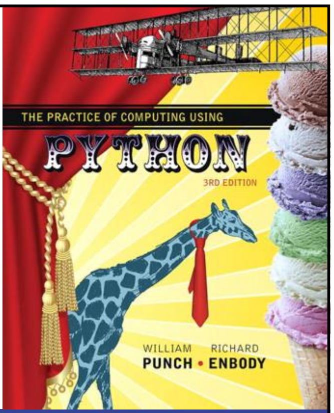
Chapter 4

Working with Strings


THE PRACTICE OF COMPUTING USING
PYTHON
3RD EDITION
WILLIAM PUNCH • RICHARD ENBODY

PEARSON ALWAYS LEARNING

1

Sequence of Characters

- we've talked about strings being a sequence of characters.
- a string is indicated between `' '` or `" "`
- the exact sequence of characters is maintained

2

And Then There Is """ """

- triple quotes preserve both the vertical and horizontal formatting of the string
- allows you to type tables, paragraphs, whatever and preserve the formatting

```
"""this is
a test
today"""
```

3

Non-printing Characters

If inserted directly, are preceded by a backslash (the \ character)

- new line `'\n'`
- tab `'\t'`

4

String Representation

- every character is "mapped" (associated) with an integer
- UTF-8, subset of Unicode, is such a mapping
- the function **`ord()`** takes a character and returns its UTF-8 integer value
- **`chr()`** takes an integer and returns the UTF-8 character

5

Subset of UTF-8

Char	Dec	Char	Dec	Char	Dec
SP	32	@	64	`	96
!	33	A	65	a	97
"	34	B	66	b	98
#	35	C	67	c	99
$	36	D	68	d	100
%	37	E	69	e	101
&	38	F	70	f	102
'	39	G	71	g	103
(	40	H	72	h	104
)	41	I	73	i	105
*	42	J	74	j	106
+	43	K	75	k	107
,	44	L	76	l	108
-	45	M	77	m	109
.	46	N	78	n	110
/	47	O	79	o	111
0	48	P	80	p	112
1	49	Q	81	q	113
2	50	R	82	r	114
3	51	S	83	s	115
4	52	T	84	t	116

See Appendix F for the full set

6

Strings

- can use single or double quotes

```
S = "spam"
s = 'spam'
```

- don't mix them

`my_str = 'hi mom"` ⇒ ERROR

- inserting an apostrophe

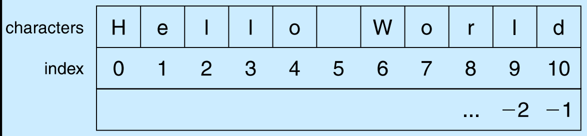
```
A = "knight's"   # mix up the quotes
B = 'knight\'s'  # escape single quote
```

7

String Index

- because the elements of a string are a sequence, we can associate each element with an ***index***, a location in the sequence
  - positive values count up from the left, beginning with index 0
  - negative values count down from the right, starting with -1

8



characters	H	e	l	l	o		W	o	r	l	d
index	0	1	2	3	4	5	6	7	8	9	10
									...	−2	−1

FIGURE 4.1 The index values for the string `'Hello World'`.

9

Accessing an Element

a particular element of the string is accessed by the index of the element surrounded by square brackets [ ]

```
hello_str = 'Hello World'
print(hello_str[1])  => prints e
print(hello_str[-1]) => prints d
print(hello_str[11]) => ERROR
```

10

Slicing: The Rules

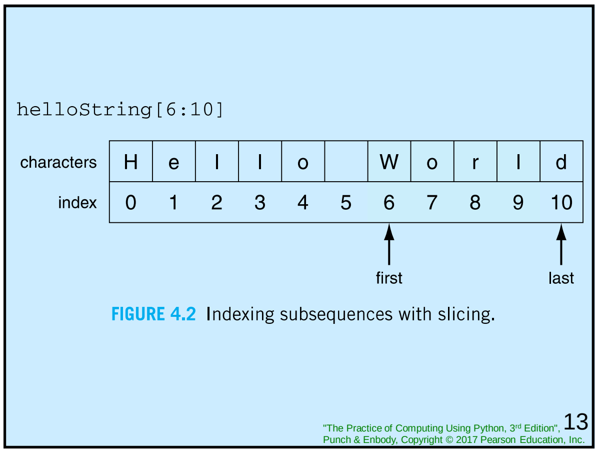
- slicing is the ability to select a subsequence of the overall sequence
- uses the syntax `[start : finish]`, where:
  - `start` is the index of where we start the subsequence
  - `finish` is the index of **one after** where we end the subsequence
- if either `start` or `finish` are not provided, it defaults to the beginning of the sequence for `start` and the end of the sequence for `finish`

11

Half Open Range for Slices

- slicing uses what is called a half-open range
- the first index is included in the sequence
- the last index is one ***after*** what is included

12



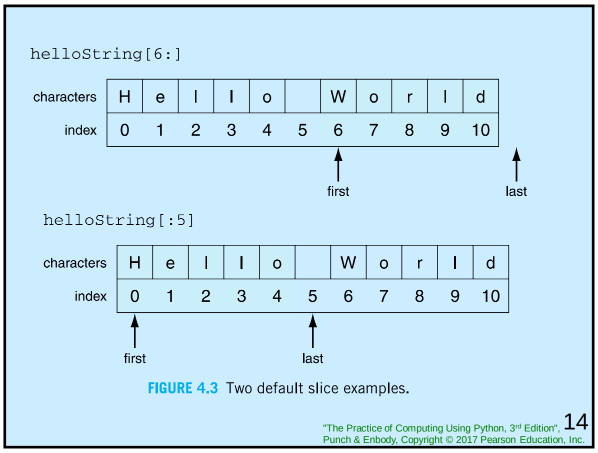
`helloString[6:10]`

characters	H	e	l	l	o		W	o	r	l	d
index	0	1	2	3	4	5	6	7	8	9	10

first last

FIGURE 4.2 Indexing subsequences with slicing.

13



`helloString[6:]`

characters	H	e	l	l	o		W	o	r	l	d
index	0	1	2	3	4	5	6	7	8	9	10

first last

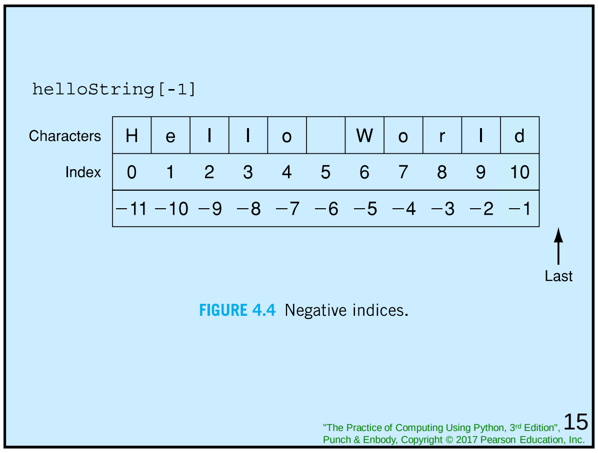
`helloString[:5]`

characters	H	e	l	l	o		W	o	r	l	d
index	0	1	2	3	4	5	6	7	8	9	10

first last

FIGURE 4.3 Two default slice examples.

14



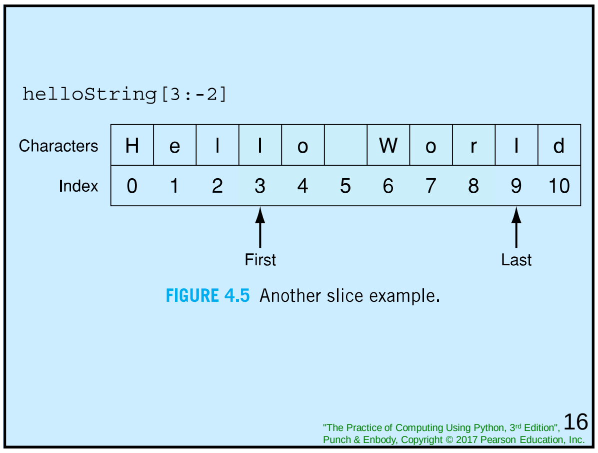
`helloString[-1]`

Characters	H	e	l	l	o		W	o	r	l	d
Index	0	1	2	3	4	5	6	7	8	9	10
	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1

Last

FIGURE 4.4 Negative indices.

15



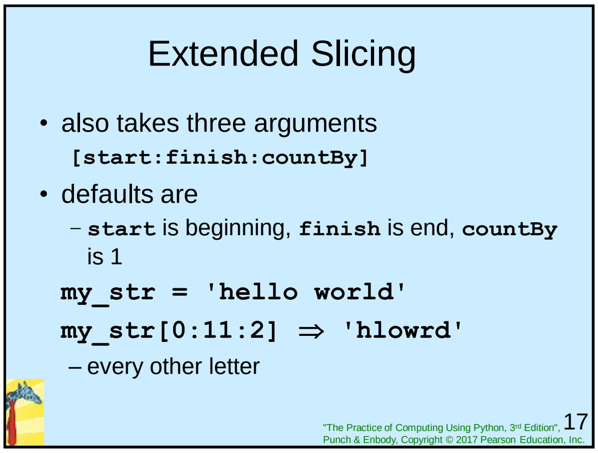
`helloString[3:-2]`

Characters	H	e	l	l	o		W	o	r	l	d
Index	0	1	2	3	4	5	6	7	8	9	10

First Last

FIGURE 4.5 Another slice example.

16



Extended Slicing

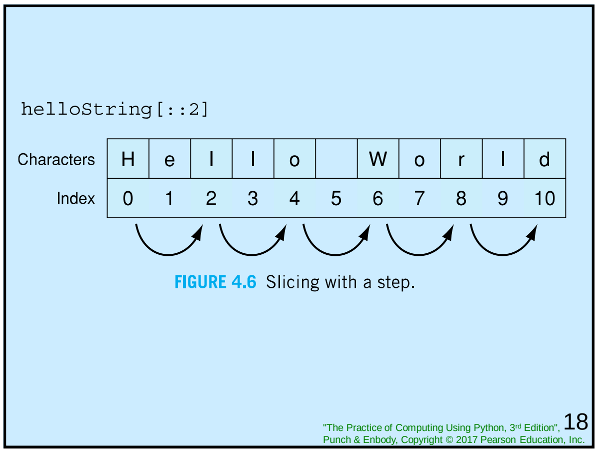
- also takes three arguments
  `[start:finish:countBy]`
- defaults are
  - **`start`** is beginning, **`finish`** is end, **`countBy`** is 1

`my_str = 'hello world'`

`my_str[0:11:2]` ⇒ **`'hlowrd'`**

- every other letter

17



`helloString[::2]`

Characters	H	e	l	l	o		W	o	r	l	d
Index	0	1	2	3	4	5	6	7	8	9	10

FIGURE 4.6 Slicing with a step.

18

Some Python Idioms

- idioms are python “phrases” that are used for a common task that might be less obvious to non-python folk
- how to make a copy of a string:

```
my_str = 'hi mom'
new_str = my_str[:]
```

- how to reverse a string

```
my_str = "madam I'm adam"
reverseStr = my_str[::-1]
```

19

19

String Operations

20

20

Sequences are Iterable

the for loop iterates through each element of a sequence in order

- for a string, this means character by character:

```
>>> for char in 'Hi mom':
        print(char, type(char))


H <class 'str'>
i <class 'str'>
  <class 'str'>
m <class 'str'>
o <class 'str'>
m <class 'str'>
>>>
```

21

21

Basic String Operations

```
s = 'spam'
```

- length operator len()
  `len(s) ⇒ 4`
- + is concatenate
  `new_str = 'spam' + '-' + 'spam-'`
  `print(new_str) ⇒ spam-spam-`
- ***** is repeat, the number is how many times
  `new_str * 3 ⇒'spam-spam-spam-spam-spam-spam-'`

22

22

Some Details

- both + and * on strings makes a new string, does not modify the arguments
- order of operation is important for concatenation, irrelevant for repetition
- the types required are specific
  - for concatenation you need two strings, for repetition a string and an integer

23

23

What Does a + b Mean?

- what operation does the above represent? it depends on the types!
  - two strings, concatenation
  - two integers addition
- the operator + is ***overloaded***
  - the operation + performs depends on the types it is working on

24

24

The **type** Function

- you can check the type of the value associated with a variable using `type`

```
my_str = 'hello world'
type(my_str) ⇒  <type 'str'>
my_str = 245
type(my_str) ⇒ <type 'int'>
```

25

String Comparisons, Single Char

- Python 3 uses the Unicode mapping for characters.
  - allows for representing non-English characters
- UTF-8, subset of Unicode, takes the English letters, numbers and punctuation marks and maps them to an integer
- single character comparisons are based on that number

26

Comparisons within Sequence

- it makes sense to compare within a sequence (lower case, upper case, digits).
  - `'a' < 'b'` → `True`
  - `'A' < 'B'` → `True`
  - `'1' < '9'` → `True`
- can be weird outside of the sequence
  - `'a' < 'A'` → `False`
  - `'a' < '0'` → `False`

27

Comparing Whole Strings

- compare the first element of each string
  - if they are equal, move on to the next character in each
  - if they are not equal, the relationship between those two characters are the relationship between the strings
  - if one ends up being shorter (but equal), the shorter is smaller

28

Examples

- `'a' < 'b'` → `True`
- `'aaab' < 'aaac'`
  - first difference is at the last char
  - `'b'<'c'` so `'aaab'` is less than `'aaac'` `True`
- `'aa' < 'aaz'`
  - the first string is the same but shorter
  - thus it is smaller: `True`

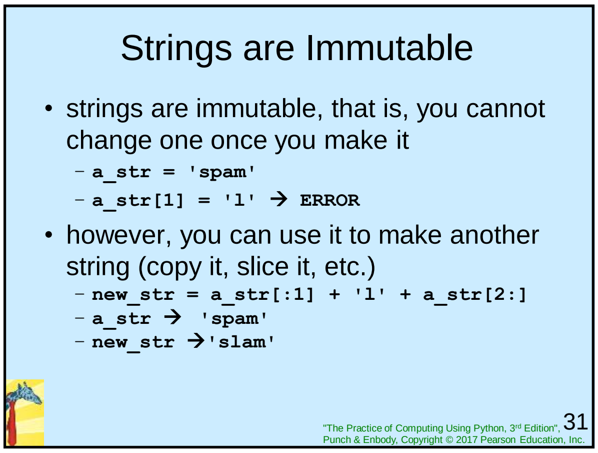
29

Membership Operations

- can check to see if a substring exists in the string, the **in** operator
  - returns True or False

```
my_str = 'aabbccdd'
'a' in my_str   ⇒ True
'abb' in my_str ⇒ True
'x' in my_str   ⇒ False
```

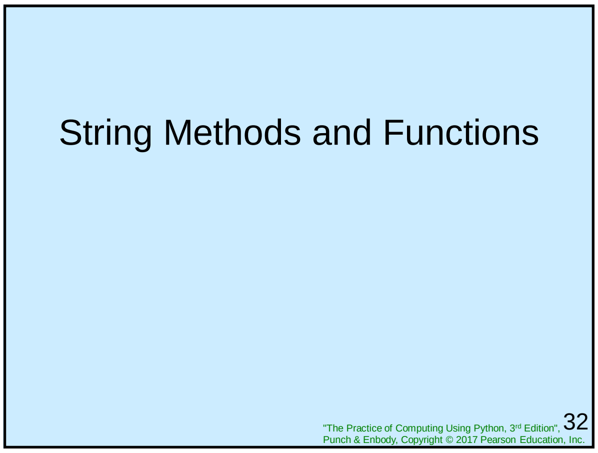
30



Strings are Immutable

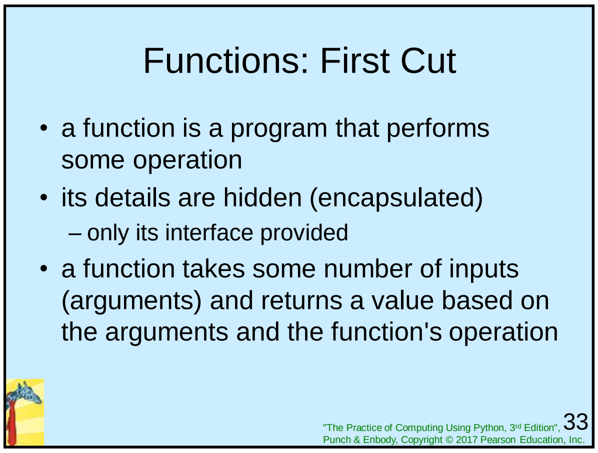
- strings are immutable, that is, you cannot change one once you make it
  - `a_str = 'spam'`
  - `a_str[1] = 'l'` → `ERROR`
- however, you can use it to make another string (copy it, slice it, etc.)
  - `new_str = a_str[:1] + 'l' + a_str[2:]`
  - `a_str` → `'spam'`
  - `new_str` →`'slam'`

31



String Methods and Functions

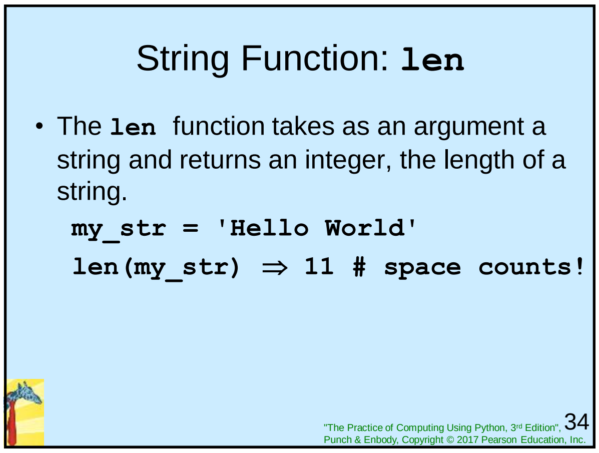
32



Functions: First Cut

- a function is a program that performs some operation
- its details are hidden (encapsulated)
  - only its interface provided
- a function takes some number of inputs (arguments) and returns a value based on the arguments and the function's operation

33

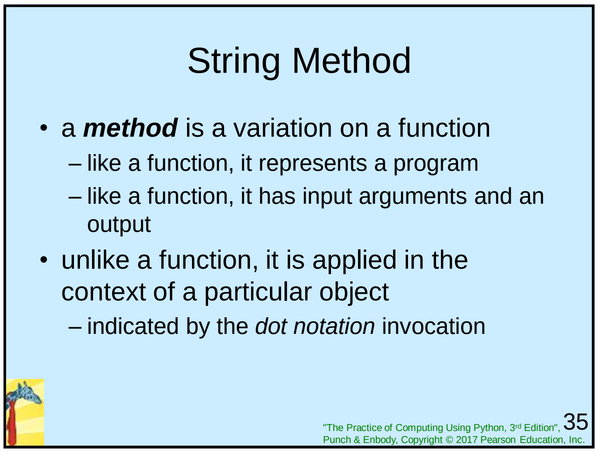


String Function: `len`

- The **`len`** function takes as an argument a string and returns an integer, the length of a string.

```
my_str = 'Hello World'
len(my_str)  ⇒ 11 # space counts!
```

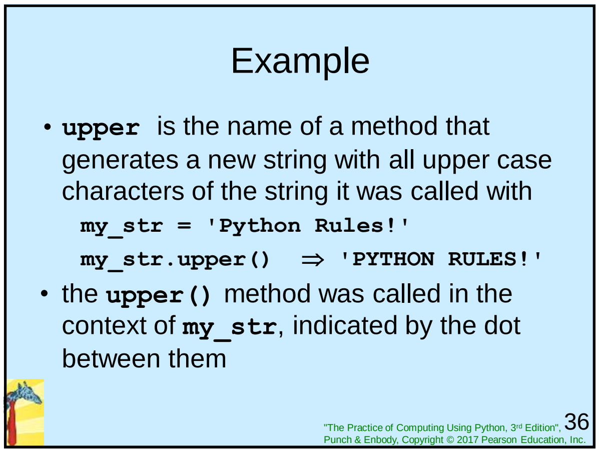
34



String Method

- a ***method*** is a variation on a function
  - like a function, it represents a program
  - like a function, it has input arguments and an output
- unlike a function, it is applied in the context of a particular object
  - indicated by the *dot notation* invocation

35



Example

- **`upper`** is the name of a method that generates a new string with all upper case characters of the string it was called with

```
my_str = 'Python Rules!'
my_str.upper()  ⇒ 'PYTHON RULES!'
```

- the **`upper()`** method was called in the context of **`my_str`**, indicated by the dot between them

36

More Dot Notation

- in general, dot notation looks like
  `object.method(…)`
- it means that the object in front of the dot is calling a method that is associated with that object's type
- the methods that can be called are tied to the type of the object calling it; each type has different methods

find

```
my_str = 'hello'
my_str.find('l') # find index of 'l' in my_str
     ⇒ 2
```

- note how the method 'find' operates on the string object **`my_str`**
- the two are associated by using the “dot” notation: **`my_str.find('l')`**
- terminology: the thing(s) in parenthesis, i.e. the 'l' in this case, is called an **argument**

Chaining Methods

methods can be chained together

- perform first operation, yielding an object
- use the yielded object for the next method

```
my_str = 'Python Rules!'
my_str.upper() ⇒  'PYTHON RULES!'
my_str.upper().find('O') ⇒ 4
```

Optional Arguments

some methods have optional arguments

- if the user doesn't provide one of these, a default is assumed
- find has a default second argument of 0, where the search begins

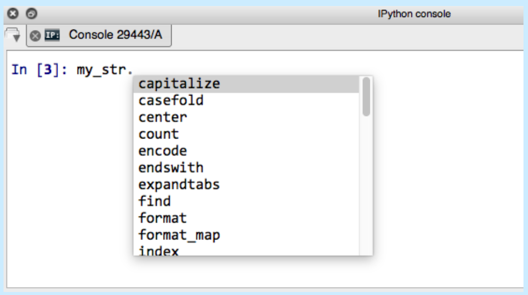
```
a_str = 'He had the bat'
a_str.find('t') ⇒ 7 # 1st 't',start at 0
a_str.find('t',8) ⇒ 13 # 2nd 't',start at 8
```

Nesting Methods

- you can “nest” methods
  - that is the result of one method is an argument to another
- remember that parenthetical expressions are done “inside out”
  - do the inner parenthetical expression first, then the next, using the result as an argument
    `a_str.find('t', a_str.find('t')+1)`
  - translation: find the second 't'

How to Know?

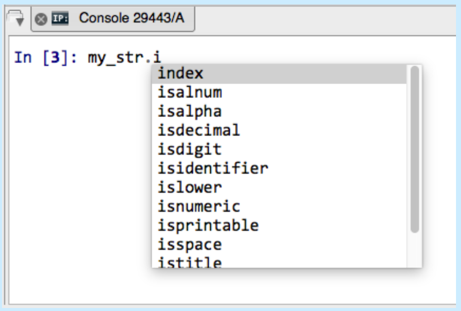
- use Spyder IDE to find available methods for any type.
  - you enter a variable of the type, followed by the `'.'` (dot) and then a tab
- remember, methods match with a type
  - different types have different methods
- if you type a method name, Spyder will remind you of the needed and optional arguments



```
In [3]: my_str.
        capitalize
        casefold
        center
        count
        encode
        endswith
        expandtabs
        find
        format
        format_map
        index
```

Figure 4.7

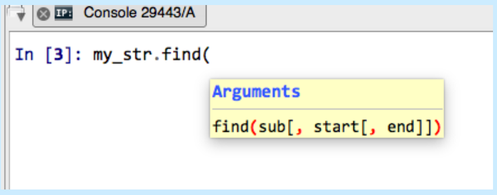
43



```
In [3]: my_str.i
        index
        isalnum
        isalpha
        isdecimal
        isdigit
        isidentifier
        islower
        isnumeric
        isprintable
        isspace
        istitle
```

Figure 4.8

44



```
In [3]: my_str.find(
        Arguments
        find(sub[, start[, end]])
```

Figure 4.9

45

capitalize( )	lstrip([*chars*])
center(*width* [, *fillchar*])	partition(*sep*)
count(*sub* [, *start* [, *end*]])	replace(*old*, *new* [, *count*])
decode([*encoding* [, *errors*]])	rfind(*sub* [,*start* [,*end*]])
encode([*encoding* [,*errors*]])	rindex(*sub* [, *start* [, *end*]])
endswith(*suffix* [, *start* [, *end*]])	rjust(*width* [, *fillchar*])
expandtabs([*tabsize*])	rpartition(*sep*)
find(*sub* [, *start* [, *end*]])	rsplit([*sep* [,*maxsplit*]])
index(*sub* [, *start* [, *end*]])	rstrip([*chars*])
isalnum( )	split([*sep* [,*maxsplit*]])
isalpha( )	splitlines([*keepends*])
isdigit( )	startswith(*prefix* [, *start* [, *end*]])
islower( )	strip([*chars*])
isspace( )	swapcase( )
istitle( )	title( )
isupper( )	translate(*table* [, *deletechars*])
join(*seq*)	upper( )
lower( )	zfill(*width*)
ljust(width [, *fillchar*])	

TABLE 4.2 Python String Methods

46

String Formatting

47

String Formatting for Better Printing

- so far, we have just used the defaults of the print function
- we can do many more complicated things to make that output “prettier” and more pleasing
- we will try this in our display function

48

Basic Form

- to understand string formatting, it is probably better to start with an example

```
print("Sorry, is this the {} minute
  {}?".format(5, 'ARGUMENT'))
```

prints

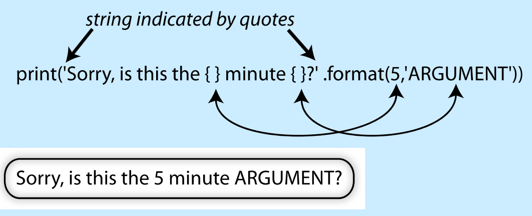
```
Sorry, is this the 5 minute ARGUMENT?
```

`format` Method

- **`format`** is a method that creates a new string where certain elements of the string are re-organized, i.e., *formatted*
- the elements to be re-organized are the curly bracket elements in the string
- formatting is complicated; this is just some of the easy stuff (see the docs)

Map Arguments to **`{}`**

- the string is modified so that the **`{}`** elements in the string are replaced by the format method arguments
- the replacement is in order:
  – first **`{}`** is replaced by the first argument
  – second **`{}`** by the second argument and so forth



```
print('Sorry, is this the { } minute { }?' .format(5,'ARGUMENT'))
```

```
Sorry, is this the 5 minute ARGUMENT?
```

FIGURE 4.10 String formatting example.

Format String

- the contents of the curly bracket elements are the format string: descriptors of how to organize that particular substitution
  – types are the kind of thing to substitute
  – numbers indicate total spaces.

s	string
d	decimal integer
f	floating-point decimal
e	floating-point exponential
%	floating-point as percent

TABLE 4.3 Most commonly used types.

<	left
>	right
^	center

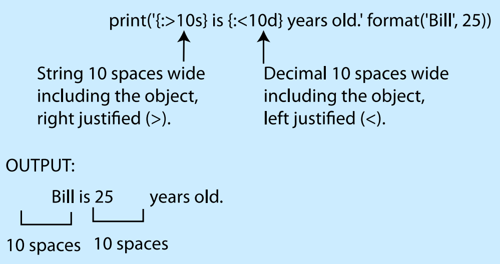
TABLE 4.4 Width alignments.

Format String

- each bracket formatted as

  `{:align width .precision descriptor}`

  – **`align`** is optional (default left)
  – **`width`** is how many spaces (default just enough)
  – **`.precision`** is for floating point rounding (default no rounding)
  – **`type`** is the expected type (error if the arg is the wrong type)



```
print('{:>10s} is {:<10d} years old.' format('Bill', 25))
```

String 10 spaces wide including the object, right justified (>).
Decimal 10 spaces wide including the object, left justified (<).
OUTPUT:
Bill is 25   years old.
10 spaces
10 spaces

FIGURE 4.11 String formatting with width descriptors and alignment.

55

Formatting a Table

```
>>> for i in range(5):
        print("{:10d} --> {:4d}".format(i,i**2))

         0 -->    0
         1 -->    1
         2 -->    4
         3 -->    9
         4 -->   16
```

56

Floating Point Precision

round floating point to specific number of decimal places

```
>>> import math
>>> print(math.pi)                    # unformatted printing
3.141592653589793
>>> print("Pi is {:.4f}".format(math.pi)) # floating—point precision 4
Pi is 3.1416
>>> print("Pi is {:8.4f}".format(math.pi)) # specify both precision and width
Pi is   3.1416
>>> print("Pi is {:8.2f}".format(math.pi))
Pi is     3.14
```

additional example

```
print ("   Surface Area = {:8.3f}".format (surface_area_fl))
```

57

Iteration

58

Iteration through a Sequence

- to date we have seen the **`while`** loop as a way to iterate over a suite (a group of Python statements)
- we briefly touched on the **`for`** statement for iteration, such as the elements of a list or a string

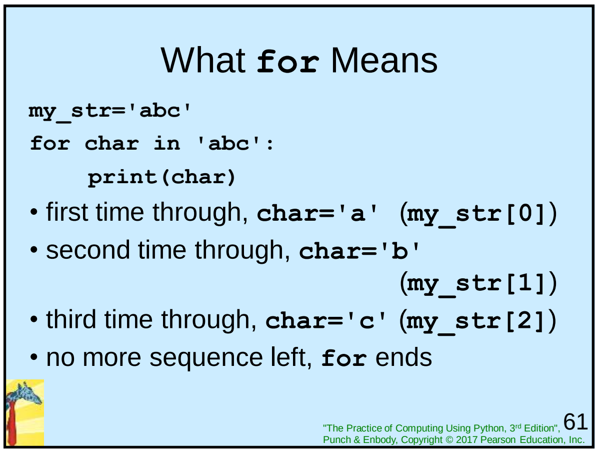
59

`for` Statement

we use the **`for`** statement to process each element of a list, one element at a time

```
for item in sequence:
    suite
```

60

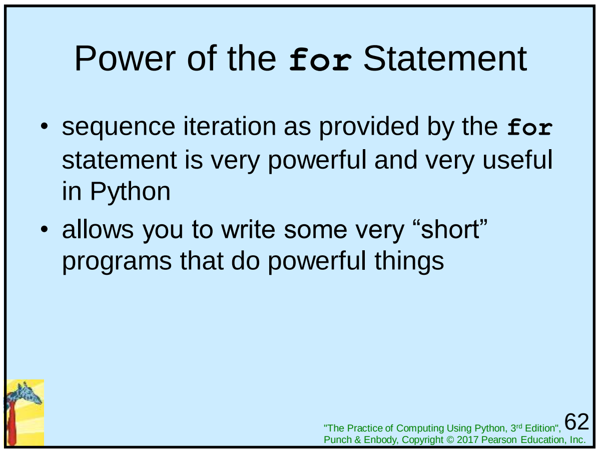


What `for` Means

```
my_str='abc'
for char in 'abc':
    print(char)
```

- first time through, **`char='a'`** (**`my_str[0]`**)
- second time through, **`char='b'`** (**`my_str[1]`**)
- third time through, **`char='c'`** (**`my_str[2]`**)
- no more sequence left, **`for`** ends

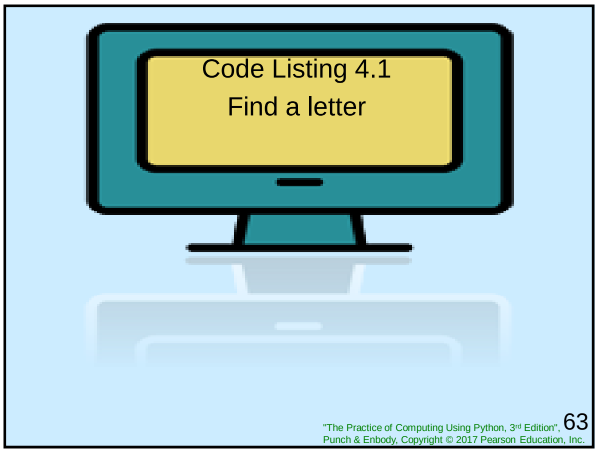
61



Power of the `for` Statement

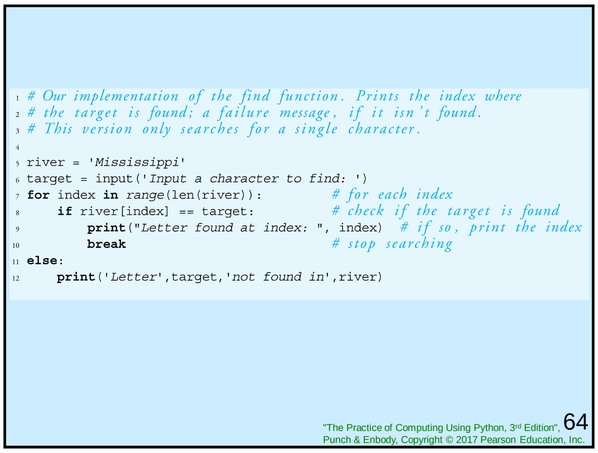
- sequence iteration as provided by the **`for`** statement is very powerful and very useful in Python
- allows you to write some very "short" programs that do powerful things

62



Code Listing 4.1
Find a letter

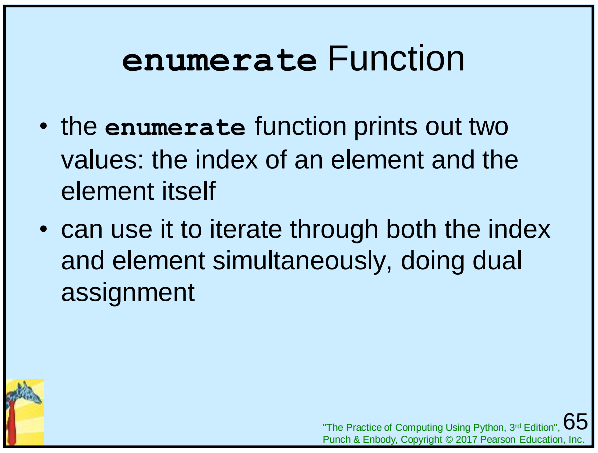
63



```
# Our implementation of the find function. Prints the index where
# the target is found; a failure message, if it isn't found.
# This version only searches for a single character.

river = 'Mississippi'
target = input('Input a character to find: ')
for index in range(len(river)):          # for each index
    if river[index] == target:           # check if the target is found
        print("Letter found at index: ", index)  # if so, print the index
        break                            # stop searching
else:
    print('Letter',target,'not found in',river)
```

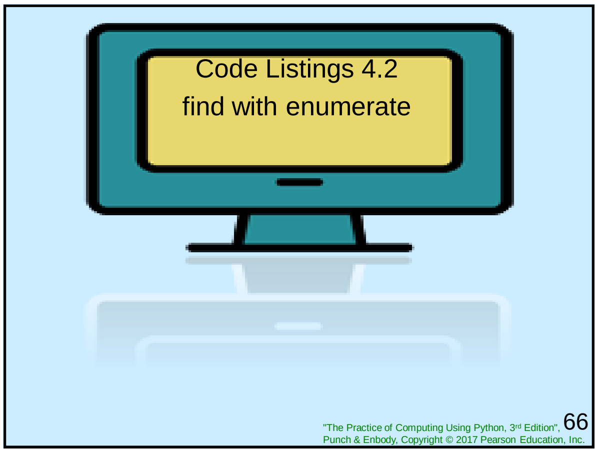
64



`enumerate` Function

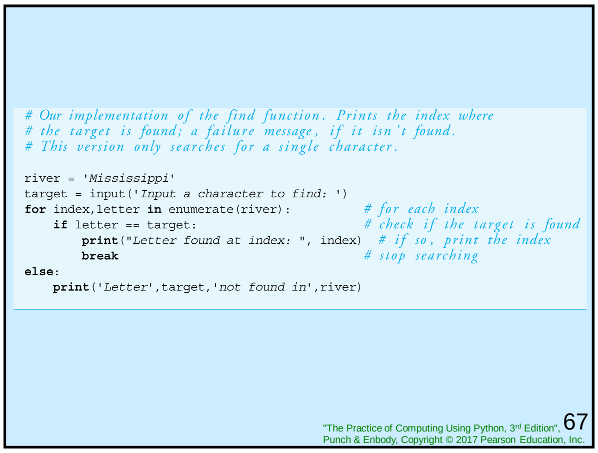
- the **`enumerate`** function prints out two values: the index of an element and the element itself
- can use it to iterate through both the index and element simultaneously, doing dual assignment

65



Code Listings 4.2
find with enumerate

66



```
# Our implementation of the find function. Prints the index where
# the target is found; a failure message, if it isn't found.
# This version only searches for a single character.

river = 'Mississippi'
target = input('Input a character to find: ')
for index,letter in enumerate(river):          # for each index
    if letter == target:                       # check if the target is found
        print("Letter found at index: ", index)  # if so, print the index
        break                                  # stop searching
else:
    print('Letter',target,'not found in',river)
```

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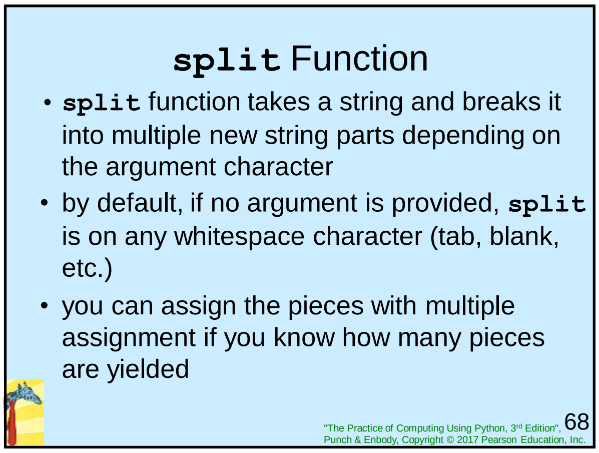
67



`split` Function

- `split` function takes a string and breaks it into multiple new string parts depending on the argument character
- by default, if no argument is provided, `split` is on any whitespace character (tab, blank, etc.)
- you can assign the pieces with multiple assignment if you know how many pieces are yielded

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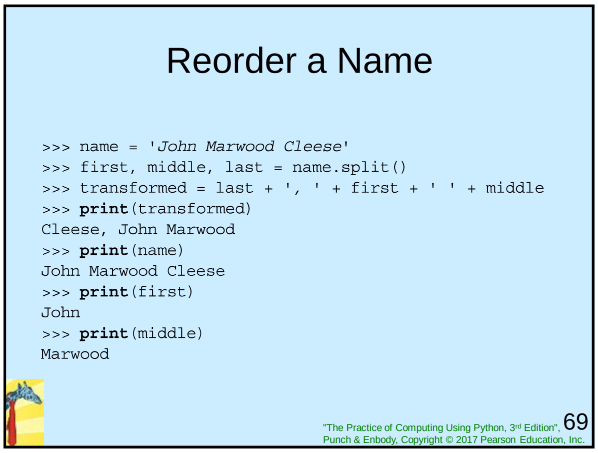
68



Reorder a Name

```
>>> name = 'John Marwood Cleese'
>>> first, middle, last = name.split()
>>> transformed = last + ', ' + first + ' ' + middle
>>> print(transformed)
Cleese, John Marwood
>>> print(name)
John Marwood Cleese
>>> print(first)
John
>>> print(middle)
Marwood
```

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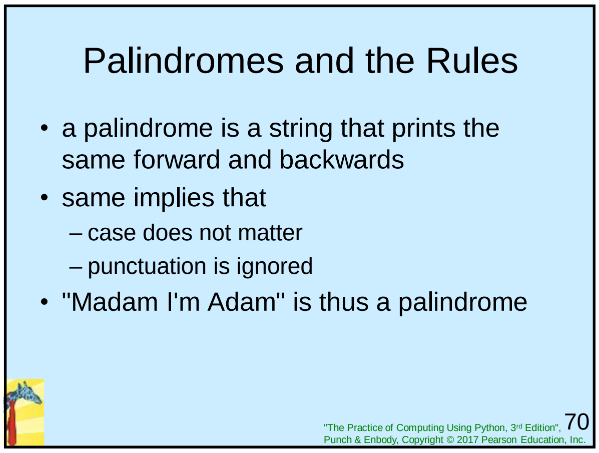
69



Palindromes and the Rules

- a palindrome is a string that prints the same forward and backwards
- same implies that
  - case does not matter
  - punctuation is ignored
- "Madam I'm Adam" is thus a palindrome

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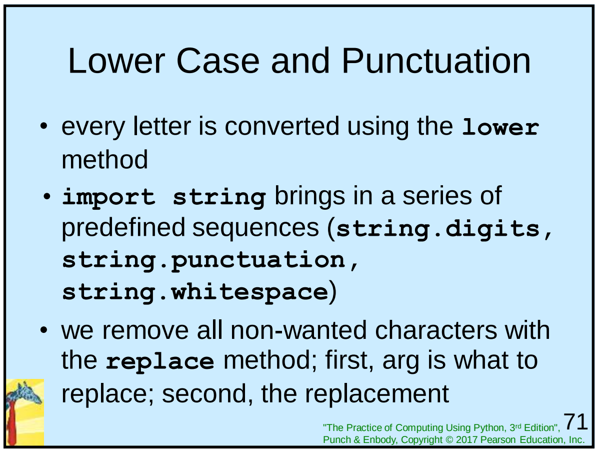
70



Lower Case and Punctuation

- every letter is converted using the **`lower`** method
- **`import string`** brings in a series of predefined sequences (**`string.digits`**, **`string.punctuation`**, **`string.whitespace`**)
- we remove all non-wanted characters with the **`replace`** method; first, arg is what to replace; second, the replacement

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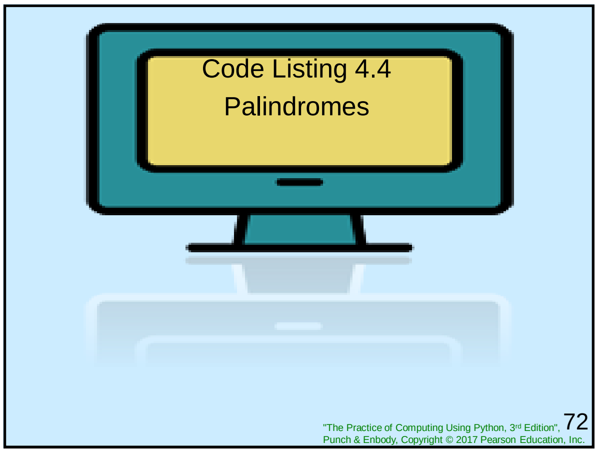
71



Code Listing 4.4
Palindromes

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72

```
# Palindrome tester
import string

original_str = input('Input a string:')
modified_str = original_str.lower()

bad_chars = string.whitespace + string.punctuation

for char in modified_str:
    if char in bad_chars:  # remove bad characters
        modified_str = modified_str.replace(char,'')

if modified_str == modified_str[::-1]: # it is a palindrome
    print(\
'The original string is:  {}\n\
 the modified string is: {}\n\
 the reversal is:        {}\n\
 String is a palindrome'.format(original_str, modified_str, modified_str[::-1
]))
else:
    print(\
'The original string is:  {}\n\
 the modified string is: {}\n\
 the reversal is:        {}\n\
 String is not a palindrome'.format(original_str,modified_str,modified_str[::-
1]))
```

More String Formatting

String Formatting

- we said a format string was of the following form:
  `{:align width .precision descriptor}`
- well, it can be more complicated than that
  `{arg : fill align sign # 0 width , .precision descriptor}`
- that's a lot, so let's look at the details

arg

to over-ride the {}-to-argument matching we have seen, you can indicate the argument you want in the bracket

- if other descriptor stuff is needed, it goes behind the arg, separated by a :

```
>>> print('{0} is {2} and {0} is also {1}'.format('Bill',25,'tall'))
Bill is tall and Bill is also 25
```

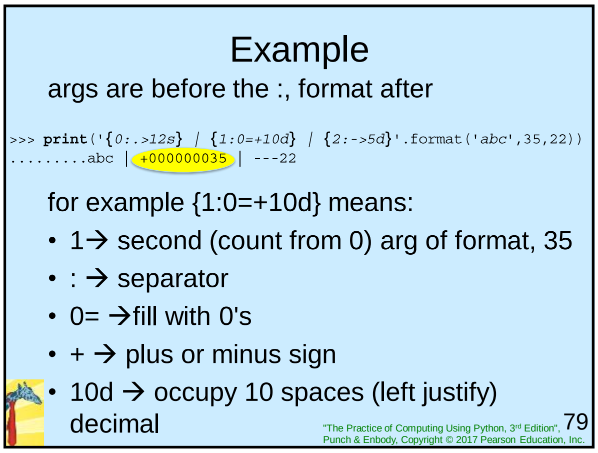
Fill

besides alignment, you can fill empty spaces with a fill character:

• 0=	fill with 0's
• +=	fill with +

Sign

- + means include a sign for both positive and negative numbers
- - means include a sign, but for only negative numbers
- space means space for positive, minus for negative



Example

args are before the :, format after

```
>>> print('{0:.>12s} | {1:0=+10d} | {2:->5d}'.format('abc',35,22))
.........abc | +000000035 | ---22
```

for example {1:0=+10d} means:

- 1→ second (count from 0) arg of format, 35
- : → separator
- 0= →fill with 0's
- + → plus or minus sign
- 10d → occupy 10 spaces (left justify) decimal

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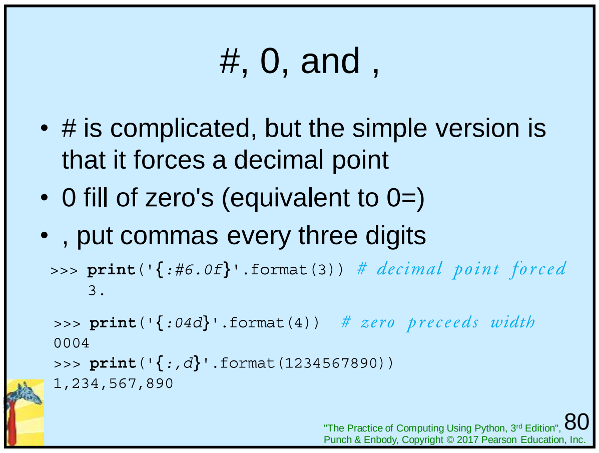
79



#, 0, and ,

- # is complicated, but the simple version is that it forces a decimal point
- 0 fill of zero's (equivalent to 0=)
- , put commas every three digits

```
>>> print('{:#6.0f}'.format(3)) # decimal point forced
     3.

>>> print('{:04d}'.format(4))   # zero preceeds width
0004
>>> print('{:,d}'.format(1234567890))
1,234,567,890
```

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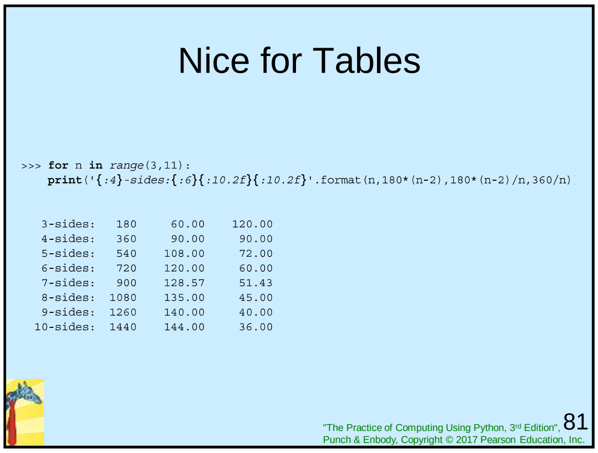
80



Nice for Tables

```
>>> for n in range(3,11):
    print('{:4}-sides:{:6}{:10.2f}{:10.2f}'.format(n,180*(n-2),180*(n-2)/n,360/n)

   3-sides:   180     60.00    120.00
   4-sides:   360     90.00     90.00
   5-sides:   540    108.00     72.00
   6-sides:   720    120.00     60.00
   7-sides:   900    128.57     51.43
   8-sides:  1080    135.00     45.00
   9-sides:  1260    140.00     40.00
  10-sides:  1440    144.00     36.00
```

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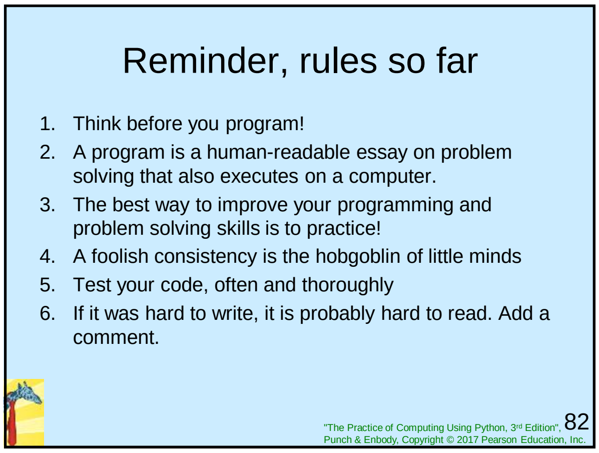
81



Reminder, rules so far

1. Think before you program!
2. A program is a human-readable essay on problem solving that also executes on a computer.
3. The best way to improve your programming and problem solving skills is to practice!
4. A foolish consistency is the hobgoblin of little minds
5. Test your code, often and thoroughly
6. If it was hard to write, it is probably hard to read. Add a comment.

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82