IST 1025

Overview of Programming

What Is a Program?

A program is like an algorithm, but describes a process that is ready or can be made ready to run on a real computer.

An algorithm is in pseudocode. To produce a program, you translate the algorithm into a programming language, such as Python.

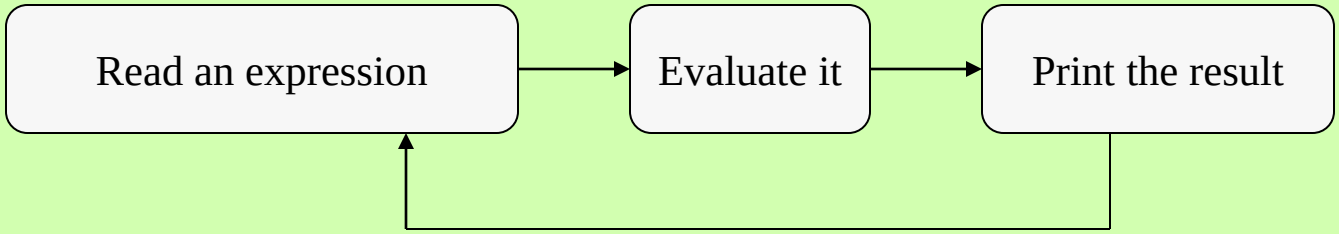
Obtaining Python

- Python was invented by Guido van Rossum in 1992
- Python comes with most Unix-based computer systems
- Python for Windows or any other operating system can be downloaded from http://www.python.org/

Developing Python Programs

- Can experiment with small pieces interactively in *shell mode*
- Can compose longer segments with an editor and run them in *script mode*

Evaluating Python Expressions in Shell Mode



Basic Elements: Data

- Numbers
  - Integers: 3, 77
  - Floats: 3.14, .22
- Strings: ‘Hi there!’, “Hi there!”, ‘\n’
- Truth values (Booleans): True, False

Basic Operations: Arithmetic

Symbol	Meaning	Example
+	Addition or concatenation	x + y
-	Subtraction	x - y
*	Multiplication	x * y
/ or //	Division	x / y or x // y
%	Remainder	x % y
**	Exponentiation	x ** y

Operator Precedence

- Exponentiation has the highest precedence
- Unary negation is evaluated next
- Multiplication, division and remainder are next
- Addition and subtraction are last.

Associativity

- Operations of equal precedence are left associative, except the following:
- Assignment and exponentiation are right associative.
- You can use brackets to change the order of evaluation. Brackets then take highest priority.

Some Arithmetic Expressions

Expression	Evaluation	Value
`5 + 3 * 2`	`5 + 6`	11
`(5 + 3) * 2`	`8 * 2`	16
`6 % 2`	`0`	0
`2 * 3 ** 2`	`2 * 9`	18
`-3 ** 2`	`-(3 ** 2)`	-9
`(3) ** 2`	`9`	9
`2 ** 3 ** 2`	`2 ** 9`	512
`(2 ** 3) ** 2`	`8 ** 2`	64
`45 / 0`	`Error: cannot divide by 0`	
`45 % 0`	`Error: cannot divide by 0`	

Built-In Functions

- A *function* is an operation that expects zero or more data values (arguments) from its user and computes and returns a single data value

- Examples:

```
abs(-5)

max(33, 66)
```

Library Functions

- A *library* is a collection of resources, including functions, that can be *imported* for use in a program

- Example:

```
import math

math.sqrt(2)
```

Variables and Assignment

- Variables are used to name data and other resources
- Instead of typing 3.14 for π, define a variable named **`pi`** to mean 3.14
- Assignment (=) is used to set (or reset) a variable to a value

```
pi = 3.14

34 * 34 * pi
```

- Variables make programs more readable and maintainable

Library Variables

- Typically define standard constants, such as **`pi`** and **`e`**
- Example:

```
import math

3 * math.pi
```

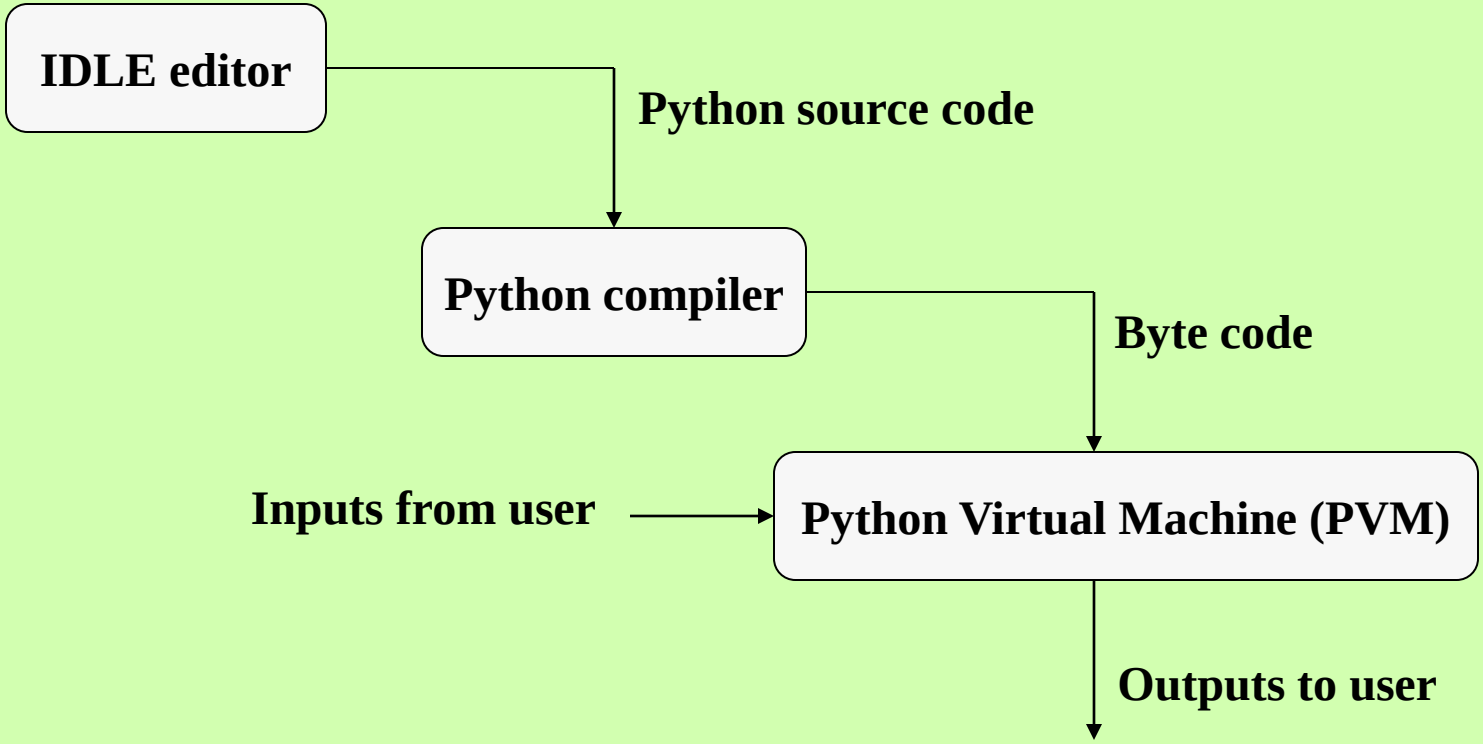
- Or:

```
from math import pi

3 * pi
```

Script Mode

- Longer programs can be edited and saved to a file and then run as *scripts* (synonymous with *programs*)
- *IDLE* is a script-mode development environment that can be used on any computer system

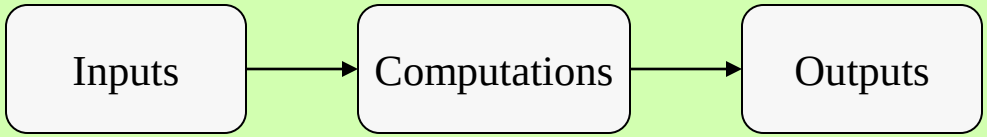
Developing a Python Script



Terminal-Based Programs

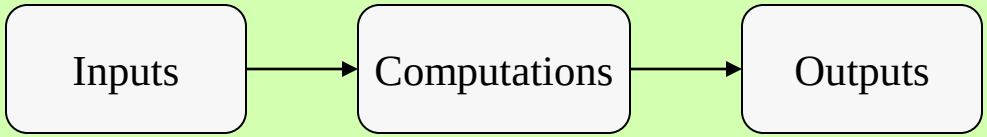
- A *terminal* allows a user to
  - run a program
  - view output as text on a screen or in a window
  - enter input as text from the keyboard
- Early computer systems were entirely terminal-based, modern systems have added a GUI (graphical user interface)

Behavior of Terminal-Based Programs



- Prompt the user for some information
- Use that information to perform some computations
- Output the results
- Exercise: Write a program that takes a radius and prints out the area of the circle.

Structure of Terminal-Based Programs




```
docstring

import statements

input statements

computation statements

output statements
```

Program code goes in a file with a **.py** extension.

The docstring

```
"""
Author: Ken Lambert
This program does nothing
yet, but just you wait!
"""
```

Not evaluated, but used to document Python programs for other programmers

Should appear at the beginning of each file

Just as important as the evaluated code!!!

`import` Statements

```
import math

print(math.pi)
print(math.sqrt(2))
```

Imports usually occur before the beginning of the executable program code

They make available resources from other Python modules

A *module* is just a file of Python code

`import` Statements

```
from math import pi

print(pi)
```

Alternatively, one can import particular resources from a given module and then omit the module qualifier from the reference

`import` Statements

```
from math import *

print(pi)
print(sqrt(2))
```

Or, one can import *all* the particular resources from a given module and then omit the module qualifier from all the references

Input of Text

```
input('Enter your name: ')
```

The **`input`** function prints its string argument and waits for user input.

The function then returns the string of characters entered at the keyboard.

Input of Numbers

```
int(input('Enter your age: '))
```

When an integer is expected, you must convert the input string to an **`int`**.

```
float(input('Enter your hourly wage: '))
```

When a real number (with a decimal point) is expected, you must convert the input string to a **`float`**.

Simple Assignment Statements

```
name = input('Enter your name: ')

income = float(input('Enter your income: '))
```

The = operator evaluates the expression to its right and sets the variable to its left to the resulting value.

We use variables to retain data for further use.

Note: = does not mean *equals* in Python!

Syntax Template for Simple Assignment

```
<variable> = <expression>
```

A *syntax template* expresses a grammar rule in a language.

The angle brackets enclose the names of phrases or terms that are defined by other rules.

```
area = math.pi * radius ** 2
century = 100
squarerootof2 = math.sqrt(2)
```

More on Variables

```
firstname = input('Enter your first name: ')
```

Any variable can name any thing.

Variables must begin with a letter or the _ character.

They can contain any number of letters, digits, or _.

Variables cannot contain spaces.

Python is case-sensitive. Use lowercase letters for now.

Variable References

```
x = 10              # x begins as 10
x = x + 1           # x is reset to 11
y = y + x           # Error! Can't find value of y
```

When Python sees a variable in an expression, it must be able to look up its value.

If a variable has no established value, the program halts with an error message.

Variables are given values by assignment statements

End of Line Comments

```
x = 10              # x begins as 10
x = x + 1           # x is reset to 11
y = y + x           # Error! Can't find value of y
```

begins an end of line comment - Python ignores text from **#** to the end of line

Evaluating Expressions

```
print(totalincome - deduction * rate)
```

```
print((totalincome - deduction) * rate)
```

```
print(10 + x * y ** 2)
```

Expressions are evaluated left to right, unless operator precedence overrides this order.

Use parentheses to override standard precedence when necessary.

Mixed-Mode Arithmetic

```
print(5 * 100)      # Prints 500

print(5 * 100.0)    # Prints 500.0
```

The value of an expression depends on the *types* of its operands.

In general, two **`int`**s produce an **`int`**, whereas at least one **`float`** produces a **`float`**.

Exception: **`x / y`** always produces a **`float`**.

Type Conversion Functions

```
str(3.72)          # Returns'3.72'

float('3.72')      # Returns 3.72

int(3.72)          # Returns 3

float(3)           # Returns 3.0
```

Each data type has a function to convert values of some other types to values of that type.

`int` *truncates* a **`float`** by removing the fractional part.

Rounding and Precision

```
round(3.72)          # Returns 4

round(3.72, 1)       # Returns 3.7

round(3.729, 2)      # Returns 3.73
```

round's optional second argument specifies the number of digits of precision in the fractional part

Using Functions

```
round(3.72)          # Returns 4

abs(-5)              # Returns 5

math.sqrt(2)         # Returns 1.4142135623730951
```

```
<function name>(<any arguments>)
```

A function can have one or more required *arguments* and/or some optional arguments

Arguments must be of the appropriate types

Composing Expressions

```
squareofa = a ** 2
squareofb = b ** 2
sumofsquares = squareofa + squareofb
c = math.sqrt(sumofsquares)
print('The hypotenuse is', c)
```

Use assignment to name the results of computations

Composing Expressions

```
squareofa = a ** 2
squareofb = b ** 2
sumofsquares = squareofa + squareofb
c = math.sqrt(sumofsquares)
print('The hypotenuse is', c)
```

Use assignment to name the results of computations

```
c = math.sqrt(a ** 2 + b ** 2)
print('The hypotenuse is', c)
```

Or just compose the expression and pass it as an argument to the function

Getting the Directory of a Module

```
>>> import math

>>> dir(math)
['__doc__', '__file__', '__name__', 'acos', 'asin',
'atan', 'atan2', 'ceil', 'cos', 'cosh', 'degrees', 'e',
'exp', 'fabs', 'floor', 'fmod', 'frexp', 'hypot',
'ldexp', 'log', 'log10', 'modf', 'pi', 'pow',
'radians', 'sin', 'sinh', 'sqrt', 'tan', 'tanh']

>>>
```

The **`dir`** function returns a list of all of the named components in a module

Getting Help on a Function

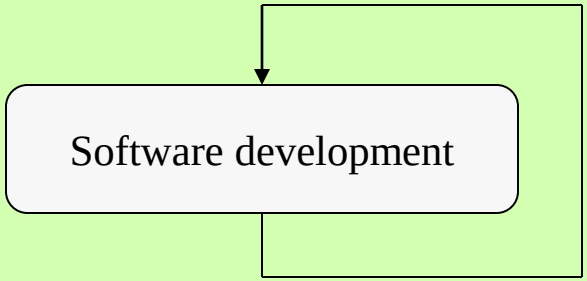
```
>>> import math

>>> dir(math)
['__doc__', '__file__', '__name__', 'acos', 'asin',
'atan', 'atan2', 'ceil', 'cos', 'cosh', 'degrees', 'e',
'exp', 'fabs', 'floor', 'fmod', 'frexp', 'hypot',
'ldexp', 'log', 'log10', 'modf', 'pi', 'pow',
'radians', 'sin', 'sinh', 'sqrt', 'tan', 'tanh']

>>> help(math.sqrt)
sqrt(x)

Return the square root of x.
```

Output

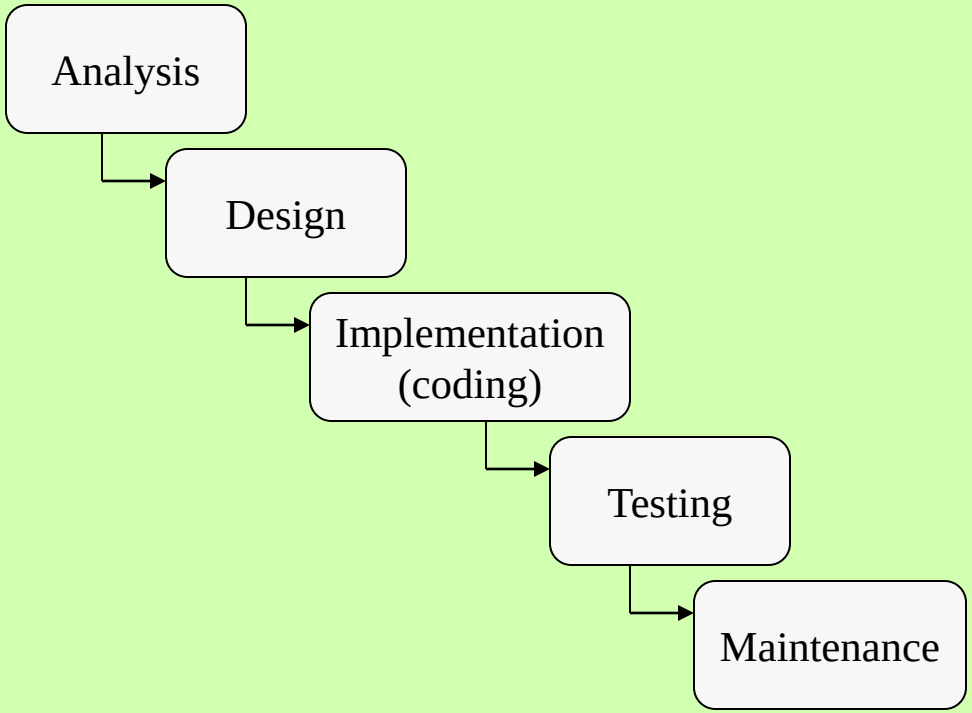
```
print(3, 4)                          # displays 3 4

print(str(3) + str(4))               # displays 34

print('Hello there\nKen!')           # displays two lines

print('Hello there ', end = '')      # displays one line
print('Ken')
```

print always ends output with a newline, unless its last argument is **end = ''**

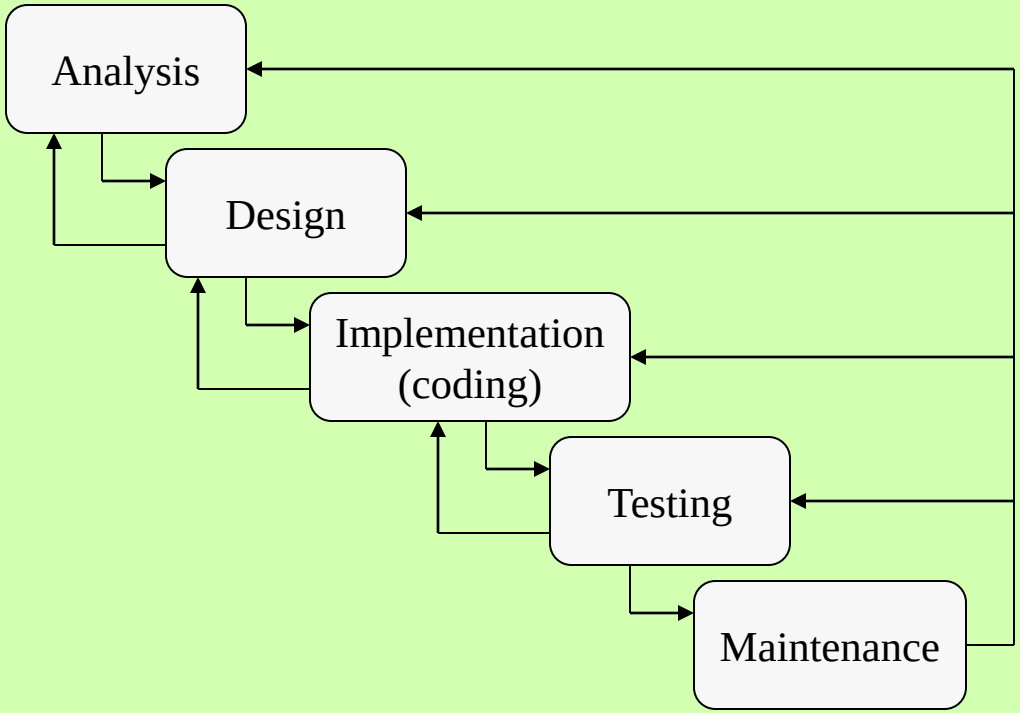
The Software Development Life Cycle



The Waterfall Model: Trickle-down



The Waterfall Model: Back up to earlier phase



Analysis

The analyst discovers what clients really need by listening to what they want.

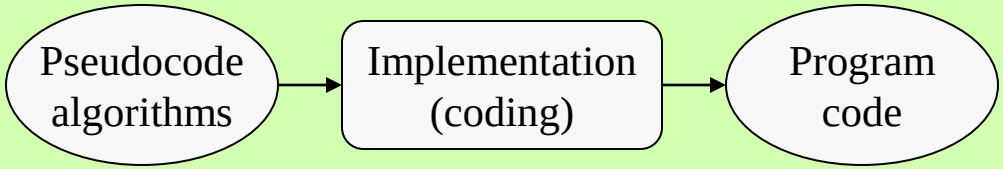
The output of analysis is a precise description of ***what*** the program does, ***not how*** it does it.

Design

The designer determines how the program will do what it does.

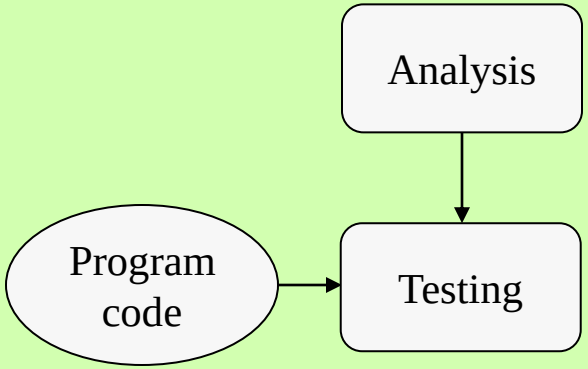
The output of design is a precise description of ***how*** the program will do what it does.

Implementation (coding)



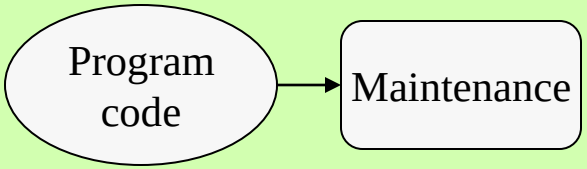
The coder translates the design description into a program in a particular programming language.

Testing



The quality assurance specialist verifies that the program behaves as expected, according to the requirements provided by the analysis phase.

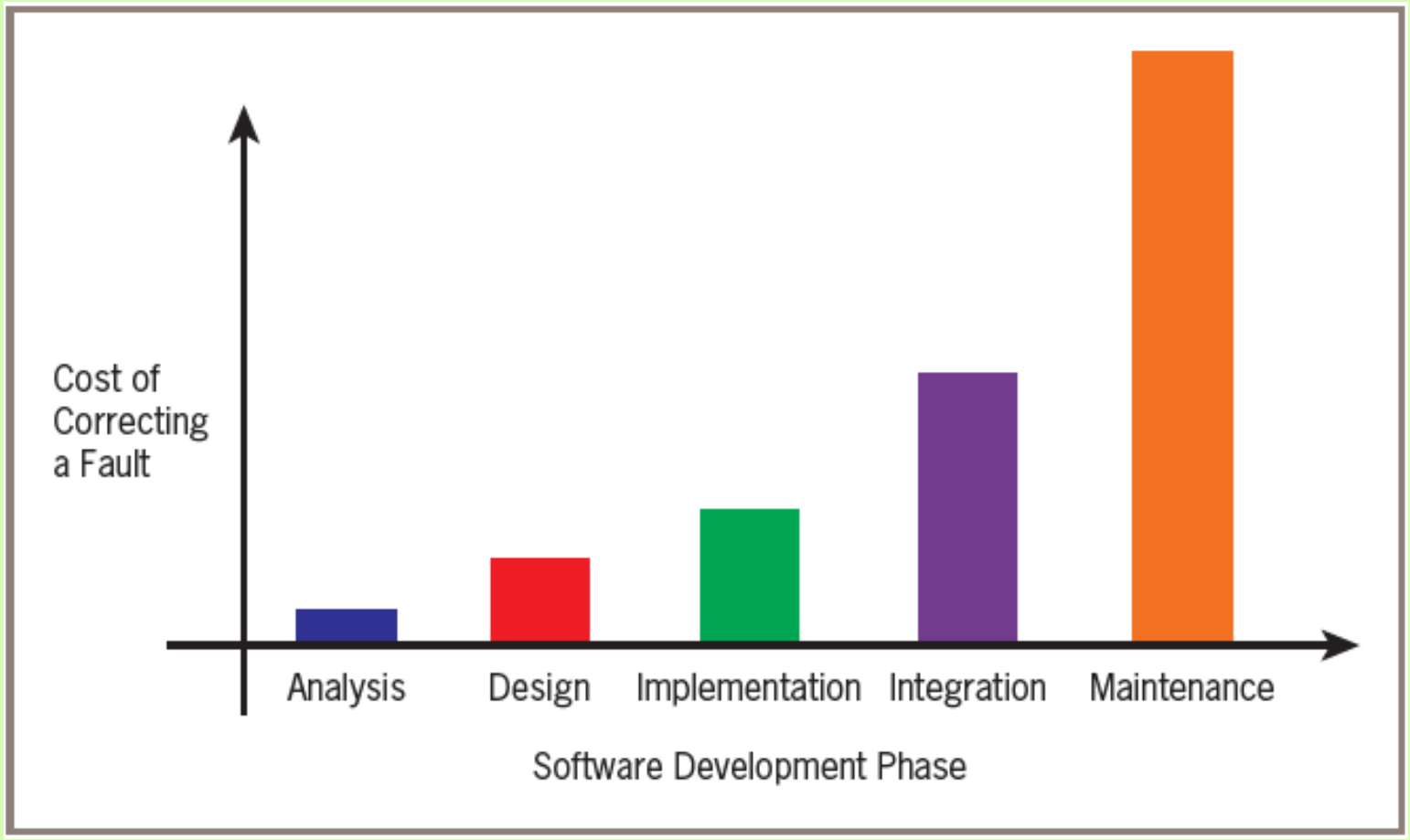
Maintenance



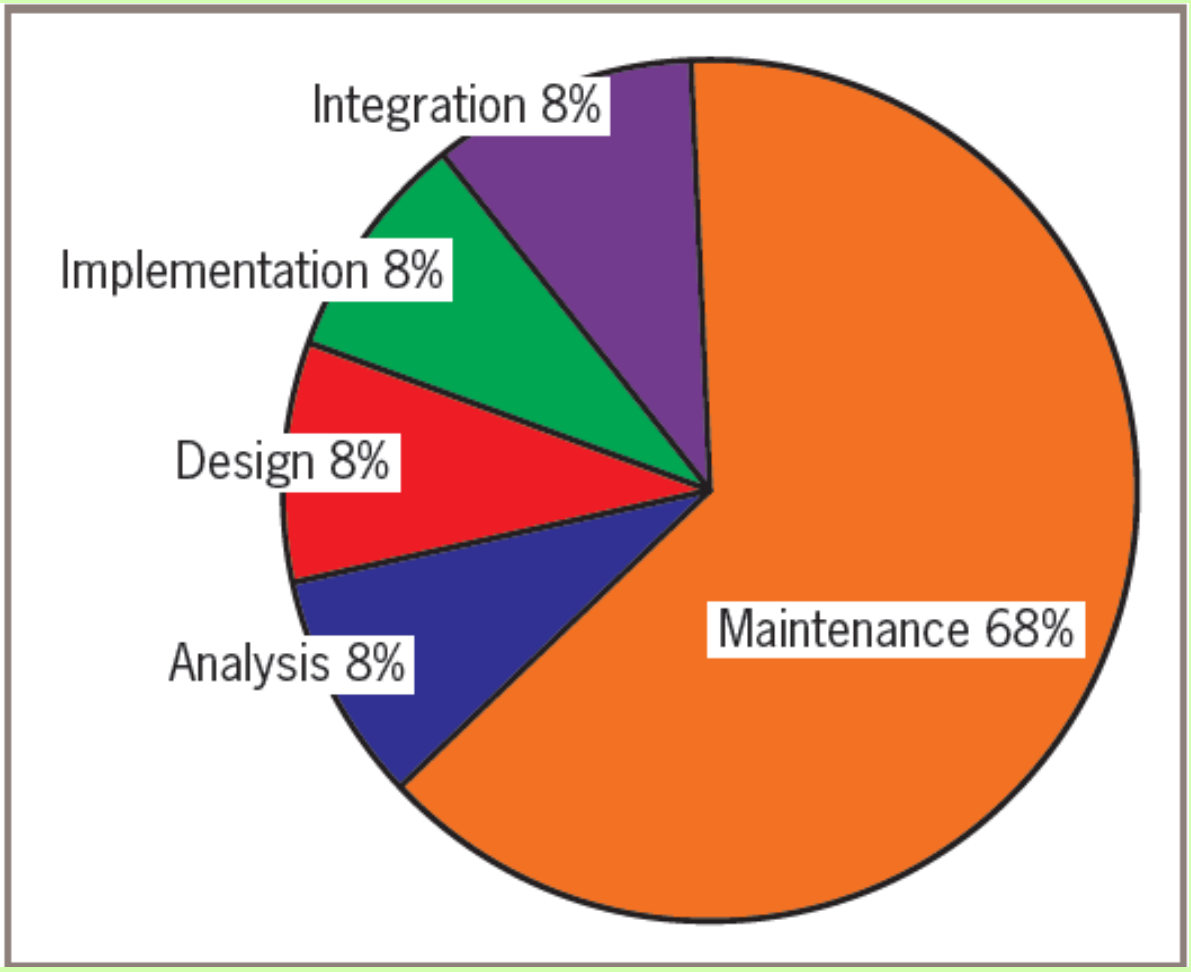
Program errors are discovered years after a program is released.

Most of the time and $ are spent not in the initial construction of a program, but in fixing and improving it after its initial release.

Cost of Correcting a Fault



Distribution of Cost of Software Development



Analysis:
Start with a User Request

Write a program that converts pounds to kilograms.

Determine the Inputs and Outputs

- The input will be the number of pounds, as an integer or floating-point number

- The output will be
  - a prompt for the number of pounds
  - A label, and the number of kilograms as a floating-point number

Example Session with the Program

```
>>> Enter the number of pounds: 330
The number of kilograms is 150.0
>>>
```

Gather Information About the Problem

There are 2.2 pounds in a kilogram

Design the Algorithm in Pseudocode

Prompt the user for the number of pounds
Input the pounds
Set the kilograms to the pounds / 2.2
Output the number of kilograms

Code as the **`convert`** Script

convert.py

```
"""
File: convert.py

This program converts pounds to kilograms.
Input: the number of pounds, as an integer or float.
Output: the number of kilograms, as a float, suitably
        labeled.
"""
```

Start with the prefatory docstring, not as an afterthought!!!

Code as the **`convert`** Script

convert.py

```
"""
File: convert.py

This program converts pounds to kilograms.
Input: the number of pounds, as an integer or float.
Output: the number of kilograms, as a float, suitably
        labeled.
"""

pounds = float(input("Enter the number of pounds: "))
kilograms = pounds / 2.2
print("The number of kilograms is", kilograms)
```

Test the program in IDLE first!

Then Test in a Terminal Window with Several Inputs