

LECTURE 7

STRINGS AND INTEGERS

MCS 260 Fall 2021

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REMINDERS

- Worksheet 3 available
- Project 1 description posted

BYTES

We've discussed the **bit** (b) or binary digit (0 or 1).

A **byte** (B) is a sequence of 8 bits, equivalently, an 8-digit binary number or a 2-digit hex number. It can represent an integer between $0=0x00$ and $255=0xff$.

Computers store information as sequences of bytes.

UNICODE

Basic problem: How to turn written language into a sequence of bytes?

Unicode (1991) splits this into two steps:

- Make a central directory of characters of most written languages; these are **code points**
- Specify ways to **encode** code points into sequences of bytes (not discussed today)

Every code point has a number (an integer between 0 and $0x10ffff=1,114,111$).

Code point numbers are always written $U+$ followed by *hexadecimal digits*.

$U+41$	A
$U+109$	â
$U+1f612$	🙄

The first 128 code points, $U+0$ to $U+7F$, include all "en-us" keyboard keys, and follow the ASCII code (1969).

STRINGS

In Python 3, a **str** is a sequence of code points.

Several syntaxes are supported for literals:

```
'Hello world' # single quotes
"Hello world" # double quotes

# multi-line string with triple single quote
'''This is a string
that contains line breaks'''

# multi-line string with triple double quote
"""François: How is MCS 260?
Binali: It's going ok. Too many slides.
François: ͇\_ (ツ) \_/͇"""
```

ESCAPE SEQUENCES

The `\` character has special meaning; it begins an **escape sequence**, such as:

- `\n` - the newline character
- `\'` - a single quote
- `\"` - a double quote
- `\\` - a backslash
- `\u0107` - Code point U+107
- `\U0001f612` - Code point U+1f612

(There is a [full list of escape sequences](#).)

Note `\` appears a lot in Windows paths!

OPERATIONS ON STRINGS

Most arithmetic operations forbid strings. Exceptions:

- `+` joins strings, e.g. `"cat"+"erpillar"`
- `*` joins a specified number of copies, e.g. `"doo"*6`

```
>>> "Hello" + " " + "world!"
'Hello world!'
>>> "Hello" - "llo"
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for -: 'str' and 'str'
>>> "Ha" * 4
'HaHaHaHa'
>>> prefix = "Dr. "
>>> fullname = "Ramanujan"
>>> prefix+fullname
'Dr. Ramanujan'
```

SEQUENCE STUFF

Reminder: Like lists, strings are sequences.

You can use indexing to get individual characters, slices to get substrings, and `len(...)` to get the length.

STR

Python's `str()` function converts **any** other value to a string, e.g.

```
>>> str(5678)
'5678'
>>> str(5678)[1]
'6'
>>> int(str(5678)[1])
6
```

`str()` is rarely needed, but it does give a way to access decimal digits of an integer individually.

INT

When converting from a string, `int()` defaults to base 10. But it supports other bases as well. The base is given as the second **argument** of the function.

```
>>> int("1001",2)
9
>>> int("3e",16)
62
```

Integer literal prefixes you'd use in code (`0b`, `0x`, etc.) *must not be present* here. The `int()` function works with *just digits* when you specify the base.

However, if a base of 0 is specified, then this signals that the string should be read as a Python literal, i.e. the base is determined by its prefix.

```
>>> int("0b1001",0)
9
>>> int("0x3e",0)
62
>>> int("77",0)
77
```

BITWISE OPERATORS

There are certain operators that only work on ints, and which are based on the bits in the binary expression:

<<	>>	&		^
left shift	right shift	bitwise AND	bitwise OR	bitwise XOR

$a \ll b$ moves the bits of a **left** by b positions.

$a \gg b$ moves the bits of a **right** by b positions.

(This destroys the lowest b bits of a .)

```
>>> 9 << 3 # 9 = 0b1001 becomes 0b1001000 = 72
72
>>> 7 << 1 # 7 = 0b111 becomes 0b1110 = 14
14
>>> 9 >> 2 # 9 = 0b1001 becomes 0b10
2
```

Notice $a \ll b$ is equivalent to $a * 2^{**}b$.

Bitwise AND compares corresponding bits, and the output bit is 1 if both input bits are 1:

```
>>> 9 & 5 # 9 = 0b1001, 5 = 0b0101  
1
```

	1	0	0	1
	<hr/>			
	0	1	0	1
	<hr/>			
AND:	0	0	0	1

Bitwise OR is similar, but the output bit is 1 if at least one of the input bits is 1.

```
>>> 9 | 5 # 9 = 0b1001, 5 = 0b0101  
13
```

	1	0	0	1
	<hr/>			
	0	1	0	1
	<hr/>			
OR:	1	1	0	1

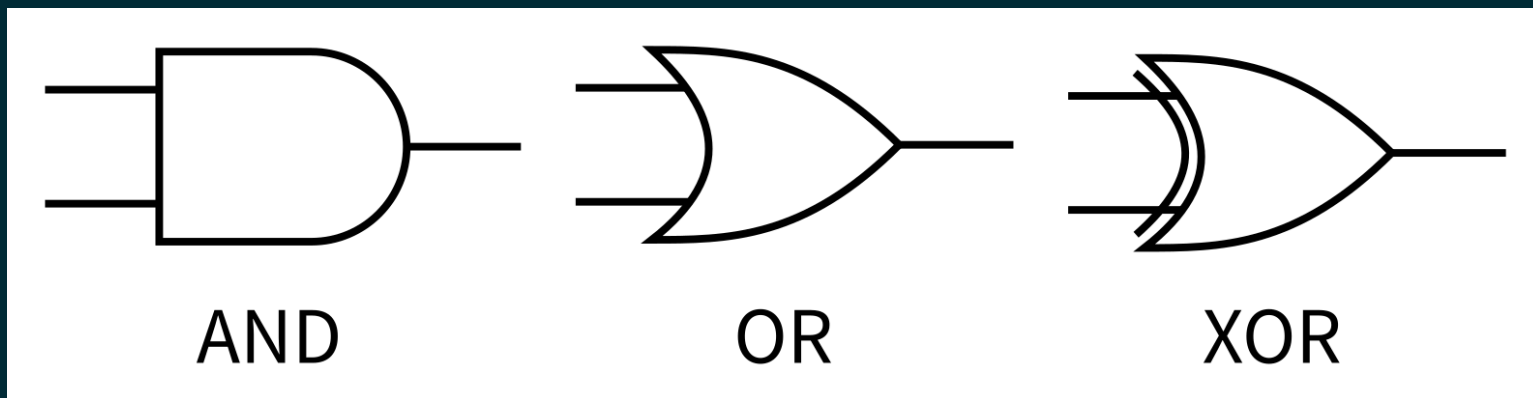
Bitwise XOR makes the output bit 1 if *exactly one* of the input bits is 1.

```
>>> 9 ^ 5 # 9 = 0b1001, 5 = 0b0101
12
```

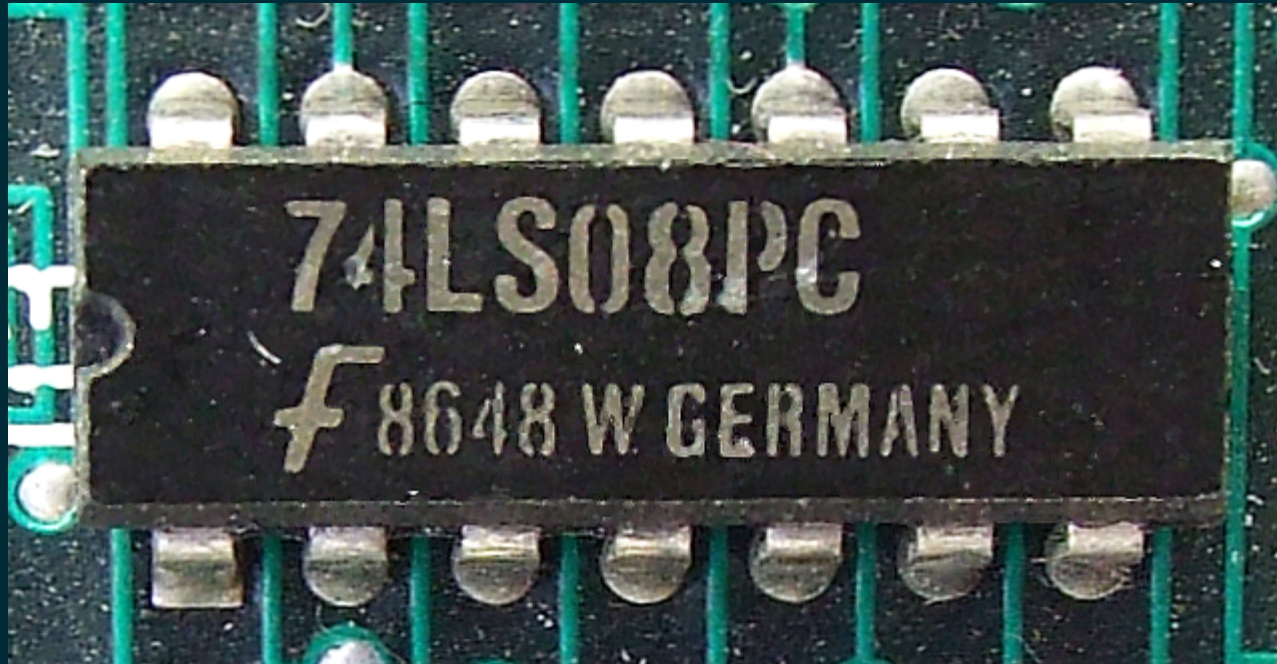
	1	0	0	1
	<hr/>			
	0	1	0	1
	<hr/>			
XOR:	1	1	0	0

LOGIC GATES

Circuits that perform logic operations on bits, **logic gates**, are fundamental building blocks of computers.



Thus the Python operators `<<`, `>>`, `&`, `|`, `^` are especially low-level operations.



74LS08PC photo by Trio3D CC-BY-SA 3.0

This chip (or **integrated circuit** / IC) contains four AND gates built from about 50 transistors. The processor in an iPhone 11 has about 8,500,000,000 transistors.

REFERENCES

- [Official Unicode code point charts](#)
- In *Downey*: Strings are discussed in [Section 2.6](#) and [Chapter 8](#)
- [Bitwise operations in the Python 3 documentation](#)
- The `int()` feature of converting from strings in other bases is also discussed in the [Python 3 documentation](#).
- Bitwise operations and logic gates are discussed in sections 1.1 and 2.4 of [Brookshear & Brylow](#).

REVISION HISTORY

- 2021-09-08 Initial publication
- 2021-09-09 Fix typo

