# Unicode and Python

Glyphs, Encodings and all that

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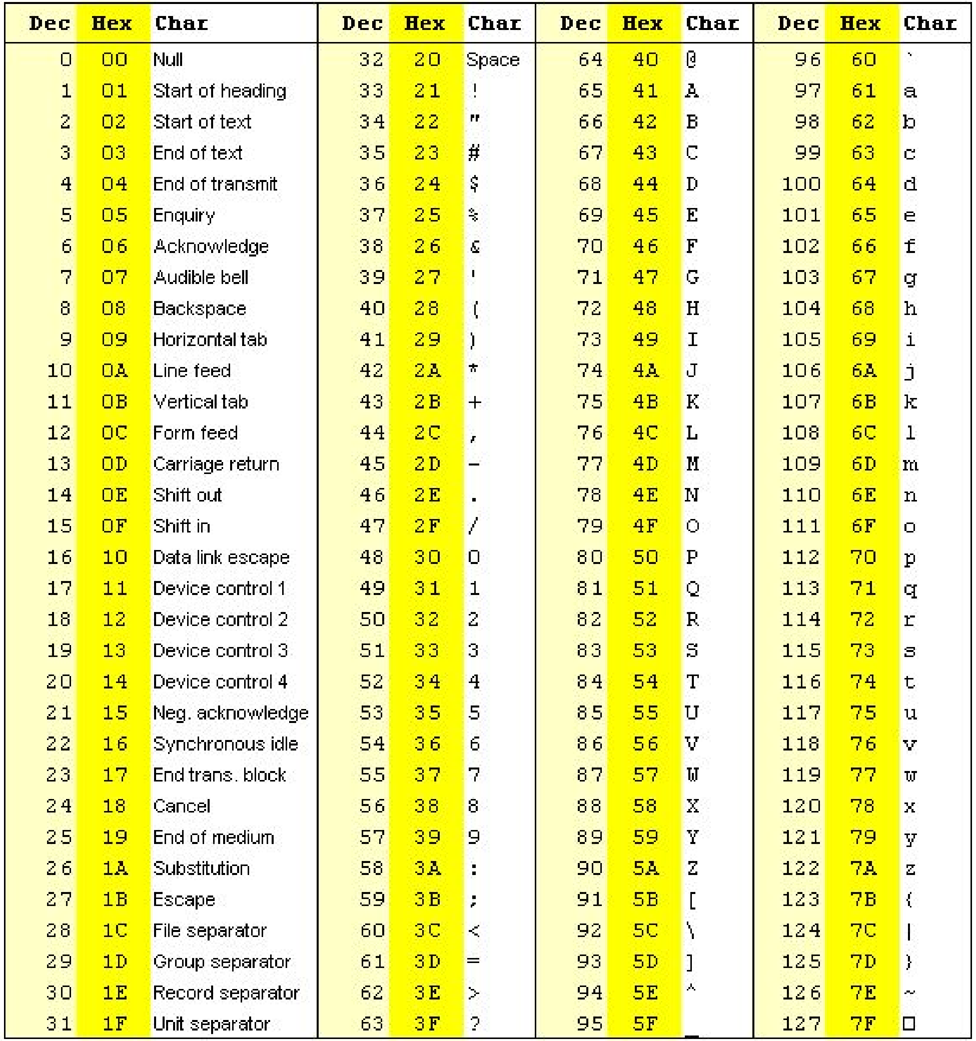
A “code point” is the number of a glyph

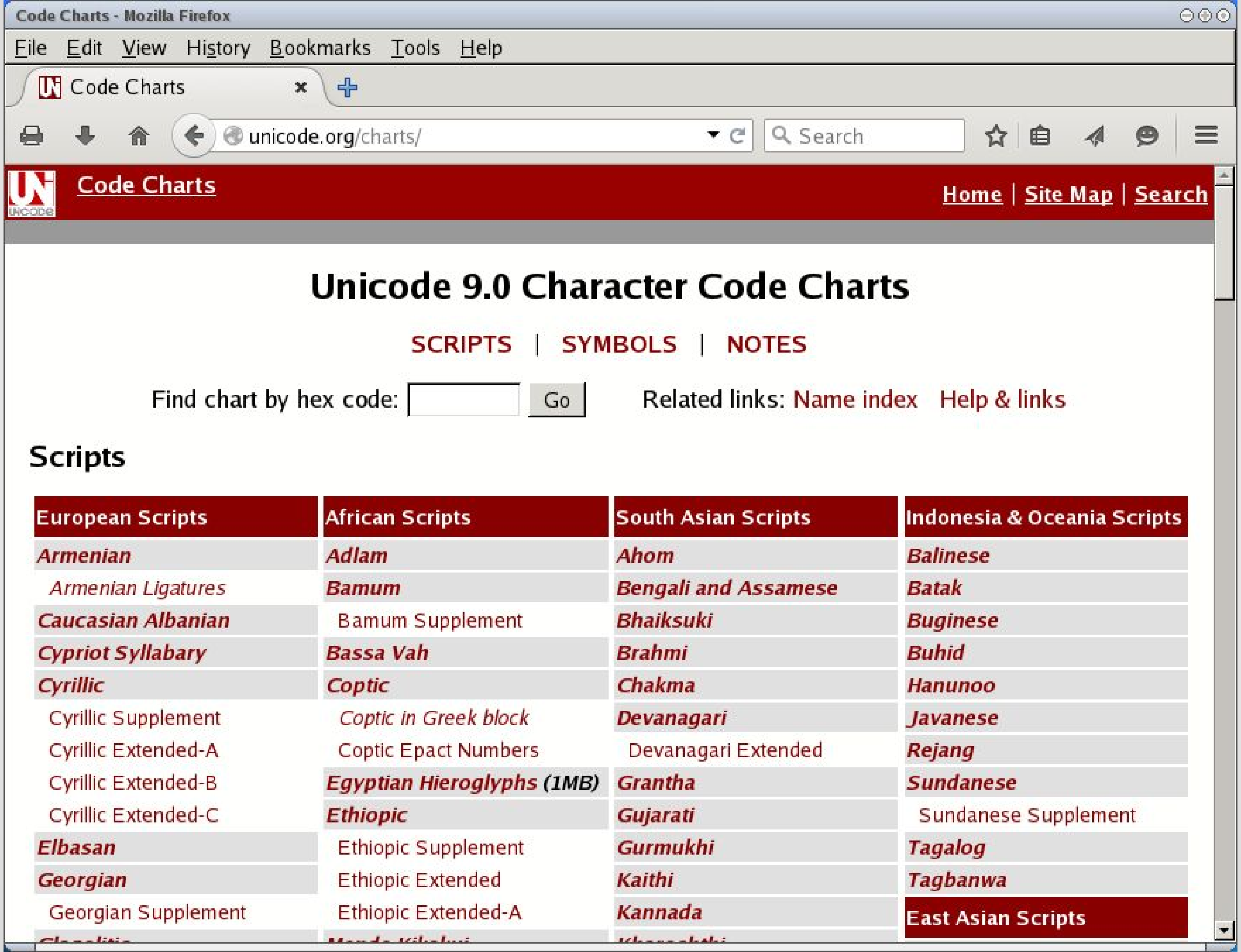
Code points written as “U+<hex digits>”
So U+41 = “A”

# American Standard Code for Information Interchange

Contains “control characters” and Glyphs



| Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 00 | Null | 32 | 20 | Space | 64 | 40 | @ | 96 | 60 | ` |
| 1 | 01 | Start of heading | 33 | 21 | ! | 65 | 41 | A | 97 | 61 | a |
| 2 | 02 | Start of text | 34 | 22 | " | 66 | 42 | B | 98 | 62 | b |
| 3 | 03 | End of text | 35 | 23 | # | 67 | 43 | C | 99 | 63 | c |
| 4 | 04 | End of transmit | 36 | 24 | $ | 68 | 44 | D | 100 | 64 | d |
| 5 | 05 | Enquiry | 37 | 25 | % | 69 | 45 | E | 101 | 65 | e |
| 6 | 06 | Acknowledge | 38 | 26 | & | 70 | 46 | F | 102 | 66 | f |
| 7 | 07 | Audible bell | 39 | 27 | ' | 71 | 47 | G | 103 | 67 | g |
| 8 | 08 | Backspace | 40 | 28 | ( | 72 | 48 | H | 104 | 68 | h |
| 9 | 09 | Horizontal tab | 41 | 29 | ) | 73 | 49 | I | 105 | 69 | i |
| 10 | 0A | Line feed | 42 | 2A | * | 74 | 4A | J | 106 | 6A | j |
| 11 | 0B | Vertical tab | 43 | 2B | + | 75 | 4B | K | 107 | 6B | k |
| 12 | 0C | Form feed | 44 | 2C | , | 76 | 4C | L | 108 | 6C | l |
| 13 | 0D | Carriage return | 45 | 2D | - | 77 | 4D | M | 109 | 6D | m |
| 14 | 0E | Shift out | 46 | 2E | . | 78 | 4E | N | 110 | 6E | n |
| 15 | 0F | Shift in | 47 | 2F | / | 79 | 4F | O | 111 | 6F | o |
| 16 | 10 | Data link escape | 48 | 30 | 0 | 80 | 50 | P | 112 | 70 | p |
| 17 | 11 | Device control 1 | 49 | 31 | 1 | 81 | 51 | Q | 113 | 71 | q |
| 18 | 12 | Device control 2 | 50 | 32 | 2 | 82 | 52 | R | 114 | 72 | r |
| 19 | 13 | Device control 3 | 51 | 33 | 3 | 83 | 53 | S | 115 | 73 | s |
| 20 | 14 | Device control 4 | 52 | 34 | 4 | 84 | 54 | T | 116 | 74 | t |
| 21 | 15 | Neg. acknowledge | 53 | 35 | 5 | 85 | 55 | U | 117 | 75 | u |
| 22 | 16 | Synchronous idle | 54 | 36 | 6 | 86 | 56 | V | 118 | 76 | v |
| 23 | 17 | End trans. block | 55 | 37 | 7 | 87 | 57 | W | 119 | 77 | w |
| 24 | 18 | Cancel | 56 | 38 | 8 | 88 | 58 | X | 120 | 78 | x |
| 25 | 19 | End of medium | 57 | 39 | 9 | 89 | 59 | Y | 121 | 79 | y |
| 26 | 1A | Substitution | 58 | 3A | : | 90 | 5A | Z | 122 | 7A | z |
| 27 | 1B | Escape | 59 | 3B | ; | 91 | 5B | [ | 123 | 7B | { |
| 28 | 1C | File separator | 60 | 3C | < | 92 | 5C | \ | 124 | 7C | \| |
| 29 | 1D | Group separator | 61 | 3D | = | 93 | 5D | ] | 125 | 7D | } |
| 30 | 1E | Record separator | 62 | 3E | > | 94 | 5E | ^ | 126 | 7E | ~ |
| 31 | 1F | Unit separator | 63 | 3F | ? | 95 | 5F | _ | 127 | 7F | □ |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# Unicode 9.0 Character Code Charts

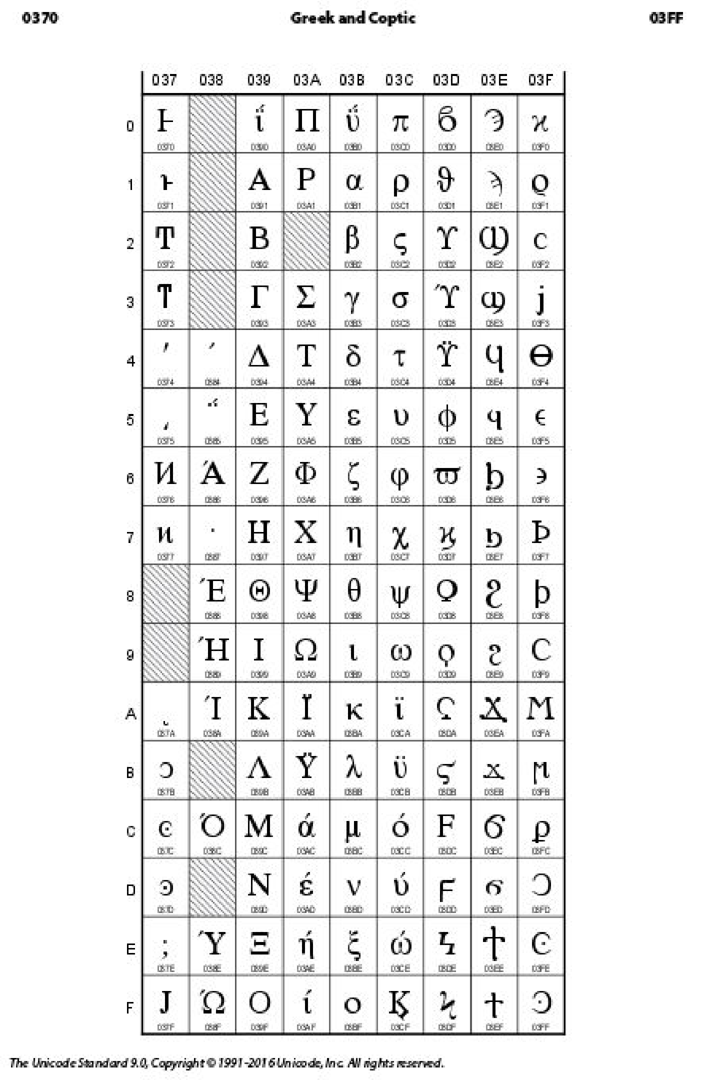
SCRIPTS | SYMBOLS | NOTES

Find chart by hex code: Go    Related links: Name index  Help & links

## Scripts

| European Scripts | African Scripts | South Asian Scripts | Indonesia & Oceania Scripts |
|---|---|---|---|
| ***Armenian*** | ***Adlam*** | ***Ahom*** | ***Balinese*** |
| *Armenian Ligatures* | ***Bamum*** | ***Bengali and Assamese*** | ***Batak*** |
| ***Caucasian Albanian*** | Bamum Supplement | ***Bhaiksuki*** | ***Buginese*** |
| ***Cypriot Syllabary*** | ***Bassa Vah*** | ***Brahmi*** | ***Buhid*** |
| ***Cyrillic*** | ***Coptic*** | ***Chakma*** | ***Hanunoo*** |
| Cyrillic Supplement | *Coptic in Greek block* | ***Devanagari*** | ***Javanese*** |
| Cyrillic Extended-A | Coptic Epact Numbers | Devanagari Extended | ***Rejang*** |
| Cyrillic Extended-B | ***Egyptian Hieroglyphs*** *(1MB)* | ***Grantha*** | ***Sundanese*** |
| Cyrillic Extended-C | ***Ethiopic*** | ***Gujarati*** | Sundanese Supplement |
| ***Elbasan*** | Ethiopic Supplement | ***Gurmukhi*** | ***Tagalog*** |
| ***Georgian*** | Ethiopic Extended | ***Kaithi*** | ***Tagbanwa*** |
| Georgian Supplement | Ethiopic Extended-A | ***Kannada*** | **East Asian Scripts** |

# Unicode Greek and Coptic



0370 **Greek and Coptic** 03FF

| | 037 | 038 | 039 | 03A | 03B | 03C | 03D | 03E | 03F |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Ͱ<br>0370 | | ΐ<br>0390 | Π<br>03A0 | ΰ<br>03B0 | π<br>03C0 | ϐ<br>03D0 | Ϡ<br>03E0 | ϰ<br>03F0 |
| 1 | ͱ<br>0371 | | Α<br>0391 | Ρ<br>03A1 | α<br>03B1 | ρ<br>03C1 | ϑ<br>03D1 | ϡ<br>03E1 | ϱ<br>03F1 |
| 2 | Ͳ<br>0372 | | Β<br>0392 | | β<br>03B2 | ς<br>03C2 | ϒ<br>03D2 | Ϣ<br>03E2 | ϲ<br>03F2 |
| 3 | ͳ<br>0373 | | Γ<br>0393 | Σ<br>03A3 | γ<br>03B3 | σ<br>03C3 | ϓ<br>03D3 | ϣ<br>03E3 | ϳ<br>03F3 |
| 4 | ʹ<br>0374 | ΄<br>0384 | Δ<br>0394 | Τ<br>03A4 | δ<br>03B4 | τ<br>03C4 | ϔ<br>03D4 | Ϥ<br>03E4 | ϴ<br>03F4 |
| 5 | ͵<br>0375 | ΅<br>0385 | Ε<br>0395 | Υ<br>03A5 | ε<br>03B5 | υ<br>03C5 | ϕ<br>03D5 | ϥ<br>03E5 | ϵ<br>03F5 |
| 6 | Ͷ<br>0376 | Ά<br>0386 | Ζ<br>0396 | Φ<br>03A6 | ζ<br>03B6 | φ<br>03C6 | ϖ<br>03D6 | Ϧ<br>03E6 | ϶<br>03F6 |
| 7 | ͷ<br>0377 | ·<br>0387 | Η<br>0397 | Χ<br>03A7 | η<br>03B7 | χ<br>03C7 | ϗ<br>03D7 | ϧ<br>03E7 | Ϸ<br>03F7 |
| 8 | | Έ<br>0388 | Θ<br>0398 | Ψ<br>03A8 | θ<br>03B8 | ψ<br>03C8 | Ϙ<br>03D8 | Ϩ<br>03E8 | ϸ<br>03F8 |
| 9 | | Ή<br>0389 | Ι<br>0399 | Ω<br>03A9 | ι<br>03B9 | ω<br>03C9 | ϙ<br>03D9 | ϩ<br>03E9 | Ϲ<br>03F9 |
| A | ͺ<br>037A | Ί<br>038A | Κ<br>039A | Ϊ<br>03AA | κ<br>03BA | ϊ<br>03CA | Ϛ<br>03DA | Ϫ<br>03EA | Ϻ<br>03FA |
| B | ͻ<br>037B | | Λ<br>039B | Ϋ<br>03AB | λ<br>03BB | ϋ<br>03CB | ϛ<br>03DB | ϫ<br>03EB | ϻ<br>03FB |
| C | ͼ<br>037C | Ό<br>038C | Μ<br>039C | ά<br>03AC | μ<br>03BC | ό<br>03CC | Ϝ<br>03DC | Ϭ<br>03EC | ϼ<br>03FC |
| D | ͽ<br>037D | | Ν<br>039D | έ<br>03AD | ν<br>03BD | ύ<br>03CD | ϝ<br>03DD | ϭ<br>03ED | Ͻ<br>03FD |
| E | ;<br>037E | Ύ<br>038E | Ξ<br>039E | ή<br>03AE | ξ<br>03BE | ώ<br>03CE | Ϟ<br>03DE | Ϯ<br>03EE | Ͼ<br>03FE |
| F | Ϳ<br>037F | Ώ<br>038F | Ο<br>039F | ί<br>03AF | ο<br>03BF | Ϗ<br>03CF | ϟ<br>03DF | ϯ<br>03EF | Ͽ<br>03FF |

Now we know how to find code points.

The unicode ‘Latin-1’ code chart is ASCII, without the control or extended characters.

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Each byte is a code point.

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Each byte is a code point.

This is the ASCII encoding

How to handle code points with more than eight bits?

Consider the capital Greek letter Delta Δ (0x0394)

# UTF-16 Encoding:  Two bytes per code point

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Two possibilities for 0x0394

| | | |
|---|---|---|
| UTF-16LE: | 0x94 0x03 | Little endian |
| UTF-16BE: | 0x03 0x94 | Big endian |

# How to tell which version you have?

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The “Byte Order Mark” (BOM)    U+FEFF

UTF-16LE strings start with    0xFF 0xFE
UTF-16BE strings start with    0xFE 0xFF

# UTF-8: A variable-length encoding

First rule: All printable ASCII characters are UTF-8 encoded

Second rule: High bits signal more bits to come

# How UTF-8 encodes glyphs

| First Byte | Second Byte | Third Byte | Fourth Byte | # of bits | Glyphs |
|---|---|---|---|---|---|
| 0xxxxxxx | | | | 7 | 0x7F = 127 |
| 110xxxxx | 10xxxxxx | | | 11 | 0x7FF = 2047 |
| 1110xxxx | 10xxxxxx | 10xxxxxx | | 16 | 0xFFFF = 65535 |
| 11110xxx | 10xxxxxx | 10xxxxxx | 10xxxxxx | 21 | 0x1FFFFF = 2,097,151 |

High bits of a start byte indicate how many bytes in glyph (maximum of six).

Glyph bits are extracted from the ‘x’ bits.

A byte of the form 10xx xxxx is always in the middle of a code sequence.

UTF-8 streams can be read backwards or starting from an arbitrary location

# Pros and Cons of different encodings

| | UTF-8 | UTF-16/32 |
|---|---|---|
| Memory usage | Compact | Wasteful |
| Processing speed | Slower | Faster |
| Self-synchronizing | Yes | No |
| Endian issues | No | Yes |
| Finding the nth glyph in a string | O(n) | O(1) |

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Create unicode ‘characters’ with unichr() built-in. Takes integer code point, returns a length-one unicode string.

Prefix constant string with ‘u’:    u’Make me Unicode!’

Put a literal unicode code point in a string via \uxxxx.    ‘Delta = \u0394’

Unicode strings are like regular python strings.

Unicode strings can be:

- Added (concatenated)
- Multiplied (replicated)
- Sliced: var[10], var[3:7]
- ord() works: `hex(ord(unichr(0x394)))` -> ‘`0x394`’

Method functions like

.find(), .rfind(), .count(), .replace(), .startswith(), .endswidth(), .center(), .ljust(), .rjust(), .lstrip(), .strip(), .rstrip(), .split(), .join() work as usual.

These functions operate on glyphs, not characters.

# One quick question, how are Python Unicode strings encoded?

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Answer:   It doesn’t matter!

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Answer:   It doesn’t matter!

Encoding comes in when we want to do Input or Output.

Unicode strings are encoded, with the `.encode()` method.
Encoding returns a regular python string.

# Example:

```
>>> def hexstr(x):
...    return ‘ ‘.join([ ‘%02X’ % ord(c) for c in x ])
...
>>> f = ‘Delta = ‘ + unichr(0x394)
>>> hexstr(f.encode(‘UTF-8’))
‘44 65 6C 74 61 20 3D 20 CE 94’
>>>
```

# Example:

```
>>> def hexstr(x):
...     return ‘ ‘.join([ ‘%02X’ % ord(c) for c in x ])
...
>>> f = ‘Delta = ‘ + unichr(0x394)
>>> hexstr(f.encode(‘UTF-8’))
‘44 65 6C 74 61 20 3D 20 CE 94’
>>>
>>> hexstr(f.encode(‘UTF-16’))
‘FF FE 44 00 65 00 6C 00 74 00 61 00 20 00 3D 00 20 00 94 03’
>>>
```

# Example:

```
>>> def hexstr(x):
...    return ‘ ‘.join([ ‘%02X’ % ord(c) for c in x ])
...
>>> f = ‘Delta = ‘ + unichr(0x394)
>>> hexstr(f.encode(‘UTF-8’))
‘44 65 6C 74 61 20 3D 20 CE 94’
>>>
>>> hexstr(f.encode(‘UTF-16’))
‘FF FE 44 00 65 00 6C 00 74 00 61 00 20 00 3D 00 20 00 94 03’
>>>
>>> hexstr(f.encode(‘UTF-16BE’))
‘00 44 00 65 00 6C 00 74 00 61 00 20 00 3D 00 20 03 94’
>>>
```

We use encode to write output (from Python).

We use decode for input (to Python).

```
>>> line = open(‘file’, ‘r’).readline()
>>> type(line)
<type ‘str’>
>>> type(line.decode(‘UTF-8’))
<type ‘unicode’>
>>>
```

# A slicker way to read a Unicode encoded file is:

```
import codecs
f_obj = codecs.openfile(‘filename’, encoding=’UTF-16’)
for line in f_obj:
   print line.encode(‘UTF-8’)

f_obj.close()
```

This translates a UTF-16 file to a UTF-8 file.

Incidentally, there is an ‘ASCII’ encoding that does what it sounds like.
Peek inside the `codecs` module to see the encodings.

Python source files can be encoded in Unicode!

The encoding must be specified in a comment on the first or second line.

```
#!/usr/bin/env python
# coding: UTF-8

f = ‘Delta is Δ!‘
print f
```

# Questions?