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# WELCOME!

(download slides and .py files and follow along!)

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6.0001 LECTURE 1

# TODAY

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- course info
- what is computation
- python basics
- mathematical operations
- python variables and types
- NOTE: **slides and code files up before each lecture**
  - highly encourage you to download them before lecture
  - take notes and run code files when I do
  - bring computers to answer **in-class practice exercises!**

# COURSE INFO

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## ■ Grading

- approx. 20% Quiz
- approx. 40% Final
- approx. 30% Problem Sets
- approx. 10% MITx Finger Exercises

# COURSE POLICIES

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- Collaboration
  - may collaborate with anyone
  - required to write code independently and write names of all collaborators on submission
  - we will be running a code similarity program on all psets
- Extensions
  - **no extensions**
  - **late days**, see course website for details
  - **drop and roll** weight of max two psets in final exam grade
  - should be EMERGENCY use only

# RECITATIONS

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- not mandatory

- two flavors

- 1) Lecture review: **review** lecture material

- if you missed lecture
- if you need a different take on the same concepts

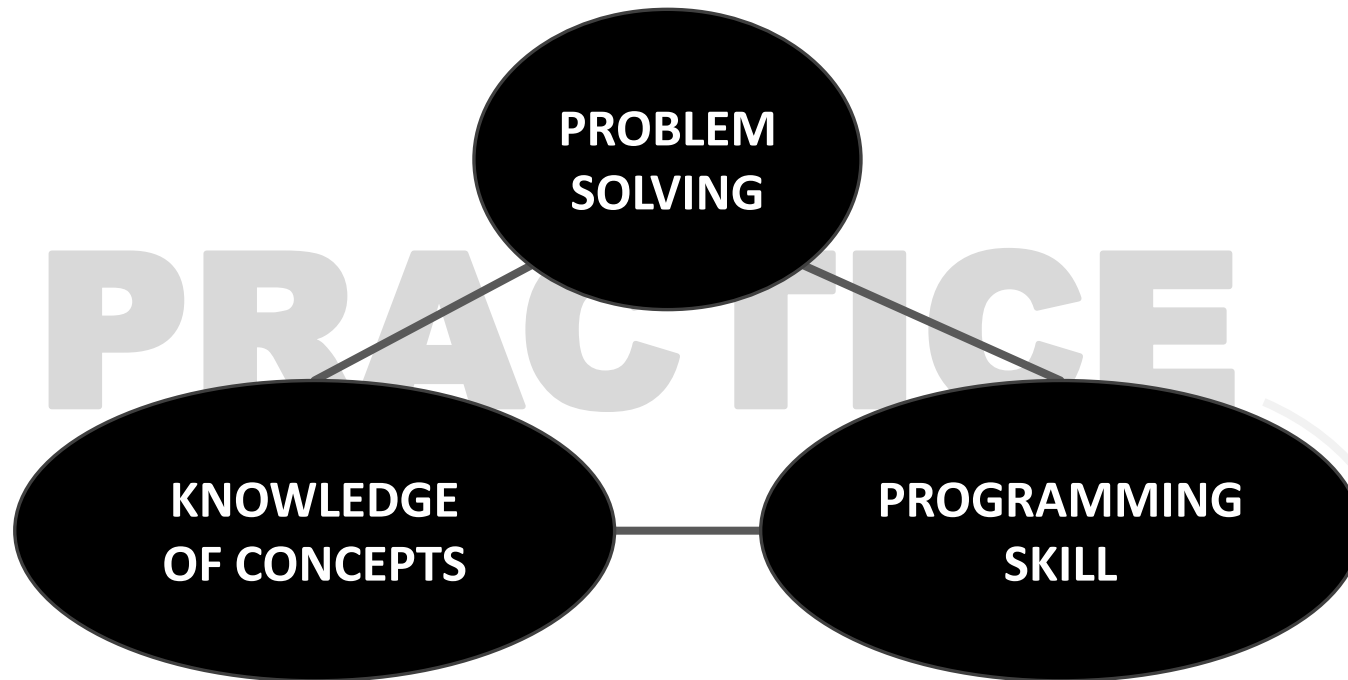
- 2) Problem solving: teach you **how to solve** programming problems

- useful if you don't know how to set up pseudocode from pset words
- we show a couple of harder questions
- walk you through how to approach solving the problem
- brainstorm code solution along with the recitation instructor
- will post solutions after

# FAST PACED COURSE

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- Position yourself to succeed!
  - **read psets when they come out** and come back to them later
  - use late days in emergency situations
- New to programming? **PRACTICE. PRACTICE? PRACTICE!**
  - can't passively absorb programming as a skill
  - download code before lecture and follow along
  - do MITx finger exercises
  - don't be afraid to try out Python commands!



# TOPICS

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- represent knowledge with **data structures**
- **iteration and recursion** as computational metaphors
- **abstraction** of procedures and data types
- **organize and modularize** systems using object classes and methods
- different classes of **algorithms**, searching and sorting
- **complexity** of algorithms



# WHAT DOES A COMPUTER DO

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- Fundamentally:
  - performs **calculations**  
a billion calculations per second!
  - **remembers** results  
100s of gigabytes of storage!
- What kinds of calculations?
  - **built-in** to the language
  - ones that **you define** as the programmer
- computers only know what you tell them

# TYPES OF KNOWLEDGE

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- **declarative knowledge** is **statements of fact**.
  - someone will win a Google Cardboard before class ends
- **imperative knowledge** is a **recipe** or “how-to”.
  - 1) Students sign up for raffle
  - 2) Ana opens her IDE
  - 3) Ana chooses a random number between 1<sup>st</sup> and n<sup>th</sup> responder
  - 4) Ana finds the number in the responders sheet. Winner!

# A NUMERICAL EXAMPLE

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- square root of a number  $x$  is  $y$  such that  $y * y = x$
- recipe for deducing square root of a number  $x$  (16)
  - 1) Start with a **guess**,  $g$
  - 2) If  $g * g$  is **close enough** to  $x$ , stop and say  $g$  is the answer
  - 3) Otherwise make a **new guess** by averaging  $g$  and  $x/g$
  - 4) Using the new guess, **repeat** process until close enough

$g$	$g * g$	$x/g$	$(g + x/g) / 2$
3	9	$16/3$	4.17
4.17	17.36	3.837	4.0035
4.0035	16.0277	3.997	4.000002

# WHAT IS A RECIPE

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- 1) sequence of simple **steps**
- 2) **flow of control** process that specifies when each step is executed
- 3) a means of determining **when to stop**

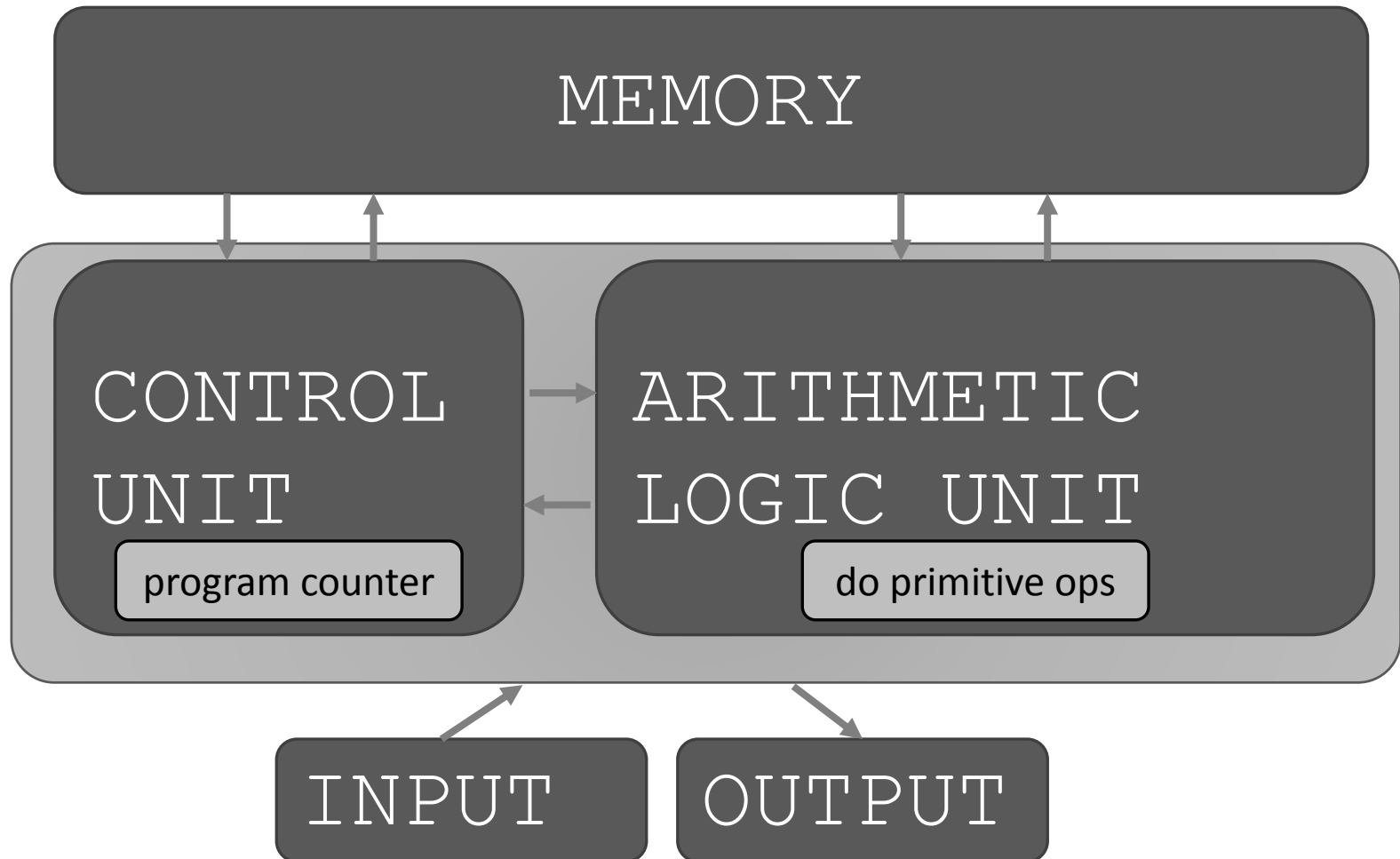
$1+2+3$  = an **algorithm**!

# COMPUTERS ARE MACHINES

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- how to capture a recipe in a mechanical process
- **fixed program** computer
  - calculator
- **stored program** computer
  - machine stores and executes instructions

# BASIC MACHINE ARCHITECTURE



# STORED PROGRAM COMPUTER

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- sequence of **instructions stored** inside computer
  - built from predefined set of primitive instructions
    - 1) arithmetic and logic
    - 2) simple tests
    - 3) moving data
- special program (interpreter) **executes each instruction in order**
  - use tests to change flow of control through sequence
  - stop when done

# BASIC PRIMITIVES

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- Turing showed that you can **compute anything** using 6 primitives
- modern programming languages have more convenient set of primitives
- can abstract methods to **create new primitives**
- anything computable in one language is computable in any other programming language



# CREATING RECIPES

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- a programming language provides a set of primitive **operations**
- **expressions** are complex but legal combinations of primitives in a programming language
- expressions and computations have **values** and meanings in a programming language

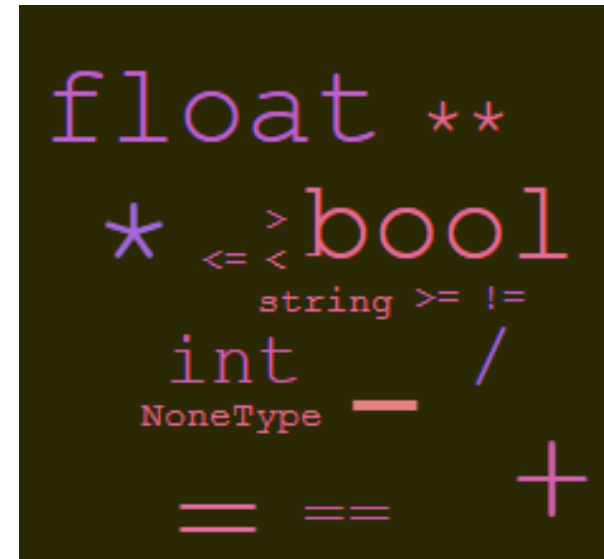
# ASPECTS OF LANGUAGES

- **primitive constructs**

- English: words
- programming language: numbers, strings, simple operators



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# ASPECTS OF LANGUAGES

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## ■ **syntax**

- English: "cat dog boy" → not syntactically valid  
"cat hugs boy" → syntactically valid
- programming language: "hi"5 → not syntactically valid  
3.2\*5 → syntactically valid

# ASPECTS OF LANGUAGES

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- **static semantics** is which syntactically valid strings have meaning
  - English: "I are hungry" → syntactically valid  
but static semantic error
  - programming language:  $3.2 * 5$  → syntactically valid  
 $3 + "hi"$  → static semantic error

# ASPECTS OF LANGUAGES

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- **semantics** is the **meaning** associated with a syntactically correct string of symbols with no static semantic errors
  - English: can have many meanings "Flying planes can be dangerous"
  - programming languages: have only one meaning but may not be what programmer intended

# WHERE THINGS GO WRONG

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- **syntactic errors**

- common and easily caught

- **static semantic errors**

- some languages check for these before running program
- can cause unpredictable behavior

- no semantic errors but **different meaning than what programmer intended**

- program crashes, stops running
- program runs forever
- program gives an answer but different than expected

# PYTHON PROGRAMS

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- a **program** is a sequence of definitions and commands
  - definitions **evaluated**
  - commands **executed** by Python interpreter in a shell
- **commands** (statements) instruct interpreter to do something
- can be typed directly in a **shell** or stored in a **file** that is read into the shell and evaluated
  - Problem Set 0 will introduce you to these in Anaconda

# OBJECTS

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- programs manipulate **data objects**
- objects have a **type** that defines the kinds of things programs can do to them
  - Ana is a human so she can walk, speak English, etc.
  - Chewbacca is a wookiee so he can walk, “mwaaarhrhh”, etc.
- objects are
  - scalar (cannot be subdivided)
  - non-scalar (have internal structure that can be accessed)



# SCALAR OBJECTS

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- `int` – represent **integers**, ex. 5
- `float` – represent **real numbers**, ex. 3.27
- `bool` – represent **Boolean** values `True` and `False`
- `NoneType` – **special** and has one value, `None`
- can use `type()` to see the type of an object

```
>>> type(5)
```

```
int
```

```
>>> type(3.0)
```

```
float
```

*what you write into  
the Python shell*

*what shows after  
hitting enter*

# TYPE CONVERSIONS (CAST)

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- can **convert object of one type to another**
- `float(3)` converts integer 3 to float 3.0
- `int(3.9)` truncates float 3.9 to integer 3

# PRINTING TO CONSOLE

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- to show output from code to a user, use `print` command

In [11]: 3+2  
Out [11]: 5

*“Out” tells you it’s an  
interaction within the  
shell only*

In [12]: `print(3+2)`  
5

*No “Out” means it is  
actually shown to a user,  
apparent when you  
edit/run files*

# EXPRESSIONS

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- **combine objects and operators** to form expressions
- an expression has a **value**, which has a type
- syntax for a simple expression  
`<object> <operator> <object>`

# OPERATORS ON ints and floats

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- $i + j$  → the **sum**
  - $i - j$  → the **difference**
  - $i * j$  → the **product**
  - $i / j$  → **division**
- if both are ints, result is int  
if either or both are floats, result is float
- result is float
- 
- $i \% j$  → the **remainder** when  $i$  is divided by  $j$
  - $i ** j$  →  $i$  to the **power** of  $j$

# SIMPLE OPERATIONS

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- parentheses used to tell Python to do these operations first
- **operator precedence** without parentheses
  - \*\*
  - \*
  - /
  - + and – executed left to right, as appear in expression

# BINDING VARIABLES AND VALUES

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- equal sign is an **assignment** of a value to a variable name

*variable*  
`pi` = `3.14159`  
*value*

`pi_approx = 22/7`

- value stored in computer memory
- an assignment binds name to value
- retrieve value associated with name or variable by invoking the name, by typing `pi`

# ABSTRACTING EXPRESSIONS

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- why **give names** to values of expressions?
- to **reuse names** instead of values
- easier to change code later

```
pi = 3.14159  
radius = 2.2  
area = pi*(radius**2)
```



# PROGRAMMING vs MATH

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- in programming, you do not “solve for x”

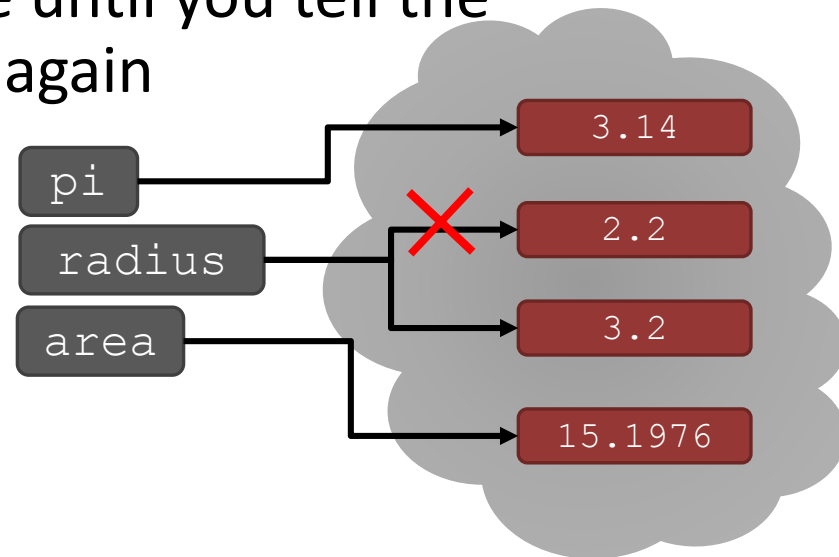
```
pi = 3.14159
radius = 2.2
# area of circle
area = pi*(radius**2)
radius = radius+1
```

*an assignment  
\* expression on the right, evaluated to a value  
\* variable name on the left  
\* equivalent expression to  $\text{radius} = \text{radius} + 1$   
is  $\text{radius} += 1$*

# CHANGING BINDINGS

- can **re-bind** variable names using new assignment statements
- previous value may still stored in memory but lost the handle for it
- value for area does not change until you tell the computer to do the calculation again

```
pi = 3.14
radius = 2.2
area = pi*(radius**2)
radius = radius+1
```



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6.0001 Introduction to Computer Science and Programming in Python  
Fall 2016

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