrete geometry investigates combinatorial properties of configurations of geometric objects To a working mathematician or computer scientist it offers sophisticated results and techniques of great diversity and it is a foundation for fields such as computational geometry or combinatorial optimization This book is primarily a textbook introduction to various areas of discrete geometry In each area it explains several key results and methods in an accessible and concrete manner It also contains more advanced material in separate sections and

thus it can serve as a collection of surveys in several narrower subfields The main topics include basics on convex sets convex polytopes and hyperplane arrangements combinatorial complexity of geometric configurations intersection patterns and transversals of convex sets geometric Ramsey type results polyhedral combinatorics and high dimensional convexity and lastly embeddings of finite metric spaces into normed spaces Jiri Matousek is Professor of Computer Science at Charles University in Prague His research has contributed to several of the considered areas and to their algorithmic applications This is his third book

**A Basic Course in Algebraic Topology** William S. Massey, 1991-03-06 This textbook is intended for a course in algebraic topology at the beginning graduate level The main topics covered are the classification of compact 2 manifolds the fundamental group covering spaces singular homology theory and singular cohomology theory These topics are developed systematically avoiding all unnecessary definitions terminology and technical machinery The text consists of material from the first five chapters of the author's earlier book Algebraic Topology an Introduction GTM 56 together with almost all of his book Singular Homology Theory GTM 70 The material from the two earlier books has been substantially revised corrected and brought up to date

*Advanced Topics in the Arithmetic of Elliptic Curves* Joseph H. Silverman, 2013-12-01 In the introduction to the first volume of The Arithmetic of Elliptic Curves Springer Verlag 1986 I observed that the theory of elliptic curves is rich varied and amazingly vast and as a consequence many important topics had to be omitted I included a brief introduction to ten additional topics as an appendix to the first volume with the tacit understanding that eventually there might be a second volume containing the details You are now holding that second volume it turned out that even those ten topics would not fit Unfortunately into a single book so I was forced to make some choices The following material is covered in this book I Elliptic and modular functions for the full modular group II Elliptic curves with complex multiplication III Elliptic surfaces and specialization theorems IV Neron models Kodaira Neron classification of special fibers Tate's algorithm and Ogg's conductor discriminant formula V Tate's theory of  $q$  curves over  $p$  adic fields VI Neron's theory of canonical local height functions

A Classical Introduction to Modern Number Theory K. Ireland, M. Rosen, 2013-03-09 This book is a revised and greatly expanded version of our book Elements of Number Theory published in 1972 As with the first book the primary audience we envisage consists of upper level undergraduate mathematics majors and graduate students We have assumed some familiarity with the material in a standard undergraduate course in abstract algebra A large portion of Chapters 1-11 can be read even without such background with the aid of a small amount of supplementary reading The later chapters assume some knowledge of Galois theory and in Chapters 16 and 18 an acquaintance with the theory of complex variables is necessary Number theory is an ancient subject and its content is vast Any introductory book must of necessity make a very limited selection from the fascinating array of possible topics Our focus is on topics which point in the direction of algebraic number theory and arithmetic algebraic geometry By a careful selection of subject matter we have found it possible to exposit some rather advanced material without requiring very much

in the way of technical background Most of this material is classical in the sense that it was discovered during the nineteenth century and earlier but it is also modern because it is intimately related to important research going on at the present time

**Number Theory** Henri Cohen, 2008-12-17 This book deals with several aspects of what is now called explicit number theory The central theme is the solution of Diophantine equations i e equations or systems of polynomial equations which must be solved in integers rational numbers or more generally in algebraic numbers This theme in particular is the central motivation for the modern theory of arithmetic algebraic geometry In this text this is considered through three of its most basic aspects The local aspect global aspect and the third aspect is the theory of zeta and L functions This last aspect can be considered as a unifying theme for the whole subject



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