

Analysis for Algebraists

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2025-12-11

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Chapter 1

Sets and Orders

Chapter 2

Algebraic Structures

2.1 Groups

2.2 Fields

2.3 Ordered Fields

Definition 2.3.1. An **ordered commutative Ring** (R, \leq) is a commutative Ring R equipped with an **ordering relation** \leq , such that for all $a, b, c \in R$, we have:

1. \leq defines a *total order* on F . i.e:
 - (a) $a \leq a$ (the order is *reflexive*),
 - (b) $a \leq b \wedge b \leq c \implies a \leq c$ (the order is *transitive*),
 - (c) $a \leq b \wedge b \leq a \implies a = b$ (the order is *antisymmetric*),
 - (d) $a \leq b \vee b \leq a$ (the order is *strongly connected*)
2. $a \leq b \implies a + c \leq b + c$
3. $0 \leq a \wedge 0 \leq b \implies 0 \leq ab$

Lemma 2.3.2. For every ordered commutative Ring (R, \leq) and $a \in R$, we have $-a \leq 0 \leq a$ or $a \leq 0 \leq -a$.

Proof. Since the order \leq is strongly connected, we have $a \leq 0$ or $0 \leq a$.

1. If $a \leq 0$, then we have $-a + a \leq 0 + -a$, i.e. $a \leq 0 \leq -a$,
2. if $0 \leq a$, then we have $-a + 0 \leq -a + a$, i.e. $-a \leq 0 \leq a$

□

Lemma 2.3.3. Let $a \in (R, \leq)$. Then $0 \leq a^2$.

Proof. Since the order \leq is strongly connected, we have $a \leq 0$ or $0 \leq a$.

1. If $0 \leq a$, then we have $0 \leq a \cdot a = a^2$,
2. if $a \leq 0$, then $0 \leq -a$ and we have $0 \leq -a \cdot (-a) = a^2$.

□

Lemma 2.3.4. *Every ordered commutative Ring has characteristic 0.*

Proof. Assume that F is a field of characteristic p . Then an ordering relation would need to fulfill:

$$1 \leq 1 + 1 \leq \sum_{i=1}^p 1 = 0 \leq 1$$

□

2.4 Vector Spaces

Chapter 3

Topology

3.1 Topological Spaces

3.2 Metric Spaces

Chapter 4

Topological Vector Spaces

4.1 Topological Vector Spaces

4.2 Normed Vector Spaces

4.3 Banach Spaces

Chapter 5

Differentiation

5.1 Frechét Spaces

5.2 The Gateaux Derivative

5.3 The Frechét Derivative

Chapter 6

Measure Theory

6.1 Set Algebras

6.2 Measure Spaces

6.3 The Lebesgue Measure

Chapter 7

Integration

7.1 The Bochner Integral