

A proposition!

Definition: A proposition

We do not care if the statement is really true or not

Definition: A **proposition** is a statement that is true

or false.

only whether it makes sense to ask if it is true or false

Definition: A **proposition** is a statement that is true

or false.

 $\label{eq:Definition: A proposition} \textbf{Definition:} \ \ \textbf{A} \ \ \textbf{proposition} \ \ \textbf{is a statement that is true} \\ \text{or false.}$

"If you do $% \left(1\right) =\left(1\right) \left(1\right) =\left(1\right) \left(1\right)$

 $\ensuremath{\textbf{Definition:}}$ A $\ensuremath{\textbf{proposition}}$ is a statement that is true or false.

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"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time

"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator:

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Definition: A **proposition** is a statement that is true or false. "You do not pay attention or false."

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"implies" operator: \rightarrow "or" operator:

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"implies" operator: →
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"implies" operator: \rightarrow "or" operator: \vee "not" function:
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"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator: \rightarrow "or" operator: \vee "not" function: \neg

or false. "If you do not attend the lectures regularly or you do

not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"or" operator: ∨ "not" function:

"implies" operator: \rightarrow

¬ "You attend the lectures regularly" ∨ ¬ "you pay **Definition:** A **proposition** is a statement that is true attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

or false.

"If you do not attend the lectures regularly or you do

Definition: A **proposition** is a statement that is true

not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator: \rightarrow "or" operator: \vee

"not" function: ¬

attention" $\lor \lnot$ "you clear your doubts in time" $\to \lnot$ "you will find this course very easy"

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay

Definition: A **proposition** is a statement that is true or false. \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"or" operator: ∨
"not" function: ¬
"and" operator:

"implies" operator: \rightarrow

In fact, it can be written in terms of the other ones

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay **Definition:** A **proposition** is a statement that is true or false. attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$

"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

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"you will find this course very easy"

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"or" operator: ∨ "not" function: ¬ "and" operator: \(\)

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attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

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 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg "you will find this course very easy"

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Variables: A, B, C, \ldots ,

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Variables: A, B, C, \ldots, P, Q, R

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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

 \neg ("You attend the lectures regularly" \wedge "you pay attention" \wedge "you clear your doubts in time") \rightarrow \neg "you will find this course very easy"

or false. "If you do not attend the lectures regularly or you do

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"and" operator: ∧ "if and only if" operator: \leftrightarrow

"implies" operator: \rightarrow "or" operator: ∨ "not" function:

Example:

Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

P := "You attend the courses regularly"

¬ ("You attend the lectures regularly" ∧ "you pay attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy"

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¬ ("You attend the lectures regularly" ∧ "you pay attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy"

"if and only if" operator: \leftrightarrow

Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

P := "You attend the courses regularly"

"implies" operator: \rightarrow "or" operator: ∨ "not" function: "and" operator: \(\)

Example:

Q := "You pay attention"

Definition: A **proposition** is a statement that is true or false. "If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult." "implies" operator: \rightarrow

Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

"or" operator: ∨ "not" function: "and" operator: \(\)

"if and only if" operator: \leftrightarrow

P := "You attend the courses regularly" Q := "You pay attention"

R := "You clear your doubts in time"

¬ ("You attend the lectures regularly" ∧ "you pay attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy"

Definition: A proposition is a statement that is true or false.

"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator: →
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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example: P := "You attend the courses regularly"

"and" operator: \(\)

"if and only if" operator: \leftrightarrow

Q := "You pay attention" R := "You clear your doubts in time"

R := "You clear your doubts in time" S := "You will find this course easy"

course easy

 \neg ("You attend the lectures regularly" \wedge "you pay attention" \wedge "you clear your doubts in time") \to ¬ "you will find this course very easy"

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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

P := "You attend the courses regularly"

Q:= "You pay attention"

R := "You clear your doubts in time"

S:= "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" gularly or you do

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Using these interpretations we get this expression

Definition: A **proposition** is a statement that is true or false. "If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult." "implies" operator: \rightarrow "or" operator: ∨ "not" function: "and" operator: \(\) "if and only if" operator: \leftrightarrow Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$ Example:

¬ ("You attend the lectures regularly" ∧ "you pay attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P$

P := "You attend the courses regularly"

Q := "You pay attention"

R := "You clear your doubts in time"

S := "You will find this course easy" $\neg (P \land Q \land R) \rightarrow \neg S$

But we know that the following expression is also equivalent

 $\neg (P \land Q \land R) \rightarrow \neg S$

"vou will find this course very easy" $\neg P \lor \neg Q$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

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P := "You attend the courses regularly"

R := "You clear your doubts in time" S := "You will find this course easy"

Q := "You pay attention"

 $\neg (P \land Q \land R) \rightarrow \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R$

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

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"if and only if" operator: ↔

"implies" operator: \rightarrow

Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

P := "You attend the courses regularly"

Q := "You plan your doubts in time"

R := "You clear your doubts in time"

S:= "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"vou will find this course very easy"

¬ "You attend the lectures regularly"

In natural language, it translates to this sentence

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P := "You attend the courses regularly"

R := "You clear your doubts in time" S := "You will find this course easy"

Q := "You pay attention"

 $\neg (P \land Q \land R) \rightarrow \neg S$

Example:

 \neg "You attend the lectures regularly" $\ \lor \ \neg$ "you pay attention"

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

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anables. $A, B, C, \ldots, I, Q, R, \ldots, A_1, A_2, \ldots$

Example: P := "You attend the courses regularly"

 $\neg (P \land Q \land R) \rightarrow \neg S$

Q := "You pay attention" R := "You clear your doubts in time" S := "You will find this course easy"

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time"

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

¬ ("You attend the lectures regularly" ∧ "you pay

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Q := "You pay attention"

R := "You clear your doubts in time" S := "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

"vou will find this course very easy"

"you will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

We will later see that we can always rewrite a the previous logical expression as this

S

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P$

¬ ("You attend the lectures regularly" ∧ "you pay

"vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P \wedge Q$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P \land Q \land R$

¬ ("You attend the lectures regularly" ∧ "you pay

Definition: A **proposition** is a statement that is true or false.

"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"or" operator: ∨
"not" function: ¬
"and" operator: ∧

"implies" operator: \rightarrow

"if and only if" operator: \leftrightarrow

Variables: $A, B, C, ..., P, Q, R, ..., A_1, A_2, ...$

Example:

P := "You attend the courses regularly"

Q := "You plant your doubts in time"

R:= "You clear your doubts in time"

S:= "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

"you will find this course very easy" ${\color{red} S} \rightarrow P \wedge Q \wedge R$

"If you find this course easy.

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

"vou will find this course very easy"

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \rightarrow P \land Q \land R$

¬ ("You attend the lectures regularly" ∧ "you pay

"If you find this course easy, then it implies you attend the lectures regularly,

 $\neg (P \land Q \land R) \rightarrow \neg S$

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P \land Q \land R$

¬ ("You attend the lectures regularly" ∧ "you pay

"If you find this course easy, then it implies you attend the lectures regularly, pay attention,

Definition: A **proposition** is a statement that is true or false. attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" "If you do not attend the lectures regularly or you do $\neg P \lor \neg Q \lor \neg R \to \neg S$ not pay attention or you do not clear your doubts in time then you will find this course very difficult." "implies" operator: \rightarrow "or" operator: ∨ "not" function: "and" operator: \(\) "if and only if" operator: Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$ Example: P := "You attend the courses regularly" Q := "You pay attention" R := "You clear your doubts in time" S := "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

¬ ("You attend the lectures regularly" ∧ "you pay

Definition: A **proposition** is a statement that is true or false.

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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator: \rightarrow "or" operator: ∨ "not" function:

"and" operator: \(\) "if and only if" operator:

Example:

P := "You attend the courses regularly"

Q := "You pay attention"

R := "You clear your doubts in time"

S := "You will find this course easy" $\neg (P \land Q \land R) \rightarrow \neg S$

P

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

$$\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay}$$

"vou will find this course very easy"

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

Do you think this expression is equivalent to the above?

Definition: A **proposition** is a statement that is true or false. attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult." "implies" operator: \rightarrow "or" operator: ∨ "not" function: "and" operator: \(\) "if and only if" operator: Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$ Example:

P := "You attend the courses regularly"

Q := "You pay attention" R := "You clear your doubts in time"

S := "You will find this course easy" $\neg (P \land Q \land R) \rightarrow \neg S$

"vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

¬ ("You attend the lectures regularly" ∧ "you pay

 $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q$

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R := "You clear your doubts in time" S := "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

 $P \wedge Q \wedge R$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"vou will find this course very easy"

"you will find this course very easy"

 $S \to P \land Q \land R$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

Definition: A **proposition** is a statement that is true or false. "If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult." "implies" operator: \rightarrow "or" operator: ∨ "not" function: "and" operator: \(\) "if and only if" operator:

Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

P := "You attend the courses regularly"

Q:= "You pay attention" R:= "You clear your doubts in time" S:= "You will find this course easy" $\neg(P \land Q \land R) \rightarrow \neg S$

doubts in time" $P \wedge Q \wedge R \rightarrow S?$

"you will find this course very easy"
$$S\to P\wedge Q\wedge R$$
 "If you find this course easy. then it implies you attend

the lectures regularly, pay attention, and clear your

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

¬ "You attend the lectures regularly" ∨ ¬ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

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"If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in time then you will find this course very difficult."

"implies" operator: \rightarrow "or" operator: \vee "not" function: \neg

Variables: $A, B, C, ..., P, Q, R, ..., A_1, A_2, ...$

Example:

P := "You attend the courses regularly"

Q := "You play attention"

R := "You clear your doubts in time"

S := "You will find this course easy"

 $\neg (P \land Q \land R) \rightarrow \neg S$

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

¬ "You attend the lectures regularly" ∨ ¬ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

"vou will find this course very easy"

"you will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

We will see later that it is not

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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example:

P := "You attend the courses regularly" Q := "You pay attention"

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 $\neg (P \land Q \land R) \rightarrow \neg S$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

"vou will find this course very easy"

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"you will find this course very easy"

$$S \to P \wedge Q \wedge R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

$$P \land Q \land R \rightarrow S$$
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"or" operator: ∨ "not" function:

"implies" operator: \rightarrow

"and" operator: \(\)

 $\neg (P \land Q \land R) \rightarrow \neg S$

"if and only if" operator:

Example:

P := "You attend the courses regularly"

Q := "You pay attention" R := "You clear your doubts in time"

S := "You will find this course easy"

You may attend the lectures regularly, pay attention,

¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

 $S \to P \land Q \land R$

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

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P := "You attend the courses regularly"

$$Q :=$$
 "You pay attention" $R :=$ "You clear your doubts in time"

$$R :=$$
 "You clear your doubts in time' $S :=$ "You will find this course easy" $\neg (P \land Q \land R) \rightarrow \neg S$

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

clear your doubts in time.

"you will find this course very easy"

 $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend

doubts in time" $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention,

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 $\neg (P \land Q \land R) \rightarrow \neg S$

¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

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attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

"vou will find this course very easy"

$$S \to P \land Q \land R$$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course!

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Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$

Example: P := "You attend the courses regularly"

Q := "You pay attention"

R := "You clear your doubts in time" S := "You will find this course easy"

this course! I might make the course very difficult!

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

$$\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay}$$

"vou will find this course very easy"

"you will find this course very easy" $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend

¬ ("You attend the lectures regularly" ∧ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

the lectures regularly, pay attention, and clear your doubts in time"

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow ¬ "you will find this course very easy"

$$\neg P \vee \neg Q \vee \neg R \to \neg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \land Q \land R \rightarrow S?$ Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Let us now change interpretations of the variables

P := "You will keep up with the lecture"

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow ¬ "you will find this course very easy"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

$$\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay}$$

attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

$$S \to P \wedge Q \wedge R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \to S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

P:= "You will keep up with the lecture" Q:= "You will find the lecture interesting"

 \neg ("You attend the lectures regularly" \wedge "you pay attention" \wedge "you clear your doubts in time") \rightarrow " "you will find this course very easy"

$$\neg P \vee \neg Q \vee \neg R \to \neg S$$
 \neg "You attend the lectures regularly" \vee \neg "you pay

attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q := "You will find the lecture interesting" R := "You will understand everything"

P := "You will keep up with the lecture"

attention" $\vee \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy" $S \to P \wedge Q \wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

¬ "You attend the lectures regularly" ∨ ¬ "you pay

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

$$\begin{split} R := & \text{``You will understand everything''} \\ S := & \text{``You pay attention''} \end{split}$$

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting"

attention" $\vee \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy" $S \to P \wedge Q \wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 $P \land Q \land R \to S?$ Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

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P:= "You will keep up with the lecture" Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" S

 \neg ("You attend the lectures regularly" \wedge "you pay attention" \wedge "you clear your doubts in time") \to \neg "you will find this course very easy"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P$

P := "You will keep up with the lecture"

"you will find this course very easy" $S\to P\wedge Q\wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

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 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

 $\begin{array}{ll} Q:=&\text{"You will find the lecture interesting"}\\ R:=&\text{"You will understand everything"}\\ S:=&\text{"You pay attention"}\\ S\to P\wedge Q \end{array}$

P := "You will keep up with the lecture"

 $S\to P\wedge Q\wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

"vou will find this course very easy"

"you will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

doubts in time" $P \wedge Q \wedge R \to S? \text{ Not necessarily!!}$

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$

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"you will find this course very easy" $S\to P\wedge Q\wedge R$ " If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

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 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

"vou will find this course very easy"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\begin{split} P := \text{ "You will keep up with the lecture"} \\ Q := \text{ "You will find the lecture interesting"} \\ R := \text{ "You will understand everything"} \\ S := \text{ "You pay attention"} \\ \frac{S}{>} P \land Q \land R \\ \text{"If you pay attention,} \end{split}$$

 \neg ("You attend the lectures regularly" \wedge "you pay attention" \wedge "you clear your doubts in time") \rightarrow \neg "you will find this course very easy"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

 $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your

$$P \wedge Q \wedge R \rightarrow S$$
? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Translates to this sentence in English

doubts in time"

$$P:=\text{ "You will keep up with the lecture"} \\ Q:=\text{ "You will find the lecture interesting"} \\ R:=\text{ "You will understand everything"} \\ S:=\text{ "You pay attention"} \\ S \to P \land Q \land R \\ \text{"If you pay attention, then you will keep up with the lecture,} \\ \end{cases}$$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ $\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay attention"} \lor \neg \text{ "you clear your doubts in time"} \to \neg \text{ "you will find this course very easy"}$ $S \to P \land Q \land R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your

"vou will find this course very easy"

doubts in time"

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

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P := "You will keep up with the lecture" Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting,

— "You attend the lectures regularly" \vee — "you pay attention" \vee — "you clear your doubts in time" \to — "you will find this course very easy" $S \to P \wedge Q \wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

"vou will find this course very easy"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

P := "You will keep up with the lecture" Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy" $S \to P \land Q \land R$ " If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

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 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

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Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P$$

clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

¬ ("You attend the lectures regularly" ∧ "you pay attention" \land "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\rightarrow \neg$

$$S \to P \land Q \land R$$
 "If you find this course easy, then it implies you attend

the lectures regularly, pay attention, and clear your doubts in time"

You may attend the lectures regularly, pay attention,

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

$$\begin{array}{ll} Q:=&\text{"You will find the lecture interesting"}\\ R:=&\text{"You will understand everything"}\\ S:=&\text{"You pay attention"}\\ S\to P\wedge Q\wedge R\\ &\text{"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"}\\ \neg P\vee \neg Q \end{array}$$

— "You attend the lectures regularly" \vee — "you pay attention" \vee — "you clear your doubts in time" \to — "you will find this course very easy" $S \to P \wedge Q \wedge R$ " If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

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attention" $\vee \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy" $S \to P \wedge Q \wedge R$ "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

¬ "You attend the lectures regularly" ∨ ¬ "you pay

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

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attention" \vee ¬ "you clear your doubts in time" \to ¬ "you will find this course very easy" $S \to P \wedge Q \wedge R$ " If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

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 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture,

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\lor \lnot$ "you clear your doubts in time" $\to \lnot$ "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

$$S \to P \land Q \land R$$
"If you find this

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \land Q \land R \rightarrow S?$ Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$ finding the lecture interesting,

P := "You will keep up with the lecture"

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy" $S \to P \land Q \land R$ "If you are not keeping up with the lecture, or you are not" If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

> You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

¬ ("You attend the lectures regularly" ∧ "you pay attention" \land "you clear your doubts in time") $\rightarrow \neg$

¬ "You attend the lectures regularly" ∨ ¬ "you pay

"vou will find this course very easy"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

everything"

finding the lecture interesting, or you do not understand

"you will find this course very easy" $S \to P \land Q \land R$ "If you are not keeping up with the lecture, or you are not" If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

"vou will find this course very easy"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

¬ ("You attend the lectures regularly" ∧ "you pay attention" \wedge "you clear your doubts in time") \rightarrow \neg

¬ "You attend the lectures regularly" ∨ ¬ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

$$P \wedge Q \wedge R \rightarrow S$$
? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

$$\begin{array}{ll} Q:=&\text{"You will find the lecture interesting"}\\ R:=&\text{"You will understand everything"}\\ S:=&\text{"You pay attention"}\\ S\to P\wedge Q\wedge R\\ &\text{"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"}\\ &\neg P\vee \neg Q\vee \neg R\to \neg S\\ &\text{"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."} \end{array}$$

d attention" \vee ¬ "you clear your doubts in time" \to ¬ "you will find this course very easy" $S \to P \wedge Q \wedge R$ not "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

"vou will find this course very easy"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 \neg ("You attend the lectures regularly" \land "you pay attention" \land "you clear your doubts in time") \rightarrow \neg

¬ "You attend the lectures regularly" ∨ ¬ "you pay

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

something, then you are not paying attention."

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg O \lor \neg R \rightarrow \neg S$

$$\neg F \lor \neg Q \lor \neg R \to \neg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\lor \lnot$ "you clear your doubts in time" $\to \lnot$ "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \land Q \land R \rightarrow S?$ Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Although each variable has an interpretation in natural language...

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

something, then you are not paying attention."

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \wedge Q \wedge R \to S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S \to P \wedge Q \wedge R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

something, then you are not paying attention."

attention" \land "you clear your doubts in time") \rightarrow ¬ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay

attention" $\lor \lnot$ "you clear your doubts in time" $\to \lnot$ "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $P \land Q \land R \rightarrow S?$ Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

something, then you are not paying attention."

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "you will find this course very easy" $\neg P \lor \neg O \lor \neg R \rightarrow \neg S$

 $S \to P \land Q \land R$

doubts in time"

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay

attention" \lor \lnot "you clear your doubts in time" \to \lnot "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

given the truth or falseness of the propositions that they are composed of.

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

finding the lecture interesting, or you do not understand

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

something, then you are not paying attention."

Let S denote the set of propositional variables.

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\neg F \lor \neg Q \lor \neg N \rightarrow \neg S$$

 \neg "You attend the lectures regularly"

¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$ "you will find this course very easy"

 \neg ("You attend the lectures regularly" \land "you pay

$$S o P \wedge Q \wedge R$$

"If you are not keeping up with the lecture, or you are not "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

> $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

So we bypass the natural language interpretations of the variables

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$

P := "You will keep up with the lecture"

"If you pay attention, then you will keep up with the

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not

everything"

finding the lecture interesting, or you do not understand something, then you are not paying attention."

lecture, find the lecture interesting, and understand

valuation is a function $\nu: S \to \{True, False, \}$.

Let S denote the set of propositional variables. Then a

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

 $S \to P \land Q \land R$

"vou will find this course very easy"

"you will find this course very easy"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention,

¬ ("You attend the lectures regularly" ∧ "you pay

attention" \wedge "you clear your doubts in time") $\rightarrow \neg$

¬ "You attend the lectures regularly" ∨ ¬ "you pay

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$
 "If you are not keeping up with the lecture, or you are not

finding the lecture interesting, or you do not understand something, then you are not paying attention."

valuation is a function $\nu: S \to \{True, False, \}$.

Let S denote the set of propositional variables. Then a

attention" \land "you clear your doubts in time") $\rightarrow \neg$ "vou will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$\neg$$
 "You attend the lectures regularly" $\lor \neg$ "you pay

"you will find this course very easy" $S \to P \land Q \land R$

attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

¬ ("You attend the lectures regularly" ∧ "you pay

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

 $\begin{array}{ll} Q:=& \text{"You will find the lecture interesting"}\\ R:=& \text{"You will understand everything"}\\ S:=& \text{"You pay attention"}\\ S\to P\wedge Q\wedge R\\ \text{"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"} \end{array}$

P := "You will keep up with the lecture"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

something, then you are not paying attention."

"If you are not keeping up with the lecture, or you are not

finding the lecture interesting, or you do not understand

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

attention" \land "you clear your doubts in time") \rightarrow ¬ "you will find this course very easy" $\neg P \lor \neg Q \lor \neg R \to \neg S$

$$eg P \lor
eg Q \lor
eg R o
eg S$$

 \neg "You attend the lectures regularly" $\lor \neg$ "you pay attention" $\lor \neg$ "you clear your doubts in time" $\to \neg$ "you will find this course very easy"

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$$S \to P \land Q \land R$$

"If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"

$$P \wedge Q \wedge R \rightarrow S$$
? Not necessarily!! You may attend the lectures regularly, pay attention, clear your doubts in time, but it may not be enough for this course! I might make the course very difficult!

R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$

everything"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

P := "You will keep up with the lecture" Q := "You will find the lecture interesting"

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

something, then you are not paying attention." Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

Q := "You will find the lecture interesting" R := "You will understand everything"

lecture, find the lecture interesting, and understand

P := "You will keep up with the lecture"

S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the

everything"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a valuation is a function $\nu:S \to \{True,False,\}.$

Semantic

S := "You pay attention"

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting" R := "You will understand everything"

 $S \to P \land Q \land R$

lecture, find the lecture interesting, and understand everything"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

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Semantic

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"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

lecture, find the lecture interesting, and understand

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting" R := "You will understand everything"

 $S \to P \land Q \land R$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

everything"

valuation is a function $\nu: S \to \{True, False, \}$.

P := "You will keep up with the lecture" Q := "You will find the lecture interesting"

Lure interestin

R := "You will understand everything" S := "You pay attention"

 $S \to P \land Q \land R$

lecture, find the lecture interesting, and understand everything"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

P := "You will keep up with the lecture" Q := "You will find the lecture interesting"

 $\hat{R}:=$ "You will understand everything"

S := "You pay attention" $S \to P \land Q \land R$

lecture, find the lecture interesting, and understand everything"

$$\neg P \vee \neg Q \vee \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

P := "You will keep up with the lecture" Q := "You will find the lecture interesting"

R := "You will understand everything"

S := "You pay attention"

$$S \to P \land Q \land R$$

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

$$\neg P \vee \neg Q \vee \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

R := "You will understand everything" S := "You pay attention" "If you pay attention, then you will keep up with the

lecture, find the lecture interesting, and understand everything"

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not

 $S \to P \land Q \land R$

finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

$$P :=$$
 "You will keep up with the lecture" $Q :=$ "You will find the lecture interesting"

$$R :=$$
 "You will understand everything"

$$S :=$$
 "You pay attention" $S \to P \land Q \land R$

$$S \to P \land Q \land R$$
 "If you pay attention, then you will keep up with the

lecture, find the lecture interesting, and understand everything"

$$\neg P \vee \neg Q \vee \neg R \to \neg S$$
 "If you are not keeping up with the lecture, or you are not

something, then you are not paying attention."

finding the lecture interesting, or you do not understand

Let S denote the set of propositional variables. Then a valuation is a function $\nu:S \to \{True,False,\}.$

P := "You will keep up with the lecture" Q := "You will find the lecture interesting" R := "You will understand everything"

S:= "You pay attention"

 $S \to P \land Q \land R$

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

Semantic

Р	-
Т	ı
F	-

 $\begin{array}{c|cccc} P & Q & P \wedge Q \\ \hline T & T & T \end{array}$

$$P :=$$
 "You will keep up with the lecture" $Q :=$ "You will find the lecture interesting"

R := "You will understand everything"

$$S:=$$
 "You pay attention"

$$S o P \wedge Q \wedge R$$

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$

Let S denote the set of propositional variables. Then a

valuation is a function $\nu: S \to \{True, False, \}$.

Semantic

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention"

P := "You will keep up with the lecture"

 $S \to P \land Q \land R$

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

Semantic

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$$S$$
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"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

P := "You will keep up with the lecture"

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Semantic

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Let S denote the set of propositional variables. Then a

"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

valuation is a function $\nu: S \to \{True, False, \}.$

F F F F

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$
 "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a valuation is a function $\nu: S \to \{True, False, \}$.

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything" P

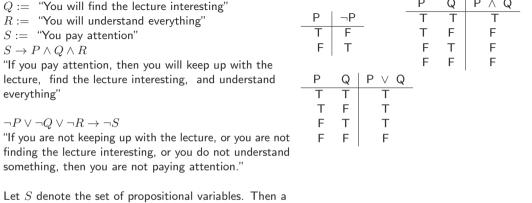
"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

 $\neg P \lor \neg Q \lor \neg R \to \neg S$

Let
$$S$$
 denote the set of propositional variables. Then a

valuation is a function $\nu: S \to \{True, False, \}$.

but now it is easier to define it by it can be false



Semantic

P := "You will keep up with the lecture"

valuation is a function $\nu: S \to \{True, False, \}$.

R:= "You will understand everything" S:= "You pay attention" $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting"

lecture, find the lecture interesting, and understand everything"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a valuation is a function $\nu: S \to \{True, False, \}$.

Semantic F

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand

something, then you are not paying attention."

P := "You will keep up with the lecture"

Q := "You will find the lecture interesting" R := "You will understand everything"

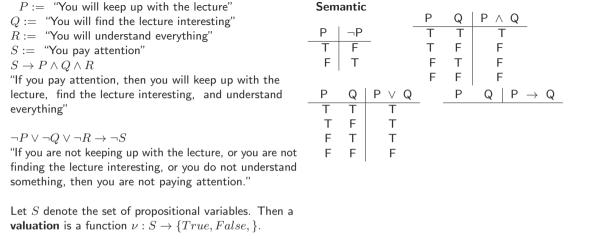
S := "You pay attention"

 $S \to P \land Q \land R$

Let S denote the set of propositional variables. Then a

valuation is a function $\nu: S \to \{True, False, \}$.

Again, it is better to understand it by asking when it can be "wrong"



Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" F $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Semantic

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

P := "You will keep up with the lecture"

everything"

An implication is false only if the assumption is true but what follows is still false

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" F $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not

Let S denote the set of propositional variables. Then a

finding the lecture interesting, or you do not understand

something, then you are not paying attention."

P := "You will keep up with the lecture"

valuation is a function $\nu: S \to \{True, False, \}$.

Semantic

Q := "You will find the lecture interesting" R := "You will understand everything" S := "You pay attention" F $S \to P \land Q \land R$ "If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not

Let S denote the set of propositional variables. Then a

something, then you are not paying attention."

P := "You will keep up with the lecture"

valuation is a function $\nu: S \to \{True, False, \}$.

Semantic finding the lecture interesting, or you do not understand $P \wedge Q \rightarrow R$

Let us consider a final and more complex example

Q:= "You will find the lecture interesting" R:= "You will understand everything" S:= "You pay attention" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the

P := "You will keep up with the lecture"

lecture, find the lecture interesting, and understand everything"

 $\neg P \vee \neg Q \vee \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a valuation is a function $\nu:S \to \{True,False,\}.$

Semantic F $P \wedge Q \mid P \wedge Q \rightarrow R$

 $\begin{array}{ll} P:=&\text{``You will keep up with the lecture''}\\ Q:=&\text{``You will find the lecture interesting''}\\ R:=&\text{``You will understand everything''}\\ S:=&\text{``You pay attention''}\\ S\to P\wedge Q\wedge R\\ \text{``If you pay attention, then you will keep up with the} \end{array}$

lecture, find the lecture interesting, and understand everything"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu:S\to \{True,False,\}.$

Semantic F $P \wedge Q \mid P \wedge Q \rightarrow R$

Q := "You will find the lecture interesting" R := "You will understand everything"

P := "You will keep up with the lecture"

S := "You pay attention" $S \to P \land Q \land R$

"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"

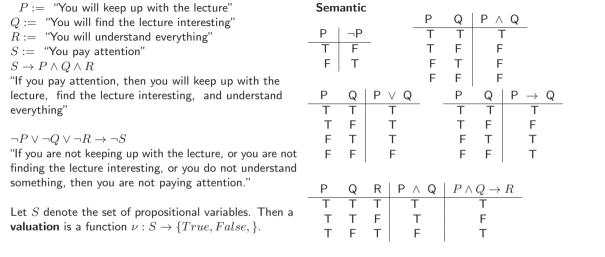
 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."

Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{True, False, \}$.

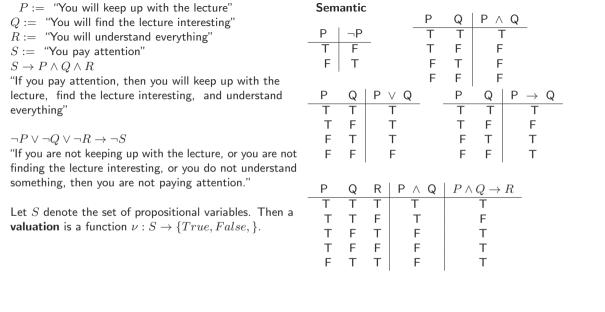
Semantic

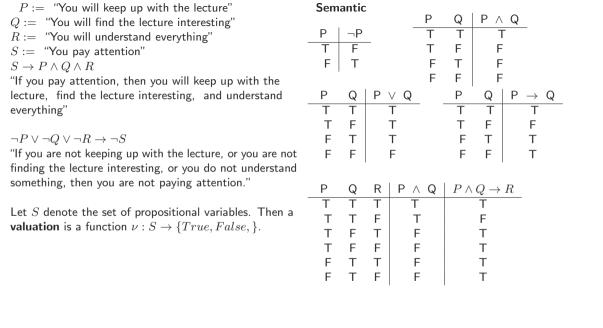
F

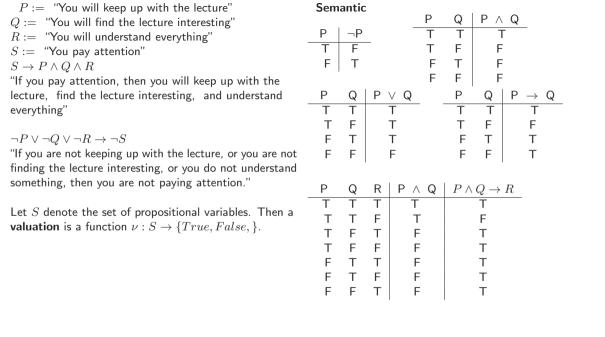
 $R \mid P \land Q \mid P \land Q \rightarrow R$

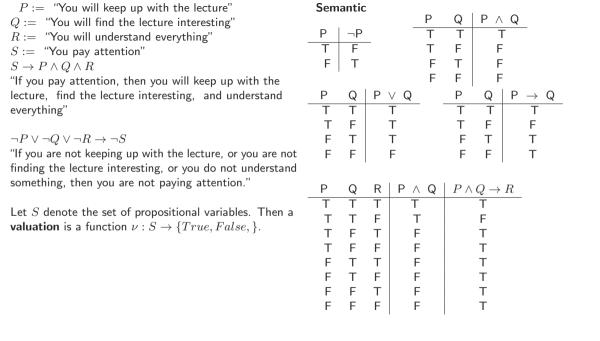


P := "You will keep up with the lecture"	Sem	antic	;					
Q := "You will find the lecture interesting"					Р	Q	P / 0	Ş
R := "You will understand everything"	Р	−P			Т	Т	Т	_
S := "You pay attention"	Т	F	_		Т	F	F	
$S \to P \wedge Q \wedge R$	F	Т			F	Т	F	
"If you pay attention, then you will keep up with the					F	F	F	
lecture, find the lecture interesting, and understand	Р	Q	Р	∨ Q		Р	Q F	$P \; o \; Q$
everything"	Т	Т		T	-	Т	Т	T
	Т	F		Т		Т	F	F
$\neg P \vee \neg Q \vee \neg R \to \neg S$	F	Т		Т		F	Т	Т
"If you are not keeping up with the lecture, or you are not	F	F		T F		F	F T F	Т
finding the lecture interesting, or you do not understand							· ·	
something, then you are not paying attention."	Р	Q	R	РΛ	Q	$P \wedge$	$Q \to R$	
	<u> </u>	Ť	T	T	~		T	_
Let S denote the set of propositional variables. Then a	т	T	F	т			F	
valuation is a function $\nu: S \to \{True, False, \}$.	Ť	F	Ť	F			Т	
	Ť	F	F	T F F			Ť	
		•	•				•	







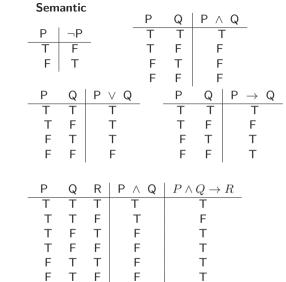


Sem	antic								
				Ρ	Q	PΛ	Q		
Р	−P			Т	Т	٦	_	_	
Т	F	_		Т	F	F			
F	Т			F	Т	F			
'				F	F	F			
Р	Q	Р	∨ Q		Р	Q	Р	\rightarrow	Q
Т	Т		Т		Т	Т		Т	
Т	F		Т		Т	F		F	
F	Т		Т		F	Т		F T	
F	F		F		F	F		Т	
							l		
Р	Q	R	P ^	Q	$P \wedge$	$Q \to$	R		
Т	Т	Т	Т			Т			
Т	Т	F	Т	-		F			
Т	F	Т	F			Τ			
Т	F	F	F	:		Τ			
F	Т	Т	F	:		Τ			
F	Т	F	F	:		Т			
F	F	Т	1			Т			
F	F	F	F	:		Т			
			1		1				

We now consider the syntactic side

Sem	antic			Р	Q	Р∧	Q		
Р	$\neg P$		_	<u>.</u> Т	T	٠ / ١		_	
T	F	_		Т	F	F			
F	Т			F	Т	F			
'				F	F	F			
Р	Q	Ρ	∨ Q		Р	Q	Р	\rightarrow	Q
Т	Т		Т		Т	Т		Т	
Т	F		Т		Т	F		F	
F	Т		Т		F	Т		Т	
F	F		F		F	F		Т	
Р	Q	R	P ^	Q	$P \wedge$	$Q \rightarrow$	R		
Т	Ť	Т	Т			T			
Т	Т	F	Т	-		F			
Т	F	Т	F	:		Т			
Т	F	F	F	:		Т			
F	Т	Т	F			Т			
F	Т	F	F			Т			
F	F	Т	F	:		Т			
F	F	F	F	:		Т			

where we are not concerned with the syntactic means

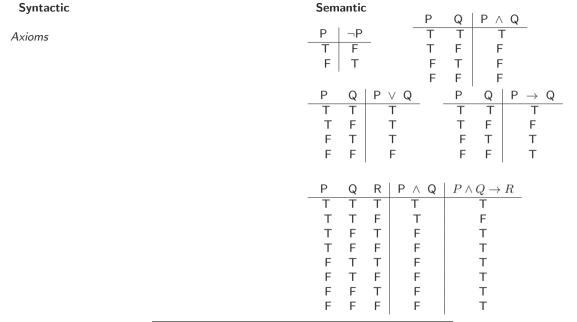


but merely they relate with each other.

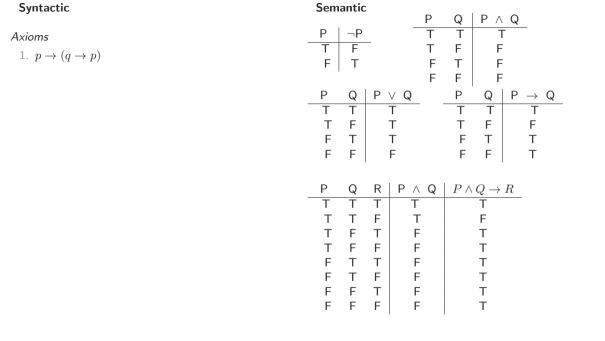
F F T

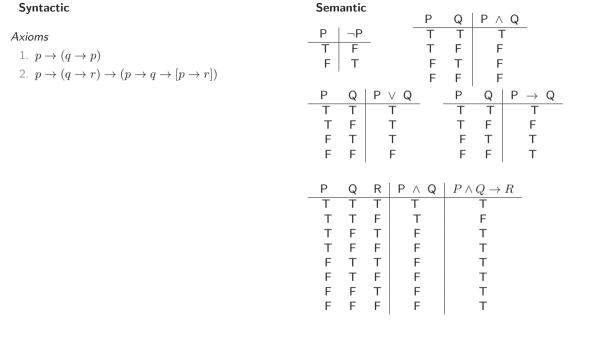
Sem	antic			_	_				
			_	Р	Q	P ^	Q	_	
Р	$\neg P$			Т	Т	7	Γ		
Т	F			Т	F	F			
F	Т			F	Т	F			
'				F	F	F			
Р	Q	Р	∨ Q		Р	Q	Р	\rightarrow	(
Т	Т		Т	-	Т	Т		Т	_
Т	F		Т		Т	F		F	
F	Т		Т		F	Т		Т	
F	F		F		F	F		Т	
	. 1		•		·	·	l		
Р	Q	R	P /	Q	$P \wedge$	$Q \rightarrow$	R		
Т	Т	Т	Т			Т			
Т	Т	F	٦	Г		F			
Т	F	Т	F	=		Т			
Т	F	F	F	=		Т			
_	_	_	_	_		_			

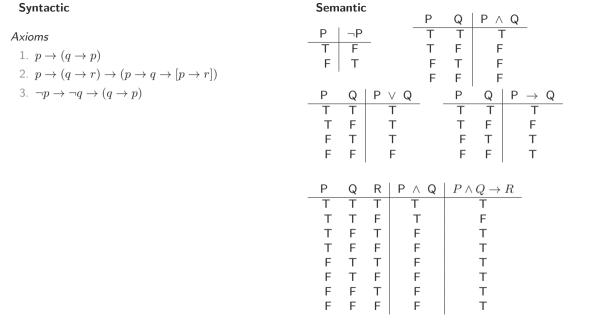
Yet, as we will see, we will be able to prove everything that we could have derived from truth tables

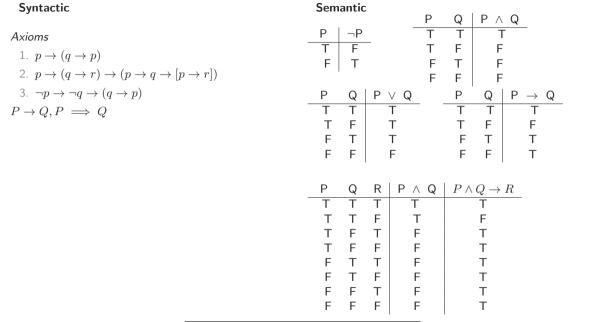


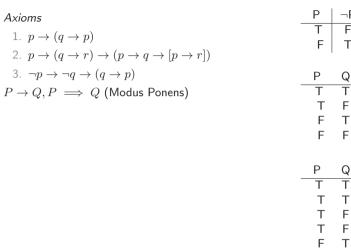
In the next lecture we will be introduced to these axioms











Т	F		Т	F	F	:
F	Т		F	Т	F	:
			F	F	F	
Р	Q	Р	√ Q	Р	Q	Р
Т	Т		Т	Т	Т	
Т	F			Т	F	
F	F T		T T	F	Т	
F	F		F	F	F	
						'
Р	Q	R	$P \wedge Q$	$P \wedge$	$Q \rightarrow$	R
Т	Q T	R	P ∧ Q	$P \wedge$	$\frac{Q o}{T}$	R
Т		Т	Т	$P \wedge$	Т	R
Т	Т	Т	Т	$P \wedge$	Т	R
T T T	T T	T F T	Т	$P \wedge$	T F T	R
Т	T T F	T F T F	Т	$P \wedge$	T F T	R
T T T T	T F F T	T F T F	Т	$P \wedge$	T F T	R
T T T F	T F F T	T F T F	T F F F	$P \wedge$	T F T	R
T T T T	T F F T	T F T F	Т	$P \wedge$	Т	R

Semantic