Theoretical Computer Science
CS 310
Chadd Williams

Office Hours: chadd@pacificu.edu
Mon 3:00 – 4:00 PM
Tues 2:00 – 4:00 PM
Fri 11:00 – 12:00 PM
and by appointment
http://zeus.cs.pacificu.edu/chadd/cs310f06/

Syllabus
http://zeus.cs.pacificu.edu/chadd/cs310f06/syllabus.html
• Introduction to the Theory of Computation by Michael Sipser, (Second Edition)
  – I will assign problems out of this book

Grades:
• Homework: 15%
• 2 Exams: 25% each
• 1 Final 35% (Comprehensive)

Dates:
• Midterm 1, Wed Oct 11, 2006
• Midterm 2, Wed Nov 13, 2005
• Final, Tue Dec 5 (8:30 – 11:00 AM)

Policies:
• Assignments are due at the beginning of class. Late assignments will not be accepted.
• The cheating policy is defined in the Pacific Catalog
• Silence all electronic devices

Today
• Overview of class
• Mathematical Notation
• Proof by Induction
• Who Am I?
Overview

- What are the fundamental capabilities and limitations of computers?
- Computer Science is really the science of computation, not of computers.
- How does theory related to programming?
- Complexity Theory
- Computability Theory
- Automata Theory

Mathematical Notation

- Basic notations we will use in this class
  - Page 16 of your book has a partial list (no symbols!)

- Set
  \{ 7, 21, 57 \} \{ 1, 2, 3, … \} \{ gold, blue \}

- Subset

- Proper Subset

Sets

- Shorthand for describing a set
  \{ n | rule about n\}

  \{ n | n = m^2 for some m \in N \}

  \{ \{ i, i^2 \} | i \in N \}
Set Operations

- What can we do with sets?
- Union
- Intersection
- Complement

Sets

- Power Set
  \{ 0, 1 \}

- Cartesian Product (Cross Product)
  \{ 0, 1 \} \times \{ a, b \}

Sequences/Tuples

- Sequence
  \( (7, 21, 57) \quad (21, 7, 57) \quad (\text{gold, blue}) \)

- Tuple
  K-tuple
Functions
• Object that takes input, produces output
  \[ f(a) = b \]
• Domain and Range
  \[ f : D \rightarrow R \]
• Onto

Functions
• \( f : A_1 \times A_2 \times \ldots \times A_k \rightarrow R \)
  \((a_1, a_2, \ldots, a_k)\)
  k-ary
  arity
  unary \(k=1\) binary \(k=2\)
• Notation
  Infix notation: \( a + b \)
  Prefix notation: \( \text{add}(a,b) \)

Relations
• Predicate (property)
  \( f : D \rightarrow \{\text{TRUE}, \text{FALSE}\} \)
• Relation
  \( f : A_1 \times A_2 \times \ldots \times A_n \rightarrow \{\text{TRUE}, \text{FALSE}\} \)
• Notation
  table
  Set
Equivalence Relations

binary relation
shows that two objects are equal
must satisfy 3 conditions:

1. R is reflexive if for every x, xRx;
2. R is symmetric if for every x and y, xRy if and only if yRx;
3. R is transitive if for every x, y, and z, xRy and yRz implies xRz

Proof by Contradiction

• Assume it is false
• Show this leads to a false consequence
• Prove √2 is irrational
  – Assume it is rational: √2 = m/n
  – Reduce m/n to lowest terms: m and n are not both even (could reduce out a 2)
  – sometimes tricky to pick exactly what false consequence to show

Proof by Induction

• Basis
  Prove P(1) is true
• Induction Step
  Prove that for each i≥1, if P(i) is true, then so is P(i+1); assume P(i) is true
• Basis + Induction Step
  P(1) is true, i = 1
  P( (i+1) ) is true
  P( (i+1) +1 ) is true …
Proof by Induction

• Prove: \(1 + 2 + \ldots + n = \frac{n(n+1)}{2}\)
  for \(n \geq 1\)

  Basis:

  Induction:

Chadd Williams

• New Computer Science Professor!
• Education
  – West Virginia University (BS)
  – University of Maryland, College Park (MS, PhD)
• Research
  – Systems
    • Runtime code patching
    • Modify instructions in a running executable
  – Programming languages/Software Engineering
    • Studying software change history to learn about the source code