Introduction to Algorithmic Thinking

Computational Problem Solving

- Computational problem solving requires 2 components:

  - Abstraction: a representation that captures <u>all the relevant aspects </u>of the problem

  - Algorithm: A procedure for solving the problem by <u>use of the representation</u>

Algorithm

- The word "algorithm" is derived from the ninth-century Arab mathematician, <u>Al-Khwarizmi</u> who worked on "written processes to achieve some goal."

- (The term "algebra" also derives from the term "al-jabr," which he introduced.)

Al-Khwarizmi

Algorithm

- An algorithm is a finite number of clearly described, unambiguous "doable" steps that can be systematically followed to produce a desired result for given input in a finite amount of time.

- Because computers can execute instructions very quickly and reliably without error, algorithms and computers are a perfect match.

What is Algorithmic Thinking?

- Algorithmic thinking is the ability to understand, execute, evaluate, and create algorithms.

- Algorithms are communicated via programming languages to the computer

Properties of Algorithms

- For any given, non-trivial task (or set of related tasks), there are many possible algorithms for accomplishing the given task

- An algorithm does not encode the underlying theory behind the instruction steps.

- Some algorithms are more efficient than other algorithms.

- Algorithms evolve over time to address changes in task requirements.
    - computer programs that are used over many years typically must be modified over time to adapt to changes in task requirements.

Writing Algorithms
Sample Problem

- Two people work for the same company and have a total combined salary of W dollars, but one person earns Q dollars more than the other person. How much did they each earn?

Principle 1: Representation

- Solve a specific instance of the problem by hand using pencil and paper.

  - A specific instance of a problem is when all the "variables" are given a specific value. Suppose we let W be $57.00 and let Q be $5.00. Now the problem reads:

- *Two people work for the same company and have a total combined salary of $57.00, but one person earns $5.00 dollars more than the other person. How much did they each earn?*

Representing/Abstracting the problem

There are multiple ways to think about this problem. Two possible solutions are:

Arithmetic Reasoning:	Algebraic reasoning:
Of the $57, Person1 gets $5 more then Person2. Therefore, both equally share $57-$5 = $52. $52 / 2 is $26, so each gets at least $26. Person1 gets $31 ($26 + $5) Person2 gets $26	Let X = Person1's pay Let Y = Person2's pay. Therefore, we know from the problem that: $X = Y + 5$ and $X + Y = 57$. Solve these 2 equations using substitution: $(Y + 5) + Y = 57$ $Y = 26$ Therefore $X = Y + 5 = 31$

Principal 2: Generalize

- Generalize your solution by replacing your specific instance values with "variables".

Arithmetic Reasoning:	Algebraic reasoning:
Of the total salary W, Person1 gets Q dollars more then Person2. Therefore they both equally share (W - Q).	Let X = Person1's pay
	Let Y = Person2's pay.
	Therefore, we know from the problem that:
Each gets at least (W – Q) / 2.	$X = Y + Q$ and
	$X + Y = W.$
	Solve these 2 equations using substitution:
Person1 gets (W – Q) / 2 + Q	$(Y + Q) + Y = W$
Person2 gets (W – Q) / 2	$Y = (W – Q)/2$
	Therefore $X = (W – Q)/2 + Q$

Principal 3: Execute generalized algorithm

- Manually execute your algorithm on several test cases to verify that it produces correct answers. This is called desk checking or walking through the algorithm.

Example 1: W = 100, Q = 10
    Person1 = (100 − 10)/2 + 10 = 55
    Person2 = (100 − 10)/2 = 45
    (This is correct because 55 + 45 = 100 and Person1 earns 10 more dollars than Person2)

Example 2: W = 31, Q = 2
    Person1 = (31 − 2)/2 + 2 = 16.5
    Person2 = (31 − 2)/2 = 14.5
    (This is correct because 16.5 + 14.5 = 31 and Person1 earns 2 more dollars than Person2)

Principle 4: Translation

- After a general solution to the task is known, write correct programming statements to implement your solution on the computer.

- We will be learning this for the remainder of this course.

- In C++:

#Write your. C++ code here

In-class Assignment 1

- Hello this is your class work one.

- Open a new notebook and write c++ code implementing the algorithm for the following problem:
  - Two people work for the same company and have a total combined salary of W dollars, but one person earns Q dollars more than the other person. How much did they each earn?

Assignment 2

- Write an algorithm to solve the following problem, use <u>the three principles</u> described, make sure its clear which principle you are refering to by labeling statements blocks using headers (<u>Principle 1</u>, <u>Principle 2</u>, <u>Principle 3</u>).

    - In a computer game, the total combined score for Ron and Terry is W. Terry's score is always Q % less than Ron's. **What are the scores for Ron and Terry?**