Elementary Analysis: The Theory of Calculus by Ross Exercise Solutions

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Chapter 1: The Set N of Natural Numbers

1. Prove $1^2 + 2^2 + \cdots + n^2 = \frac{1}{2}n(n+1)(2n+1)$ for all positive integers n

Solution:

Base Case: $1 = \frac{1}{2}(1)(2)(3) = 1$

Inductive Step: Assume that $1^2 + 2^2 + \cdots + n^2 = \frac{1}{2}n(n+1)(2n+1)$ is true for some $n \in \mathbb{N}$. Then,

$$\begin{aligned} 1^2 + 2^2 + \dots + n^2 + (n+1)^2 &= \frac{1}{6}n(n+1)(2n+1) + (n+1)^2 \\ &= \frac{1}{6}n(n+1)(2n+1) + \frac{6(n+1)^2}{6} \\ &= \frac{1}{6}(n+1)[n(2n+1) + 6(n+1)] \\ &= \frac{1}{6}(n+1)[2n^2 + n + 6n + 6] \\ &= \frac{1}{6}(n+1)(n+1+1)(2(n+1) + 1) \end{aligned}$$

Hence, $1^2 + 2^2 + \cdots + n^2 = \frac{1}{8}n(n+1)(2n+1)$ for all $n \in \mathbb{N}$

Prove 3 + 11 + · · · + (8n − 5) = 4n² − n for all positive integers n.

Solution:

Base Case: $3 = 4(1)^2 - 1 = 3$

Inductive Step: Assume that $3 + 11 + \cdots + (8n - 5) = 4n^2 - n$ for some $n \in \mathbb{N}$. Then,

$$3 + 11 + \cdots + (8n - 5) + (8(n + 1) -)5 = 4n^2 - n + (8(n + 1) - 5)$$

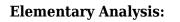
= $4n^2 + 7n + 3$
= $4(n^2 + 2n + 1) - n - 1$
= $4(n + 1)^2 - (n + 1)$

Hence, $3 + 11 + \cdots + (8n - 5) = 4n^2 - n$ for all $n \in \mathbb{N}$

3. Prove $1^3 + 2^3 + \cdots + n^3 = (1 + 2 + \cdots + n)^2$ for all postive integers n

Elementary Analysis

Lei Shi



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Table of Contents Elementary Analysis

- 1. Understanding the eBook Elementary Analysis
 - The Rise of Digital Reading Elementary Analysis
 - Advantages of eBooks Over Traditional Books
- 2. Identifying Elementary Analysis
 - 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 Elementary Analysis
 - User-Friendly Interface
- 4. Exploring eBook Recommendations from Elementary Analysis
 - Personalized Recommendations
 - Elementary Analysis User Reviews and Ratings

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

- 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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