

Elementary Analysis: The Theory of Calculus by Ross Exercise Solutions

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Chapter 1: The Set \mathbb{N} of Natural Numbers

1. Prove $1^2 + 2^2 + \cdots + n^2 = \frac{1}{6}n(n+1)(2n+1)$ for all positive integers n .

Solution:

Base Case: $1 = \frac{1}{6}(1)(2)(3) = 1$ ✓

Inductive Step: Assume that $1^2 + 2^2 + \cdots + n^2 = \frac{1}{6}n(n+1)(2n+1)$ is true for some $n \in \mathbb{N}$. Then,

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

Hence, $1^2 + 2^2 + \cdots + n^2 = \frac{1}{6}n(n+1)(2n+1)$ for all $n \in \mathbb{N}$ ■

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

$$\begin{aligned}3 + 11 + \cdots + (8n-5) + (8(n+1)-5) &= 4n^2 - n + (8(n+1)-5) \\&= 4n^2 + 7n + 3 \\&= 4(n^2 + 2n + 1) - n - 1 \\&= 4(n+1)^2 - (n+1)\end{aligned}$$

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 positive integers n .

Elementary Analysis

Lei Shi



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