# **Python Basics!**

data types, strings, indexing

CS101 Lecture #3

# Administrivia

Administrivia 1/39

#### Administrivia

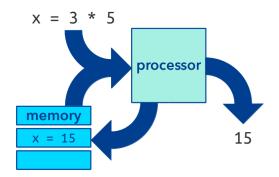
- Register your i>clickers on the course Compass page.
- Complete Homework #1 before Wednesday at 5:00 p.m.
- Lab #2 this week, no lab next week (Labor Day).

Administrivia 2/3

# Warmup Quiz

Warmup Quiz 3/39

#### Our execution model



Warmup Quiz 4/39

```
x = 10

y = x + 1

y = x * y
```

What is the value of  $\mathbf{y}$ ?

A 11

B 100

C 110

D None of the above

Warmup Quiz 5/3

```
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

Warmup Quiz 6/39

```
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

Warmup Quiz 7/3

```
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

Warmup Quiz 8/39

```
    x = 10
    y = x
    x = 5
    What is the value of y?
    A 10
    B 5
```

Warmup Quiz 9/39

# **Data Types**

## What is an **encoding**?

**01001000 01000101 01001100 01001100**What does this binary data value represent?

> What does this binary data represent?

Data Types 11/3

## What is an **encoding**?

**01001000 01000101 01001100 01001100**What does this binary data value represent?

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

Data Types 11/3

## What is an **encoding**?

**01001000 01000101 01001100 01001100**What does this binary data value represent?

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

Data Types 11/3

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

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

Data Types 12/3

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

- **▶** A data type defines an encoding rule.
- All values have a type.
- The type defines how data is represented in memory.

Data Types 12/3

# What is a **data type**?

- **▶** 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.

Data Types 12/3

## Example

01100111 can be the number 103, the letter g, hexadecimal 67, 3.5, etc.

So what are these data types?

Data Types 13/3

# **Numeric Data Types**

Numeric Data Types 14/39

## How do binary numbers work?

Numeric types can be represented in binary:

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

Numeric Data Types 15/39

## How do binary numbers work?

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.

Numeric Data Types 15/39

#### How do binary numbers work?

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**.

Numeric Data Types 15/3

#### Integers, $\mathbb{Z}$

Integers have been our only type thus far.

$$\dots, -4, -3, -2, -1, 0, +1, +2, +3, \dots$$

What are limits?

Numeric Data Types 16/39

#### Integer operations

 Evaluating an expression of integers will generally result in an integer answer

**3** + 5

EXCEPTION: DIVISION!

Numeric Data Types 17/3

#### Integer operations

 Evaluating an expression of integers will generally result in an integer answer

```
3 + 5
EXCEPTION: DIVISION!
```

 $\bullet$  3 / 4  $\rightarrow$  0.75

ightharpoonup 3 // 4 
ightharpoonup 0 (floor division)

Numeric Data Types 17/3

# Floating-point numbers, R

Floating-point numbers include a fractional part.
 (Anything with a decimal point-2.4, 3.0.)

Numeric Data Types 18/39

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

- Floating-point numbers include a fractional part.
   (Anything with a decimal point-2.4, 3.0.)
- What are limits?

Numeric Data Types 18/39

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

Floating-point numbers include a fractional part.

(Anything with a decimal point-2.4, 3.0.)

- What are limits?
  - Overflow/underflow
  - Arbitrary precision  $(\pi,)$

Numeric Data Types 18/39

#### Floating-point operations

Evaluating an expression of floating-point values will result in a floating-point answer.

Numeric Data Types 19/3

#### Floating-point operations

Evaluating an expression of floating-point values will result in a floating-point answer.

```
 ■ 3.0 + 5.5 → 8.5
```

- ightharpoonup 3.0 + 5.0 ightharpoonup 8.0
- ightharpoonup 3 + 5.5 ightharpoonup? (what happens here?)

Numeric Data Types 19/3

# Floating-point operations

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.

Numeric Data Types 19/3

## Complex numbers, ${\mathbb C}$

Represent numbers with an imaginary component.

Numeric Data Types 20/3

## Complex numbers, C

- Represent numbers with an imaginary component.
- Use j for i: 1.0 + 1j

Numeric Data Types 20/39

## Complex numbers, C

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

Numeric Data Types 20/3

#### Example

```
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
```

Numeric Data Types 21/3

#### Attribute operator.

▶ Reaches inside of a value to access part of its data (called an attribute).

Numeric Data Types 22/3

#### Attribute operator.

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

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

Numeric Data Types 22/39

#### Attribute operator.

- Reaches inside of a value to access part of its data (called an attribute).
- Extracts special variables stored "inside" the type.
  - print(x.real) print(x.imag)
- **▶** Both of these components are floats.

Numeric Data Types 22/3

#### Example

B 4.5 C 1j D 1.0

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

What is the value of z.imag?
A 4.5 + 1j
```

Numeric Data Types 23/39

# **String Data Type**

#### How does text work?

Each symbol is stored individually, one byte

```
01001000 72
01000101 69
long: 01001100 76
```

01001100 76 01001111 79

String Data Type 25/3:

#### ASCII encoding table

```
048 0
       (nul)
               016 ► (dle)
                               032 sp
                                                   064 @
                                                            080 P
                                                                     096 `
                                                                              112 p
001 ⊕
      (soh)
               017
                    ◄ (dc1)
                               033
                                          049 1
                                                   065 A
                                                            081 0
                                                                     097 a
                                                                              113 a
002 @ (stx)
               018
                               034
                                          050
                                                   066 B
                                                            082 R
                                                                     098 b
                                                                              114 r
                    t (dc2)
003 ♥ (etx)
               019
                    11
                               035
                                         051
                                                   067 C
                                                            083
                                                                S
                                                                     099 c
                                                                              115 s
                      (dc3)
004
               020
                    П
                               036
                                          052
                                                   068 D
                                                            084 T
                                                                     100 d
                                                                              116 t
      (eot)
                      (dc4)
                                              4
005 & (eng)
               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
800
      (bs)
               024
                               040
                                          056 8
                                                   072 H
                                                            088 X
                                                                     104 h
                                                                              120 x
    (can)
009
               025
                               041
                                         057 9
                                                   073 I
                                                            089 Y
                                                                     105 i
                                                                              121 y
       (tab)
                    T
                      (em)
010
       (1f)
               026
                               042 *
                                          058:
                                                   074 J
                                                            090
                                                                     106 i
                                                                              122 z
                       (eof)
                               043 +
                                          059;
                                                   075 K
                                                            091
                                                                     107 k
                                                                              123
011
      (vt)
               027 ← (esc)
012
       (np)
               028 L (fs)
                               044
                                          060 <
                                                   076 L
                                                            092
                                                                     108 1
                                                                              124
013
                               045 -
                                          061 =
                                                   077 M
                                                            093 1
                                                                     109 m
                                                                              125 }
       (cr)
               029 ↔
                      (qs)
014
    П
               030 A (rs)
                               046 .
                                          062 >
                                                   078 N
                                                            094
                                                                     110 n
                                                                              126 ~
      (so)
015 🌣 (si)
               031 ▼ (us)
                               047 /
                                          063 ?
                                                   079 0
                                                            095
                                                                     111 o
                                                                              127 △
```

tring Data Type 26/3

#### ASCII encoding table

```
(nul)
               016 ► (dle)
                               032 sp
                                         048 0
                                                  064 @
                                                           080 P
                                                                    096 `
                                                                             112 p
                               033 !
                                                  065 A
                                                                    097 a
001 @
      (soh)
               017 ◄ (dc1)
                                         049 1
                                                           081 Q
                                                                             113 q
002 @ (stx)
               018
                      (dc2)
                               034
                                         050 2
                                                  066 B
                                                           082 R
                                                                    098 b
                                                                             114 r
003 ♥ (etx)
               019
                   11
                               035 #
                                         051 3
                                                  067 C
                                                           083 S
                                                                    099 c
                                                                             115 s
                      (dc3)
                                         052 4
                                                  068 D
                                                                    100 d
                                                                             116 t
004 ♦ (eot)
               020
                    П
                      (dc4)
                               036 $
                                                           084 T
005 4 (eng)
               021
                    S
                               037 %
                                         053 5
                                                  069 E
                                                           085 U
                                                                    101 e
                                                                             117 u
                      (nak)
               022 -
                               038
                                                  070 F
                                                                    102 f
                                                                             118 v
006 & (ack)
                      (syn)
                                         054 6
                                                           086 V
007
      (bel)
               023
                               039 '
                                         055 7
                                                  071 G
                                                           087 W
                                                                    103 q
                                                                             119 w
                      (etb)
                                         056 8
                                                  072 H
                                                           088 X
008 a (bs)
               024
                      (can)
                               040 (
                                                                    104 h
                                                                             120 x
009
      (tab)
               025
                      (em)
                               041 )
                                         057 9
                                                  073 I
                                                           089 Y
                                                                    105 i
                                                                             121 y
010
       (1f)
               026
                      (eof)
                               042 *
                                         058:
                                                  074 J
                                                           090 Z
                                                                    106 ј
                                                                             122 z
011
    ൃ
      (vt)
               027 ← (esc)
                               043 +
                                         059 ;
                                                  075 K
                                                           091
                                                                    107 k
                                                                             123
012
               028 L (fs)
                               044
                                         060 <
                                                  076 L
                                                           092 \
                                                                    108 1
                                                                             124
      (np)
013
       (cr)
               029 ↔
                     (gs)
                               045 -
                                         061 =
                                                  077 M
                                                           093 1
                                                                    109 m
                                                                             125 }
014 #
               030 A (rs)
                               046 .
                                         062 >
                                                  078 N
                                                           094 ^
                                                                    110 n
                                                                             126 ~
      (so)
015 $ (si)
               031 ▼ (us)
                               047 /
                                                           095
                                                                             127 0
                                         063 ?
                                                  079 0
                                                                    111 o
```

72 69 76 76 79 = ?

String Data Type 27/3

#### ASCII encoding table

```
(nul)
               016 ► (dle)
                               032 sp
                                         048 0
                                                  064 @
                                                           080 P
                                                                    096 `
                                                                             112 p
                               033 !
                                                  065 A
                                                                    097 a
001 @
      (soh)
               017 ◄ (dc1)
                                         049 1
                                                           081 Q
                                                                             113 q
002 🖷
      (stx)
               018
                      (dc2)
                               034
                                         050 2
                                                  066 B
                                                           082 R
                                                                    098 b
                                                                             114 r
003 ♥ (etx)
               019
                   11
                               035
                                         051 3
                                                  067 C
                                                           083 S
                                                                    099 c
                                                                             115 s
                      (dc3)
                                         052 4
                                                  068 D
                                                                             116 t
004
    ♦ (eot)
               020
                    П
                      (dc4)
                               036 $
                                                           084 T
                                                                    100 d
005 4 (eng)
               021
                    S
                               037 %
                                         053
                                             5
                                                  069 E
                                                           085 U
                                                                    101 e
                                                                             117 u
                      (nak)
               022 -
                               038
                                                  070 F
                                                                    102 f
                                                                             118 v
006 🛊
     (ack)
                      (syn)
                                         054 6
                                                           086 V
007
      (bel)
               023
                               039 '
                                         055 7
                                                  071 G
                                                           087 W
                                                                    103 q
                                                                             119 w
                      (etb)
008
                                         056 8
                                                  072 H
                                                           088 X
                                                                             120 x
      (bs)
               024
                      (can)
                               040 (
                                                                    104 h
009
      (tab)
               025
                      (em)
                               041 )
                                         057 9
                                                  073 I
                                                           089 Y
                                                                    105 i
                                                                             121 y
010
       (1f)
               026
                      (eof)
                               042 *
                                         058:
                                                  074 J
                                                           090 Z
                                                                    106 ј
                                                                             122 z
011
    ൃ
      (vt)
               027 ← (esc)
                               043 +
                                         059 ;
                                                  075 K
                                                           091
                                                                    107 k
                                                                             123
012
               028 L (fs)
                               044
                                         060 <
                                                  076 L
                                                           092
                                                                    108 1
                                                                             124
      (np)
013
       (cr)
               029 ↔
                     (gs)
                               045 -
                                         061 =
                                                  077 M
                                                           093 1
                                                                    109 m
                                                                             125 }
014 #
               030 A (rs)
                               046 .
                                         062 >
                                                  078 N
                                                           094 ^
                                                                    110 n
                                                                             126 ~
      (so)
015 $ (si)
               031 ▼ (us)
                                                  079 0
                                                           095
                                                                             127 △
                               047 /
                                         063 ?
                                                                    111 o
```

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

String Data Type 28/39

## Strings

As a literal: text surrounded by quotes.

"DEEP"

String Data Type 29/39

## Strings

- As a literal: text surrounded by quotes.
  - "DEEP"
- ▶ Each symbol is a character.

String Data Type 29/39

## Strings

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

String Data Type 29/39

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

#### String operations

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

Creates string with value inserted

## Formatting operator

- Creates string with value inserted
  - Formats nicely
  - Requires indicator of type inside of string

## Formatting operator

- Creates string with value inserted
  - Formats nicely
  - Requires indicator of type inside of string

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

#### Example

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

#### Example

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

What does this program print?

A 33333333333

B 44444444

C 9999

D %i%i%i%i%i

Extracts single character

Extracts single character
a = "FIRE"
a[0]

- Extracts single charactera = "FIRE"a[0]
- ➤ The integer is the index.

- Extracts single character
  a = "FIRE"
  a[0]
- ➤ The integer is the index.
- We count from zero!

• 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

Reminders 38/39

#### Reminders

- Register your i>clicker on Compass. (last chance before it counts!)
- Homework #1 due Wednesday, Aug. 31, 5:00 p.m.

Reminders 39/39