***Logic and Philosophy of Science***

Objectives:

* knowledge/understanding of what logic is and possible applications
* Basic knowledge of logic apparata, basic terminology in philosophy of science
* Knowledge/understanding of main forms of inference, and mixed forms of reasoning
* Express ourselves and ideas clearly consequently and support ourselves with arguments

Acquiring a capacity to reason/argue well and being able to apply this skill to other subjects. Logic being a method to reason correctly. Learning logical tools is not an end in itself.

* Importance of contexts of use.
* The context of scientific reasoning is where one can apply logic.

Ex: building a simulation where to see how communities interact with each other.

Questions we will see in this subject What it means for an argument to be correct, what is an inference, what is the different in a module of traditional vs. classic logic, is truth the most important aspect in logical reasoning?

**Elements/Tools of logical reasoning:**  
  
**Validity**; In a valid argument, the truth of the premises entails the truth of the conclusion. This means that it is impossible for the premises to be true and the conclusion false. A valid argument may have a false conclusion because the validity of an argument does not imply the truth of the premises. If the premises of a valid argument are true, then the argument is sound. Clearly the conclusion of any sound argument will be true.

**Truth value**; In standard logic, the truth-values are T and F or 1 and 0 for respectively [true](https://maartens.home.xs4all.nl/philosophy/Dictionary/T/True.htm) and [false](https://maartens.home.xs4all.nl/philosophy/Dictionary/F/False.htm) or, sometimes, untrue.

**Inference;** process of reasoning that correlates one type of sentence (‘***premise***’), with another type of sentence (‘*conclusion*’), on the basis of a series of rules – (*rules of deduction*, or of logical derivation .

**Evidence;** In the philosophy of science, evidence is taken to be what confirms or refutes scientific theories, and thereby constitutes our grounds for rationally deciding between competing pictures of the world. In view of this, an understanding of evidence would be indispensable for comprehending the proper functioning of the scientific enterprise.  
 **Syllogism** is a valid deductive argument or argument form with two premises and a conclusion, that involves universal and existential statements involving three terms. For example:  
  
All As are Bs .All Bs are Cs .Therefore, all As are Cs

Some As are Bs. No Bs are Cs .Therefore some As are not Cs

In these examples, B is the middle term; it appears in the premises to connect the terms in the conclusion, but does not itself appear in the conclusion. A is the minor term because it is the subject of the conclusion and C is the major term because it is the predicate of the conclusion.

**Forms of inferential reasoning**

(induction; modus tollens; abduction)

**Informal logic**

(authority; persuasion; analogies; post-hoc a.)

Induction – why is induction attractive to scientists/philosophers? Some people believe induction should not be applied to science since it makes it murky, believed by Karl Popper.

The logic of falsification which is a deductive argument. We will see how the module of logical reasoning works by Karl Popper.

The Logic vs. the ontology of science

Charles Peirce (look up)

What is abduction (type of reasoning) and how does it work?

Scientific realism – debate whether the outside world is real or just a projection

**Exam**: 3 fixed questions, about a particular topic, address the question and answer the question.

**What is ‘logic’?**

*logos* – ‘discourse’, ‘rule’, ‘reason’

* the study of correct reasoning, or valid arguments
* the study of rules/principles for reasoning correctly

Logic can count on a number of principles. Logic is not an empirical, logic doesn’t care about content it cares about form (in a normative sense) by relying on its own rules/principles, logic tells us how we ought to reason if we want to reason correctly. Logic is a normative discipline and not an empirical one. Two aspects support this:

Logic has to do with primarily with the form of our reason/arguments.

* If x is y x is z
* X is y
* X is z

The principles of logic are not contingent, but they are **necessary**. They do not depend on or change if empirical context changes.

If A is A then A is A. Period.

**Aristotelian (traditional) logic**

For Aristotle the term to explain the domain of logic was analytics. (The analysis of reasoning through the form of syllogism)

Syllogism is the model for deductive reasoning.

*Prior analytics*: work on syllogistic reasoning  
*Posterior Analytics:* work on demonstration

Examples of syllogism:

All men are mortal men is a medium term

Socrates is a man minor premise

Socrates is a mortal Conclusion

Men is a medium term (M)  
Mortal major term or extreme (P)  
Socrates – minor term or extreme (S)

**Summary of syllogism**

P1 **MP** Mortal-men  
P2 **SM** Socrates-men  
C **SP** Socrates-mortal

**S is P**

* Propositions
* Sentences
* Statements

You always find propositions in syllogism. In a proposition we assert or state, we propose that something is the case.

**Types of propositions**

Universal – affirmative (All S are P) or negative (All S are not P)  
  
Particular – affirmative (Some S are P) or negative (Some S are not P)

Syllogism fortifies itself by following an array of rules. We are inferring a conclusion from the premise.

**Inferences**

Process of reasoning that correlates one type of sentence (premise) with another type of sentence (conclusion) on the basis of a series of rules. (rules of deduction, or of logical derivation)

**Rules of logical derivation**

* In a syllogism there can be only three terms (major, medium, minor)
* The medium term can never be present in the conclusion
* From two affirmative premises we can only derive an affirmative conclusion
* From two particular premises we can never derive a general conclusion

**General principles of logical derivation**

1. **Identity**: given A, A is A. It cannot change halfway/
2. **Non-contradiction:** it is not possible that ‘A is x’ e ‘A is not x’. (at the same time) its an are or nor)
3. **Excluded middle:** a sentence is either true or false. There is no other possibility.

It is only by following these principles that we are guaranteed we are reasoning correctly. Any transgression will make our argument invalid/a falsity.

**Validity and truth**

A valid reasoning guarantees that a certain correlation of sentences is **correct by virtue of its inferential form**, independently of whether the sentences are actually true or not. A valid reasoning is not necessary is a true reasoning. Correct syllogism does not guarantee the conclusion is true but does guarantee it follows the premise)

**Correct correlation**

* If man is an amphibian, then man can live under water (valid inference even though the conclusion is false)
* If man is an amphibian, then man cannot live in water (not a valid inference but a true conclusion)

**From 256 syllogisms…. ….. down to 24!**

What’s left: **fallacies**

**grey area of syllogistic logic** Syllogisms deal only with **properties** (‘to be mortal’; ‘to be a man’), that is with the conjunction or separation between two **terms/categories**. It does not deal with relations. (love, to lose) **Relations** are left out

* ‘Oedipus **loves** Jocasta’ we can translate as (Oedipus is Jocasta’s lover)
* ‘The Greek **won** against the Persian (The Persians were defeated by the Greeks)

The predicate is defeated the Persians. The Greeks is the subject

Grammatical relations are limited and therefore not that good for logic because it makes one miss the big picture.

Pair subject/predicate and their properties

* a universal can be both subject and predicate (a man; is a man)
* a particular can only be a subject; it never can be predicated of anything (we can’t say of someone ‘he is a Socrates’).

Gottlobe Frege was considered the founding father of Classic Logic.

The logical form of a sentence should based on mathematics not on grammar. Not relying longer on subject and predicate.

**Function and argument**

* **Socrates is mortal**
* X is mortal = function
* Socrates = argument

The property of being mortal is predicated by Socrates (aristotean logic)

a function is something we ought to fill in by means of something else. What we use to fill in the function is the argument; we are in the presence of a statement. What we need to think of is an argument that substitutes a function.

**Mathematical analogue**

* The square of (x) = y
* The capital of (x) = y

What matter is we have the same function that represents different properties and relations.

* Even numbers (x) = y
* man (x) = y
* x > z = y
* (x) hates (z) = y

**Logic as a calculus**

* *Propositional logic/calculus* (*sentential logic* or *statement logic)*:
* propositions = functions to be filled in (by arguments)

Difference with categorical logic

* “All humans are mortal”
* “All H are M”
* H/M = classes of objects in categorical logic

Propositional logic **level of propositions taken as wholes**

Look ‘inside’ propositions (predicate logic)

* Connectives
* Quantifiers
* Variables

**Connectives**

* negation **¬**
* conjunction **&**
* disjunction ∨
* material implication ⊃
* double material implication ⇔

**Negation**

* **p**
* **¬p**
* Either proposition can be true or false

**Truth Table:**



**Principle of non-contradiction:**

**p ¬p p&¬p**

**T F F**

**F T F**

**Quantifiers:**

* **all men are mortal**
* **every man is mortal**
* **some man is bold**

**Types of quantifiers:**

* *universal* (all, every) symbol ∀
* *existential* (it exists an x such that ….) symbol ∃

**Logic of quantification**

A variable is a symbol used to refer to something else that is not a symbol. A constant has some kind of a fixed meaning, something that doesn’t change.

**Quantified universal statements**:

All x are f; For every x, x is an f

In symbols: (∀**x)f**x

**Quantified existential statements**:

There is an x that is f; some x is f

In symbols: (∃**x)fx**

**Variables**

**Place holders** (different from constants)

* Bound, occurrence is completely guided by quantifiers.
* Free

(∀**x)f**x, (E**x)f**x.

Quantified statements can be joined by using the connectus, to get complex quantified statements. Which the truth value depends on the truth values of being joined.

Ex: of a complex quantified statements: All dog are mammals

(∀x)fxgx) (out of all the xs some mammals are dogs)

**‘All men’**

* **‘Aristotelian sense:** all and only those who belong to the domain ‘human beings’
* **Fregean sense:** ‘For every x, in those cases where x is a man’ – (∀x)fx.

All men quantifies all but those who belong to the domain human beings. (Aristotelian sense).   
The truth value of this sentence is independent of classes of objects, it can be calculated and recalculated. (Fregean sense)

Quantifiers in the fregean sense have more applicable possibilities than the Aristotelian sense

**‘All men are mortal’**

Frege: ‘For every x, if x is a man x is mortal’ – (∀x)fxgx)

* Conditional reasoning

truth-value of the sentence independent of its content

**Meanings of ‘is’**

* ***Socrates is Xantippe’s husband*** a = b (the verb to be expresses an identity. The symbol for equal is a connective that expresses the relation of identity)
* ***Socrates is a man fa (a belongs to f)***
* ***There are men*** (∃**x)f**x (verb is used an in existential sense)
* ***All men are mortal*** (∀x)fxgx (included in to be a man and to be a mortal domain)

Aristotean logic (traditional, categorical)  
  
**Categorical logic**

About sentences that predicate things about classes of subjects, or objects that belong to those classes. Logic of classes of categories.

Logic of statements that can be represented in terms of classes of things and relationships between those classes. Logic that separates valid arguments from invalid ones.

**Binary Logic**

The conclusion of syllogism can only be true or false, validity and truthfulness are not the same thing .Saying something is the case, it is true/false that something is the case.

**Propositional logic**

•What determines the truth value of the whole sentence is the truth values of the individual component sentences, together with the rules for interpreting logical connectives like “and”, “or” and “if…then…”

•In propositional logic we learn the rules for determining the truth values of the following compound claims:

* **not-*p***
* ***p* and *q***
* ***p* or *q***
* **If *p* then *q***

**Predicate logic (both categorical and propositional)**

It formalizes the different parts of a proposition.

**Fregean logic**

It can handle all combinations of quantifiers (all, some, none)

It can handle conjunctions (and), disjunctions (or), conditionals, (if then) and biconditionals (if and only if)

It can represent predicates that involve relations between variables. Ex: x is the father of y.

**NON CLASSIC LOGIC**

Modal logic broadly used in science or reflecting on scientific reasoning

* It is necessary that □
* It is possible that ◊

MODAL LOGIC (BROADER SENSE)

Types of reasoning that are not centered on truth functions:

* *epistemic* (“it is known that”)
* *deontic* (“it ought to be the case that”)
* *temporal* (“it has been the case that”)

**ARISTOTELIAN MODAL LOGIC (CONTEXT OF SYLLOGISM)**

In prior analytics Aristotle talks about 4 modalities:

•Plain or assertoric (A applies to every B)

•Necessity (A necessarily applies to every B)

•Possibility (A possibly applies to every B)

•Two-way possibility, or contingent (A possibly applies and possibly does not apply to every B)

**Problems with Aristotle’s modalities**

Becker, A. 1933, *Die Aristotelische Theorie der Möglichkeitsschlüsse*. Berlin: Junker

Two types of modalities in Aristotle:

* ‘All lions are necessarily animals’ might mean two things: it is a necessary truth that all lions are animals or in a fregean sense it is true that each and every lion being an animal applies to it. (both statements are true)
* ’Everything lying down in a particular place is in fact a lion’. We could say it is true that everything lying down there that being a lion applies to it but it is a necessary truth that not everything lying down there is a lion.

**DE DICTO/DE RE MODALITIES**

* *‘de dicto’* modalities concern entire statements: necessity is a property of what is expressed by a proposition (the ‘dicta’).
* *‘de re’* modalities are properties of the things of which the propositions (the dicta) assert something

WHATEVER IS TRUE DE DICTO IS NOT NECESSARILY TRUE DE RE.

* ‘Socrates is necessarily rational’ might be true – if x is Socrates, x is necessarily rational  
  but there is no necessity in that.
* So, ‘It is necessary that Socrates is rational’ is false.

**NECESSITY AND ESSENTIALISM**

* ‘It is necessary that water is H20’. It is contingent that water might become frozen.
* it is the essence of water to have the chemical structure H2O.
* de re necessity is a type of natural necessity; but natural necessity should not be confused with logical necessity

**SUMMARY**

•**A de dicto modal claim is one in which a whole proposition is attributed a modal property** (e.g, 'It is contingent that some mammals swim', or 'Necessarily, every husband is married').

•**A de re modal claim is one in which an object is attributed a modal property** (e.g. 'The Prime Minister might have never been born', or 'Every husband is necessarily married').

•If some de re modal claims are true, Essentialism follows: **objects have essences at least insofar as they have some properties necessarily** (and other properties only contingently).

C.I. Lewis considered the father of modern logic.

**MATERIAL IMPLICATION**

Implication: ‘if….then’ is the framework for conditional reasoning. There are different types of conditionals:

•**Logical**: "If all philosophers are thinkers and E. is a philosopher, then E. is a thinker."   
  
•**Definitional**: "If E. is anemic, then E. has a low concentration of erythrocytes in her blood."   
  
•**Causal**: if you do something, something will follow. "If you switch on the plug, the TV will turn on" “if you strike a match, the match will light”  
  
•**Decisional**: if you make a decision someone else will make a decision based on it "If you go for a drink to Bar Rosso, I will go with you” “if all employees donate to a charity,

**P**  **Q**

Not a piece of reasoning, but a **connective**

"If you study diligently, then you might see positive results"

* the antecedent: "You study diligently" (p)
* the consequent: "You might see positive results" (q)
* material implication: 