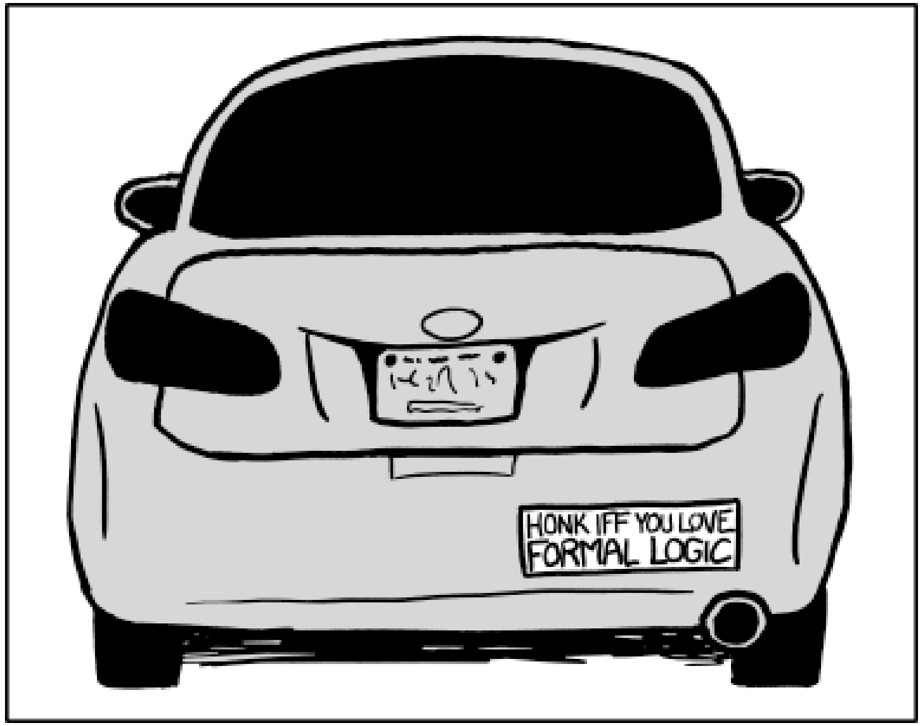
Here Early?

Here for CSE 311?

Welcome! You’re early!

Want a copy of these slides to take notes?

- You can download them from the calendar webpage cs.uw.edu/311



Logistics and Propositional Logic

CSE 311: Foundations of Computing I
Lecture 1

Outline

Course logistics

What is the goal of this course?

Start of Propositional Logic

COVID logistics

We're following the university's COVID policies.

- For right now, that means masks are recommended, but not required.

Follow the university's guidance when you have close contact or symptoms.

- That may require isolating and if you test positive a report to UW EH&S.

There's no required attendance for regular lectures or sections.

- Lectures are recorded. Sections won't be recorded, but we'll post "recap" videos walking through the covered problems.

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This is where syllabus information would go

If we had time…

Since it's Spring, we have fewer lectures than normal.

So detailed information is in an extra recording on panopto. Part of HW1 is watching that video.

What you need to know right now

We're following the university's COVID policies.

For right now, that means masks are recommended, but not required.

We'll have a mix of zoom and in-person office hours.

We'll have a **take-home** "mini-midterm"

I wrote the syllabus assuming things will be "mostly like Fall" this quarter.

If things aren't "mostly like Fall" then we'll switch the final to take-home (more in the syllabus).

We don't know when the final will be yet! Working with UW to figure out combined-or-separate finals.

We're in a pandemic…

I've put as much into the syllabus as I can, but fundamentally ¯_(ツ)_/¯

Now is a great time to:

Ask DRS for accommodations if you think you might need formal ones.

Ensure your travel plans are consistent with either in-person or remote finals week.

Start looking for a study group!

CSE 390Z

390Z is:
Practice with concepts
Lessons on study skills
Place to find study groups

390Z is NOT:
Extra office hours
Homework help

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.

Contact Omar Ibrahim for more information

What is this course?

What is this course?

In this course, you will learn how to make and communicate rigorous and formal arguments.

Why? Because you’ll have to do technical communication in real life.

If you become a PM – you’ll have to convert non-technical requirements from experts into clear, unambiguous statements of what is needed.

If you become an engineer – you’ll have to justify to others exactly why your code works, and interpret precise requirements from your PM.

If you become an academic – to explain to other academics how your algorithms and ideas improve on everyone else’s.

What is this course?

In this course, you will learn how to make and communicate rigorous and formal arguments.

Two verbs

Make arguments – what kind of reasoning is allowed and what kind of reasoning can lead to errors?

Communicate arguments – using one of the common languages of computer scientists (no one is going to use your code if you can't tell them what it does or convince them it's functional)

Course Outline

Symbolic Logic (training wheels; lectures 1-7)

Just make arguments in mechanical ways.

- Using notation and rules a computer could understand.

Understand the rules that are allowed, without worrying about pretty words.

Set Theory/Arithmetic (bike in your backyard; lectures 8-19)

Make arguments, and communicate them to humans

Arguments about numbers and sets, objects you already know

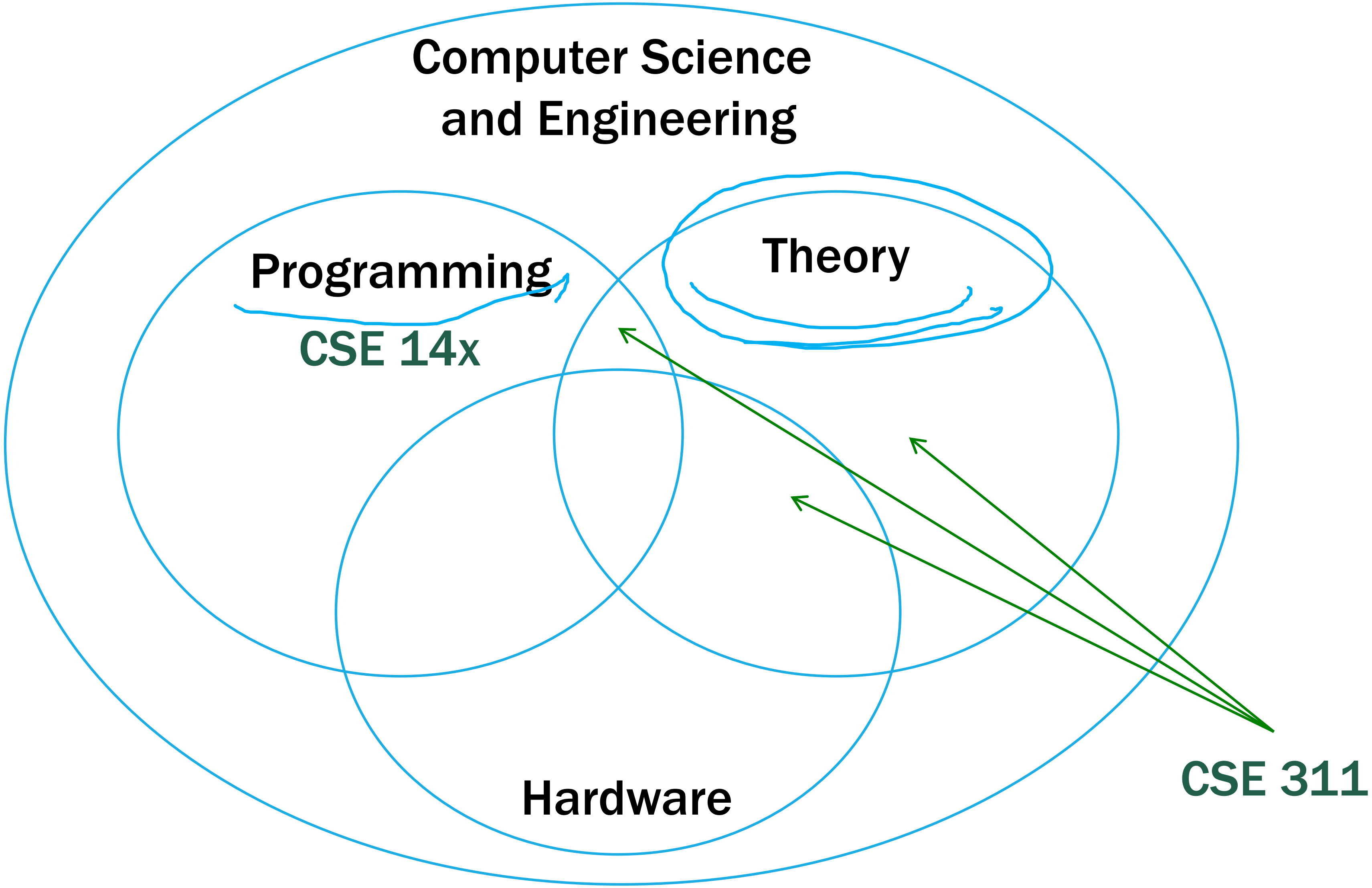
Models of computation (biking in your neighborhood; lectures 20-28)

Still make and communicate rigorous arguments

But now with objects you haven't used before.

- A first taste of how we can argue rigorously about computers.

Some Perspective



Symbolic Logic

What is symbolic logic and why do we need it?

Symbolic 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)

Symbolic Logic will let us **mechanically** simplify expressions and make arguments.

The new language will let us focus on the (sometimes familiar, sometimes unfamiliar) rules of logic.

Once we have those rules down, we'll be able to apply them "intuitively" and won't need the symbolic representation as often

but we'll still go back to it when things get complicated.

Propositions: building blocks of logic

Proposition

A statement that has a truth value (i.e. is true or false) and is "well-formed"

Propositions are the basic building blocks in symbolic logic.

Here are two propositions.

All cats are mammals

True, (and a proposition)

All mammals are cats

False, but is well-formed and has a truth value, so still a proposition.

Analogy

In 142/143 you talked about a variable type that could be either true or false.

You called it a `“Boolean”`

Boolean variables are a useful analogy for propositions.

They aren’t identical, but they’re very similar.

Are These Propositions?

2 + 2 = 5

x + 2 = 5

Akjsdf!

Who are you?

There is life on Mars.

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.

There is life on Mars.

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…

To make statements easier to read we'll use propositional variables like $p, q, r, s, \ldots$

Lower-case letters are standard.

Usually start with p (for proposition), and avoid t, f, because…

Truth Values:

T for true (note capitalization)

F for false

Analogy

We said propositions were a lot like Booleans…

How did you connect Booleans in code?

&&

||

!

Logical Connectives

And (&&) works exactly like it did in code.

But with a different symbol ∧

Or (||) works exactly like it did in code.

But with a different symbol ∨

Not (!)works exactly like it did in code.

But with a different symbol ¬

Some Truth Tables

p	$\neg p$

p	q	$p \wedge q$

p	q	$p \vee q$

Truth tables are the simplest way to describe how logical connectives operate.

Some Truth Tables

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

Truth tables are the simplest way to describe how logical connectives operate.

Implication

Another way to connect propositions

If p then q.

"If it is raining, then I have my umbrella."

$p \to q$

Think of an implication as a promise.

Implication

The first two lines should match your intuition.

The last two lines are called “vacuous truth.” For now, they’re the definition. We’ll explain why in a few lectures.

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

This is the definition of implication. When you write “if…then…” in a piece of mathematical English, this is how you will be interpreted.

Implication ($p \to q$)

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

It's useful to think of implications as promises. An implication is false exactly when you can ***demonstrate*** *I'm lying.*

	It's raining	It's not raining
I have my umbrella		
I do not have my umbrella		

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

Implication ($p \to q$)

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

It's useful to think of implications as promises. An implication is false exactly when you can ***demonstrate*** *I'm lying.*

	It's raining	It's not raining
I have my umbrella	No lie. True	No lie. True
I do not have my umbrella	**LIE! False**	No lie. True

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

$p \rightarrow q$

$p \rightarrow q$ and $q \rightarrow p$ are different implications!

"If the sun is out, then we have class outside."

"If we have class outside, then the sun is out."

Only the first is useful to you when you see the sun come out.

Only the second is useful if you forgot your umbrella.

$p \rightarrow q$

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

q is necessary for p

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

Implications are super useful, so there are LOTS of translations.
You'll learn these in detail in section.

A More Complicated Statement

"Robbie knows the Pythagorean Theorem if he is a mathematician and took geometry, and he is a mathematician or did not take geometry."

Is this a proposition?

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

In particular, is it true?

A Compound Proposition

"Robbie knows the Pythagorean Theorem if he is a mathematician and took geometry, and he is a mathematician or did not take geometry."

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

First find the simplest (atomic) propositions:

p	"Robbie knows the Pythagorean Theorem"
q	"Robbie is a mathematician"
r	"Robbie took geometry"

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

(p if $(q \wedge r)) \wedge (q \vee (\neg r))$

A Compound Proposition

"Robbie knows the Pythagorean Theorem if he is a mathematician and took geometry, and he is a mathematician or did not take geometry."

$$(p \text{ if } (q \land r)) \land (q \lor (\neg r))$$

p	**"Robbie knows the Pythagorean Theorem"**
q	**"Robbie is a mathematician"**
r	**"Robbie took geometry"**

How did we know where to put the parentheses?

- Subtle English grammar choices (top-level parentheses are independent clauses).
- Context/which parsing will make more sense.
- Conventions

A reading on this is coming soon!

Back to the Compound Proposition…

"Robbie knows the Pythagorean Theorem if he is a mathematician and took geometry, and he is a mathematician or did not take geometry."

$(p \text{ if } (q \wedge r)) \wedge (q \vee (\neg r))$

p	**"Robbie knows the Pythagorean Theorem"**
q	**"Robbie is a mathematician"**
r	**"Robbie took geometry"**

What promise am I making?

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

The first one! Being a mathematician and taking geometry goes with the "if." Knowing the Pythagorean Theorem is the consequence.

A Compound Proposition

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

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p "Robbie knows the Pythagorean Theorem"

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

$$(p \text{ if } (q \wedge r)) \wedge (q \vee (\neg r))$$

Analyzing the Sentence with a Truth Table

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

Order of Operations

Just like you were taught PEMDAS

e.g. $3 + 2 \cdot 4 = 11$ not 24.

Logic also has order of operations.

Parentheses

Negation

And

Or, exclusive or

Implication

Biconditional

For this class: each of these is it's own level!
e.g. "and"s have precedence over "or"s

Within a level, apply from left to right.

Other authors place And, Or at the same level – it's good practice to use parentheses even if not required.

Logical Connectives

Negation (not)	$\neg p$
Conjunction (and)	$p \land q$
Disjunction (or)	$p \lor q$
Exclusive Or	$p \oplus q$
Implication(if-then)	$p \longrightarrow q$
Biconditional	$p \leftrightarrow q$

These ideas have been around for so long most have at least two names.

Two more connectives to discuss!

Biconditional: $p \leftrightarrow q$

Think: $(p \rightarrow q) \wedge (q \rightarrow p)$

p if and only if *q*

p iff q

p is equivalent to *q*

p implies *q* and *q* implies *p*

p is necessary and sufficient for *q*

p	q	$p \leftrightarrow q$

Biconditional: $p \leftrightarrow q$

Think: $(p \rightarrow q) \wedge (q \rightarrow p)$

p if and only if *q*

p iff q

p is equivalent to *q*

p implies *q* and *q* implies *p*

p is necessary and sufficient for *q*

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

$p \leftrightarrow q$ is the proposition:
"p" and "q" have the same truth value.

Exclusive Or

Exactly one of the two is true.

$p \oplus q$

p	q	$p \oplus q$

In English "either p or q" is the most common, but be careful.

Often translated "p or q" where you're just supposed to understand that exclusive or is meant (instead of the normal inclusive or).

Try to say "either…or…" in your own writing.

Exclusive Or

Exactly one of the two is true.

$p \oplus q$

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

In English "either p or q" is the most common, but be careful.

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Try to say "either…or…" in your own writing.

Active learning!

We'll pause lectures for a few minutes

Why? It works!

https://www.pnas.org/content/111/23/8410 a meta-analysis of 225 studies.

Just listening to me isn't as good for you as listening to me then trying problems on your own and with each other.

Lecture 1 Activity

Go to pollev.com/uwcse311

You have to login, but no "points" are associated; these help me adjust explanation.

Introduce yourselves!

Break this sentence down into its smallest propositions and convert it into logical notation.

"If I read the book or watch the movie, then I'll know the plot."

What’s next?

A proof!

We want to be able to make iron-clad guarantees that something is true.

And convince others that we really have ironclad guarantees.

Todo

Tonight:
Make sure you can access the Ed discussion board.

Wednesday (and Friday):

Lectures in-person (or recorded)

Thursday:

Go to section

Soon:

Form a study group! Threads to organize on the Ed board.