DM536 / DM550 Part I
Introduction to Programming

Peter Schneider-Kamp

petersk@imada.sdu.dk

http://imada.sdu.dk/~petersk/DM536/

http://imada.sdu.dk/~petersk/DM550/

COURSE ORGANIZATION

Course Elements

- Lectures 1-2 times per week
- 3 sections:
  - D1 & D2: Computer Science (1st year)
  - H1: Mathematics-Economy & Minor in Computer Science (2nd year)
- Exercises (marked "TE" in your schedule)
- Labs (marked "TL" in your schedule)
- Exam for DM536 = 1 practical project
- Exam for DM550 = 2 practical projects
- project for DM550 Part 1 == project for DM536

Course Goals

- **Solve problems by writing computer programs**

- To this end, you will learn
  - to view programming as a problem solving approach
  - principles of imperative & object-oriented programming
  - how to model, test, debug, and document programs

- Focus on general principles, NOT on the language Python

Practical Issues / Course Material

- You need an IMADA account (≠ SDU account)

- Regularly check one of the (identical) course home pages:
  - http://imada.sdu.dk/~petersk/DM536/
  - http://imada.sdu.dk/~petersk/DM550/
  - Slides, weekly notes, projects, schedule, additional notes

- Reading material:
  - Allen B. Downey: *Think Python*, Green Tea Press, 2014.
  - Available as PDF and HTML from: http://greenteapress.com/thinkpython/thinkpython.html

Course Contract

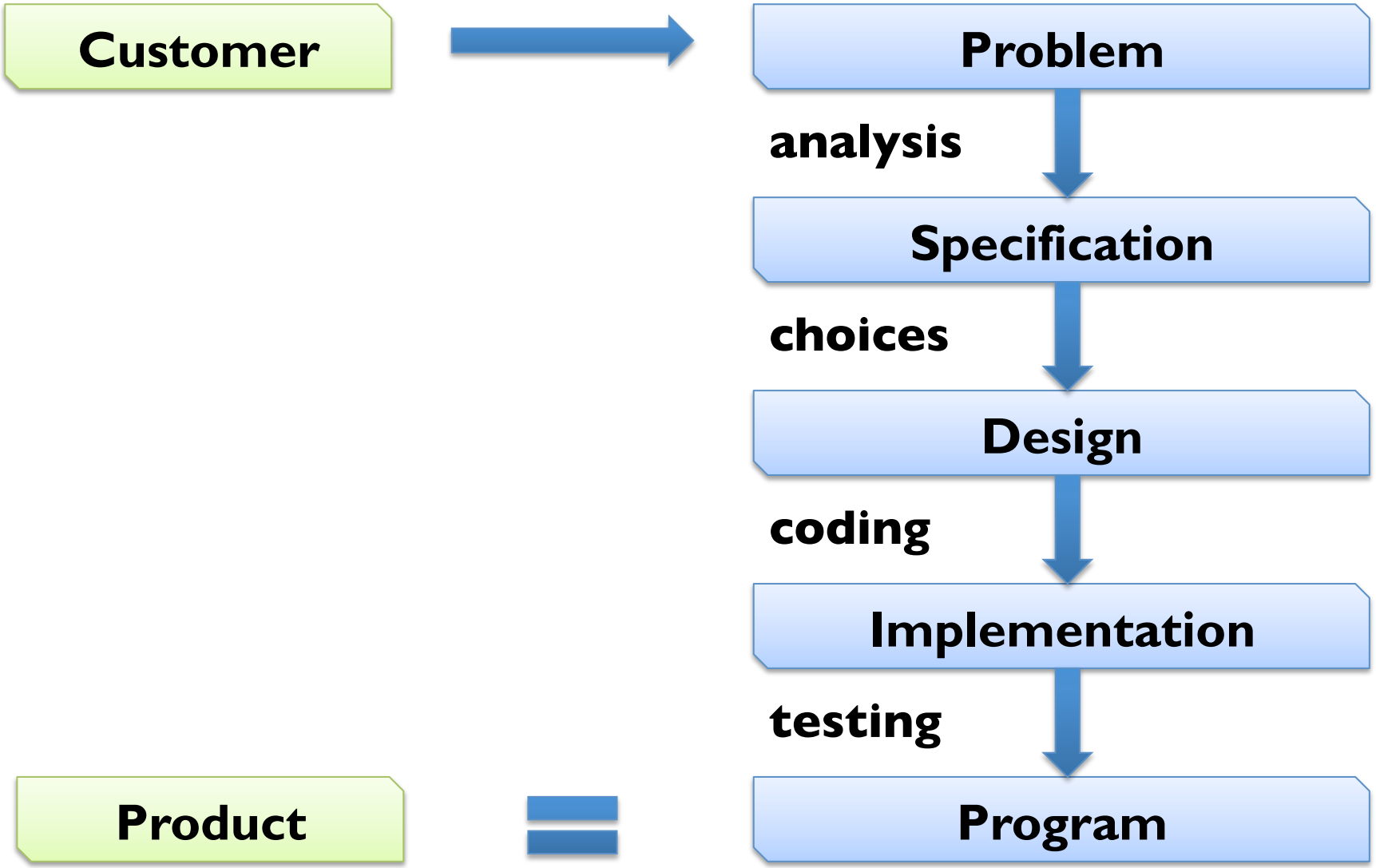
- I am offering you the following:
  1. I explain all needed concepts (as often as needed)
  2. I am available as much as possible and willing to help you
  3. I guide your learning by assigning exercises

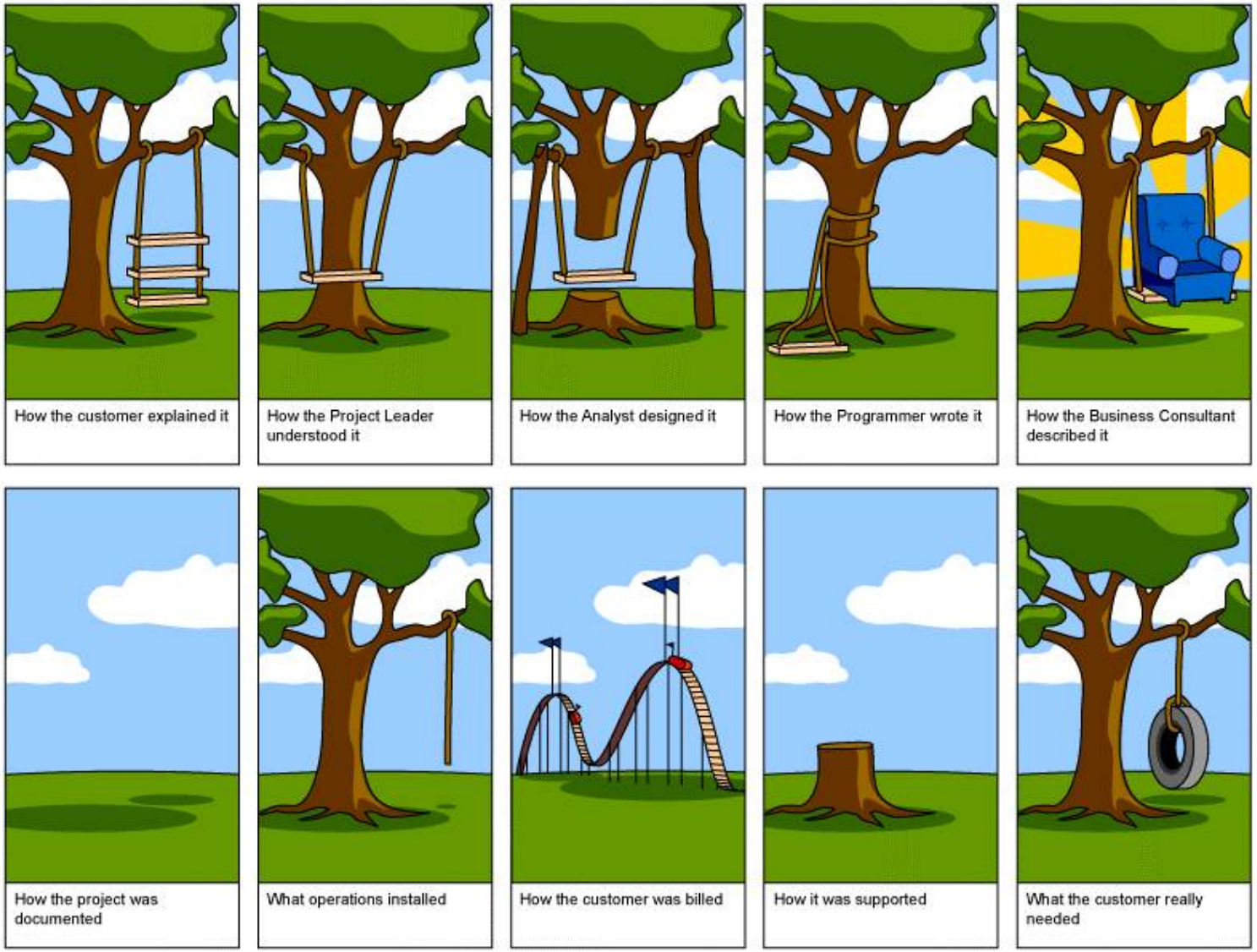
- From you I expect the following:
  1. You ask questions, when something is unclear
  2. You contact a TA (or me), when you need help
  3. You prepare for lectures and discussion sections

- You and I have the right and duty to call upon the contract!

PROGRAMMING

Programming as Problem Solving





Real Life "Programming"

Programming in a Nutshell

- Computers only have very limited abilities
- Computers are used to solve complex problems

- Programmers needed to break down complex problems into a sequence of simpler (sub-)problems

- program = sequence of simple instructions
- instructions = vocabulary of a programming language

- Programmers needed to express problems as sequence of instructions understandable to the computer

Simple Instructions

- Administrative:

```
from math import sqrt
```

- Input:

```
a = input()
b = input()
```

- Arithmetic operations:

```
c = sqrt(a**2+b**2)
```

- Output:

```
print "Result:", c
```

- That is basically ALL a computer can do.

Combining Instructions

- Sequence: <instr$_1$>; <instr$_2$>; <instr$_3$>
- Conditional Execution:

```
if <cond>:
    <instr1>; <instr2>
else:
    <instr3>; <instr4>; <instr5>
```

- Subprograms / Functions:

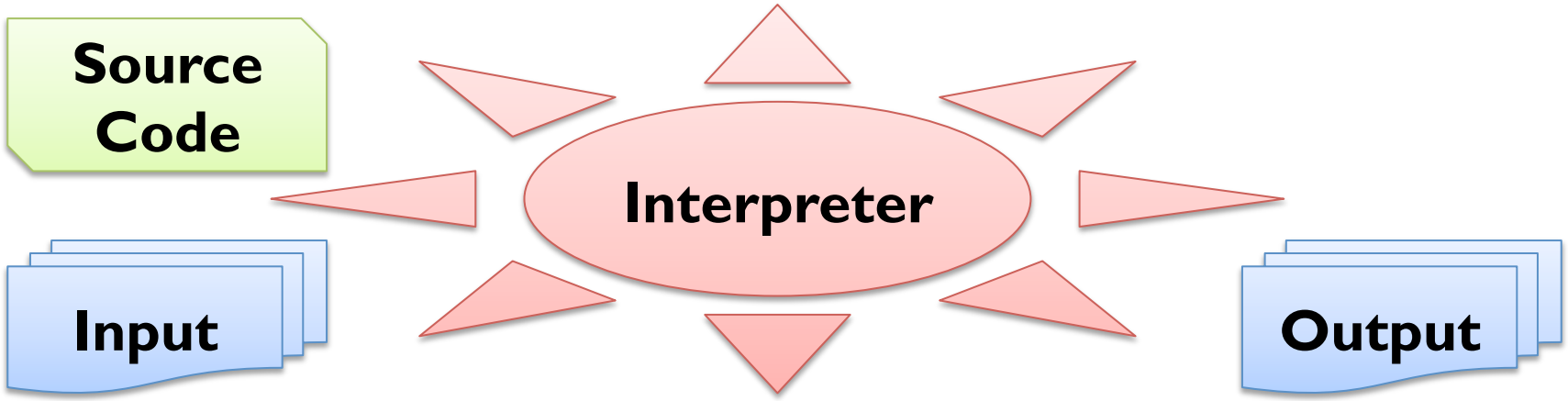
```
def <function>(<argument>):
    <instr1>; <instr2>
<var> = <function>(<input>)
```

- Repetition:

```
while <cond>:
    <instr1>; <instr2>; <instr3>
```

Executing Programs

- Program stored in a file (*source code* file)
- Instructions in this file executed top-to-bottom
- Interpreter executes each instruction



Debugging

- Any reasonably complex program contains errors
- Three types of errors (in Python)
  - Syntax Errors `a = input)(`
  - Runtime Errors `c = 42 / 0`
  - Semantic Errors `c = a**2+b**2`
- Debugging is finding out why an error occurred

VARIABLES, EXPRESSIONS & STATEMENTS

Values and Types

- Values = basic data objects — 42 — 23.0 — "Hello!"
- Types = classes of values — integer — float — string

- Values can be printed:
  - print <value> — print "Hello!"
- Types can be determined:
  - type(<value>) — type(23.0)
- Values and types can be compared:
  - <value> == <value> — type(3) == type(3.0)

Variables

- variable = name that refers to a value
- program state = mapping from variables to values

- values are *assigned* to variables using "=":
  - <var> = <value> b = 4

- the value referred to by a variable can be printed:
  - print <var> print b

- the type of a variable is the type of the value it refers to:
  - type(b) == type(4)

Variable Names

- start with a letter (convention: a-z)
- contain letters a-z and A-Z, digits 0-9, and underscore "_"

- can be any such name except for 31 reserved names:

and	del	from	not	while
as	elif	global	or	with
assert	else	if	pass	yield
break	except	import	print	
class	exec	in	raise	
continue	finally	is	return	
def	for	lambda	try	

Multiple Assignment

- variables can be assigned to different values at different times:
  - Example:
    ```
    x = 3
    x = 4
    ```
  - Instructions are executed top-to bottom => x refers to 4

- be careful, e.g., when exchanging values serially:
  - Example:
    ```
    x = y
    y = x
    ```
  - later x and y refer to the same value
  - Solution 1 (new variable): `z = y; y = x; x = z`
  - Solution 2 (parallel assign.): `x, y = y, x`

Operators & Operands

- Operators represent computations: + * - / **
  - Example: 23+19 day+month*30 2**6-22

- Addition "+", Multiplication "*", Subtraction "-" as usual
- Exponentiation "**": x**y means x^y

- Division "/" rounds down integers:
  - Example 1: 21/42 has value 0, NOT 0.5
  - Example 2: 21.0/42 has value 0.5
  - Example 3: 21/42.0 has value 0.5

Expressions

- Expressions can be:
  - Values: 42 23.0 "Hej med dig!"
  - Variables: x y name1234
  - built from operators: 19+23.0 x**2+y**2
- grammar rule:
  - <expr> => <value> |
    <var> |
    <expr> <operator> <expr> |
    (<expr>)
- every expression has a value:
  - replace variables by their values
  - perform operations

Operator Precedence

- expressions are evaluated left-to-right
  - Example: 64 - 24 + 2 == 42
- BUT: like in mathematics, "*" binds more strongly than "+"
  - Example: 2 + 8 * 5 == 42
- parentheses have highest precedence: 64 - (24 + 2) == 38
- PEMDAS rule:
  - Parentheses "(<expr>)"
  - Exponentiation "**"
  - Multiplication "*" and Division "/"
  - Addition "+" and Subtraction "-"

String Operations

- Addition "+" works on strings:
  - Example 1: `print "Hello w" + "orld!"`
  - Example 2: `print "4" + "2"`

- Multiplication "*" works on strings, if 2nd operands is integer:
  - Example: `print "Hej!" * 10`

- Subtraction "-", Division "/", and Exponentiation "**" do NOT work on strings

Debugging Expressions

- most beginners struggle with common Syntax Errors:
  - check that all parentheses and quotes are closed
  - check that operators have two operands
  - sequential instruction should start on the same column or be separated by a semicolon ";"

- common Runtime Error due to misspelling variable names:
  - Example:

```
a = input(); b = input()
reslut = a**b+b**a
print result
```

Statements

- instructions in Python are called *statements*

- so far we know 2 different statements:
  - print statement: print "Ciao!"
  - assignments "=": c = a**2+b**2

- as a grammar rule:

<stmt> => print <expr> |
<var> = <expr> |
<expr>

Comments

- programs are not only written, they are also read

- document program to provide intuition:
  - Example 1: `c = sqrt(a**2+b**2)  # use Pythagoras`
  - Example 2: `x, y = y, x  # swap x and y`

- all characters after the comment symbol "#" are ignored
  - Example: `x = 23 #+19`

    results in x referring to the value 23

CALLING FUNCTIONS

Calling Functions

- so far we have seen three different *function calls*:
  - input(): reads a value from the keyboard
  - sqrt(x): computes the square root of x
  - type(x): returns the type of the value of x

- in general, a function call is also an expression:
  - <expr> => … | <function>(<arg_1>, …, <arg_n>)
  - Example 1:
    ```
    x = input()
    print type(x)
    ```
  - Example 2:
    ```
    from math import log
    print log(439804651111104, 2)
    ```

Importing Modules

- we imported the sqrt function from the math module:

  from math import sqrt

- alternatively, we can import the whole module:

  import math

- using the built-in function "dir(x)" we see math's functions:

acos	cos	floor	log	sin
asin	cosh	fmod	log10	sinh
atan	degrees	frexp	modf	sqrt
atan2	exp	hypot	pow	tan
ceil	fabs	ldexp	radians	tanh

- access using "math.<function>": c = math.sqrt(a**2+b**2)

The Math Module

- contains 25 functions (trigonometric, logarithmic, …):
  - Example:

```
x = input()
print math.sin(x)**2+math.cos(x)**2
```

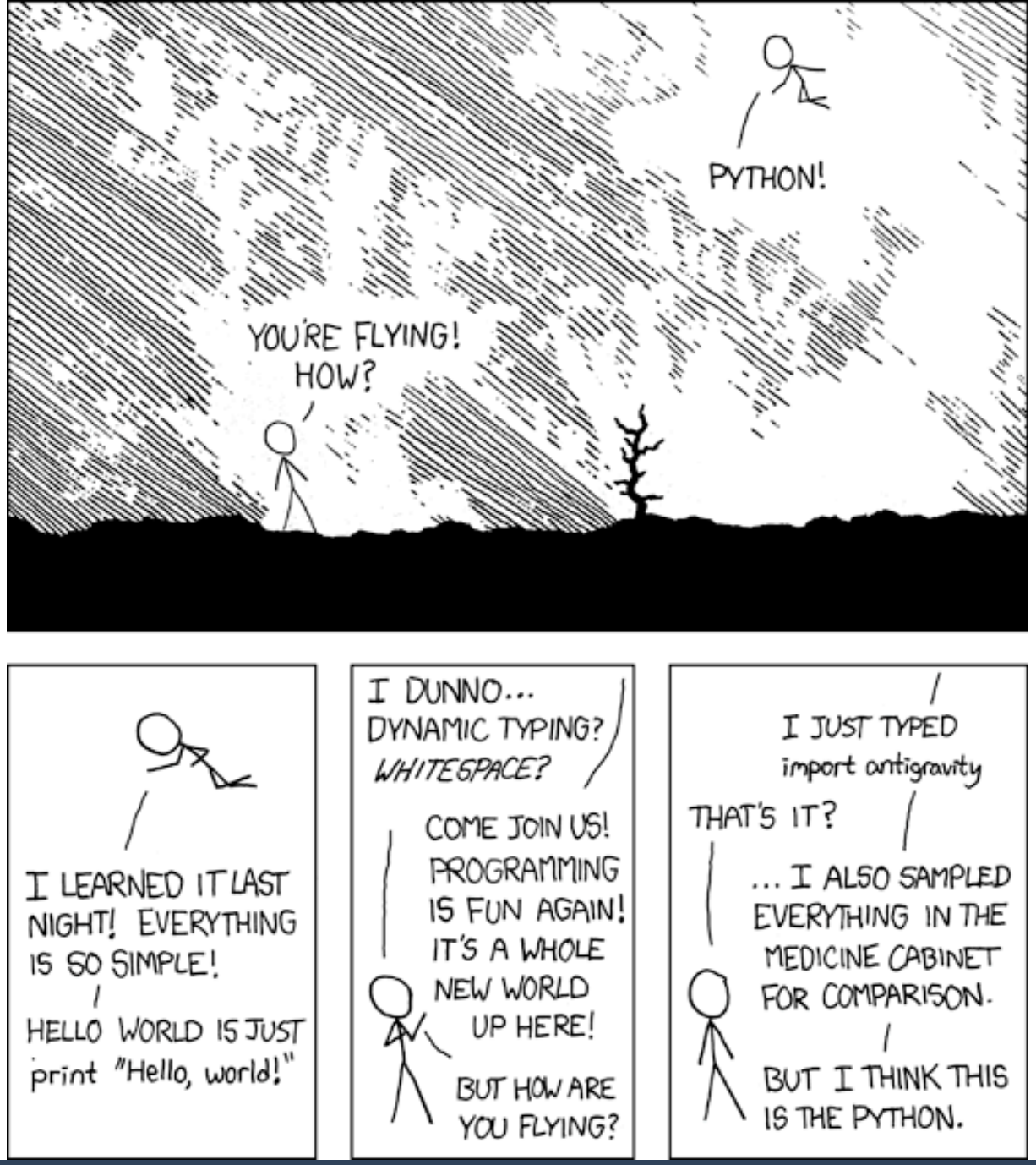
- contains 2 constants (math.e and math.pi):
  - Example:

```
print math.sin(math.pi / 2)
```

- contains 3 meta data (__doc__, __file__, __name__):
  - print math.__doc__
  - print math.frexp.__doc__
  - print type.__doc__

Type Conversion Functions

- Python has pre-defined functions for converting values
- int(x): converts x into an integer
  - Example 1: int("1234") == int(1234.9999)
  - Example 2: int(-3.999) == -3
- float(x): converts x into a float
  - Example 1: float(42) == float("42")
  - Example 2: float("Hej!") results in Runtime Error
- str(x): converts x into a string
  - Example 1: str(23+19) == "42"
  - Example 2: str(type(42)) == "<type 'int'>"


PYTHON!
YOU'RE FLYING! HOW?
I LEARNED IT LAST NIGHT! EVERYTHING IS SO SIMPLE!
HELLO WORLD IS JUST print "Hello, world!"
I DUNNO... DYNAMIC TYPING? WHITESPACE?
COME JOIN US! PROGRAMMING IS FUN AGAIN! IT'S A WHOLE NEW WORLD UP HERE!
BUT HOW ARE YOU FLYING?
I JUST TYPED import antigravity
THAT'S IT?
... I ALSO SAMPLED EVERYTHING IN THE MEDICINE CABINET FOR COMPARISON.
BUT I THINK THIS IS THE PYTHON.