Set Theory

Understanding Set Operations

Set Operations, Venn Diagram, Set Equality

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A U B :

Let A,B be two sets(same or different)
A U B represents the set you get when you combine everything from A and B together

"$x \in A \cup B$ if and only if $x \in A$ or $x \in B$."

$x \in A \cup B$ iff $x \in A$ OR $x \in B$. ✓

$x \in A$ or $x \in B$ then $x \in A \cup B$ ✓

$x \in A \cup B$ then $x \in A$ or $x \in B$ ✓

$x \in A$ then $x \in A \cup B$ ✓

$x \in A \cup B$ then $x \in A$ ✗

$x \notin A$ then $x \notin A \cup B$ ✗

$x \notin A$, $x \in A \cup B$ then $x \in B$ ✓

$S \cup T = \{ x \mid x \in S \text{ or } x \in T \text{ (or both)} \}$

$S \cap T = \{ x \mid x \in S \text{ and } x \in T \}$

$S - T = \{ x \mid x \in S \text{ and } x \notin T \}$

$S \Delta T = \{ x \mid \text{either } x \in S \text{ and } x \notin T, \text{ or } x \notin S \text{ and } x \in T \}$

If you know $x \in S \cup T$, you can conclude $x \in S$ or $x \in T$.

If you know $x \in S \cap T$, you can conclude $x \in S$ and $x \in T$.

If you know $x \in S - T$, you can conclude $x \in S$ and $x \notin T$.

If you know $x \in S \Delta T$, you can conclude either $x \in S$ and $x \notin T$, or $x \notin S$ and $x \in T$.

$x \in S \cap T$ then $x \in S$ and $x \in T$ $\checkmark$

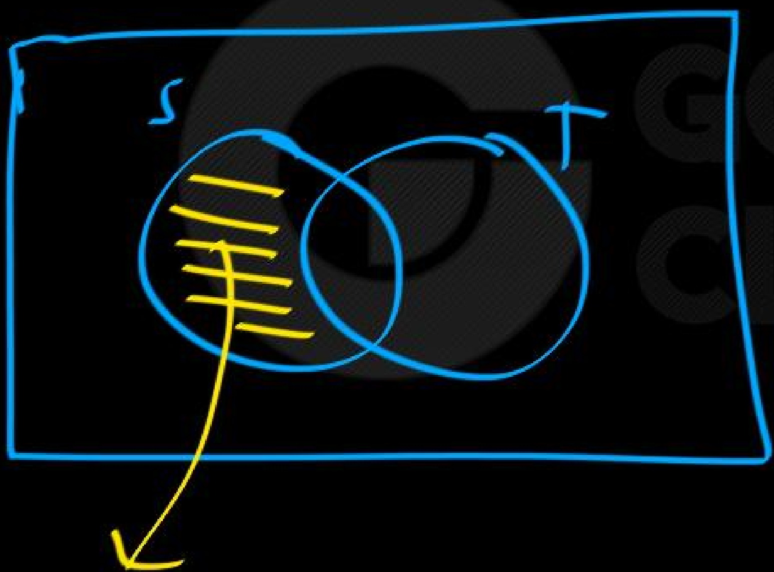
$x \in S \cap T$ then $x \in S$ $\checkmark$

$x \in S$ then $x \in S \cap T$ $\times$

$x \in S$ and $x \in T$ then $x \in S \cap T$ $\checkmark$

$x \notin S$ then $x \notin S \cap T$ $\checkmark$

$x \notin S \cap T$ then $x \notin S$ ✗



$S - T$

$$\boxed{S-T \equiv S \setminus T}$$

$x \notin S-T$ iff $x \in T$ OR $x \notin S$

$x \in S$, $x \notin T$ then $x \in S - T$ ✓

$x \in S - T$ then $x \in S$, $x \notin T$ ✓

$x \notin S$ then $x \notin S - T$ ✓

When $x \in S - T$?

iff $x \in S$ and $x \notin T$

$x \in T$ then $x \notin S - T$ ✓

$x \notin S$ then $x \notin S - T$ ✓

$x \notin S - T$ then $x \notin S$ ✗

$x \notin S - T$ iff $x \notin S$ OR $x \in T$ ✓

$$A \triangle B = \left\{ x \;\middle|\; \begin{array}{c} (x \in A, x \notin B) \\ \text{OR} \\ (x \notin A, x \in B) \end{array} \right\}$$

$$A \triangle B = (A - B) \cup (B - A)$$

$x \notin A,\ x \in B$ then $x \in B - A$ ✓

$x \notin A,\ x \in B$ then $x \in A \Delta B$ ✓

$x \in B - A$ then $x \in B,\ x \notin A$ ✓

$x \in A \Delta B$ then $x \notin A,\ x \in B$ ✗

To prove that $x \in A \cup B$

Idea: $x \in A$ OR $x \in B$

To prove that $x \in A \cap B$

Idea: $x \in A$ AND $x \in B$

To prove that $x \in A - B$

Idea: $x \in A$ AND $x \notin B$

To prove that $x \in B - A$

Idea: $x \in B$ AND $x \notin A$

To prove $x \in A \triangle B$

Idea!

$(x \in A \text{ AND } x \notin B)$ ✓

OR

$(x \notin A \text{ AND } x \in B)$ ✓

To prove $x \in S \cup T$, prove that $x \in S$ or that $x \in T$.

To prove $x \in S \cap T$, prove that $x \in S$ and $x \in T$.

☞ **To prove $x \in S - T$, prove that $x \in S$ and $x \notin T$.** ☜

To prove that $x \in S \Delta T$, prove that $x \in S$ and $x \notin T$, or that $x \in S$ and $x \in T$.

$x \notin A - B$ then $x \notin A$ OR $x \in B$

$x \notin A \cap B$ then $x \notin A$ OR $x \notin B$

$x \notin A \cup B$ then $x \notin A$ and $x \notin B$

$x \notin A \Delta B$ then $\left\{ \begin{array}{l} x \in A \cap B \text{ OR} \\ x \notin A \cup B \end{array} \right\}$

Note: let P, Q, R be sets.

1. If $a \in P$ then $a \in P \cup Q$
2. If $a \notin P$ then $a \notin P \cap Q$
3. If $a \notin P \cup Q$ then $a \notin P$, $a \notin Q$
4. If $a \in P \cap Q$ then $a \in P$, $a \in Q$
5. If $a \notin P \cap Q$ then $a \notin P$ OR $a \notin Q$

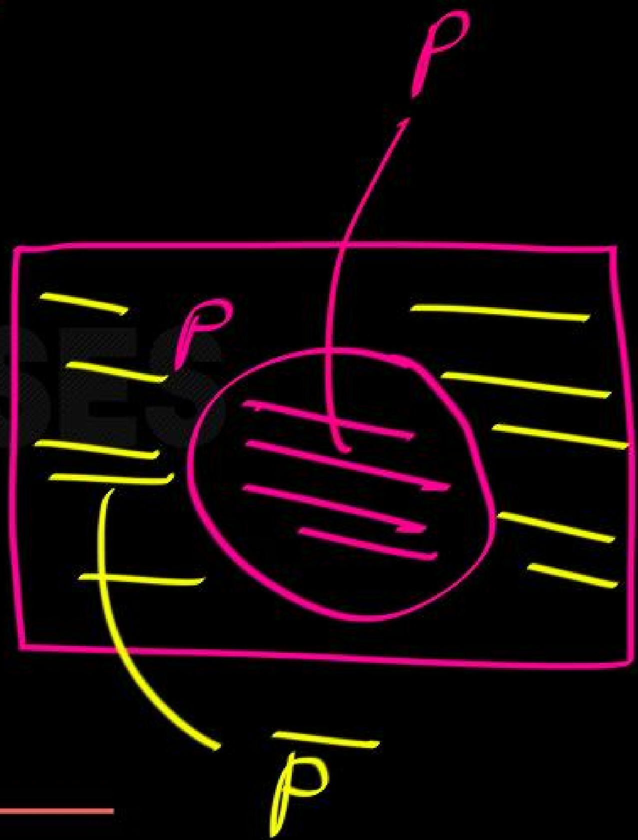
$x \notin P$ then $\begin{cases} x \notin P \cap Q & \checkmark \\ x \notin P \cup Q & \times \\ x \notin P - Q & \checkmark \end{cases}$

$x \in P$ then $x \notin \overline{P}$

$x \notin P$ then $x \in \overline{P}$

$x \in \overline{P}$ then $x \notin P$

$x \notin \overline{P}$ then $x \in P$



$(x \in A)$ OR $(x \in \overline{A}) \equiv$ True

$(x \in A)$ OR $(x \notin A) \equiv$ True

$a \in P - Q$ iff $a \in P$ and $\boxed{a \in \overline{Q}}$

$$|||$$

$a \in P - Q$ iff $a \in P$ and $\boxed{a \notin Q}$

(6) If $a \in P \cup Q$ then $a \in P$ OR $a \in Q$

(7) If $a \in P - Q$ then $a \in P$ and $a \notin Q$

(8) If $a \notin P - Q$ then $a \notin P$ OR $a \in Q$

(9) If $a \in P$ then $a \notin \overline{P}$

(10) If $a \notin P$ then $a \in \overline{P}$

$a \in \overline{Q}$

$$P \triangle Q = P \oplus Q$$

(11) If $a \in P \oplus Q$ and $a \in P$ then $a \notin Q$

(12) If $a \notin Q$, $a \in P$ then $a \in P \oplus Q$

(13) If $x \in P(Q)$ then $x \subseteq Q$

Power set of Q

$x \in P(A)$ iff $x \subseteq A$

Power set of A

$x \subseteq A$ then $x \in P(A)$

$x \notin P(A)$ then $x \notin A$

$x \notin A$ then $x \notin P(A)$

$$\boxed{x \in P(A) \text{ iff } x \subseteq A}$$

(14) If $x \notin P(Q)$ then $x \nsubseteq Q$

(15) $x \in P(Q)$ iff $x \subseteq Q$

(16) $\boxed{\text{If whenever } x \in A \text{ then } x \in B}$

then

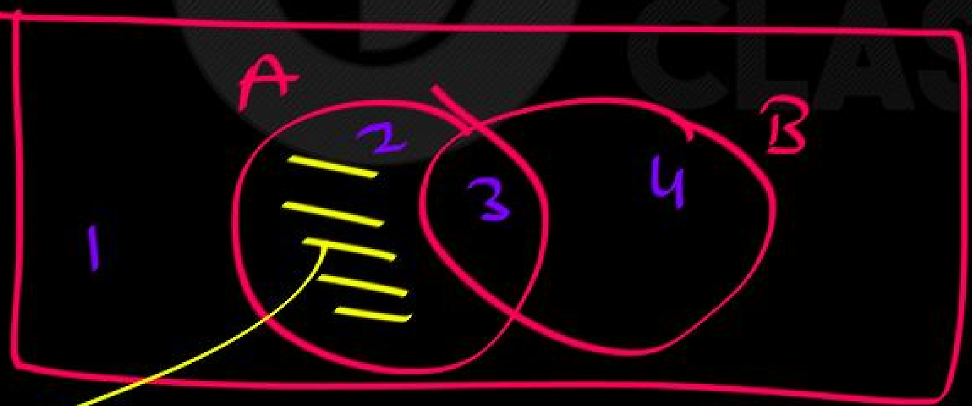
$A \subseteq B$

$$\boxed{A - B} = \boxed{\overline{B} - \overline{A}} \longrightarrow \overline{B} \cap A$$

$A \cap \overline{B}$

$$\boxed{A - B} = \boxed{A \cap \overline{B}} \longrightarrow 2$$

2



$A - B$

$A - B = A \cap \overline{B}$

$$\boxed{A - B} = \boxed{\overline{B} - \overline{A}}$$

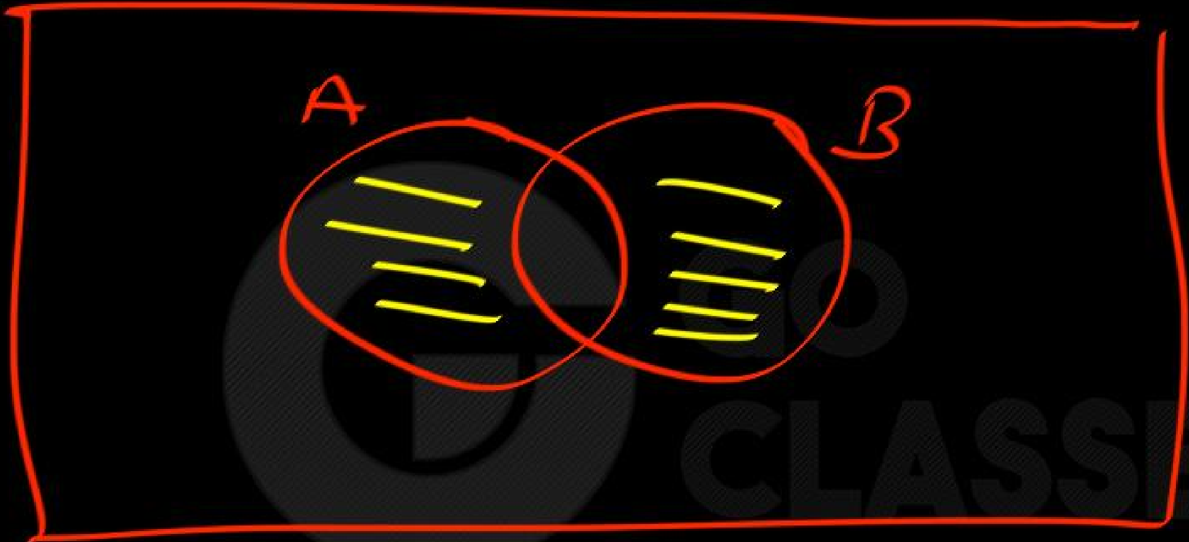
$$\begin{array}{ccc} \equiv & & \equiv \\ A \cap \overline{B} & = & \overline{B} \cap A \end{array}$$

17 $A - B = \overline{B} - \overline{A}$

19 $A \oplus B = (A-B) \cup (B-A)$

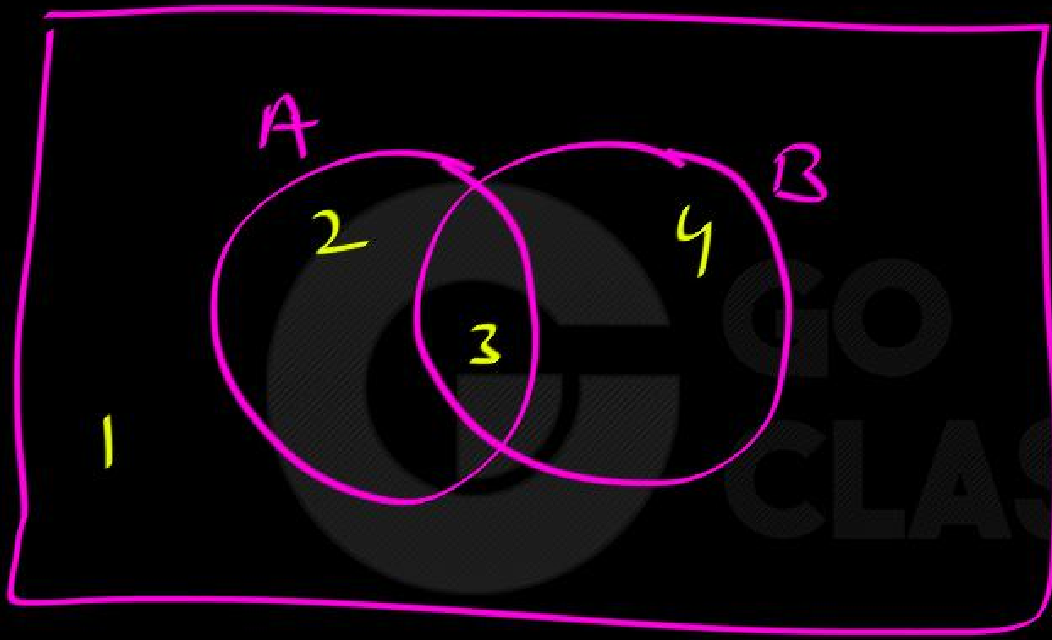
$A \oplus B = (A \cup B) - (A \cap B)$

20 $A - B = (A \cup B) - B$



$(A \cup B) - (A \cap B)$

$$A \,\Delta\, B = A \oplus B = (A \cup B) - (A \cap B)$$



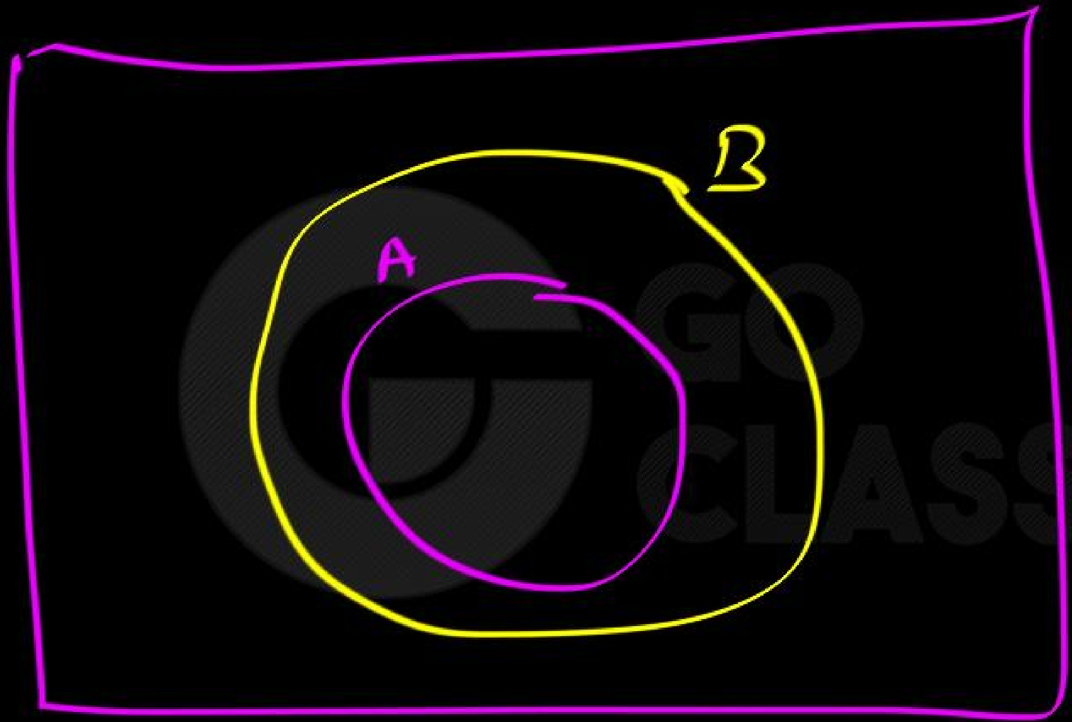
$(A \cup B) - B = 2$

$B = 3, 4$

$A \cup B = 2, 3, 4$

$A = 2, 3$

$A - B = 2 = (A \cup B) - B$



$A - B = \phi$

21 $A \oplus B = B \oplus A$

22 If $A \subseteq B$ then $A - B = \phi$

23 If $A \subseteq B$ then $A \in P(B)$

24 $\overline{(A \cup B)} = \overline{A} \cap \overline{B}$

25 $\overline{(A \cap B)} = \overline{A} \cup \overline{B}$

$x \notin A \cup B$ iff $x \notin A$ **and** $x \notin B$

$x \in \overline{A \cup B}$ iff $x \in \overline{A}$ and $x \in \overline{B}$

$x \in \overline{A \cup B}$ iff $x \in \overline{A} \cap \overline{B}$

$$\overline{(A \cup B)} = \overline{A} \cap \overline{B}$$

$$\overline{A \cap B} = \overline{A} \cup \overline{B}$$

De-morgan laws

$x \notin A \cap B$ iff $x \notin A$ or $x \notin B$

$x \in \overline{A \cap B}$ iff $x \in \overline{A}$ OR $x \in \overline{B}$

$x \in \overline{A \cap B}$ iff $x \in \overline{A} \cup \overline{B}$

26 $A - B = A \cap \overline{B}$

27 $A \oplus B = (A \cap \overline{B}) \cup (B \cap \overline{A})$

$A \oplus B = (A \cap \overline{B})$ or $(B \cap \overline{A})$

$A \times B = \{ (x, y) \mid x \in A, y \in B \}$

$x \in A \times B$ then $x = (a, b)$

$$x \in A \cup B \Leftrightarrow x \in A \text{ or } x \in B$$

$$x \notin A \cup B \Leftrightarrow x \notin A \text{ and } x \notin B$$

$$x \in A \cap B \Leftrightarrow x \in A \text{ and } x \in B$$

$$x \notin A \cap B \Leftrightarrow x \notin A \text{ or } x \notin B$$

$$x \in A - B \Leftrightarrow x \in A \text{ and } x \notin B$$

$$x \notin A - B \Leftrightarrow x \notin A \text{ or } x \in B$$

$$x \in A \times B \Leftrightarrow x = (a, b) \text{ for some } a \in A \text{ and } b \in B$$

$$A \subseteq B \Leftrightarrow \text{If } x \in A\text{, then } x \in B.$$

$$A = B \Leftrightarrow A \subseteq B \text{ and } B \subseteq A.$$