# Advanced Programming

Chapter 4: Sorting and Selection Algorithm

# What is an Algorithm?

process or a set of rules to be followed in calculations or other problem-solving operations

more informally:

a recipe for solving a problem

# Example: Square Root Algorithm

1. Guess the square root of the number

2. Divide the working number by the guess

3. Average the quotient (from 2) and the guess

4. Make the new guess the average from step 3

5. If the new guess is “sufficiently different” from the old guess, go back to step 2, else halt.

# Algorithm vs. Program

an **algorithm** is a description of how to solve a problem

a **program** is an implementation of an algorithm in a particular language to run on a computer (usually a particular kind of computer)

difference between **what we want to do** and **what we actually did**

# What’s the Difference, Really?

we can analyze the algorithm independent of its implementation. This is the science in Computer Science.

we can examine how easily, or with what difficulty, a language allows us to realize an algorithm

we can examine how different computers impact the realization of an algorithm

# Aspects of an Algorithm

Detailed: Provide enough detail to be implementable. Can be tricky to define completely, relies on “common sense”

Effective: the algorithm should eventually halt, and halt in a “reasonable” amount of time. “reasonable” might change under different circumstances (faster computer, more computers, etc.)

# Aspects of an Algorithm (2)

Specify Behavior: the algorithm should be specific about the information that goes in (quantity, type, etc.) and the information that comes out.

General Purpose: algorithms should be idealized and therefore general purpose. A sorting algorithm should be able to sort anything (numbers, letters, patient records, etc.)

# A Lot to Do!

That is a lot to do for the burgeoning programmer.

Get better as we go along, but good to know what the standards are!

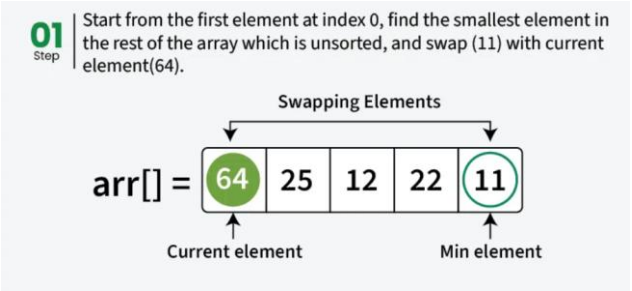
# Example 4-1.py: Bubble Sort Algorithm

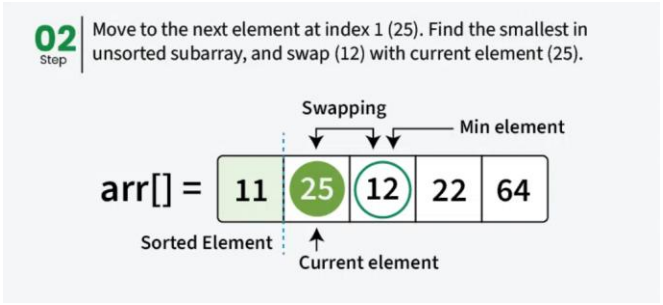
Bubble Sort is a simple sorting algorithm that repeatedly swaps adjacent elements if they are in the wrong order.

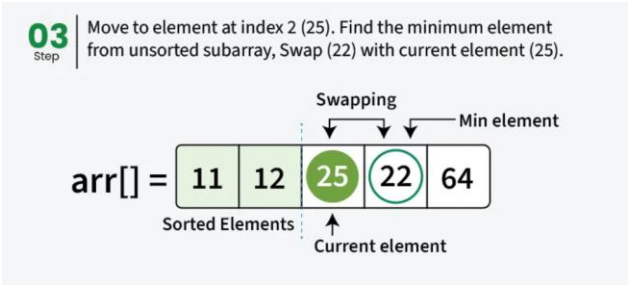
# Example 4-2.py: Quicksort Algorithm

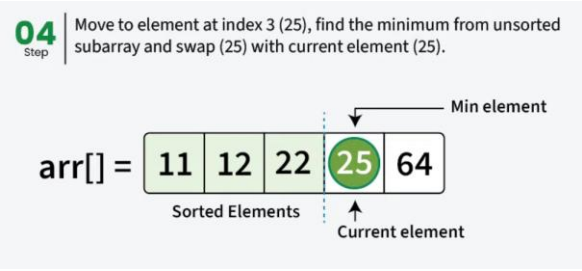
Quicksort is a more efficient sorting algorithm with an average time complexity of O(n log n).

It selects a pivot element and partitions the array such that all elements smaller than the pivot go to the left and all greater elements go to the right.



# Example 4-3.py: Selection Algorithm (Finding the k-th Smallest Element)

The selection problem refers to finding the k-th smallest element in an array.

This can be efficiently done using a modified version of quicksort known as Quickselect.

Here, we only partition the relevant portion of the array.

# Aspects of a Program: Readability

We will emphasize, over and over, that a program is an essay on problem solving intended to be read by other people, even if “other people” is you in the future!

Write a program so that you can read it, because it is likely that sometime in the future **you will** have to read it!

# Readability(2): Naming

The easiest thing to do that affects readability is good naming

use names for the items you create that reflect their purpose

to help keep straight the types used, include that as part of the name. Python does not care about the type stored, but you do!

# What Does this Do?

```
a = input("give a number: ")
b,c = 1,0
while b <= a :
    c = c + b
    b = b + 1
print (a,b,c)
print ("Result: ", float(c)/b - 1)
```

example6.py

```
# average of a sum of integers in a given range
limit_str = input(“range is 1 to input:”)
limit_int = int(limit_str)
count_int = 1
sum_int = 0
while count_int <= limit_int:
    sum_int = sum_int + count_int
    count_int = count_int + 1
average = float(sum_int)/(count_int – 1)
```

example7.py

# Readability(3): Comments

info at the top, the goal of the code

purpose of variables (if not obvious by the name)

purpose of other functions being used

anything “tricky”. If it took you time to write, it probably is hard to read and needs a comment

# Readability(4): Indenting

indenting is a visual cue to say what code is “part of” other code.

This is not always required as it is in Python, but Python forces you to indent.

This aids readability greatly.

# Aspects of Programming (2)

Robust: As much as possible, the program should account for inputs that are not what is expected. More on  this with error handling in Chapter 14

Correct: Our programs should produce correct results. Much harder to ensure than it looks!

# More on Problem Solving

# The Problem is “Problem-Solving”

Remember, two parts to our goal:

Understand the problems to be solved

Encode the solution in a programming language, e.g. Python

# Mix of Both

The goal in each class is to do a little of both: problem solving and Python

Terribly important that we impress on you *to try and understand how to solve the problem* ***first*** *before you try and code it.*

# Steps to Problem Solving

*From "PProblem SSSolving",*
*DeFranco & Vinsonhaler*
Be **P**roactive
**S**ee it
**S**implify it
**S**tir it up
**P**ause and Reflect

# Steps to Problem Solving

Engage/Commit
Visualize/See
Try it/Experiment
Simplify
Analyze/Think
Relax

# Engage

You need to commit yourself to addressing the problem.
 Don’t give up easily
 Try different approaches
 Set the “mood”

Just putting in time does not mean you put in a real effort!!!

# Visualize/See the Problem

Find a way that works for you,
some way to make the problem tangible.

draw pictures

layout tables

literally “see” the problem somehow

Everyone has a different way, find yours!

# Try It/Experiment

For some reason, people are afraid to just “try” some solution. Perhaps they fear failure, but experiments, done just for you, are the best way to figure out problems.

Be willing to try, and fail, to solve a problem. Get started, don’t wait for enlightenment!

# Simplify

Simplifying the problem so you can get a handle on it is one of the **most powerful** problem solving tools.

Given a hard problem, make is simpler (smaller, clearer, easier), figure that out, then ramp up to the harder problem.

# Think it Over/Analyze

If your solution isn’t working:
stop
evaluate how you are doing

analyze and keep going, or start over.

People can be amazingly “stiff”, banging their heads against the same wall over and over again. Loosen up, find another way!

# One More Thing: Relax

Take your time. Not getting an answer right away is not the end of the world. Put it away and come back to it.

You'd be surprised how easy it is to solve if you let it go for awhile. That's why **starting early** is a luxury you should afford yourself.

# Babylonian Square Root Example

# Algorithm

1.Guess the square root of the number.
2. Divide the number by the guess.
3.Average the quotient (from step 2) and the guess
4. Make the new guess the average from step 3.
5. If the new guess differs from the old guess by more than the specified tolerance, go back to step 2; otherwise stop

# Program Algorithm Skeleton

User provides 3 inputs: an integer number to find the square root of, an integer initial guess, a floating-point tolerance.

Apply the algorithm

Output the original conditions, its square root and the number of iterations.

CL03-5.py