



Expressions

CS106A, Stanford University

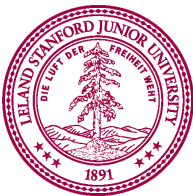
Express Yourself With Code

"I was able to work with a team of Peruvian faculty on building and coding a rapid response ventilator system for patients with COVID-19. After weeks of hard work and tinkering, our team achieved excellent results in tests by doctors and now we got approval from the Peruvian health ministry to move on with the production of our first thousand ventilators."

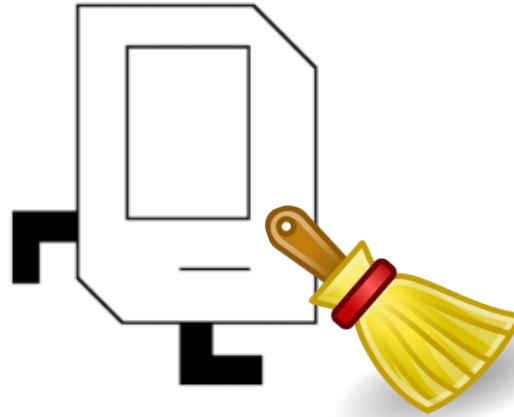
Marcelo Pena
(was a freshman at Stanford University when he did this!)

Martin Vizcarra
President of Peru

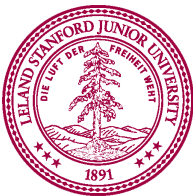
Sahami, CS106A, Stanford University



Housekeeping



- Assignment #1 due on Friday, April 8th at 12:15pm
 - Only use features from Karel lectures and Karel course reader
 - Notably, you should **not** use variables in Karel!
 - Information on submitting assignments in the "Submitting Assignments" handout (under "Handouts" on class webpage).
- LaIR is open (Sun-Thurs, 7pm-11pm in Durand 353)
 - Need to sign-up. See class webpage for details.



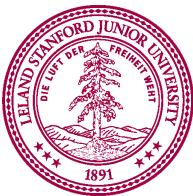
Recall, add2numbers.py Program

```
def main():  
    print("This program adds two numbers.")  
    num1 = input("Enter first number: ")  
    num1 = int(num1)  
    num2 = input("Enter second number: ")  
    num2 = int(num2)  
    total = num1 + num2  
    print("The total is " + str(total) + ".")
```



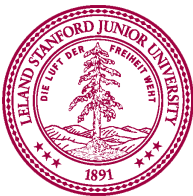
Recall, add2numbers.py Program

```
def main():  
    print("This program adds two numbers.")  
    num1 = int(input("Enter first number: "))  
  
    num2 = input("Enter second number: ")  
    num2 = int(num2)  
    total = num1 + num2  
    print("The total is " + str(total) + ".")
```



Recall, add2numbers.py Program

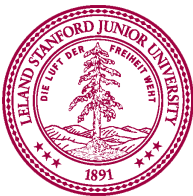
```
def main():  
    print("This program adds two numbers.")  
    num1 = int(input("Enter first number: "))  
  
    num2 = int(input("Enter second number: "))  
  
    total = num1 + num2  
    print("The total is " + str(total) + ".")
```



Recall, add2numbers.py Program

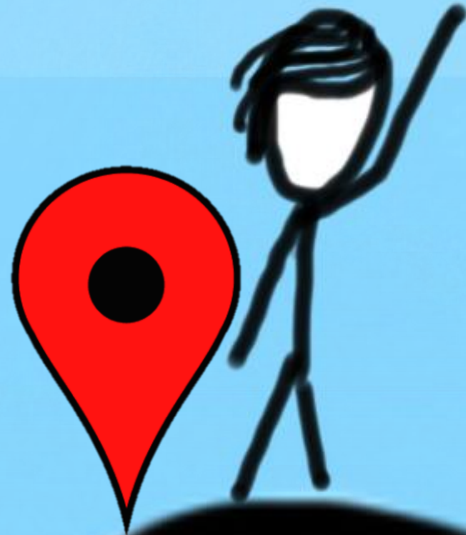
```
def main():  
    print("This program adds two numbers.")  
    num1 = int(input("Enter first number: "))  
    num2 = int(input("Enter second number: "))  
    total = num1 + num2  
    print("The total is " + str(total) + ".")
```

- Often, this is how you'll see code that gets input
- But, what if I want to do more than add?
- It's time for the world of *expressions*



Today's Goal

1. Understanding arithmetic expressions
2. Using constants
3. Random number generation



Arithmetic Operators

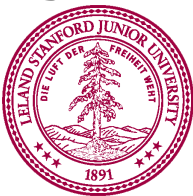
```
num1 = 5
```

```
num2 = 2
```

- Operations on numerical types (`int` and `float`)

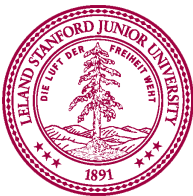
- Operators

			<u>num3</u>
+	"addition"	Ex.: <code>num3 = num1 + num2</code>	7
-	"subtraction"	Ex.: <code>num3 = num1 - num2</code>	3
*	"multiplication"	Ex.: <code>num3 = num1 * num2</code>	10
/	"division"	Ex.: <code>num3 = num1 / num2</code>	2.5
//	"integer division"	Ex.: <code>num3 = num1 // num2</code>	2
%	"remainder"	Ex.: <code>num3 = num1 % num2</code>	1
**	"exponentiation"	Ex.: <code>num3 = num1 ** num2</code>	25
-	"negation" (unary)	Ex.: <code>num3 = -num1</code>	-5



Precedence

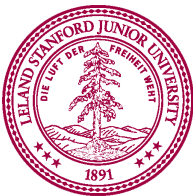
- Precedence of operator (in order)
 - () "parentheses" highest
 - ** "exponentiation"
 - "negation" (unary)
 - *, /, //, %
 - +, - lowest
- Operators in same precedence category are evaluated left to right
 - Similar to rules of evaluating expressions in algebra



Precedence Example

$$\begin{array}{ccccccc} \mathbf{x} & = & 1 & + & 3 & * & 5 & / & 2 \\ & & & & \underbrace{} & & & & \\ & & & & & & 15 & & \\ & & & & & & \underbrace{} & & \\ & & & & & & & & 7.5 \\ & & \underbrace{} & & & & & & \\ & & & & 8.5 & & & & \end{array}$$

$$\mathbf{x} \quad \boxed{8.5}$$



Implicit Type Conversion

```
num1 = 5
num2 = 2
num3 = 1.9
```

- Operations on two `ints` (except `/`) that would result in an integer value are of type `int`

```
num1 + 7 = 12      (int)
```

- Dividing (`/`) two `ints` results in a `float`, even if result is a round number (Ex.: `6 / 2 = 3.0`)

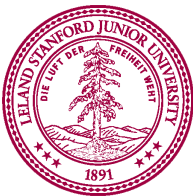
- If either (or both) of operands are `float`, the result is a `float`

```
num3 + 1 = 2.9     (float)
```

- Exponentiation depends on the result:

```
num2 ** 3 = 8      (int)
```

```
2 ** -1 = 0.5     (float)
```



Explicit Type Conversion

```
num1 = 5
num2 = 2
num3 = 1.9
```

- Use **float** (*value*) to create new real-valued number

```
float(num1) = 5.0 (float)
```

- Note that **num1** is not changed. We created a new value.

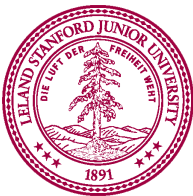
```
num1 + float(num2) = 7.0 (float)
```

```
num1 + num2 = 7 (int)
```

- Use **int** (*value*) to create a new integer-valued number (truncating anything after decimal)

```
int(num3) = 1 (int)
```

```
int(-2.7) = -2 (int)
```



Float is Not Always Exact

```
num1 = 5
num2 = 2
num3 = 1.9
```

- What is type of: `num3 - 1`
 - Answer: `float`
- What is value of: `num3 - 1`
 - Answer: `0.8999999999999999`
 - WHAT?!

I find your lack of precision disturbing!



Don't be so negative, Darth Integer!



Expression Shorthands

```
num1 = 5
```

```
num2 = 2
```

```
num3 = 1.9
```

```
num1 = num1 + 1    same as    num1 += 1
```

```
num2 = num2 - 4    same as    num2 -= 4
```

```
num3 = num3 * 2    same as    num3 *= 2
```

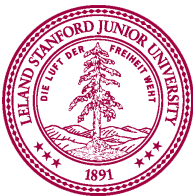
```
num1 = num1 / 2    same as    num1 /= 2
```

- Generally:

variable = variable operator (expression)

is same as:

variable operator= expression



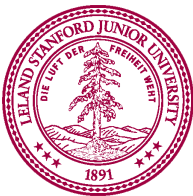
Let's consider an example
`average2numbers.py`

average2numbers.py

```
"""
File: average2numbers.py
-----
This program asks the user for two numbers
and prints their average.
"""

def main():
    print("This program averages two numbers.")
    num1 = float(input("Enter first number: "))
    num2 = float(input("Enter second number: "))
    total = (num1 + num2) / 2
    print("The average is", total)

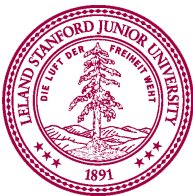
# This provided line is required at the end of a
# Python file to call the main() function.
if __name__ == '__main__':
    main()
```



Constants

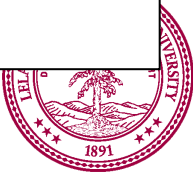
```
INCHES_IN_FOOT = 12  
PI = 3.1415
```

- Constants make code easier to read (good style):
 - `area = PI * (radius ** 2)`
 - Written in all capital SNAKE_CASE with descriptive names
 - Constants are really variables that represent quantities that don't change while the program is running
 - Can be changed between runs (as necessary)
 - "Hey, we need to compute a trajectory to get us to Mars"
`PI = 3.141592653589793`
 - Code should be written with constants in a general way so that it still works when constants are changed



Example of Using Constants

```
"""  
File: constants.py  
-----  
An example program with constants  
"""  
  
INCHES_IN_FOOT = 12  
  
def main():  
    feet = float(input("Enter number of feet: "))  
    inches = feet * INCHES_IN_FOOT  
    print("That is", inches, "inches!")  
  
# This provided line is required at the end of a Python file  
# to call the main() function.  
if __name__ == '__main__':  
    main()
```



Python math Library

```
import math
```

- math library has many built-in constants:

`math.pi`

mathematical constant π

`math.e`

mathematical constant e

- and useful functions:

`math.sqrt(x)`

returns square root of x

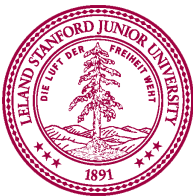
`math.exp(x)`

returns e^x

`math.log(x)`

returns natural log (base e) of x

- These are just a few examples of what's in math



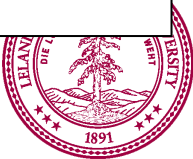
Example of Using `math` Library

```
"""
File: squareroot.py
-----
This program computes square roots
"""

import math

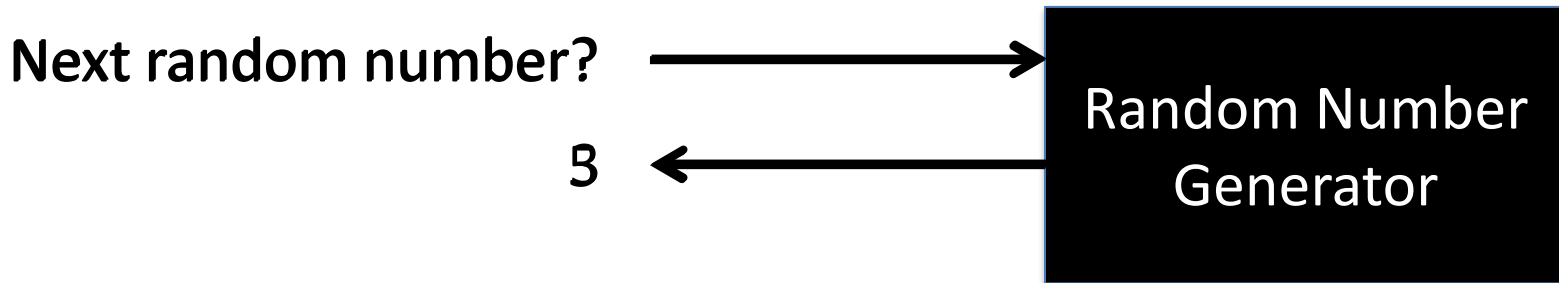
def main():
    num = float(input("Enter number: "))
    root = math.sqrt(num)
    print("Square root of", num, "is", root)

# This provided line is required at the end of a Python file
# to call the main() function.
if __name__ == '__main__':
    main()
```



Random Number Generation

- Want a way to generate random number
 - Say, for games or other applications
- No "true" randomness in computer, so we have *pseudorandom* numbers
 - "That looks pretty random to me"
- Want "black box" that we can ask for random numbers



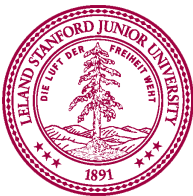
- Can "seed" the random number generator to always produce the same sequence of "random" numbers



Python random Library

```
import random
```

Function	What it does
<code>random.randint(<i>min</i>, <i>max</i>)</code>	Returns a random integer between <i>min</i> and <i>max</i> , inclusive.
<code>random.random()</code>	Returns a random real number (float) between 0 and 1.
<code>random.uniform(<i>min</i>, <i>max</i>)</code>	Returns a random real number (float) between <i>min</i> and <i>max</i> .
<code>random.seed(<i>x</i>)</code>	Sets "seed" of random number generator to <i>x</i> .



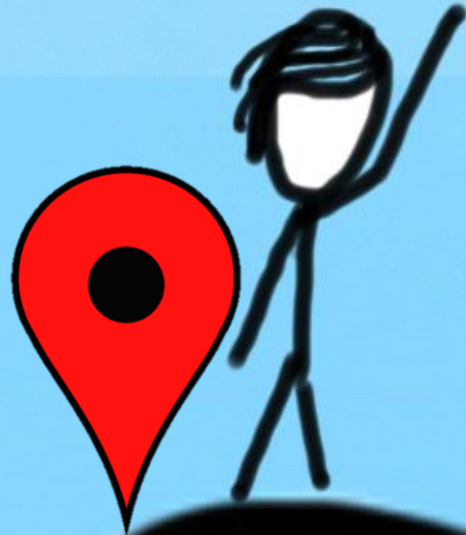
Let's consider an example
rolldice.py

Example of Using random Library

```
"""  
File: rolldice.py  
-----  
Simulate rolling two dice  
"""  
  
import random  
  
NUM_SIDES = 6  
  
def main():  
    # setting seed is useful for debugging  
    # random.seed(1)  
    die1 = random.randint(1, NUM_SIDES)  
    die2 = random.randint(1, NUM_SIDES)  
    total = die1 + die2  
    print("Dice have", NUM_SIDES, "sides each.")  
    print("First die:", die1)  
    print("Second die:", die2)  
    print("Total of two dice:", total)
```

Today's Goal

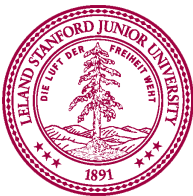
1. Understanding arithmetic expressions
2. Using constants
3. Random number generation



Putting it all together:
dicesimulator.py

What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

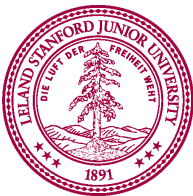


What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10



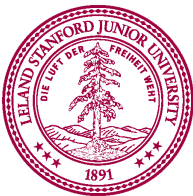
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10
```



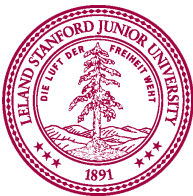
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

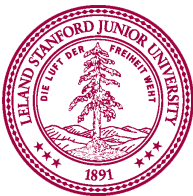
```
        print("Total of two dice: " + str(total))
```

die1

die2

total

```
die1 in main() starts as: 10
```



What's Going On?

```
def main():
```

```
def roll_dice():
```

```
    die1 = random.randint(1, NUM_SIDES)
```

```
    die2 = random.randint(1, NUM_SIDES)
```

```
    total = die1 + die2
```

```
    print("Total of two dice: " + str(total))
```

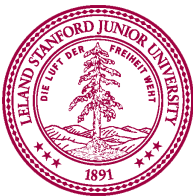
die1

2

die2

total

```
die1 in main() starts as: 10
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

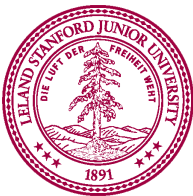
2

die2

5

total

```
die1 in main() starts as: 10
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

2

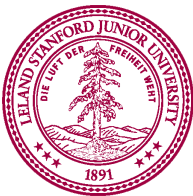
die2

5

total

7

```
die1 in main() starts as: 10
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

2

die2

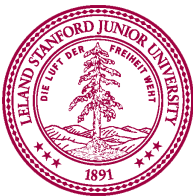
5

total

7

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```



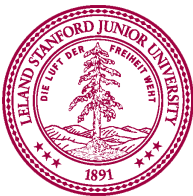
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10  
Total of two dice: 7
```



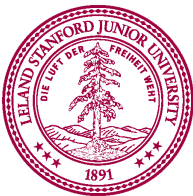
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10  
Total of two dice: 7
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

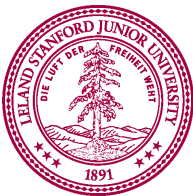
die1

die2

total

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

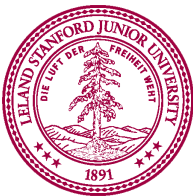
1

die2

total

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

1

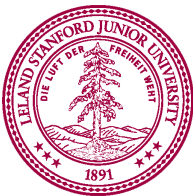
die2

3

total

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

1

die2

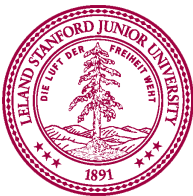
3

total

4

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```



What's Going On?

```
def main():
```

```
    def roll_dice():
```

```
        die1 = random.randint(1, NUM_SIDES)
```

```
        die2 = random.randint(1, NUM_SIDES)
```

```
        total = die1 + die2
```

```
        print("Total of two dice: " + str(total))
```

die1

1

die2

3

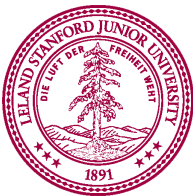
total

4

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```

```
Total of two dice: 4
```



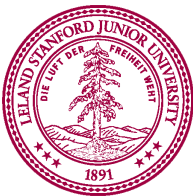
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10  
Total of two dice: 7  
Total of two dice: 4
```



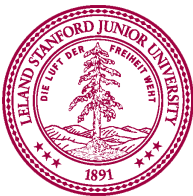
What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10  
Total of two dice: 7  
Total of two dice: 4
```



What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

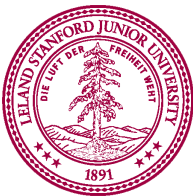
10

```
die1 in main() starts as: 10
```

```
Total of two dice: 7
```

```
Total of two dice: 4
```

```
Total of two dice: 5
```



What's Going On?

```
def main():  
    die1 = 10  
    print("die1 in main() starts as: " + str(die1))  
    roll_dice()  
    roll_dice()  
    roll_dice()  
    print("die1 in main() is: " + str(die1))
```

die1

10

```
die1 in main() starts as: 10  
Total of two dice: 7  
Total of two dice: 4  
Total of two dice: 5  
die1 in main() is: 10
```



You're rockin' it!

