

CS 4104: Data and Algorithm Analysis

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CS4014: 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- Ω , Θ
- Most of what was covered in CS2606
 - ▶ Basic data structures
 - ▶ Algorithms for searching and sorting

CS4104: 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

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Process:

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

Introduction to Problem Solving (1)

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

Introduction to Problem Solving (2)

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.

Introduction to Problem Solving (2)

Getting your hands dirty

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- Example: Repairing a wobbly table
 - ▶ Get underneath and look

Introduction to Problem Solving (2)

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 (1)

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

- Puzzles
- Math and CS test or homework problems

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A list of standard Heuristics:

1 Externalize: 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 ± 2 pieces of information
- ▶ Take advantage of your environment to get around this
- ▶ Write things down
- ▶ Manipulate problem (good representation)

Heuristics for Problem Solving (2)

2 Get your hands dirty

- ▶ “Play around” with the problem to get some initial insight.

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3 Look for special features

- ▶ Example: Cryptogram addition problems.

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4 Go to the extremes

- ▶ Study problem boundary conditions

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5 Simplify

- ▶ This might give a partial solution that can be extended to the original problem.

Heuristics for Problem Solving (3)

6 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.

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- ▶ Don't be lead into a blind alley.
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8 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

Heuristics for Problem Solving (4)

9 Sleep on it

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10 Symmetry & Invariants

- ▶ Symmetries in the problem might give clues to the solution

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.