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 Search

Chapters
Linear Algebra Home
Systems of Equations and Matrices
Determinants
Euclidean n-Space
Vector Spaces
Eigenvalues and Eigenvectors
Misc
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Downloads
FAQ
Links
My Students
Site Map
Terms of Use

Online Notes / Linear Algebra / Vector Spaces / Fundamental Subspaces
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Fundamental Subspaces

In this section we want to take a look at some important subspaces that are associated with matrices. In fact they are so important that they are often called the fundamental subspaces of a matrix. We've actually already seen one of the fundamental subspaces, the null space, [previously](#) although we will give its definition here again for the sake of completeness.

Before we give the formal definitions of the fundamental subspaces we need to quickly review a concept that we first saw back when we were looking at matrix arithmetic.

Given an $(n \times n)$ matrix

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

The **row vectors** (we called them row matrices at the time) are the vectors in \mathbb{R}^n formed out of the rows of A . The **column vectors** (again we called them column matrices at the time) are the vectors in \mathbb{R}^n that are formed out of the columns of A .

Example 1 Write down the row vectors and column vectors for

$$A = \begin{bmatrix} -1 & 5 \\ 0 & -4 \\ 9 & 2 \\ 3 & -7 \end{bmatrix}$$

Solution

The row vectors are,

$$\mathbf{r}_1 = [-1 \quad 5] \quad \mathbf{r}_2 = [0 \quad -4] \quad \mathbf{r}_3 = [9 \quad 2] \quad \mathbf{r}_4 = [3 \quad -7]$$

The column vectors are

$$\mathbf{c}_1 = \begin{bmatrix} -1 \\ 0 \\ 9 \\ 3 \end{bmatrix} \quad \mathbf{c}_2 = \begin{bmatrix} 5 \\ -4 \\ 2 \\ -7 \end{bmatrix}$$

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Table of Contents Pauls Notes Linear Algebra

1. Understanding the eBook Pauls Notes Linear Algebra
 - The Rise of Digital Reading Pauls Notes Linear Algebra
 - Advantages of eBooks Over Traditional Books
2. Identifying Pauls Notes Linear Algebra
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Pauls Notes Linear Algebra
 - User-Friendly Interface
4. Exploring eBook Recommendations from Pauls Notes Linear Algebra
 - Personalized Recommendations
 - Pauls Notes Linear Algebra User Reviews and Ratings
 - Pauls Notes Linear Algebra and Bestseller Lists
5. Accessing Pauls Notes Linear Algebra Free and Paid eBooks
 - Pauls Notes Linear Algebra Public Domain eBooks
 - Pauls Notes Linear Algebra eBook Subscription Services

- Pauls Notes Linear Algebra Budget-Friendly Options
- 6. Navigating Pauls Notes Linear Algebra eBook Formats
 - ePub, PDF, MOBI, and More
 - Pauls Notes Linear Algebra Compatibility with Devices
 - Pauls Notes Linear Algebra Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Pauls Notes Linear Algebra
 - Highlighting and Note-Taking Pauls Notes Linear Algebra
 - Interactive Elements Pauls Notes Linear Algebra
- 8. Staying Engaged with Pauls Notes Linear Algebra
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Pauls Notes Linear Algebra
- 9. Balancing eBooks and Physical Books Pauls Notes Linear Algebra
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Pauls Notes Linear Algebra
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Pauls Notes Linear Algebra
 - Setting Reading Goals Pauls Notes Linear Algebra
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Pauls Notes Linear Algebra
 - Fact-Checking eBook Content of Pauls Notes Linear Algebra
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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