COMPSCI 101

Principles of Programming

Lecture 3 – Evaluating expressions, modulus and integer division operators, docstring and comments, the math module, developing a program in steps

Learning outcomes

At the end of this lecture, you will know how to:

- import modules and use the functions defined in the module
- use the floor division and the modulus operators
- include a docstring at the top of a program and use comments

At the end of this lecture, you will understand:

- that the use of self-documenting code makes a program easier to read and understand
- that all expressions evaluates to one single value
- the order of operations which are used to evaluate an algebraic expression
- how to develop a program in steps

Recap

From lecture 2

- perform calculations using standard arithmetic operators
- use variables to store values
- describe differences between int and float types
- print numbers and strings to standard output

```
amount_to_convert = 500
nz_to_aus_rate = 0.95

nz_dollars = amount_to_convert
aus_from_nz = nz_dollars * nz_to_aus_rate
print("NZ $", nz_dollars, " = ", "AUS $", aus_from_nz, sep = "")
aus_dollars = amount_to_convert
aus_to_nz_rate = 1 / nz_to_aus_rate
nz_from_aus = aus_dollars * aus_to_nz_rate

print("AUS $", aus_dollars, " = ", "NZ $", nz_from_aus, sep = "")
```

```
NZ $500 = AUS $475.0
AUS $500 = NZ $526.3157894736842
```

Literals, variables and expressions

Literals are the actual values which can be stored in the program memory, e.g.

- 34
- -67.5
- "a particular string"

Variables can be assigned any literal value (or expressions). Variables are used to refer to (point to) a single piece of information, e.g.

- **result** = 567
- **final_result** = result + 45
- **phrase** = "a particular string"
- **phrase** = 'Please tell me more'
- **first_name** = "Izzy"

Expressions are made up of literal values and variables. Expressions always evaluate to a single value. The right hand side of the assignment operator is an expression, e.g.

- number = **3**
- final_result = **567 + 16 ** number**
- final_result = **final_result + number * 5 / 7**

Docstrings

A **docstring** is a special kind of string (text) used to provide documentation. A docstring:

- appears at the top of every CompSci 101 program,
- three double-quotes are used to surround the docstring,
- all programs should include a docstring at the top of the program,
- the docstring contains the author and a description of what the program does.

```
"""
Program which calculates the area of a circle.
Author: Adriana Ferraro
"""


radius = 10
area = 3.14159265359 * radius ** 2
print("Area of circle", area)
```

Skeleton of a Python program

In general the format of a Python program is:

docstring →
initialisation →
calculation →
output →

```
"""
Calculates the area of a rectangle.
Author: Adriana Ferraro
"""
width = 3.56
height = 8.4

area = width * height

print("Area of rectangle", area)
```

```
Area of rectangle 29.904
```

Every Python program is stored in a file which has .py at the end of the file name (the file extension), e.g. CalculateArea.py, CompoundInterest.py

Comments

As well as the docstring describing the purpose of the program at the top of **ALL** our programs, comments can be added to the program code. A programming comment is a note to other programmers who need to understand the code.

- Anything between a **#** (hash) and the end of the line is a comment and is ignored by the interpreter.

```
"""
Converts a length in inches to a length in centimetres.
Author: Adriana Ferraro
"""
cm_per_inch = 2.54
length_in_inches = 142  #Change the value of length_in_inches here
length_in_cm = length_in_inches * cm_per_inch
print("Length", length_in_cm)
```

```
Length 360.68
```

Use self documenting code

Add comments sparingly to explain code that is difficult, or to tell other programmers something they need to know about the code.

It is always important to use good descriptive variable names.

The program below does the same job as the program on the previous slide but it uses very poor variable names which makes the program difficult to read and difficult to understand.

```
"""
Author: Not Adriana Ferraro
"""

a = 2.54
b = 142
c = b * a

print("Length", c)
```

```
Length 360.68
```

Python libraries

Python has libraries of code which contain definitions and functions which perform useful tasks and calculations. The files in these libraries are called modules. The name of a module is the name of the file without the .py extension.

The **math module** contains many useful math functions and constants, e.g. math.sin(), math.cos(), math.pow(), math.sqrt(), math.floor(), …

In order to be able to use the functions of a module, we need to import the module. Importing a module means that we can then use all the functions defined inside that module, e.g.

```
"""Calculates the radius of a circle, given the area.
   Author: Adriana Ferraro
"""
import math

area = 221.67

radius = math.sqrt(area / math.pi)

print("Radius of circle", radius)
```

```
Radius of circle 8.399985266079987
```

www.python.org

The following website contains documentation about all the Python modules: **https://docs.python.org/3/py-modindex.html**

Python » English 3.8.5 Documentation » | modules | index

Python Module Index

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math — Mathematical functions — Python 3.8.5 documentation

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Previous topic: numbers — Numeric abstract base classes

Next topic: cmath — Mathematical functions for complex numbers

This Page: Report a Bug, Show Source

math — Mathematical functions

This module provides access to the mathematical functions defined by the C standard.

These functions cannot be used with complex numbers; use the functions of the same name from the cmath module if you require support for complex numbers. The distinction between functions which support complex numbers and those which don't is made since most users do not want to learn quite as much mathematics as required to understand complex numbers. Receiving an exception instead of a complex result allows earlier detection of the unexpected complex number used as a parameter, so that the programmer can determine how and why it was generated in the first place.

The following functions are provided by this module. Except when explicitly noted otherwise, all return values are floats.

Number-theoretic and representation functions

`math.ceil(x)`

Return the ceiling of *x*, the smallest integer greater than or equal to *x*. If *x* is not a float, delegates to `x.__ceil__()`, which should return an `Integral` value.

`math.comb(n, k)`

Return the number of ways to choose *k* items from *n* items without repetition and without order.

Evaluates to `n! / (k! * (n - k)!)` when `k <= n` and evaluates to zero when `k > n`.

Also called the binomial coefficient because it is equivalent to the coefficient of k-th term in polynomial expansion of the expression `(1 + x) ** n`.

Raises `TypeError` if either of the arguments are not integers. Raises `ValueError` if either of the arguments are negative.

Expressions – order of operations

Expressions containing numbers are evaluated in the same way as in mathematical expressions, i.e. BEDMAS applies:

- **B**rackets
- **E**xponents
- **D**ivision, **M**ultiplication
- **A**ddition, **S**ubtraction

Note that the **/** operator always results in a float, e.g. 8 / 4 is 2.0.

Give the output.

```
result1 = (25 - 7) * 3 + 12 / 3

result2 = 17 - 3 * 2 - 12 / 4 + 15

result3 = 32 / 4 ** (3 + 2 * 3 - 7) / 5

print(result1, result2, result3)
```

Remember to work from left to right when evaluating operators with the same priority.

More arithmetic operators

So far, we have seen these algebraic operators: `+, -, *, /, **`

Two more mathematical operators:

- **Floor division** (integer division) `//`
- **Modulus** (remainder) `%`

Floor division performs the division, i.e. evaluates to the greatest whole number less than or equal to the result, e.g.

- 16 // 5 gives 3
- 17 // 5 gives 3
- 34 // 5 gives 6

Modulus performs gives the remainder left over from the division, e.g.

- 16 % 5 gives 1
- 17 % 5 gives 2
- 34 % 5 gives 4
- 16 % 30 gives 16

Arithmetic operators with different numeric types

These are the mathematical operators we will be using:

+, -, *, /, **, //, %

When an arithmetic operator has operands of different numeric types, the operand with the "narrower" type is widened to that of the other operand (integer is narrower than floating point), e.g.

- 3 % 5.0 evaluates to 3.0
- 16.0 / 8 evaluates to 2.0
- 17 // 5.0 evaluates to 3.0
- 34.0 // 5 evaluates to 6.0
- 16.0 % 5 evaluates to 1.0
- 17 % 5.0 evaluates to 2.0

Exercise

Give the output.

```
result1 = 25 % 3

result2 = 20 % 34

result3 = 20 // 3.0

result4 = 5 // 7

result5 = (26.7 // 1) % 3

print(result1, result2, result3, result4, result5)
```

Exercise

Order of operations

Brackets

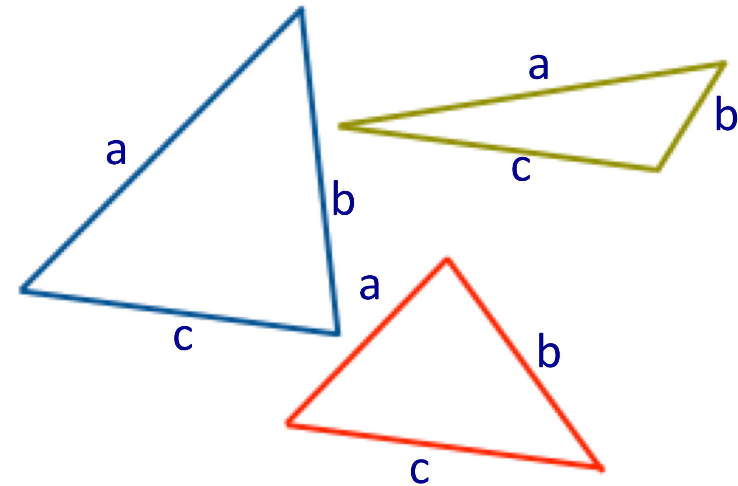
Exponents (**)

Division, Multiplication, Modulus, Floor division

Addition, Subtraction

Give the output.

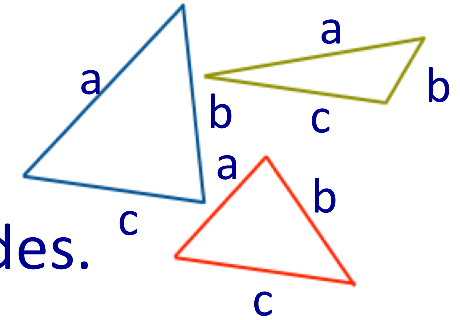
```
result1 = 25 / 4 // 3 + 4 * 10 % 3

result2 = 10 - 7 // 3 * 3 + 13 % 5 / 5 * 2

result3 = 17 % 3 * 2 - 3 ** 2 * 3 + 19 // 2

print(result1, result2, result3)
```



Heron's formula states that the area of a triangle whose sides have lengths a, b, and c is:

$$A = \frac{1}{4}\sqrt{4(a^2b^2 + a^2c^2 + b^2c^2) - (a^2 + b^2 + c^2)^2}$$

Write a program which uses **Heron's formula** to calculate and print the area of a triangle (use floor division for the result) given the length of the three sides.



$$A = \frac{1}{4}\sqrt{4(a^2b^2 + a^2c^2 + b^2c^2) - (a^2 + b^2 + c^2)^2}$$

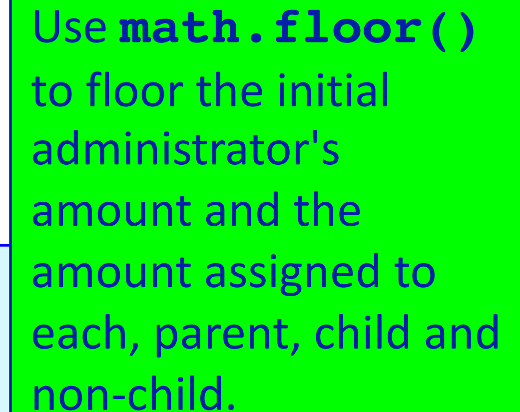
```
import math

side1 = 4
side2 = 7
side3 = 9

#Complete the code

print("Length of sides: ", side1, ', ', side2, ' and ',
                                          side3, sep = "")
print("Area:", area)
```

```
Length of sides: 4, 7 and 9
Area: 13
```

Exercise

An inheritance is apportioned as follows:

- Firstly, the administrator gets a quarter of one percent of the inheritance plus whatever is left over (nobody receives fractions of dollars, just whole dollars).
- Each non-child, non-parent relative gets one portion
- Each child get 100 times the amount of each relative
- Each parent get twice as much as each child




```
import math

total_inheritance = 1587654
administrator_percent = 0.0025
num_children = 3
num_parents = 2
num_relatives = 10

#Complete the code
```

```
Of the $1587654:
 Children get $223054 each
 Parents get $446108 each
 Relatives get $2230 each
 Administrator gets $3976
```

Summary

In a Python program we can:

- import modules and use the functions defined in the imported module
- use integer division and modulus operators
- use comments. Every program contains a docstring at the top of the program
- use self-documenting code to make the program easy to understand
- understand that an expression evaluates to one value
- understand the order of operations when an expression is evaluated
- understand how to develop a program in steps

Examples of Python features used in this lecture

- import modules and use the functions defined in the module

```
import math
result = math.sqrt(345)
```

- use integer division and modulus operators

```
whole_number = 456 // 3
left_overs = 456 % 12
```

- understand the order of operations when an expression is evaluated

```
result = 32 / 4 ** (1 + 2 * 3 – 7 % 4) / 5
```