

MATH1081 notes

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1 Topic 1

1.1 Introduction

1. addition, multiplication, division and subtraction
2. Mainly dealing with finite sets

1.2 Sets and subsets

A set is a well defined collection of distinct objects

Example: $S = \{1, a, 3\}, A = \{\Pi, 1\}$.

1. $e \notin A$; it is not in A
2. For example, if A is a set of all integers; $\{\text{all even integers}\} = \{n \in \mathbb{R} | n \text{ is even}\}$.
3. We can remove superfluous items (elements that occur more than one).
 $A = \{1, 2, 3, 3\}$ where 3 can be removed.

Example:

$A = \{1, 2, 3\}, B = \{2, 3, 1\}, C = \{1, 2, 3, 3\}, D = \{1, 3\}$.

Here, D is a proper subset of A, B, C; A, B, C are supersets of D.

\subseteq : Subset (proper subset), \supseteq : Superset.

1. To prove if a set is a proper subset; do the following:

For example, if $D \in A$, then check if $e \in D$

If $e \in D$, then $e \in A$. Thus, it would be a proper subset (here, e is just an element).

2. To prove that two sets are equal;

For example, if $A = B$, prove:

- i) $A \subseteq B$; if an element is in A, then the element is in B.
- ii) $B \subseteq A$; if an element is in B, then the element is in A.

1.3 Power Sets and Stability

Subsets of $A = \{1, 2, 3\}$:

1. Could throw everything out to get empty set Φ ,
2. One element each: $\{1\}, \{2\}, \{3\}$,
3. Two elements: $\{1, 2\}, \{2, 3\}, \{1, 3\}$,
4. Set itself: A .

The set containing 1, 2, 3, 4 is called the powerset of A.

Given $A = \{1, 2, 3\}, B = \{1, 2, 3, 3\}, C = \{1, 3\}, D = \{1, 3\}$, where $A = B, C \subseteq A, B$ and $D \not\subseteq A, B, C$.

1. size of A = 3, B = 3, C = 2, D = 2.

[Exercise with A = 0, 1, 0, 1, B done in word].

1.4 Set Operations

Boolean Operators ("not" operation in programming):

1. Complement:

Let there be a set A in U (A : all of the people in the video, U : universal set of everyone in the world, A^c = complement of A).

$$A^c = \{x \in U | x \notin A\}.$$

2. Intersecting ("and" operation in programming):

If there is A, B , intersecting,

$$A \cap B = \{x \in A | x \in B\}.$$

3. Union ("or" operation in programming): If there is A, B , A or B is:

$$A \cup B = \{x \in U | x \in A \text{ or } x \in B\}.$$

4. Difference: If there is A, B , intersecting,

$$A - B = \{x \in A | x \notin B\}.$$

[examples in word doc]

1.5 The Inclusion-Exclusion Principle

[example in Word]

$$|A \cup B| = |A| + |B| - |A \cap B|.$$

For three elements,

$$|A \cup B \cup C| = |A| + |B| + |C| - |A \cap B| - |A \cap C| - |B \cap C| + |A \cap B \cap C|.$$

[example in word]

1.6 Sets Proofs

[proof question in word]

Hints for proofs:

1. To prove that $S \subseteq T$, we can assume that $x \in S$ and show that $x \in T$.
2. To prove that $S = T$, we can show that $S \subseteq T$ and $T \subseteq S$.

Scaffold:

Proof: Suppose that (proof) we see that/ it follows ... (conclusion) (end with shaded box to indicate end of proof)

Note that the "Suppose that" part of the proof is usually whatever the if statement mentions.

For example, if the question is "Prove that if $A \cap B = A$, then $A \cup B = B$ ", then the proof starts like this:

<u>Proof</u> : Suppose that $A \cap B = A$.
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For questions like "is this statement true", there are two ways to approach the question:

1. If the statement is true (if you think it is true), then prove it.
2. If the statement is false, then give a counter-example that proves it false.

[examples in word]

1.7 Laws of Set Algebra

Laws of Set Algebra

1. $A \cap B = B \cap A$: Commutative Law.
2. $A \cap (B \cap C) = (A \cap B) \cap C$: Associative Law.
3. $A \cap (B \cap C) = (A \cap B) \cup (A \cap C)$: Distributive Law.
4. $A \cap (A \cap B) = A$: Absorption Law.
5. $A \cap U = U \cap A = A$: Identity Law.
6. $A \cap A = A$: Idempotent Law.
7. $(A^c)^c = A$: Double Complement Law.
8. $A \cap \emptyset = \emptyset \cap A = \emptyset$: Domination Law.
9. $A \cap A^c = \emptyset$: Intersection with Complement Law.
10. $(A \cap B)^c = A^c \cap B^c$: De Moirve's Law.