Adam Blank Spring 2016

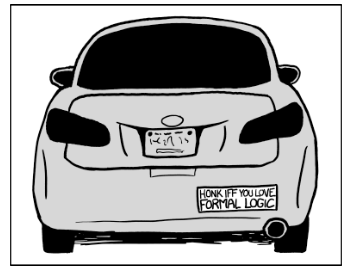
CSE 311

Foundations of Computing I

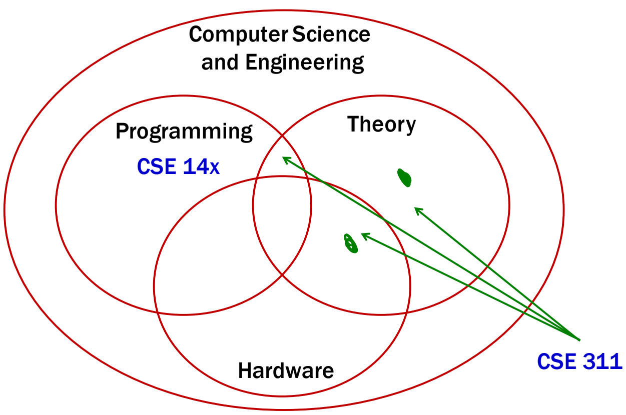
CSE 311: Foundations of Computing I

Lecture 1: Propositional Logic

Hi!



Some Perspective



About the Course

We will study the *theory* needed for CSE:

Logic:
How can we describe ideas *precisely*?

Formal Proofs:
How can we be *positive* we're correct?

Number Theory:
How do we keep data *secure?*

Relations/Relational Algebra:
How do we store information?

Finite State Machines:
How do we design hardware and software?

Turing Machines:
Are there problems computers *can't* solve?

About the Course

It's about perspective!

- Example: Sudoku
  - Given *one*, solve it by hand
  - Given *most*, solve them with a program
  - Given *any*, solve it with computer science
- Tools for reasoning about difficult problems
- Tools for communicating ideas, methods, objectives…
- Tools for automating difficult problems
- Fundamental structures for computer science

This is NOT a programming course!

Administrivia

Instructor: Adam Blank

Teaching Assistants:
John Armstrong
Phillip Huang
Johan Michalove
Emerson Matson
Melissa Medsker
Logan Weber
Jefferson Van Wagenen
Ollin Boer Bohan
Jasper Hugunin
Michael Lee
Evan McCarty
Matthew Rockett

Homework: (Yes)
Due WED at start of class
Write up individually

Section:
Thursdays

(Optional) Books:
Rosen, Velleman, MIT Book
Don't buy new copies!

Grading (roughly):
50% Homework
20% Midterm
30% Final Exam

All Course Information @ cs.uw.edu/311

Logic: The Language of Reasoning

Why not use English?

- Turn right here…
  - Does "right" mean the direction or now?
- Buffalo buffalo Buffalo buffalo buffalo buffalo Buffalo buffalo
  - This means "Bison from Buffalo, that bison from Buffalo bully, themselves bully bison from Buffalo.
- We saw her duck
  - Does "duck" mean the animal or crouch down?

"Language of Reasoning" like Java or English

- Words, sentences, paragraphs, arguments…
- Today is about **words** and **sentences**

Why Learn A New Language?

Logic, as the "language of reasoning", will help us…

- Be more **precise**
- Be more **concise**
- Figure out what a statement means more **quickly**

Propositions

A **proposition** is a statement that

- has a truth value, and
- is "well-formed"

and hello wft.

Are These Propositions?

2 + 2 = 5

This is a proposition. It's okay for propositions to be false.

The home page renders correctly in IE.

This is a proposition. It's okay for propositions to be false.

Turn in your homework on Wednesday.

This is a "command" which means it doesn't have a truth value.

This statement is false.

This statement does not have a truth value! (If it's true, it's false, and vice versa.)

Akjsdf!

This is not a proposition because it's gibberish.

Who are you?

This is a question which means it doesn't have a truth value.

Every positive even integer can be written as the sum of two primes.

This is a proposition. We don't know if it's true or false, but we know it's one of them!

Propositions

A **proposition** is a statement that

- has a truth value, and
- is "well-formed"

We need a way of talking about *arbitrary* ideas…

Propositional Variables: $p, q, r, s, \ldots$

Truth Values:

- T for true
- F for false

A Proposition

"Roger is an orange elephant who has toenails if he has tusks, and has toenails, tusks, or both."

We'd like to *understand* what this proposition means.

This is where logic comes in. There are pieces that appear multiple times in the phrase (e.g., "Roger has tusks").

These are called **atomic propositions**. Let's list them:

RElephant: "Roger is an orange elephant"

RTusks: "Roger has tusks"

RToenails: "Roger has toenails"

Putting Them Together

"Roger is an orange elephant who has toenails if he has tusks, and has toenails, tusks, or both."

RElephant: "Roger is an orange elephant"
RTusks: "Roger has tusks"
RToenails: "Roger has toenails"

Now, we put these together to make the sentence:

RElephant and (RToenails if RTusks) and (RToenails or RTusks or (RToenails and RTusks))

This is the general idea, but now, let's define our *formal language.*

Logical Connectives

Negation (not)	$\neg p$
Conjunction (and)	$p \wedge q$
Disjunction (or)	$p \vee q$
Exclusive Or	$p \oplus q$
Implication	$p \longrightarrow q$
Biconditional	$p \longleftrightarrow q$

RElephant:
"Roger is an orange elephant"
RTusks:
"Roger has tusks"
RToenails:
"Roger has toenails"

"Roger is an orange elephant who has toenails if he has tusks, and has toenails, tusks, or both."

↓

RElephant and (RToenails if RTusks) and (RToenails or RTusks or (RToenails and RTusks))

↓

RElephant ∧ (RToenails if RTusks) ∧ (RToenails ∨ RTusks ∨ (RToenails ∧ RTusks))

Some Truth Tables

p	$\neg p$
T	F
F	T

p	q	$p \wedge q$
T	T	T
T	F	F
F	T	F
F	F	F

p	q	$p \vee q$
T	T	T
T	F	T
F	T	T
F	F	F

p	q	$p \oplus q$
T	T	F
T	F	T
F	T	T
F	F	F

Implication

"If it's raining, then I have my umbrella"

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

It's useful to think of implications as promises. That is "Did I lie?"

	It's raining	It's not raining
I have my umbrella	No	No
I do not have my umbrella	Yes	No

*The only **lie** is when:*

(a) It's raining AND

(b) I don't have my umbrella

Implication

"If it's raining, then I have my umbrella"

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

Are these true?

2 + 2 = 4 → earth is a planet

The fact that these are unrelated doesn't make the statement false! "2 + 2 = 4" is true; "earth is a planet" is true. T→T is true. So, the statement is true.

2 + 2 = 5 → 26 is prime

Again, these statements may or may not be related. "2 + 2 = 5" is false; so, the implication is true. (Whether 26 is prime or not is irrelevant).

Implication is not a causal relationship!