STRINGS, BRANCHING, ITERATION

VARIABLES (REVISITED)

- **name**
  - descriptive
  - meaningful
  - helps you re-read code
  - cannot be keywords

- **value**
  - information stored
  - can be updated

VARIABLE BINDING WITH =

- compute the **right hand side** → **VALUE**
- store it (aka bind it) in the **left hand side** → **VARIABLE**
- left hand side will be replaced with new value
- = is called assignment

```
x = 2
x = x*x
y = x+1
```

Compute value first, then bind it to variable name; this will overwrite value of x

BINDING EXAMPLE

- swap variables
  - is this ok?

```
x = 1
y = 2
y = x
x = y
```

This does NOT do what you think it does!

- swap variables
  - this is ok!

```
x = 1
y = 2
temp = y
y = x
x = temp
```

TYPES

- variables and expressions
  - `int`
  - `float`
  - `bool`
  - `string` -- NEW
  - ... and others we will see later

STRINGS

- letters, special characters, spaces, digits
- enclose in **quotation marks or single quotes**

```
hi = "hello there”
greetings = ‘hello’
```

- **concatenate** strings

```
name = "eric"
greet = hi + name
greeting = hi + " " + name
```

OPERATIONS ON STRINGS

- `‘ab’+ ‘cd’` → **concatenation**
- `3* ‘eric’` → **successive concatenation**
- `len(‘eric’)` → the **length**
- `‘eric’[1]` → **indexing**
  - Begins with index 0
  - Attempting to index beyond length – 1 is an error
- `‘eric’[1:3]` → **slicing**
  - Extracts sequence starting at first index, and ending before second index
  - If no value before :, start at 0
  - If no value after :, end at length
  - If just :, make a copy of entire sequence

INPUT/OUTPUT: `print`

- used to **output** stuff to console
- keyword is `print`

```
x = 1
print(x)
x_str = str(x)
print("my fav num is", x, ".", "x =", x)
print("my fav num is " + x_str + ". " + "x = " + x_str)
```

INPUT/OUTPUT: `input("")`

- prints whatever is within the quotes
- user types in something and hits enter
- returns entered sequence
- can bind that value to a variable so can reference

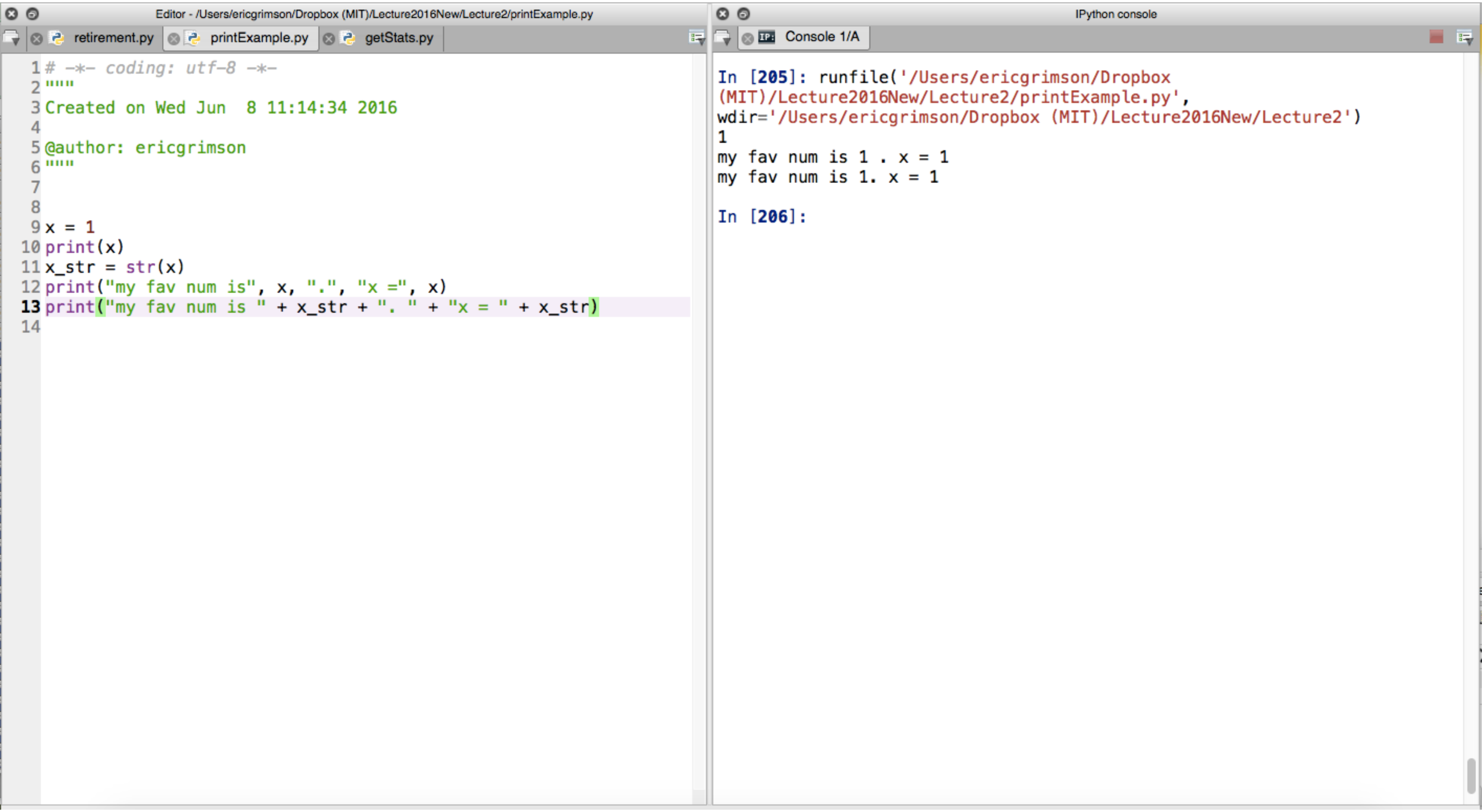
```
text = input("Type anything... ")
print(5*text)
```

- `input` **returns a string** so must cast if working with numbers

```
num = int(input("Type a number... "))
print(5*num)
```

IDE’s

- painful to just type things into a shell
- better to have a text editor – integrated development environment (IDE)
  - IDLE or Anaconda are examples
- comes with
  - Text editor – use to enter, edit and save your programs
  - Shell – place in which to interact with and run your programs; standard methods to evaluate your programs from the editor or from stored files
  - Integrated debugger (we’ll use later)



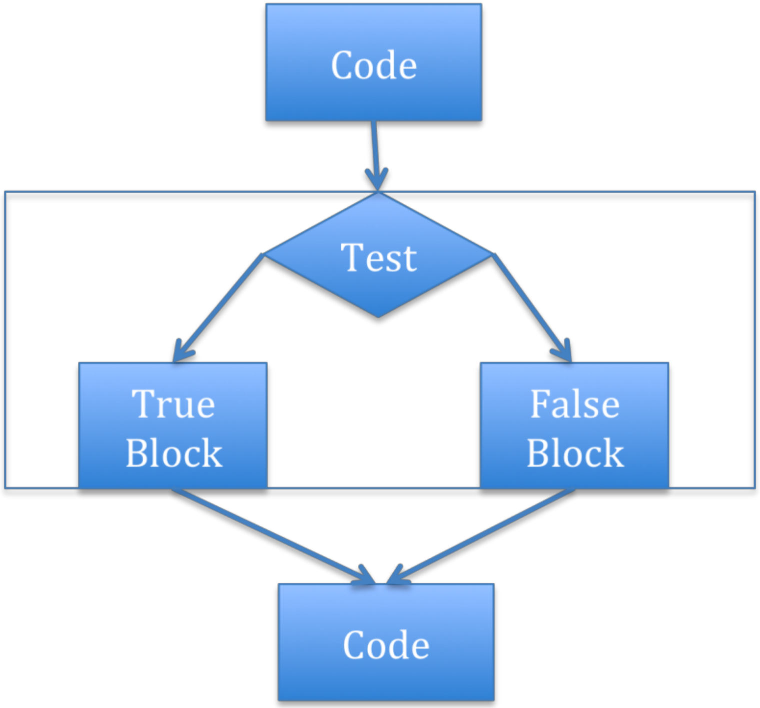
Editor - /Users/ericgrimson/Dropbox (MIT)/Lecture2016New/Lecture2/printExample.py
retirement.py
printExample.py
getStats.py
IPython console
Console 1/A

```python
# -*- coding: utf-8 -*-
"""
Created on Wed Jun  8 11:14:34 2016

@author: ericgrimson
"""


x = 1
print(x)
x_str = str(x)
print("my fav num is", x, ".", "x =", x)
print("my fav num is " + x_str + ". " + "x = " + x_str)

```

```
In [205]: runfile('/Users/ericgrimson/Dropbox
(MIT)/Lecture2016New/Lecture2/printExample.py',
wdir='/Users/ericgrimson/Dropbox (MIT)/Lecture2016New/Lecture2')
1
my fav num is 1 . x = 1
my fav num is 1. x = 1

In [206]:
```

BRANCHING PROGRAMS (REVISITED)

- The simplest branching statement is a **conditional**
  - A test (expression that evaluates to `True` or `False`)
  - A block of code to execute if the test is `True`
  - An optional block of code to execute if the test is `False`



COMPARISON OPERATORS ON `int` and `float`

- `i` and `j` are any variable names

`i>j`

`i>=j`

`i<j`

`i<=j`

`i==j` → **equality** test, `True` if `i` equals `j`

`i!=j` → **inequality** test, `True` if `i` not equal to `j`

LOGIC OPERATORS ON bools

- a and b are any variable names

not a → True if a is False

False if a is True

a and b → True if both are True

a or b → True if either or both are True

CONTROL FLOW - BRANCHING

```
if <condition>:
    <expression>
    <expression>
    ...
```

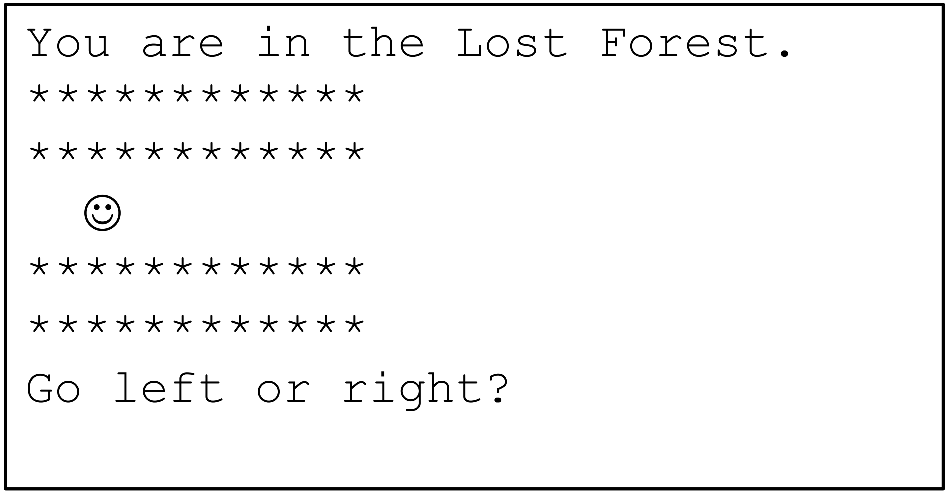
```
if <condition>:
    <expression>
    <expression>
    ...
else:
    <expression>
    <expression>
    ...
```

```
if <condition>:
    <expression>
    <expression>
    ...
elif <condition>:
    <expression>
    <expression>
    ...
else:
    <expression>
    <expression>
    ...
```

- `<condition>` has a value `True` or `False`
- evaluate expressions in that block if `<condition>` is `True`

USING CONTROL IN LOOPS

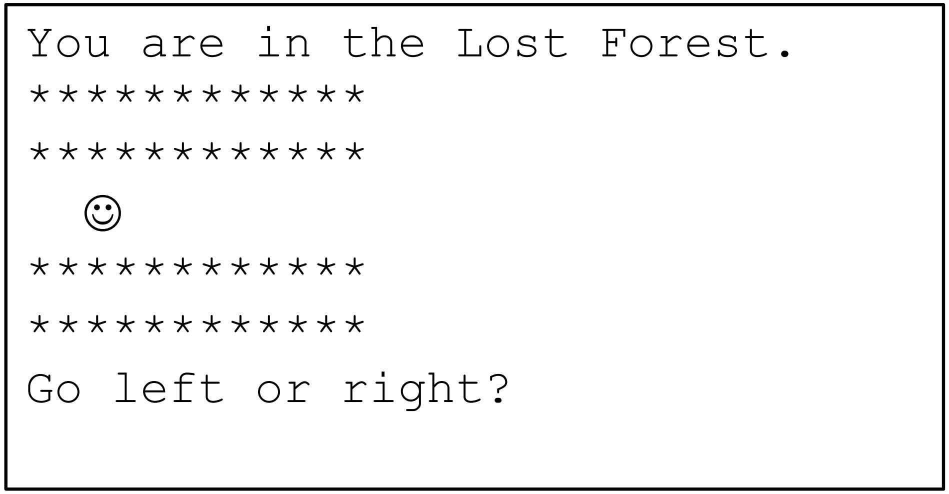
- simple branching programs just make choices, but path through code is still linear
- sometimes want to reuse parts of the code indeterminate number of times



```
You are in the Lost Forest.
************
************
  ☺
************
************
Go left or right?
```

- You are playing a video game, and are lost in some woods
- If you keep going right, takes you back to this same screen, stuck in a loop

```
if <exit right>:
    <set background to woods_background>
    if <exit right>:
        <set background to woods_background>
        if <exit right>:
            <set background to woods_background>
            and so on and on and on...
        else:
            <set background to exit_background>
    else:
        <set background to exit_background>
else:
    <set background to exit_background>
```



```
You are in the Lost Forest.
************
************
  ☺
************
************
Go left or right?
```

- You are playing a video game, and are lost in some woods
- If you keep going right, takes you back to this same screen, stuck in a loop

```
while <exit right>:
    <set background to woods_background>
<set background to exit_background>
```

CONTROL FLOW: `while` LOOPS

```
while <condition>:
    <expression>
    <expression>
    ...
```

- `<condition>` evaluates to a Boolean
- if `<condition>` is `True`, do all the steps inside the while code block
- check `<condition>` again
- repeat until `<condition>` is `False`

while LOOP EXAMPLE

```
You are in the Lost Forest.
************
************
  ☺
************
************
Go left or right?
```

```python
n = input("You are in the Lost Forest. Go left or right? ")
while n == "right":
    n = input("You are in the Lost Forest. Go left or right? ")
print("You got out of the Lost Forest!”)
```

CONTROL FLOW: while and for LOOPS

```
# more complicated with while loop
n = 0
while n < 5:
    print(n)
    n = n+1


# shortcut with for loop
for n in range(5):
    print(n)
```

range(5) gives us the integers 0, 1, 2, 3, 4 in turn

CONTROL FLOW: `for` LOOPS

```
for <variable> in range(<some_num>):
    <expression>
    <expression>
    ...
```

- each time through the loop, `<variable>` takes a value
- first time, `<variable>` starts at the smallest value
- next time, `<variable>` gets the prev value + 1
- etc.

`range(start,stop,step)`

- default values are `start = 0` and `step = 1` and is optional
- loop until value is `stop - 1`

```
mysum = 0
for i in range(7, 10):
    mysum += i
print(mysum)
```

```
mysum = 0
for i in range(5, 11, 2):
    mysum += i
print(mysum)
```

break STATEMENT

- immediately exits whatever loop it is in
- skips remaining expressions in code block
- exits only innermost loop

```
while <condition_1>:
    while <condition_2>:
        <expression_a>
        break
        <expression_b>
    <expression_c>
```

break STATEMENT

```
mysum = 0
for i in range(5, 11, 2):
    mysum += i
    if mysum == 5:
        break
print(mysum)
```

- what happens in this program?

for VS while LOOPS

for loops

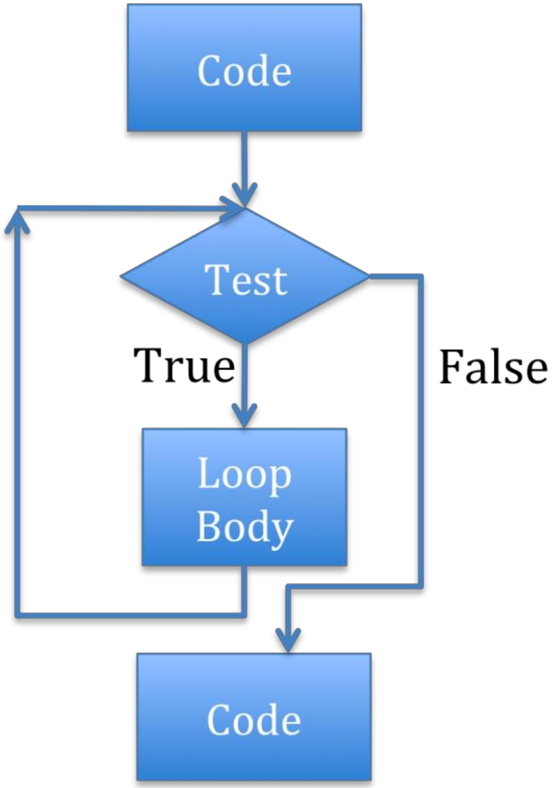
- **know** number of iterations
- can **end early** via break
- uses a **counter**
- **can rewrite** a for loop using a while loop

while loops

- **unbounded** number of iterations
- can **end early** via break
- can use a **counter but must initialize** before loop and increment it inside loop
- **may not be able to rewrite** a while loop using a for loop

ITERATION

- Concept of iteration let’s us extend simple branching algorithms to be able to write programs of arbitrary complexity
  - Start with a test
  - If evaluates to `True`, then execute loop body once, and go back to reevaluate the test
  - Repeat until test evaluates to `False`, after which code following iteration statement is executed



AN EXAMPLE

```
x = 3
ans = 0
itersLeft = x
while (itersLeft != 0):
    ans = ans + x
    itersLeft = itersLeft - 1
print(str(x) + '*' + str(x) + ' = ' + str(ans))
```

This code squares the value of x by repetitive addition.

STEPPING THROUGH CODE

```
x = 3
ans = 0
itersLeft = x
while (itersLeft != 0):
    ans = ans + x
    itersLeft = itersLeft – 1
print(str(x) + '*' + str(x) + ' = ' + str(ans))
```

x	ans	itersLeft
3	0	3
	3	2
	6	1
	9	0

Some properties of iteration loops:

- need to set an iteration variable outside the loop
- need to test variable to determine when done
- need to change variable within the loop, in addition to other work

ITERATIVE CODE

- Branching structures (conditionals) let us jump to different pieces of code based on a test
  - Programs are **constant time**
- Looping structures (e.g., while) let us repeat pieces of code until a condition is satisfied
  - Programs now take time that depends on values of variables, as well as length of program

CLASSES OF ALGORITHMS

- Iterative algorithms allow us to do more complex things than simple arithmetic
- We can repeat a sequence of steps multiple times based on some decision; leads to new classes of algorithms
- One useful example are “guess and check” methods

GUESS AND CHECK

- Remember our “declarative” definition of square root of `x`

- If we could guess possible values for square root (call it `g`), then can use definition to check if `g*g = x`

- We just need a good way to generate guesses

FINDING CUBE ROOT OF INTEGER

- One way to use this idea of generating guesses in order to find a cube root of `x` is to first try `0**3`, then `1**3`, then `2**3`, and so on
- Can stop when reach `k` such that `k**3 > x`
- Only a finite number of cases to try

SOME CODE

```
x = int(input('Enter an integer: '))
ans = 0
while ans**3 < x:
    ans = ans + 1
if ans**3 != x:
    print(str(x) + ' is not a perfect cube')
else:
    print('Cube root of ' + str(x) + ' is ' + str(ans))
```

EXTENDING SCOPE

- Only works for positive integers
- Easy to fix by keeping track of sign, looking for solution to positive case

SOME CODE

```
x = int(input('Enter an integer: '))
ans = 0
while ans**3 < abs(x):
    ans = ans + 1
if ans**3 != abs(x):
    print(str(x) + ' is not a perfect cube')
else:
    if x < 0:
        ans = - ans
    print('Cube root of ' + str(x) + ' is ' + str(ans))
```

LOOP CHARACTERISTICS

- Need a loop variable
  - Initialized outside loop
  - Changes within loop
  - Test for termination depends on variable
- Useful to think about a **decrementing function**
  - Maps set of program variables into an integer
  - When loop is entered, value is non-negative
  - When value is <= 0, loop terminates, and
  - Value is decreased every time through loop
- Here we can use `abs(x) - ans**3`

WHAT IF MISS A CONDITION?

- Suppose we don’t initialize the variable?
  - Likely get a NameError; or worse use an expected value to initiate the computation
- Suppose we don’t change the variable inside the loop?
  - Will end up in an infinite loop, never reaching the terminating condition

GUESS-AND-CHECK

- you are able to **guess a value** for solution
- you are able to **check if the solution is correct**
- keep guessing until find solution or guessed all values
- the process is **exhaustive enumeration**

CLEANER GUESS-AND-CHECK – cube root

```
cube = 8
for guess in range(cube+1):
    if guess**3 == cube:
        print("Cube root of ", cube, ” is ", guess)
```

CLEANER GUESS-AND-CHECK – cube root

```
cube = 8

for guess in range(abs(cube)+1):

    if guess**3 >= abs(cube):

        break

if guess**3 != abs(cube):

    print(cube, ’is not a perfect cube’)

else:

    if cube < 0:

        guess = -guess

    print('Cube root of ' + str(cube) + ' is ' + str(guess))
```

EXHAUSTIVE ENUMERATION

- Guess and check methods can work on problems with a finite number of possibilities
- Exhaustive enumeration is a good way to generate guesses in an organized manner