

Chapter 4.

Vector Space

Vector spaces with real scalars are called *real vector spaces* and those with complex scalars are called *complex vector spaces*. For now, we will be concerned exclusively with real vector spaces.

4.1 Real Vector Spaces

Let V be a nonempty set of objects, on which two operations are defined:

- a) Addition
- b) Multiplication by scalars

With the following properties:

1. If \vec{u} and \vec{v} are elements in V , then $\vec{u} + \vec{v}$ is in V . (**V is closed under addition**)
2. $\vec{u} + \vec{v} = \vec{v} + \vec{u}$, for all \vec{u}, \vec{v} in V . (**holds Commutative Law**)
3. $\vec{u} + (\vec{v} + \vec{w}) = (\vec{u} + \vec{v}) + \vec{w}$ (**holds Associative Law**)
4. There is an object $\vec{0}$ in V , called the zero vector for V such that $\vec{0} + \vec{u} = \vec{u} + \vec{0} = \vec{u}$, for each \vec{u} in V . (**have Additive Identity**)
5. For each \vec{u} in V , there is an object $-\vec{u}$ in V , called a negative of \vec{u} , such that $\vec{u} + (-\vec{u}) = -\vec{u} + \vec{u} = \vec{0}$. (**have Additive Inverse**)
6. If k is any scalar and \vec{u} is any object in V , then $k\vec{u}$ is in V . (**Closed under Scalar Multiplication**).
7. $k(\vec{u} + \vec{v}) = k\vec{u} + k\vec{v}$
8. $(k + m)\vec{u} = k\vec{u} + m\vec{u}$
9. $k(m\vec{u}) = (km)\vec{u}$
10. $1\vec{u} = \vec{u}$ (**have Multiplicative Identity**)

then V is called a vector space and the objects in V are *vectors*.

Example 1: Let $V = R^2 = \{(x, y); x, y \in R\}$, prove that V is a vector space under the usual operations of addition and scalar multiplication defined by:

$$\vec{u} + \vec{v} = (u_1, u_2) + (v_1, v_2) = (u_1 + v_1, u_2 + v_2)$$

$$k\vec{u} = k(u_1, u_2) = (ku_1, ku_2)$$

Solution:

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John Horvath



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Table of Contents Vector Spaces Full Chapter Fybsc

1. Understanding the eBook Vector Spaces Full Chapter Fybsc
 - The Rise of Digital Reading Vector Spaces Full Chapter Fybsc
 - Advantages of eBooks Over Traditional Books
2. Identifying Vector Spaces Full Chapter Fybsc
 - 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 Vector Spaces Full Chapter Fybsc
 - User-Friendly Interface
4. Exploring eBook Recommendations from Vector Spaces Full Chapter Fybsc
 - Personalized Recommendations
 - Vector Spaces Full Chapter Fybsc User Reviews and Ratings
 - Vector Spaces Full Chapter Fybsc and Bestseller Lists

5. Accessing Vector Spaces Full Chapter Fybsc Free and Paid eBooks
 - Vector Spaces Full Chapter Fybsc Public Domain eBooks
 - Vector Spaces Full Chapter Fybsc eBook Subscription Services
 - Vector Spaces Full Chapter Fybsc Budget-Friendly Options
6. Navigating Vector Spaces Full Chapter Fybsc eBook Formats
 - ePub, PDF, MOBI, and More
 - Vector Spaces Full Chapter Fybsc Compatibility with Devices
 - Vector Spaces Full Chapter Fybsc Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Vector Spaces Full Chapter Fybsc
 - Highlighting and Note-Taking Vector Spaces Full Chapter Fybsc
 - Interactive Elements Vector Spaces Full Chapter Fybsc
8. Staying Engaged with Vector Spaces Full Chapter Fybsc
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Vector Spaces Full Chapter Fybsc
9. Balancing eBooks and Physical Books Vector Spaces Full Chapter Fybsc
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Vector Spaces Full Chapter Fybsc
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Vector Spaces Full Chapter Fybsc
 - Setting Reading Goals Vector Spaces Full Chapter Fybsc
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Vector Spaces Full Chapter Fybsc
 - Fact-Checking eBook Content of Vector Spaces Full Chapter Fybsc
 - 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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