



**HUMAN CAPITAL**  
NATIONAL COHESION STRATEGY



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Philosophy and Methodology of Sciences  
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# Logic 1

(lecture 1)

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# Programme

- Logic: classical propositional calculus
- Logic: elements of predicate logic and the concept of model
- What are laws of nature?
- Interpreting probability: frequentism, Bayesianism, and propensity approach
- Defining determinism
- A surprising simple failure of determinism in Newton's mechanics
- Understanding agents and agency
- Free will and (in)determinism: the good luck argument
- Psychology of the free-will: Libet's experiment and its critics
- Do animals freely act: neurological and evolutionary perspective
- What is knowledge? (Classical concept, Gettier's problem, counterfactual definition)
- Delineating science from pseudo-science.

# Exam

Oral exam; the exam's topic is chosen by a student from among topics discussed in the course, and is extended by readings suggested by the instructors.

A necessary prerequisite to taking the oral exam is a successful accomplishment of the group discussion sections which depends on:

(1) attendance, (2) homework, and (2) a final test.

The result achieved during the sections is a substantial part of the final grade for the course.

# Logic: art and science of reasoning

Link to psychology and philosophy

-psychology: how people think / reason?

-logic: how people should reason?

Logic: emphasis on language. Our reasonings are carried out in a language (non-controversial).

To characterize valid reasonings, logic focuses on *forms* of language.

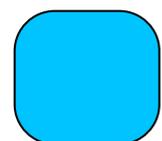
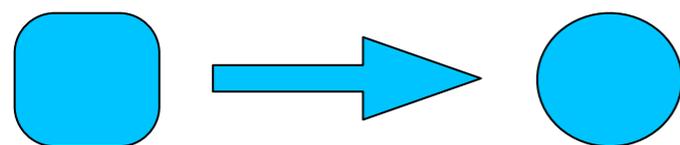
What is meant there by *forms of language*? Consider this reasoning as an illustration:

If it is Wednesday today, then we have our philosophy seminar.

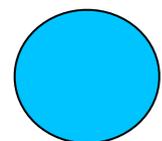
It is Wednesday today.

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We have our philosophy seminar



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Digression: can this reasoning fail us? After all  
Wednesday Dec 25th is Christmas...

The first premise is incorrect then.

But, if the premises are correct, the reasoning of the  
above form is reliable, i.e., its conclusion must be  
correct.

The reasoning of this form transfers truth from its  
premises to its conclusion.

There are unreliable forms of reasonings as well.

Forms of language do not necessarily coincide with grammatical forms.

Illustration: logic of counterfactuals.

\* If it had rained heavily on Aug. 12, we would have called off our garden party.

We want to construct a language in which there is our sentence \* as well as sentences:

\*\* It rains heavily on Aug 12

\*\*\* We call off our garden party.

As things stand, \*\* and \*\*\* cannot be considered building blocks of \*.

\* If it **had rained** heavily on Aug. 12, we **would have called** off our garden party.

\*\* It **rains** heavily on Aug 12

\*\*\* We **call off** our garden party.

We do a little of language engineering:

Instead of

\* If it had rained heavily on Aug. 12, we would have called off our garden party.

we write

If it had been the case that it rains heavily on Aug. 12, it would be the case that we call off our garden party.

If it had been the case that it rains heavily on Aug. 12, it would be the case that we call off our garden party.

If it had been the case that it rains heavily on Aug. 12, it would be the case that we call off our garden party.

$p$  = it rains heavily on Aug. 12

$q$  = we call off our garden party

$\Box \rightarrow$  = if it had been the case that ....., it would be the case that ....

We thus meshed together our simple sentences with a counterfactual sentence, and can write

$p, q, p \Box \rightarrow q$

We improved on natural language, introducing a form that wasn't there (or at least, wasn't clear).

Reasonings are done in language. So, whether a reasoning can be carried out depends on resources available in a language. Here are some examples (of not always correct reasonings) and resources needed to state them.

Jan jest Polish **or** Jan jest Dutch. Jan is **not** Polish. So Jan is Dutch. (connectives: “or”, “not”)

**Everybody** likes somebody. Jan does not like Mark. So Jan likes someone else (quantifiers “every” and negation “not”)

On Oct 15th is cloudy. So it was already the case on Oct 14 that it would be cloudy a day later. (tenses)

Two weeks ago a winter semester began. It is thus now **settled** that a winter semester began. (tenses + historical modalities like settled or inevitable)

It is not **possible** that Jan has no money. So it is **necessary** that Jan has money. (modalities: “possible”, “necessary”)

If it had been raining, I would have gone fishing. If I had gone fishing, I would have had great time. Ergo, if it had been raining, I would have had great time. (counterfactual connective; is it transitive?)

We'll limit our attention to reasonings available in the simplest language, i.e., without tenses, modalities of any sort, or counterfactual connectives.

So what will this language have? Logical connectives (“classical”)

Polish or English is not at all so simple, so what we'll we do? We'll ignore (= not analyze) such complexities.  
Illustration:

In the reasoning below some modalities occur:

It is possible that Jan is fair. It is necessary that he is a male. Ergo,

It is possible that Jan is fair **and** it is necessary that he is a male.

I option of analysis: we take our sentences for complex, i.e., identify operator “it is possible that” and a sub-sentence “Jan is fair”. The form of our first sentence is then: it is possible(Jan is fair)

II option (ours): we ignore the above structure and assume that “It is possible that Jan is fair” is a basic (atomic) sentence.

Two theories of classical logic (we'll do only first)

- classical propositional logic (CPL)
- classical predicate calculus (calculus of quantifiers)

What makes them classical?

**principle of bivalence** – each sentence is either true or false

**a sentence in the sense of logic** is any utterance that one can be ascent to, or dissent to. (Imperative and interrogative sentences are not sentences in logic sense)

a truth-value of a sentence – truth or falsehood.

1 or 0

# Classical Predicate Logic

- atomic and complex sentences

a sentence is **complex** in the sense of logic if it (1) has another sentence as its proper part and (2) has an operator whose arguments are sentences and values are sentences as well

# Classical Predicate Logic

It is not the case that it is raining.

It is possible that Simon Amman will win gold at the next Olympic.

I see and describe.

# Classical Predicate Logic

- selected connectives

it is not the case that          negation

It is not the case that it is raining.

and                                  conjunction

I see and describe.

or                                    disjunction

I'll write or call you.

if ..., then                        implication

If it's Monday today, then I can sleep a bit longer.

if and only if          equivalence (or bi-conditional)

A triangle is equilateral if and only if its angles all measure 60 deg.

# Extensional/intensional connectives

- extensional connectives  
a truth-value of a complex sentence whose connectives are extensional is fully determined by truth-values of its component sentences.

It is not the case that Kraków lies on the Vistula River.

It is not the case that  $3 + 4 = 7$ .

It is not the case that the Earth is round

# Extensional/intensional connectives

Thanks to its being extensional, negation is fully characterized by a truth-value table:

p	it is not the case that p
1	0
0	1

# Extensional/intensional connectives

Not all operators are extensional.

Consider “it is necessary that...”

It is necessary that  $2 + 2 = 4$ .

It is necessary that if today is Monday, tomorrow is Tuesday.

It is necessary that the Vistula River is polluted.

It is necessary that in Poland a prime-minister is a representative of the largest party in Parliament.

Intensional = non-extensional

# Extensional/intensional connectives

it is not the case that, and, or, if...then, if and only if: these connectives are assumed to be extensional (classical connectives)

If a reasoning is expressed in a language with extensional connectives only, the content of sentences involved is inessential for validity of that reasoning.