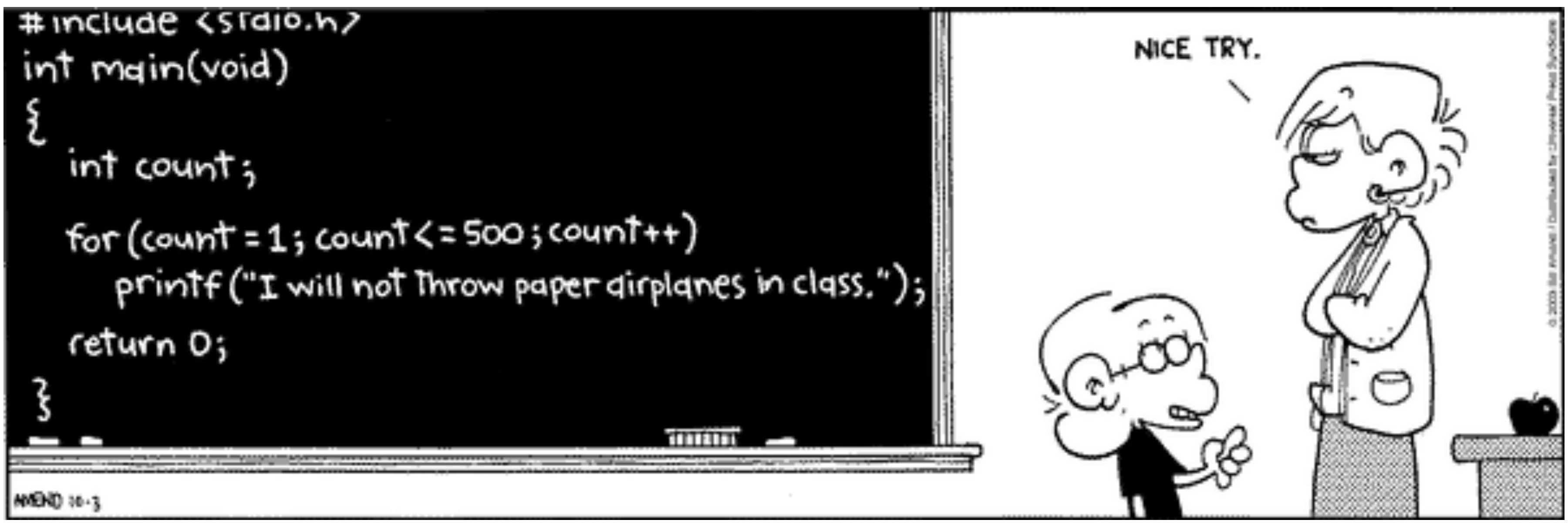
Lecture 13
Python



https://informationsecurity.princeton.edu/phish-bowl

The Phish Bowl

Latest Phishing Attempts

YOUR COVID-19 PANDEMIC RELIEF FUND IS READY
10/20/2021 PM

Amazon Shipment Update
10/19/2021 PM

HTML
10/18/2021 PM

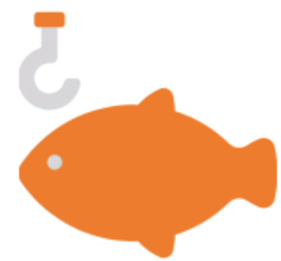
Action Required!
10/16/2021 AM

Tutoring
10/13/2021 PM

"STUDENT EMPLOYMENT" alternate subject "JOB POSTING"
10/12/2021 AM

Weekly Position Announcement PT/FT
10/12/2021 AM

Forward suspicious messages to: phishbowl@princeton.edu



View The Phish Bowl video.

View our handout, "Phishing - Don't Take the Bait!"

Programming language components

- syntax: grammar rules for defining legal statements
  - what's grammatically legal? how are things built up from smaller things?
- semantics: what things mean
  - what do they compute?
- statements: instructions that say what to do
  - compute values, make decisions, repeat sequences of operations
- variables: places to hold data in memory while program is running
  - numbers, text, ...

- most languages are higher-level and more expressive than the assembly language for the toy machine
  - statements are much richer, more varied, more expressive
  - variables are much richer, more varied
  - grammar rules are more complicated
  - semantics are more complicated
- but it's basically the same idea

What is Python?

- a comparatively simple language that scales well to large(ish) programs
- designed & implemented in 1990
  by Guido van Rossum at CWI in Amsterdam
- very widely used
  - standard language for many intro courses (though not here)
  - standard language for data science
  - arguably the best choice for a first language
- use version 3, not version 2

Python components

- Python language
  - statements that tell the computer what to do
    get user input, display output, set values, do arithmetic,
    test conditions, repeat groups of statements, …
- libraries, built-in functions
  - pre-fabricated pieces that you don't have to create yourself
    `print`, **`input`**, math functions, text manipulation, ...
- access to the environent
  - file system, network, ...

- <u>you are not expected to remember syntax or other details</u>
- <u>you are not expected to write code in exams</u>
  (though a bit in problem sets and labs)

- you <u>are</u> expected to understand the ideas
  - how programming and programs work
  - figure out what a tiny program does or why it's broken

Basic example 0: Hello world (hello.py)

- this is the basic example for most programming languages

```
print("Hello, world")
```

- how we run it:
  - commandline interactive
  - commandline from a file
  - browser with local files
  - on the web with Colab or other cloud service

Basic example 1: echo a name (name.py)

- read some input, print it back

```
name = input("What's your name? ")
print("hello,", name)
```

Basic example 2: join 2 names (name2.py)

- shows variables

```
firstname = input("Enter first name: ")
secondname = input("Enter lastname: ")
result = firstname + secondname
print ("hello,", result)
```

Adding up lots of numbers: addup.py

- variables, operators, expressions, assignment statements
- while loop, relational operator (`!=` means "not equal to")

```
sum = 0
num = input("Enter new value, or \"\" to end: ")
while num != "":
  sum = sum + float(num)
  num = input("Enter new value, or \"\" to end: ")
print(sum)
```

Find the largest number: max.py

- needs an If to test whether new number is bigger
- needs another relational operator
- needs int( ) or float( ) to treat input as a number

```
max = 0
num = float(input("Enter new value, or 0 to end: "))
while num != 0:
  if num > max:
    max = num
  num = float(input("Enter new value, or 0 to end: "))
print(max)
```

Variables, constants, expressions, operators

- a *variable* is a place in memory that holds a value
  - has a **name** that the programmer gave it, like **sum** or **Area** or **n**
  - in Python, can hold any of multiple types, most often

    numbers like **1** or **3.14**, or

    sequences of characters like **"Hello"** or **"Enter new value"**
  - always has a **value**
  - has to be set to some value initially before it can be used
  - its value will generally change as the program runs
  - ultimately corresponds to a location in memory
  - but it's easier to think of it just as a name for information
- a *constant* is an unchanging literal value like 3 or "hello"
- an *expression* uses operators, variables and constants to compute a value

  3.14 * rad * rad
- *operators* include + - * /

Computing area: area.py

```
import math

r = input("Enter radius: ")
while r != "":
  area = math.pi * float(r) ** 2
  print("radius =", r, ", area =", area)
  r = input("Enter radius: ")
```

- how do we terminate the loop?
  - 0 is a valid data value
  - `input()` returns `""` for empty input so use that

- exponentiation operator is `**`

- note use of the math library

Types, declarations, conversions

- each variable holds information of a specific <u>type</u>
  - really means that bits are to be interpreted as info of that type
  - internally, 3 and 3.00 and "3.00" are represented differently

- Python sometimes infers types from context and does conversions automatically

- usually we have to be explicit:
  - **`int(...)`**
  - **`float(...)`**
  - **`str(...)`**

Making decisions and repeating statements

- if-else statement makes decisions
  - the Python version of decisions written with ifzero, ifpos, ...

```
if condition is true:
      do this group of statements
else:
    do this group of statements instead
```

- while statement repeats groups of statements
  - a Python version of loops written with ifzero and goto

```
while condition is true:
     do this group of statements
```

if-else examples (sign.py)

- can include else-if sections for a series of decisions:

```
num = input("Enter number: ")
while num != "":
  num = int(num)
  if num > 0:
    print(str(num) + " is positive")
  elif num < 0:
    print(str(num) + " is negative")
  else:
    print(str(num) + " is zero")
  num = input("Enter number: ")
```

while-loop examples

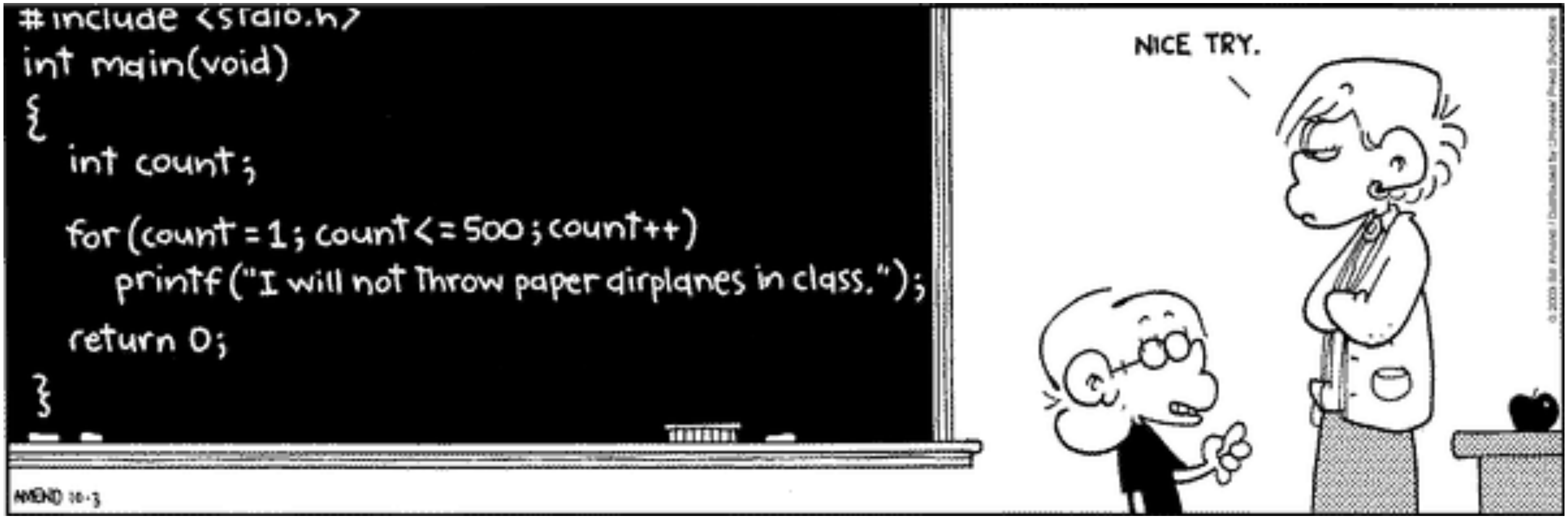
- counting or "indexed" loop:

```
i = 1
while i <= 10:
   # do something (maybe using current value of i)
   i = i + 1
```

- "nested" loops (while.py):

```
n = input("Enter number: ")
while n != "":
  i = 0
  while i <= int(n):
    print(i, i * i)
    i = i + 1
  n = input("Enter number: ")
```

Another kind of loop: "for"




```
for i in range(0, 500):
   print("I will not throw paper airplanes in class.")
```

Functions

- **a function is a group of statements that does some computation**
  - the statements are collected into one place and given a name
  - other parts of the program can "call" the function
    that is, use it as a part of whatever they are doing
  - can give it values to use in its computation (arguments or parameters)
  - the function computes a value that can be used in expressions
  - the value need not be used
- **Python provides some useful built-in functions**
  - e.g., print, input, ...
- **you can write your own functions**

Function examples

- syntax

  `def` *name* **`(`***list of "arguments"* **`):`**

  the statements of the function

- example of a function definition:

```
def area(r):
    return math.pi * r ** 2;
```

- using ("calling") the function:

```
r = input("Enter radius ");
print("radius =", r, ", area =", area(r))
```

- calling it twice in one expression:

```
print("CD recording surface =", area(2.3) - area(0.8))
```

Why use functions?

- if a computation appears several times in one program
  - a function collects it into one place
- breaks a big job into smaller, manageable pieces
  - that are separate from each other
- defines an interface
  - implementation details can be changed as long as it still does the same job
  - different implementations can interoperate
- multiple people can work on the program
- a way to use code written by others long ago and far away
  - most of Python's library of useful stuff is accessed through functions
- a good library encourages use of the language

Summary: elements of (most) programming languages

- constants: literal values like 1, 3.14, "Error!"
- variables: places to store data and results during computing
- declarations: specify name (and type) of variables, etc.
- expressions: operations on variables and constants to produce new values
- statements: assignment, conditional, loop, function call
  - assignment: store a new value in a variable
  - conditional: compare and branch; if-else
  - loop: repeat statements while a condition is true
- functions: package a group of statements so they can be called / used from other places in a program
- libraries: functions already written for you

How Python works

- recall the process for Fortran, C, etc.:
  compiler => assembler => machine instructions

- Python is analogous, but differs significantly in details

- Python compiler
  - checks for errors
  - compiles the program into instructions for something like the toy machine, but richer, more complicated, higher level
  - runs a simulator program (like the toy) that interprets these instructions

- simulator is often called an "interpreter" or a "virtual machine"
  - probably written in C or C++ but could be written in anything

The process of programming

- **what we saw with Python or Toy is like reality, but very small**

- **figure out what to do**
  - start with a broad specification
  - break into smaller pieces that will work together
  - spell out precise computational steps in a programming language
- **build on a foundation (rarely start from scratch)**
  - a programming language that's suitable for expressing the steps
  - components that others have written for you
    functions from libraries, major components, ...
  - which in turn rest on others, often for several layers
  - runs on software (the operating system) that manages the machine

- **it never works the first time**
  - test to be sure it works, debug if it doesn't
  - evolve as get a better idea of what to do, or as requirements change

Real-world programming

- the same thing, but on a grand scale
  - programs may be millions of lines of code

    typical productivity: 1-10K lines/year/programmer
  - thousands of people working on them
  - lifetimes measured in years or even decades
- big programs need teams, management, coordination, meetings, …
- schedules and deadlines
- constraints on how fast the program must run, how much memory it can use
- external criteria for reliability, safety, security, interoperability with other systems, …

- maintenance of old ("legacy") programs is hard
  - programs must evolve to meet changing environments and requirements
  - machines and tools and languages become obsolete
  - expertise disappears