COMP110: Principles of Computing

3: Basic data types

Data types

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  - How the data is stored in memory
  - What operations can be done on it

Memory

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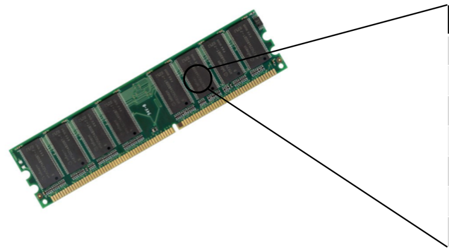

Address	Data
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3	01101100
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...	...

- Memory works like a set of **boxes**

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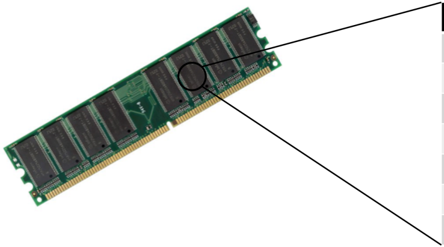

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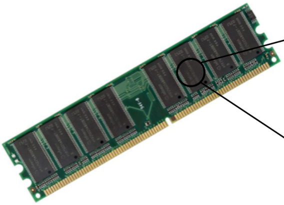

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- Memory works like a set of **boxes**
- Each box has a number, its **address**
- Each box contains a **byte** (8 bits)

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  - Sequence of numbers between 0–255

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Numeric types

Integers

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- Stored in memory using binary notation, with 2's complement for negative values

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- You can think of this as a base-256 numbering system

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- However it is more efficient when programs need to convert one size of integer to another

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- (Note: `float` in Python 3 has the same precision as `double` in C++/C#/etc)

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  - However == etc still know how to compare them sensibly

Other number formats

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- Broadly speaking, a single **printable symbol**
- There are also some special **non-printable characters** e.g. line break

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Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value
00	NUL	10	DLE	20	SP	30	0	40	@	50	P	60	`	70	p
01	SOH	11	DC1	21	!	31	1	41	A	51	Q	61	a	71	q
02	STX	12	DC2	22	"	32	2	42	B	52	R	62	b	72	r
03	ETX	13	DC3	23	#	33	3	43	C	53	S	63	c	73	s
04	EOT	14	DC4	24	$	34	4	44	D	54	T	64	d	74	t
05	ENQ	15	NAK	25	%	35	5	45	E	55	U	65	e	75	u
06	ACK	16	SYN	26	&	36	6	46	F	56	V	66	f	76	v
07	BEL	17	ETB	27	'	37	7	47	G	57	W	67	g	77	w
08	BS	18	CAN	28	(	38	8	48	H	58	X	68	h	78	x
09	HT	19	EM	29	)	39	9	49	I	59	Y	69	i	79	y
0A	LF	1A	SUB	2A	*	3A	:	4A	J	5A	Z	6A	j	7A	z
0B	VT	1B	ESC	2B	+	3B	;	4B	K	5B	[	6B	k	7B	{
0C	FF	1C	FS	2C	,	3C	<	4C	L	5C	\	6C	l	7C	|
0D	CR	1D	GS	2D	-	3D	=	4D	M	5D	]	6D	m	7D	}
0E	SO	1E	RS	2E	.	3E	>	4E	N	5E	^	6E	n	7E	~
0F	SI	1F	US	2F	/	3F	?	4F	O	5F	_	6F	o	7F	DEL

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- However 256 characters isn't enough...

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- Also covers mathematical symbols and emoji

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  - More common Unicode characters are smaller $\implies$ more efficient than UTF-32

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H	a	h	a	space	😂				null
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- String literals are wrapped in `'single quotes'` or `"double quotes"` (there is no difference)

Escape sequences

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- How to type a backslash character? Use `"\\"`

String literal tricks in Python

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String literal tricks in Python

- Use triple quotes `'''` or `"""` for a multi-line string
- Use `r" "` or `r' '` to turn off escape characters (useful for strings with lots of backslashes, e.g. Windows file paths, regular expressions)

Text files

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    - Most languages allow files to be opened in “text mode” which automatically converts

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- Python type: `bool`
- In Python, we have the keywords `True` and `False`
- Could be represented by a single bit in memory...
- ... but since memory is addressed in bytes (or words of multiple bytes), usually represented as an `int` with 0 meaning `False` and any non-zero (e.g. 1) meaning `True`

Boolean values

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- Variables can also store boolean values:

```
result = (x > 10)    # result now stores True or False
if result:
    print(x)
```

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- Note that `type()` returns a value of type `type`
- You can use these `type` values like any other value, e.g.

```
if type(x) == int:
    print("x has type int")
elif type(x) == type(y):
    print("x and y have the same type")
```

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  - Functions, modules, classes, exceptions, ...

Converting types

Weak vs strong typing

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  - Examples: Python, JavaScript
- In **strongly typed** languages, the type of a variable must be **declared**
  - Examples: C#, C++, Java

Weak typing (example in Python)

```python
x = 7
# Now x has type int

x = "hello"
# Now x has type string
```

Strong typing (example in C#)

```
int x = 7;
// x is declared with type int

x = "hello";
// Compile error: cannot convert type "string" to "int"
```

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    - `str(1 + 1 == 2)` → `"True"`

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  - `str(1 + 1 == 2)` → `"True"`
  - `int("123")` → `123`

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- It is often useful to **cast**, or **convert**, a value from one type to another
- In Python, this is done by calling the type as if it were a function
  - `float(17)` → `17.0`
  - `int(3.14)` → `3`
  - `str(3.14)` → `"3.14"`
  - `str(1 + 1 == 2)` → `"True"`
  - `int("123")` → `123`
  - `int("five")` gives an error

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- Can't add string and int: `"COMP" + 110` → error

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- Sometimes called **type coercion**
- E.g. in JavaScript, `"COMP" + 110` → `"COMP110"`
- The integer `110` is implicitly converted to a string `"110"` to make the addition work
- Equivalent in Python with explicit casts:

```
"COMP" + str(110)
```

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- E.g. in JavaScript:
  - `"5" + 3` $\rightarrow$ `"53"`
  - `"5" - 3` $\rightarrow$ 2

Worksheet 3

- Flowcharts and pseudocode
- Due **next Friday**