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: $Z^+ = \{1, 2, 3, 4, \ldots\}$

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:

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

Common Sets

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

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

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

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

Elements and Cardinality

Elements are the things contained in the set.
Let $C = \{Yellow, Blue, Red\}$

$Yellow \in C$: **Yellow** is an element of C.

$Green \notin C$: **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.

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

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

Set Builder Notation defines the set as:
$Desk = \{x \mid x \text{ is on the desk}\}$

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

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

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

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

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

Examples:

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

$Q = \{\frac{m}{n} \mid m, n \in Z, n \neq 0\}$: 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:
$A_1 \times A_2 \times \cdots \times A_n = \{(a_1, a_2, \ldots, a_n) \mid a_1 \in A_1, a_2 \in A_2, \ldots, a_n \in A_n\}$
$\emptyset \times A = \emptyset$

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 $A = \{a, b\}$

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

$P(\emptyset) = \emptyset$

Power Sets Cardinality

If $|A| = n$, then $|P(A)| = 2^n$
Let $|A| = 2$
$|P(A)| = 2^2 = 4$

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

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

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Ulf Rehmann,Yuri Tschinkel

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Synergies in Analysis, Discrete Mathematics, Soft Computing and Modelling P. V. Subrahmanyam,V. Antony Vijesh,Balasubramaniam Jayaram,Prakash Veeraraghavan,2023-02-02 This book contains select papers on mathematical analysis and modeling discrete mathematics fuzzy sets and soft computing All the papers were presented at the international conference on FIM28 SCMSPS20 virtually held at Sri Sivasubramaniya Nadar SSN College of Engineering Chennai India and Stella Maris College Autonomous Chennai from November 23 27 2020 The conference was jointly held with the support of the Forum for Interdisciplinary Mathematics Both the invited articles and submitted papers were broadly grouped under three heads Part 1 on analysis and modeling six chapters Part 2 on discrete mathematics and applications six chapters and Part 3 on fuzzy sets and soft computing three chapters *Discrete Mathematics* Gary Chartrand,Ping Zhang,2011-03-31 Chartrand and Zhangs Discrete Mathematics presents a clearly written student friendly introduction to discrete mathematics The authors draw from their background as researchers and educators to offer lucid discussions and descriptions fundamental to the subject of discrete mathematics Unique among discrete mathematics textbooks for its treatment of proof techniques and graph theory topics discussed also include logic relations and functions especially equivalence relations and bijective functions algorithms and analysis of algorithms introduction to number theory combinatorics counting the Pascal triangle and the binomial theorem discrete probability partially ordered sets lattices and Boolean algebras cryptography and finite state machines This highly versatile text provides mathematical background used in a wide variety of disciplines including mathematics and mathematics education computer science biology chemistry engineering communications and business Some of the major features and strengths of this textbook Numerous carefully explained examples and applications facilitate learning More than 1 600 exercises ranging from elementary to challenging are included with hints answers to all odd numbered exercises Descriptions of proof techniques are accessible and lively Students benefit from the historical discussions throughout the textbook **Foundations of Discrete Mathematics** Albert D. Polimeni,H. Joseph Straight,1985

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