

Algorithmic Thinking



To be effective computer users it is necessary to have a general idea of how to make a computer solve a problem. Thinking algorithmically is a necessary first step toward solving a problem by computer.

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Unambiguous Instructions

- ❖ An *algorithm* is an unambiguous sequence of step-by-step instructions for producing a specified result

- ❖ Two activities – “telling what to do” and “doing it”
 - Specifying the algorithm (telling what to do) – let’s call the person who does this the programmer
 - Executing the algorithm (following its instructions or doing it) without the intervention of the programmer – let’s call the agent (person or computer) who does this the computer

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Recipes

- ❖ Recipes are an example of algorithms written by chefs (programmers) and followed by cooks (computers) to produce a specified food

S'mores: Place a toasted marshmallow on a Graham cracker and then place a square of chocolate on top



The 5 Properties of Algorithms

- ❖ All algorithms must have certain properties if a computer is to execute them successfully without intervention by the programmer
 - ❑ Input Specification
 - ❑ Output Specification
 - ❑ Definiteness
 - ❑ Effectiveness
 - ❑ Finiteness

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Input Specification

- ❖ The “input” is the data that will be transformed by the algorithm to create the output
- ❖ The input must exist in a format the “computer” can access and manipulate
- ❖ In giving an algorithm, state:
 - ❑ The types of data expected -- whole numbers, letter strings
 - ❑ The number of data items expected (or how the computer will know it has reached the end of the data)
 - ❑ The structure, if any, of the data expected -- a list, table, etc.

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Output Specification

- ❖ The “output” is the result of the computation -- its description often forms the name of the algorithm
- ❖ The “output” must be specified in a format that the “computer” can express (e.g., on a screen, audio)
- ❖ The features specified are the same as for input:
 - ❑ The types of data forming the result
 - ❑ The number of data items forming the result (or how the computer will know it has reported all of the data)
 - ❑ The structure of the result

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Definiteness

- ❖ An algorithm must be explicit about how to realize the computation
- ❖ Definiteness is achieved by giving commands that state unambiguously what to do, in sequence
- ❖ The commands may be ...
 - ❑ Conditional, i.e. require a decision to be made, and so must be explicit about how to respond to all different outcomes
 - ❑ Repeated, and so must be explicit about when to stop the repetition

The definiteness property assures that the executing agent will always know what command to perform next

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Effectiveness

- ❖ Effectiveness assures that the computer can perform the algorithm's operations mechanically without intervention
 - + No additional inputs, special talent, clairvoyance, creativity or help from Superman
- ❖ Effectiveness is achieved by reducing the task to the primitive operations known to the computer
- ❖ Definiteness assures the computer knows what command to perform next; effectiveness assures the computer can accomplish the command

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Finiteness

- ❖ An algorithm must eventually terminate with either
 - + The “right” output
 - + An indication that no solution is possible
- ❖ A non-terminating algorithm is useless since it is impossible to distinguish between continued progress and being “stuck”
- ❖ Finiteness is relevant to computer algorithms since they typically repeat instructions

$$\begin{array}{r} 3.3 \\ \hline 3 \overline{) 10.0000000000...} \\ \underline{9} \\ 10 \\ \underline{9} \\ 1 \end{array}$$

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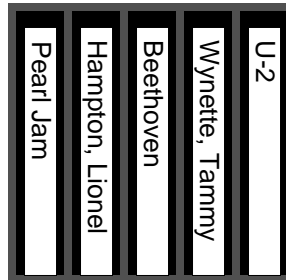
Trying Your Hand at Writing an Algorithm

- ❖ Write an algorithm to sort 5 numbers from largest to smallest.
- ❖ Take out a piece of paper. Tear it into 5 small pieces. Write the following numbers, one on each piece of paper: 2, 17, 33, 4, 6.
- ❖ Shuffle them around.
- ❖ Take out a second piece of paper. Write your name on it.
- ❖ Write down the steps (an algorithm) to sort these 5 numbers.
Note: You can only view and compare 2 numbers at any single point in time.
- ❖ (I'll collect these at the end of class today. These won't be graded.)

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Alphabetize CDs



- ❖ *Input*: Unordered CDs filling a slotted rack
- ❖ *Output*: CDs in slotted rack, alphabetized

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Alphabetizing Algorithms

- 1 “*Artist_Of*” means the name of the group
- 2 Pick one end of the rack to be the beginning of the alphabetic sequence. Call that end’s slot the “*Alpha*” slot
- 3 Call the slot adjacent to the *Alpha* slot the “*Bet*” slot
- 4 If the *Artist_Of* of the CD in the *Alpha* slot is later in the alphabet than the *Artist_Of* of the CD in the *Bet* slot, then interchange the CDs
- 5 If there is a slot following the *Bet* slot, begin calling it the “*Bet*” slot and go to step 4; otherwise, continue on
- 6 If there are two or more slots following the *Alpha* slot, then begin calling the slot following the *Alpha* slot, “*Alpha*” and the slot following it the “*Bet*” slot, and go to step 4; otherwise, stop

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Some Ideas for Sorting Algorithms

- ❖ Insertion Sort
 - ❑ Make the first number a list by itself – it is already sorted
 - ❑ “Insert” each number, one at a time, into the correct place in the list; shift the other numbers if you need to
 - ❑ The list slowly “grows” in sorted order

- ❖ Bubble Sort
 - ❑ Compare each pair of numbers, one pair at a time; if the pairs are out of order, swap them.
 - ❑ Keep doing this step until you go through the complete list without having to swap a single pair.

- ❖ Exchange Sort
 - ❑ Go through the list, at each step swapping the smallest number into the first slot in the list.
 - ❑ Repeat this step with each successive position in the list.

Algorithm vs. Program

- ❖ A program is simply an algorithm specialized to a particular situation ...
- ❖ Alphabetize CDs is an instance of Exchange Sort
- ❖ Exchange Sort can be specialized to other cases
 - + Sort CDs by other criteria, e.g. title
 - + Sort books by title or other criteria
 - + Sort canceled checks, students' homework assignments, vehicles, etc.

The algorithm, being a process with only a limited number of specifics given, is more abstract than is the program

All programs are algorithms. However, not all algorithms are programs.