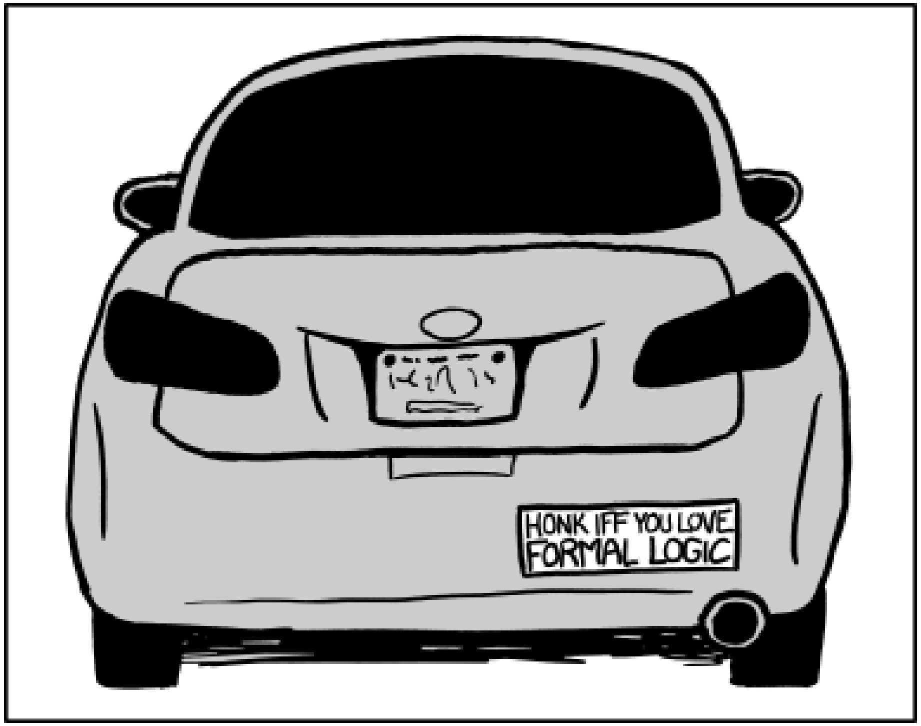
CSE 311: Foundations of Computing I

Spring 2015

Lecture 1: Propositional Logic

Hi.



about the course

We will study the **theory** needed for CSE.

Logic:

How can we describe ideas and arguments **precisely**?

Formal proofs:

Can we prove that we're right? [to ourselves? to others?]

Number theory:

How do we keep data **secure**? [really? we need to justify numbers?]

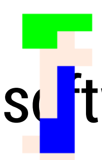
Relations/Relational Algebra:

How do we store information?

How do we reason about the effects of connectivity?

Finite state machines:

How do we design hardware and software? [state!]



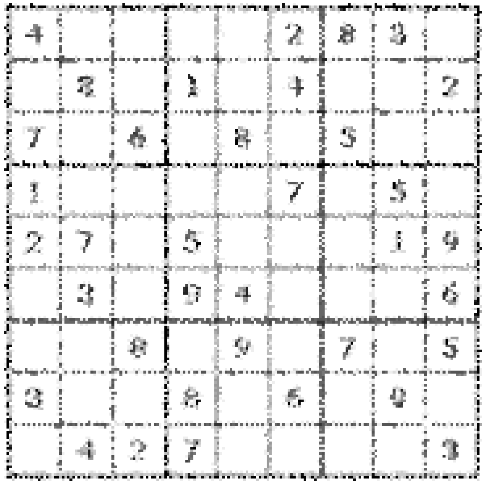
Turing machines:

What is computation? [the universe? superheroes?]

Are there problems computers **can't** solve?

about the course

The computational perspective.



Example: Sudoku

Given *one*, solve by hand.
Given *most*, solve with a program.
Given *any*, solve with computer science.

[given one, by hand
given most, with a program
. . .   computer science]

- Tools for reasoning about difficult problems
- Tools for communicating ideas, methods, objectives
- Fundamental structures for computer science

[like, uhh, smart stuff]

administrivia

Prof: James R. Lee [James "PG 13" Lee was less fun]

Teaching assistants:

Evan McCarty	Mert Saglam
Krista Holden	Gunnar Onarheim
Ian Turner	Ian Zhu

cse311-staff@cs

Quiz Sections:

Thursdays

(Optional) **Book**:

Rosen
Discrete Mathematics
6th or 7th edition
Can buy online for ~$50

Homework:

Due **Fridays** on **Gradescope**
Write up individually

Exams:

Midterm: date soon
Final: TBA

Grading (roughly):

50% homework
35% final exam
15% midterm

All course information at http://www.cs.washington.edu/311.

CSE 311: Foundations of Computing I

Spring, 2015

Instructor: James R. Lee

> Office hours: MW 2:30-3:30pm, CSE 640

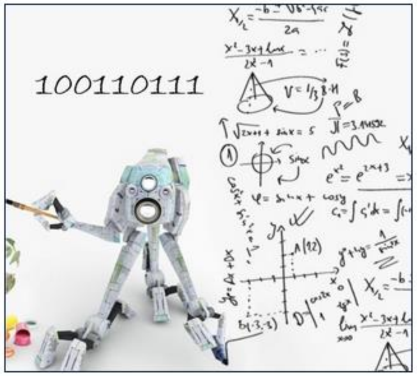
MWF 1:30-2:20pm, MLR 301

Email:

Class email list: cse311a_sp15 [archives]
Please send any e-mail about the course to **cse311-staff@cs**.

Textbook:

There is no required text for the course. Some lectures will have associated reading material linked below. Over the first 6 weeks or so, the following textbook can be a useful companion: Rosen, *Discrete Mathematics and Its Applications*, McGraw-Hill.
(The 6th or 7th editions of the text are equally useful. Used or rental copies of either edition are available for vastly less than the ridiculously high new copy prices.)



Lectures

date	topic	slides (pdf)	slides (ink)	reading
30-Mar	Logic			1.1-1.2 (7th), 1.1 (6th)
1-Apr				
3-Apr				
6-Apr				
8-Apr				
10-Apr				
13-Apr				
15-Apr				
17-Apr				
20-Apr				
22-Apr				
24-Apr				
27-Apr				
29-Apr				
1-May				
4-May				
6-May				
8-May				
11-May				

TA	Office hours
Evan McCarty	
Mert Saglam	
Krista Holden	
Gunnar Onarheim	
Ian Turner	
Junhao (Ian) Zhu	

Section	Day/Time	Room
AA	Th, 1230-120	THO 234
AB	Th, 130-220	DEN 217
AC	Th, 230-320	MGH 254
AD	Th, 1130-1220	MGH 251

Homeworks [Grading guidelines]:

Assignments will be submitted via Gradescope. An account will be created for you.

Exams:

- **Midterm exam**
- **Final exam**

logic: the language of reasoning

- Why not use English?
  - Turn right here…
  - Buffalo buffalo Buffalo buffalo buffalo buffalo Buffalo buffalo.

    [The sentence means "Bison from Buffalo, that bison from Buffalo bully, themselves bully bison from Buffalo."]
  - We saw her duck.

- "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**

[please stop]

A **proposition** is a statement that

- has a truth value, and
- is “well-formed”

[“If I were to ask you out, would your answer to that question be the same as your answer to this one?”]

proposition is a statement that has a truth value and is “well-formed”

Consider these statements:

- 2 + 2 = 5
- The home page renders correctly in IE.
- This is the song that never ends.
- Turn in your homework on Wednesday.
- This statement is false.
- Akjsdf? [hey, I akjsdf you a question]
- The Washington State flag is red.
- Every positive even integer can be written as the sum of two primes.

- A **proposition** is a statement that
  - has a truth value, and
  - is "well-formed"

- 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."

[might as well just end it all now, Roger]

- What does this proposition mean?
- It seems to be built out of other, more basic propositions that are sitting inside it!   What are they?

“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”

logical connectives

- Negation (not) $\neg p$
- Conjunction (and) $p \wedge q$
- Disjunction (or) $p \vee q$
- Exclusive or $p \oplus q$
- Implication $p \rightarrow q$
- Biconditional $p \leftrightarrow q$

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.”

$\wedge$ $\wedge$ $\vee$ $\vee$ $\wedge$

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

RTusks $\longrightarrow$ RToenails

p	¬ p
T	F
F	T

p	q	p ∧ q
T	T	T
T	F	F
F	T	F
F	F	F

p	q	p ∨ q
T	T	T
T	F	T
F	T	T
F	F	F

p	q	p ⊕ q
T	T	F
T	F	T
F	T	T
F	F	F

"If p, then q" is a **promise**:

- Whenever p is true, then q is true
- Ask "has the promise been broken?"

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

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

Suppose it's not raining...

~~q~~ p

"I am a Pokémon master only if I have collected all 151 Pokémon."

~~p~~ q

Can we re-phrase this as "if p, then q" ?

$\cancel{p \to q}$

$\boxed{p \to q}$

Implication:

- p implies q
- whenever p is true q must be true
- if p then q
- q if p
- p is sufficient for q
- p only if q

p	q	$p \to q$

converse, contrapositive, inverse

- Implication: $p \rightarrow q$
- Converse: $q \rightarrow p$
- Contrapositive: $\neg q \rightarrow \neg p$
- Inverse: $\neg p \rightarrow \neg q$

How do these relate to each other?

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

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

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

Define shorthand ...

p : RElephant

q : RTusks

r : RToenails

$p \wedge (q \rightarrow r) \wedge (r \vee q \vee (r \wedge q))$

Roger's sentence with a truth table

p	q	r	$q \to r$	$p \wedge (q \to r)$	$r \vee q$	$r \wedge q$	$(r \vee q) \vee (r \wedge q)$	$p \wedge (q \to r) \wedge \ (r \vee q \vee (r \wedge q))$
T	T	T	T	T	T	T	T	T
T	T	F	F	F	T	F	T	F
T	F	T	T	T	T	F	T	T
T	F	F	T	T	F	F	F	F
F	T	T	T	F	T	T	T	F
F	T	F	F	F	T	F	T	F
F	F	T	T	F	T	F	T	F
F	F	F	T	F	F	F	F	F

Shorthand:

p : RElephant

q : RTusks

r : RToenails

more about Roger

Roger is only orange if whenever he either has tusks or toenails, he doesn't have tusks and he is an orange elephant."

p : "Roger is an orange elephant"
q : "Roger has tusks"
r : "Roger has toenails"

more about Roger

Roger is only orange if whenever he either has tusks or toenails, he doesn't have tusks and he is an orange elephant."

↓

(RElephant **only if (whenever (**RTusks **xor** RToenails**) then not** RTusks**)) and** RElephant

↓

(RElephant → (whenever **(**RTusks ⊕ RToenails**) then** ¬ RTusks**))** ∧ RElephant

↓

p : RElephant
q : RTusks
r : RToenails

$$(p \rightarrow ((q \oplus r) \rightarrow \neg q)) \land p$$

Roger's second sentence with a truth table

p	q	r	$q \oplus r$	$\neg q$	$((q \oplus r) \rightarrow \neg q)$	$p \rightarrow ((q \oplus r) \rightarrow \neg q)$	$(p \rightarrow ((q \oplus r) \rightarrow \neg q)) \wedge p$
T	T	T	F	F	T	T	T
T	T	F	T	F	F	F	F
T	F	T	T	T	T	T	T
T	F	F	F	T	T	T	T
F	T	T	F	F	T	T	F
F	T	F	T	F	F	T	F
F	F	T	T	T	T	T	F
F	F	F	F	T	T	T	F

biconditional: $p \leftrightarrow q$

- p iff q
- p is equivalent to q
- p implies q and q implies p

p	q	$p \leftrightarrow q$
T	T	T
T	F	F
F	T	F
F	F	T