

Discrete MATH

Logic of Statements

Statements & Logical Connectives

A **statement** is a sentence that is either true or false, but not both.

EC: This moon orbits this Earth is a true statement.

EC: One plus one equals three is a false statement.

A **compound statement** is a statement that is made up of one or more simple statements using **logical connectives**.

For statements p and q , the table summarizes the logical connectives that can be used to create compound statements.

Logical Connectives		
Expression	How it is read	Type of connective
$\neg p$	"not p "	negation
$p \wedge q$	" p and q "	conjunction
$p \vee q$	" p or q "	disjunction

Compound statements may contain multiple logical connectives. For compound statements that contain a negation and another logical connective, the negation (\neg) is performed first.

EC: $\neg p \vee q$ is equivalent to $[\neg p] \vee q$.

EC: $\neg p \wedge q$ is equivalent to $[\neg p] \wedge [q]$.

You can express compound statements symbolically using \neg , \wedge , and \vee .

EC: Let p represent the statement "It is cloudy." Let q represent the statement "It is raining." Represent each compound statement below symbolically.

It is not raining. $\neg q$

It is cloudy and it is raining. $p \wedge q$

It is cloudy but it is not raining. $p \wedge \neg q$ or $p \wedge [\neg q]$

It is not cloudy and it is not raining. $\neg p \wedge \neg q$ or $[\neg p] \wedge [\neg q]$

Truth Tables

A **statement** is either true or false and has a well-defined **truth value**. Compound statements also have well-defined truth values that are determined by the truth values of the simple statements that comprise them. **Truth tables** can be used to show the truth value of a compound statement based on the truth values of its components.

EC: Negation of a statement

For a statement p , the negation of p is written $\neg p$ and means "not p ." The truth value of $\neg p$ is the opposite of the truth value of p . If p is true, then $\neg p$ is false. If p is false, then $\neg p$ is true.

p	$\neg p$
T	F
F	T

EC: Conjunction of a statement

For statements p and q , the **conjunction** of p and q is written $p \wedge q$ and means " p and q ." The truth value of a conjunction is true when, and only when, both p and q are true. If either p or q is false, or if both p and q are false, the conjunction is false.

p	q	$p \wedge q$
T	T	T
T	F	F
F	T	F
F	F	F

EC: Disjunction of a statement

For statements p and q , the **disjunction** of p and q is written $p \vee q$ and means " p or q ." The truth value of a disjunction is true when at least one of p or q is true. If both p and q are false, then the disjunction is false.

p	q	$p \vee q$
T	T	T
T	F	T
F	T	T
F	F	F

Truth tables can also be used to determine the truth values of more complicated compound statements.

Logic, Graphs & Trees, Sets, Probability

EC: Construct a truth table for the compound statement $\neg p \vee (q \wedge r)$.

p	q	r	$\neg p$	$q \wedge r$	$\neg p \vee (q \wedge r)$
T	T	T	F	T	T
T	T	F	F	F	F
T	F	T	F	F	F
T	F	F	F	F	F
F	T	T	T	T	T
F	T	F	T	F	T
F	F	T	T	F	T
F	F	F	T	F	T

Logical Equivalence & De Morgan's Laws

Two statements are **logically equivalent** if and only if they have identical truth values. The symbol \equiv is used to denote logical equivalence.

Steps to Determine Logical Equivalence

For compound statements P and Q :

1. Construct a truth table for P .
2. Construct a truth table for Q using the same statement variables as step 1.
3. Compare the truth values of the tables. If the truth values in each row are the same, the statements are logically equivalent. If the tables have a different truth value in any row, the statements are not logically equivalent.

De Morgan's laws are used to determine the negation of a conjunction and the negation of a disjunction.

The negation of a conjunction is logically equivalent to a disjunction in which each component is negated.

$\neg(p \wedge q) \equiv \neg p \vee \neg q$

EC: Find the negation of the statement *Justine is a sophomore and has blonde hair*.

The negation of this statement is *Justine is not a sophomore or does not have blonde hair*.

The negation of a disjunction is logically equivalent to a conjunction in which each component is negated.

$\neg(p \vee q) \equiv \neg p \wedge \neg q$

EC: Find the negation of the statement *Luis was sick on Monday or he missed the school bus*.

The negation of this statement is *Luis was not sick on Monday and he did not miss the school bus*.

As with other compound statements, a truth table can be used to demonstrate the logical equivalence of De Morgan's laws.

EC: Construct a truth table to show that $\neg(p \vee q) \equiv \neg p \wedge \neg q$.

p	q	$\neg p$	$\neg q$	$p \vee q$	$\neg(p \vee q)$	$\neg p \wedge \neg q$
T	T	F	F	T	F	F
T	F	F	T	T	F	F
F	T	T	F	T	F	F
F	F	T	T	F	T	T

Conditional Statements

A **conditional statement** is an if-then statement of the form "if p , then q ," where p is the **hypothesis** and q is the **conclusion**. This is symbolized by $p \rightarrow q$ or read as " p implies q ."

EC: If 12 is divided by 4, then the quotient is 3.

If Nathan makes the soccer team, then he will play fullback.

If Christy does not earn at least a B on her final, then she will earn a C for the class.

A conditional statement is false when, and only when, the hypothesis p is true and the conclusion q is false. Otherwise, the conditional statement is true.

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

Truth tables can be used to analyze compound conditional statements.

Guide For Discrete Mathematics

Annelies Wilder-Smith



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