Python Basics!

data types, strings, indexing

CS101 Lecture #3

2016-10-08

Administrivia

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- Homework #2–#6 will be later.

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- Final answer counts.

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- Final answer counts.
- Answers will be released 18 hours later.

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- Where can you get help in this class?
  - Blackboard forum
  - Instructors in labs and office hours
- You don't need to install Python—but if you do, use Python 3.
- This is not a "weeder" class—you can succeed!

Quick Review & A Bit New

How Assignment Works

```
x = 10
```

How Assignment Works

```
x = 10
y = x * x
```

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```
x = 10
y = x * x
x * x = y
```

How Assignment Works

```
x = 10
y = x * x
x * x = y

x,y = y,x  # a neat trick
```

Warmup Quiz

Question #1

```
x = 10
y = x + 1
y = x * y
```

What is the value of `y`?

A 11
B 100
C 110
D None of the above

Question #2

```
x = 10
y = x + 1
y = x * y
```

What do we call `x`?

A a literal
B a variable
C an expression
D a statement

Question #3

```
x = 10
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What do we call `10`?

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B a variable
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Question #2

```
x = 10
y = x + 1
y = x * y
```

What do we call `y = x * y`?

A a literal
B a variable
C an expression
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Question #5

```
x = 10
y = x
x = 5
```

What is the value of `y`?

A 10

B 5

Reminder

- You will have graded quiz starting from the upcoming Monday lecture!

Data Types

*What is an **encoding**?*

`01001000 01000101 01001100 01001100`
What does a binary data value like this represent?

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`01001000 01000101 01001100 01001100`
What does a binary data value like this represent?

- What does binary data represent?
- How does the processor know?

*What is a **data type**?*

- A **data type** defines an encoding rule.
- All values have a type.

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- A **data type** defines an encoding rule.
- All values have a type.
- The type defines how data is represented in memory.
- The type defines allowed operations and how they work.

Example

01100111 can be the number 103, the letter g, hexadecimal 67, etc.

- So what are these data types?

Numeric Data Types

Representing numbers in binary

- Binary can naturally represent 'natural numbers' :

00000000	0	00000100	4	00001000	8
00000001	1	00000101	5	00001001	9
00000010	2	00000110	6	...	
00000011	3	00000111	7	11111111	255

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https://en.wikipedia.org/wiki/Binary_number
https://www.bottomupcs.com/chapter01.xhtml#d0e660

Integers (int), $\mathbb{Z}$

- How about *Integers*?

$$..., -3, -2, -1, 0, 1, 2, 3, ...$$

- Negative numbers?

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- What are the limits of a 8-bit integer representation (with nagatives)?

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- How about *Integers*?

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- What are the limits of a 8-bit integer representation (with nagatives)?

$$-128...127$$

History

- Old version python **int** are 32 bits long (in the range of -2^{31} to $2^{31} - 1$)
- That's -2147483648 to 2147483647
- values too big: *overflow*
- values too small: *underflow*

History

- Python has another integer type: **long**
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History

- Python has another integer type: **long**
- Represents with no restrictions on size (no overflow/underflow)
- Since v2.2, python converts int overflow to a **long**
- newer Python versions promises there is no distinction between **int** and **long**
- Don't get spoiled by this (many languages still have clear integer types and limits).

https://en.wikipedia.org/wiki/Integer_(computer_science)

Integer operations

- Evaluating an expression of integers will generally result in an integer answer
  - 3 + 5

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  - `3 / 4` $\rightarrow$ `0.75`

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  - `3 // 4` $\rightarrow$ `0` (floor division)

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  - `3 + 5`
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  - `3 / 4` $\rightarrow$ `0.75`
  - `3 // 4` $\rightarrow$ `0` (floor division)
  - `4 / 2` $\rightarrow$ `??`

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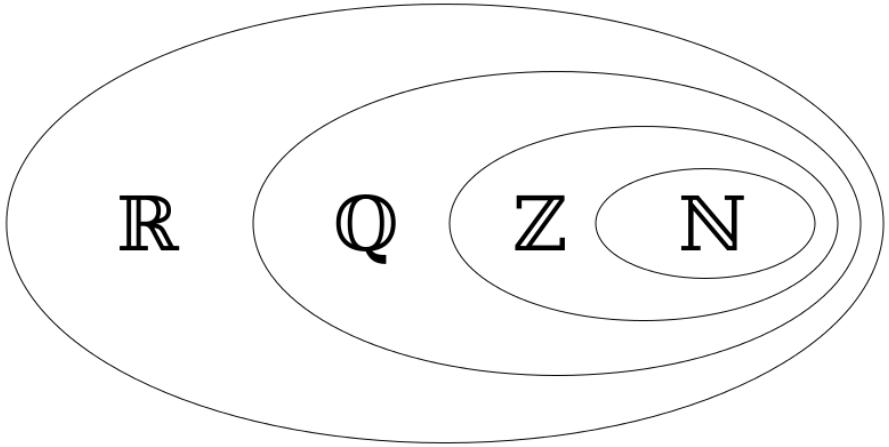
- What are limits?
  - Overflow/underflow
  - Precision (π, e)
- Float representation in Binary

`http://sites.cs.queensu.ca/courses/cisc121/Record/Week09/Arith.pdf`

Floating-point numbers, $\mathbb{R}$



Real numbers (R) include the rational (Q), which include the integers (Z), which include the natural numbers (N).

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  - `3.0 + 5.0` $\rightarrow$ `8.0`
  - `3 + 5.5` $\rightarrow$ `?` (what happens here?)
- Engineers and scientists need to think carefully about data type, precision, and the *conversion*.

Complex numbers, $\mathbb{C}$

- Represent numbers with an imaginary component.

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- Represent numbers with an imaginary component.
- Use `j` for i:

```
1.0 + 1j
2 + 0j
```

Example

```
x = 4
y = 3 + 1j
z = 33.3333
print( x + y + z )
```

What is printed to the screen?

A `40`
B `40.3333`
C `40.3333 + 1j`
D None of the above

Attribute operator .

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print(x.real)
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- Reaches inside of a value to access part of its data (called an attribute).
- Extracts special variables stored "inside" of the type.

```
print(x.real)
print(x.imag)
```

- Both of these components are floats.

Example

```
x = (3.5 + 1j)
y = 1
z = x + y
```

What is the value of `z.imag`?

Example

```
x = (3.5 + 1j)
y = 1
z = x + y
```

What is the value of `z.imag`?

A `4.5 + 1j`

B `4.5`

C `1j`

D `1.0`

String Data Type

How does text work?

- Each symbol is stored individually, one byte long:

  01001000 72
  01000101 69
  01001100 76
  01001100 76
  01001111 79

ASCII encoding table

000		(nul)	016	▶	(dle)	032	sp	048	0	064	@	080	P	096	`	112	p
001	☺	(soh)	017	◀	(dc1)	033	!	049	1	065	A	081	Q	097	a	113	q
002	☻	(stx)	018	↕	(dc2)	034	"	050	2	066	B	082	R	098	b	114	r
003	♥	(etx)	019	‼	(dc3)	035	#	051	3	067	C	083	S	099	c	115	s
004	♦	(eot)	020	¶	(dc4)	036	$	052	4	068	D	084	T	100	d	116	t
005	♣	(enq)	021	§	(nak)	037	%	053	5	069	E	085	U	101	e	117	u
006	♠	(ack)	022	–	(syn)	038	&	054	6	070	F	086	V	102	f	118	v
007	•	(bel)	023	↨	(etb)	039	'	055	7	071	G	087	W	103	g	119	w
008	◘	(bs)	024	↑	(can)	040	(	056	8	072	H	088	X	104	h	120	x
009		(tab)	025	↓	(em)	041	)	057	9	073	I	089	Y	105	i	121	y
010		(lf)	026		(eof)	042	*	058	:	074	J	090	Z	106	j	122	z
011	♂	(vt)	027	←	(esc)	043	+	059	;	075	K	091	[	107	k	123	{
012	♀	(np)	028	∟	(fs)	044	,	060	<	076	L	092	\	108	l	124	|
013		(cr)	029	↔	(gs)	045	-	061	=	077	M	093	]	109	m	125	}
014	♫	(so)	030	▲	(rs)	046	.	062	>	078	N	094	^	110	n	126	~
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006 ♠	(ack)	022 ▬	(syn)	038	&	054	6	070	F	086	V	102	f	118	v
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72 69 76 76 79 = H E L L O

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```
72 69 76 76 79 = H E L L O
'HELLO'
```

Strings

- As a literal: text surrounded by quotes.
  - `"DEEP"`

Strings

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Strings

- As a literal: text surrounded by quotes.
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- Each symbol is a character.
- Unlike numeric types, strings vary in length.

String operations

- **Concatenation**: combine two strings
  - Uses the + symbol
  - `'RACE' + 'CAR'`

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  - `'HELLO '*10`

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- **Concatenation**: combine two strings
  - Uses the + symbol
  - `'RACE' + 'CAR'`
- **Repetition**: repeat a string
  - Uses the *
  - `'HELLO '*10`
- **Formatting**: used to encode other data as string
  - Uses % symbol

Formatting operator

- Creates string with value inserted

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  - Formats nicely
  - Requires indicator of type inside of string

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  - Formats nicely
  - Requires indicator of type inside of string

```
x = 100 * 54
s = "String is: %i" % x
print(s)
```

Example

```
name = "Tao"
grade = 2 / 3
m1 = "Hello, %s!" % name
m2 = "Your grade is:  %f." % grade
print(m1)
print(m2)
```

Example

```
name = "Tao"
grade = 2 / 3
m1 = "Hello, %s!" % name
m2 = "Your grade is:  %f." % grade
print(m1)
print(m2)
```

```
Hello, Tao!
Your grade is 0.66667.
```

Example

```
x = 3
s = ("%i" % (x+1)) * x**(5%x)
print(s)
```

What does this program print?

A 333333333333
B 444444444
C 9999
D %i%i%i%i%i

Indexing operator

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a = "FIRE"
a[0]
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- **We count from zero!** (same in C, C++, Java)

Indexing operator

- Extracts single character
  ```
  a = "FIRE"
  a[0]
  ```
- The integer is the index.
- **We count from zero!** (same in C, C++, Java)
- If negative, counts down from end.
- a[-1] refers to the last character

Question

```
s = "ABCDE"
i = 3
x = s[i]
```

What is the value of `x`?

A `'A'`
B `'B'`
C `'C'`
D `'D'`
E `'E'`

Question

```
s = "ABCDE"
i = 25 % 3
y = s[i]
```

What is the value of `y`?

A `'A'`
B `'B'`
C `'C'`
D `'D'`
E `'E'`

Question

```
s = "ABCDE"
i = (11 % 3) - 7
z = s[i]
```

What is the value of z?

A `'A'`
B `'B'`
C `'C'`
D `'D'`
E `'E'`

Question

```
s = "ABCDE"
i = (11 % 3) - 7
z = s[i]
```

What is the value of z?

A `'A'`
B `'B'`
C `'C'`
D `'D'`
E `'E'`

Question

```
s = "ABCDE"
i = (11 % 3) + 3
z = s[i]
```

What is the value of z?

Question

```
s = "ABCDE"
i = (11 % 3) + 3
z = s[i]
```

What is the value of `z`?
How about `s[-6]`?

Reminders

Reminders

- Lab #2 tomorrow Sunday.