Announcements

- go.illinois.edu/cs101
- exam1 available through Saturday
- Prior assignments due today.
Spreadsheets Redux
=-B5^2
Assume that B5 has the value 5. What is the result of the above expression?

A  25
B  -25
\[-B5^2\]

Assume that B5 has the value 5. What is the result of the above expression?

A 25 ★ (Spreadsheets are odd!)
B -25
Solving equations

\[ x^3 + x^2 + x = x^{-1} + 1 \]

- Set a cell for \( x \).
- Calculate the left-hand side dependent on \( x \).
- Calculate the right-hand side dependent on \( x \).
- Calculate the difference of RHS and LHS.
- Use Goal Seek to set the difference to zero by varying \( x \).
Solving equations
Solving equations

Spreadsheets Redux
Representation
What is a program?

A set of instructions a computer executes to achieve a goal. For us, “programming” = “computing” = “coding.”
What is a program?

- A set of instructions a computer executes to achieve a goal.
A set of instructions a computer executes to achieve a goal.

For us, “programming” = “computing” = “coding”.
Recall our four elements of computing:

- **Calculation**—mathematics, physics
- **Storage**—punch cards, tape, drives, RAM
- **Control**—punch cards, gears, vacuum tubes, transistors
- **Communication**—network
We can reframe these into two aspects:

- **Data**
- **Control**
What is data?

Representation

Information stored in a computer. All data is stored in binary.
What is data?

- Information stored in a computer.
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Representation
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- All data is stored in binary.
What is data?

- Binary data must be interpreted:
  - value (number, character)
What is data?

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  - value (number, character)
  - memory location
  - instruction
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What is a program?

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

Instructions are encoded in binary.

add $t0, $t1, $t2
What is a program?

Representation

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What is a program?

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

```
000000001 00101010 01000000 00100000
add $t0, $t1, $t2
= B5 + B6
```
What is a program?

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

representation

```
00000001 00101010 01000000 00100000
add $t0, $t1, $t2
=B5+B6
x = y + z
```
What is a program?

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

```
000000001 00101010 01000000 00100000
add $t0, $t1, $t2
= B5+B6
x = y + z
```

- High-level languages express things more like humans.
- Low-level languages are “closer to the metal”.
Elements of Programs
### A simple program

<table>
<thead>
<tr>
<th>DEG F</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEG C</td>
<td>((B1 - 32) \times \frac{5}{9})</td>
</tr>
<tr>
<td><strong>TEST:</strong> 100 C = 212 F</td>
<td></td>
</tr>
</tbody>
</table>
A simple program

```python
F = 212  # deg F
C = (F-32) * 5/9  # deg C
print( F, 'deg F is ',C,' deg C.' )
assert C == 100
```
A simple program

F = 212      # deg F
C = (F-32) * 5/9  # deg C
print( F,' deg F is ',C,' deg C.' )
assert C == 100

- Note the structure here.
- Structure—syntax—is explicit!
What is a literal?

- Fixed value (noun)
- Represents data that doesn’t change (3 or ‘firefly’)

Elements of Programs
What is an operator?

- Manipulates data (verb)
What is an expression?

- Combines literals and operators (phrase)
What is an expression?

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

- Can be arbitrarily complicated
  - $3 + 8\times5 + 4 - 7/100$
1 + 1 * 2 = ?
A 4
B 3
C Something else
Question

$1 + 1 \times 2 = ?$

A 4
B 3 * Order of operations
C Something else
23 + 6/2 - 4 = ?

A 22
B 18
C -9
D None of these are correct.
Question

\[ 23 + 6/2 - 4 = ? \]

A 22  ✗ Again, OOO
B 18
C -9
D None of these are correct.
Use parentheses!

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

- exponentiation, **

Elements of Programs
What are some other operators?

- 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, >>
What are some other operators?

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You don’t need to know these, but—
$1^2 = ?$

A 0
B 1
C 2
D 3
Example

\[
1 \ ^\ 2 \ \equiv \\
\begin{align*}
A & \ 0 \\
B & \ 1 \\
C & \ 2 \\
D & \ 3 \ \star! \ XOR, \ NOT \ exponentiation!
\end{align*}
\]
The machine state hasn’t changed just because of an expression.
So what?

- The machine state hasn’t changed just because of an expression.
- Programs are complex, and we need to remember results.
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?

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- Variables name a memory location
What is a variable?

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- Variables store a value
What is a variable?

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- 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?
What new operator do we need?

- assignment, = (single equals sign)
What value is stored in the variable $x$?

$x = 17 + 7 \times 9$

A 3
B 31
C 80
D 216
What value is stored in the variable $x$?

$x = 17 + 7 \times 9$

A 3
B 31
C 80 ★
D 216
What value is stored in the variable $x$?
$x = 17 + 7 \times 9$
$x = 3$

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

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

\[
x = 10 \\
y = x ** 2 \\
y = y + y
\]
What is a comment?

- A comment is ignored by the interpreter
What is a comment?

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- Example: `# anything after a hash`
What is a **keyword**?

- A keyword is a reserved word with a special meaning to Python
- Shown with bold or coloured type.
What is a keyword?

- A keyword is a reserved word with a special meaning to Python.
- Shown with bold or coloured type.
- Example: `for`, `in`, `assert`
How can I use Python?

- Obtain a distribution of Python 3.
  - We recommend Anaconda.
How can I use Python?

- Obtain a distribution of Python 3.
  - We recommend Anaconda.
  - HPL uses Py2—Py3 print needs parentheses!
How can I use Python?

- 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?

Elements of Programs
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.
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