Basic Data Types

Outline

Types

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A data type is a set of values along with a set of operations defined on those values

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2. `int` for integers

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3. `float` for floating-point numbers

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The four basic data types:

1. `str` for sequences of characters
2. `int` for integers
3. `float` for floating-point numbers
4. `bool` for true/false values

Expressions

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A literal is a representation of a data-type value

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Example:

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- `"Hello, World"` and `"Cogito, ergo sum"` are string literals
- `42` and `1729` are integer literals
- `3.14159` and `2.71828` are floating-point literals

Expressions

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Example:

- `"Hello, World"` and `"Cogito, ergo sum"` are string literals
- `42` and `1729` are integer literals
- `3.14159` and `2.71828` are floating-point literals
- `True` and `False` are boolean literals

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- `abc`, `Ab_`, `abc123`, and `a_b` are valid identifiers

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Example:

- `abc`, `Ab_`, `abc123`, and `a_b` are valid identifiers
- `Ab*`, `1abc`, and `a+b` are not

Keywords such as `and`, `def`, `import`, `lambda`, and `while` cannot be used as identifiers

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Example: `total` representing the running total of a sequence of numbers

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Example: `total` representing the running total of a sequence of numbers

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A variable's value is accessed as `[<target>.]<name>`

Expressions

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Example: `total` representing the running total of a sequence of numbers

A constant variable is one whose associated data-type value does not change during the execution of a program

Example: `SPEED_OF_LIGHT` representing the known speed of light

A variable's value is accessed as `[<target>.]<name>`

Example: `total`, `SPEED_OF_LIGHT`, `sys.argv`, and `math.pi`

Expressions

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`+`, `-`, `*`, `/`, and `%` represent arithmetic operations on integers and floats

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An operator is a representation of a data-type operation

`+`, `-`, `*`, `/`, and `%` represent arithmetic operations on integers and floats

`not`, `or`, and `and` represent logical operations on booleans

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A function is called as `[<library>.]<name>(<argument1>, <argument2>, ...)`

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A function is called as `[<library>.]<name>(<argument1>, <argument2>, ...)`

Example: `stdio.writeln("Hello, World")`

Expressions

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Three kinds of functions:

1. Built-in functions
2. Functions defined in standard libraries
3. Functions defined in user-defined libraries

A function is called as `[<library>.]<name>(<argument1>, <argument2>, ...)`

Example: `stdio.writeln("Hello, World")`

Some functions (called void functions) do not return a value while others (called non-void functions) do return a value

Expressions

Example

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`int(x)`	returns the integer value of `x`
`float(x)`	returns the floating-point value of `x`
`str(x)`	returns string value of `x`

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`exp(x)`	returns e^x
`sqrt(x)`	returns $\sqrt{x}$

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stdio

`writeln(x = "")`	writes `x` followed by newline to standard output
`write(x = "")`	writes `x` to standard output

Expressions

Example

`int(x)`	returns the integer value of `x`
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`exp(x)`	returns e^x
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stdio

`writeln(x = "")`	writes `x` followed by newline to standard output
`write(x = "")`	writes `x` to standard output

stdrandom

`uniformFloat(lo, hi)`	returns a float chosen uniformly at random from the interval `[lo, hi)`
`bernoulli(p = 0.5)`	returns `True` with probability `p` and `False` with probability `1 - p`

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- `2, 4`
- `a, b, c`

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An expression is a combination of literals, variables, operators, and non-void function calls that evaluates to a value

Example:

- `2, 4`
- `a, b, c`
- `b * b - 4 * a * c`

Expressions

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Example:

- `2, 4`
- `a, b, c`
- `b * b - 4 * a * c`
- `math.sqrt(b * b - 4 * a * c)`

Expressions

An expression is a combination of literals, variables, operators, and non-void function calls that evaluates to a value

Example:

- `2, 4`
- `a, b, c`
- `b * b - 4 * a * c`
- `math.sqrt(b * b - 4 * a * c)`
- `(-b + math.sqrt(b * b - 4 * a * c)) / (2 * a)`

Statements

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Import statement

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Example

```
import stdio
import sys
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Function call statement

```
[<library>.]<name>(<argument1>, <argument2>, ...)
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Example

```
stdio.write("Cogito, ")
stdio.write("ergo sum")
stdio.writeln()
```

Statements

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Assignment statement

```
<name> = <expression>
```

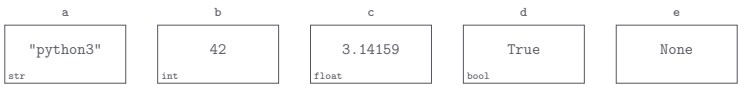
Statements

Assignment statement

```
<name> = <expression>
```

Example

```
a = "python3"
b = 42
c = 3.14159
d = True
e = None
```



Statements

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Example (exchanging the values of two variables `a` and `b`)

```
a = 42
b = 1729

t = a # t is now 42
a = b # a is now 1729
b = t # b is now 42

stdio.writeln(a)
stdio.writeln(b)
```

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a = 42
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t = a # t is now 42
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b = t # b is now 42

stdio.writeln(a)
stdio.writeln(b)
```

```
1729
42
```

Statements

Equivalent assignment statement forms

```
<name> <operator>= <expression>
<name> = <name> <operator> <expression>
```

where `<operator>` is `**`, `*`, `/`, `//`, `%`, `+`, or `-`

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<name> = <name> <operator> <expression>
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where `<operator>` is `**`, `*`, `/`, `//`, `%`, `+`, or `-`

Example

```
x *= 5
x = x * 5
```

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Operations:

- Concatenation (`+`)
  Example: `"123" + "456"` evaluates to `"123456"`

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Example: `"Hello, world\n"` and `"\"Python\" is great"`

Operations:

- Concatenation (`+`)
  Example: `"123" + "456"` evaluates to `"123456"`
- Replication (`*`)
  Example: `3 * "ab"` and `"ab" * 3` evaluate to `"abab"`

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Program: `dateformats.py`

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- Command-line input: *d* (str), *m* (str), and *y* (str) representing a date

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```
>_ ~/workspace/ipp/programs
$ _
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```
>_ ~/workspace/ipp/programs
$ python3 dateformats.py 14 03 1879
```

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- Command-line input: d (str), m (str), and y (str) representing a date
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```
>_ ~/workspace/ipp/programs

$ python3 dateformats.py 14 03 1879
14/03/1879
03/14/1879
1879/03/14
$ _
```

Strings

Strings

dateformats.py

```
import stdio
import sys

d = sys.argv[1]
m = sys.argv[2]
y = sys.argv[3]
dmy = d + "/" + m + "/" + y
mdy = m + "/" + d + "/" + y
ymd = y + "/" + m + "/" + d
stdio.writeln(dmy)
stdio.writeln(mdy)
stdio.writeln(ymd)
```

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Operations:

- Addition (`+`)

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Operations:

- Addition (`+`)
- Subtraction/negation (`-`)

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Example: `42` and `1729`

Operations:

- Addition (`+`)
- Subtraction/negation (`-`)
- Multiplication (`*`)

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Example: `42` and `1729`

Operations:

- Addition (`+`)
- Subtraction/negation (`-`)
- Multiplication (`*`)
- Division (`/`)

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Operations:

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- Division (`/`)
- Floored division(`//`)

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- Division (`/`)
- Floored division(`//`)
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- Multiplication (`*`)
- Division (`/`)
- Floored division(`//`)
- Remainder (`%`)
- Exponentiation (`**`)

Integers

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Program: `sumofsquares.py`

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- Command-line input: x (int) and y (int)

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- Standard output: $x^2 + y^2$

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```
>_ ~/workspace/ipp/programs
$ python3 sumofsquares.py 3 4
```

Integers

Program: `sumofsquares.py`

- Command-line input: x (int) and y (int)
- Standard output: $x^2 + y^2$

```
>_ ~/workspace/ipp/programs

$ python3 sumofsquares.py 3 4
25
$ _
```

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25
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```

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>_ ~/workspace/ipp/programs

```
$ python3 sumofsquares.py 3 4
25
$ python3 sumofsquares.py 6 8
100
$ _
```

Integers

Integers

sumofsquares.py

```
import stdio
import sys

x = int(sys.argv[1])
y = int(sys.argv[2])
result = x * x + y * y
stdio.writeln(result)
```

Floats

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Scientific notation: `6.022e23` represents 6.022×10^{23} and `6.674e-11` represents 6.674×10^{-11}

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Operations:

- Addition (`+`)

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Operations:

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- Subtraction/negation (`-`)
- Multiplication (`*`)
- Division (`/`)
- Exponentiation (`**`)

Floats

Floats

Program: `quadratic.py`

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- Command-line input: *a* (float), *b* (float), and *c* (float)

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- Command-line input: a (float), b (float), and c (float)
- Standard output: roots of the quadratic equation $ax^2 + bx + c = 0$

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```
>_ ~/workspace/ipp/programs
$ python3 quadratic.py 1 -5 6
```

Floats

Program: `quadratic.py`

- Command-line input: a (float), b (float), and c (float)
- Standard output: roots of the quadratic equation $ax^2 + bx + c = 0$

```
>_ ~/workspace/ipp/programs

$ python3 quadratic.py 1 -5 6
Root # 1 = 3.0
Root # 2 = 2.0
$ _
```

Floats

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- Command-line input: a (float), b (float), and c (float)
- Standard output: roots of the quadratic equation $ax^2 + bx + c = 0$

```
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Root # 1 = 3.0
Root # 2 = 2.0
$ python3 quadratic.py 1 -1 -1
```

Floats

Program: `quadratic.py`

- Command-line input: a (float), b (float), and c (float)
- Standard output: roots of the quadratic equation $ax^2 + bx + c = 0$

```
>_ ~/workspace/ipp/programs

$ python3 quadratic.py 1 -5 6
Root # 1 = 3.0
Root # 2 = 2.0
$ python3 quadratic.py 1 -1 -1
Root # 1 = 1.618033988749895
Root # 2 = -0.618033988749895
$ _
```

Floats

Floats

quadratic.py

```
import math
import stdio
import sys

a = float(sys.argv[1])
b = float(sys.argv[2])
c = float(sys.argv[3])
discriminant = b * b - 4 * a * c
root1 = (-b + math.sqrt(discriminant)) / (2 * a)
root2 = (-b - math.sqrt(discriminant)) / (2 * a)
stdio.writeln("Root # 1 = " + str(root1))
stdio.writeln("Root # 2 = " + str(root2))
```

Booleans

Booleans

The `bool` data type represents truth values (true or false) from logic

Booleans

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Operations:

- Logical not (`not`)
- Logical or (`or`)
- Logical and (`and`)

Truth tables for the logical operations

x	not x
False	True
True	False

x	y	x or y
False	False	False
False	True	True
True	False	True
True	True	True

x	y	x and y
False	False	False
False	True	False
True	False	False
True	True	True

Booleans

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- Less than or equal (`<=`)
- Greater than (`>`)
- Greater than or equal (`>=`)

Booleans

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Program: `leapyear.py`

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- Command-line input: y (int)

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```
>_ ~/workspace/ipp/programs
$ _
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>_ ~/workspace/ipp/programs

$ python3 leapyear.py 2020
```

Booleans

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>_ ~/workspace/ipp/programs

$ python3 leapyear.py 2020
True
$ _
```

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- Command-line input: y (int)
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>_ ~/workspace/ipp/programs

$ python3 leapyear.py 2020
True
$ python3 leapyear.py 1900
```

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- Standard output: whether y is a leap year or not

```
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$ python3 leapyear.py 2020
True
$ python3 leapyear.py 1900
False
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```

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- Command-line input: y (int)
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$ python3 leapyear.py 2020
True
$ python3 leapyear.py 1900
False
$ python3 leapyear.py 2000
```

Booleans

Program: `leapyear.py`

- Command-line input: y (int)
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```
>_ ~/workspace/ipp/programs

$ python3 leapyear.py 2020
True
$ python3 leapyear.py 1900
False
$ python3 leapyear.py 2000
True
$ _
```

Booleans

Booleans

leapyear.py

```
import stdio
import sys

y = int(sys.argv[1])
result = y % 4 == 0 and y % 100 != 0 or y % 400 == 0
stdio.writeln(result)
```

Operator Precedence

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Operator precedence (highest to lowest)

`**`	exponentiation
`+, -`	unary
`*, /, //, %`	multiplicative
`+, -`	additive
`<, <=, >, >=`	comparison
`==, !=`	equality
`=, **=, *=, /=, //=, %=, +=, -=`	assignment
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Parentheses can be used to override precedence rules

Python Console

Python Console

The Python Console[1] available in PyCharm can be used as an interactive calculator

[1] To launch from terminal, run the command `python3`; and to return to the terminal, run the built-in function `exit()`

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>>> 3 ** 2 + 4 ** 2
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>>> 3 ** 2 + 4 ** 2
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>>> 3 ** 2 + 4 ** 2
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>>> math.sqrt(x)
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>>> 3 ** 2 + 4 ** 2
25
>>> import math
>>> x = 2
>>> math.sqrt(x)
1.4142135623730951
>>> _
```

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>>> dir(math)
```

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Run `dir(<library>)` to get a list of attributes for a library

Example

```
>_ ~/workspace/ipp/programs

>>> dir(math)
['__doc__', '__loader__', '__name__', '__package__', '__spec__', 'acos', 'acosh', 'asin', 'asinh',
'atan', 'atan2', 'atanh', 'ceil', 'copysign', 'cos', 'cosh', 'degrees', 'e', 'erf', 'erfc', 'exp',
'expm1', 'fabs', 'factorial', 'floor', 'fmod', 'frexp', 'fsum', 'gamma', 'gcd', 'hypot', 'inf',
'isclose', 'isfinite', 'isinf', 'isnan', 'ldexp', 'lgamma', 'log', 'log10', 'log1p', 'log2', 'modf',
'nan', 'pi', 'pow', 'radians', 'sin', 'sinh', 'sqrt', 'tan', 'tanh', 'tau', 'trunc']
>>> _
```

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>>> help(math)

Help on built-in module math:

NAME
    math

FILE
    (built-in)

DESCRIPTION
    This module is always available.  It provides access to the
    mathematical functions defined by the C standard.

FUNCTIONS
    acos(...)
        acos(x)

        Return the arc cosine (measured in radians) of x.
...
DATA
    e = 2.718281828459045
    pi = 3.141592653589793
>>> _
```

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>>> help(math.sqrt)
```

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Run `help(<library>.<name>)` to access documentation for a particular function from a library

Example

```
>_ ~/workspace/ipp/programs

>>> help(math.sqrt)
Help on built-in function sqrt in module math:

sqrt(...)
    sqrt(x)

    Return the square root of x.
>>> _
```