CSE 311: Foundations of Computing I

Lecture 1: Propositional Logic
About CSE 311
Some Perspective

Computer Science and Engineering

Programming

CSE 14x

Theory

Hardware

CSE 311
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          Saagar Mehta
Ketaki Deuskar       Ansh Nagda
Shreya Jayaraman    Andrey Ryabtsev
Sangwon Kim          Zoey Shi
Audrey Elise Ma      David Kealii Shiroma
Aerin Claire Malana  Ivy Wang
Raymond Guo

Section:

    Thursdays
    - starting this week

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

• Grades were very important up until now

• Grades are much less important going forward
  – companies care much more about your interviews
  – grad schools care much more about recommendations
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• Understanding the material is much more important
  – interviews test your knowledge from these classes
  – good recommendations involve knowledge beyond the classes
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• Please relax 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
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](http://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 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?
Why not use English?

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  Does “duck” mean the animal or crouch down?

Natural languages can be imprecise
Why not use Java?

What does this code do:

```java
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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    return x > 1;
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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
A *proposition* is a statement that

- is either true or false
- is “well-formed”
Propositions: building blocks of logic

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.
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.

First find the simplest (atomic) propositions:

- $q$ “Garfield has black stripes”
- $r$ “Garfield is an orange cat”
- $s$ “Garfield likes lasagna”
A Compound Proposition

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We’d like to understand what this proposition means.

First find the simplest (atomic) propositions:

\[ q \quad \text{“Garfield has black stripes”} \]
\[ r \quad \text{“Garfield is an orange cat”} \]
\[ s \quad \text{“Garfield likes lasagna”} \]

\( (q \text{ if } (r \text{ and } s)) \text{ and } (r \text{ or } (\text{not } s)) \)
## Logical Connectives

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$q$ “Garfield has black stripes”  
$r$ “Garfield is an orange cat”  
$s$ “Garfield likes lasagna”

“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 $(\neg s))$
Logical Connectives

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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 \text{ if } (r \land s)) \land (r \lor \neg s)
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Some Truth Tables

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Implication

“If it’s raining, then I have my umbrella”

It’s useful to think of implications as promises. That is “Did I lie?”

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<th>It’s raining</th>
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<td>I have my umbrella</td>
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<td>I do not have my umbrella</td>
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“If it’s raining, then I have my umbrella”

It’s useful to think of implications as promises. That is “Did I lie?”

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”

Are these true?

\[ 2 + 2 = 4 \rightarrow \text{earth is a planet} \]

\[ 2 + 2 = 5 \rightarrow 26 \text{ is prime} \]
Implication

“If it’s raining, then I have my umbrella”

Are these true?

\[2 + 2 = 4 \rightarrow \text{earth is a planet}\]

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.

\[2 + 2 = 5 \rightarrow 26 \text{ is prime}\]

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!*
\( q \rightarrow r \)

(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:
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.
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 $q$
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 $r$

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Back to Garfield...

- $q$: “Garfield has black stripes”
- $r$: “Garfield is an orange cat”
- $s$: “Garfield likes lasagna”

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

\[(q \text{ if } (r \land s)) \land (r \lor \neg s)\]
Back to Garfield...

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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”

\[(q \text{ if } (r \text{ and } s)) \text{ and } (r \text{ or } \neg s)\]

\[(q \text{ “if” } (r \text{ and } s)) \land (r \lor \neg s)\]

\[((r \land s) \rightarrow q) \land (r \lor \neg s)\]
Analyzing the Garfield Sentence with a Truth Table

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<tr>
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<th>$\neg s$</th>
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