Python Basics!

data types, strings, indexing

CS101 Lecture #3

2017-9-26

Administrivia

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- Homework #1 deadline just passed.
- Final answer counts.
- Answers have been released on CodeLab.

Administrivia

- Where can you get help in this class?
  - Blackboard forum
  - Instructors in labs and office hours
  - Email me

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- You don't need to install Python—but you're encouraged to have one.

Administrivia

Course enrollment and CodeLab registration using zju.edu.cn account (or the intl. account) is OK.

But **Lab submissions** (to: cs101homework@intl.zju.edu.cn) have to come from your intl.zju.edu.cn account.

Administrivia

- Lab #2 tomorrow.

Quick Review & A Bit New

How Assignment Works

```
x = 10
```

How Assignment Works

```
x = 10
y = x * x
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x * x = y   # error! assignment is from rhs to lhs

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

What do we call `10`?

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

Question #4

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

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

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

Question #5

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

What do we call `x * y`?

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

Question #6

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

What is the value of `y`?

A 10

B 5

Data Types

Why need data type?

`01001000 01000101 01001100 01001100`
A binary code that passes through a processor

- Machine binary code represents different kinds of data (5, 'apple', operator $+$, memory address)

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A binary code that passes through a processor

- Machine binary code represents different kinds of data (5, 'apple', operator $+$, memory address)
- Different types of data are **encoded** in binary with different rules
- The same binary data can be interpreted in different ways based on their *data type*

Example

`01100111` can be the number 103, hexadecimal 67, or a letter `'g'`, etc.

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`01100111` can be the number 103, hexadecimal 67, or a letter `'g'`, etc.

In order to interpret it correctly, we need to know its data type.

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- A **data type** defines an encoding rule.
  - i.e. how data is represented in memory by 0s and 1s.
- It also defines the allowed operations
  - e.g. cannot do arithmetic to characters.

Numeric Data Types

Representing numbers in binary

- Binary encoding for numbers:

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

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- example: 01011010

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https://www.bottomupcs.com/chapter01.xhtml

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

- How about *Integers*?

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

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$$-128...127$$

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

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History

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- 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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  - `4 / 2` $\rightarrow$ `??`

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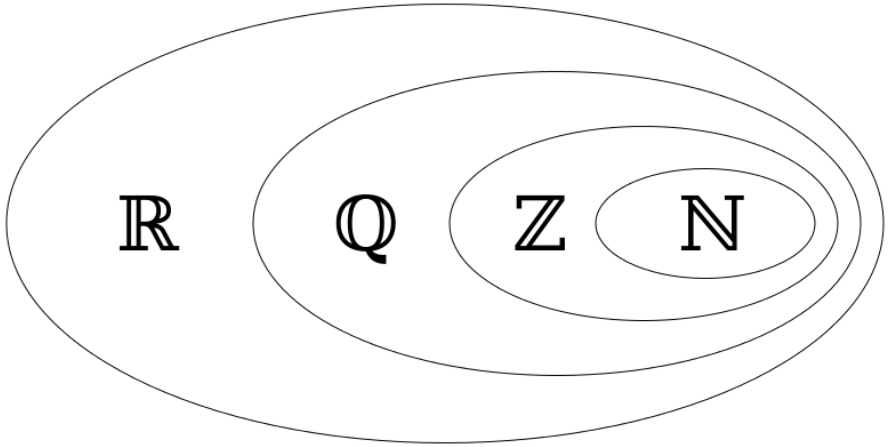
  - up to a precision
- Floating point representation in Binary

`https://en.wikipedia.org/wiki/IEEE_754-1985` (IEEE 754 standard)

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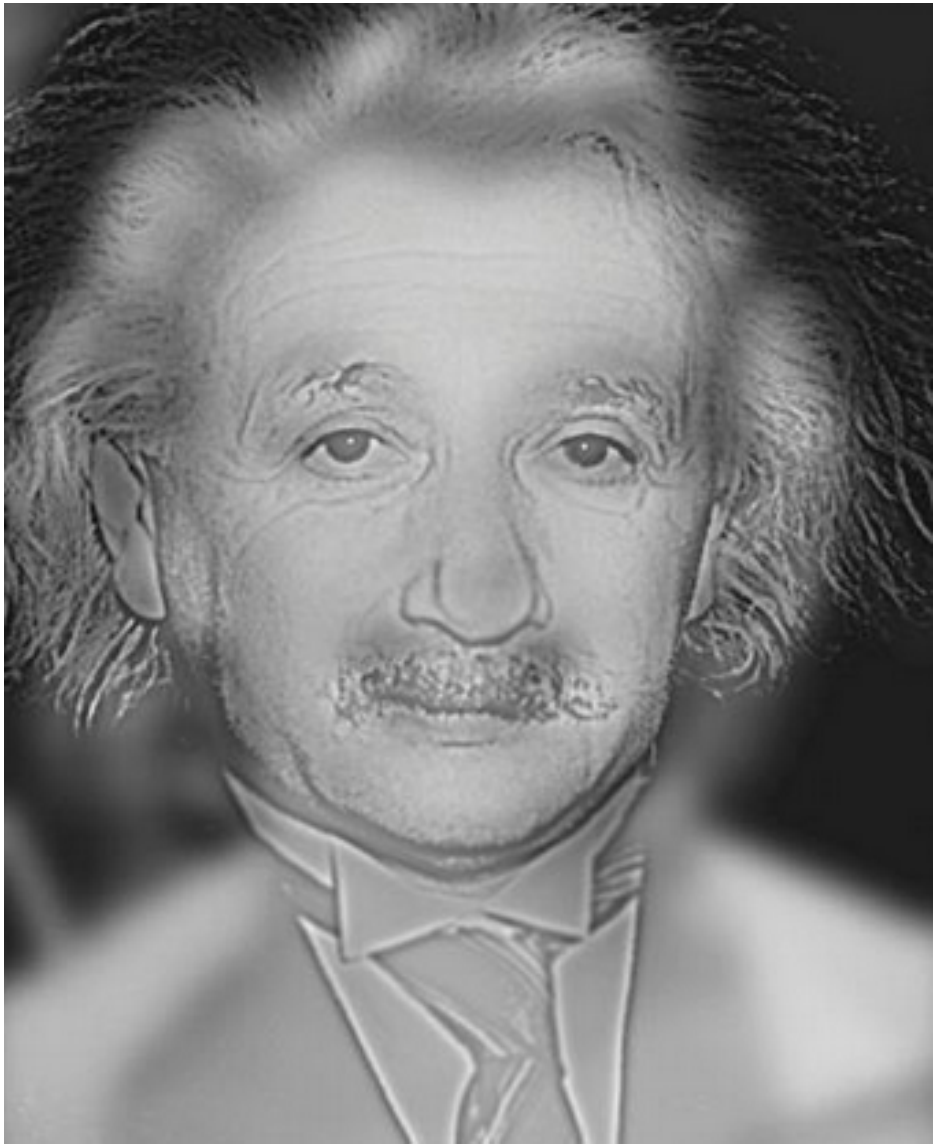
  - `3 + 5.5` $\rightarrow$ `?` (what happens here?)
- Engineers and scientists need to think carefully about data type, precision, and type *conversion*.



String Data Type

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	~
015 ☼	(si)	031 ▼	(us)	047	/	063	?	079	O	095	_	111	o	127	⌂

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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
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015	☼	(si)	031	▼	(us)	047	/	063	?	079	O	095	_	111	o	127	⌂

The table provides an *encoding* scheme from number to symbols

72 69 76 76 79 = H E L L O

How to store text on computer?

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- Each symbol is stored individually, one byte long:

72	01001000
69	01000101
76	01001100
76	01001100
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- `H E L L O` = 72 69 76 76 79
- Each symbol is stored individually, one byte long:

72	01001000
69	01000101
76	01001100
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`'HELLO'` : `01001000 01000101 01001100 01001100 01001111`

How to store text on computer?

- What's the size of a plain txt file with 1000 english words?

Strings

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

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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`

String operations

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  - the "same" operator work differently with different operands (*operator overload*)
- **Repetition**: repeat a string
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  - `'HELLO '*10`
- **Formatting**: used to encode other data as string
  - Uses % symbol

Formatting operator

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  - Requires indicator of type inside of string

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```
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)
```

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```

```
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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- 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) + 3
z = s[i]
```

What is the value of z?