Python Basics!

data types, strings, indexing

CS101 Lecture #3

2016-10-08

Administrivia

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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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- Lab #2 tomorrow Sunday.
- 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
```

How Assignment Works

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

How Assignment Works

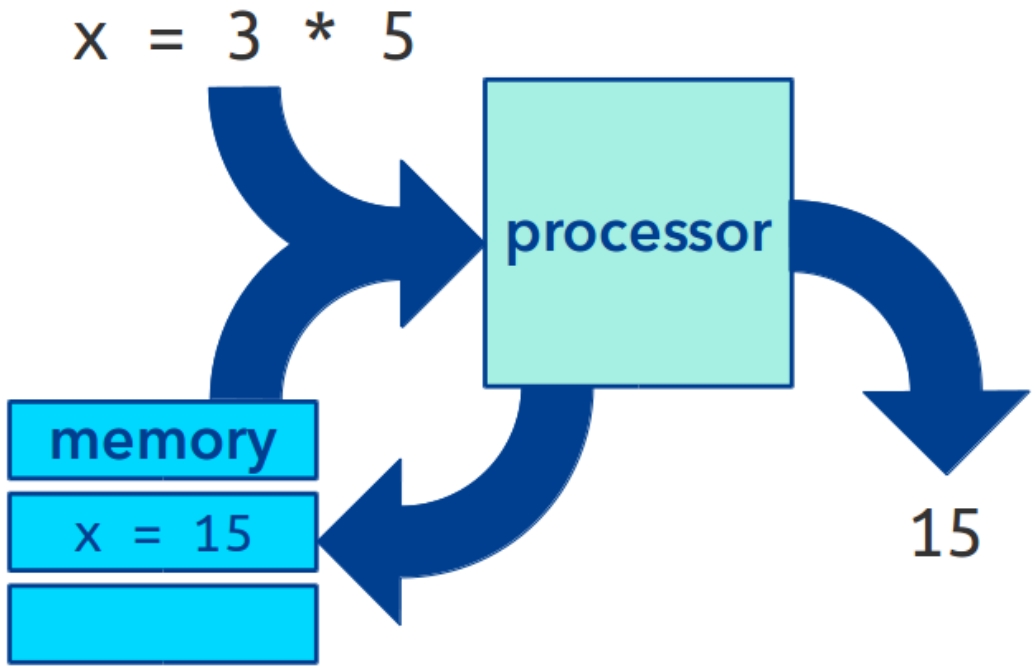
```
x = 10
y = x * x
x * x = y

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

Warmup Quiz

Reminder

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

Our execution model



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 #2

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

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

A a literal
B a variable
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Question #5

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

What is the value of `y`?

A 10

B 5

Data Types

*What is an **encoding**?*

`01001000 01000101 01001100 01001100`

What does a binary data value like this represent?

- What does binary data represent?

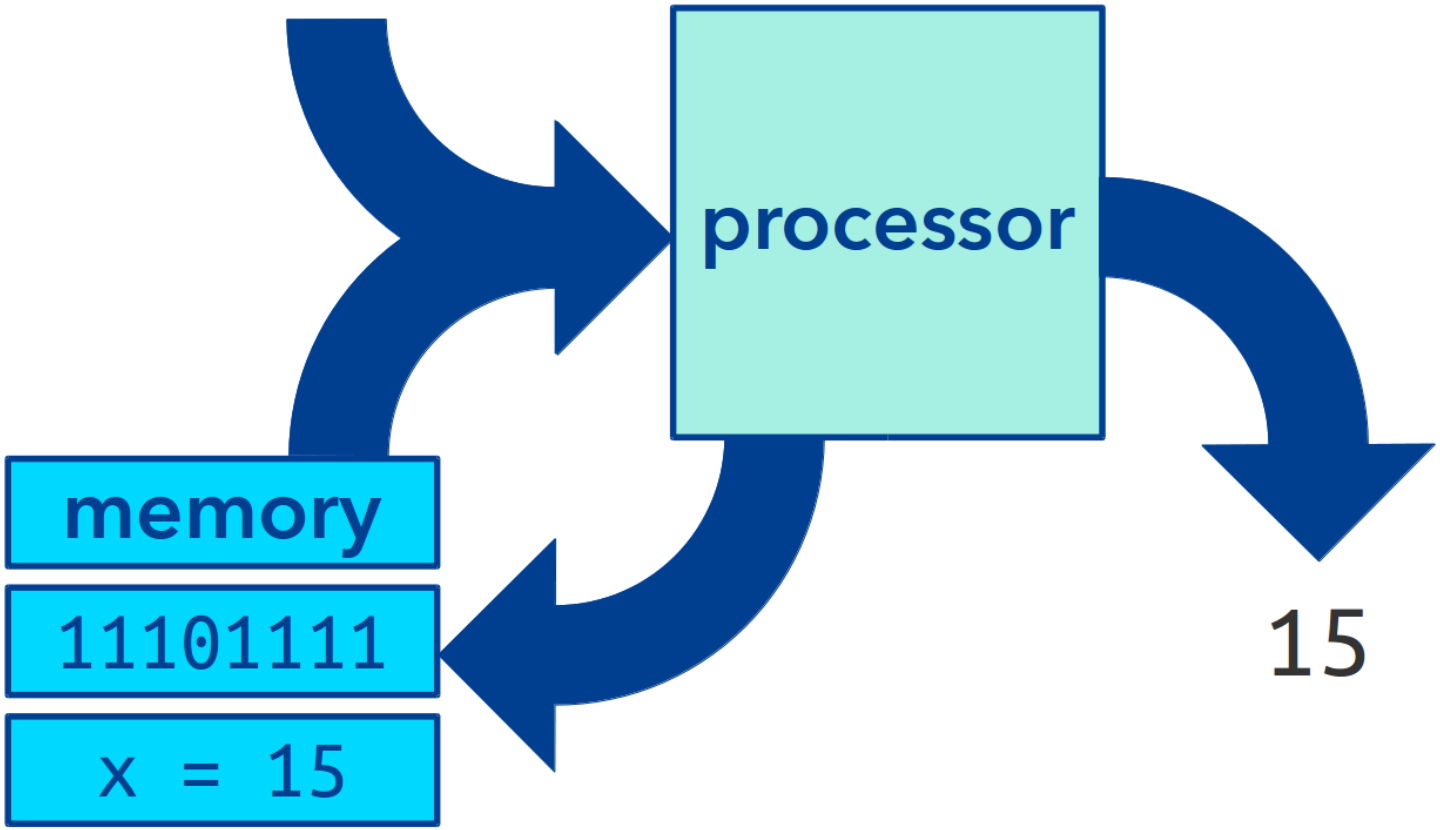
*What is an **encoding**?*

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

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

Our execution model

```
00111101 11101111 00000010
```

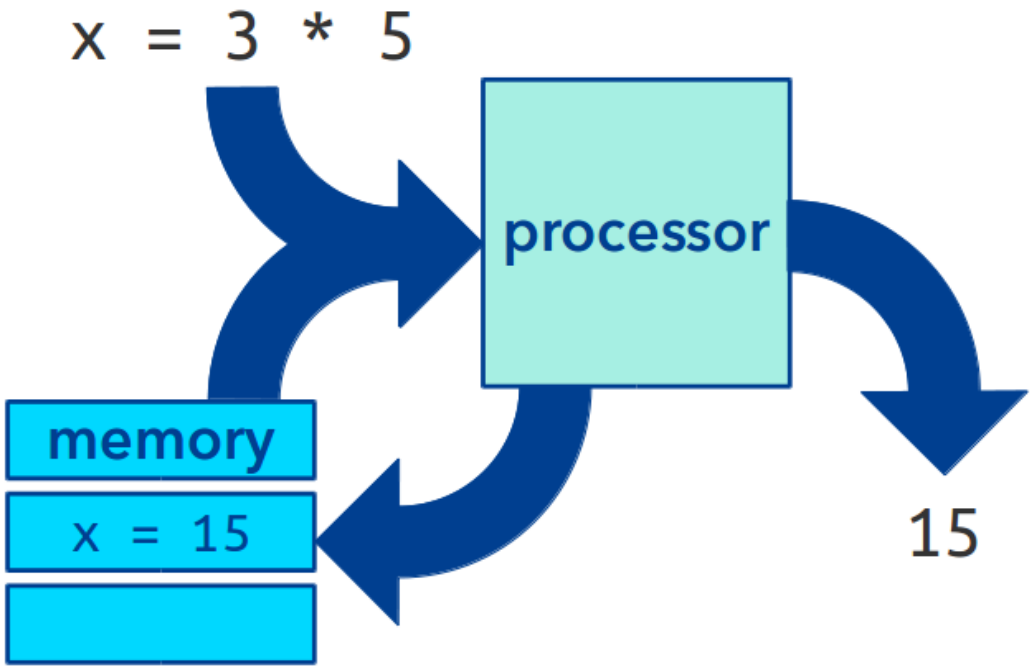


*What is an **encoding**?*

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

- What does binary data represent?
- How does the processor know?
- The **encoding** interprets the value.

Our execution model



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- A **data type** defines an encoding rule.
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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`, `3.5`, etc.

- So what are these data types?

Numeric Data Types

How do binary numbers work?

- Numeric types can be represented in binary:

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001	1	101	5
010	2	110	6
011	3	111	7

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- If we add more, the number **overflows**.

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- Numeric types can be represented in binary:

000	0	100	4
001	1	101	5
010	2	110	6
011	3	111	7

- If we add more, the number **overflows**.
- Negative numbers? Add a **sign bit**.

Integers, $\mathbb{Z}$

- Integers have been our only type thus far.

$$..., -4, -3, -2, -1, 0, +1, +2, +3, ...$$

- What are limits?

Integer operations

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

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  - `3 + 5`
  - EXCEPTION: DIVISION!
  - `3 / 4` $\rightarrow$ `0.75`
  - `3 // 4` $\rightarrow$ `0` (floor division)

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

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- Floating-point numbers include a fractional part. (Anything with a decimal point—`2.4`, `3.0`.)
- What are limits?
  - Overflow/underflow
  - Arbitrary precision (π, e)

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  - `3 + 5.5` $\rightarrow$ `?` (what happens here?)

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- Evaluating an expression of floating-point values will result in a floating-point answer.
  - `3.0 + 5.5` $\rightarrow$ `8.5`
  - `3.0 + 5.0` $\rightarrow$ `8.0`
  - `3 + 5.5` $\rightarrow$ `?` (what happens here?)
- Engineers and scientists need to think carefully about the precision of answers.

Complex numbers, $\mathbb{C}$

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- Use `j` for i:

```
1.0 + 1j
```

Complex numbers, $\mathbb{C}$

- Represent numbers with an imaginary component.
- Use `j` for i:
  ```
  1.0 + 1j
  ```
- Think of "jmaginary" numbers, I suppose.

Example

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

What is printed to the screen?

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)
print(x.imag)
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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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006 ♠	(ack)	022 ▬	(syn)	038	&	054	6	070	F	086	V	102	f	118	v
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015 ☼	(si)	031 ▼	(us)	047	/	063	?	079	O	095	_	111	o	127	⌂

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'HELLO'

Strings

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

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- Each symbol is a character.

Strings

- As a literal: text surrounded by quotes.
  - `"DEEP"`
- 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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- **Repetition**: repeat a string
  - Uses the *
  - `'HELLO '*10`

String operations

- **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

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  - Formats nicely
  - 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)
```

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

- Extracts single character

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```
a = "FIRE"
a[0]
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Indexing operator

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- The integer is the index.

Indexing operator

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```

- The integer is the index.
- We count from zero!

Indexing operator

- Extracts single character

```
a = "FIRE"
a[0]
```

- The integer is the index.
- We count from zero!
- If negative, counts down from end.

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'`

Reminders

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- Lab #2 tomorrow Sunday.