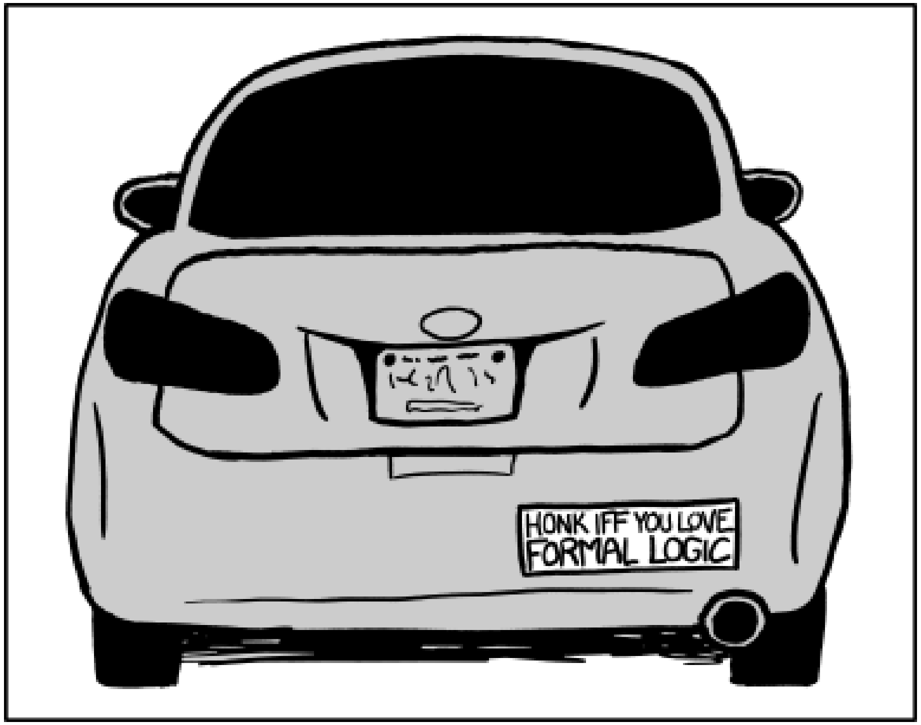
CSE 311: Foundations of Computing I

Autumn 2015

Lecture 1: Propositional Logic



Overload Request Link: http://tinyurl.com/p5vs5xb

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?]

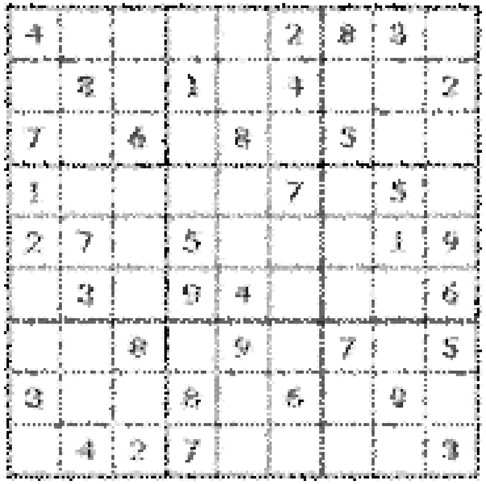
Are there problems computers **can’t** solve?

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]

professors

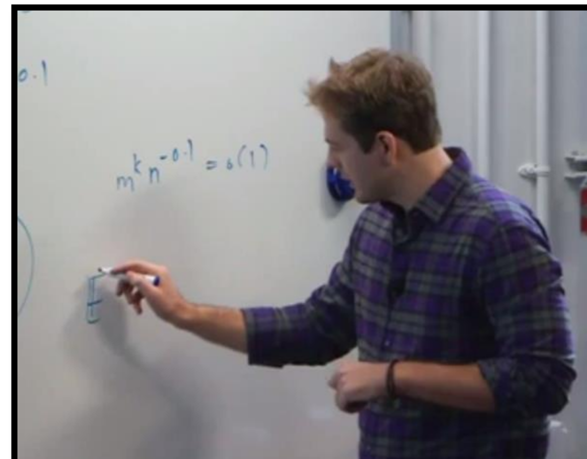
Prof. Oveis Gharan

CSE 636

Section A
MWF 9:30-10:20 in CMU 120
Office hours MW 10:30-11:30

Prof. Lee

CSE 640



Section B EEB 105
MWF 1:30-2:20 in ~~MGH 241~~
Office hours MW 2:30-3:30

We will each sometimes teach both sections.

The person who teaches is the one holding office hours after class.

You can go to any office hours any time.

administrivia

Teaching assistants:

[office hours TBD soon]

Sam Castle	Jiechen Chen
Rebecca Leslie	Evan McCarty
Tim Oleskiw	Spencer Peters
Robert Weber	Ian Zhu

cse311-staff@cs

Quiz Sections:

Thursdays

No sections tomorrow!

(Optional) **Book**:

Rosen

Discrete Mathematics

6th or 7th edition

Can buy online for ~$50

Homework:

Due **Fridays** on **Gradescope**

Write up individually

First homework out this Friday (Oct 2)

Exams:

Midterm: Monday, Nov. 9, in class

Final: Monday, Dec. 14

Grading (roughly):

50% homework

35% final exam

15% midterm

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

administrivia

CSE 311: Foundations of Computing I

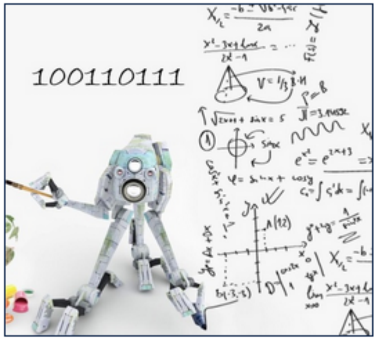
Autumn, 2015

James R. Lee

Section B: MWF 1:30-2:20, MGH 241
Office hours: MW 2:30-3:30, CSE 640

Shayan Oveis Gharan

Section A: MWF 9:30-10:20, CMU 120
Office hours: MW 10:30-11:30, CSE 636



Email and discussion:

Class email list: multi_cse311a_au15 [archives]
Please send any e-mail about the course to **cse311-staff@cs**.

Discussion board (moderated by TBA)
Use this board to discuss the content of the course. That includes everything **except** the solutions to current homework problems. Feel free to discuss homeworks and exams from past incarnations of the course, and any confusion over topics discussed in class. It is also acceptable to ask for *clarifications* about the statement of homework problems, but not about their solutions.

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	inked (A)	inked (B)	reading
30-Sep	Propositional logic				1.1-1.2 (7th), 1.1 (6th)
2-Oct	Digital circuits, more logic				1.1-1.3 (7th) 1.1-1.2 (6th)
5-Oct	Booelan algebra, combinatorial logic				12.1-12.3 (7th) 11.1-11.3 (6th)
7-Oct	Boolean algebra and circuits				12.1-12.3 (7th) 11.1-11.3 (6th)
9-Oct	Canonical forms, predicate logic				1.4-1.5 (7th) 1.3-1.4 (6th)
12-Oct	Predicate logic, logical inference				1.6-1.7 (7th) 1.5-1.7 (6th)
14-Oct	Proofs I				1.6-1.7 (7th) 1.5-1.7 (6th)
16-Oct	Proofs II				1.6-1.7 (7th) 1.5-1.7 (6th)
19-Oct	Set theory				2.1-2.3 (6th,7th)
21-Oct	Functions, modular arithmetic				4.1-4.2 (7th) 3.4-3.5 (6th)
23-Oct	Modular arithmetic and applications				4.1-4.3 (7th) 3.4-3.6 (6th)
26-Oct	Primes, GCD				4.3-4.4 (7th), 3.5-3.7 (6th)
28-Oct	Primes, GCD, fewer tangents				4.3-4.4 (7th), 3.5-3.7 (6th)
30-Oct	Solving modular equations				4.4, 5.1 (7th), 3.7, 4.1

TA	Office hours	Room
Sam Castle		
Jiechen Chen		
Rebecca Leslie		
Evan McCarty		
Tim Oleskiw		
Spencer Peters		
Robert Weber		
Ian Zhu		

Section	Day/Time	Room
AA	Th, 830-920	MGH 242
AB	Th, 930-1020	MGH 234
AC	Th, 1030-1120	JHN 075
BA	Th, 1230-120	MGH 228
BB	Th, 130-220	MGH 242
BC	Th, 230-320	MEB 242

Homeworks [Grading guidelines]:

Assignments will be submitted via Gradescope. An

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.”

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

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

some truth tables

✓ AND

p	¬ p
T	F
F	T

p	q	p ∧ q
T	T	T
T	F	F
F	T	F
F	F	F

OR

p	q	p ∨ q
T	T	T
T	F	T
F	T	T
F	F	F

XOR

p	q	p ⊕ q
T	T	F
T	F	T
F	T	T
F	F	F

$p \to q$

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

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

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

Suppose it's not raining…

F F ✓

T T ✓

T F X

F T ✓

p	q	$p \to q$
T	T	T
T	F	F
F	T	T
F	F	T

$p \rightarrow q$

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

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

p = I'm a Pokémon master

q = I have ... 151 Pokémon.

$\rightarrow q \rightarrow p$

$\boxed{p \rightarrow q}$

$*$

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	$p \rightarrow q$

$p \rightarrow q$

converse, contrapositive, inverse

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

How do these relate to each other?

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

Shorthand:

p : RElephant
q : RTusks
r : RToenails

exercise.

let's think about fruits

A fruit is an apple only if it is either red or green and a fruit is not red and green.

p : “Fruit is an apple”
q : “Fruit is red”
r : “Fruit is green”

Let's think about fruits

A fruit is an apple only if it is either red or green and a fruit is not red and green.

(FApple **only if (**FGreen **xor** FRed**)) and** (**not (**FGreen **and** FRed))

$(\text{FApple} \rightarrow (\text{FGreen} \oplus \text{FRed})) \wedge (\neg (\text{FGreen} \wedge \text{Fred}))$

p : FApple
q : FGreen
r : FRed

Fruit Sentence with a truth table

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

biconditional: $p \leftrightarrow q$

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

p	q	$p \leftrightarrow q$