# Unicode solutions in Python 2 and 3

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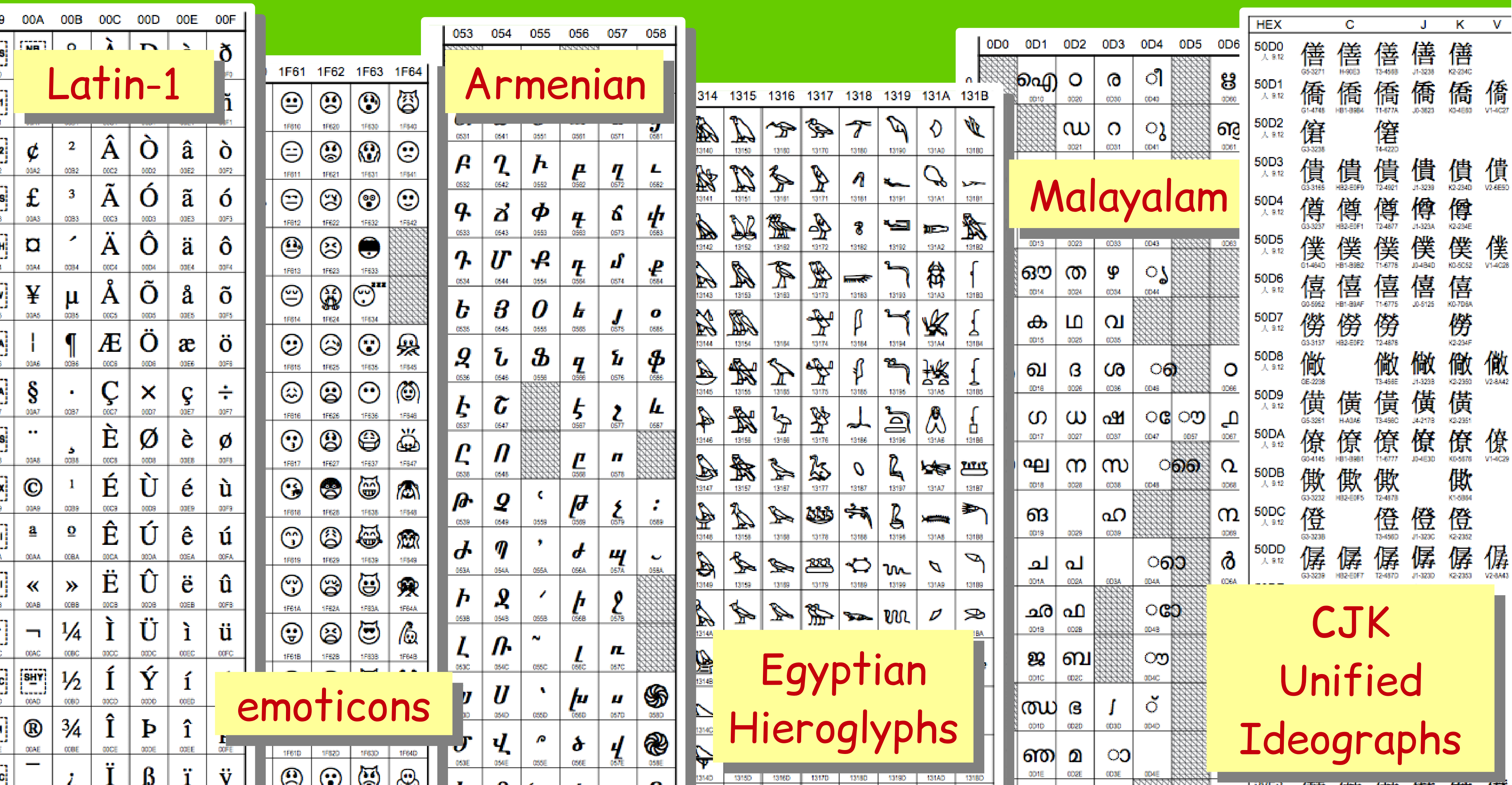
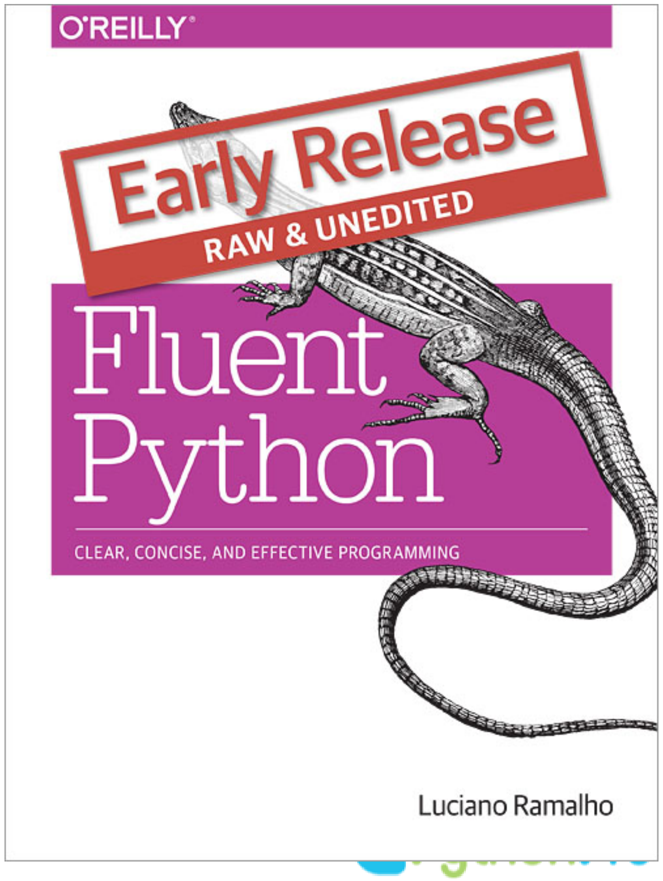


# About me: Luciano Ramalho

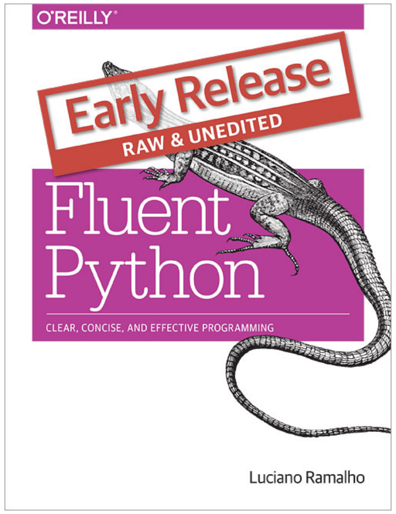
- Programming in Python since 1998
- Focus on content management (i.e. text wrangling)
- Teaching Python since 1999
- Speaker at PyCon US, OSCON, FISL, PythonBrasil, RuPy, QCon...
- Author of **Fluent Python**
- Twitter: @ramalhoorg
- Native language: Português
  - “ação”

4 non-ASCII characters here

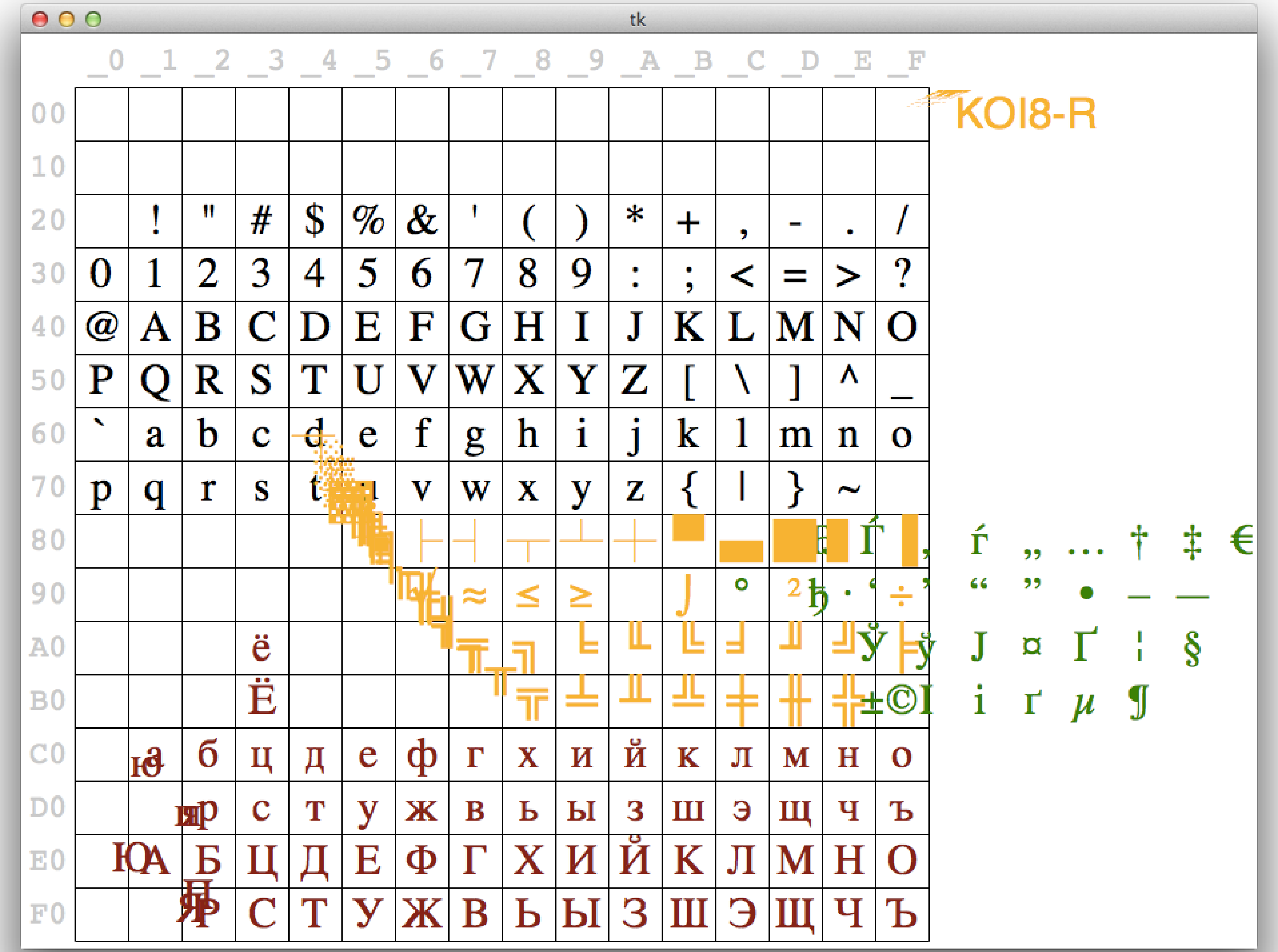


# Material de apoio

- Repositório de exemplos:
  - https://github.com/pythonprobr/unicode_pybr
- **Python Fluente**
  - http://www.novatec.com.br/livros/pythonfluente/
  - Conteúdo relevante e examplos:
    - Capítulo 4: *Texto versus Bytes*
      - http://bit.ly/pyflu04
    - Capítulo 18: *Concorrência com asyncio*
      - os exemplos *charfinder*



# The single-byte codepage ballet



| | _0 | _1 | _2 | _3 | _4 | _5 | _6 | _7 | _8 | _9 | _A | _B | _C | _D | _E | _F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | |
| 20 | | ! | " | # | $ | % | & | ' | ( | ) | * | + | , | - | . | / |
| 30 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? |
| 40 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| 50 | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | _ |
| 60 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| 70 | p | q | r | s | t | u | v | w | x | y | z | { | \| | } | ~ | |
| 80 | | | | | | | ├ | ┤ | ┬ | ┴ | ┼ | ▀ | ▄ | █ | ▌ | ▐ |
| 90 | | | | | | | | ≈ | ≤ | ≥ | | ⌡ | ° | ² | · | ÷ |
| A0 | | | | ё | | | | | | ╘ | ╙ | ╚ | ╛ | ╜ | ╝ | ╞ |
| B0 | | | | Ё | | | | | ╦ | ╧ | ╨ | ╩ | ╪ | ╫ | ╬ | © |
| C0 | | а | б | ц | д | е | ф | г | х | и | й | к | л | м | н | о |
| D0 | | | р | с | т | у | ж | в | ь | ы | з | ш | э | щ | ч | ъ |
| E0 | | А | Б | Ц | Д | Е | Ф | Г | Х | И | Й | К | Л | М | Н | О |
| F0 | | | Р | С | Т | У | Ж | В | Ь | Ы | З | Ш | Э | Щ | Ч | Ъ |

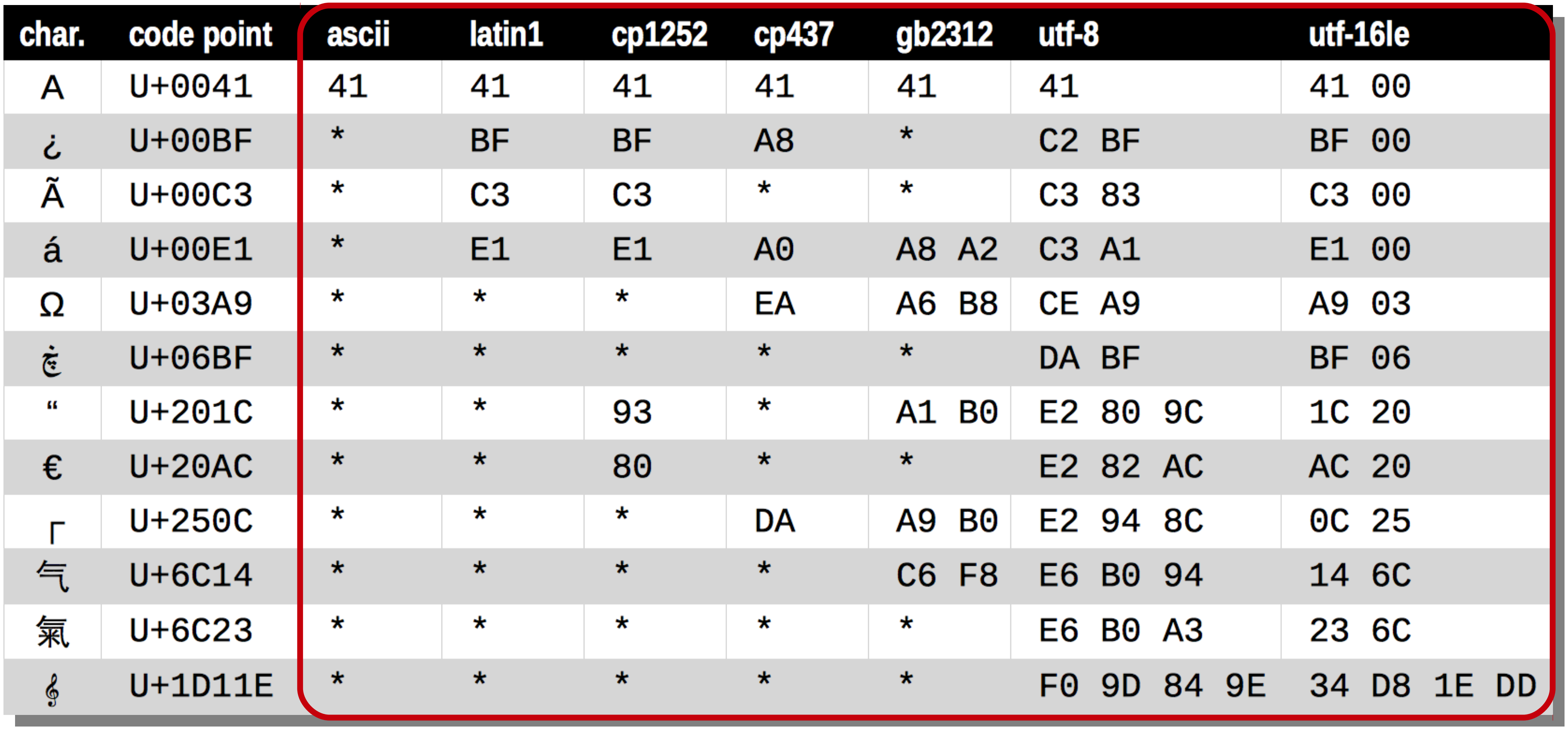
Video: `https://www.youtube.com/watch?v=J4qioAacrYo`
Source code: `http://bit.ly/1Oqt0MZ`

# Why Unicode

- Too many incompatible byte encodings
- Separate concepts:
  - character identity: one **code point** for each abstract character
    - `U+0041 → LATIN CAPITAL LETTER A`
    - `U+096C → DEVANAGARI DIGIT SIX`
  - binary representation: multiple **encodings**
    - `U+0041 → 0x41` | `0x41 0x00`
    - `U+096C → 0xE0 0xA5 0xAC` | `0x6C 0x09`

$\underbrace{\texttt{0x41} \;/\; \texttt{0xE0 0xA5 0xAC}}_{\text{UTF-8}} \quad \underbrace{\texttt{0x41 0x00} \;/\; \texttt{0x6C 0x09}}_{\text{UTF-16LE}}$

# A sample of encodings



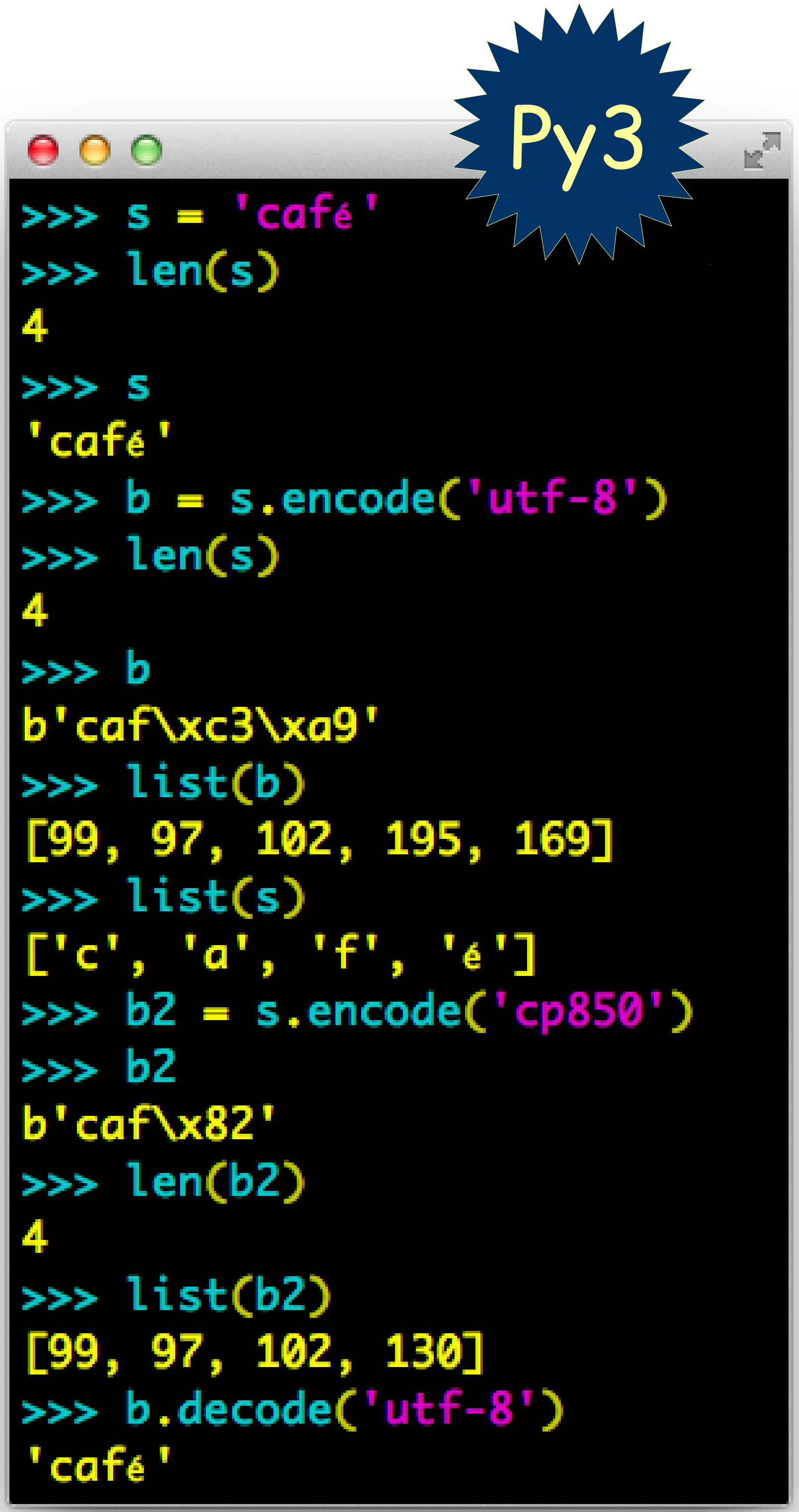
| char. | code point | ascii | latin1 | cp1252 | cp437 | gb2312 | utf-8 | utf-16le |
|---|---|---|---|---|---|---|---|---|
| A | U+0041 | 41 | 41 | 41 | 41 | 41 | 41 | 41 00 |
| ¿ | U+00BF | * | BF | BF | A8 | * | C2 BF | BF 00 |
| Ã | U+00C3 | * | C3 | C3 | * | * | C3 83 | C3 00 |
| á | U+00E1 | * | E1 | E1 | A0 | A8 A2 | C3 A1 | E1 00 |
| Ω | U+03A9 | * | * | * | EA | A6 B8 | CE A9 | A9 03 |
| ڿ | U+06BF | * | * | * | * | * | DA BF | BF 06 |
| “ | U+201C | * | * | 93 | * | A1 B0 | E2 80 9C | 1C 20 |
| € | U+20AC | * | * | 80 | * | * | E2 82 AC | AC 20 |
| ┌ | U+250C | * | * | * | DA | A9 B0 | E2 94 8C | 0C 25 |
| 气 | U+6C14 | * | * | * | * | C6 F8 | E6 B0 94 | 14 6C |
| 氣 | U+6C23 | * | * | * | * | * | E6 B0 A3 | 23 6C |
| 𝄞 | U+1D11E | * | * | * | * | * | F0 9D 84 9E | 34 D8 1E DD |

*Figure 4-1 of Fluent Python*

# Data types for text or bytes

| | **Python 2.7** | **Python 3.4** |
|---:|---|---|
| **Human text** | **unicode**<br>u'café', u'caf\xe9' | **str**<br>'café', u'café' |
| **Bytes** (immutable) | **str**<br>'café', 'caf\xe9', b'café'... | **bytes**<br>b'caf\xc3\xa9' |
| **Bytes** (mutable) | **bytearray**<br>bytearray(b'caf\xc3\xa9') | **bytearray**<br>bytearray(b'caf\xc3\xa9') |

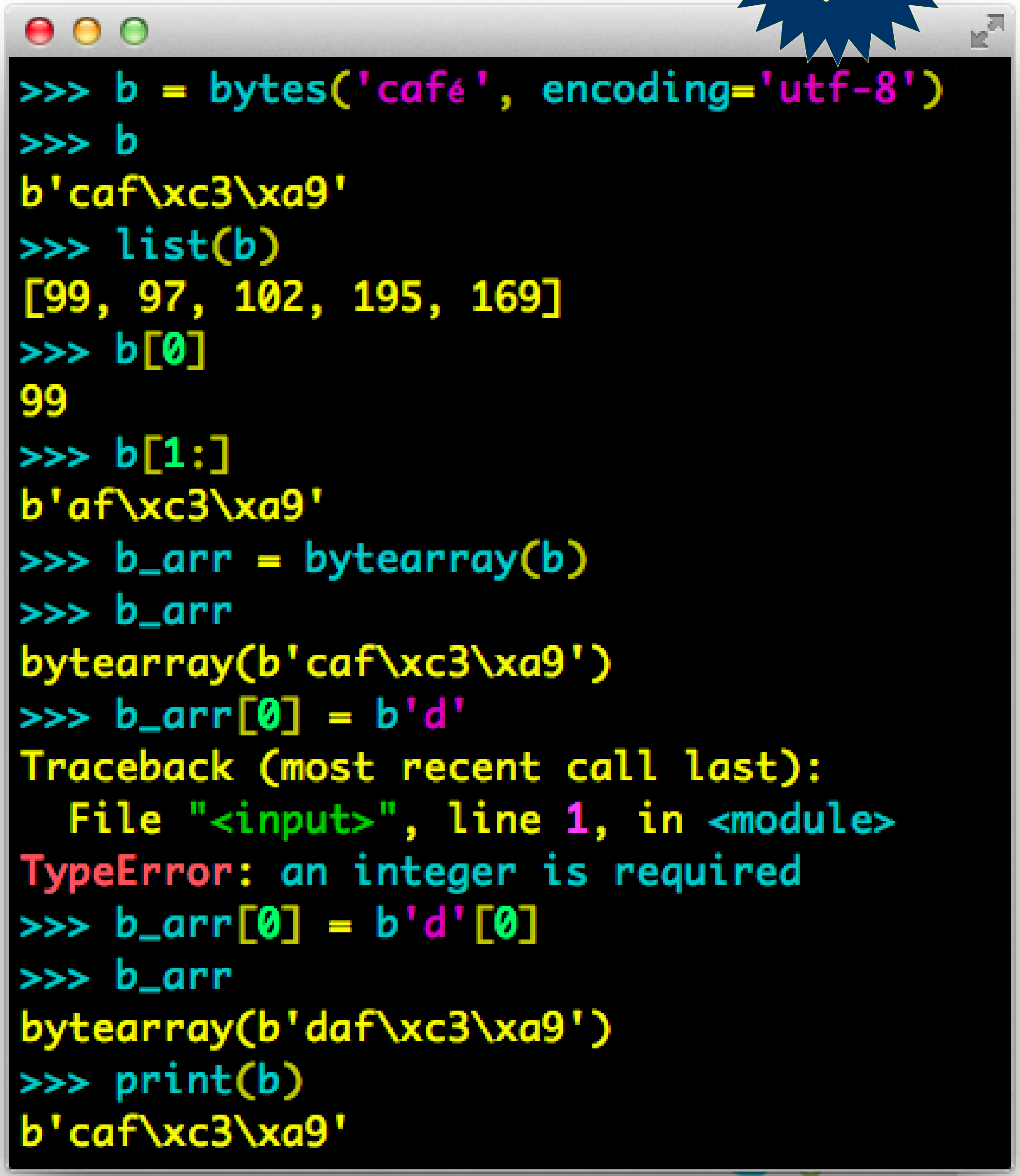
## **str** v. **bytes** in Py3



```
>>> s = 'café'
>>> len(s)
4
>>> s
'café'
>>> b = s.encode('utf-8')
>>> len(s)
4
>>> b
b'caf\xc3\xa9'
>>> list(b)
[99, 97, 102, 195, 169]
>>> list(s)
['c', 'a', 'f', 'é']
>>> b2 = s.encode('cp850')
>>> b2
b'caf\x82'
>>> len(b2)
4
>>> list(b2)
[99, 97, 102, 130]
>>> b.decode('utf-8')
'café'
```

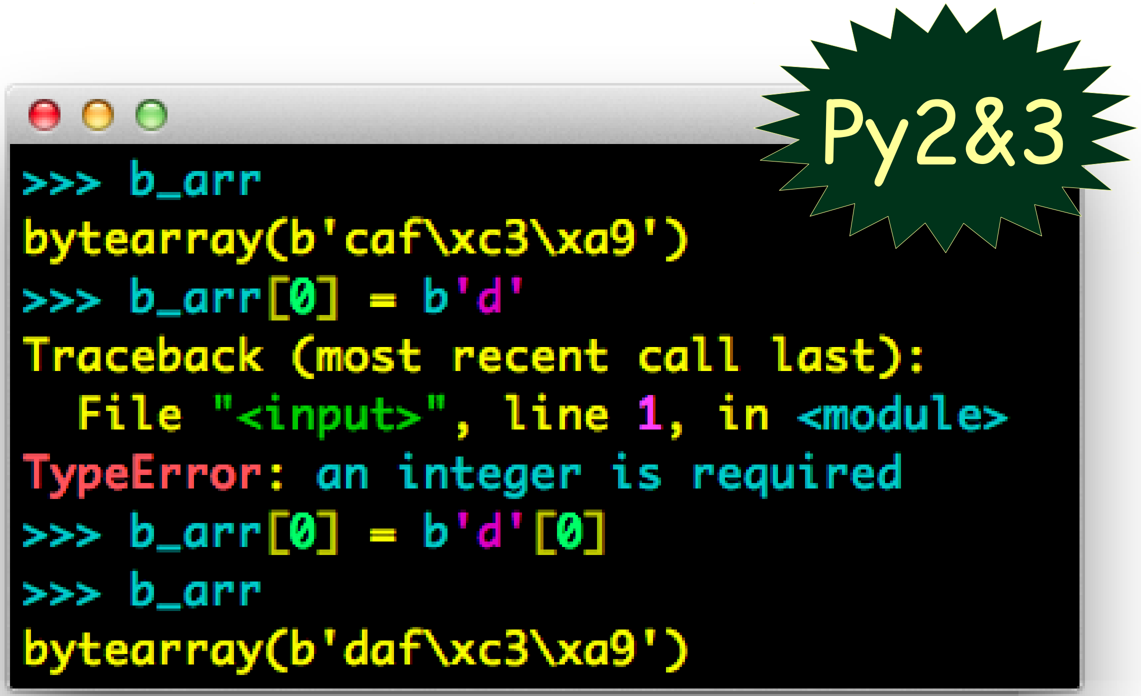
# **bytes** in Py3

Py3



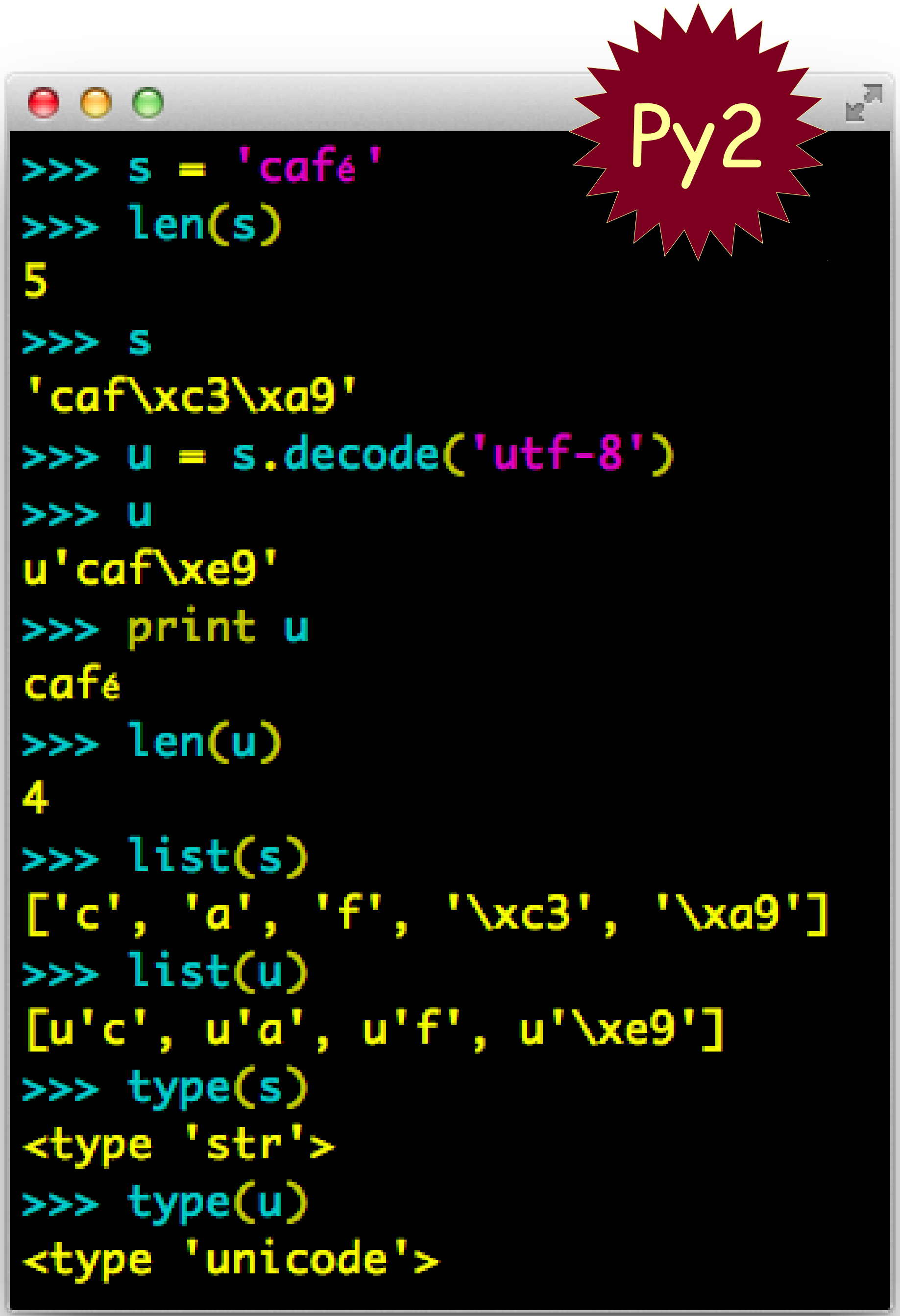
```
>>> b = bytes('café', encoding='utf-8')
>>> b
b'caf\xc3\xa9'
>>> list(b)
[99, 97, 102, 195, 169]
>>> b[0]
99
>>> b[1:]
b'af\xc3\xa9'
>>> b_arr = bytearray(b)
>>> b_arr
bytearray(b'caf\xc3\xa9')
>>> b_arr[0] = b'd'
Traceback (most recent call last):
  File "<input>", line 1, in <module>
TypeError: an integer is required
>>> b_arr[0] = b'd'[0]
>>> b_arr
bytearray(b'daf\xc3\xa9')
>>> print(b)
b'caf\xc3\xa9'
```

# **bytearray** in Py2 & 3



```
>>> b_arr
bytearray(b'caf\xc3\xa9')
>>> b_arr[0] = b'd'
Traceback (most recent call last):
  File "<input>", line 1, in <module>
TypeError: an integer is required
>>> b_arr[0] = b'd'[0]
>>> b_arr
bytearray(b'daf\xc3\xa9')
```

## **unicode** v. **str** in Py2



```
>>> s = 'café'
>>> len(s)
5
>>> s
'caf\xc3\xa9'
>>> u = s.decode('utf-8')
>>> u
u'caf\xe9'
>>> print u
café
>>> len(u)
4
>>> list(s)
['c', 'a', 'f', '\xc3', '\xa9']
>>> list(u)
[u'c', u'a', u'f', u'\xe9']
>>> type(s)
<type 'str'>
>>> type(u)
<type 'unicode'>
```

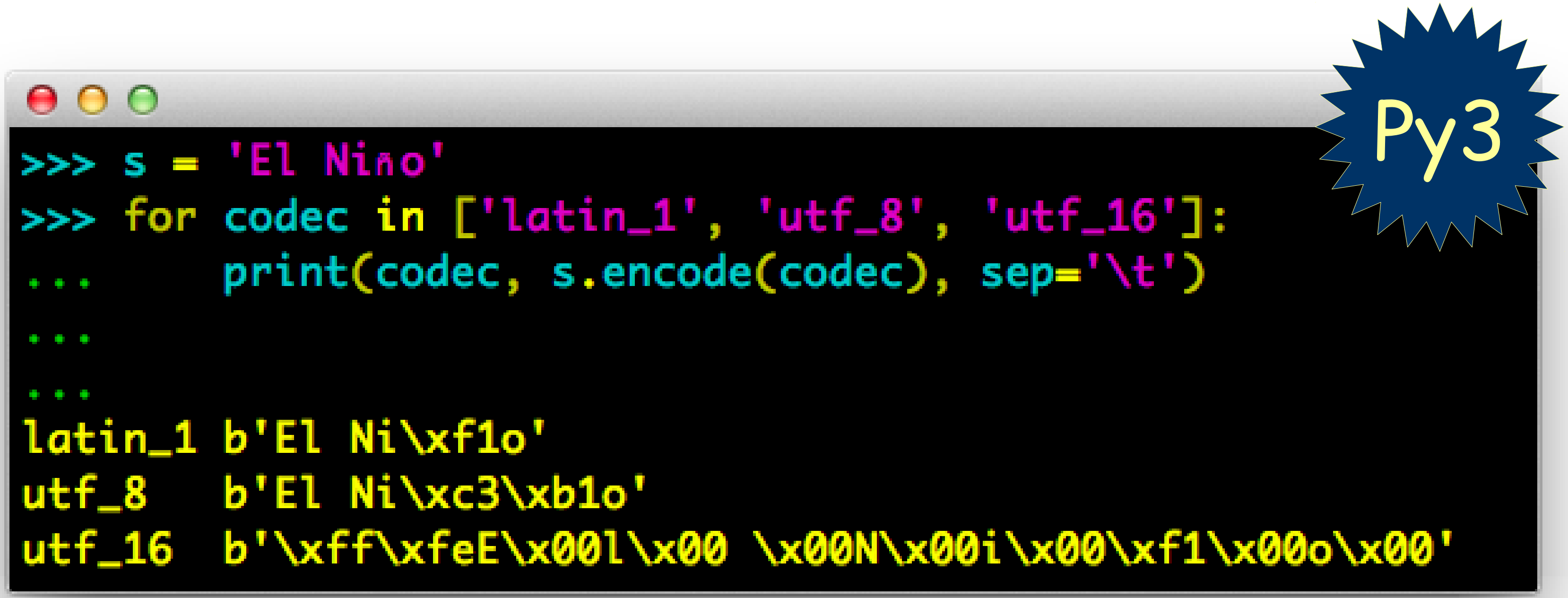
# .encode() vs .decode()

- "Humans use text. Computers speak bytes."
  - Esther Nam and Travis Fischer in *Character encoding and Unicode in Python (Pycon US 2014)*

- Use .encode() to convert **human** text to **bytes**
- Use .decode() to convert **bytes** to **human** text

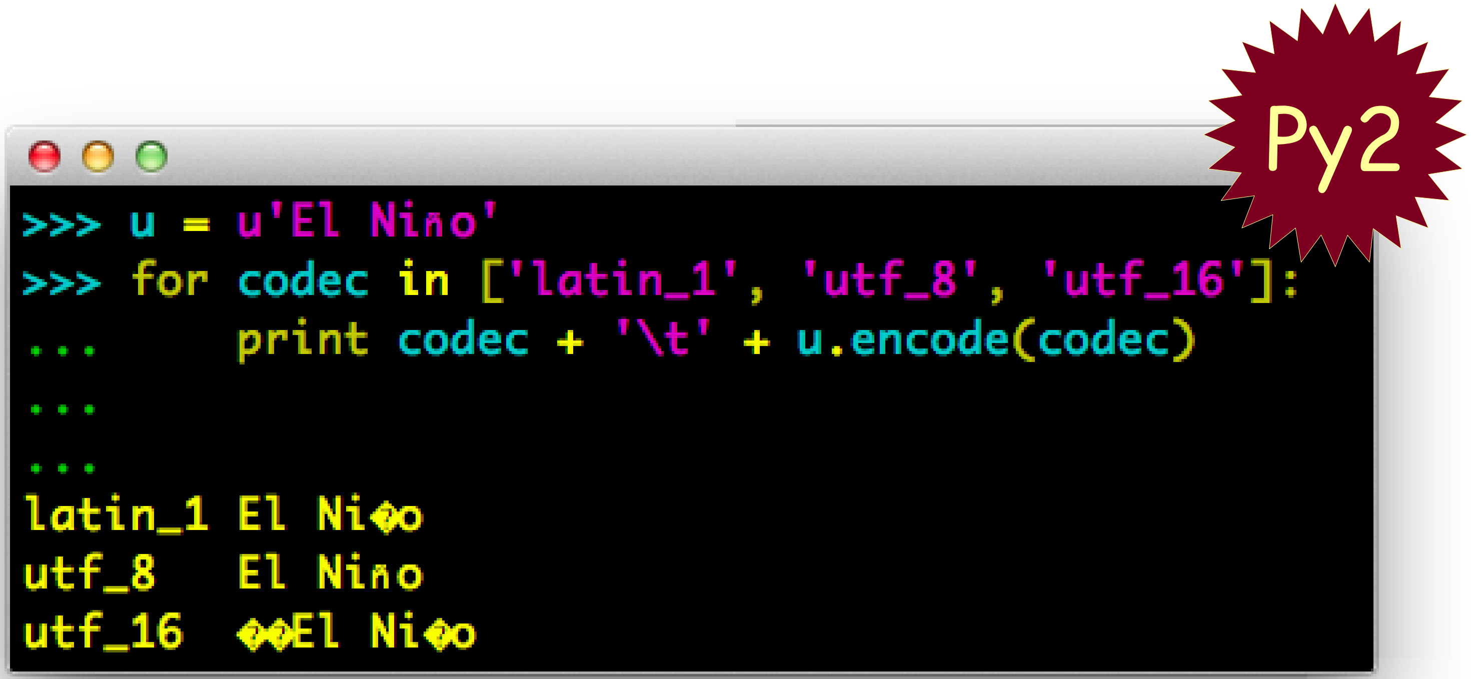
2.7 gotcha:
the methods
.encode() and .decode()
exist in **str** and **unicode**

# str.encode(...) in Py3



```
>>> s = 'El Niño'
>>> for codec in ['latin_1', 'utf_8', 'utf_16']:
...     print(codec, s.encode(codec), sep='\t')
...
...
latin_1 b'El Ni\xf1o'
utf_8   b'El Ni\xc3\xb1o'
utf_16  b'\xff\xfeE\x00l\x00 \x00N\x00i\x00\xf1\x00o\x00'
```

# unicode.encode(...) in Py2

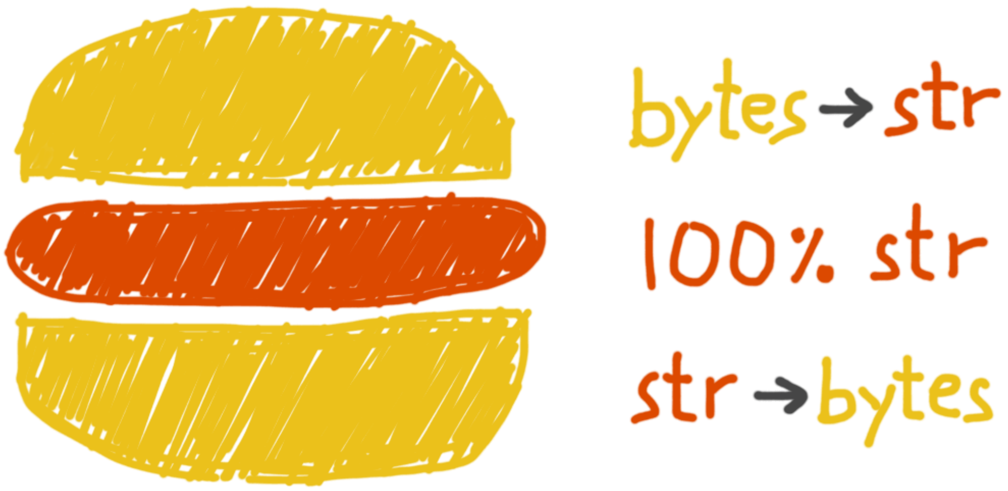


```
>>> u = u'El Niño'
>>> for codec in ['latin_1', 'utf_8', 'utf_16']:
...     print codec + '\t' + u.encode(codec)
...
...
latin_1 El Ni�o
utf_8   El Niño
utf_16  ��El Ni�o
```

PythonPro

## Best practice

**The Unicode sandwich**



Decode bytes on input,

process text only,

encode text on output.

*Figure 4-2 of Fluent Python*

# How to implement the sandwich (1)

- Always specify encoding when reading/writing text files
  - that way you get text, and not bytes
  - in Python 2.7, use `io.open()`

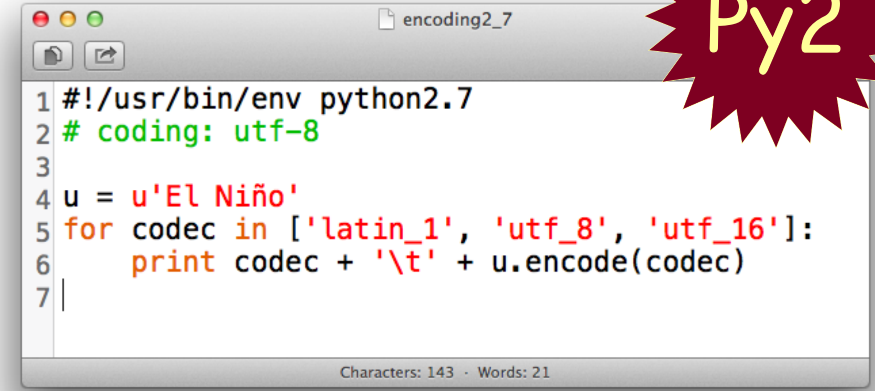
2.7 gotcha:
no way to specify
encoding in built-in open(...).
Must use io.open(...).

## Coping with Unicode Errors

- **SyntaxError**
  - A .py file is loaded with contents in an unexpected encoding
- **UnicodeDecodeError**
  - A binary sequence is contains bytes that are not valid in the expected encoding
- **UnicodeEncodeError**
  - A Unicode string contains codepoints that have no representation in the desired encoding

# Coping with SyntaxError

- A .py file is loaded with contents in an unexpected source code encoding
  - The source file encoding is not the default, and no `# coding` comment was found.
  - The source file encoding is not the one declared in the `# coding` comment
- Default source encoding:
  - Python 2.7 == ASCII
  - Python 3.x == UTF-8

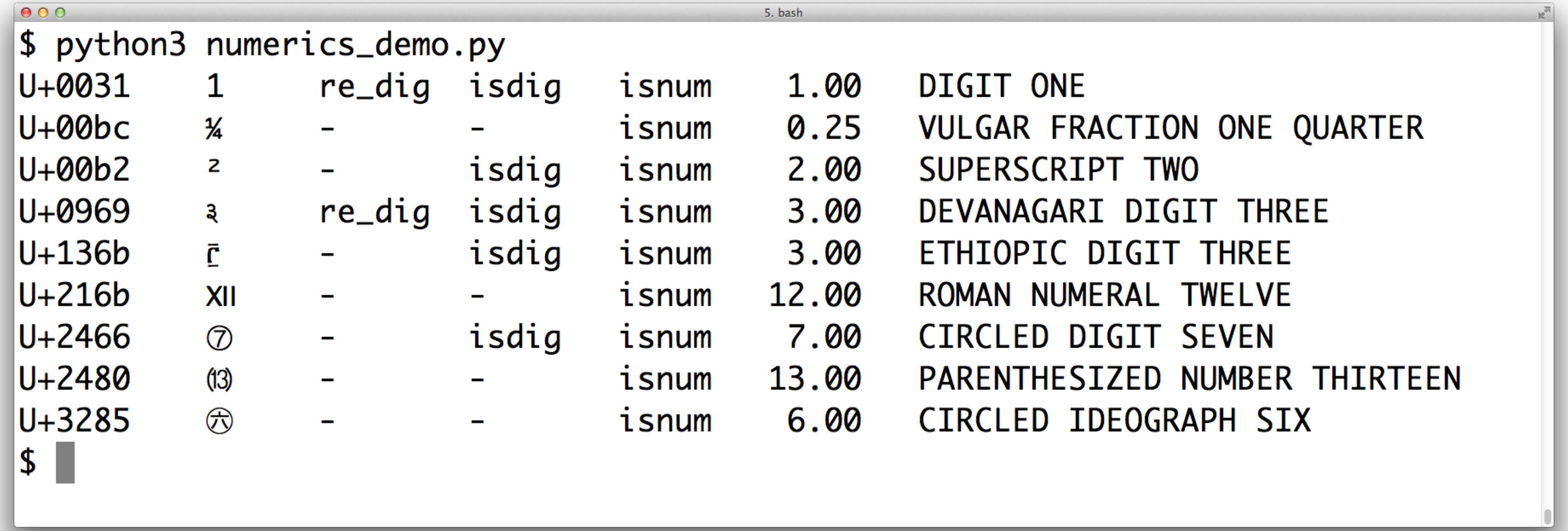


```
#!/usr/bin/env python2.7
# coding: utf-8

u = u'El Niño'
for codec in ['latin_1', 'utf_8', 'utf_16']:
    print codec + '\t' + u.encode(codec)

```

Py2

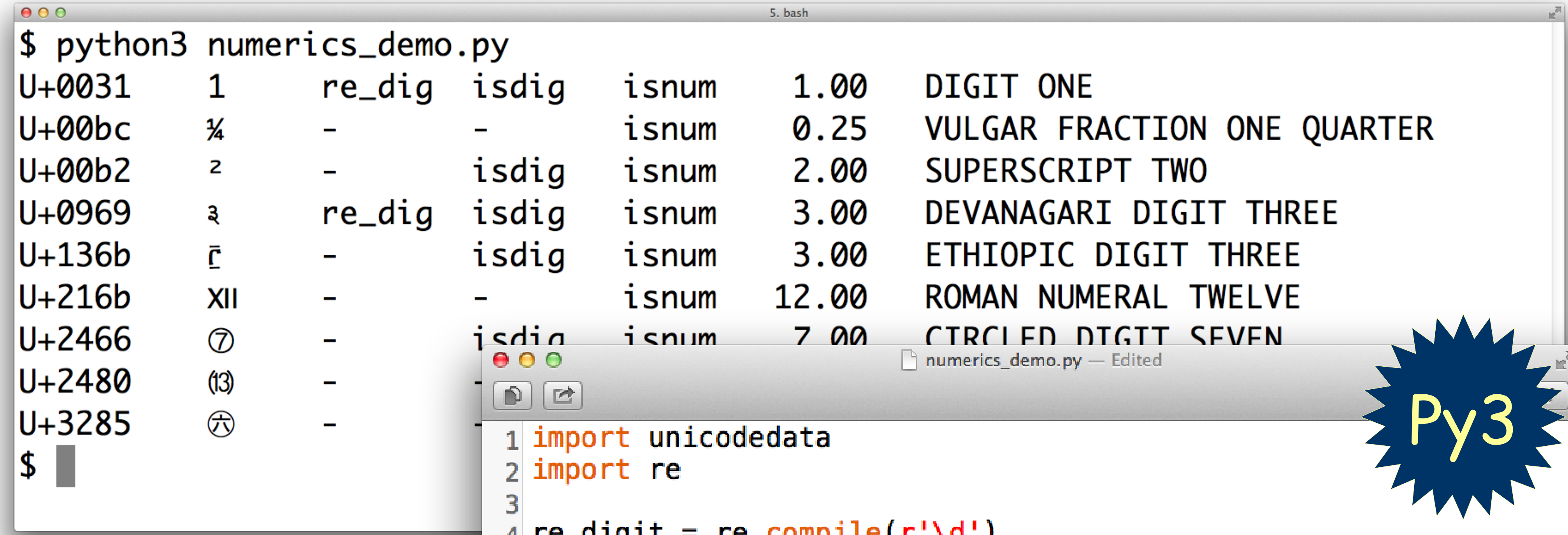
2.7 gotcha: default source encoding is ASCII

# Unicode database

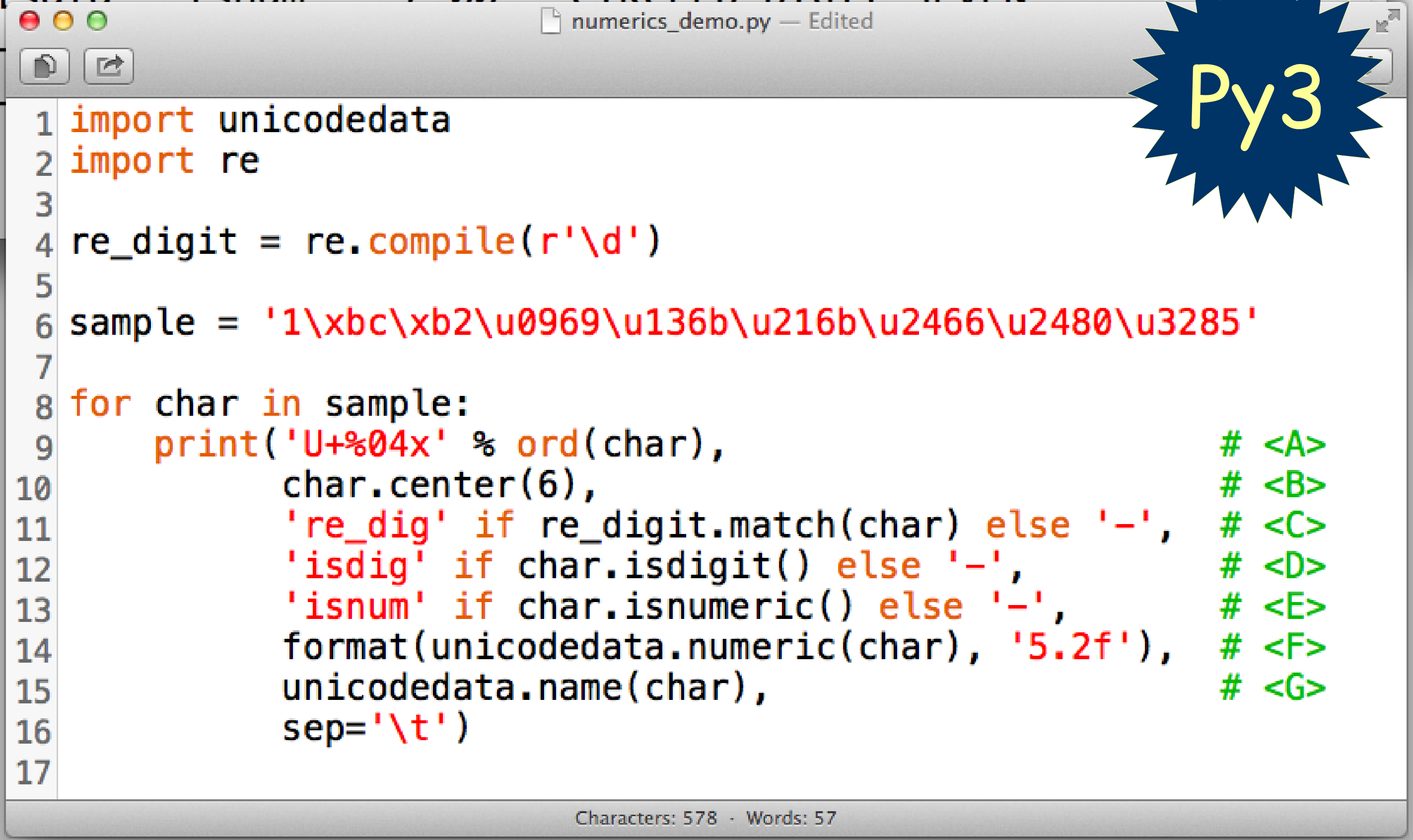


```
$ python3 numerics_demo.py
U+0031    1     re_dig  isdig   isnum    1.00   DIGIT ONE
U+00bc    ¼     -       -       isnum    0.25   VULGAR FRACTION ONE QUARTER
U+00b2    ²     -       isdig   isnum    2.00   SUPERSCRIPT TWO
U+0969    ३     re_dig  isdig   isnum    3.00   DEVANAGARI DIGIT THREE
U+136b    ፫     -       isdig   isnum    3.00   ETHIOPIC DIGIT THREE
U+216b    Ⅻ     -       -       isnum   12.00   ROMAN NUMERAL TWELVE
U+2466    ⑦     -       isdig   isnum    7.00   CIRCLED DIGIT SEVEN
U+2480    ⒀     -       -       isnum   13.00   PARENTHESIZED NUMBER THIRTEEN
U+3285    ㊅     -       -       isnum    6.00   CIRCLED IDEOGRAPH SIX
$
```

# Unicode database

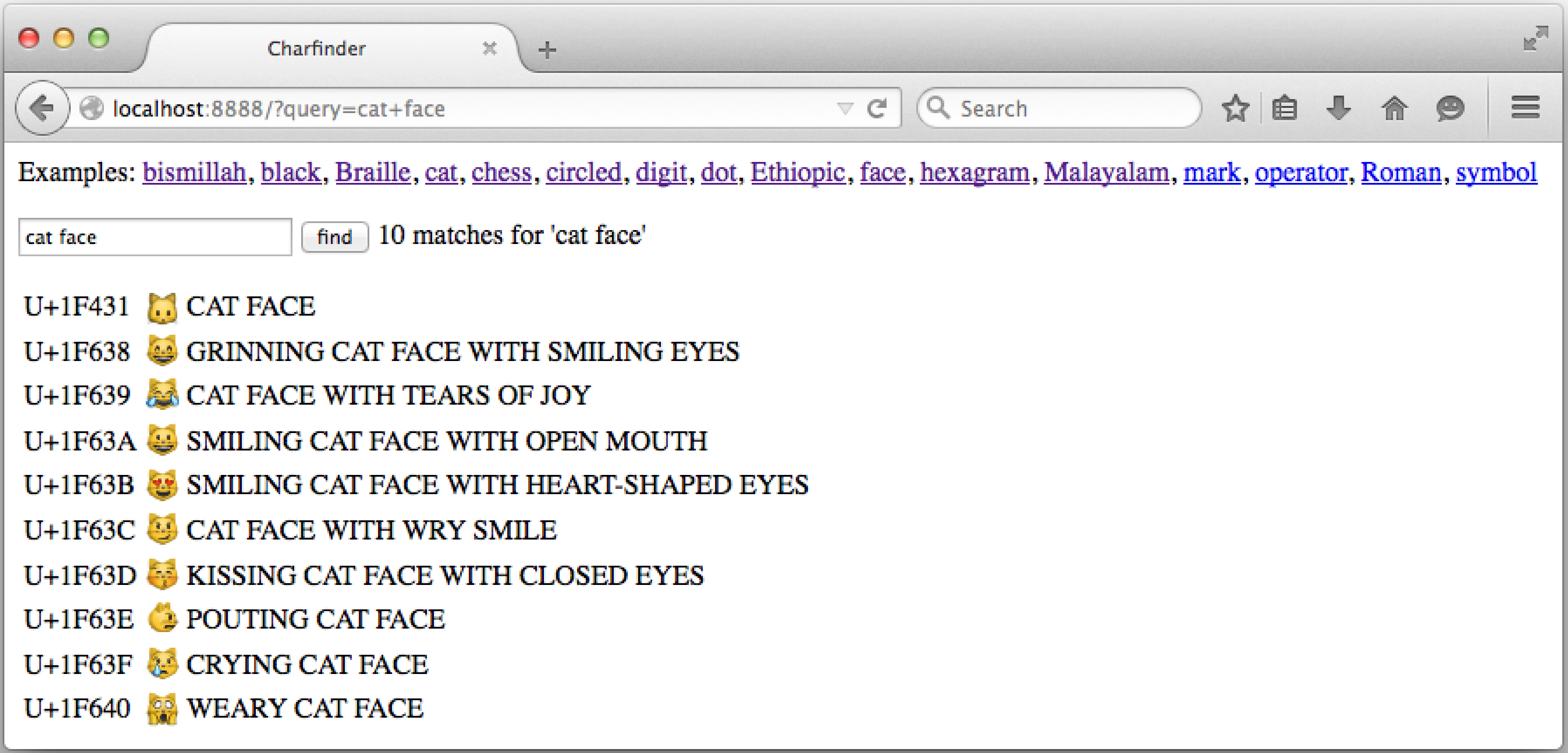


```
$ python3 numerics_demo.py
U+0031    1     re_dig  isdig   isnum    1.00   DIGIT ONE
U+00bc    ¼     -       -       isnum    0.25   VULGAR FRACTION ONE QUARTER
U+00b2    ²     -       isdig   isnum    2.00   SUPERSCRIPT TWO
U+0969    ३     re_dig  isdig   isnum    3.00   DEVANAGARI DIGIT THREE
U+136b    ፫     -       isdig   isnum    3.00   ETHIOPIC DIGIT THREE
U+216b    Ⅻ     -       -       isnum   12.00   ROMAN NUMERAL TWELVE
U+2466    ⑦     -       isdig   isnum    7.00   CIRCLED DIGIT SEVEN
U+2480    ⒀     -       -
U+3285    ㊅     -       -
$ 
```



```python
import unicodedata
import re

re_digit = re.compile(r'\d')

sample = '1\xbc\xb2\u0969\u136b\u216b\u2466\u2480\u3285'

for char in sample:
    print('U+%04x' % ord(char),                          # <A>
          char.center(6),                                # <B>
          're_dig' if re_digit.match(char) else '-',     # <C>
          'isdig' if char.isdigit() else '-',            # <D>
          'isnum' if char.isnumeric() else '-',          # <E>
          format(unicodedata.numeric(char), '5.2f'),     # <F>
          unicodedata.name(char),                        # <G>
          sep='\t')

```

# flupy-ch18/http_charfinder.py



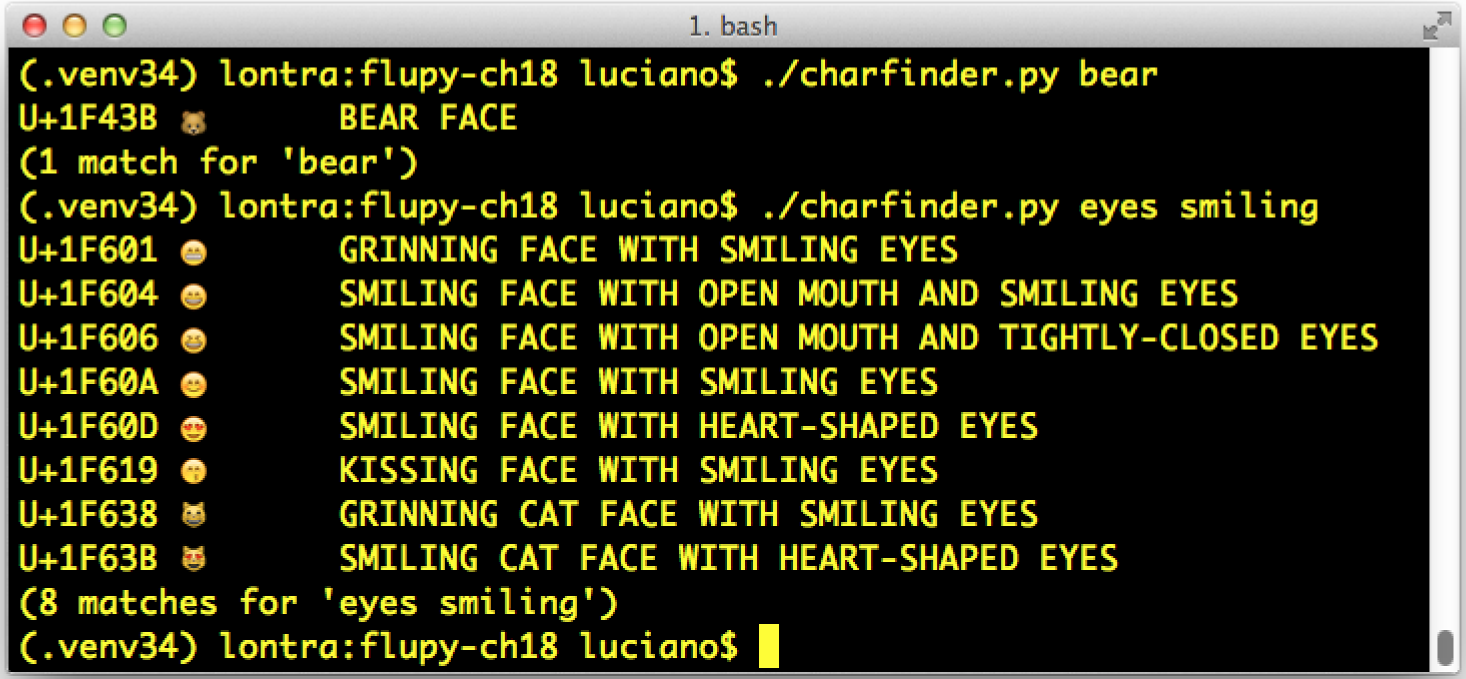
Examples: bismillah, black, Braille, cat, chess, circled, digit, dot, Ethiopic, face, hexagram, Malayalam, mark, operator, Roman, symbol

cat face find 10 matches for 'cat face'

```
U+1F431 🐱 CAT FACE
U+1F638 😸 GRINNING CAT FACE WITH SMILING EYES
U+1F639 😹 CAT FACE WITH TEARS OF JOY
U+1F63A 😺 SMILING CAT FACE WITH OPEN MOUTH
U+1F63B 😻 SMILING CAT FACE WITH HEART-SHAPED EYES
U+1F63C 😼 CAT FACE WITH WRY SMILE
U+1F63D 😽 KISSING CAT FACE WITH CLOSED EYES
U+1F63E 😾 POUTING CAT FACE
U+1F63F 😿 CRYING CAT FACE
U+1F640 🙀 WEARY CAT FACE
```

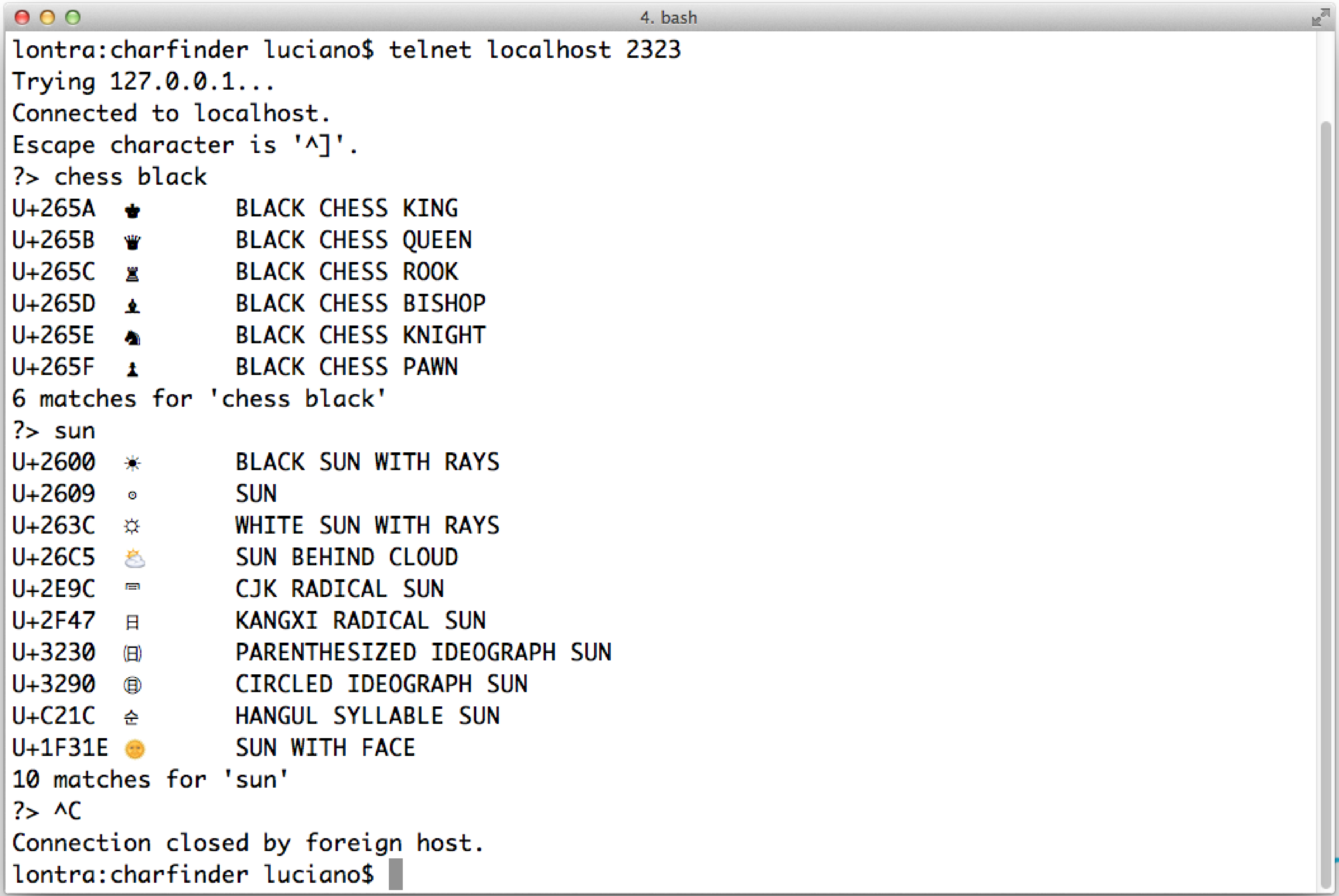
PythonPro

# flupy-ch18/charfinder.py



```
(.venv34) lontra:flupy-ch18 luciano$ ./charfinder.py bear
U+1F43B 🐻      BEAR FACE
(1 match for 'bear')
(.venv34) lontra:flupy-ch18 luciano$ ./charfinder.py eyes smiling
U+1F601 😁      GRINNING FACE WITH SMILING EYES
U+1F604 😄      SMILING FACE WITH OPEN MOUTH AND SMILING EYES
U+1F606 😆      SMILING FACE WITH OPEN MOUTH AND TIGHTLY-CLOSED EYES
U+1F60A 😊      SMILING FACE WITH SMILING EYES
U+1F60D 😍      SMILING FACE WITH HEART-SHAPED EYES
U+1F619 😙      KISSING FACE WITH SMILING EYES
U+1F638 😸      GRINNING CAT FACE WITH SMILING EYES
U+1F63B 😻      SMILING CAT FACE WITH HEART-SHAPED EYES
(8 matches for 'eyes smiling')
(.venv34) lontra:flupy-ch18 luciano$ 
```

# flupy-ch18/tcp_charfinder.py



4. bash

```
lontra:charfinder luciano$ telnet localhost 2323
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
?> chess black
U+265A ♚       BLACK CHESS KING
U+265B ♛       BLACK CHESS QUEEN
U+265C ♜       BLACK CHESS ROOK
U+265D ♝       BLACK CHESS BISHOP
U+265E ♞       BLACK CHESS KNIGHT
U+265F ♟       BLACK CHESS PAWN
6 matches for 'chess black'
?> sun
U+2600 ☀       BLACK SUN WITH RAYS
U+2609 ☉       SUN
U+263C ☼       WHITE SUN WITH RAYS
U+26C5 ⛅       SUN BEHIND CLOUD
U+2E9C ⺜       CJK RADICAL SUN
U+2F47 ⽇       KANGXI RADICAL SUN
U+3230 ㈰       PARENTHESIZED IDEOGRAPH SUN
U+3290 ㊐       CIRCLED IDEOGRAPH SUN
U+C21C 순       HANGUL SYLLABLE SUN
U+1F31E 🌞      SUN WITH FACE
10 matches for 'sun'
?> ^C
Connection closed by foreign host.
lontra:charfinder luciano$
```