COMP1730/COMP6730
Programming for Scientists

Strings

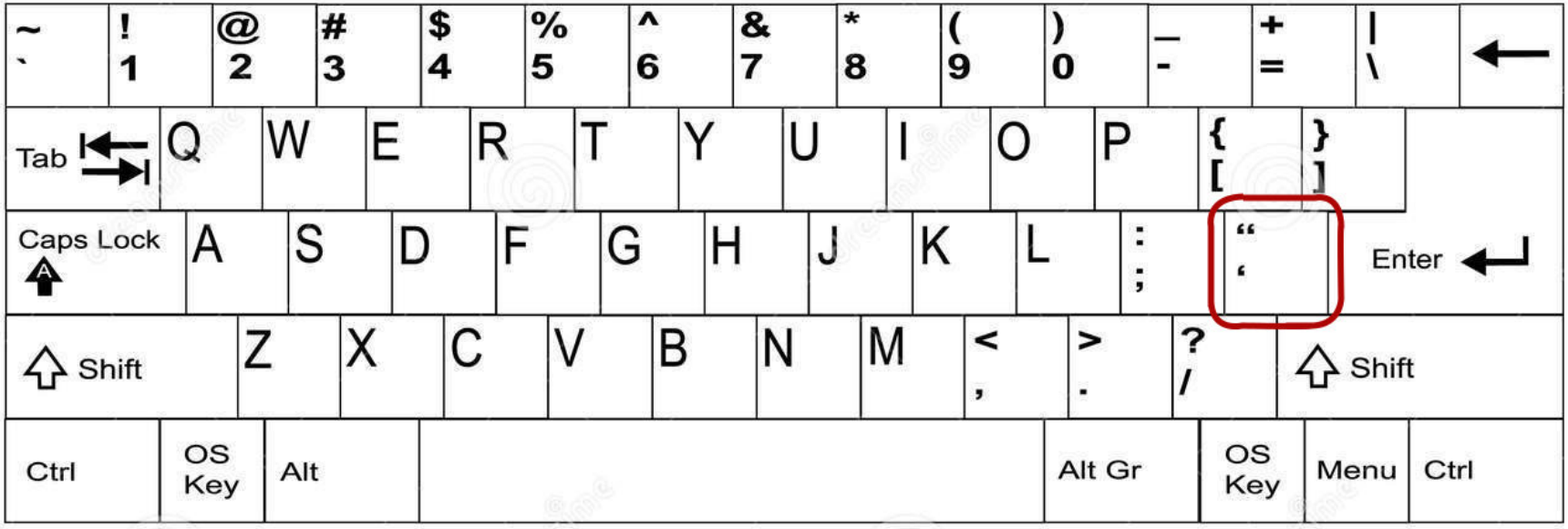
Lecture outline

* Character encoding & strings
* Indexing & more slicing
* Iteration over sequences

Characters & strings

Strings

* Strings – values of type `str` in python – are used to store and process text.
* A string is a *sequence* of *characters*.
  - `str` is a sequence type.
* String literals can be written with
  - single quotes, as in `'hello there'`
  - double quotes, as in `"hello there"`
  - triple quotes, as in `'''hello there'''`


~ `
! 1
@ 2
# 3
$ 4
% 5
^ 6
& 7
* 8
(9
) 0
_ -
+ =
| \
Tab
Q W E R T Y U I O P
{ [
}]
Caps Lock
A S D F G H J K L
: ;
“ ‘
Enter
Shift
Z X C V B N M
< ,
> .
? /
Shift
Ctrl
OS Key
Alt
Alt Gr
OS Key
Menu
Ctrl

* Quoting characters other than those enclosing a string can be used inside it:

```
>>> "it's true!"
>>> '"To be," said he, ...'
```

* Quoting characters of the same kind can be used inside a string if escaped by backslash (\):

```
>>> 'it\'s true'
>>> "it's a \"quote\""
```

* Escapes are used also for some non-printing characters:

```
>>> print("\t1m\t38s\n\t12m\t9s")
```

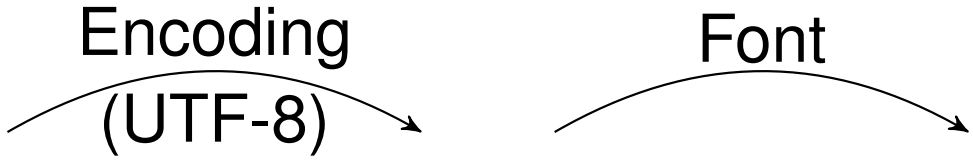
Character encoding

* Idea: Every character has a number.
* Baudot code (1870).
* 5-bit code, but also sequential ("letter" and "figure" mode).

V	IV			I	II	III							
							●	●	*Erasure*	*Erasure*			
		A	1	●			●	●	K	(	●		
		É	&	●	●		●	●	L	=	●	●	
		E	2		●		●	●	M	)		●	
		I	o		●	●	●	●	N	N°		●	●
		O	5	●	●	●	●	●	P	%	●	●	●
		U	4	●		●	●	●	Q	/	●		●
		Y	3			●	●	●	R	-			●
	●	B	8			●	●		S	;			●
	●	C	9	●		●	●		T	!	●		●
	●	D	0	●	●	●	●		V	'	●	●	●
	●	F	f		●	●	●		W	?		●	●
	●	G	7		●		●		X	,		●	
	●	H	h	●	●		●		Z	:	●	●	
	●	J	6	●			●		t	.	●		
	●	*Figure*	*Blank*				●		*Blank*	*Letter*			

Unicode, encoding and font

* *Unicode* defines numbers ("*code points*") for >120,000 characters (in a space for >1 million).



Byte(s)	Code point	Glyph
0100 0101	69	EEE$\mathcal{E}$
1110 0010 1000 0010 1010 1100	8364	€€€€

* python 3 uses the unicode character representation for all strings.
* Functions `ord` and `chr` map between the character and integer representation:

```
>>> ord('A')
>>> chr(65 + 4)
>>> chr(32)
>>> chr(8364)
>>> chr(20986)+chr(21475)
>>> ord('3')
```

* See `unicode.org/charts/`.

Indexing & length (reminder)

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'`.

Image from Punch & Enbody

* In python, all sequences are indexed from 0.
* ...or from end, starting with -1.
* The index must be an integer.
* The length of a sequence is the number of elements, *not* the index of the last element.

* `len(`*`sequence`*`)` returns sequence length.
* Sequence elements are accessed by placing the index in square brackets, `[]`.

```
>>> s = "Hello World"
>>> s[1]
'e'
>>> s[-1]
'd'
>>> len(s)
11
>>> s[11]
IndexError:  string index out of range
```

Slicing

* Slicing returns a subsequence:

  `s[start:end]`

  - *`start`* is the index of the first element in the subsequence.
  - *`end`* is the index of the first element after the end of the subsequence.

* Slicing also works on strings.
* If *`start`* or *`end`* are left out, they default to the beginning and end (i.e., after the last element).

* The slice range is “half-open”: start index is included, end index is one after last included element.

```
>>> s = "Hello World"
>>> s[6:10]
'Worl'
```

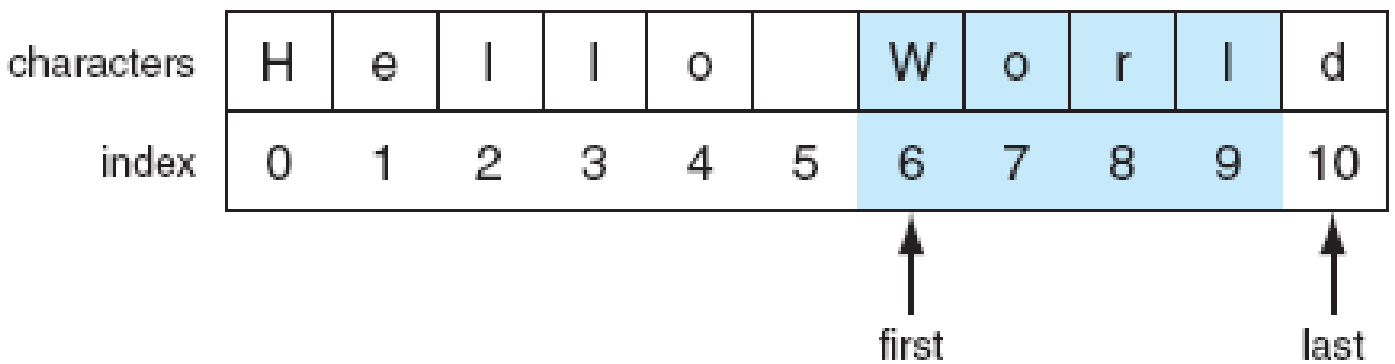


FIGURE 4.2 Indexing subsequences with slicing.

Image from Punch & Enbody

* The end index defaults to the end of the sequence.

```
>>> s = "Hello World"
>>> s[6:]
'World'
```

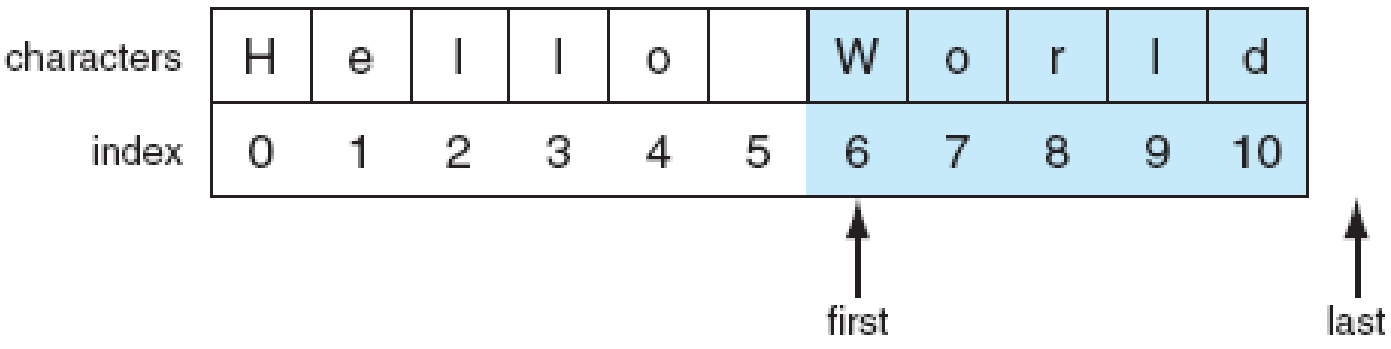


Image from Punch & Enbody

* The start index defaults to the beginning of the sequence.

```
>>> s = "Hello World"
>>> s[:5]
'World'
```

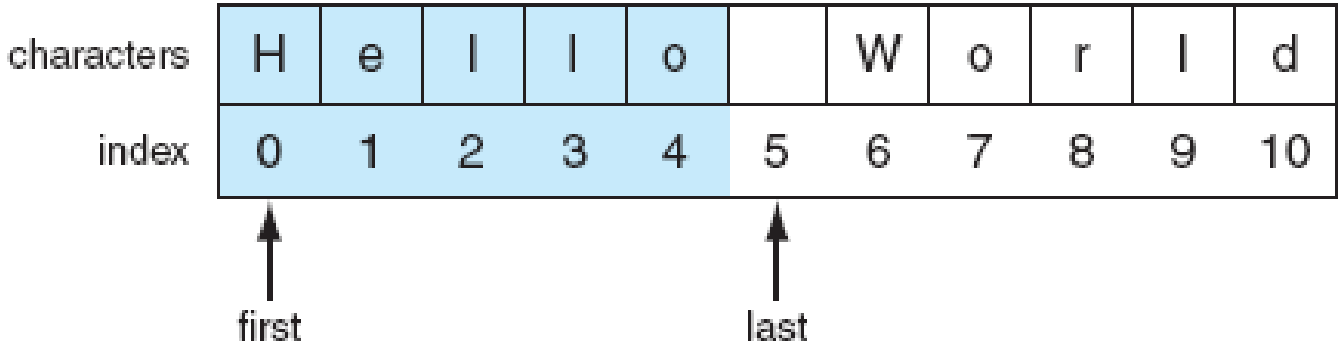


Image from Punch & Enbody

```
>>> s = "Hello World"
>>> s[9:1]
''
>>> s[-100:5]
'Hello'
```

* An empty slice (index range) returns an empty sequence
* Slice indices can go past the start/end of the sequence without raising an error.

Operations on strings

* Reminder: *value types determine the meaning of operators applied to them*.
* Concatenation: *`str + str`*

  ```
  >>> "comp" + "1730"
  ```
* Repetition: *`str * int`*

  ```
  >>> "Oi!  " * 3
  ```
* Membership (substring): *`str`* `in` *`str`*
* Equality: *`seq == seq`*, *`str != str`*.
* Comparison: *`str < str`*, *`str <= str`*, *`str > str`*, *`str >= str`*.

Sequence comparisons

* Two sequences are equal if they have the same length and equal elements in every position.
* *`seq1 < seq2`* if
  - *`seq1[i] < seq2[i]`* for some index *`i`* and the elements in each position before *`i`* are equal; or
  - *`seq1`* is a prefix of *`seq2`*.
* Reminder: Comparison of NumPy arrays is *element-wise* and returns an array of `bool`.

String comparisons

* Each character corresponds to an integer.
  - `ord(' ') == 32`
  - `ord('A') == 65, ..., ord('Z') == 90`
  - `ord('a') == 97, ..., ord('z') == 122`
* Character comparisons are based on this.

```
>>> "the ANU" < "The anu"
>>> "the ANU" < "the anu"
>>> "nontrivial" < "non trivial"
```

Iteration over sequences

The `for .. in ..` statement

```
for name in expression :
    suite
```

1. Evaluate the expression, to obtain a sequence.
   - If value is not iterable: TypeError.
2. For each element *E* in the sequence:

2.1 assign *name* the value *E*;

2.2 execute the loop suite.

```
for char in "The quick brown fox":
    print(char, "is", ord(char))
```

vs.

```
s = "The quick brown fox"
i = 0
while i < len(s):
    char = s[i]
    print(char, "is", ord(char))
```

Iteration over sequences

* Sequences are an instance of the general concept of an *iterable* data type.
  - An iterable type is defined by supporting the `iter(.)` function.
  - python also has data types that are iterable but not indexable (for example, sets and files).
* The `for .. in ..` statement works on any iterable data type.
  - On sequences, the `for` loop iterates through the elements *in order*.

String methods

Methods

* Methods are only functions with a slightly different call syntax:

```
"Hello World".find("o")
```

instead of

```
str.find("Hello World", "o")
```

* python's built-in types, like `str`, have many useful methods.
  - `help(str)`
  - `docs.python.org`

Programming problem

* Find a longest repeated substring in a word:
  - `'backpack'` → `'ack'`
  - `'singing'` → `'ing'`
  - `'independent'` → `'nde'`
  - `'philosophically'` → `'phi'`
  - `'monotone'` → `'on'`
  - `'wherever'` → `'er'`
  - `'repeated'` → `'e'`
  - `'programming'` → `'r'` (or `'g'`,`'m'`)
  - `'problem'` → `''`