Problem Solving

- Problem solving is the process of transforming the description of a problem into the solution of that problem.
- We use our knowledge of the problem domain (requirements).
- We rely on our ability to select and use appropriate problem-solving strategies, techniques, and tools.

Algorithms

- An **algorithm** is a step by step solution to a problem.
- Why bother writing an algorithm?
  - For your own use in the future. You won’t have to rethink the problem.
  - So others can use it, even if they know very little about the principles behind how the solution was derived.

Examples of Algorithms

- Washing machine instructions
- Instructions for a ready-to-assemble piece of furniture
- A classic: finding the greatest common divisor (GCD) using Euclid’s Algorithm

Washing Machine Instructions

- Separate clothes into white clothes and colored clothes.
- Add 1 cup of powdered laundry detergent to tub.
- For white clothes:
  - Set water temperature knob to HOT.
  - Place white laundry in tub.
- For colored clothes:
  - Set water temperature knob to COLD.
  - Place colored laundry in tub.
- Close lid and press the start button.

Observations About the Washing Machine Instructions

- There are a finite number of steps.
- We are capable of doing each of the instructions.
- When we have followed all of the steps, the washing machine will wash the clothes and then will stop.
Refinement of Algorithm Definition

- Our old definition:
  - An algorithm is a step by step solution to a problem.
- Adding our observations:
  - An algorithm is a finite set of executable instructions that directs a terminating activity.

Instructions for a Ready-to-Assemble Piece of Furniture

- "Align the marks on side A with the grooves on Part F."
- How could these instructions be hard to follow?
  - Which side is A? A & B look alike -- both line up with Part F! This instruction is ambiguous.

Final Version of the Algorithm Definition

- Our old definition:
  - An algorithm is a finite set of executable instructions that directs a terminating activity.
- Final version:
  - An algorithm is a finite set of unambiguous, executable instructions that directs a terminating activity.

History of Algorithms

- The study of algorithms began as a subject in mathematics.
- The search for algorithms was a significant activity of early mathematicians.
- Goal: To find a single set of instructions that can be used to solve any problem of a particular type (a general solution).

Euclid’s Algorithm

Problem: Find the largest positive integer that divides evenly into two given positive integers (i.e., the greatest common divisor).

Algorithm:
1. Assign M and N the values of the larger and smaller of the two positive integers, respectively.
2. Divide M by N and call the remainder R.
3. If R is not 0, then assign M the value of N, assign N the value of R, and return to Step 2. Otherwise, the greatest common divisor is the value currently assigned to N.

Finding the GCD of 24 and 9

<table>
<thead>
<tr>
<th>M</th>
<th>N</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

So, 3 is the GCD of 24 and 9.
Euclid’s Algorithm (cont.)

- Do we need to know the theory that Euclid used to come up with this algorithm in order to use it?
- What intelligence is required to find the GCD using this algorithm?

The Idea Behind Algorithms

- Once an algorithm behind a task has been discovered – we can just use it!
  - We don’t need to understand the principles.
  - The task is reduced to following the instructions.
  - The intelligence is “encoded into the algorithm.”

Algorithm Representation

- Syntax and Semantics
  - Syntax refers to the representation itself.
  - Semantics refers to the concept represented (i.e., the logic).

Contrasting Syntax and Semantics

- In the English language, we have both syntax and semantics.
  - Syntax is the grammar of the language.
  - Semantics is the meaning.
  - Given the following sentence,
    I walked to the corner grocery store.
  - Is this sentence syntactically correct?
  - Is it semantically correct?

Contrasting Syntax and Semantics (cont.)

- Given the following sentence,
  I talked to the funny grocery store.
  - Is this sentence syntactically correct?
  - Is it semantically correct?
- How about
  I grocery store walked corner the to.

Contrasting Syntax and Semantics (cont.)

- Conclusion: An English sentence may be syntactically correct, yet semantically incorrect.
- This is also true of algorithms.
- And it is also true of computer code.