

COURSENOTES

**CS4104:**  
**Data and Algorithm Analysis**

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# CS4014 Prereqs and Major Topics

What you need to already know:

- Discrete Math
  - Proof by contradiction and induction
  - Summations
  - Set theory, relations
- The basics of Asymptotic Analysis
  - Big-oh, Big- $\Omega$ ,  $\Theta$
- Most of what was covered in CS2606
  - Basic data structures
  - Algorithms for searching and sorting

What we will do:

- Finally understand upper/lower bounds
- Lower bounds proofs
- Analysis techniques (no hand waving!)
  - Recurrence Relations
- Reductions,  $\mathcal{NP}$ -completeness theory, and a little computability theory

Process:

- Weekly homework sets (they are hard!)
- Work in pairs

# Introduction to Problem Solving

- Principle of Intimate Engagement
  - This is the most important consideration
  - Actively engaging the problem, getting involved
  - Need to build up “mental muscles” for problem solving
- Effective vs. Ineffective problem solvers (Engagers vs. Dismissers)
  - Engagers have a history of success
  - Dismissers have a history of failure
  - You probably engage some problems and dismiss others
  - You could solve more problems if you overcame the mental hurdles that lead to dismissing
  - Transfer successful problem solving in some parts of your life to other areas.
- Getting your hands dirty
  - Example: Repairing a wobbly table
  - Get underneath and look
  - Example: Repairing a dryer
  - Open up back panel and look

# Investigation and Argument

Problem solving has two parts: the investigation and the argument.

- Students are used to seeing only the argument in their textbooks and lectures.
- To be successful in school and in life, one needs to be good at both
- To solve the problem, you must investigate successfully.
- Then, to give the answer to your client, you need to be able to make the argument in a way that gets the solution across clearly and succinctly.
- Writing skills. Proof Skills
- Methods of argument: Deduction (direct proof), contradiction, induction

# Heuristics for Problem Solving

These are most appropriate for problem solving “in the small.”

- Puzzles
- Math and CS test or homework problems

A list of standard Heuristics:

- Write it down
  - After motivation and mental attitude, the most important limitation on your ability to solve problems is biological
  - For active manipulation, you can only store  $7 \pm 2$  pieces of information
  - Take advantage of your environment to get around this
  - Write things down
  - Manipulate problem (good representation)
- Get your hands dirty
  - “Play around” with the problem to get some initial insight.

## Heuristics (2)

- Look for special features
  - Example: Cryptogram addition problems.

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- Go to the extremes
  - Study problem boundary conditions
- Simplify
  - This might give a partial solution that can be extended to the original problem.
- Penultimate step
  - What precondition must take place before the final solution step is possible?
  - Solving the penultimate step might be easier than the original problem.
- Lateral thinking
  - Don't be lead into a blind alley.
  - Using an inappropriate problem solving strategy might blind you to the solution.

## Heuristics (3)

- Wishful thinking
  - A version of simplifying the problem
  - Transform problem into something easy; take start position to something that you “wish” was the solution
  - That might be a smaller step to the actual solution
- Symmetry
  - Symmetries in the problem might give clues to the solution

# Problem Solving “In the Large”

- Problem Definition
  - Reformulate problem statement to get at the “real problem”.
- Generate Solutions
  - Getting around mental blocks.
  - Blockbusting.
  - Brainstorming.
- Decide the course of action.
  - Situation analysis.
  - Pareto analysis.
  - K.T. Problem analysis.
  - Decision analysis.
- Implement the solution.
  - Getting approval
  - Planning
  - Gantt charts
  - Critical path analysis
  - Experimental design
  - Report results.
- Evaluation
  - Make it an ongoing process at all stages



# Pairs Problem Solving

An effective way to work in pairs to solve problems:

- Partner roles: problem solver and listener

Responsibilities of the problem solver

- Constant vocalization
- Spell out all the assumptions
- Carefully detail all steps taken

Responsibilities of the listener

- Continually check for accuracy
- Demand constant vocalization

# Errors in Reasoning

Getting the wrong answer on a test or homework usually results from a “breakdown” in problem solving. Typical breakdowns:

- Failing to observe and use all relevant facts of a problem.
- Failing to approach the problem in a systematic manner. Instead, making leaps in logic without checking steps.
- Failing to spell out relationships fully.
- Being sloppy and inaccurate in collecting information and carrying out mental activities.

Myths about reading: These are some popularized misconceptions

- Don't subvocalize when you read
- Read only key words
- Don't be a word-by-word reader
- Read in thought groups
- You can be a speed reader without loss of comprehension
- Don't re-read