

Discrete Mathematics Cheat Sheet

Set Theory

Definitions

Set Definition: A set is a collection of objects called elements



Visual Representation:

List Notation: $\{1, 2, 3\}$

Characteristics

Sets can be finite or infinite.

Finite: $A = \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$

Infinite: $\mathbb{Z}^+ = \{1, 2, 3, 4, \dots\}$

Dots represent an implied pattern that continues infinitely

Repeated Elements are only listed once: $\{a, b, a, c, b, a\} = \{a, b, c\}$



Sets are Unordered:

$\{3, 2, 1\} = \{1, 2, 3\} = \{3, 1, 3\}$

Common Sets

Natural Numbers: $\mathbb{N} = \{0, 1, 2, 3, \dots\}$

Positive Integers: $\mathbb{Z}^+ = \{1, 2, 3, \dots\}$

Integers: $\mathbb{Z} = \{\dots, -2, -1, 0, 1, 2, \dots\}$

Rational Numbers: $\mathbb{Q} = \{\dots, \frac{1}{2}, \frac{1}{3}, \frac{2}{3}, \frac{3}{2}, \dots\}$

Elements and Cardinality

Elements are the things contained in the set.

Let $C = \{\text{Yellow, Blue, Red}\}$

$\text{Yellow} \in C$: Yellow is an element of C .

$\text{Green} \notin C$: Green is not an element of C .

Cardinality refers to the number of elements in the set.

$|C| = 3$: The **Cardinality (size)** of C is 3.

The Empty Set

$\emptyset = \{\}$: The empty set is a set with no elements.

$|\emptyset| = |\{\}| = 0$: The cardinality of the empty set is 0.

$\{\emptyset\} \neq \emptyset$.

$\{\emptyset\} = \{\{\}\}$

$|\{\emptyset\}| = 1$: The set contains the empty set.

Set Builder Notation

Elements in the list are defined as variables.

$X = \{\text{expression} \mid \text{rule}\}$

If $\text{Desk} = \{\text{drink, laptop, microphone}\}$

Set Builder Notation defines the set as:

$\text{Desk} = \{x \mid x \text{ is on the desk}\}$

Let $E = \{2n \mid n \in \mathbb{Z}\}$

Reads as: The set of all things with form $2n$ such that n is an element of \mathbb{Z} .

$2n$ is an expression that defines the **form** of the elements.

$n \in \mathbb{Z}$ defines a rule for elements appearing in the set.

\mid is read "such that" and separates the expression from the rule.

Examples:

$E = \{2n \mid n \in \mathbb{Z}\}$: A set containing even integers.

$\mathbb{Q} = \{\frac{m}{n} \mid m, n \in \mathbb{Z}, n \neq 0\}$: A set containing rational numbers (m and n are integers and n is not zero).

Ordered Pairs

An **Ordered Pair** is any list of things enclosed in parentheses: (x, y) .

$(1, 2) \neq (2, 1)$

Cartesian Products

AKA Cross Product

Given 2 sets, A and B , a Cartesian Product is denoted by $A \times B$.

The Cartesian Product is a set of Ordered Pairs where the first element comes from A and the second element comes from B .

$A \times B = \{(a, b) \mid a \in A, b \in B\}$

Let $X = \{0, 1, 2\}$ and $Y = \{0, 1\}$

$X \times Y = \{(0, 0), (0, 1), (1, 0), (1, 1), (2, 0), (2, 1)\}$

$Y \times X = \{(0, 0), (0, 1), (0, 2), (1, 0), (1, 1), (1, 2)\}$

3-tuple: $A \times B \times C = \{(a, b, c) \mid a \in A, b \in B, c \in C\}$

n-tuple:

$A_1 \times A_2 \times \dots \times A_n = \{(a_1, a_2, \dots, a_n) \mid a_1 \in A_1, a_2 \in A_2, \dots, a_n \in A_n\}$

$\emptyset \times A = \emptyset$

Cartesian Product Cardinality

The cardinality of a cross product is the product of the cardinalities of each set.

If $|A| = m$ and $|B| = n$, then $|A \times B| = m \times n$

Let $|X| = 3$ and $|Y| = 2$.

$|X \times Y| = 3 \times 2 = 6$

$|\emptyset| \times |A| = 0$

Subsets

A is a subset of B if every element in A is also in B .



$A \subseteq B$: A is a subset of B .

$\{a, b\} \subseteq \{a, b, c\}$

$\{c, d\} \subseteq \{c, d\}$

$\{a\} \not\subseteq \{\{a\}\}$: The element a is not an element of the second set.

$\emptyset \subseteq \{x, y, z\}$: The empty set is a subset of every set.

Proper Subsets

A is a **proper subset** of B if every element in A is also in B and A is smaller than B



$A \subset B$: A is a proper subset of B .

$\{a, b\} \subset \{a, b, c\}$

$\{c, d\} \not\subset \{c, d\}$

$\emptyset \subset \{x, y, z\}$

Power Sets

A **Power Set** of a set A is the set containing all possible subsets of A .

Let $A = \{a, b\}$

$\mathcal{P}(A) = \{\emptyset, \{a\}, \{b\}, \{a, b\}\}$

$\mathcal{P}(\emptyset) = \emptyset$

Power Sets Cardinality

If $|A| = n$, then $|\mathcal{P}(A)| = 2^n$

Let $|A| = 2$

$|\mathcal{P}(A)| = 2^2 = 4$

Set Operations

Universes

Every set A exists within some universe U .



Complement

The complement of a set A is everything outside of A that is in the Universe.

A^c (or \bar{A}) = $\{a \in U \text{ and } a \notin A\}$

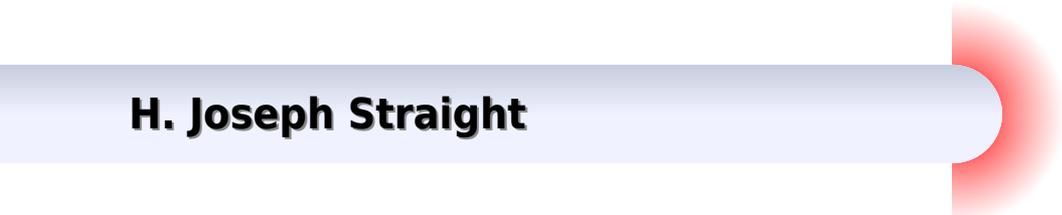
Let $A = \{1\}$ and $U = \{1, 2, 3\}$.

$A^c = \{2, 3\}$



Discrete Mathematics Chartrand Answers

H. Joseph Straight



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