



**THE CS106A
SAGA CONTINUES**

**STAR THE
Control Flow
STRIKES BACK
WARS**

Control Flow Revisited

Chris Piech

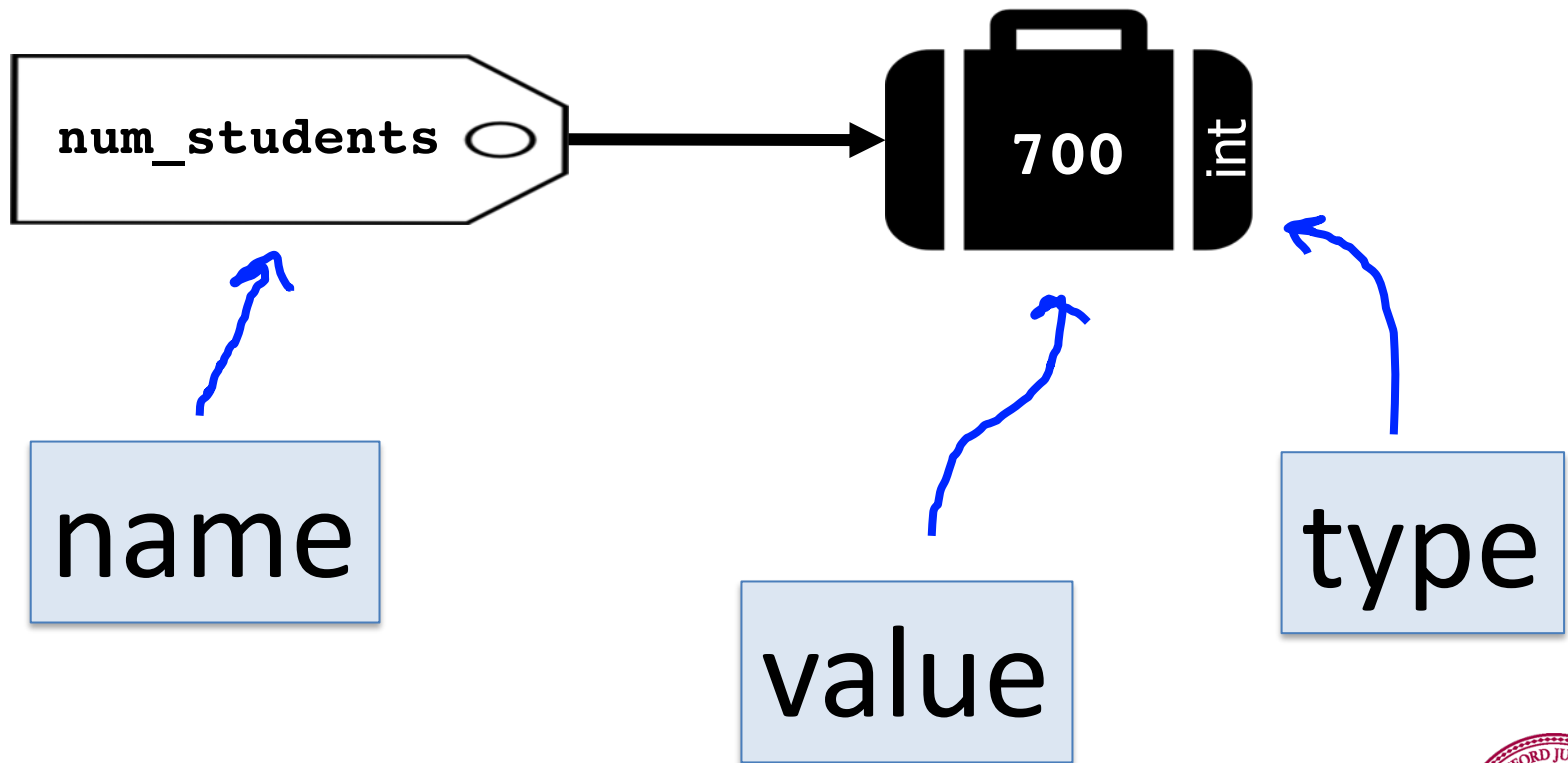
CS106A, Stanford University



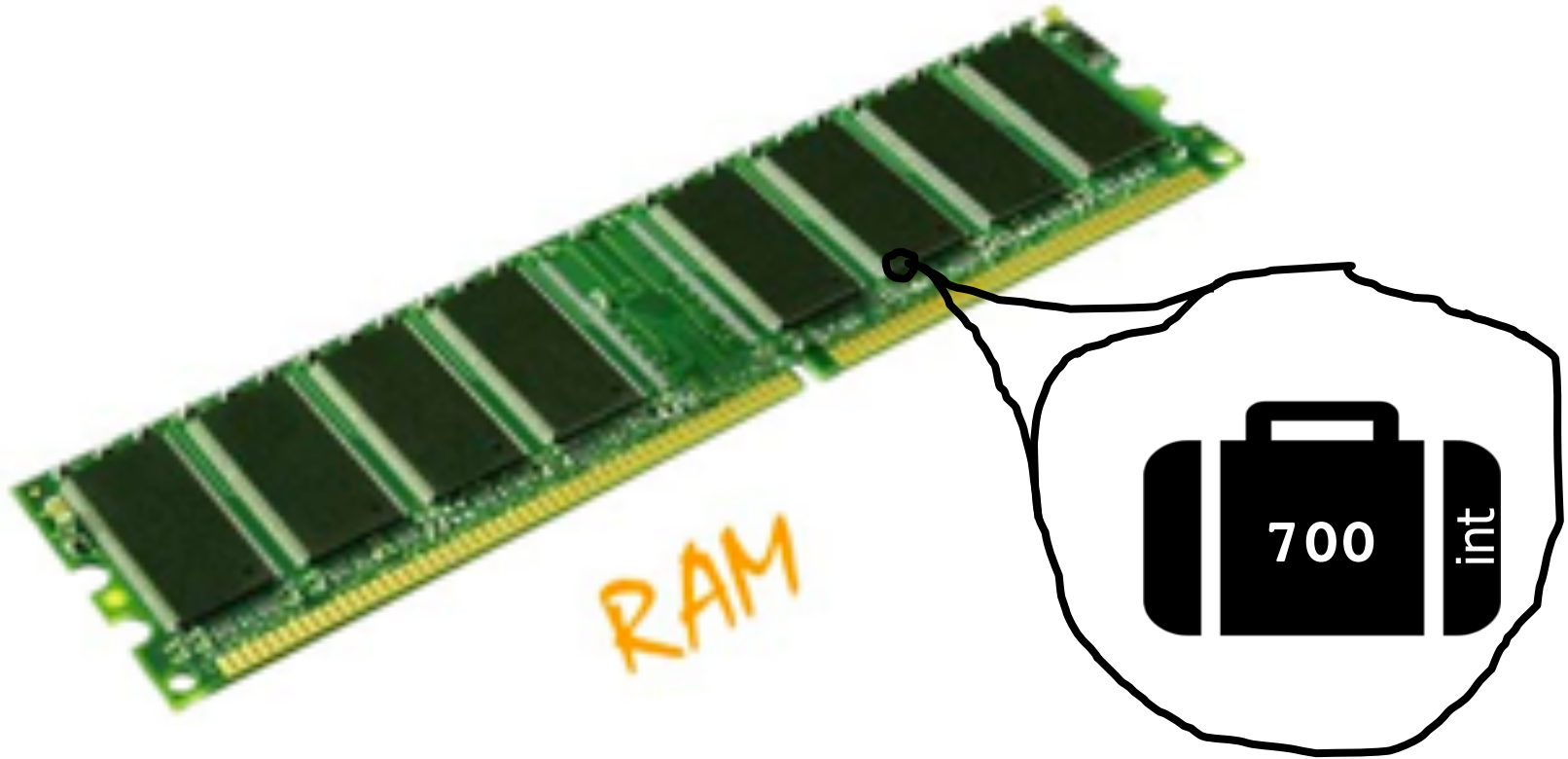
Review

Suitcase Analogy

`num_students = 700`



Teeny Tiny Suitcases



My computer has space for about 2 billion boxes

Create, Modify, Use

```
# Create a variable, of type int  
# called age with the value 30.
```

```
age = 30
```

```
# Modify age to be one greater.
```

```
age = age + 1
```

```
# Use the value in age (output it)
```

```
print("age is: " + age)
```



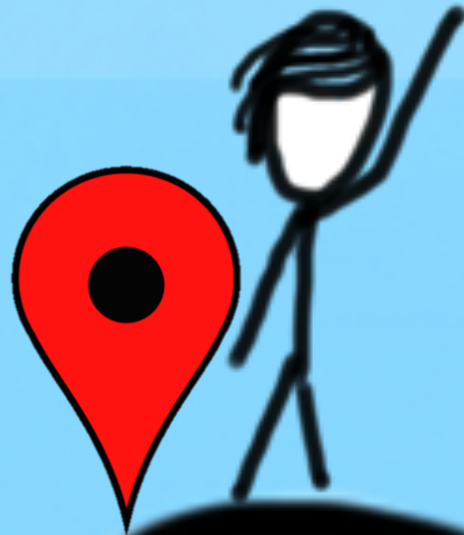
Binary Operators

+	Addition	*	Multiplication
−	Subtraction	/	Division
%	Remainder	//	Int Division

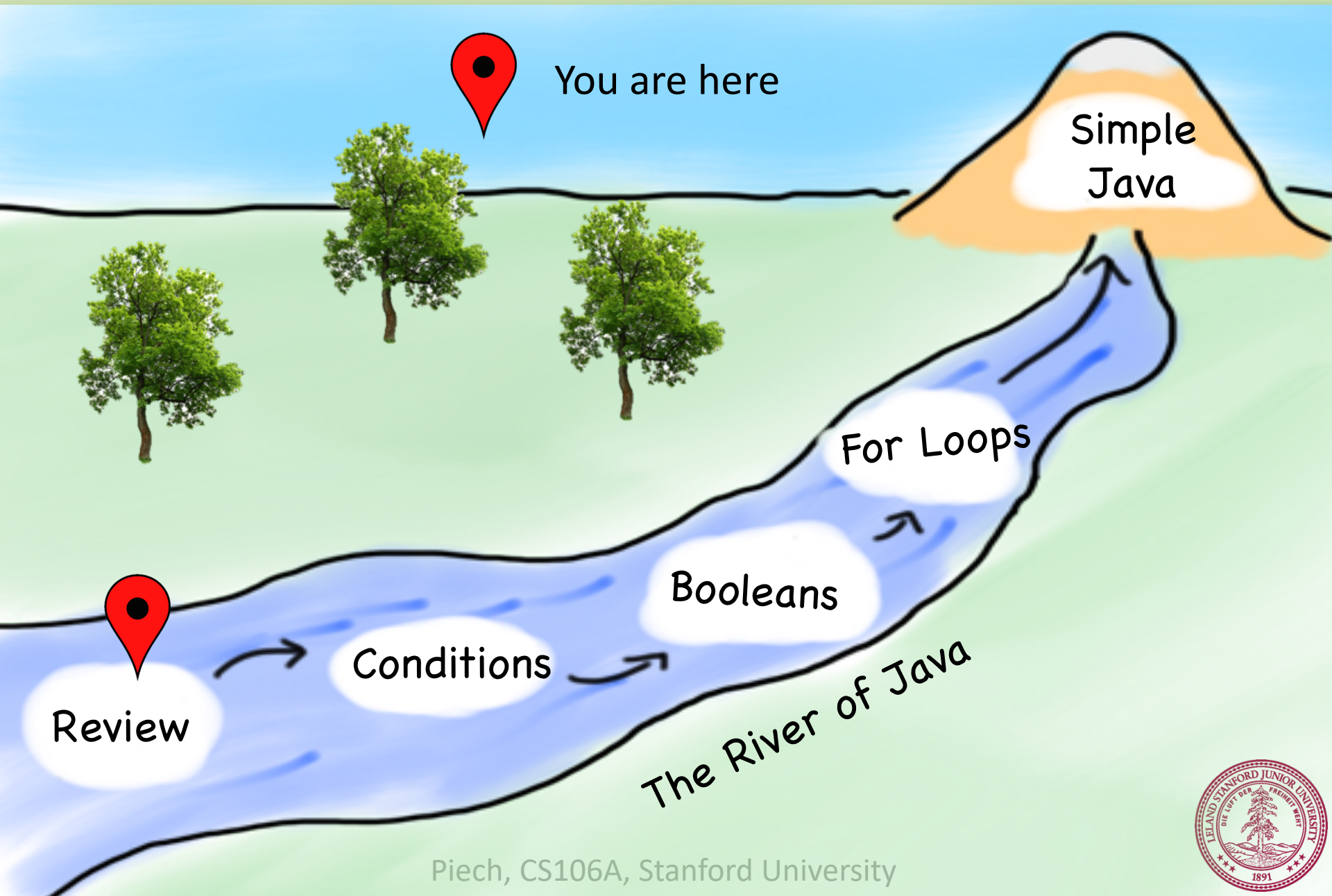


Today's Goal

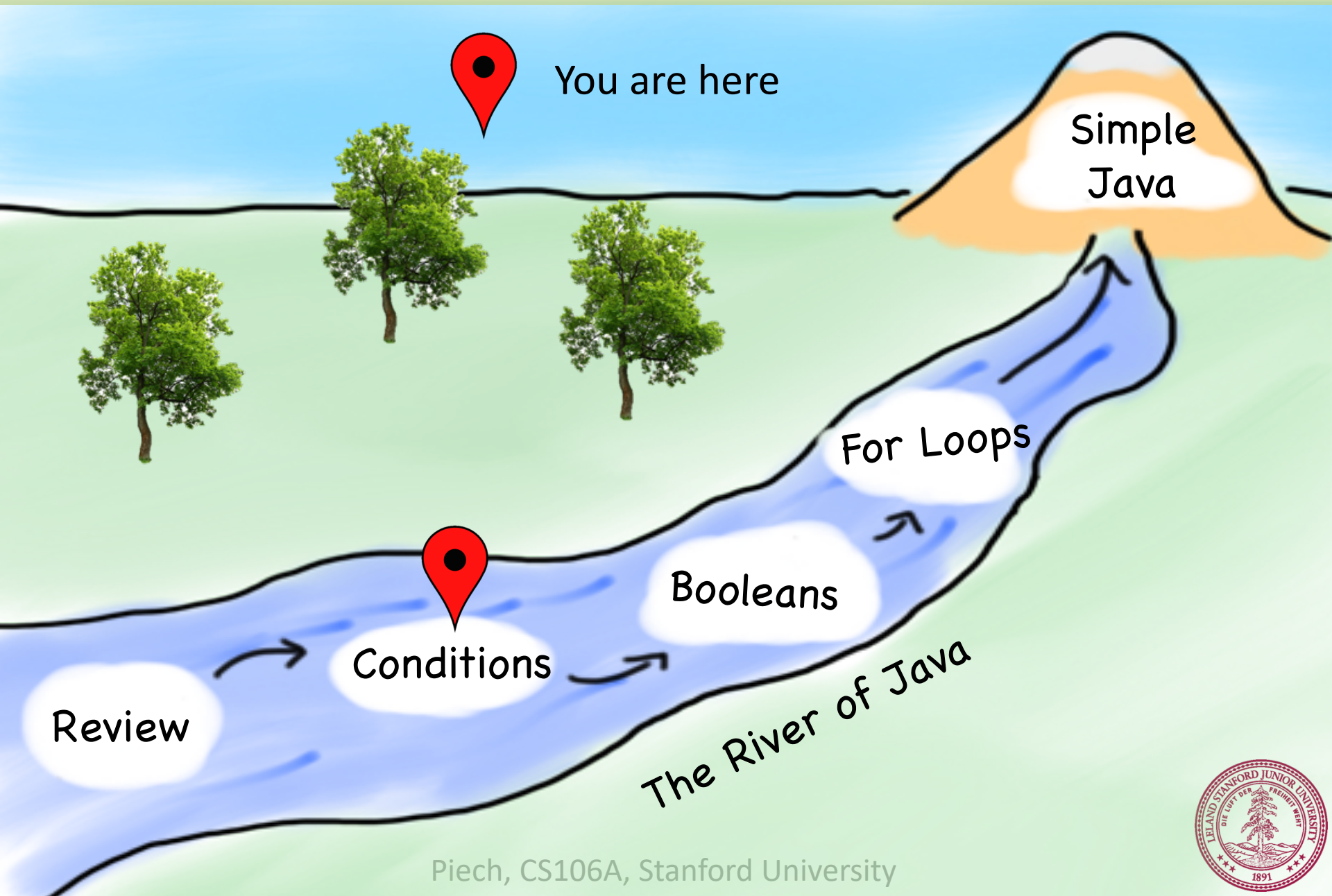
1. Be able to use For / While / If in Java



Today's Route



Today's Route



While Loop in Karel

```
while front_is_clear() :  
    body
```

```
if beepers_present() :  
    body
```



While Loop Redux

while *condition* :
 body

if *condition* :
 body

The condition should be a “boolean” which
is either **True** or **False**



Cool Example: Carbon Dating



C14 = 1.2 dpm



C14 = 13.6 dpm

$$\text{age} = K \cdot \log\left(\frac{\% \text{ c14}}{100}\right)$$

Cool Example: Carbon Dating

```
def main():  
    calculate_age_single_sample()  
  
def calculate_age_single_sample():  
    # use the half life formula to calculate the age  
    # https://en.wikipedia.org/wiki/Radiocarbon_dating  
    pct_left = float(input("% of natural c14 in your sample:"))  
    age = math.log(pct_left / 100) * HALF_LIFE_CONSTANT  
    print("Your sample is " + str(age) + " years old.")
```

* It calculates the age of a C14 sample



Cool Example: Carbon Dating

Before repeating the body,
check if this statement
evaluates to True

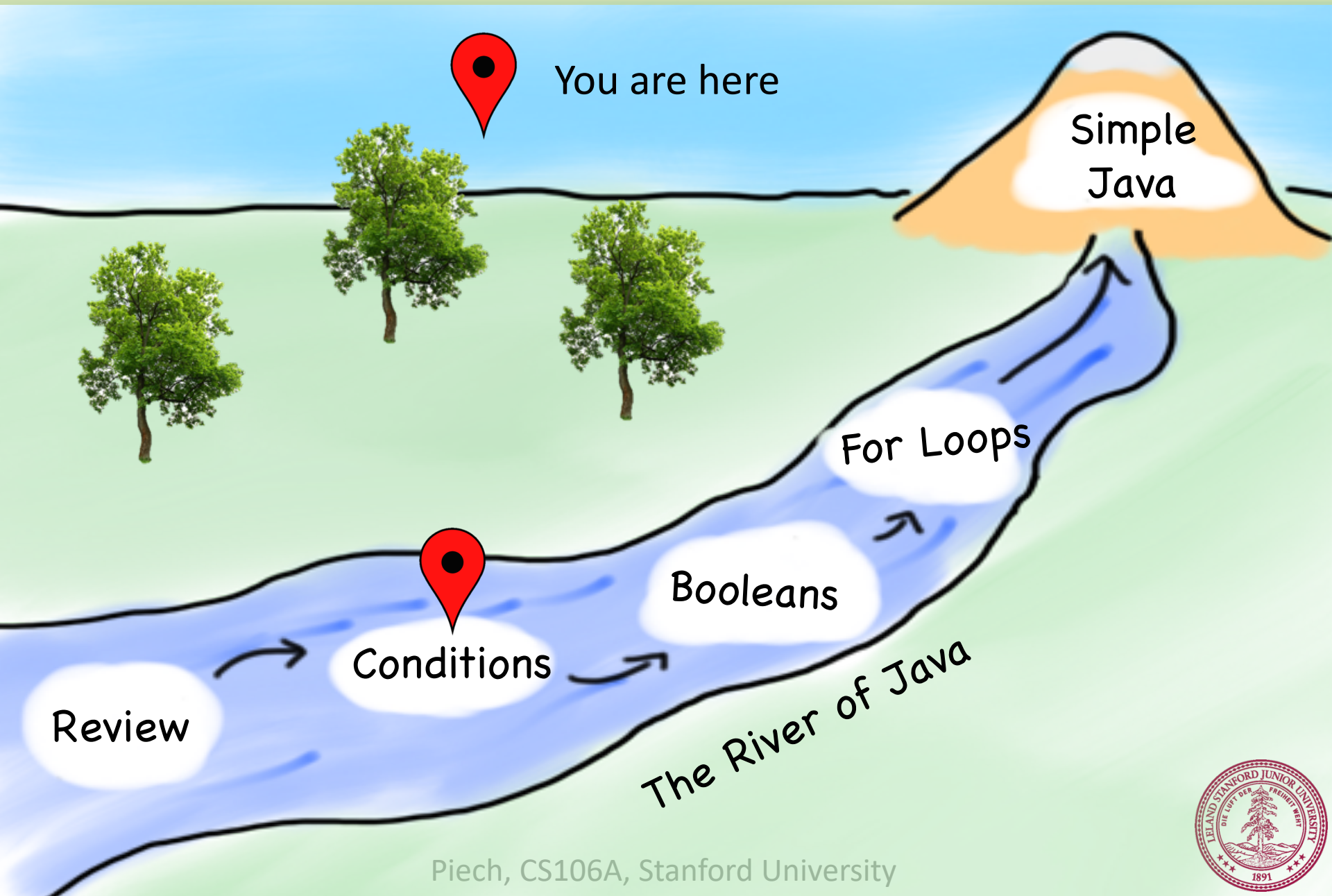
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def main():  
    while True:  
        calculate_age_single_sample()
```

```
def calculate_age_single_sample():  
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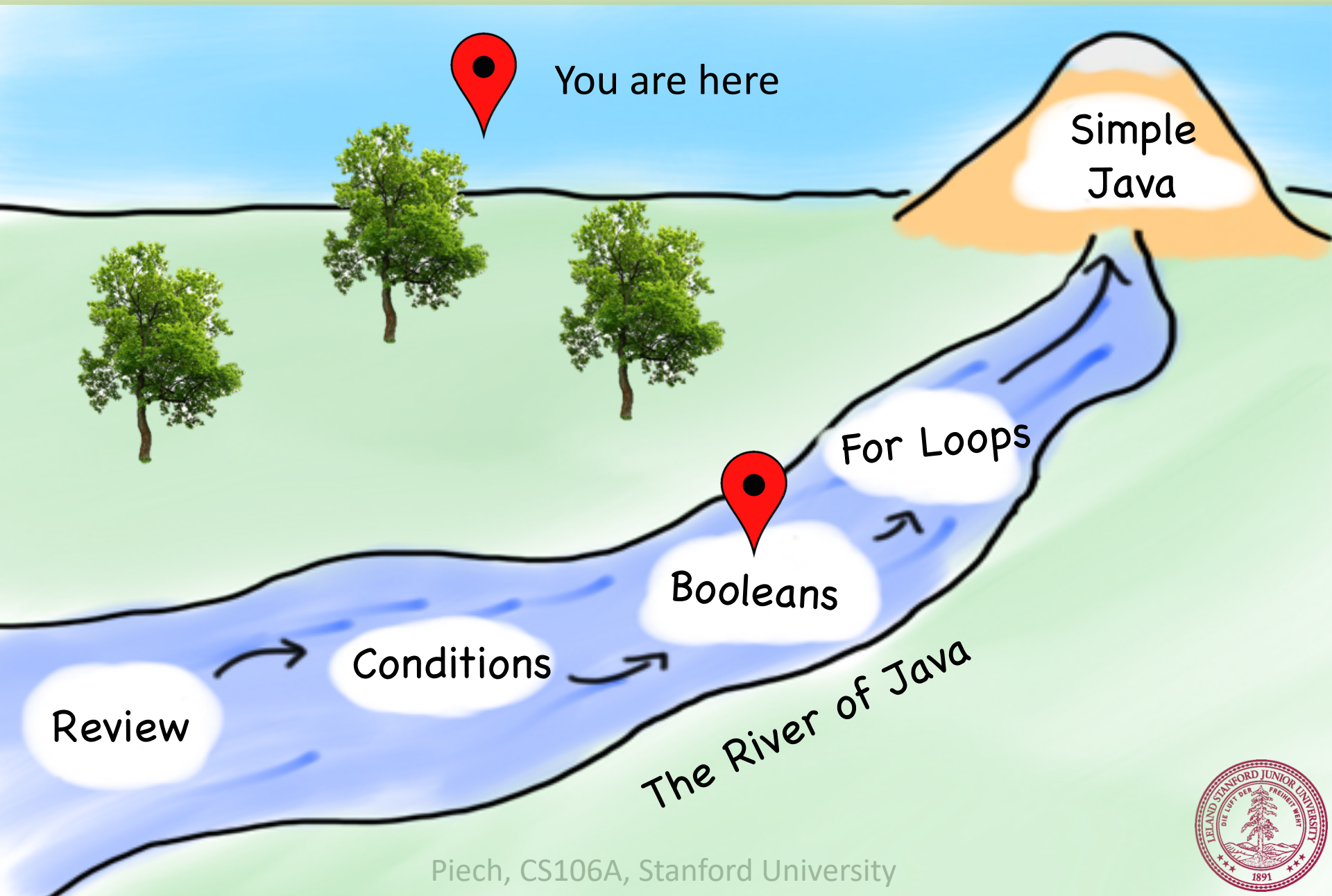
* It calculates the age of a C14 sample



Today's Route



Today's Route



Booleans

$1 < 2$



Booleans

$1 < 2$

True



Comparison Operators

Operator	Meaning	Example	Value
<code>==</code>	equals	<code>1 + 1 == 2</code>	True
<code>!=</code>	does not equal	<code>3.2 != 2.5</code>	True
<code><</code>	less than	<code>10 < 5</code>	False
<code>></code>	greater than	<code>10 > 5</code>	True
<code><=</code>	less than or equal to	<code>126 <= 100</code>	False
<code>>=</code>	greater than or equal to	<code>5.0 >= 5.0</code>	True

* All have equal precedence



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* All have equal precedence



Comparison Operators

```
if 1 < 2 :  
    print("1 is less than 2")
```

```
num = int(input("Enter a number: "))  
if num == 0:  
    print("That number is 0")  
else :  
    print("That number is not 0.")
```



If Else Revisited

```
num = int(input("Enter a number: "))  
if num == 0:  
    print("Your number is 0 ")  
else:  
    if num > 0:  
        print("Your number is positive")  
    else:  
        print("Your number is negative")
```



If Else Revisited

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num = int(input("Enter a number: "))  
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If Else Revisited

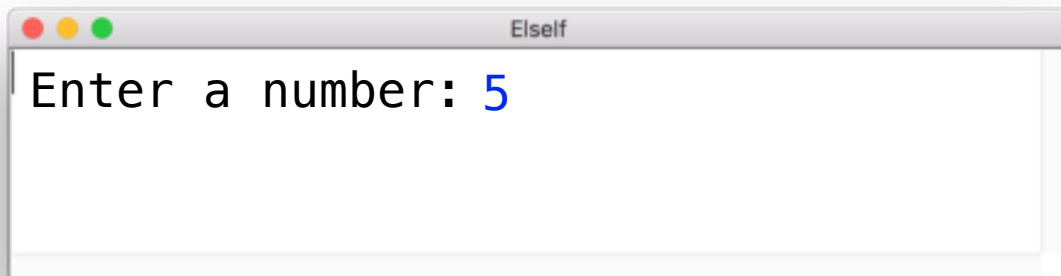
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```



If Else Revisited

"5"

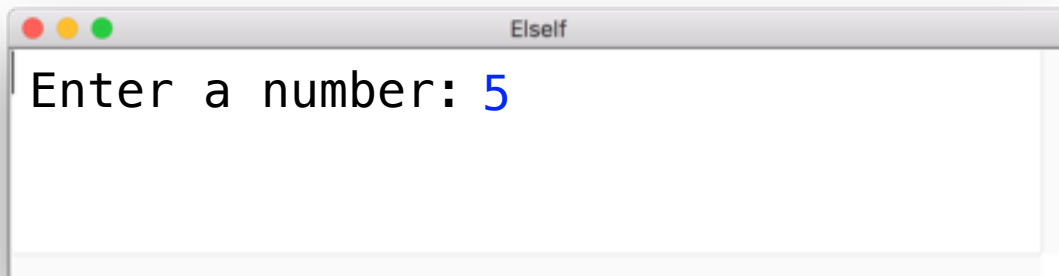
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```



If Else Revisited

5

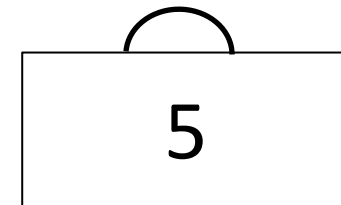
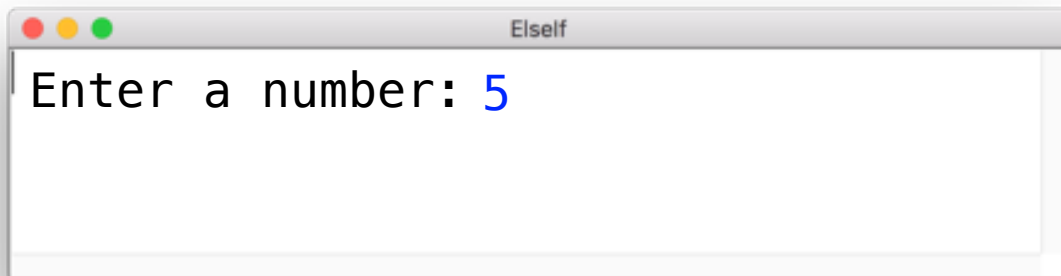
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```



If Else Revisited

5

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elif num > 0:  
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```

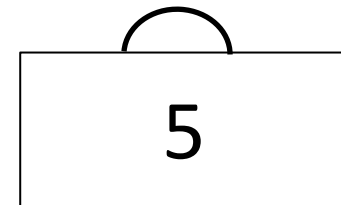
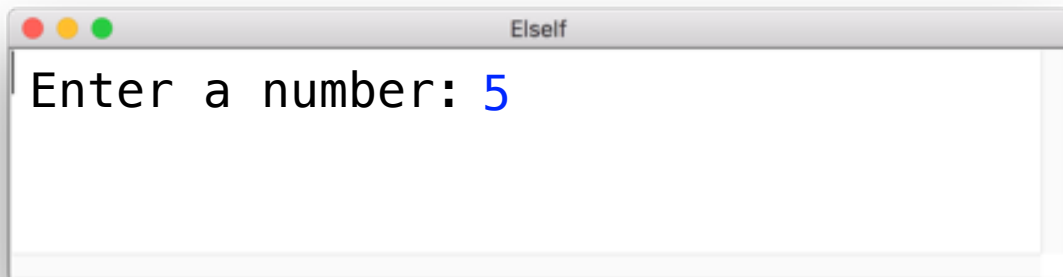


num



If Else Revisited

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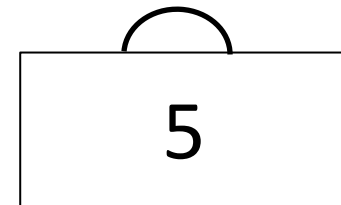
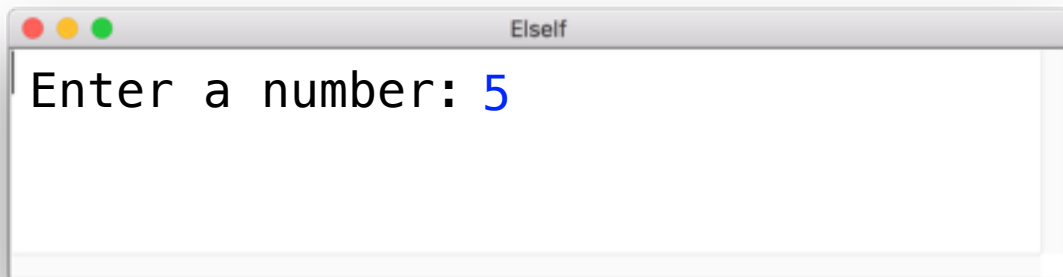


num



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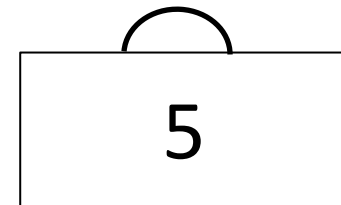
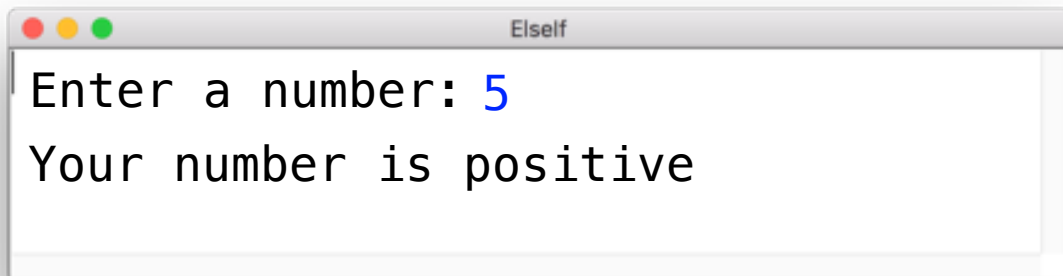


num



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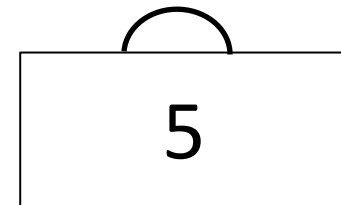
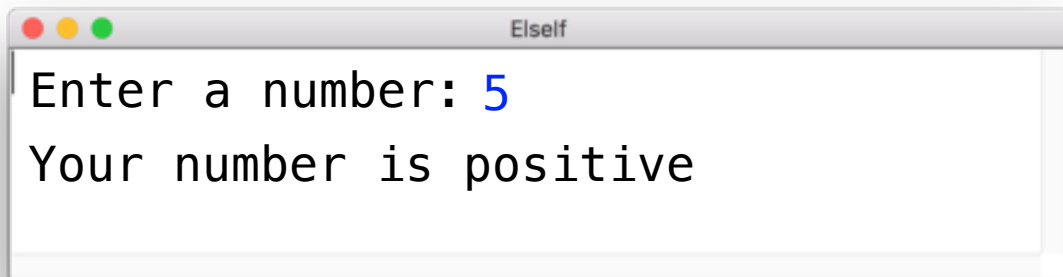


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```



num



Conditions in Python



Use **while** and **if** statements in Python.

They are the same as in Karel, except that the *test* can be any expression that evaluates to **True** or **False**



Amazing

Guess My Number

```
GuessMyNumber
I am thinking of a number between 0 and 99...
Enter a guess: 50
Your guess is too high

Enter a new number: 25
Your guess is too low

Enter a new number: 40
Your guess is too low

Enter a new number: 45
Your guess is too low

Enter a new number: 48
Congrats! The number was: 48
|
```

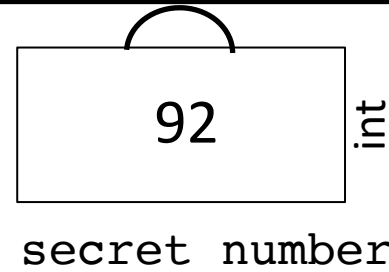


Guess My Number

```
secret_number = random.randint(1, 99)
print("I am thinking of a number between 1 and 99...")
guess = int(input("Enter a guess: "))
# True if guess is not equal to secret number
while guess != secret_number:
    # True if guess is less than secret number
    if guess < secret_number:
        print("Your guess is too low")
    else:
        print("Your guess is too high")

    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```

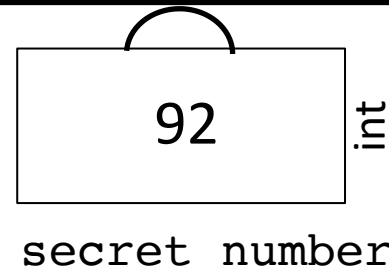


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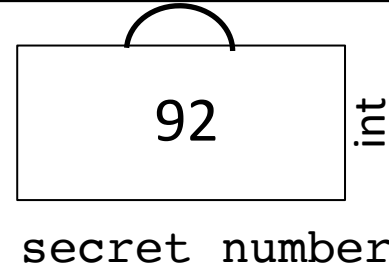
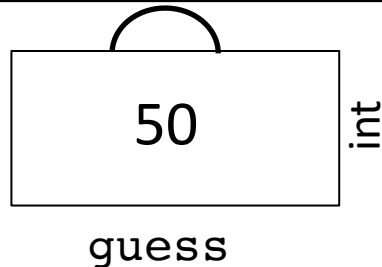


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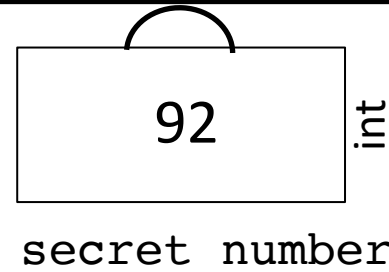
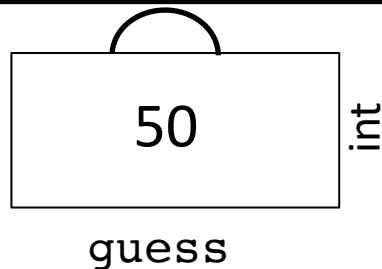


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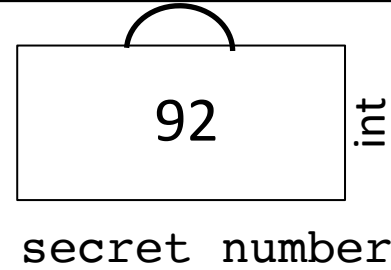
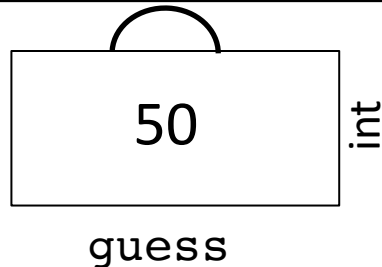


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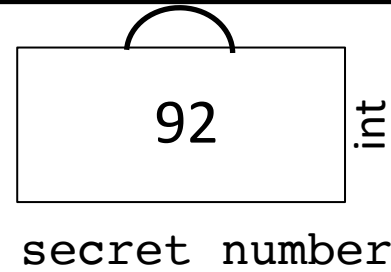
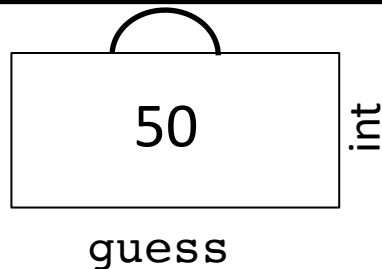


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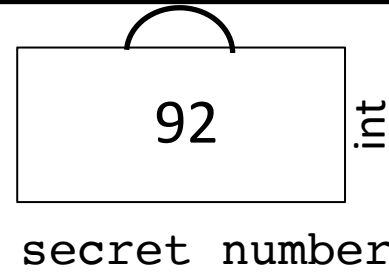
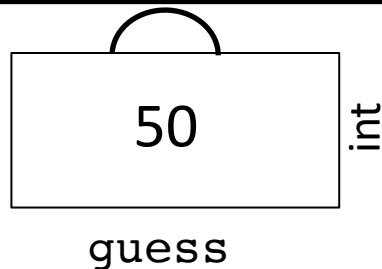


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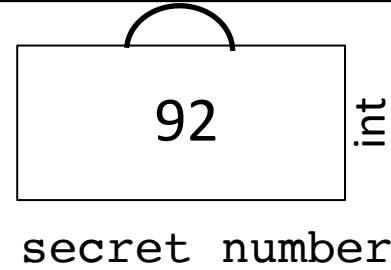
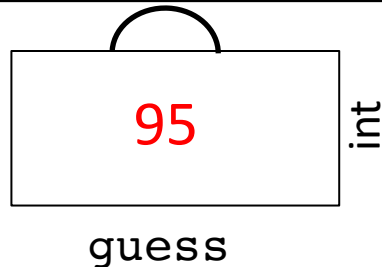


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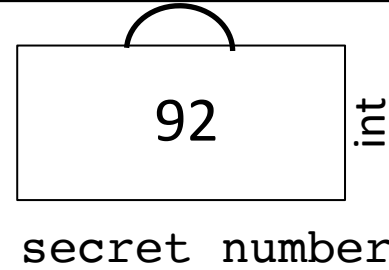
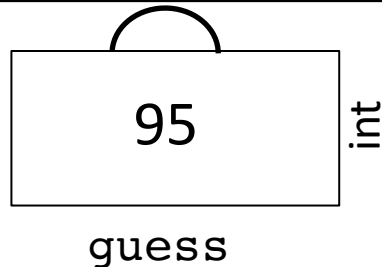
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```



Guess My Number

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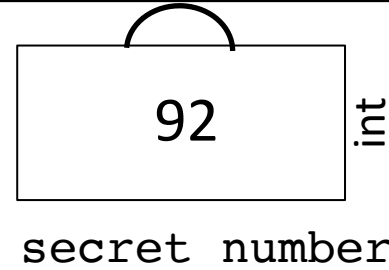
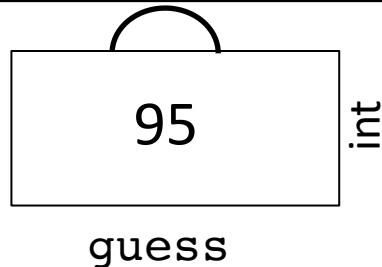


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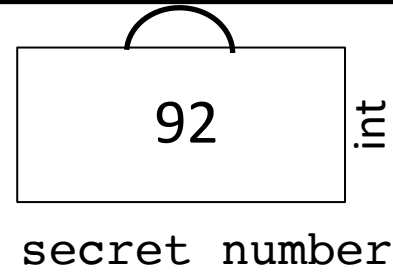
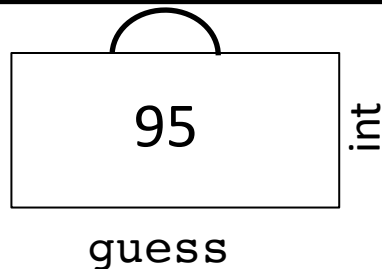


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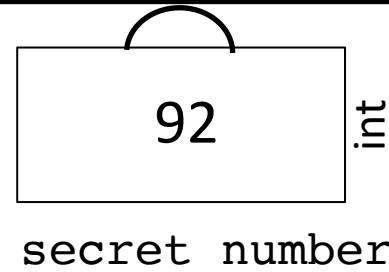
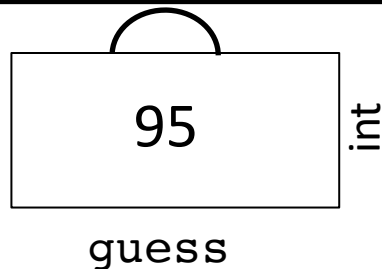


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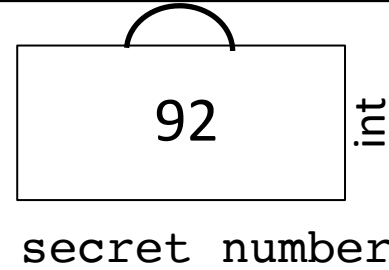
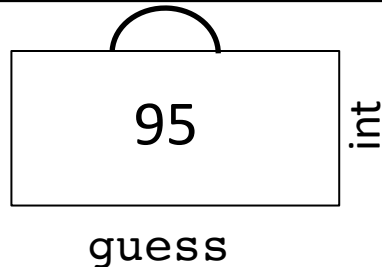


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    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```

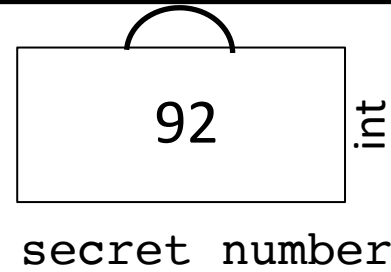
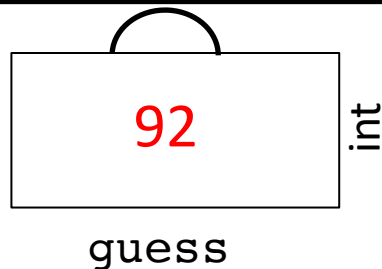


Guess My Number

```
secret_number = random.randint(1, 99)
print("I am thinking of a number between 1 and 99...")
guess = int(input("Enter a guess: "))
# True if guess is not equal to secret number
while guess != secret_number:
    # True if guess is less than secret number
    if guess < secret_number:
        print("Your guess is too low")
    else:
        print("Your guess is too high")

    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```

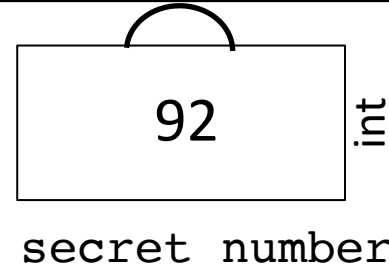
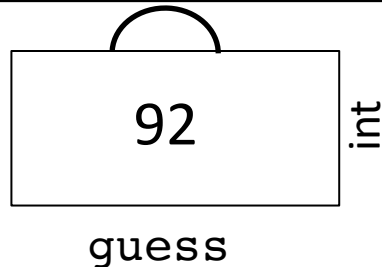


Guess My Number

```
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print("I am thinking of a number between 1 and 99...")
guess = int(input("Enter a guess: "))
# True if guess is not equal to secret number
while guess != secret_number:
    # True if guess is less than secret number
    if guess < secret_number:
        print("Your guess is too low")
    else:
        print("Your guess is too high")

    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```

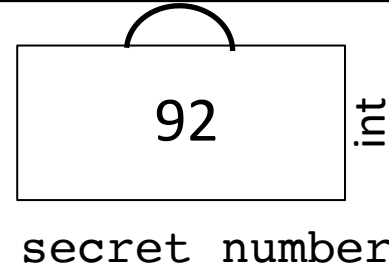
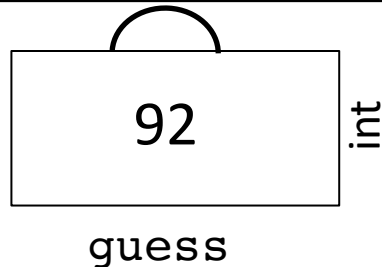


Guess My Number

```
secret_number = random.randint(1, 99)
print("I am thinking of a number between 1 and 99...")
guess = int(input("Enter a guess: "))
# True if guess is not equal to secret number
while guess != secret_number:
    # True if guess is less than secret number
    if guess < secret_number:
        print("Your guess is too low")
    else:
        print("Your guess is too high")

    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```

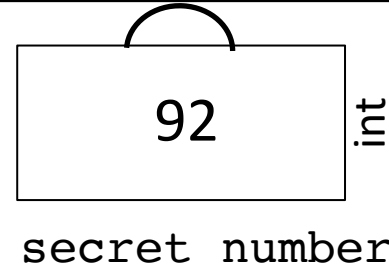
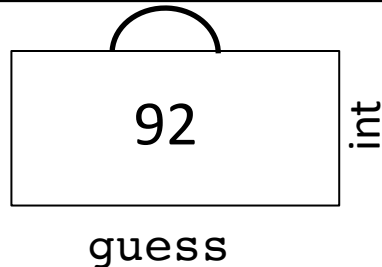


Guess My Number

```
secret_number = random.randint(1, 99)
print("I am thinking of a number between 1 and 99...")
guess = int(input("Enter a guess: "))
# True if guess is not equal to secret number
while guess != secret_number:
    # True if guess is less than secret number
    if guess < secret_number:
        print("Your guess is too low")
    else:
        print("Your guess is too high")

    print("") # an empty line
    guess = int(input("Enter a new guess: "))

print("Congrats! The number was: " + str(secret_number))
```



Challenge: Sentinel Loops

- **sentinel**: A value that signals the end of user input.
 - **sentinel loop**: Repeats until a sentinel value is seen.
- Example: Write a program that prompts the user for numbers until the user types -1, then output the total of the numbers.
 - In this case, -1 is the sentinel value.

Type a number: 10

Type a number: 20

Type a number: 30

Type a number: -1

total is 60





Example: Sentinel Loops

```
# fencepost problem!
```

```
# ask for number - post
```

```
# add number to total - fence
```

```
total = 0
```

```
while num != -1:
```

```
    num = int(input("Enter a number: "))
```

```
    total += num
```

```
print("total is " + total)
```

NameError:

name 'num' is not defined



Example: Sentinel Loops

```
# fencepost problem!
# ask for number - post
# add number to total - fence

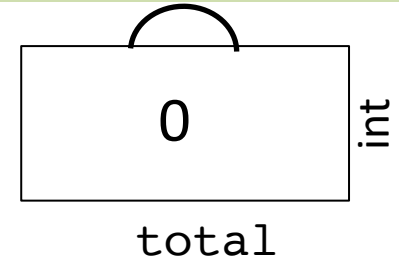
total = 0
num = int(input("Enter a number: "))
while num != -1:
    total += num
    num = int(input("Enter a number: "))

print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```



```
total = 0
```

```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

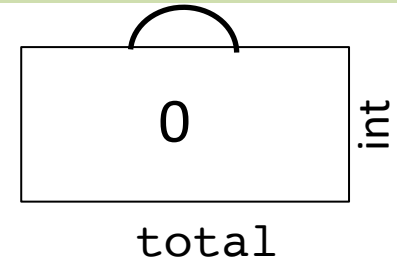
```
    num = int(input("Enter a number: "))
```

```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```



```
total = 0
```

```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

```
    num = int(input("Enter a number: "))
```

```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0
```

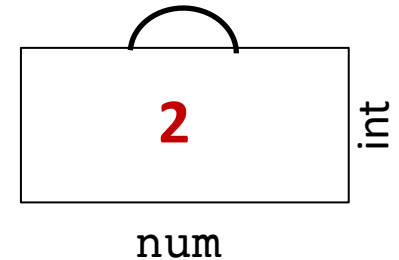
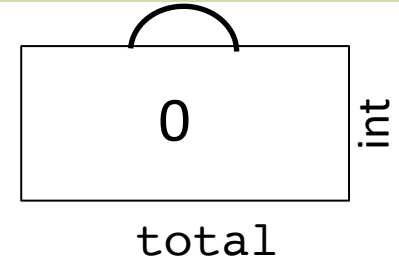
```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

```
    num = int(input("Enter a number: "))
```

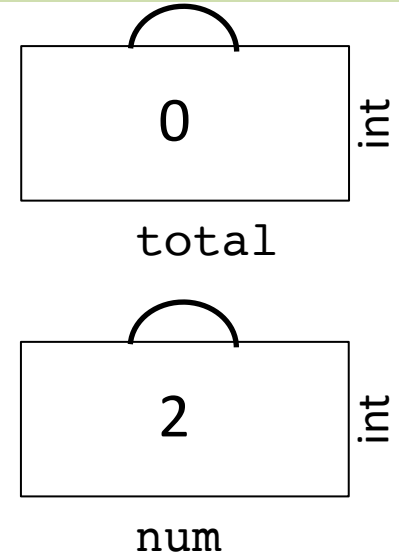
```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

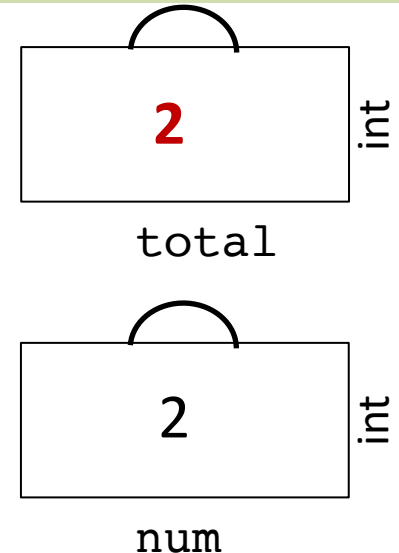
```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0
```

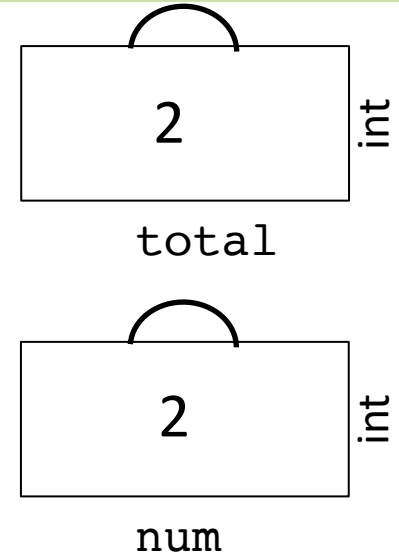
```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

```
    num = int(input("Enter a number: "))
```

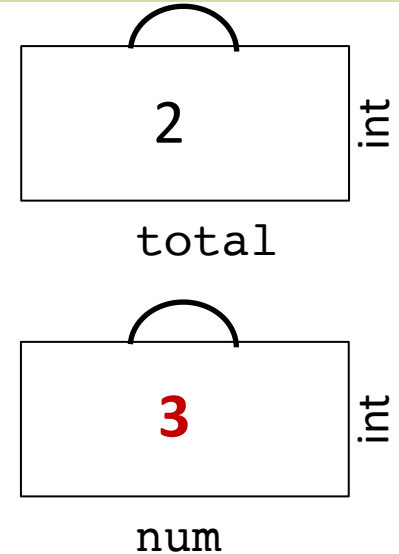
```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

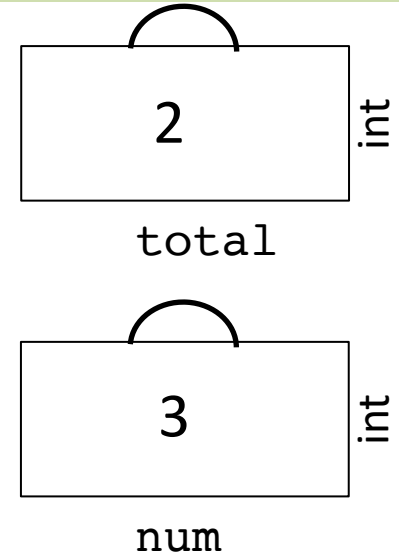
```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

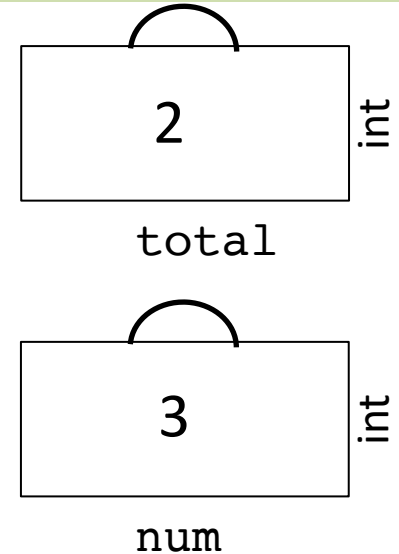
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    num = int(input("Enter a number: "))  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

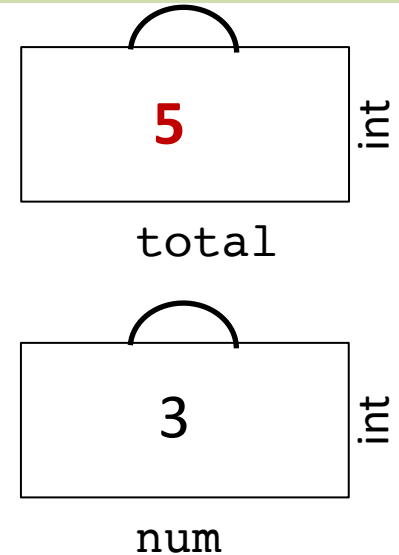
```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0
```

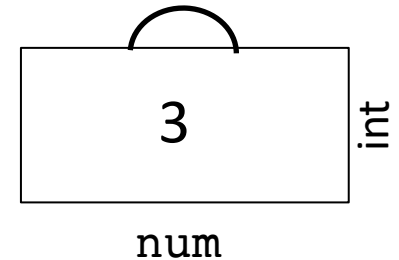
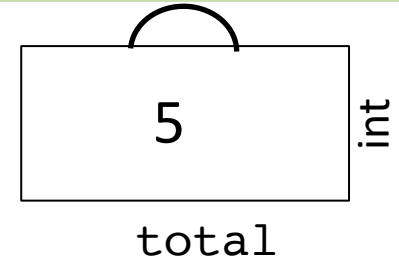
```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

```
    num = int(input("Enter a number: "))
```

```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0
```

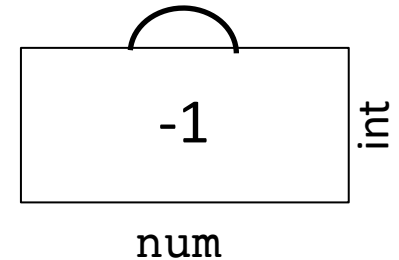
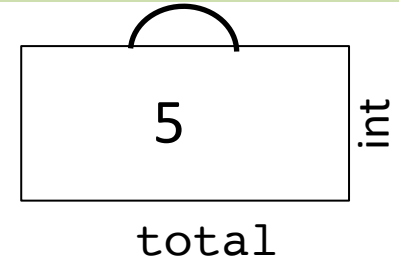
```
num = int(input("Enter a number: "))
```

```
while num != -1:
```

```
    total += num
```

```
    num = int(input("Enter a number: "))
```

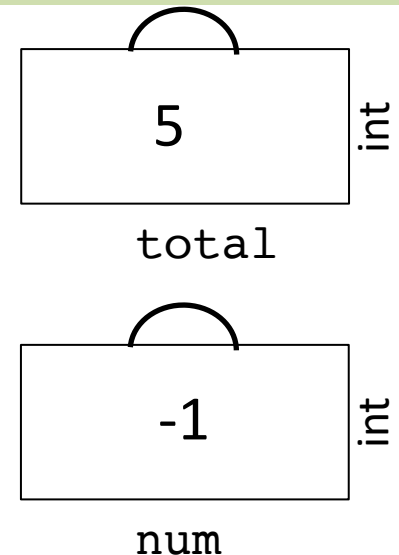
```
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

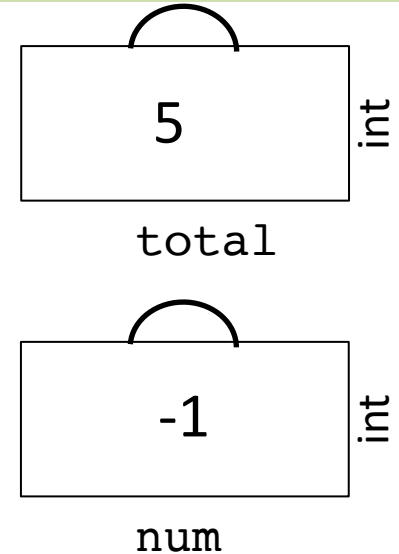
```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

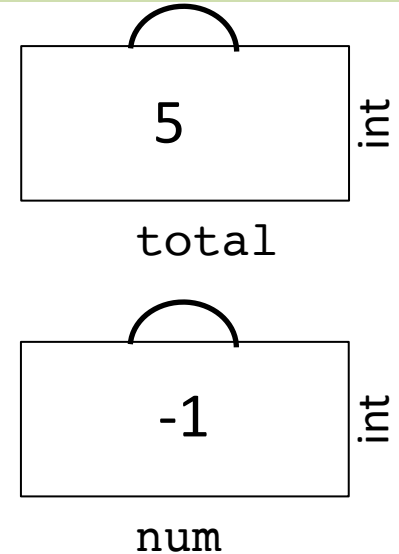
```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!  
# ask for number - post  
# add number to total - fence
```

```
total = 0  
num = int(input("Enter a number: "))  
while num != -1:  
    total += num  
    num = int(input("Enter a number: "))  
print("total is " + total)
```



Example: Sentinel Loops

```
# fencepost problem!
# ask for number - post
# add number to total - fence

total = 0
while True:
    num = int(input("Enter a number: "))
    if num == -1:
        break # immediately exits loop
    total += num
print("total is " + total)
```



Logical Operators

In order of precedence:

Operator	Example	Result
<code>not</code>	<code>not (2 == 3)</code>	<code>True</code>
<code>and</code>	<code>(2 == 3) and (-1 < 5)</code>	<code>False</code>
<code>or</code>	<code>(2 == 3) or (-1 < 5)</code>	<code>True</code>

Can "chain" tests as in algebra

```
# assume x is 15
2 <= x <= 10
```

```
# identical version
2 <= x and x <= 10
```



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

5 * 7 >= 3 + 5 * 6 and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False

35 >= 3 + 30 and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False

35 >= 3 + 30 and not False

35 >= 33 and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False

35 >= 3 + 30 and not False

35 >= 33 and not False

True and not False



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False

35 >= 3 + 30 and not False

35 >= 33 and not False

True and not False

True and True



Precedence Madness

Precedence:

arithmetic > comparison > not > and/or

5 * 7 >= 3 + 5 * (7 - 1) and not False

35 >= 3 + 5 * 6 and not False

35 >= 3 + 30 and not False

35 >= 33 and not False

True and not False

True and True

True



George Boole



English Mathematician teaching in Ireland 1815 – 1864
Boole died of being too cool

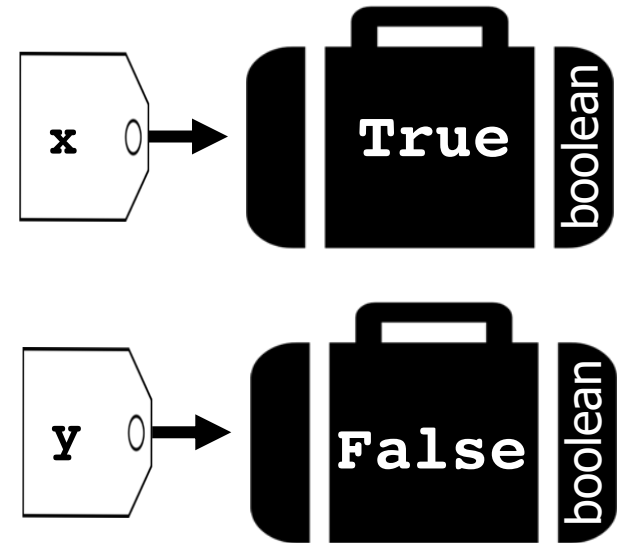


Boolean Variables

Store expressions that evaluate to True/False

x = 1 < 2 # True

y = 5.0 == 4.0 # False



Boolean Variables

```
# Store expressions that evaluate to True/False
x = 1 < 2      # True
y = 5.0 == 4.0 # False

# Directly set to True/False
is_sheltering = True
is_raining = False
```



Boolean Variables

```
# Store expressions that evaluate to True/False
```

```
x = 1 < 2      # True
```

```
y = 5.0 == 4.0 # False
```

```
# Directly set to True/False
```

```
is_sheltering = True
```

```
is_raining = False
```

```
play_again = input('Play again? "y" or "n"') == 'y'
```

```
if play_again:
```

```
    ...
```





FreeSignsPrint.com

is_allowed = **not** food **or** drinks

*know your logical precedence





FreeSignsPrint.com

is_allowed = **not** food **or** drinks
False

*know your logical precedence





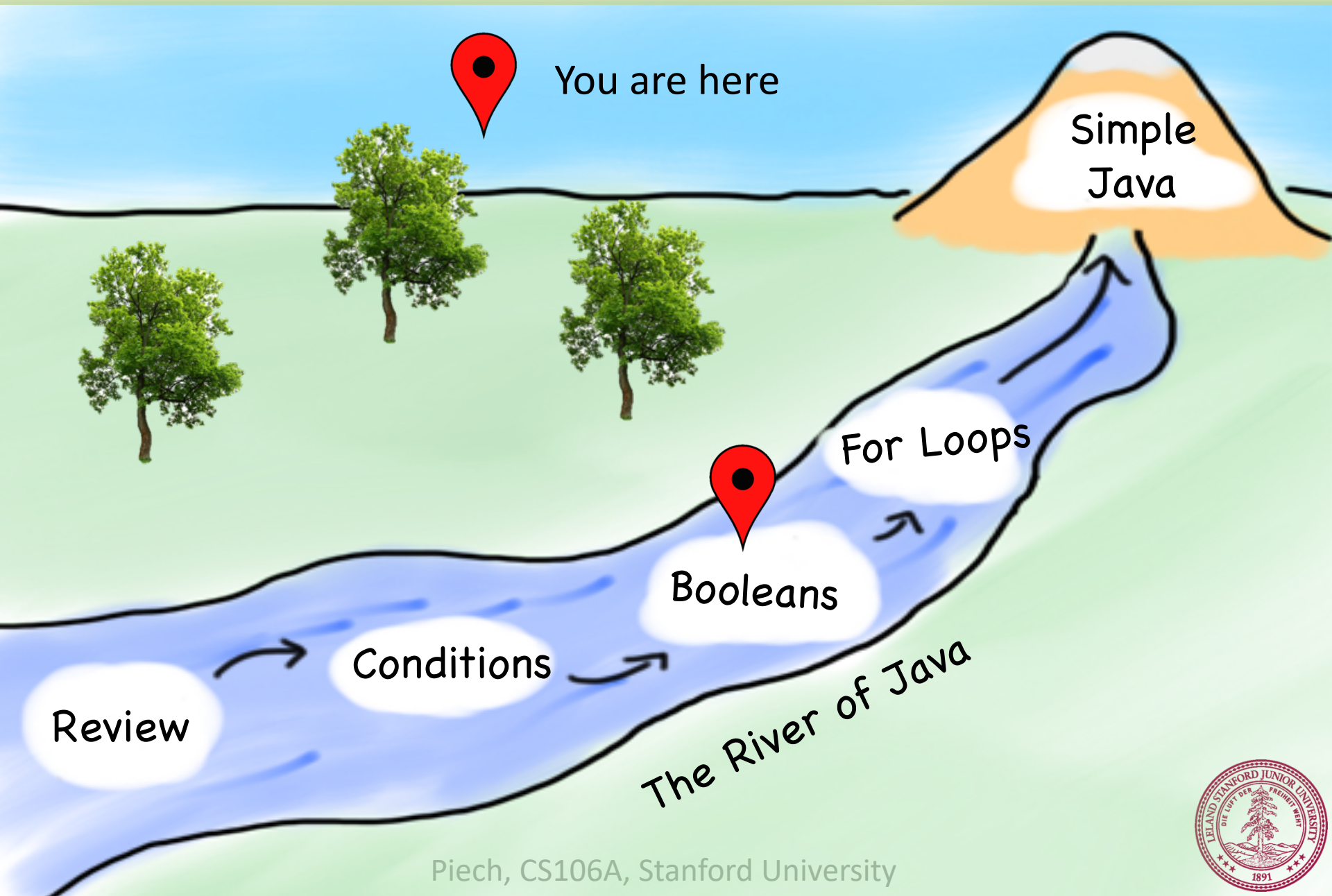
FreeSignsPrint.com

is_allowed = **not** food **or** drinks
False **True**

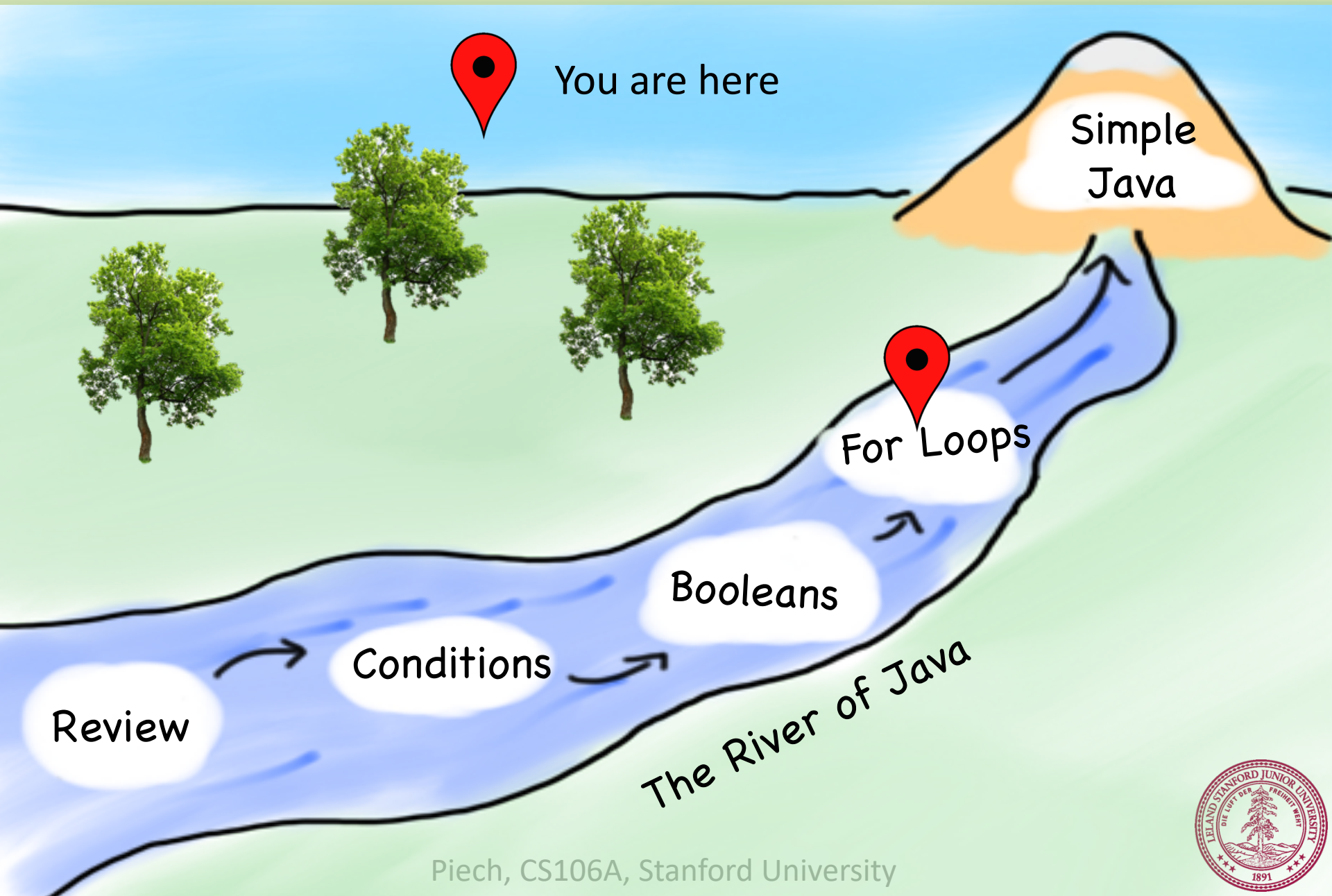
*know your logical precedence



Today's Route



Today's Route



How would you print “Python rocks socks”
100 times

For Loop Redux

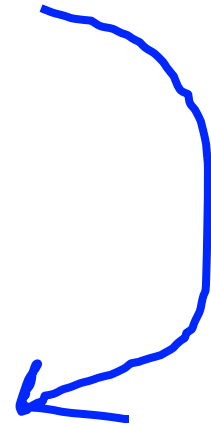
```
def run() :  
    for i in range(100):  
        print("Python rocks socks!")
```



For Loop Redux

```
for i in range(100):  
    print("Python rocks socks!")
```

```
i = 0  
while i < 100:  
    print("Python rocks socks!")  
    i += 1
```



For Loop Redux

Create a counting
variable *i*

Which takes on
the values 0 to 99
one at a time

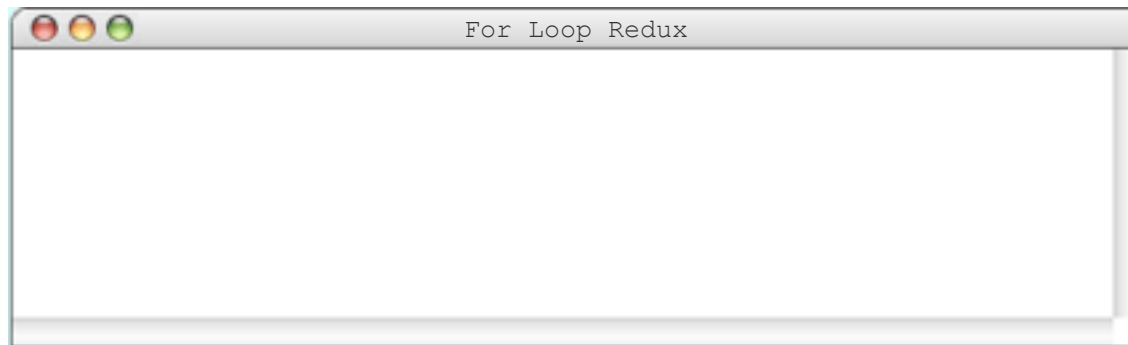
```
for i in range(100):  
    print("Python rocks socks!")
```



For Loop Redux

range(3) -> 0, 1, 2

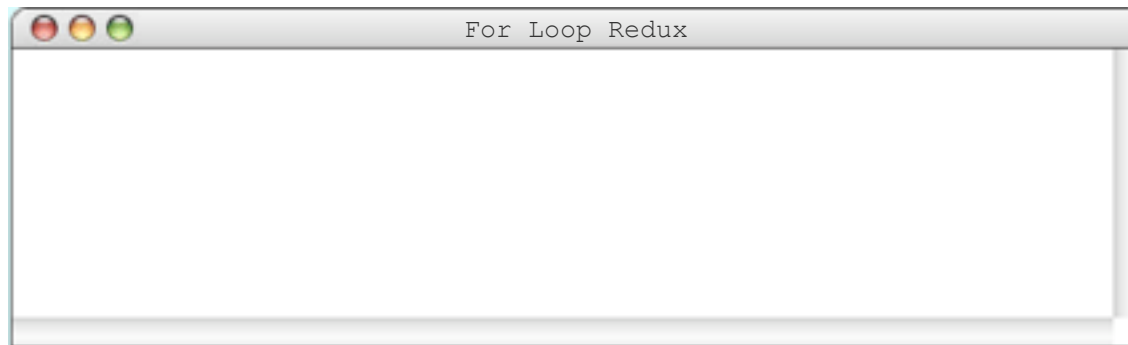
```
for i in range(3):  
    print("Python rocks socks!")
```



For Loop Redux

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```

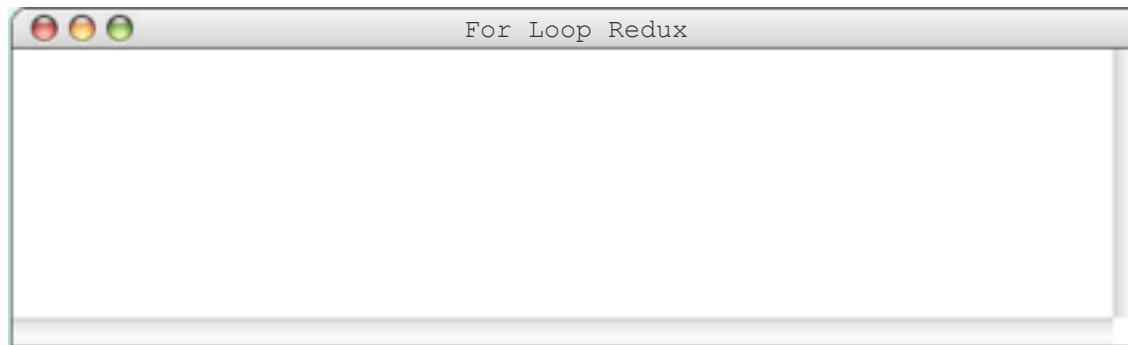


For Loop Redux

i 0

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```



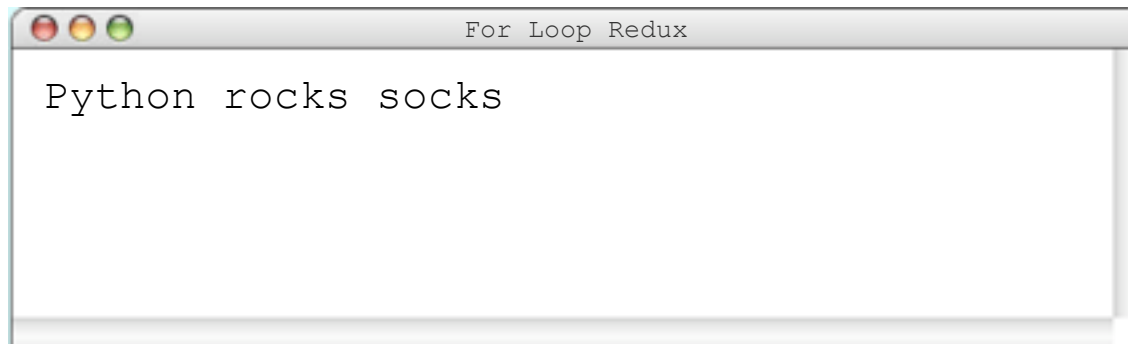
For Loop Redux

i 0

range(3) -> 0, 1, 2

```
for i in range(3):
```

```
    print("Python rocks socks!")
```

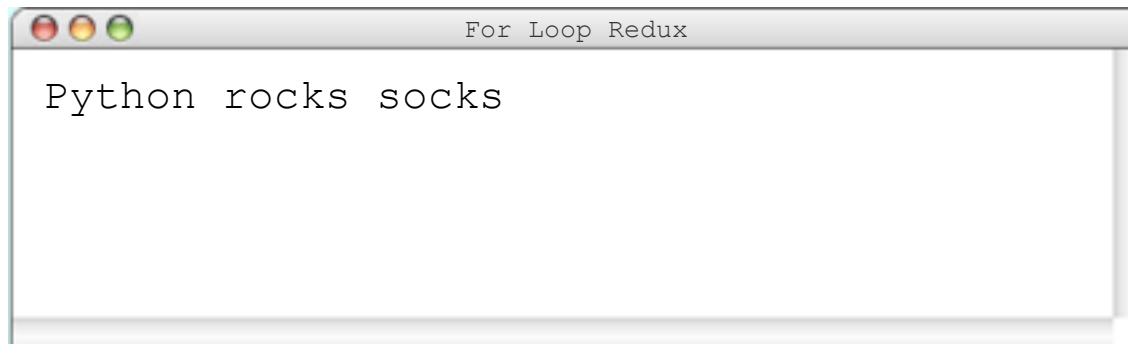


For Loop Redux

i 0

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```

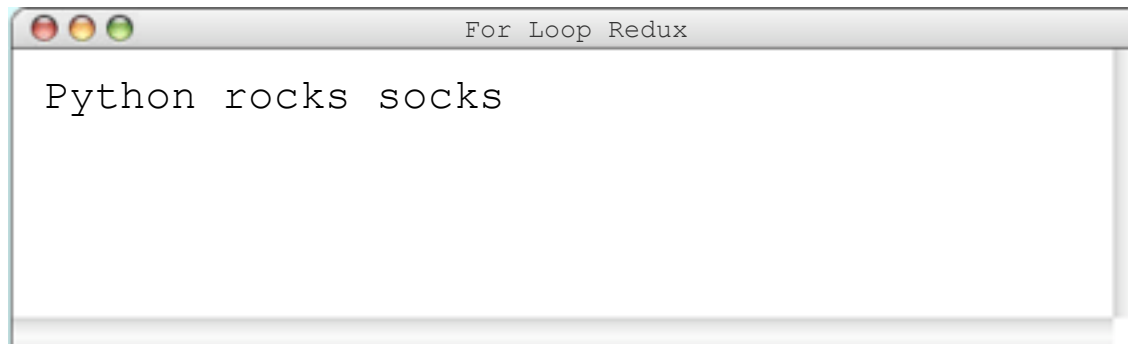


For Loop Redux

i 1

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```



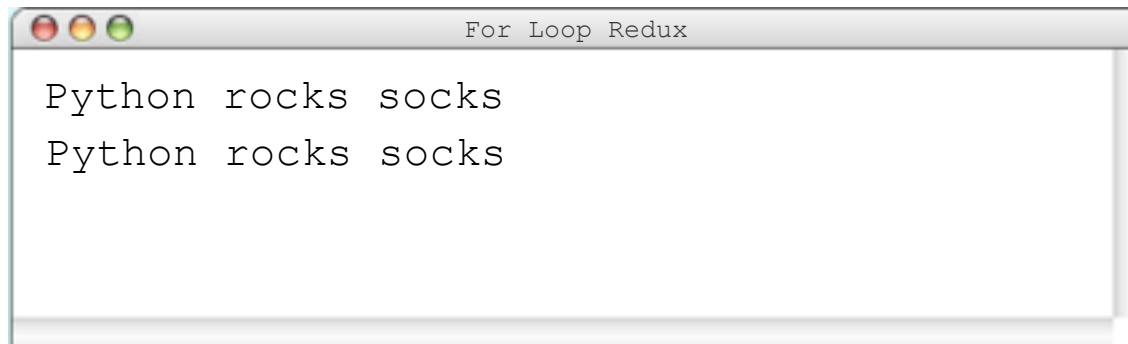
For Loop Redux

i 1

range(3) -> 0, 1, 2

```
for i in range(3):
```

```
    print("Python rocks socks!")
```



```
For Loop Redux  
Python rocks socks  
Python rocks socks
```

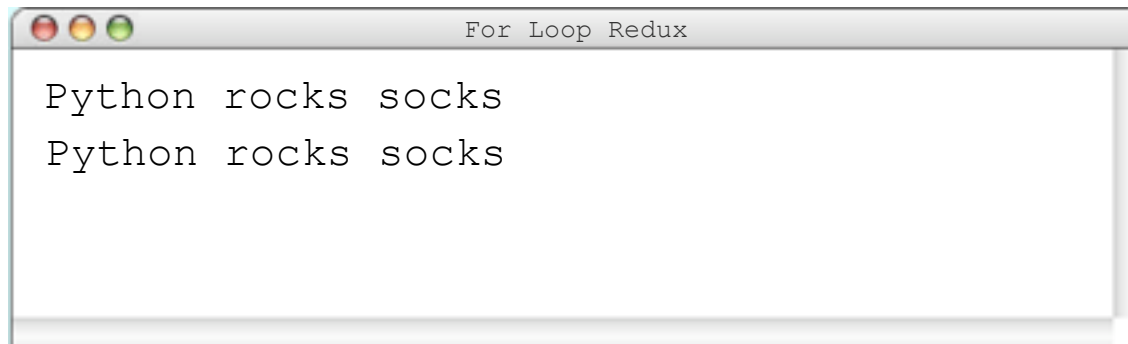


For Loop Redux

i 1

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```

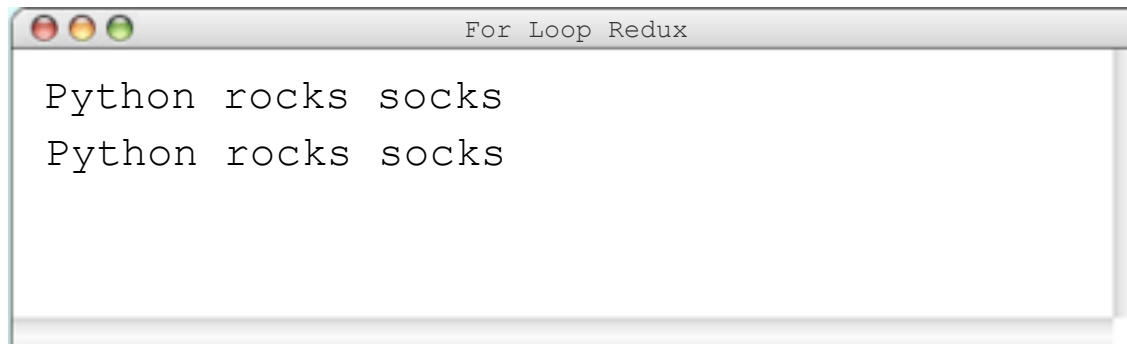


For Loop Redux

i 2

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```

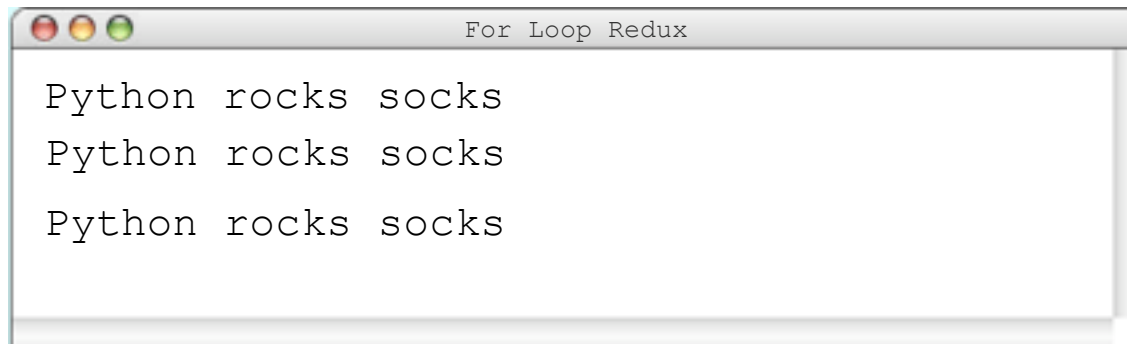


For Loop Redux

i 2

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```



```
For Loop Redux  
Python rocks socks  
Python rocks socks  
Python rocks socks
```

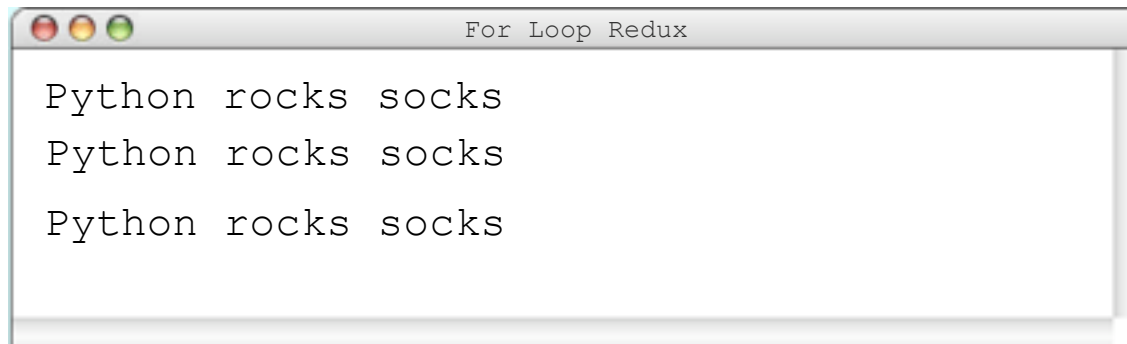


For Loop Redux

i 2

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```

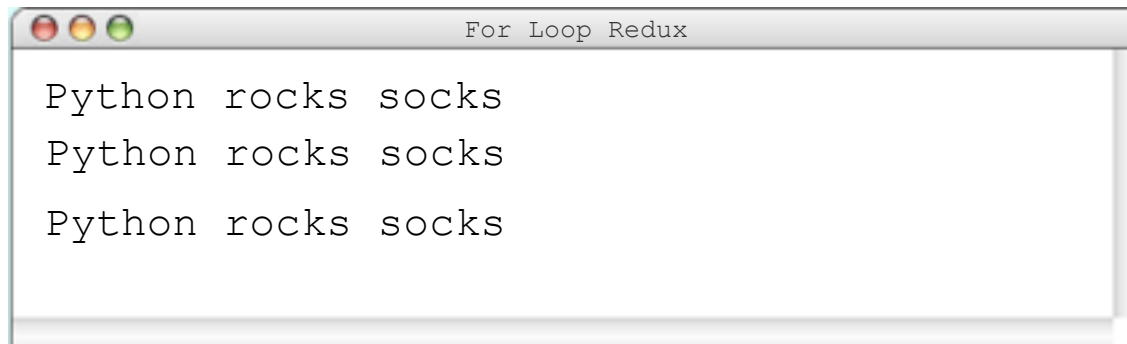


For Loop Redux

i 3

range(3) -> 0, 1, 2

```
for i in range(3):  
    print("Python rocks socks!")
```



```
For Loop Redux  
  
Python rocks socks  
Python rocks socks  
Python rocks socks
```

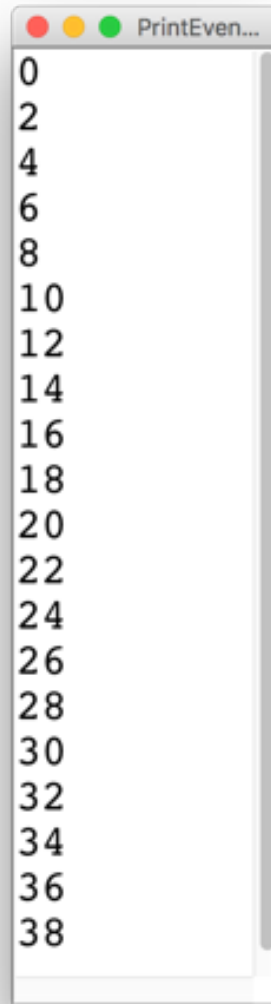


You can use the for loop variable



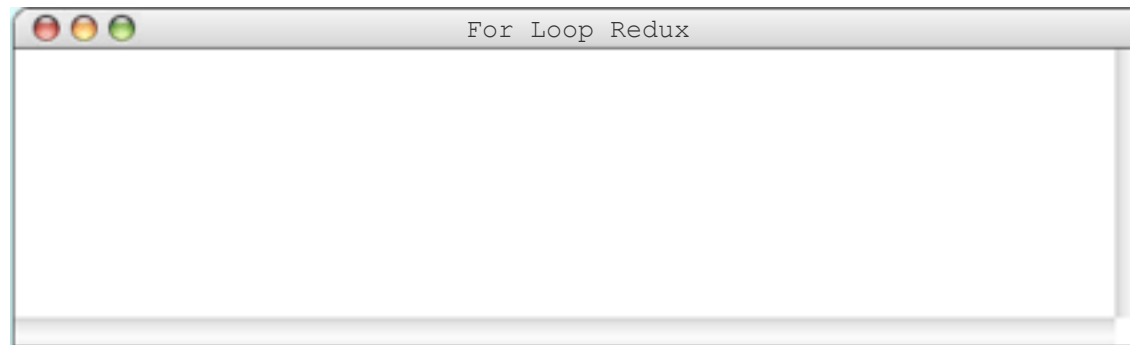
How would you print the first 100 even numbers?

Printing Even Numbers



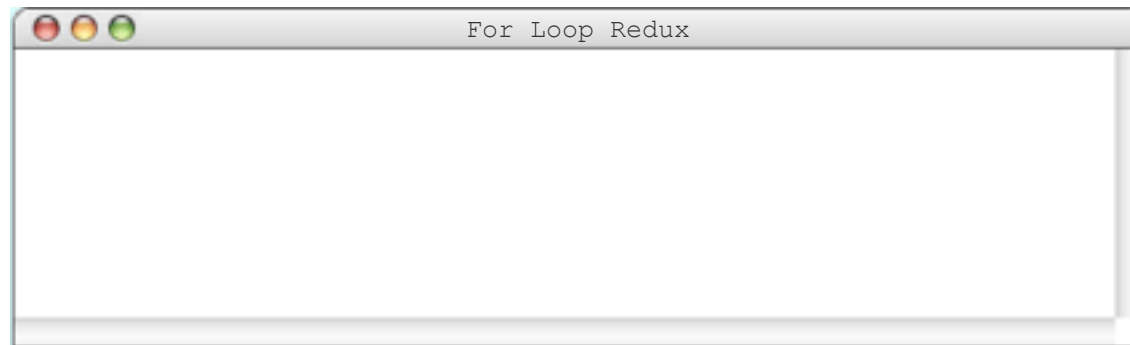
Printing Even Numbers

```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

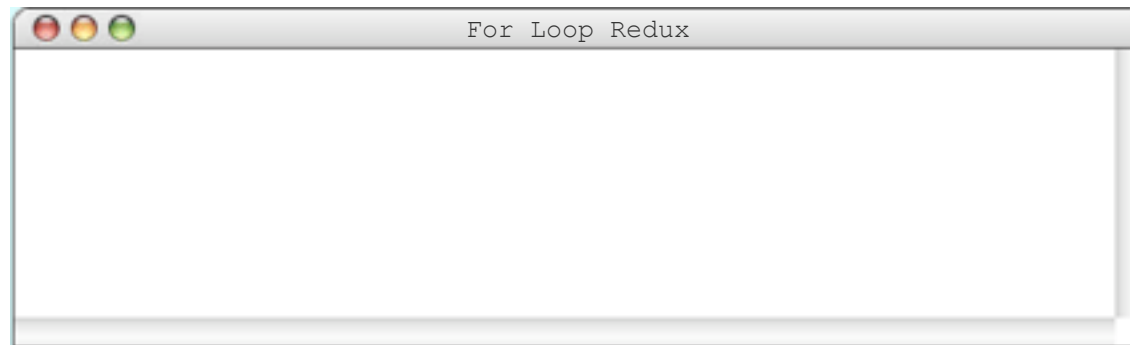
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 0

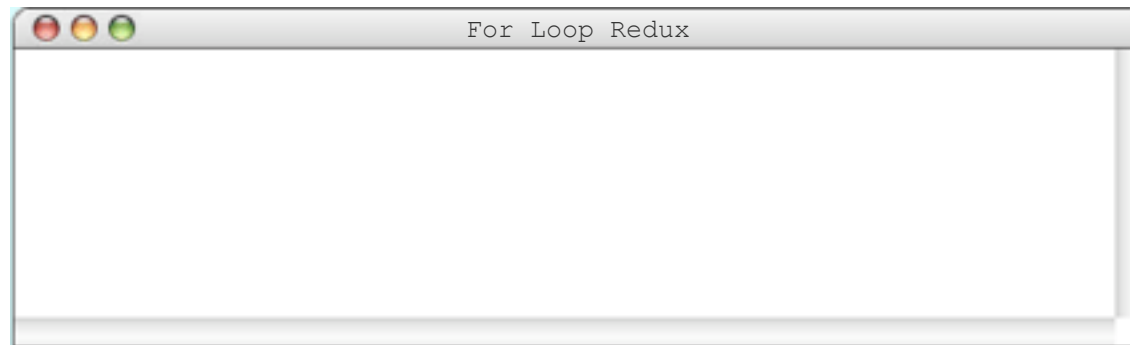
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 0

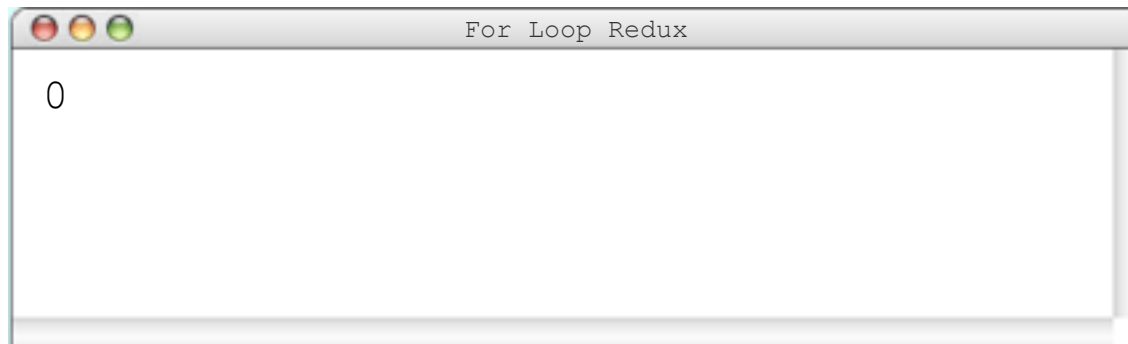
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 0

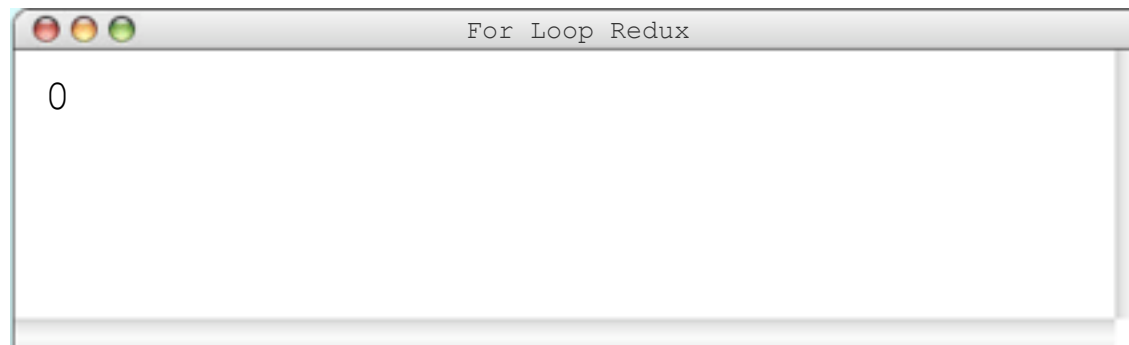
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 1

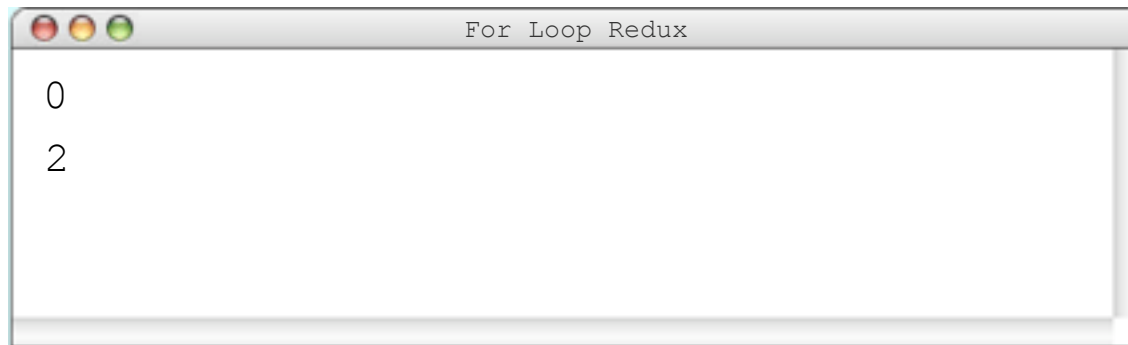
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 1

```
for i in range(3):  
    print(i * 2)
```



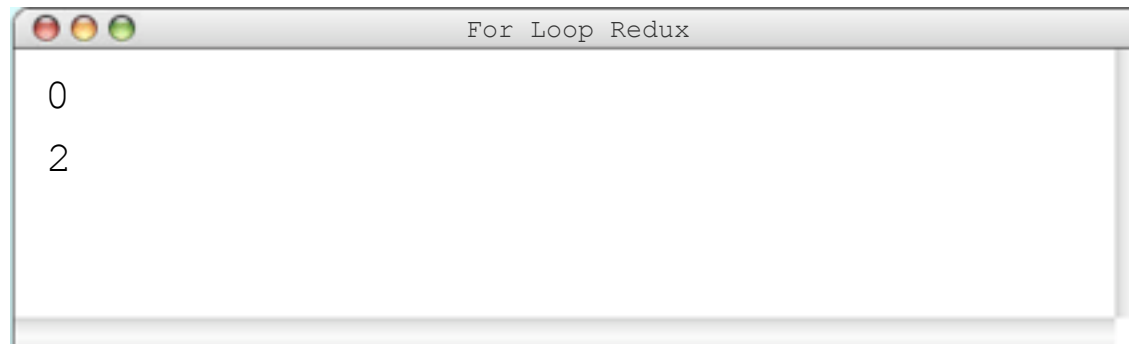
```
For Loop Redux  
0  
2
```



Printing Even Numbers

i 2

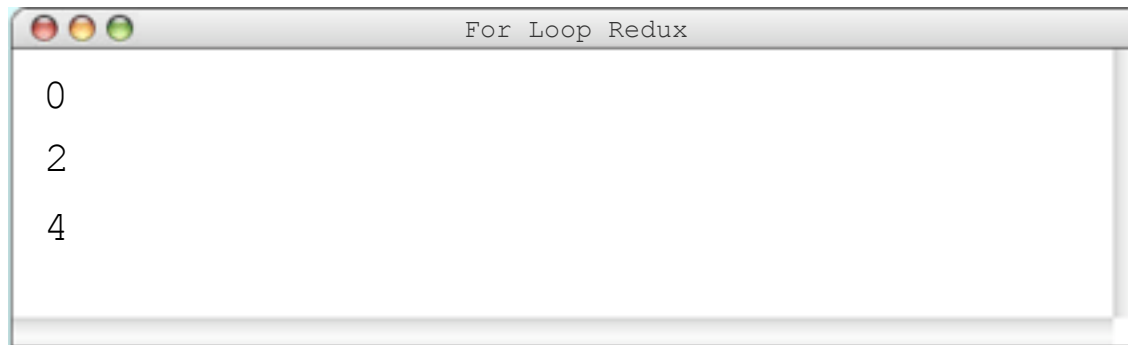
```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

i 2

```
for i in range(3):  
    print(i * 2)
```



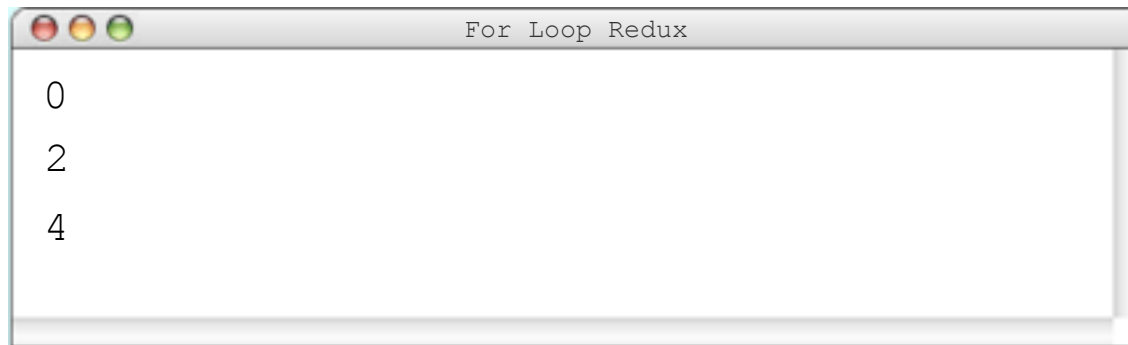
A terminal window titled "For Loop Redux" showing the output of the Python code. The output consists of three lines: 0, 2, and 4, each on a new line.



Printing Even Numbers

i 3

```
for i in range(3):  
    print(i * 2)
```



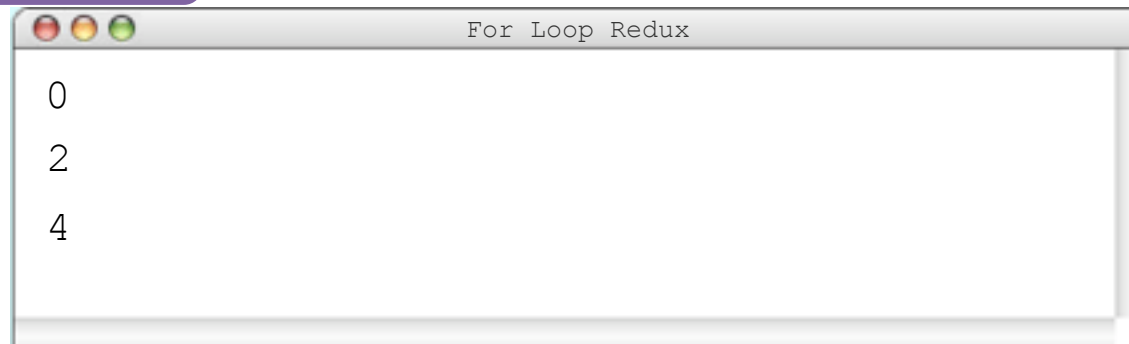
A terminal window titled "For Loop Redux" showing the output of the code. The output consists of three lines: 0, 2, and 4, each on a new line.



Printing Even Numbers

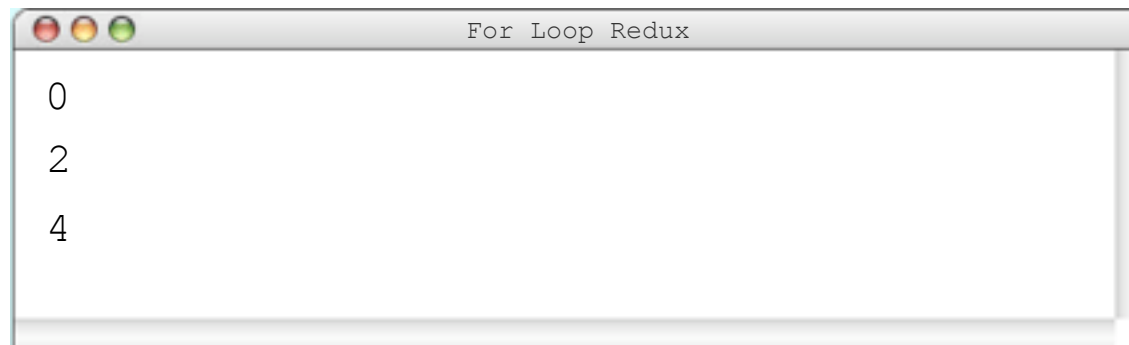
i 3

```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

```
for i in range(3):  
    print(i * 2)
```



Printing Even Numbers

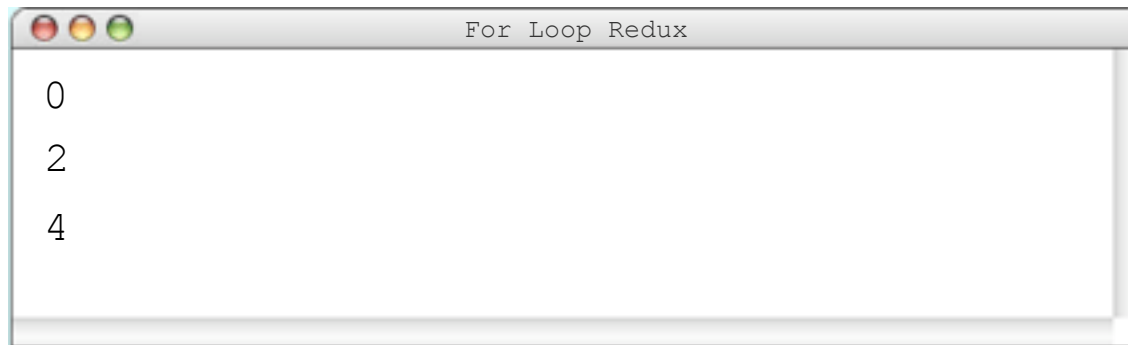
```
# our solution 0, 1, 2
for i in range(3):
    print(i * 2)
```

```
# equivalently
for i in range(0, 6, 2):
    print(i)
```

Start at 0

Stop before 6

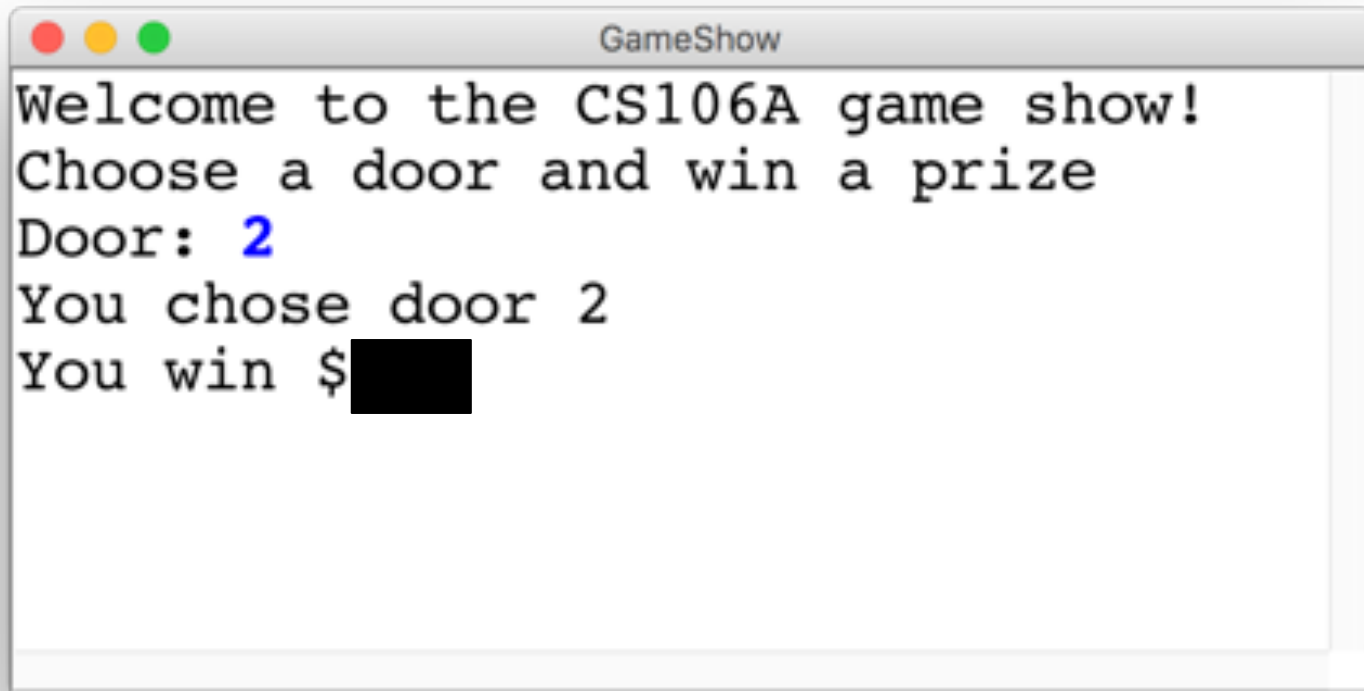
Skip by 2 each time



```
For Loop Redux
0
2
4
```



Game Show



* To be delivered via amazon
gift cards



Choose a Door

```
door = int(input("Door: "))  
# while the input is invalid  
while door < 1 or door > 3 :  
    # tell the user the input was invalid  
    print("Invalid door!")  
    # ask for a new input  
    door = int(input("Door: "))
```

or
and



The Door Logic

```
prize = 4
```

```
if door == 1:  
    prize = 2 + 9 // 10 * 100
```

```
elif door == 2:  
    locked = prize % 2 != 0  
    if not locked:  
        prize += 6
```

```
elif door == 3 :  
    for i in range(door):  
        prize += i
```

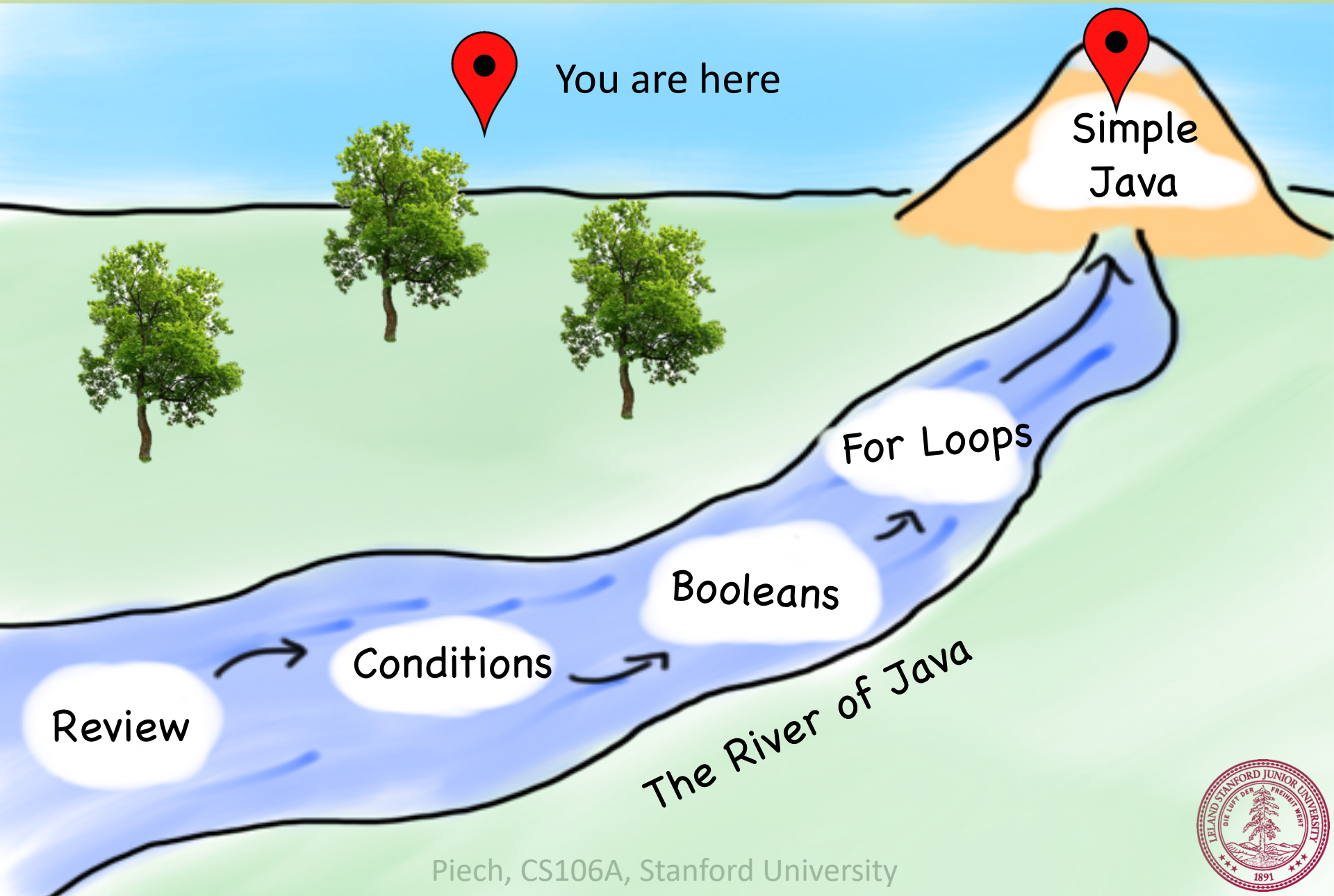


That's all

```
def main() :  
    for i in range(999999):  
        print("You rock!")  
        print("See you on Monday")
```



Today's Route



Today's Goal

1. Be able to use For / While / If in Java

