

An Introduction to Language & Logic

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<http://www.cs.bham.ac.uk/~mgl/languageandlogic/>

"Most people would rather die than think; in fact, they do so." (Bertrand Russell)

"Logic is the beginning of wisdom, not the end." (Mr. Spock)

A simple puzzle

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You are shown a set of four cards placed on the table. Each card has a number on one side and either a vowel or consonant on the other side. You are given a rule "every card with an even number has a vowel on the other side".

Which cards do you need to turn over to test this rule?

Module Information

This module is taught by two lectures per week. Typically (but not always) Mondays's lecture will introduce material to be learnt and Tuesdays's lecture will test this material through exercises and discussion.

Most weeks there will be a short assessment to be completed. This will be given out during the Tuesday lecture and should be completed by the Monday lecture.

At the end of term there will be a class test worth 10% of the module mark. In addition there is an examination in May. Therefore the breakdown of marks for this module is as follows:

Weekly exercises 10%

Class test 10%

May exam 80%

You will not pass the exam in May or the resit in August without understanding the coursework. Therefore, if you are planning of failing in May - you still need to do the coursework!

All coursework should be submitted to the Language and Logic pigeon hole which is located by the CS front office. You will need to attach a work slip and write your student ID and academic advisor's name on the slip. This should be second nature now.

Lateness

No guarantee is made that anything will make sense if you turn up late for lectures.

Any work submitted late will not be marked unless an extension is given by the welfare team.

Plagiarism

Any work which is shown to be plagiarised will receive a zero mark for the work and the Senior Tutor informed. Any repeat offence will be forwarded to the Senior Tutor for action.

Feedback

Logic can be baffling at times & I expect everybody here to feel confused occasionally. To help, I hope to return all marked work within two weeks *with feedback*. I also expect to see you at my office hour if you don't achieve a decent grade on any exercise so we can discuss the work and make sure you fully understand the module's content.

Reading list

There are a lot of good books on logic. However logic is a very large subject and most books will cover far more material than this module will cover. An excellent logic book is

Logic Paul Tomassi (1999) Routledge.

This book covers all of the logic material covered in the module and some far more advanced topics. It's probably worth buying especially if you intend to study formal languages/logic in later parts of your degree.

Logic Wilfred Hodges (1997) Penguin

This book is considered by many to be a classic. It's slightly dated in places but nevertheless excellent (though again its scope is beyond this module).

There is also a webpage to support this module at:

<http://www.cs.bham.ac.uk/~mgl/languageandlogic/>

where I'll put all the lecture notes, assessments, model answers etc. You should regularly check this page for reading material.

Detailed syllabus

Week 1

Introduction to Module (Today) Introduction to Language (Tuesday)

Week 2

Syntax of formal & natural languages

Week 3

Language Semantics & Truth Tables

Week 4

Propositional Logic

Week 5

Natural Deduction for Propositional Logic

Week 6

Predicate Calculus

Week 7

Predicate Calculus
Week 8
Natural Deduction for Predicate calculus
Week 10
Natural Deduction for Predicate calculus (part 2)
Week 10
Advanced topics in Logic (if there's time)
Week 11 - Class test!!!

How to pass this module

Work **hard**.

Logic is not a subject which can be taught solely from a logic book. Instead it needs to be practiced. Therefore you should attempt every assessment and do the tutorial work on Thursdays. You should also at least attempt to answer any question in the lectures. Even better you should ask me questions whenever you do not understand anything.

This module should be enjoyable but it will be hard in some places. Logic is probably a novel topic for most of you but I expect that you will all be able to reason about simple (and not so simple) logic at the end of this module.

Why Language and Logic?

The aims of this module are to provide an introduction to both the formal analysis of languages and arguments. Computer Science as a subject is directly concerned with the following concepts:

Language (from natural language to programming languages)
Information
Arguments
Logic

It should be apparent that all these concepts are connected. Moreover, logic is not only used as a tool in theoretical computer science, even very applied computer programming often makes use of logical constructions and representations.

If you're still not convinced that all these concepts are related then try the following puzzle.

A second simple puzzle

19 13 Whisky Orange Juice

You are shown a set of four cards placed on the table. Each card has a number on one side which is the person's age and on the other side is either an alcoholic or non-alcoholic drink. You are given a rule, "If the age is under 18 then the drink on the other side of the card will be non-alcoholic".

Which cards do you need to turn over to test this rule?

Argument structure

Arguments consist of propositions. A proposition is a sentence which states a fact. This fact can be true or false. The following are some sentences but not all are propositions.

I am studying logic.
If you like, I will cook dinner tonight.
Please stay awake during my lecture!
What is the answer to the first exercise?
Ireland is more south than Spain.
 $2 + 7 = 9$.
Euthanasia is justifiable in some circumstances.
The present King of France is bald.

An argument is a collection of propositions. Basic arguments (in English at least) have the following structure:

If everything is determined, then people are not free.
People are free.
So not everything is determined.

This argument is *valid*. Validity is a technical term.

Validity:

an argument is valid if (and only if)
whenever the premises are true then so is the conclusion.

Consider the following argument:

If the moon is made of cheese then the sun would melt it.
The moon is made of cheese.
So the sun is melting it.

Again the argument is valid. If the premises are correct then the conclusion follows. However, it is not sound.

Soundness

an argument is sound if (and only if) an argument is valid,
and in addition the premises are all true.

So the conclusion of a sound argument must also be true.

As you will see, validity & soundness are central concepts in logic. In fact we will spend a large amount of the module reasoning about validity and discussing techniques for determining whether or not particular arguments are valid or not.

Some arguments

If a cat has no tail then it is a Manx cat.
Whiskers is a cat and has no tail.
Therefore Whiskers is a Manx cat.

If John is at home, then his television is on.
His television is not on.
Therefore John is not at home.

If England beat France then Fiji finish third.
If Fiji finish third then Fiji are better than New Zealand
Therefore if England beat France then Fiji are better than New Zealand

If John works late on his lecture then he'll buy a microwave meal.
John's bought a microwave meal.
Therefore John worked late on his lecture.

These arguments should be fairly easy to evaluate. However notice the pattern of each argument. Each argument is an example of a different argument structure. Some of these structures are invalid. Could a computer decide which is valid and which isn't?

A final example (or two)

Nothing is better than steak.
A burger is better than nothing.
Therefore a burger is better than steak.

No cat has eight tails.
One cat has one more tail than no cat.
Therefore, all cats have nine tails.

Thursday's lecture will talk more about language and how language can be analysed in terms of structure and meaning.