About the course

• From the CSE catalog:
  – CSE 311 Foundations of Computing I (4)
    Examines fundamentals of logic, set theory, induction, and algebraic structures with applications to computing; finite state machines; and limits of computability. Prerequisite: CSE 143; either MATH 126 or MATH 136.

• What I think the course is about:
  – Foundational structures for the practice of computer science and engineering

Why this material is important

• Language and formalism for expressing ideas in computing
• Fundamental tasks in computing
  – Translating imprecise specification into a working system
  – Getting the details right

Topic List

• Logic/boolean algebra: hardware design, testing, artificial intelligence, software engineering
• Mathematical reasoning/induction: algorithm design, programming languages
• Number theory: cryptography, security, algorithm design
• Relations/relational algebra: databases
• Finite state machines: Hardware and software design, automatic verification
• Turing machines: Halting problem

CSE 311 Foundations of Computing I
Spring 2013
Lecture 1
Propositional Logic
Administration

- Instructor
  - Paul Beame
- Teaching Assistants
  - Caitlin Bonnar
  - Chelsea Dallas
  - Chantal Murthy
  - Noah Siegel
- Quiz sections
  - Thursdays
- Text: Rosen, Discrete Mathematics
  - 6th Edition or 7th Edition

Propositional Logic

- Homework
  - Due Wednesdays at start of class
  - Individual
- Exams
  - Midterm, Friday, May 10
  - Final Exam, Monday, June 10, 2:30-4:20 pm
  - All course information posted on the web:
    http://www.cs.washington.edu/311
- Grading Weight (Roughly)
  - 50% homework
  - 35% final exam
  - 15% midterm

Propositions

- A statement that has a truth value
- Which of the following are propositions?
  - The Washington State flag is red
  - It snowed in Whistler, BC on January 4, 2011.
  - There is an Argentinian Pope named Francis I.
  - Space aliens landed in Roswell, New Mexico
  - Turn your homework in on Wednesday
  - Why are we taking this class?
    - If n is an integer greater than two, then the equation $a^n + b^n = c^n$ has no solutions in non-zero integers a, b, and c.
    - Every even integer greater than two can be written as the sum of two primes
    - This statement is false
  - Propositional variables: $p, q, r, s, \ldots$
  - Truth values: $T$ for true, $F$ for false

Compound Propositions

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

<table>
<thead>
<tr>
<th>p</th>
<th>¬p</th>
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<tr>
<th>p</th>
<th>q</th>
<th>p ∧ q</th>
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or example: prerequisites for 311: either Math 126 or Math 136

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
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x-or example: “you may have soup or salad with your entree”

Understanding complex propositions

- Either Harry finds the locket and Ron breaks his wand or Fred will not open a joke shop

Atomic propositions

h: Harry finds the locket
r: Ron breaks his wand
f: Fred opens a joke shop

(h ∧ r) ⊕ ¬f

Understanding complex propositions with a truth table

<table>
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<tr>
<th>h</th>
<th>r</th>
<th>f</th>
<th>h ∧ r</th>
<th>¬f</th>
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Aside: Number of binary operators

- How many different binary operators are there on atomic propositions?
$p \rightarrow q$

- 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 $q$

If pigs can whistle then horses can fly

Converse, Contrapositive, Inverse

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

- Are these the same?

Biconditional $p \leftrightarrow q$

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

Example:

- $p$: "$x$ is divisible by 2"
- $q$: "$x$ is divisible by 4"
English and Logic

• You cannot ride the roller coaster if you are under 4 feet tall unless you are older than 16 years old
  – $q$: you can ride the roller coaster
  – $r$: you are under 4 feet tall
  – $s$: you are older than 16

$((r \land \neg s) \rightarrow \neg q)$