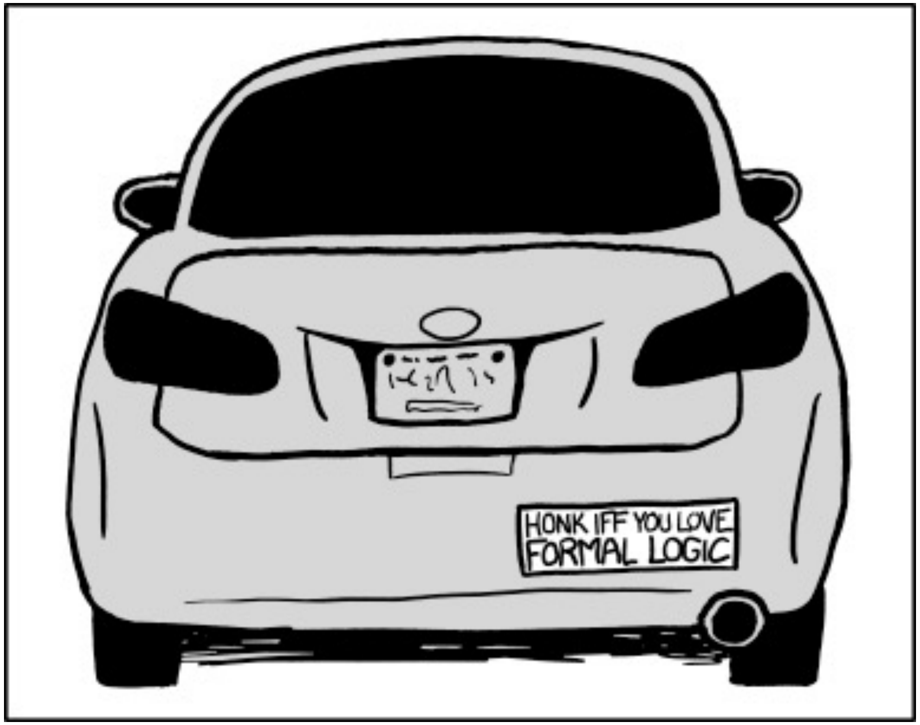
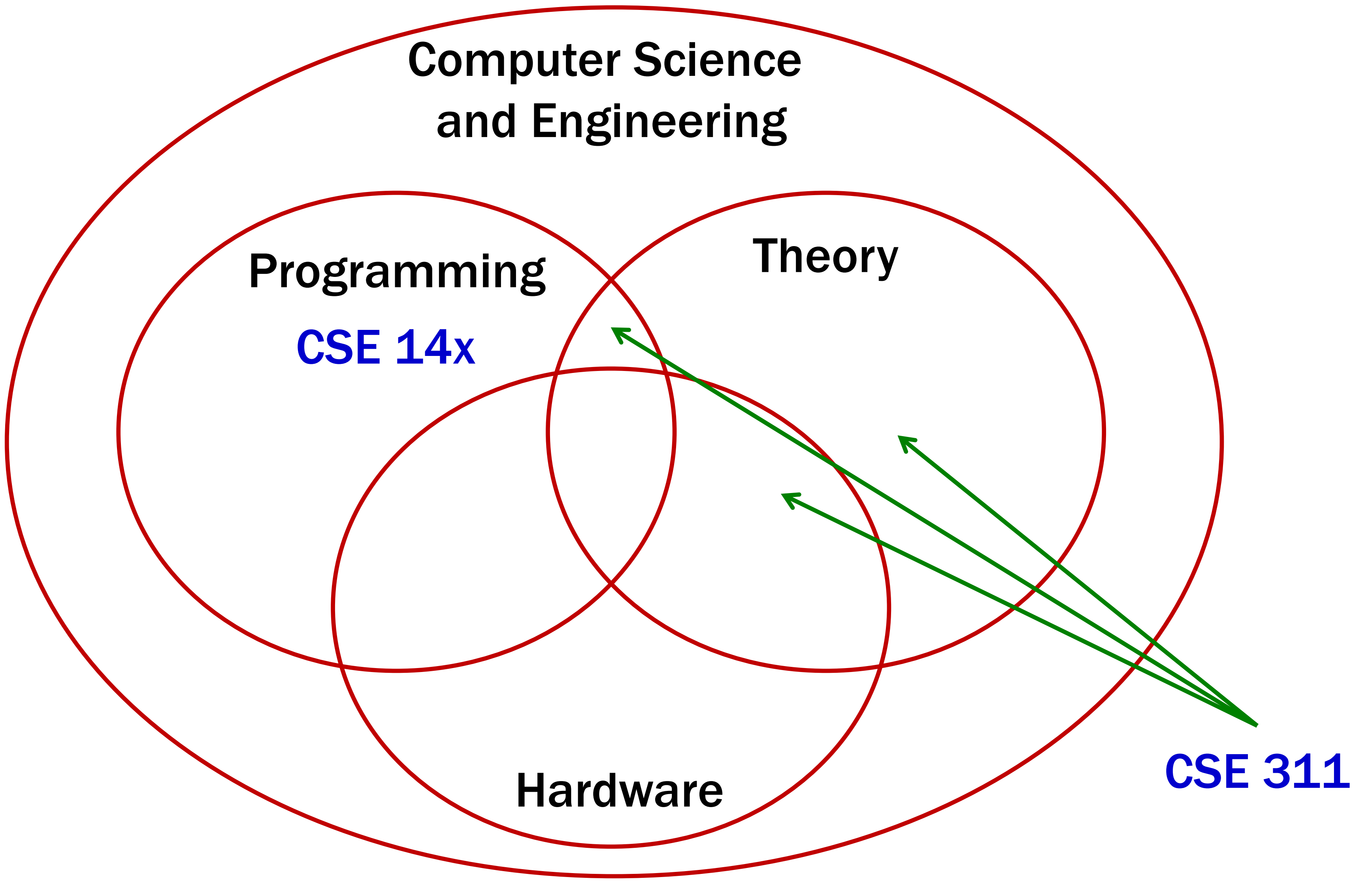
CSE 311: Foundations of Computing I

Lecture 1: Propositional Logic



About CSE 311

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

And become a better programmer

By the end of the course, you will have the tools to....

- reasoning about difficult problems
- automating difficult problems
- communicating ideas, methods, objectives
- understand fundamental structures of CS

Course Logistics

Instructors

Philip Garrison

Office Hours:
M 2:30-3:30
W 3:30-4:30

Thomas Rothvoss

Office Hours:
M 10:30-11:30
W 11:30-12:30

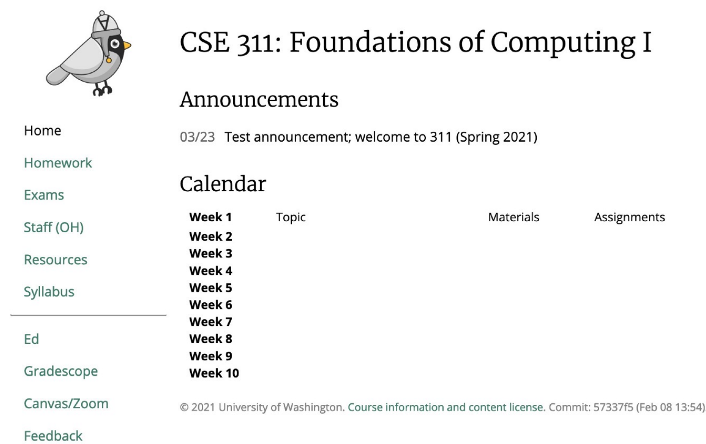
Instructors teach alternatingly both sections!

Office hours are for students in both sections

Lectures of morning section will be recorded

Infrastructure & Zoom logistics

- The whole course (lectures + sections + office hours) will be fully remote via **Zoom**
- Some info like Zoom links, recordings, polls/quizzes will be on **Canvas** (non-public)
- Main course webpage is https://cs.uw.edu/311



Zoom lectures:

- You can use chat or microphone to ask questions
- No requirement to leave on video – but seeing at least part of the audience helps us in lecturing

TAs

Teaching Assistants:

Sandy Chien
Ketaki Deuskar
Shreya Jayaraman
Sangwon Kim
Audrey Elise Ma
Aerin Claire Malana
Raymond Guo
Saagar Mehta
Ansh Nagda
Andrey Ryabtsev
Zoey Shi
David Kealii Shiroma
Ivy Wang

Section:

Thursdays

– starting this week

Office Hours: TBD

Administrivia

(Optional) Book:
Rosen: Readings for 6th (used) or
7th (cut down) editions.
Good for practice with solved problems

Administrivia

Homework:

- Weekly. Due WED at 11:00 pm online
- Collaborative discussion strongly encouraged; write up must be individual

Grade contribution:

- 74% Homework
- 7.5% in lecture activities
- 18.5% comprehensive final problem set

No exam!

“In-lecture activity” can also be done offline

Contact Us

Ed message board

Staff mailing list
- private matters
- cse311-staff at cs

All Course Information @ cs.uw.edu/311

About grades…

- Grades were very important up until now…

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  - good recommendations involve knowledge beyond the classes

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- Grades are **much less** important going forward
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- Please <u>relax</u> and focus on learning

Collaboration Policy

- Collaboration with others is encouraged
- BUT you must:
  - list anyone you work with
  - turn in only your own work

- Recommended approach for group work
  - do not leave with any solution written down or photographed
  - wait 30 minutes before writing up your solution

- See Allen School Academic Misconduct policy also

Late Work

- You have **5 late days** during the quarter for submitting homework assignment
- Max 2 late days (=48h) per single homework
- No need to ask us for permission – just submit late; we keep track

390Z

CSE 390Z is a **workshop** designed to provide **academic support** to students enrolled concurrently in CSE 311.

During each 2-hour workshop, students will reinforce concepts through

- Collaborative problem solving
- Practice study skills and **effective learning** habits
- **Build community** for peer support

All students enrolled in CSE 311 are welcome to register for this class. If you are interested in receiving an add code, please fill out a form here: HTTPS://TINYURL.COM/CSE390Z. If you have any questions or concerns please contact Rob (minneker@uw.edu). Add code requests accepted until 5:00PM PST Friday, April 2nd, 2021.

Accommodations

- If you have, or think you may have, a temporary health condition or permanent disability, contact Disability Resources for Students (DRS) to get started with accommodations.
- Accommodations for faith or conscience reasons must be requested within the first two weeks using the Registrar's request form.
- Your performance in this course should not be affected by circumstances beyond your control. We can still work with you for situations other than the university-wide accommodations. If anything does come up, you should contact the course staff as early as you can.

Lecture 1 Activity

- You will be assigned to **breakout rooms**. Please:
- Introduce yourself
- Choose someone to share screen, showing this PDF
- Answer these “get to know you” questions:
  - What is your favorite socially-distanced activity?
  - What class are you most excited about this quarter?
  - And why is it 311?
  - Found a new friend? A new study group? Share your emails!

Practice filling out a poll everywhere for Activity Credit!
Go to pollev.com/philipmg and login with your UW identity

Propositional Logic

What is logic and why do we need it?

Logic is a language, like English or Java, with its own

- words and rules for combining words into sentences (syntax)
- ways to assign meaning to words and sentences (semantics)

Why learn another language when we know English and Java already?

Why not use English?

– Turn right here…

– Buffalo buffalo Buffalo buffalo buffalo buffalo Buffalo buffalo

– We saw her duck

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?

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Natural languages can be imprecise

Why not use Java?

What does this code do:

```
public static boolean mystery(int x) {
  for (int r = 2; r < x; r++) {
    for (int q = 2; q < x; q++) {
      if (r*q == x)
        return false;
      }
    }
  }
  return x > 1;
}
```

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Determines if x is a prime number

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  }
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}
```

Determines if x is a prime number

Programming languages can be verbose

Why learn a new language?

We need a language of reasoning to

- state sentences more precisely
- state sentences more concisely
- understand sentences more quickly

Propositions: building blocks of logic

A ***proposition*** is a statement that

- is either true or false
- is “well-formed”

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A ***proposition*** is a statement that

- is either true or false
- is "well-formed"

All cats are mammals

true

All mammals are cats

false

Are These Propositions?

$2 + 2 = 5$

$x + 2 = 5$

Akjsdf!

Who are you?

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

Are These Propositions?

2 + 2 = 5

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

x + 2 = 5

Not a proposition. Doesn't have a fixed truth value

Akjsdf!

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

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

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

Truth Values:

- T for true
- F for false

A Compound Proposition

“Garfield has black stripes if he is an orange cat and likes lasagna, and he is an orange cat or does not like lasagna”

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

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First find the simplest (**atomic) propositions**:

- q "Garfield has black stripes"
- r "Garfield is an orange cat"
- s "Garfield likes lasagna"

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q "Garfield has black stripes"

r "Garfield is an orange cat"

s "Garfield likes lasagna"

(q if (r and s)) and (r or (not s))

Logical Connectives

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

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(q if (r and s)) and (r or (not s))

(q if $(r \wedge s)) \wedge$ **(r** $\vee \neg s)$

Some Truth Tables

q	$\neg q$

q	r	$q \wedge r$

q	r	$q \vee r$

q	r	$q \oplus r$

Some Truth Tables

q	$\neg q$
T	F
F	T

q	r	$q \wedge r$
T	T	T
T	F	F
F	T	F
F	F	F

q	r	$q \vee r$
T	T	T
T	F	T
F	T	T
F	F	F

q	r	$q \oplus r$
T	T	F
T	F	T
F	T	T
F	F	F

Implication

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

q	r	$q \rightarrow r$
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		
I do not have my umbrella		

Implication

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

q	r	$q \to r$
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"

q	r	$q \rightarrow r$
T	T	T
T	F	F
F	T	T
F	F	T

Are these true?

$2 + 2 = 4 \rightarrow$ *earth is a planet*

$2 + 2 = 5 \rightarrow$ *26 is prime*

Implication

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

q	r	$q \rightarrow r$
T	T	T
T	F	F
F	T	T
F	F	T

Are these true?

$2 + 2 = 4 \rightarrow$ *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$\rightarrow$T is true. So, the statement is true.

$2 + 2 = 5 \rightarrow$ *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!

$q \to r$

(1) "I have collected all 151 Pokémon if I am a Pokémon master"

(2) "I have collected all 151 Pokémon only if I am a Pokémon master"

These sentences are implications in opposite directions:

$q \rightarrow r$

(1) "I have collected all 151 Pokémon if I am a Pokémon master"

(2) "I have collected all 151 Pokémon only if I am a Pokémon master"

These sentences are implications in opposite directions:

(1) "Pokémon masters have all 151 Pokémon"

(2) "People who have 151 Pokémon are Pokémon masters"

So, the implications are:

(1) If I am a Pokémon master, *then* I have collected all 151 Pokémon.

(2) If I have collected all 151 Pokémon, *then* I am a Pokémon master.

$q \rightarrow r$

Implication:

– *q* implies *r*

– whenever *q* is true *r* must be true

– if *q* then *r*

– *r* if *q*

– *q* is sufficient for *r*

– *q* only if *r*

– *r is necessary for q*

q	r	$q \rightarrow r$
T	T	T
T	F	F
F	T	T
F	F	T

Biconditional: $q \leftrightarrow r$

- q iff r
- q is equivalent to r
- q implies r and r implies q
- q is necessary and sufficient for r

q	r	$q \leftrightarrow r$

Biconditional: $q \leftrightarrow r$

- *q* iff *r*
- *q* is equivalent to *r*
- *q* implies *r* and *r* implies *q*
- *q* is necessary and sufficient for *r*

q	r	$q \leftrightarrow r$
T	**T**	**T**
T	**F**	**F**
F	**T**	**F**
F	**F**	**T**

Back to Garfield...

q	"Garfield has black stripes"
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"Garfield has black stripes if he is an orange cat and likes lasagna, and he is an orange cat or does not like lasagna"

↓

(q if (r and s)) and (r or (not s))

↓

(q "if" $(r \wedge s)) \wedge$ **(r** $\vee \neg$ **s)**

Back to Garfield...

q "Garfield has black stripes"
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↓

(q if (r and s)) and (r or (not s))

↓

$(\mathbf{q}$ **"if"** $(r \land s)) \land (\mathbf{r} \lor \neg \mathbf{s})$

↓

$((r \land s) \longrightarrow q) \land (\mathbf{r} \lor \neg \mathbf{s})$

Analyzing the Garfield Sentence with a Truth Table

q	r	s	$\neg s$	$r \vee \neg s$	$r \wedge s$	$(r \wedge s) \rightarrow q$	$((r \wedge s) \rightarrow q) \wedge (r \vee \neg s)$
F	F	F					
F	F	T					
F	T	F					
F	T	T					
T	F	F					
T	F	T					
T	T	F					
T	T	T					

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F	F	F	T	T	F	T	T
F	F	T	F	F	F	T	F
F	T	F	T	T	F	T	T
F	T	T	F	T	T	F	F
T	F	F	T	T	F	T	T
T	F	T	F	F	F	T	F
T	T	F	T	T	F	T	T
T	T	T	F	T	T	T	T