

LAY LINEAR ALGEBRA

LAY LINEAR ALGEBRA: A GENTLE INTRODUCTION TO THE FUNDAMENTALS

INTRODUCTION:

ARE YOU INTIMIDATED BY THE WORD "LINEAR ALGEBRA"? DO YOU ENVISION ENDLESS MATRICES AND CRYPTIC EQUATIONS? MANY FIND THE SUBJECT DAUNTING, BUT THE TRUTH IS, LINEAR ALGEBRA UNDERLIES MUCH OF THE MODERN WORLD – FROM COMPUTER GRAPHICS AND MACHINE LEARNING TO DATA ANALYSIS AND QUANTUM PHYSICS. THIS COMPREHENSIVE GUIDE OFFERS A "LAY" APPROACH TO LINEAR ALGEBRA, STRIPPING AWAY THE INTIMIDATING JARGON AND FOCUSING ON INTUITIVE UNDERSTANDING. WE'LL EXPLORE THE CORE CONCEPTS, PROVIDING CLEAR EXPLANATIONS AND PRACTICAL EXAMPLES TO MAKE LINEAR ALGEBRA ACCESSIBLE TO EVERYONE, REGARDLESS OF THEIR MATHEMATICAL BACKGROUND. PREPARE TO UNRAVEL THE BEAUTY AND POWER OF THIS FUNDAMENTAL FIELD!

1. VECTORS: THE BUILDING BLOCKS OF LINEAR ALGEBRA

LINEAR ALGEBRA FUNDAMENTALLY DEALS WITH VECTORS AND THEIR INTERACTIONS. FORGET THE ABSTRACT DEFINITIONS FOR A MOMENT; THINK OF A VECTOR AS A DIRECTED ARROW. IT POSSESSES BOTH MAGNITUDE (LENGTH) AND DIRECTION. WE CAN REPRESENT VECTORS GRAPHICALLY OR USING COORDINATES. FOR INSTANCE, A 2D VECTOR MIGHT BE REPRESENTED AS $(2, 3)$, INDICATING A DISPLACEMENT OF 2 UNITS HORIZONTALLY AND 3 UNITS VERTICALLY.

VECTOR OPERATIONS: WE CAN PERFORM VARIOUS OPERATIONS ON VECTORS, SUCH AS ADDITION (COMBINING DISPLACEMENTS) AND SCALAR MULTIPLICATION (SCALING THE LENGTH). THESE OPERATIONS ARE VISUALLY INTUITIVE AND CRUCIAL FOR UNDERSTANDING MORE COMPLEX CONCEPTS.

LINEAR COMBINATIONS: A LINEAR COMBINATION OF VECTORS INVOLVES MULTIPLYING EACH VECTOR BY A SCALAR AND THEN ADDING THE RESULTS. THIS SEEMINGLY SIMPLE OPERATION IS THE CORNERSTONE OF MANY LINEAR ALGEBRA CONCEPTS. IT ALLOWS US TO EXPRESS ONE VECTOR AS A COMBINATION OF OTHERS, REVEALING RELATIONSHIPS AND DEPENDENCIES.

VECTOR SPACES: A VECTOR SPACE IS A COLLECTION OF VECTORS THAT'S CLOSED UNDER VECTOR ADDITION AND SCALAR MULTIPLICATION. THIS MEANS IF YOU ADD ANY TWO VECTORS IN THE SPACE, THE RESULT IS ALSO IN THE SPACE, AND SIMILARLY FOR SCALAR MULTIPLICATION. THIS SEEMINGLY ABSTRACT CONCEPT PROVIDES A FRAMEWORK FOR ORGANIZING AND WORKING WITH VECTORS SYSTEMATICALLY.

2. MATRICES: ORGANIZING VECTORS AND TRANSFORMATIONS

MATRICES ARE RECTANGULAR ARRAYS OF NUMBERS THAT SERVE AS POWERFUL TOOLS FOR ORGANIZING AND MANIPULATING VECTORS. THINK OF A MATRIX AS A COLLECTION OF VECTORS STACKED TOGETHER. A 3×2 MATRIX, FOR INSTANCE, CONTAINS THREE 2-DIMENSIONAL VECTORS.

MATRIX OPERATIONS: LIKE VECTORS, MATRICES SUPPORT VARIOUS OPERATIONS, INCLUDING ADDITION, SUBTRACTION, AND MULTIPLICATION (WHICH IS NOT COMMUTATIVE, MEANING THE ORDER MATTERS). MATRIX MULTIPLICATION IS A POWERFUL OPERATION THAT REPRESENTS LINEAR TRANSFORMATIONS.

LINEAR TRANSFORMATIONS: A LINEAR TRANSFORMATION IS A FUNCTION THAT MAPS VECTORS FROM ONE VECTOR SPACE TO ANOTHER WHILE PRESERVING LINEAR COMBINATIONS. THIS IS WHERE MATRICES TRULY SHINE. MATRIX MULTIPLICATION EFFECTIVELY PERFORMS THESE TRANSFORMATIONS, ROTATING, SCALING, SHEARING, AND GENERALLY MANIPULATING VECTORS.

MATRIX INVERSES AND DETERMINANTS: THE INVERSE OF A MATRIX, IF IT EXISTS, "UNDOES" THE TRANSFORMATION REPRESENTED BY THE ORIGINAL MATRIX. THE DETERMINANT IS A SCALAR VALUE THAT INDICATES WHETHER A MATRIX IS INVERTIBLE (NON-SINGULAR) AND PROVIDES INFORMATION ABOUT THE TRANSFORMATION'S SCALING EFFECT.

3. SYSTEMS OF LINEAR EQUATIONS: SOLVING FOR UNKNOWNNS

A SYSTEM OF LINEAR EQUATIONS INVOLVES MULTIPLE EQUATIONS WITH MULTIPLE UNKNOWNNS. SOLVING SUCH SYSTEMS IS A CENTRAL PROBLEM IN LINEAR ALGEBRA. MATRICES PROVIDE A CONCISE AND EFFICIENT WAY TO REPRESENT AND SOLVE THESE

SYSTEMS.

AUGMENTED MATRICES AND ROW REDUCTION: AN AUGMENTED MATRIX COMBINES THE COEFFICIENT MATRIX AND THE CONSTANT VECTOR OF A SYSTEM OF EQUATIONS. ROW REDUCTION (GAUSSIAN ELIMINATION) IS AN ALGORITHMIC PROCESS TO SIMPLIFY THE AUGMENTED MATRIX, ULTIMATELY REVEALING THE SOLUTION TO THE SYSTEM.

SOLUTIONS AND THEIR INTERPRETATION: A SYSTEM OF LINEAR EQUATIONS CAN HAVE A UNIQUE SOLUTION, INFINITELY MANY SOLUTIONS, OR NO SOLUTION AT ALL. THE GEOMETRIC INTERPRETATION OF THESE POSSIBILITIES HELPS SOLIDIFY THE UNDERSTANDING.

APPLICATIONS: SYSTEMS OF LINEAR EQUATIONS APPEAR EVERYWHERE, FROM MODELING PHYSICAL SYSTEMS TO SOLVING OPTIMIZATION PROBLEMS IN ENGINEERING AND ECONOMICS.

4. EIGENVALUES AND EIGENVECTORS: UNDERSTANDING TRANSFORMATIONS

EIGENVALUES AND EIGENVECTORS ARE SPECIAL VALUES AND VECTORS ASSOCIATED WITH A SQUARE MATRIX. THEY REVEAL CRUCIAL INFORMATION ABOUT THE MATRIX'S TRANSFORMATION PROPERTIES.

EIGENVALUE EQUATION: AN EIGENVECTOR REMAINS POINTING IN THE SAME DIRECTION AFTER THE TRANSFORMATION, ONLY SCALED BY A FACTOR—THE EIGENVALUE. THIS EQUATION, OFTEN WRITTEN AS $Av = \lambda v$ (WHERE A IS THE MATRIX, v IS THE EIGENVECTOR, AND λ IS THE EIGENVALUE), IS FUNDAMENTAL.

APPLICATIONS OF EIGENVALUES AND EIGENVECTORS: EIGENVALUES AND EIGENVECTORS HAVE NUMEROUS APPLICATIONS, INCLUDING ANALYZING STABILITY IN DYNAMICAL SYSTEMS, PERFORMING PRINCIPAL COMPONENT ANALYSIS (PCA) IN DATA SCIENCE, AND UNDERSTANDING VIBRATIONS IN MECHANICAL STRUCTURES.

5. VECTOR SPACES AND SUBSPACES: ORGANIZING AND CLASSIFYING VECTORS

WE'VE TOUCHED ON VECTOR SPACES BEFORE. NOW, LET'S DELVE DEEPER. A SUBSPACE IS A SUBSET OF A VECTOR SPACE THAT IS ITSELF A VECTOR SPACE (CLOSED UNDER ADDITION AND SCALAR MULTIPLICATION).

BASIS AND DIMENSION: A BASIS FOR A VECTOR SPACE IS A SET OF LINEARLY INDEPENDENT VECTORS THAT SPAN THE ENTIRE SPACE. THE NUMBER OF VECTORS IN A BASIS IS THE DIMENSION OF THE SPACE.

LINEAR INDEPENDENCE AND SPAN: UNDERSTANDING LINEAR INDEPENDENCE (VECTORS NOT BEING LINEAR COMBINATIONS OF EACH OTHER) AND THE SPAN (ALL POSSIBLE LINEAR COMBINATIONS) IS CRUCIAL FOR GRASPING THE STRUCTURE OF VECTOR SPACES.

A LAY LINEAR ALGEBRA TEXTBOOK OUTLINE:

TITLE: UNLOCKING LINEAR ALGEBRA: A PRACTICAL GUIDE

INTRODUCTION: WHAT IS LINEAR ALGEBRA? WHY IS IT IMPORTANT? OVERVIEW OF THE BOOK'S STRUCTURE.

CHAPTER 1: VECTORS: INTRODUCTION TO VECTORS, VECTOR OPERATIONS, LINEAR COMBINATIONS, VECTOR SPACES.

CHAPTER 2: MATRICES: INTRODUCTION TO MATRICES, MATRIX OPERATIONS, LINEAR TRANSFORMATIONS, MATRIX INVERSES, DETERMINANTS.

CHAPTER 3: SYSTEMS OF LINEAR EQUATIONS: SOLVING SYSTEMS OF LINEAR EQUATIONS USING AUGMENTED MATRICES AND ROW REDUCTION. GEOMETRIC INTERPRETATION OF SOLUTIONS.

CHAPTER 4: EIGENVALUES AND EIGENVECTORS: INTRODUCTION TO EIGENVALUES AND EIGENVECTORS, SOLVING THE EIGENVALUE EQUATION, APPLICATIONS.

CHAPTER 5: VECTOR SPACES AND SUBSPACES: EXPLORING VECTOR SPACES, SUBSPACES, BASIS, DIMENSION, LINEAR INDEPENDENCE, AND SPAN.

CONCLUSION: SUMMARY OF KEY CONCEPTS AND FURTHER EXPLORATION SUGGESTIONS.

DETAILED EXPLANATION OF OUTLINE POINTS:

EACH CHAPTER IN THE PROPOSED TEXTBOOK WOULD FOLLOW A SIMILAR STRUCTURE: STARTING WITH INTUITIVE EXPLANATIONS AND GRADUALLY INTRODUCING MORE FORMAL CONCEPTS. EACH SECTION WOULD BE PEPPERED WITH EXAMPLES AND VISUAL AIDS TO FACILITATE UNDERSTANDING. REAL-WORLD APPLICATIONS OF EACH CONCEPT WOULD BE HIGHLIGHTED THROUGHOUT. FOR EXAMPLE, CHAPTER 3 ON SYSTEMS OF LINEAR EQUATIONS WOULD INCLUDE EXAMPLES FROM NETWORK ANALYSIS, CIRCUIT

THEORY, AND ECONOMIC MODELING. CHAPTER 4 ON EIGENVALUES AND EIGENVECTORS WOULD FEATURE APPLICATIONS IN IMAGE COMPRESSION, MARKOV CHAINS, AND GOOGLE'S PAGERANK ALGORITHM. THE BOOK WOULD EMPHASIZE A STEP-BY-STEP APPROACH TO PROBLEM-SOLVING, AND PRACTICE PROBLEMS WOULD BE INTEGRATED THROUGHOUT EACH CHAPTER.

FAQs:

1. WHAT IS THE DIFFERENCE BETWEEN A ROW VECTOR AND A COLUMN VECTOR? A ROW VECTOR IS A $1 \times N$ MATRIX (ONE ROW, N COLUMNS), WHILE A COLUMN VECTOR IS AN $N \times 1$ MATRIX (N ROWS, ONE COLUMN).
2. WHAT DOES IT MEAN FOR A MATRIX TO BE SINGULAR? A SINGULAR MATRIX IS A SQUARE MATRIX THAT DOES NOT HAVE AN INVERSE. ITS DETERMINANT IS ZERO.
3. WHAT ARE THE APPLICATIONS OF LINEAR ALGEBRA IN COMPUTER GRAPHICS? LINEAR ALGEBRA IS CRUCIAL FOR TRANSFORMATIONS (ROTATION, SCALING, TRANSLATION) OF OBJECTS IN 3D SPACE.
4. HOW ARE EIGENVALUES AND EIGENVECTORS USED IN MACHINE LEARNING? EIGENVECTORS OF COVARIANCE MATRICES ARE USED IN PRINCIPAL COMPONENT ANALYSIS (PCA) FOR DIMENSIONALITY REDUCTION.
5. WHAT IS THE SIGNIFICANCE OF THE DETERMINANT OF A MATRIX? THE DETERMINANT PROVIDES INFORMATION ABOUT THE SCALING FACTOR OF A LINEAR TRANSFORMATION REPRESENTED BY THE MATRIX. IT ALSO INDICATES WHETHER THE MATRIX IS INVERTIBLE.
6. WHAT IS A BASIS OF A VECTOR SPACE? A BASIS IS A SET OF LINEARLY INDEPENDENT VECTORS THAT SPAN THE ENTIRE VECTOR SPACE. IT'S LIKE A COORDINATE SYSTEM FOR THE SPACE.
7. WHAT IS THE RANK OF A MATRIX? THE RANK OF A MATRIX IS THE DIMENSION OF THE VECTOR SPACE SPANNED BY ITS COLUMNS (OR ROWS).
8. WHAT IS THE DIFFERENCE BETWEEN LINEAR AND NON-LINEAR EQUATIONS? LINEAR EQUATIONS INVOLVE ONLY LINEAR COMBINATIONS OF VARIABLES (NO POWERS OR PRODUCTS OF VARIABLES), WHILE NON-LINEAR EQUATIONS DO.
9. CAN I LEARN LINEAR ALGEBRA WITHOUT A STRONG CALCULUS BACKGROUND? WHILE SOME ADVANCED LINEAR ALGEBRA TOPICS BUILD UPON CALCULUS, A BASIC UNDERSTANDING OF LINEAR ALGEBRA IS POSSIBLE WITHOUT AN EXTENSIVE CALCULUS BACKGROUND.

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lay linear algebra: Linear Algebra And Its Applications Tzuong-tsieng Moh, 2020-10-21 From Tzuong-Tsieng Moh, a seasoned expert in algebra, comes a new book for students to better understand linear algebra. Writing from an experienced standpoint, Moh covers the many standard aspects comprising linear algebra, such as echelon forms, matrix algebra, linear transformations, and more. Moh further includes several advanced topics and applications, as well as self-correcting codes, Heisenberg's uncertainty principle, Maxwell's equations in relativity form, Google's search

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lay linear algebra: Linear Algebra Gems David H. Carlson, 2002 Undergraduate linear algebra is both beautiful and replete with real world applications and connections to the rest of mathematics. The purpose of the present volume is to enrich the understanding of linear algebra for a wide audience by placing a broad collection of short items in the hands of teachers, students, and others who enjoy the subject. Because undergraduate linear algebra is so fundamental to the mathematics curriculum, it is often taught by non-specialists and specialists alike. Linear Algebra Gems offers to all teachers clever ways in which core ideas can be presented to their students. Most articles are accessible to those with modest preparation in linear algebra, including beginning students. However, many items will also contain pleasant surprises even to those well-versed in the subject. The editors have combed through the literature, and have selected from original submissions, to find expository articles and problems to enrich the reader's understanding. The seventy-three articles selected are organized into nine sections, with over 120 problems grouped into subject categories as a tenth section. Contributors to the volume include experts in the field and long-time teachers of linear algebra. The book was prepared as part of a broad contract with the National Science Foundation to improve undergraduate linear algebra education. The editors hope that many readers will find enjoyment from this collection.--Amazon.com viewed Oct. 26, 2020.

lay linear algebra: Student Study Guide, Linear Algebra and Its Applications, Fifth Edition, David C. Lay, University of Maryland, Steven R. Lay, Lee University, Judi J. McDonald, Washington State University David C. Lay, Judith McDonald, Steven R. Lay, 2016 An integral part of this text, the Study Guide incorporates detailed solutions to every third odd-numbered exercise, as well as solutions to every odd-numbered writing exercise for which the main text only provides a hint.

lay linear algebra: Linear Algebra Done Right Sheldon Axler, 1997-07-18 This text for a second course in linear algebra, aimed at math majors and graduates, adopts a novel approach by banishing determinants to the end of the book and focusing on understanding the structure of linear operators on vector spaces. The author has taken unusual care to motivate concepts and to simplify proofs. For example, the book presents - without having defined determinants - a clean proof that every linear operator on a finite-dimensional complex vector space has an eigenvalue. The book starts by discussing vector spaces, linear independence, span, basics, and dimension. Students are introduced to inner-product spaces in the first half of the book and shortly thereafter to the finite-dimensional spectral theorem. A variety of interesting exercises in each chapter helps students understand and manipulate the objects of linear algebra. This second edition features new chapters on diagonal matrices, on linear functionals and adjoints, and on the spectral theorem; some sections, such as those on self-adjoint and normal operators, have been entirely rewritten; and hundreds of minor improvements have been made throughout the text.

lay linear algebra: Linear Algebra and Its Applications (Fifth Edition) David C. Lay, Steven R.

Lay, Judith McDonald, 2020

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lay linear algebra: Convex Sets and Their Applications Steven R. Lay, 2007-01-01 Suitable for advanced undergraduates and graduate students, this text introduces the broad scope of convexity. It leads students to open questions and unsolved problems, and it highlights diverse applications. Author Steven R. Lay, Professor of Mathematics at Lee University in Tennessee, reinforces his teachings with numerous examples, plus exercises with hints and answers. The first three chapters form the foundation for all that follows, starting with a review of the fundamentals of linear algebra and topology. They also survey the development and applications of relationships between hyperplanes and convex sets. Subsequent chapters are relatively self-contained, each focusing on a particular aspect or application of convex sets. Topics include characterizations of convex sets, polytopes, duality, optimization, and convex functions. Hints, solutions, and references for the exercises appear at the back of the book.

lay linear algebra: A Course in Linear Algebra David B. Damiano, John B. Little, 2011-01-01 Suitable for advanced undergraduates and graduate students, this text introduces basic concepts of linear algebra. Each chapter contains an introduction, definitions, and propositions, in addition to multiple examples, lemmas, theorems, corollaries, and proofs. Each chapter features numerous supplemental exercises, and solutions to selected problems appear at the end. 1988 edition--

lay linear algebra: Linear Algebra and Its Applications David C. Lay, 2003

lay linear algebra: LINEAR ALGEBRA S. KUMARESAN, 2000-01-01 This clear, concise and highly readable text is designed for a first course in linear algebra and is intended for undergraduate courses in mathematics. It focusses throughout on geometric explanations to make the student perceive that linear algebra is nothing but analytic geometry of n dimensions. From the very start, linear algebra is presented as an extension of the theory of simultaneous linear equations and their geometric interpretation is shown to be a recurring theme of the subject. The integration of abstract algebraic concepts with the underlying geometric notions is one of the most distinguishing features of this book — designed to help students in the pursuit of multivariable calculus and differential geometry in subsequent courses. Explanations and concepts are logically presented in a conversational tone and well-constructed writing style so that students at a variety of levels can understand the material and acquire a solid foundation in the basic skills of linear algebra.

lay linear algebra: Linear Algebra Jim Hefferon, 2015 This text covers a standard first course : Gauss's method, vector spaces, linear maps and matrices, determinants, and eigenvalues and eigenvectors. In addition, each chapter ends with some topics such as brief applications. What sets it apart is careful motivation, many examples, and extensive exercise sets. Together these help each student master the material of this course, and also help an instructor develop that student's level of mathematical maturity. This book has been available online for many years and is widely used, both in classrooms and for self-study. It is supported by worked answers for all exercises, beamer slides for classroom use, and a lab manual of computer work--Page 4 of cover.

lay linear algebra: Linear Algebra As An Introduction To Abstract Mathematics Bruno Nachtergaele, Anne Schilling, Isaiah Lankham, 2015-11-30 This is an introductory textbook designed for undergraduate mathematics majors with an emphasis on abstraction and in particular, the concept of proofs in the setting of linear algebra. Typically such a student would have taken calculus, though the only prerequisite is suitable mathematical grounding. The purpose of this book

is to bridge the gap between the more conceptual and computational oriented undergraduate classes to the more abstract oriented classes. The book begins with systems of linear equations and complex numbers, then relates these to the abstract notion of linear maps on finite-dimensional vector spaces, and covers diagonalization, eigenspaces, determinants, and the Spectral Theorem. Each chapter concludes with both proof-writing and computational exercises.

lay linear algebra: Linear Algebra John B. Fraleigh, 1995 Contains the complete solutions, including proofs, for every third problem in each exercise set.

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lay linear algebra: *Applied Linear Algebra* Peter J. Olver, Chehrzad Shakiban, 2018-05-30 This textbook develops the essential tools of linear algebra, with the goal of imparting technique alongside contextual understanding. Applications go hand-in-hand with theory, each reinforcing and explaining the other. This approach encourages students to develop not only the technical proficiency needed to go on to further study, but an appreciation for when, why, and how the tools of linear algebra can be used across modern applied mathematics. Providing an extensive treatment of essential topics such as Gaussian elimination, inner products and norms, and eigenvalues and singular values, this text can be used for an in-depth first course, or an application-driven second course in linear algebra. In this second edition, applications have been updated and expanded to include numerical methods, dynamical systems, data analysis, and signal processing, while the pedagogical flow of the core material has been improved. Throughout, the text emphasizes the conceptual connections between each application and the underlying linear algebraic techniques, thereby enabling students not only to learn how to apply the mathematical tools in routine contexts, but also to understand what is required to adapt to unusual or emerging problems. No previous knowledge of linear algebra is needed to approach this text, with single-variable calculus as the only formal prerequisite. However, the reader will need to draw upon some mathematical maturity to engage in the increasing abstraction inherent to the subject. Once equipped with the main tools and concepts from this book, students will be prepared for further study in differential equations, numerical analysis, data science and statistics, and a broad range of applications. The first author's text, *Introduction to Partial Differential Equations*, is an ideal companion volume, forming a natural extension of the linear mathematical methods developed here.

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lay linear algebra: *Elementary Linear Algebra* Stephen Andrilli, David Hecker, 2010-02-04 *Elementary Linear Algebra* develops and explains in careful detail the computational techniques and fundamental theoretical results central to a first course in linear algebra. This highly acclaimed text focuses on developing the abstract thinking essential for further mathematical study The authors give early, intensive attention to the skills necessary to make students comfortable with mathematical proofs. The text builds a gradual and smooth transition from computational results to

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professor and author Gilbert Strang demonstrates that linear algebra is a fascinating subject by showing both its beauty and value. While the mathematics is there, the effort is not all concentrated on proofs. Strang's emphasis is on understanding. He explains concepts, rather than deduces. This book is written in an informal and personal style and teaches real mathematics. The gears change in Chapter 2 as students reach the introduction of vector spaces. Throughout the book, the theory is motivated and reinforced by genuine applications, allowing pure mathematicians to teach applied mathematics.

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algebra, plus a little. The remaining chapters treat singular value decompositions, convexity, special classes of matrices, projections, assorted algorithms, and a number of applications. The applications are drawn from vector calculus, numerical analysis, control theory, complex analysis, convex optimization, and functional analysis. In particular, fixed point theorems, extremal problems, best approximations, matrix equations, zero location and eigenvalue location problems, matrices with nonnegative entries, and reproducing kernels are discussed. This new edition differs significantly from the second edition in both content and style. It includes a number of topics that did not appear in the earlier edition and excludes some that did. Moreover, most of the material that has been adapted from the earlier edition has been extensively rewritten and reorganized.

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