

Getting Started

Atomic Sentences, LPL Software & More on Arguments

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Announcements

For 08.30

- ① The textbook...
- ② Digital copies are available on Bb, but you still have to buy the book
- ③ HW1 is due **Tuesday 09.06**
- ④ Remember to do the reading; consult syllabus for reading assignments
- ⑤ There is a teaching assistant for this course (Theodore Korzuhkin)
 - He will hold **office hours** and offer an **optional section**
 - None this week, details to be announced Thursday

Outline

- ① **Introductory Remarks**
- ② Atomic Sentences in FOL
- ③ The LPL Software
- ④ More on Arguments & Inferences

About our Approach

Methodological Points

- The central concepts in logic are:
 - ① Inference
 - ② Proof
 - ③ Truth
- Our goal in this course will be to develop precise and adequate definitions of these concepts
- Today, we'll take the first step towards defining an **inference**
- We've already learned that an inference consists of some **premises** and a **conclusion**
- So, to investigate what inference is, we are going to have to look harder at what **premises** and **conclusions** are!

About our Approach

First-Order Logic

- Premises and conclusions are ordinary sentences of natural language
- This creates a difficulty:
 - Natural languages are intricate and complicated things used to do many things other than state inferences
 - But we want to focus on the features of sentences that are relevant to inference only
- To achieve this goal we will learn how to represent premises and conclusions in a simplified **artificial language** called **First-Order Logic**, or **FOL**
- FOL offers a simple picture of the inferential properties of premises and conclusions
- Today we will learn the very basics of this picture

Remember Monty Python

Real Arguments

- Real arguments are different from abuse, name-calling or fisticuffs
- The point of a real argument is to establish a **conclusion** by showing how it follows from some more basic claims or **premises**

Example

- Every human is mortal (Premise)
- Burt Reynolds is human (Premise)
- So, Burt Reynolds is mortal (Conclusion)

The Anatomy of An Argument

Premises & Conclusions

- So, an argument is composed of two basic parts:
 - ① Premise(s)
 - ② A Conclusion
- To represent an argument we need to learn how to represent its parts, namely premises and conclusions
- This forces us to answer a question:
 - What are premises and conclusions?

Premises & Conclusions?

- Both premises and conclusions are expressed with **declarative** sentences
 - Example: *Burt Reynolds is mortal*
- These kinds of sentences are used to make **factual** claims that are **true** or **false**
 - Contrast:
 - Stop sleeping!
 - Why is there a cat in my sleeping bag?

Declarative Sentences

The Simplest Kind

- There are many different kinds of declarative sentences
- Over the course of the semester we will be learning how to represent these different kinds of declarative sentences in FOL
- Today, we are going to start at the beginning by considering the simplest kind: **atomic sentences**

Declarative Sentences

Atomic Sentences

Examples of Atomic Sentences

- ① Mars is red
 - Name: *Mars*
 - Predicate: *is red*
- ② Eric saw Kristen
 - Names: *Eric, Kristen*
 - Predicate: *saw Kristen*
- ③ Sandra gave Spot to Sarah
 - Names: *Sandra, Spot, Sarah*
 - Predicate: *gave Spot to Sarah*

- Atomic sentences consist of one or more **names** and a **predicate**
- Names label things
- Predicates say stuff about those things
- FOL is based on this distinction btwn names & predicates

Atomic Sentences

From English to FOL

Translation of Examples into FOL

English	FOL Translation
<i>Mars is red</i>	$\text{Red}(\text{mars})$
<i>Alex saw Mary</i>	$\text{Saw}(\text{alex}, \text{mary})$
<i>Sandra gave Fluffy to Sarah</i>	$\text{Gave}(\text{sandra}, \text{fluffy}, \text{sarah})$

- For each **English name**, there is a corresponding **name in FOL**
- For each **English predicate**, there is a corresponding **predicate symbol in FOL**
- The subject goes first, the direct object second & the indirect object third (order matters!)

Names

Aka Individual Constants

- Names in FOL are often called *individual constants* or *singular terms*

What Individual Constants Are For

Individual Constants are symbols used to refer to a fixed individual object

- This is reflected in our translations:
 - *mars* refers to Mars, just as the English name *Mars* does
- The version of FOL found in Tarski's World uses **a-f** & n_1, n_2, n_3, \dots as individual constants

Predicate Symbols

The Basics

The Purpose of Predicate Symbols

The **predicate symbols** of FOL used to express one of two things:

- ① A property of one object (e.g. redness)
 - ② A relation between multiple objects, or an object and itself (e.g. love)
- This is reflected in FOL's way of writing them:
 - $\text{Red}()$ has one place for an individual constant
 - It says that an object has the property of redness
 - $\text{Love}()$ has two places for individual constants
 - It says of two objects that one saw the other

Predicate Symbols

Arity

The number of places a predicate symbol has for individual constants is called its **arity**

- For example:
 - The arity of $\text{Red}()$ is 1
 - The arity of $\text{Gave}()$ is 3
- In FOL every predicate symbol has a **fixed arity**
- This is **not** true of English:
 - ① Sandra gave
 - ② Sandra gave Fluffy
 - ③ Sandra gave Fluffy to Sarah
 - ④ Sandra gave Fluffy to Sarah in Michigan

Atomic Sentences

Summary

- An atomic sentence is composed of:
 - ① A predicate symbol, e.g. $\text{Red}()$
 - ② One or more individual constants, e.g. mars
- Individual constants refer to particular **individuals**
- Predicate symbols express **properties** or **relations**
- Atomic sentences express claims that are **true or false**

Atomic Sentences

Tarski's World

Let's solidify these ideas by looking at the Tarski's World application

Check List:

- The *blocks language*
- Multiple names
- Properties vs. relations
- Order of names matters

An Overview

- Our textbook comes with four pieces of software:
 - ① Tarski's World (language & the world)
 - ② Fitch (proof)
 - ③ Boole (truth tables)
 - ④ Submit (homework submission)
- We will use **all four** of these programs
- What to do if you are having problems with the software:
 - ① Visit the textbook website:
<http://ggww2.stanford.edu/GUS/lpl/index.jsp>
 - ② If you can't get an answer to your question there, *then* contact me

Tarski's World & Submit

Getting Familiar





Demo Time!

Check list:

- Sentence Files vs. World Files
- World Panel:
 - Add/Remove Blocks, Select, Change Shape, Move, 2-D View, Rotate
- Sentence Panel:
 - Writing Formulas, Creating List, Verifying
- Exercises 1.5 & 1.9

Submit & Homework

Turning-In Your Homework

- Our homework exercises come in three varieties:
 - ① Written: 
 - Physical copy handed-in to me
 - ② Electronic: 
 - Submitted to Grade Grinder w/Submit
 - ③ Combo: 
 - A handed-in component & an electronic component
- Exercises 1.5 & 1.9 are marked with , so let's send them to the **Grade Grinder**
- This is done using the **Submit** application
- Let's try it

What Do We Know?

Not Enough!

- We know that arguments/inferences consist of premises and conclusions
- But how do we determine if some sentence is intended as a premise or a conclusion?
 - Maybe premises come first and the conclusion last?
 - No, consider:

Argument 1

- ① Pat is mortal (Conclusion)
- ② After all, Pat is a man (Premise)
- ③ And, all men are mortal (Premise)

Some Tricks of the Trade

Key Words

- As it turns out, the premises and conclusion can occur in pretty much any order
- However, they are usually tagged with some key words:

Identifying Words

Conclusion Identifiers	Premise Identifiers
<i>hence</i>	<i>because</i>
<i>thus</i>	<i>since</i>
<i>so</i>	<i>after all</i>
<i>consequently</i>	
<i>therefore</i>	

Examples

So What?

Argument 2

- ① All grandmothers are omnipotent
- ② Leticia is a grandmother
- ③ *So* Leticia is omnipotent

- Note the use of *so* in 3
 - *So* indicates that 3 is the conclusion of Argument 2
 - In that case, 1 & 2 must be the premises!

Examples

After all

Argument 1

- ① Pat is mortal (Conclusion)
- ② *After all*, Pat is a man (Premise)
- ③ *And*, all men are mortal (Premise)

- Recall that *after all* marks premises, so 2 must be a premise
- In 3 *And* suggests that 2 & 3 are intended to play the same role in the argument
- So, 1 must be the conclusion
 - That seems right. The point of the argument seems to be that Pat is mortal

Chopping Up Arguments

Summary

- So, premises and conclusions occur in many different places
 - Identifier words such as *since*, *therefore* and *so* organize this mess
- This works for everyday purposes, but when you are really analyzing an argument it's nice to have a more explicit notation
- One very nice way of writing arguments is called **Fitch Format**
 - Let's learn it!

Fitch Format

What it Looks Like

Argument 1

- ① Pat is mortal (Conclusion)
- ② After all, Pat is a man (Premise)
- ③ And, all men are mortal (Premise)

Fitch Format for Argument 1

- | | |
|---|--------------------|
| 1 | Pat is a man |
| 2 | All men are mortal |
| 3 | Pat is mortal |

Fitch Format

It's Easy

Fitch Format for Argument 1

- | | |
|---|--------------------|
| 1 | Pat is a man |
| 2 | All men are mortal |
| 3 | Pat is mortal |

- The **horizontal bar** is called the **Fitch Bar**
 - It separates the premises from the conclusion
- This format let's us do without words like *therefore*
- It also allows us to understand the exact structure of the argument from a quick glance

Summary

And a Look at What's Next

- Today, we've learned how to represent some very basic premises & conclusions in FOL
- We've also learned some helpful techniques for 'chopping up' and representing arguments
- On Thursday we'll take the next step in understanding the kinds of arguments that can be built from atomic sentences:
 - We will study the relationships that must hold between premises and conclusions in order for them to form a **good** argument (logical consequence)
 - We'll also study the techniques that can be used to show whether or not those relationships hold (proof)

Homework 1

Due Tuesday 09.06

Homework 1

Due by class on **Tuesday 09.06:**

- ① Read the introduction (pp.1-10) of the textbook and pp.1-12 of the software manual
 - ② **Do exercises 1.1-4, 2.1, 2.2, 2.6, 2.8**
- The [LPL website](#) has partial solutions to selected exercises, take a look!
 - Also, do the reading for next class: §§2.1, 2.2