

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 $% \left(1\right) =\left(1\right) \left(1\right) =\left(1\right) \left(1\right)$

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

 $\ensuremath{\textbf{Definition:}}$ A $\ensuremath{\textbf{proposition}}$ 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

"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:

"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

"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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Definition: A **proposition** is a statement that is true "You do n or false. "or pay attent time" \ "''e

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"implies" operator: ightarrow

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

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

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"implies" operator: →
"or" operator: ∨

or false.

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

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

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

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:

¬ "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"

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

"implies" operator: →
"or" operator: ∨
"not" function: ¬

Now we will introduce an operator we do not strictly need

 \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."

"or" operator: ∨ "not" function: ¬

"implies" operator: \rightarrow

"and" operator:

"you will find this course very easy"

Definition: A **proposition** is a statement that is true \neg "You attend the lectures regularly" $\lor \neg$ "you pay or false. \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"

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

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ots in

 \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."

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

"implies" operator: \rightarrow

"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

 \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"

"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: ∧
"if and only if" operator:

"implies" operator: \rightarrow

 \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"

"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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"or" operator: ∨
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"and" operator: ∧

"implies" operator: \rightarrow

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

Variables: A, B, C, \ldots ,

 \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"

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"or" operator: ∨
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"and" operator: ∧
"if and only if" operator: ↔

"implies" operator: \rightarrow

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

 \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"

"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: ∨
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"implies" operator: \rightarrow

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

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

 \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"

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"not" function: \neg "and" operator: \land

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

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

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."

"not" function: "and" operator: ∧ "if and only if" operator: \leftrightarrow

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Example:

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

P := "You attend the courses regularly"

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

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

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."

"and" operator: \(\) "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"

Q := "You pay attention"

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

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"

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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: →

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

Example:

P := "You attend the courses regularly"

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

"if and only if" operator: \leftrightarrow

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

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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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"

S := "You will find this 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"

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

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

¬ ("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." "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:

 \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" $\neg P$

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

S := "You will find this course easy"

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

 $\neg P \lor \neg Q$

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

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

"vou will find this course very easy"

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

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

In natural language, it translates to this sentence

¬ ("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"

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

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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" \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"

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

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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" ∨ ¬ "you 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" \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"

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: P := "You attend the courses regularly"

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

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

¬ ("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"

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

S

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

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

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

"vou will find this course very easy"

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" $S \to P \wedge Q$

¬ ("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" $S \to P \land Q \land R$

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

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

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:

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

In natural language, it is this

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" \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"

¬ ("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,

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

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

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"

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

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

 \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"

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

"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") $\rightarrow \neg$

P

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: $S \to P \land Q \land R$ "and" operator: \(\) "if and only if" operator: Variables: $A, B, C, \ldots, P, Q, R, \ldots, A_1, A_2, \ldots$ $P \wedge Q$ 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"

"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.

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

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:

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

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 "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"

"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") $\rightarrow \neg$

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

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

 $P \wedge Q \wedge R$

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

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:

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

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

 $\neg P \vee \neg Q \vee \neg R \to \neg S$ $\neg \text{ "You attend the lectures regularly"} \vee \neg \text{ "you pay attention"} \vee \neg \text{ "you clear your doubts in time"} \to \neg \text{ "you will find this course very easy"}$

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

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

"vou 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

the lectures regularly, pay attention, and clear your doubts in time"
$$P \wedge Q \wedge R \to S?$$

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"

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

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

"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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Example:

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

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S := "You will find this course easy"

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

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

"vou will find this course very easy"

¬ "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") $\rightarrow \neg$

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

"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, or false.

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

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

time then you will find this course very difficult."

"implies" operator: →
"or" operator: ∨
"not" function: ¬

"and" operator: \(\triangle \)

"if and only if" operator: \leftrightarrow Variables: $A, B, C, \dots, P, Q, R, \dots, A_1, A_2, \dots$

Example:

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

 $\neg P \vee \neg Q \vee \neg R \to \neg S$ $\neg \text{ "You attend the lectures regularly"} \vee \neg \text{ "you pay attention"} \vee \neg \text{ "you clear your doubts in time"} \to \neg \text{ "you will find this course very easy"}$

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

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

"vou 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, or false. "If you do not attend the lectures regularly or you do not pay attention or you do not clear your doubts in

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

time then you will find this course very difficult." "implies" operator: \rightarrow

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

"and" operator: \(\)

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

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"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "you pay attention" $\vee \neg$ "you clear your doubts in time" $\rightarrow \neg$

"vou will find this course very easy"

"you will find this course very easy"

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

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

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

clear your doubts in time.

"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,

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."

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

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

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

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") $\rightarrow \neg$

"vou 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!

And here is why it is necessarily 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

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

time then you will find this course very difficult."

"implies" operator: \rightarrow

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$$\land$$

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

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$$S:=$$
 "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

"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

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

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!

 \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 \neg "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"

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

"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!

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 ¬ "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

"vou will find this course very easy"

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

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

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

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

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

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"

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

 $P \wedge Q \wedge R \rightarrow S?$ 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!

 \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

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!

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

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

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ $\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay attention"} \lor \neg \text{ "you clear your doubts in time"} \to \neg$ "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

"vou will find this course very easy"

the lectures regularly, pay attention, and clear your doubts in time" $P \wedge Q \wedge R \to S? \text{ Not necessarily!!}$

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

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!

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

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"

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

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

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

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

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

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

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

 $P \wedge Q \wedge R \rightarrow S$? 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!

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

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

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

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

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

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" $S\to P\wedge Q\wedge R$ "If you pay attention, then you will keep up with the ecture, find the lecture interesting,
octors, ma the lecture medicating,

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

 $P \wedge Q \wedge R \rightarrow S$? 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!

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"

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

"vou will find this course very easy"

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

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

$$\neg P$$

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

¬ ("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" $\rightarrow \neg$

"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"

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

— "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

"vou will find this course very easy"

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

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

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!

¬ "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

"vou will find this course very easy"

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

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

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!

¬ "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

"vou will find this course very easy"

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

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, $% \left(1\right) =\left(1\right) \left(1\right) \left$

attention" \wedge "you clear your doubts in time") $\to \neg$ "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" $\lor \lnot$ "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"

 $P \wedge Q \wedge R \rightarrow S$? 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" $S \to P \land Q \land R$ "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"

¬ "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 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!

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

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

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

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

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

finding the lecture interesting, or you do not understand

something

 $S \to P \land Q \land R$ the lectures regularly, pay attention, and clear your doubts in time"

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

attention" $\vee \neg$ "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"

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

 $P \wedge Q \wedge R \rightarrow S$? 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!

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

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

"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

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"

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

"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" $\neg P \lor \neg Q \lor \neg R \rightarrow \neg S$

$$\neg$$
 "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

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

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

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

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

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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

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

$$- \text{"Vow attend the lecture}$$

 \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

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

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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

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

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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

something, then you are not paying attention."

attention" \land "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

doubts in time"

attention" \vee ¬ "you clear your doubts in time" \to ¬ "you will find this course very easy" $S \to P \wedge Q \wedge R$

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

 $P \wedge Q \wedge R \to S? \text{ Not necessarily!!}$ 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!

"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"

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

something, then you are not paying attention."

Let ${\cal S}$ denote the set of propositional variables.

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

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

 \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"

 $P \land Q \land R \rightarrow S?$ 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"

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

something, then you are not paying attention."

Let S denote the set of propositional variables. Then a

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

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

"vou will find this course very easy"

"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"

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

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

attention" \wedge "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!

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."

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

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

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

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

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"

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

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

everything"

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 $\nu: S \to \{T, F\}$. if,

lecture, find the lecture interesting, and understand

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

doubts in time"

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

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

"you will find this course very easy"

"vou will find this course very easy"

 \neg ("You attend the lectures regularly" \land "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" $\rightarrow \neg$

"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!

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

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

lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg Q \lor \neg R \to \neg S$

1. $\nu(\neg p) = F \text{ iff } \nu(p) = T$

something, then you are not paying attention."

Let S denote the set of propositional variables. Then a

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

not "If you find this course easy, then it implies you attend the lectures regularly, pay attention, and clear your doubts in time"
$$P \wedge Q \wedge R \rightarrow S? \text{ Not necessarily!!}$$

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!

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

"you will find this course very easy"

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

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

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"

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

something, then you are not paying attention."

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

1.
$$\nu(\neg p) = F \text{ iff } \nu(p) = T$$

1.
$$\nu(\neg p) = F$$
 iff $\nu(p) = I$
2. $\nu(p \land q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ $\neg \text{ "You attend the lectures regularly"} \lor \neg \text{ "you pay attention"} \lor \neg \text{ "you clear your doubts in time"} \to \neg$

"vou will find this course very easy"

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

$$P \wedge Q \wedge R \rightarrow S$$
? 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!

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

"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"

R := "You will understand everything"

S := "You pay attention"

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

everything"

valuation is a function
$$\nu:S \to \{T,F\}$$
. if,
 1. $\nu(\neg p)=F$ iff $\nu(p)=T$

Let S denote the set of propositional variables. Then a

2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

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

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

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

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

"vou will find this course very easy"

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

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!

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ "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 $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$ 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$

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

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

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

everything"

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"

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

attention" \wedge "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!

"vou will find this course very easy"

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

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 $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$ 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$ 5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q).$

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

Q := "You will find the lecture interesting"

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "You attend the lectures regularly" ∨ ¬ "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!

"you will find this course very easy"

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

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

Q := "You will find the lecture interesting" attention" \wedge "you clear your doubts in time") $\rightarrow \neg$ R := "You will understand everything" "you will find this course very easy" 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 $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$ 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$ 5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q)$. F

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

 $\neg P \lor \neg Q \lor \neg R \to \neg S$ ¬ "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" $S \to P \land Q \land R$ "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!

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

"If you are not keeping up with the lecture, or you are not "If you find this course easy, then it implies you attend finding the lecture interesting, or you do not understand the lectures regularly, pay attention, and clear your something, then you are not paying attention." doubts in time" 1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$ 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$ 5. $\nu(p\leftrightarrow q)=T$ iff $\nu(p)-\nu(q)$. F A valuation is, therefore, determined by its value on variables.

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

R := "You will understand everything"

S := "You pay attention"

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

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

everything"

 $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{T, F\}$. if,

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" \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" $\rightarrow \neg$

"you will find this course very easy"

"you will find this course very easy"

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

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

"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." doubts in time" $P \wedge Q \wedge R \rightarrow S$? Not necessarily!! Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{T, F\}$. if, You may attend the lectures regularly, pay attention,

1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

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

R := "You will understand everything"

S := "You pay attention"

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

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

everything"

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T$ iff $\nu(p) = \nu(q)$. FOR Observe that if there are n variables, then then there are 2^n different valuations

this course! I might make the course very difficult!

clear your doubts in time, but it may not be enough for

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

$$\neg$$
 "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

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

"you will find this course very easy"

lecture, find the lecture interesting, and understand everything" $\neg P \lor \neg O \lor \neg R \to \neg S$

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

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

valuation is a function $\nu: S \to \{T, F\}$. if,

1.
$$\nu(\neg p) = F$$
 iff $\nu(p) = T$
2. $\nu(p \land q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p\vee q)=F$$
 iff $\nu(p)=F$, and $\nu(q)=F$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$
5. $\nu(p \leftrightarrow q) = T$ iff $\nu(p) = \nu(q)$. F

$$\begin{array}{ll} Q:= \text{ "You will find the lecture interesting"} \\ R:= \text{ "You will understand everything"} \\ S:= \text{ "You pay attention"} \\ S \to P \wedge Q \wedge R \\ \text{"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand everything"} \\ \neg P \vee \neg Q \vee \neg R \to \neg S \\ \text{"If you are not keeping up with the lecture, or you are not finding the lecture interesting, or you do not understand something, then you are not paying attention."} \\ \text{Let S denote the set of propositional variables. Then a valuation is a function $\nu: S \to \{T, F\}$. if,} \\ 1. \ \nu(\neg p) = F \text{ iff } \nu(p) = T \\ 2. \ \nu(p \wedge q) = T \text{ iff } \nu(p) = T, \text{ and } \nu(q) = F \\ 3. \ \nu(p \vee q) = F \text{ iff } \nu(p) = F, \text{ and } \nu(q) = F \\ 4. \ \nu(p \to q) = F \text{ iff } \nu(p) = T, \text{ and } \nu(q) = F \\ 5. \ \nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q), \ F \\ \end{array}$$

Semantic

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

S := "You pay attention"

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

1. $\nu(\neg p) = F$ iff $\nu(p) = T$

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

everything"

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

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

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

everything"

"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 $\nu:S\to \{T,F\}$. if,

something, then you are not paying attention."

1. $\nu(\neg p) = F \text{ iff } \nu(p) = T$

2. $\nu(p \land q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

If $\nu(p) = T$, and $\nu(q) = T$

3. $\nu(p \lor q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$

4. $\nu(p \to q) = F \text{ iff } \nu(p) = T \text{, and } \nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q) - F$

This is the "semantic" side, as opposed to the "syntactic" side that we will see later.

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

Semantic

 $\neg P$

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

finding the lecture interesting, or you do not understand

1.
$$\nu(\neg p) = F$$
 iff $\nu(p) = T$

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"

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

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

everything"

2.
$$\nu(p \land q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$
3. $\nu(p \lor q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q) - F$

$$\nu(q) = F$$

"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 $\nu:S\to \{T,F\}$. if,
$$1. \ \nu(\neg p)=F \ \text{iff} \ \nu(p)=T$$

$$2. \ \nu(p\wedge q)=T \ \text{iff} \ \nu(p)=T, \ \text{and} \ \nu(q)=T$$

It will have just two possible functions, so we will have 2 rows

Semantic

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

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

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

3. $\nu(p \lor q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(\underline{p}) = \nu(q) - F$

S := "You pay attention"

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

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

everything"

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

Semantic

something, then you are not paying attention."

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

valuation is a function $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$

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

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

S := "You pay attention"

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

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

everything"

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

$$4 \quad v(n \rightarrow a) = F \text{ iff } v(n) = T \text{ and } v(a) = F$$

4.
$$\nu(p \rightarrow q) = F \text{ iff } \nu(p) = T \text{, and } \nu(q) = F$$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q), \ F$

If the input is T, the output is F

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

Semantic

"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"

S := "You pay attention"

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

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

something, then you are not paying attention." 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

valuation is a function $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

4. $\nu(p \to q) = F$ iff $\nu(p) = T$ and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q), \ F$

If the input is
$$F$$
, the output is T

"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 $\nu: S \to \{T, F\}$. if,
$$1. \ \nu(\neg p) = F \ \text{iff} \ \nu(p) = T$$
$$2. \ \nu(p \land q) = T \ \text{iff} \ \nu(p) = T, \ \text{and} \ \nu(q) = T$$
$$3. \ \nu(p \lor q) = F \ \text{iff} \ \nu(p) = F, \ \text{and} \ \nu(q) = F$$
$$4. \ \nu(p \to q) = F \ \text{iff} \ \nu(p) = T, \ \text{and} \ \nu(q) = F$$
$$5. \ \nu(p \leftrightarrow q) = T \ \text{iff} \ \nu(p) = \nu(q), \ F$$
Operators like \land will have two arguments

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

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

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

S := "You pay attention"

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

everything"

_

$$\neg P \lor \neg Q \lor \neg R \to \neg S$$
"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 $\nu: S \to \{T, F\}$. if,

1. $\nu(\neg p) = F$ iff $\nu(p) = T$

2. $\nu(p \land q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

3. $\nu(p \lor q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$

4. $\nu(p \to q) = F$ iff $\nu(p) = T$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T$ iff $\nu(p) = \nu(q) = F$

so 4 different valuations, represented as 4 rows

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

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

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

S := "You pay attention"

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

everything"

1 1

Semantic

· 1

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

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

lecture, find the lecture interesting, and understand everything"

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

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

1.
$$\nu(\neg p) = F$$
 iff $\nu(p) = T$

something, then you are not paying attention."

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p \vee q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

$$A \quad u(n \rightarrow a) = F \text{ iff } u(n) = T \text{ and } u(a) = F$$

4.
$$\nu(p \rightarrow q) = F \text{ iff } \nu(p) = T \text{, and } \nu(q) = F$$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(n) = \nu(q) - F$

Semantic

The first row is easy because keeping the usual interpretation of land

"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 $\nu:S\to\{T,F\}$. if,
$$1. \ \nu(\neg p)=F \ \text{iff} \ \nu(p)=T$$

$$2. \ \nu(p\land q)=T \ \text{iff} \ \nu(p)=T, \ \text{and} \ \nu(q)=T$$

$$3. \ \nu(p\lor q)=F \ \text{iff} \ \nu(p)=F, \ \text{and} \ \nu(q)=F$$

$$4. \ \nu(p\to q)=F \ \text{iff} \ \nu(p)=T, \ \text{and} \ \nu(q)=F$$

$$5. \ \nu(p\leftrightarrow q)=T \ \text{iff} \ \nu(p)=\frac{\nu(q)}{T} \ F$$
 The output should be true if both P and Q are true

Semantic

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

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

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

S := "You pay attention"

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

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

everything"

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 $\nu: S \to \{T, F\}$. if,
$$1. \ \nu(\neg p) = F \ \text{iff} \ \nu(p) = T$$

$$2. \ \nu(p \land q) = T \ \text{iff} \ \nu(p) = T, \ \text{and} \ \nu(q) = T$$

$$3. \ \nu(p \lor q) = F \ \text{iff} \ \nu(p) = F, \ \text{and} \ \nu(q) = F$$

$$4. \ \nu(p \to q) = F \ \text{iff} \ \nu(p) = T, \ \text{and} \ \nu(q) = F$$

$$5. \ \nu(p \leftrightarrow q) = T \ \text{iff} \ \nu(p) = \nu(q), \ F$$
 But false in all other circumstances

Semantic

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

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

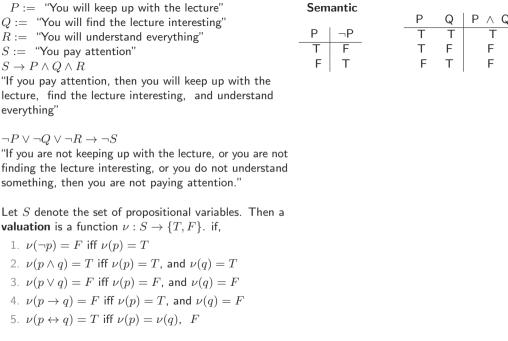
"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

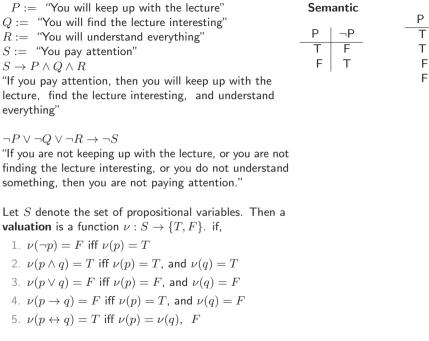
S := "You pay attention"

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

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

everything"





1. $\nu(\neg p) = F$ iff $\nu(p) = T$

valuation is a function $\nu: S \to \{T, F\}$. if,

something, then you are not paying attention."

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

O := "You will find the lecture interesting"

$$2 \quad \nu(n \land a) = T \text{ iff } \nu(n) = T \text{ and } \nu(a) = T$$

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

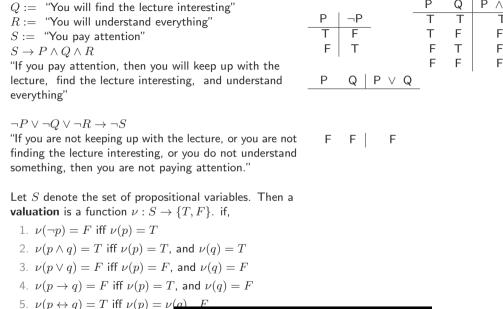
4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

Let S denote the set of propositional variables. Then a

and
$$\nu(q) = F$$

5.
$$\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q) = F$$

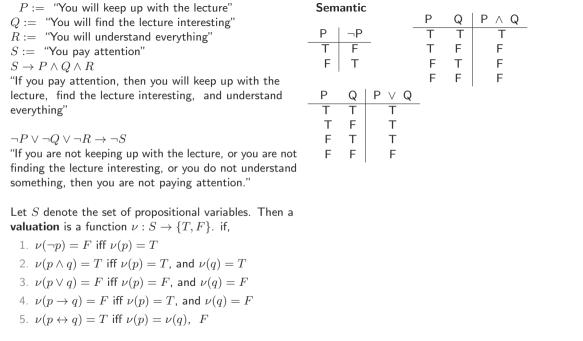
The "or" operator has the same number of arguments



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

Semantic

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



3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$

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

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

S := "You pay attention"

1. $\nu(\neg p) = F$ iff $\nu(p) = T$

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

everything"

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q), F$

The trickiest one is "implies"

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 $\nu: S \to \{T, F\}$. if,

1.
$$\nu(\neg p) = F$$
 iff $\nu(p) = T$

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

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

2.
$$\nu(p \wedge q) = T \text{ iff } \nu(p) = T \text{, and } \nu(q) = T$$

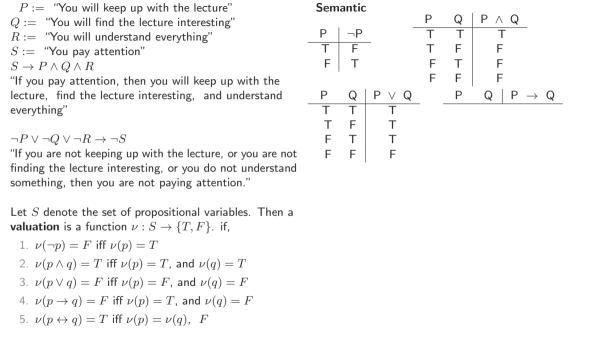
3.
$$\nu(p \vee q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

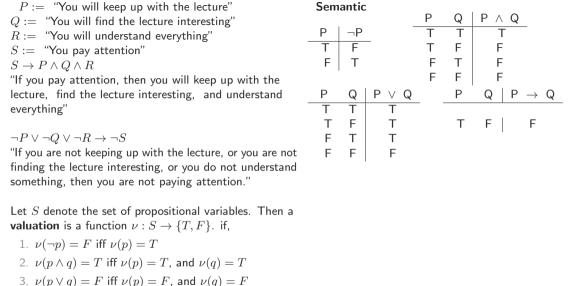
$$A \quad v(n) = F \text{ iff } v(n) = T \text{ and } v(n) = T$$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = I$, and $\nu(q) = F$
5. $\nu(p \leftrightarrow q) = T$ iff $\nu(p) = \nu(q) = F$

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





4.
$$\nu(p \to q) = F \text{ iff } \nu(p) = T \text{, and } \nu(q) = F$$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = T$
5. $\nu(p \leftrightarrow q) = T$ iff $\nu(n) = \nu(q) = F$

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

Semantic

1. $\nu(\neg p) = F$ iff $\nu(p) = T$

valuation is a function $\nu: S \to \{T, F\}$. if,

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

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

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

Let S denote the set of propositional variables. Then a

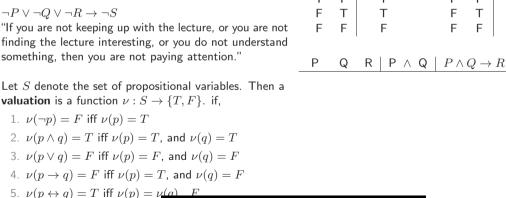
2.
$$\nu(p \land q) = 1 \text{ iff } \nu(p) = 1, \text{ and } \nu(q) = 1$$

3.
$$\nu(p \vee q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

$$A = u(m + a) - F \text{ iff } u(m) - T \text{ and } u(a) - T$$

4.
$$\nu(p \to q) = F$$
 iff $\nu(p) = T$, and $\nu(q) = F$

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(n) = \nu(q)$ However, if P is false, the implication does not "apply", so it is still "vaccuously" true



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

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

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

S := "You pay attention"

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

everything"

Let us consider a final and more complex example

Semantic

F

 $R \mid P \land Q \mid P \land Q \rightarrow R$ Let S denote the set of propositional variables. Then a 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$

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

valuation is a function $\nu: S \to \{T, F\}$. if,

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

1.
$$\nu(\neg p) = F \text{ iff } \nu(p) = T$$

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

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

S := "You pay attention"

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

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

everything"

2.
$$\nu(p \wedge q) = T$$
 iff $\nu(p) = T$, and $\nu(q) = T$

3.
$$\nu(p \lor q) = F$$
 iff $\nu(p) = F$, and $\nu(q) = F$

$$A \cdot u(n \rightarrow a) = F \text{ iff } u(n) = T \text{ and } u(a) = I$$

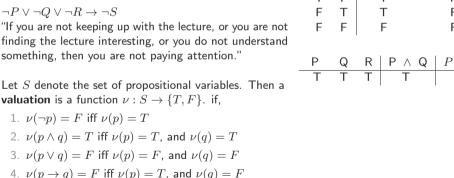
5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q) - F$

4.
$$\nu(p \to q) = F \text{ iff } \nu(p) = T \text{, and } \nu(q) = F$$

We use the "and" truth table to figure out the
$$T$$

Semantic

F



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

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

5. $\nu(p \leftrightarrow q) = T \text{ iff } \nu(p) = \nu(q) - F$

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

S := "You pay attention"

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

everything"

Semantic

F

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." $R \mid P \land Q \mid P \land Q \rightarrow R$ Let S denote the set of propositional variables. Then a **valuation** is a function $\nu: S \to \{T, F\}$. if, 1. $\nu(\neg p) = F$ iff $\nu(p) = T$ 2. $\nu(p \wedge q) = T$ iff $\nu(p) = T$, and $\nu(q) = T$ 3. $\nu(p \vee q) = F$ iff $\nu(p) = F$, and $\nu(q) = F$ 4. $\nu(p \to q) = F$ iff $\nu(p) = T$ and $\nu(q) = F$

Now see if you can see why each of the rest of the rows are correct

Semantic

F

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

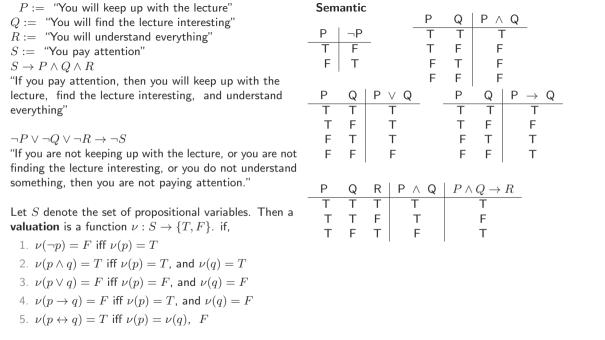
Q := "You will find the lecture interesting" R := "You will understand everything"

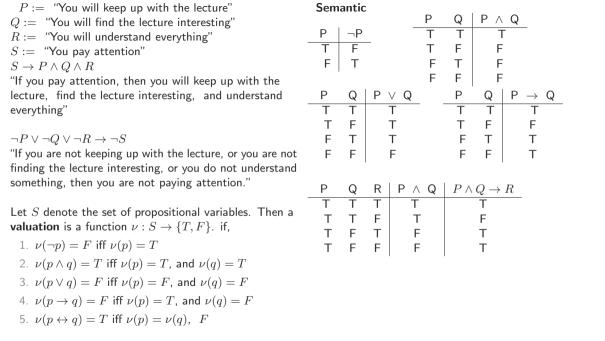
5. $\nu(p \leftrightarrow q) = T \text{ iff } \underline{\nu(n)} = \nu(q) - F$

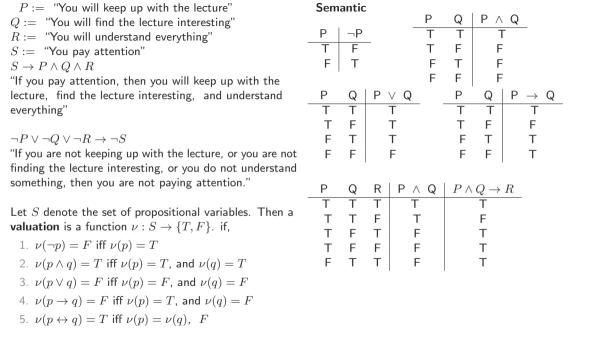
"If you pay attention, then you will keep up with the lecture, find the lecture interesting, and understand

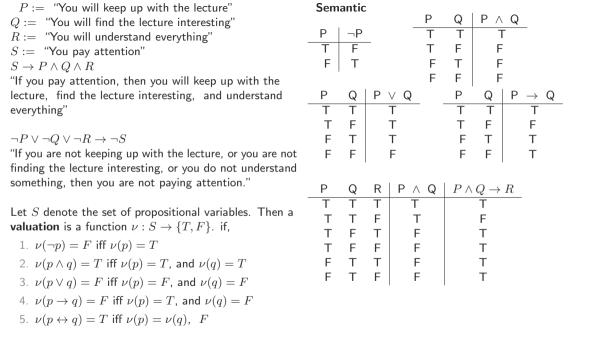
S := "You pay attention"

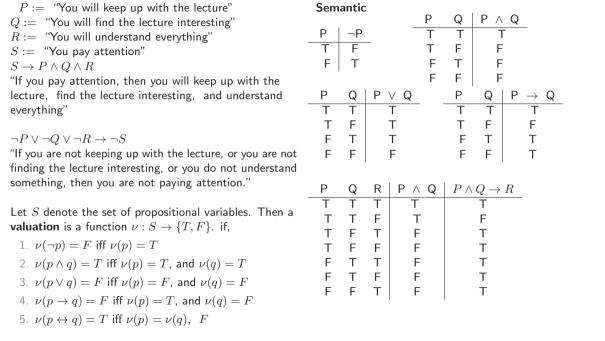
 $S \to P \land Q \land R$

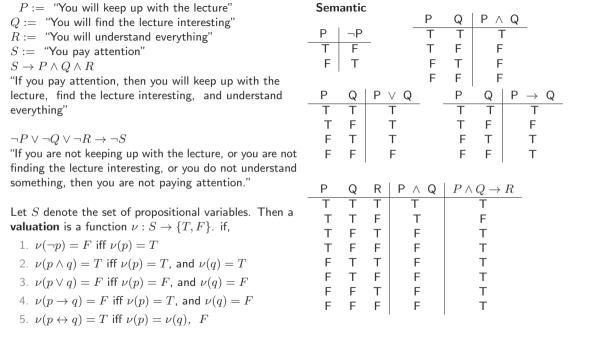










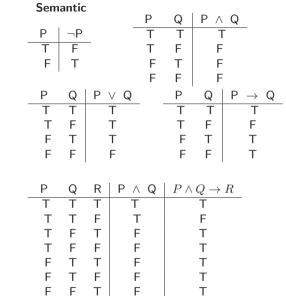


Sem	antic								
				Ρ	Q	PΛ	Q		
Р	−P			Т	Т	٦	_	_	
Т	F	_		Т	F	F			
F	Т			F	Т	F			
'				F	F	F			
Р	Q	Р	∨ Q		Р	Q	Р	\rightarrow	Q
Т	Т		Т		Т	Т		Т	
Т	F		Т		Т	F		F	
F	Т		Т		F	Т		F T	
F	F		F		F	F		Т	
							l		
Р	Q	R	P ^	Q	$P \wedge$	$Q \to$	R		
Т	Т	Т	Т			Т			
Т	Т	F	Т	-		F			
Т	F	Т	F			Τ			
Т	F	F	F	:		Τ			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

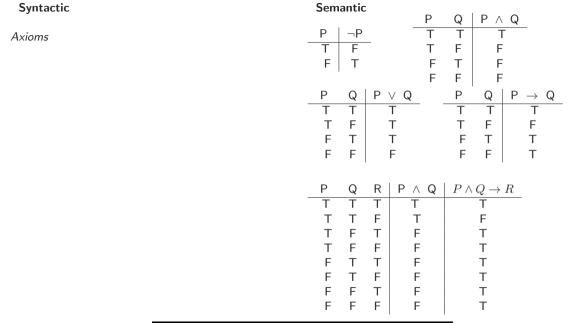


but merely they relate with each other.

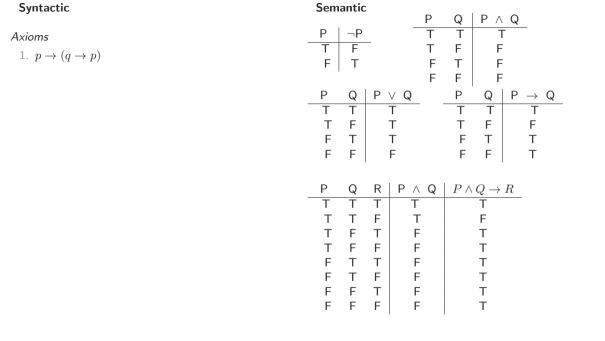
FFF

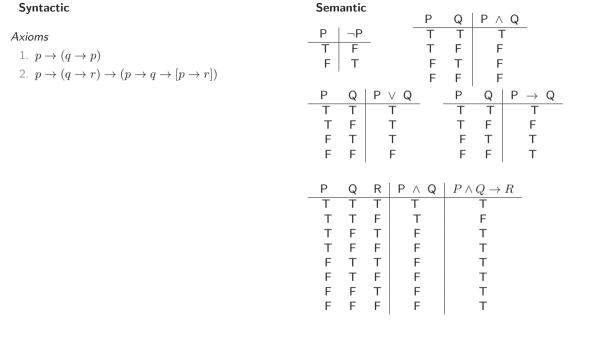
Sem	antic								
				Р	Q	P \	Q		
Р	−P			Т	Т	٦		_	
Т	F	_		Т	F	F			
F	Т			F	Т	F			
	1			F	F	F			
Р	Q	Р	√ Q		Р	Q	Р	\rightarrow	C
Т	Т		Т		Т	Т		Т	
Т	F		Т		Т	F		F	
F	Т		Т		F	Т		Т	
F	F		F		F	F		Т	
	'						'		
Р	Q	R	P ^	Q	$P \wedge$	$Q \rightarrow$	R		
Т	Т	Т	Т			Т			
Т	Т	F	Т	-		F			
Т	F	Т	F	:		Т			
Т	F	F	F	:		Т			
_	т	т				т			

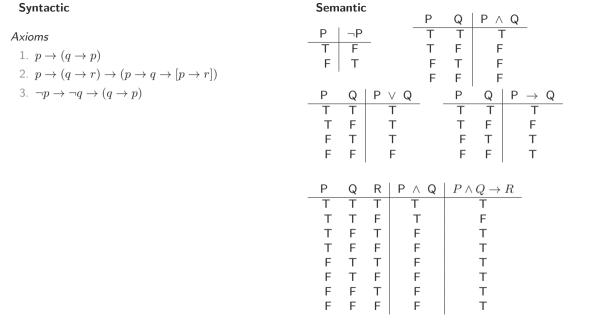
Yet, as we will see, we will be able to prove everything that we could have derived from truth tables

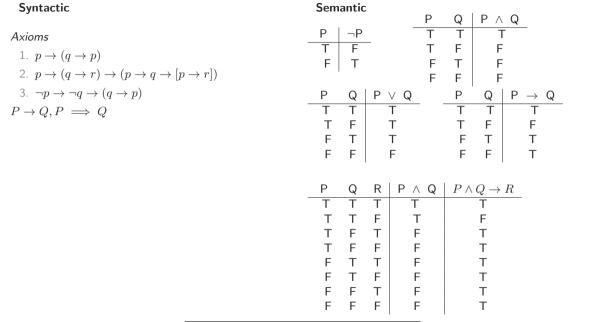


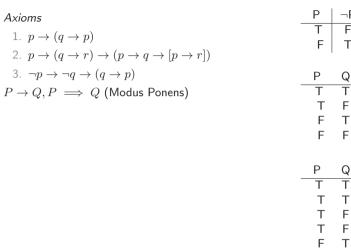
In the next lecture we will be introduced to these axioms











Т	F		Т	F	F	:
F	Т		F	Т	F	:
			F	F	F	
Р	Q	Р	√ Q	Р	Q	Р
Т	Т		T	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