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?
- Number theory: How do we keep data secure?
- 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?
- Turing machines: What is computation?
- Are there problems computers can’t solve?

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**The computational perspective.**

*Example: Sudoku*

Given one, solve by hand.

Given most, solve with a program.

Given any, solve with computer science.

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

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**Administrivia**

**Prof:** James R. Lee

[James “PG 13” Lee was less fun]

**Teaching assistants:**
- Evan McCarty
- Mert Saglam
- Ian Turner
- Ian Zhu
  - cse311-staff@cs

**Homework:**
- Due Fridays on Gradescope
- Write up individually

**Exams:**
- Midterm: date soon
- Final: TBA

**Grading (roughly):**
- 50% homework
- 35% final exam
- 15% midterm


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**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**

A **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.

**Proposition** is a statement that has a truth value and is "well-formed"

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

- Propositional variables: $p, q, r, s, ...$
- Truth values: $T$ for true, $F$ for false

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

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


**logical connectives**

- Negation (not)  \( \neg p \)
- Conjunction (and)  \( p \land q \)
- Disjunction (or)  \( p \lor q \)
- Exclusive or  \( p \oplus q \)
- Implication  \( p \rightarrow q \)
- Biconditional  \( p \leftrightarrow q \)

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

**some truth tables**

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
p & \neg p \\
\hline
0 & 1 \\
1 & 0 \\
\hline
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
p & q & p \land q \\
\hline
0 & 0 & 0 \\
0 & 1 & 0 \\
1 & 0 & 0 \\
1 & 1 & 1 \\
\hline
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
p & q & p \lor q \\
\hline
0 & 0 & 0 \\
0 & 1 & 1 \\
1 & 0 & 1 \\
1 & 1 & 1 \\
\hline
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
p & q & p \oplus q \\
\hline
0 & 0 & 0 \\
0 & 1 & 1 \\
1 & 0 & 1 \\
1 & 1 & 0 \\
\hline
\end{array}
\]

“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...

\[
\begin{array}{c|c|c|c|c|c|c}
\hline
p & q & p \rightarrow q \\
\hline
0 & 0 & 1 \\
0 & 1 & 1 \\
1 & 0 & 0 \\
1 & 1 & 1 \\
\hline
\end{array}
\]

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

Can we re-phrase this as “if \( p \), then \( q \)”?

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

Define shorthand...

\[
\begin{align*}
p & : \text{RElephant} \\
q & : \text{RTusks} \\
r & : \text{RToenails}
\end{align*}
\]

Roger's second sentence with a truth table

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>( q \oplus r )</th>
<th>( p \rightarrow (q \oplus r) \rightarrow \neg q )</th>
<th>( p = (q \oplus r) \rightarrow \neg q )</th>
<th>( p \land (q \oplus r) \land \neg q )</th>
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Shorthand:

\[
\begin{align*}
p & : \text{RElephant} \\
q & : \text{RTusks} \\
r & : \text{RToenails}
\end{align*}
\]

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

Biconditional: \( p \leftrightarrow q \)

- \( p \) iff \( q \)
- \( p \) is equivalent to \( q \)
- \( p \) implies \( q \) and \( q \) implies \( p \)