Computational Basics

Representing Process & Data
Recap
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- Late adds need to see the FAQ
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i>clickers start 1/30
What is a program?

A set of instructions a computer executes to achieve a goal. For us, "programming" = "computing" = "coding".
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Recall our four elements of computing:
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- **Storage**—punch cards, tape, drives, RAM
- **Control**—punch cards, gears, vacuum tubes, transistors
- **Communication**—network
We can reframe these:

- Data
- Control
What is data?

Information stored in a computer.

All data is stored in binary.
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  - value (number, character)
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```
00000001 00101010 01000000 00100000
add $t0, $t1, $t2
```
What is a program?

- Programs are data!
- Instructions are encoded in binary.

- High-level languages express things more like humans.
- Low-level languages are “closer to the metal”.

```
00000001 00101010 01000000 00100000
add $t0, $t1, $t2
x = y + z
```
Elements of Programs
F = 112  # deg F
C = (F-32) * 5/9
print( F,' deg F is ',C,' deg C.' )
assert C == (400/9)
What is a **literal**?

- **Fixed value (noun)**
- Represents data that doesn’t change (3 or 'firefly')
Executing a literal?

processor
Executing a literal?

3 → processor
Executing a literal?

```
3
processor
3
```
What is an **operator**?

- Manipulates data (verb)
Executing an operator?
It needs a statement to make sense!

* processor

!?
What is an expression?

- Combines literals and operators (phrase)
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- Produce a new value
  - $3 \times 5$
  - $100 - 23$
Executing an expression?

3 + 5 → processor
Executing an expression?

3 + 5 ➔ processor ➔ 8
What is an expression?

- Can be arbitrarily complicated
  - $3 + 8 \times 5 + 4 - \frac{7}{100}$
Question

$1 + 1 \times 2 = ?$

A. 4
B. 3
C. Something else


**Question**

\[ 23 + \frac{6}{2} - 4 = ? \]

A. 22  
B. 18  
C. -9  
D. Something else
Use parentheses!

23 + (6/2) − 4 is always clearer.
What are some other operators?

- exponentiation, **
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- exponentiation, **
- modulus, % (important)
What are some other operators?

- exponentiation, **
- modulus, % (important)
- floor division, //
What are some other operators?

- bitwise OR, `|`
- bitwise XOR, `^`
- bitwise AND, `&`
- bitwise left shift, `<<`
- bitwise right shift, `>>`
Example

$1^2 = ?$

A 0
B 1
C 2
D 3
The machine state hasn’t changed.
The machine state hasn’t changed.
Programs are complex, and we need to remember results.
How do we keep values around?

- Memory
- Processor
How do we keep values around?
How do we reuse values?

Low-level languages refer directly to memory address:

ADD DATA AT 10101101 11010100
TO DATA AT 11010100 01001001
STORE RESULT AT 00001101 01001110
What is a variable?

The solution: name memory locations!
What is a **variable**?

- The solution: *name memory locations!*
- Variables name a memory location
What is a variable?

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- Variables store a value
What is a variable?

- The solution: name memory locations!
- Variables name a memory location
- Variables store a value
- This value can change over time—it is a placeholder.
What new operator do we need?

- assignment, = (single equals sign)
How do we reuse values?

\[ x = 5 \]

memory

processor
How do we reuse values?

\[ x = 5 \]

memory

\[ x = 5 \]
How do we reuse values?

ElementsofPrograms

```
memory
x = 5

x + 1

processor
```
How do we reuse values?

\[ x + 1 \]

memory

\[ x = 5 \]

processor
How do we reuse values?

$\text{x + 1}$

memory

$x = 5$

processor

6
What value is stored in the variable $x$?

$x = 17 + 7 \times 9$

A 3
B 31
C 55
D 78
What value is stored in the variable $x$?

$x = 17 + 7 \times 9$

$x = 3$

A 0
B 1
C 2
D 3
What is a **statement**?

- A statement changes the state of the computer (sentence)
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- A statement changes the state of the computer (sentence)
- Example: an assignment
A first program

```python
x = 10
y = x ** 2
y = y + y
```
How can I use Python?

- Obtain a distribution of Python 3.
  - We recommend Anaconda.
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- We recommend Anaconda.
- HPL uses Py2–Py3 print needs parentheses!
Write code in one of three ways:
How can I use Python?

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  - Directly (`python.exe`)
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  - Script (text editor)
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- Write code in one of three ways:
  - Directly (`python.exe`)
  - Script (text editor)
  - Jupyter (IPython) notebook (as in labs)
What is a program?

- Programs consist of series of statements:
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  - A script is a file containing a series of Python statements.
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  - A notebook (as we use in the lab) also collects series of Python statements.
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- Programs consist of series of statements:
  - A script is a file containing a series of Python statements.
  - A notebook (as we use in the lab) also collects series of Python statements.
  - These are stored in text (there’s no magic, just text).
What is a *program*?

- Programs consist of series of statements:
  - A script is a file containing a series of Python statements.
  - A notebook (as we use in the lab) also collects series of Python statements.
  - These are stored in text (there’s no magic, just text).

- Each instruction is executed in order from top to bottom—together, these statements make up a program.
Next steps
Next steps

- Acquire course materials
- Register i>clicker on Compass
- Complete hw00, hw01 (due 1/30)
- Attend your first lab
- Read for the next class