Writing code that makes decisions: if/else statements

Lesson 2 – 9/9/16

With notes!

Today's topics

1. `if/else` statements
2. Built-in functions
   - `raw_input()`,`len()`,`abs()`, `round()`
3. Non-built-in functions
   - a brief intro to modules
4. How to read the PyDocs
5. Commenting your code

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Most of the class will focus on if/else statements and the logical statements ("conditionals") that are used to build them.
Then I'll go over a few useful functions (some built into standard Python; some requiring you to import a "module" first)
Finally, I'll talk about commenting your code - a very simple but important topic

1. if/else statements

Control statements – what are they?

Programming is a lot like giving someone instructions or directions. For example, if I wanted to give you directions to my house, I might say...

- Turn right onto Main Street
- Turn left onto Maple Ave
- **If** there is construction, continue straight on Maple Ave, turn right on Cat Lane, and left on Fake Street; **otherwise** cut through the empty lot to Fake Street
- Go straight on Fake Street until house 123

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Control statements – what are they?

The same directions, but in code:

```
construction = False
print "Turn right onto Main Street"
print "Turn left onto Maple Ave"
if construction:
          print "Continue straight on Maple Ave"
          print "Turn right onto Cat Lane"
          print "Turn left onto Fake Street"
else:
          print "Cut through the empty lot to Fake Street"
print "Go straight on Fake Street until house 123"
```

Output:

```
Turn right onto Main Street
Turn left onto Maple Ave
Cut through the empty lot to Fake Street
Go straight on Fake Street until house 123
```

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Control statements – what are they?

The same directions, but in code:

```
construction = False
print "Turn right onto Main Street"
print "Turn left onto Maple Ave"
if construction:
        print "Continue straight on Maple Ave"
        print "Turn right onto Cat Lane"
        print "Turn left onto Fake Street"
else:
        print "Cut through the empty lot to Fake Street"
print "Go straight on Fake Street until house 123"
```

`True` and `False` are special words in Python called **Booleans**

This is called an "**if statement**". It works pretty much how you'd expect it to: if the statement is true, it executes the first block of code; if the statement is false, it executes the second block of code (under the `else`)

Output:

```
Turn right onto Main Street
Turn left onto Maple Ave
Cut through the empty lot to Fake Street
Go straight on Fake Street until house 123
```

Since `construction` holds the value `False`, the `if` statement skips the first block of print statements and only executes what is in the `else:` block.

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Control statements are things like the if statement here, which control the flow of your program. Each control statement has some sort of condition which it checks for True-ness or False-ness. For example, here the condition is simply the variable "construction". Since the value of this condition is False, we do not execute the "if" block, and instead execute the "else" block. Thus, we have changed the flow of the program based on the value of the variable "construction".
Control statements also include loops, which we'll talk about today.

Booleans - the logical datatype

- A Boolean ("bool") is actually a type of variable, like a string, int, or float. However, a Boolean is only allowed to take the values `True` or `False`.
- `True` and `False` are always capitalized and never in quotes.
- Don't think of `True` and `False` as words. You can't treat them like you would strings. To the computer, they're actually interpreted as the numbers 1 and 0, respectively.

`if/else` statement

Purpose: creates a "fork" in the flow of the program.

- Based on the Boolean value of a conditional statement, either executes the `if`-block or the `else`-block
- The "blocks" are indicated by indentation.
- The `else`-block is optional.

`if/else` statement

Syntax:

```
if conditional:
    this code is executed
else:
    this code is executed
```

Example:

```
x = 5
if (x > 0):
    print "x is positive"
else:
    print "x is negative"
```

Important to note:

- Colons are required after the `if` condition and after the `else`
- All code that is part of the `if/else` statement must be indented.

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The conditional can be pretty much anything that can be evaluated as either True or False. See next slide.

What kinds of "conditionals" are allowed?

Anything that can be evaluated as true or false!

- is `a` True?
- is `a` less than `b`?
- is `a` equal to `b`?
- is `a` equal to "ATGCTG"?
- is (`a` greater than `b`) and (`b` greater than `c`)?

Forming conditionals

We use a special set of symbols/words to test whether statements are true or false:

Symbol	Meaning	Example
==	is equal to	`if (a == 4):`
!=	is not equal to	`if (a != "applesauce"):`
<	is less than	`if (a < 10.5):`
<=	is less than or equal to	`if (a <= b):`
>	is greater than	`if (a > (b * 2)):`
>=	is greater than or equal to	`if (a >= -1):`
and	and	`if (a > 0) and (a != 3):`
or	or	`if (a > 5) or (a < -5):`
not	not	`if not (a == 1):`

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Most of these are pretty intuitive. The big one people tend to mess up on in the beginning is ==. Remember, a single equals sign means **assignment**. A double equals means **is the same as/is equal to**. You will NEVER use a single equals sign in a conditional statement.

Question 1

What will this code print?

```
a = True
if a:
   print "Hooray, a was true!"
```

Optional: enter your answers online!
https://goo.gl/forms/x1G57MV2QXJ8tXQG2

https://goo.gl/forms/x1G57MV2QXJ8tXQG2

Question 1

What will this code print?

```
a = True
if a:
   print "Hooray, a was true!"
```

Result

```
Hooray, a was true!
```

Question 2

What will this code print?

```
a = True
if a:
   print "Hooray, a was true!"
print "Goodbye now!"
```

Question 2

What will this code print?

```
a = True
if a:
   print "Hooray, a was true!"
print "Goodbye now!"
```

Result

```
Hooray, a was true!
Goodbye now!
```

Question 3

What will this code print?

```
a = False
if a:
   print "Hooray, a was true!"
print "Goodbye now!"
```

Question 3

What will this code print?

```
a = False
if a:
   print "Hooray, a was true!"
print "Goodbye now!"
```

Result

```
Goodbye now!
```

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Since the line 'print "Goodbye now!" ' is not indented, it is NOT considered part of the if statement.
Therefore, it is printed no matter how the if-statement is evaluated.

Question 4

What will this code print?

```
morning = True
if morning:
    print "Good morning!"
else:
    print "Hello!"
print "How are you?"
```

Question 4

What will this code print?

```
morning = True
if morning:
    print "Good morning!"
else:
    print "Hello!"
print "How are you?"
```

Result

```
Good morning!
How are you?
```

Question 5

What will this code print?

```
a = True
b = False
if a and b:
    print "Apple"
else:
    print "Banana"
```

Question 5

What will this code print?

```
a = True
b = False
if a and b:
    print "Apple"
else:
    print "Banana"
```

Result

```
Banana
```

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Since a and b are not both True, we go to the else statement.

Question 6

What will this code print?

```
a = True
b = False
if a and not b:
    print "Apple"
else:
    print "Banana"
```

Question 6

What will this code print?

```
a = True
b = False
if a and not b:
    print "Apple"
else:
    print "Banana"
```

Result

```
Apple
```

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By using "not" before b, we negate its current value (False), making b True. Thus the entire conditional as a whole becomes True, and we execute the if-block.

Question 7

What will this code print?

```
a = True
b = False
if not a and b:
    print "Apple"
else:
    print "Banana"
```

Question 7

What will this code print?

```
a = True
b = False
if not a and b:
    print "Apple"
else:
    print "Banana"
```

Result

```
Banana
```

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"not" only applies to what's directly in front of it. So a more clear way to show this statement might be like this:
(not a) and b

This turns into
(False) and False

and thus the overall conditional is not true. We therefore go to the else statement.

Question 8

What will this code print?

```
a = True
b = False
if not (a and b):
    print "Apple"
else:
    print "Banana"
```

Question 8

What will this code print?

```
a = True
b = False
if not (a and b):
    print "Apple"
else:
    print "Banana"
```

Result

```
Apple
```

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Using parentheses works like you'd expect in conditionals: grouped statements are evaluated first.

So Python first decides: (a and b)? ("are a and b both true?") -> False
Then it applies the not, which flips the False into a True. So then the final answer is True.

Here's another way of breaking down what's happening, in order:
not (a and b)
not (True and False)
not (False)
True

Question 9

What will this code print?

```
a = True
b = False
if a or b:
    print "Apple"
else:
    print "Banana"
```

Question 9

What will this code print?

```
a = True
b = False
if a or b:
    print "Apple"
else:
    print "Banana"
```

Result

```
Apple
```

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"is a or b True?"

As you'd expect, with "or" only one of them has to be True

Question 10

What will this code print?

```
a = True
b = False
if not (a or b):
    print "Apple"
else:
    print "Banana"
```

Question 10

What will this code print?

```
a = True
b = False
if not (a or b):
    print "Apple"
else:
    print "Banana"
```

Result

```
Banana
```

Question 11

What will this code print?

```
a = 5
b = 10
if (a == 5) and (b > 0):
    print "Apple"
else:
    print "Banana"
```

Question 11

What will this code print?

```
a = 5
b = 10
if (a == 5) and (b > 0):
    print "Apple"
else:
    print "Banana"
```

Result

```
Apple
```

Question 12

What will this code print?

```
a = 5
b = 10
if ((a == 1) and (b > 0)) or (b == (2 * a)):
    print "Apple"
else:
    print "Banana"
```

Question 12

What will this code print?

```
a = 5
b = 10
if ((a == 1) and (b > 0)) or (b == (2 * a)):
    print "Apple"
else:
    print "Banana"
```

Result

```
Apple
```

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How to solve these? Sometimes it's best to just write it down, and write down True or False as you solve each part.

```
((a == 1) and (b > 0)) or (b == (2 * a))
((5 == 1) and (10 > 0)) or (10 == (2 * 5))
((False) and (True)) or (True)
(False) or (True)
True
```

Hopefully you won't ever have to write or understand such a convoluted conditional. But, if you do, make sure to logic-check it very thoroughly, because it's very easy to make mistakes.

Note on indentation

- Indentation is very important in Python; it's how Python tells what code belongs to which control statements
- Consecutive lines of code with the same indenting are sometimes called "blocks"
- Indenting should only be done in specific circumstances (if statements are one example, and we'll see a few more soon). Indent anywhere else and you'll get an error.
- You can indent by however much you want, but you must be consistent. Pick one indentation scheme (e.g. 1 tab per indent level, or 4 spaces) and stick to it.

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Some people recommend using 4 spaces instead of a tab. I believe this is the official Python recommendation as well. Personally, I prefer tabs. People argue about this a lot, and there's no real consensus, unfortunately. You can pretty much use whatever you want when you code on your own, but if you ever start collaborating with someone else on the same code, just make sure you agree on one convention, or you're in for a real headache.

Other forms of the `if` statement

Multi-`if/else`:

```
choice = raw_input("Choose option 1, 2, or 3: ")
if (choice == "1"):
        print "You have chosen option 1: cake"
elif (choice == "2"):
        print "You have chosen option 2: ice cream"
elif (choice == "3"):
        print "You have chosen option 3: broccoli"
else:
        print "Invalid input."
```

Only one of these code blocks will be executed.

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Use "if" for the first block, "elif" for the middle blocks, and "else" for the final block (again, else is optional--it's like a catch-all for anything that didn't match an earlier statement)

Other forms of the `if` statement

"Nested" `if/else`:

```
test = raw_input("What is 1+1? ")
if (test == "2"):
        print "Correct!"
        test2 = raw_input("What is 2314*32626? ")
        if (test2 == "75496564"):
                print "Correct! You passed all my tests!"
        else:
                print "Sorry, that's wrong."
else:
        print "Sorry, that's wrong."
```

2. Built-in functions

What's a built-in function?

- Python provides some useful built-in functions that perform specific tasks
- What makes them "built-in"?
  - Simply that you don't have to "import" anything in order to use them -- they're always available
- We've already seen some examples:
  - `print`, `int()`, `float()`, `str()`
- Now we'll look at a few more

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"Built-in" is in contrast the the non-built-in functions, which are packaged into modules of similar functions (e.g. "math") that you must import before using. More on this in a minute!

You can also create your own functions, which is super useful...more on that in a future class!
We'll talk more about what a function actually IS when we get to that class. For now, it's fine to think of them like commands.

`raw_input()`

Description: A built-in function that allows user input to be read from the terminal.

- As seen in the lab1 problem set.
- The execution of the code will pause when it reaches the `raw_input()` function and wait for the user to input something.
- The input ends when the user hits "enter".
- The data that is read by `raw_input()` can then be stored in a variable and used in the code.
- **This function always returns a string, even if the user entered a number.**

This allows us to change what our program does without actually changing the code itself!

raw_input()

Syntax:

```
raw_input("Optional prompt: ")
```

Examples:

```
name = raw_input("Your name: ")
age = int(raw_input("Your age: "))
```

Important to note:

We can **nest commands** inside of each other, as in the second example here. This works a lot like the order of operations in math—whatever is the most nested is executed first, and then execution proceeds outward.

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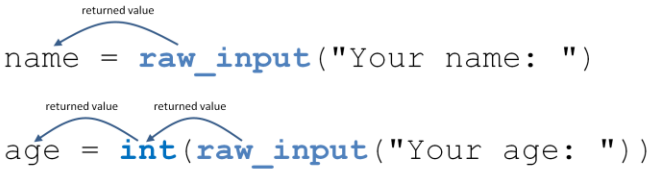
What happens if you don't assign the result of raw_input() to some variable?
> Well, nothing. You lose whatever was read. When you use a function, you only have one chance to "capture" their output. However, sometimes we don't care about the output, and in those cases we can just ignore it.

raw_input()

Syntax:

```
raw_input("Optional prompt: ")
```

Examples:



We say that `raw_input()` "returns" a value (in this case, a string version of whatever was entered in the terminal)
This value can then be used by another function (e.g. `int()`) or saved in a variable.

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Side note: you actually won't use raw_input() very much, if ever, after this lesson. There are much better ways of obtaining dynamic input– e.g. command line arguments and reading from files. We're only going over it because it's the only way of getting outside input that doesn't require explaining a whole lot of other concepts. ☺

`len()`

Description: Returns the length of a string (also works on certain data structures). Doesn't work on numerical types.

Examples:

```
print len("cat")
```

```
3
```

```
print len("hi there")
```

```
8
```

```
seqLength = len("ATGGTCGCAT")
```

returned value
saved in variable

abs()

Description: Returns the absolute value of a numerical value. Doesn't accept strings.

Examples:

```
print abs(-10)
```

```
10
```

```
print abs("-10")
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-7-441ce54f04bb> in <module>()
----> 1 print abs("-10")

TypeError: bad operand type for abs(): 'str'
```

```
print(int("-10"))
```

```
-10
```

```
positiveNum = abs(-23423)
```

round()

Description: Rounds a float to the indicated number of decimal places. If no number of decimal places is indicated, rounds to zero decimal places.

Synatx:

```
round(someNumber, numDecimalPlaces)
```

Examples:

```
print round(10.12345)
10.0
print round(10.12345, 2)
10.12
print round(10.9999, 2)
11.0
```

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There are many more!

- Most of the other built-in functions are too advanced right now, but we'll see some more in the future
- If you're curious, there's a full list here:

https://docs.python.org/2/library/functions.html

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3. Non-built-in functions

What is a non-built-in function?

- The only difference is that these functions aren't accessible until you **import** them
- Why aren't they all just built-in? It improves speed and memory usage to only import what is needed.
- Related functions are grouped into modules. Importing a module imports all the module's functions.
- We'll go over two modules today: `math` and `random`

How to use a module

1. First you must import the module. Add this to the top of your script:

```
import <moduleName>
```

2. To use a function of the module, you must prefix the function with the name of the module (using a period between them):

```
<moduleName>.<functionName>
```

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Replace <moduleName> with the name of the module you want, and <functionName> with the name of a function in the module.

The `<moduleName>.<functionName>` synatx is needed so that Python knows where the function comes from. There can potentially be other functions with the same name (e.g.

The `math` module

Description: Contains many advanced math-related functions.

Usage example:

```
import math

math.sqrt(4)
math.log10(1000)
math.sin(1)
math.cos(0)
```

Important to note:

These functions all return values! (As do most functions)

You must save the returned value in a variable to use it elsewhere in the code.

The `random` module

Description: contains functions for generating random numbers.

Usage example:

```
import random

random.random()
random.randint(0,10)
random.gauss(5, 2)
```

Important to note:

These functions all return values! (As do most functions)

You must save the returned value in a variable to use it elsewhere in the code.

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`random.random()` – Return the next random floating point number in the range [0.0, 1.0).
random.randint(a, b) - Return a random integer *N* such that a <= N <= b.
`random.gauss(mu, sigma) – draw from the` Normal distribution. *mu* is the mean, and *sigma* is the standard deviation.

Variations of importing

- You can import more than one module at a time:

```
import math, random
```

- You can give a module an alias and use that in your code (good when module name is long):

```
import random as rnd
```

- You can import individual functions from a module (note that if you do this, you must call the function *WITHOUT* prefixing it):

```
from math import log10
log10(100)
```

- You can import all functions as above if you use * (so then you can use all functions without prefixing with the module name):

```
from math import *
sqrt(64)
```

Important to note:
This last one is generally a bad idea, actually. It can lead to a lot of confusion in large scripts with many modules in use. Use it sparingly, if at all.

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There are many more!

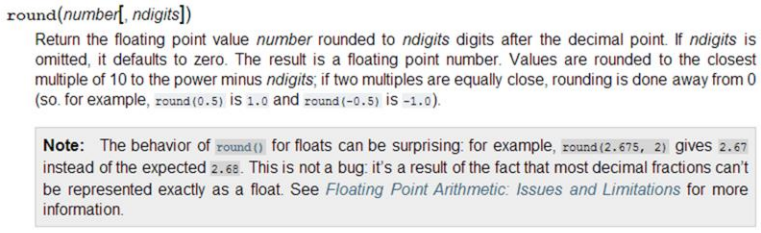
If you are curious, there's a list of modules here:

https://docs.python.org/2.7/py-modindex.html

4. Understanding the PyDocs

A quick primer on reading the PyDocs

Example PyDoc entry:



round(*number*[, *ndigits*])

Return the floating point value *number* rounded to *ndigits* digits after the decimal point. If *ndigits* is omitted, it defaults to zero. The result is a floating point number. Values are rounded to the closest multiple of 10 to the power minus *ndigits*; if two multiples are equally close, rounding is done away from 0 (so. for example, `round(0.5)` is `1.0` and `round(-0.5)` is `-1.0`).

Note: The behavior of `round()` for floats can be surprising: for example, `round(2.675, 2)` gives `2.67` instead of the expected `2.68`. This is not a bug: it's a result of the fact that most decimal fractions can't be represented exactly as a float. See *Floating Point Arithmetic: Issues and Limitations* for more information.

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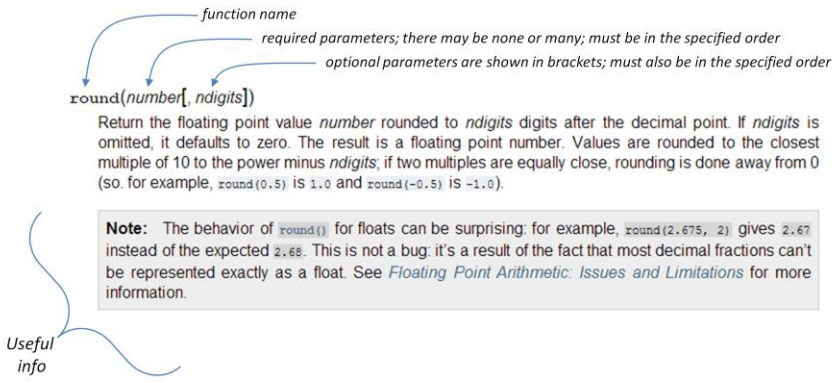
PyDocs: the documentation of all Python, found here:
https://docs.python.org/2/index.html

This will often pop up as the first google search hit, so it's important to be able to understand the various conventions used

A quick primer on reading the PyDocs

Example PyDoc entry:



A quick primer on reading the PyDocs

Another example:

`sorted`(*iterable*[, *cmp*[, *key*[, *reverse*]]])
Return a new sorted list from the items in *iterable*.

A quick primer on reading the PyDocs

Another example:

When brackets are nested like this, it means that to use the more nested parameters, you must also specify the previous parameters (i.e. the ones "less" nested)

sorted(*iterable*[, *cmp*[, *key*[, *reverse*]]])

Return a new sorted list from the items in *iterable*.

Examples:

Allowed:

```
sorted(iterable)
sorted(iterable, cmp)
sorted(iterable, cmp, key)
sorted(iterable, cmp, key, reverse)
```

Not allowed:

```
sorted(cmp)
sorted(iterable, key)
sorted(iterable, reverse, cmp, key)
```

However, you can specify in any order if you refer to parameters by name:

```
sorted(interable = someIterableThing, reverse = True)
```

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5. Commenting your code

Commenting your code

Comments are text you add to your code that is ignored by Python. Comments are meant to help others (and yourself) better understand what your code is doing.

```
# this is a comment
# comments are ignored by Python
print "Hello!" # you can put them almost anywhere
print "How are you?" # use them often!
```

What this code prints:

```
Hello!
How are you?
```

Important to note:

If you add a comment in an indented block, the comment must be indented as well (otherwise you will get an error).

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Everything after the # sign on the same line will be ignored.

Multi-line comments

Single line comments are made using the # sign.

For a multi-line comment, use """ or ''' like so:

Example:

```
"""
This here is a multi-line comment.
Make sure to end it with matching quotes!
"""
print "hello"
'''
This is another mutli-line comment!
What fun!
'''
```

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Everything between the pairs of """ or ''' will be ignored

Same thing about indenting goes for these -- they must have the same indent as the code that surrounds them

When should I comment?

- Comments are meant to improve the understandability of your code to another person (and possibly yourself in the future).
- Use them whenever you think a piece of code might be particularly confusing to a reader.
- You can also use them to "section" your code. Sometimes I write comments first, before the code, and use it as an outline for the overall code structure.
- **Most importantly, though**: always keep your comments up to date! Inaccurate comments are worse than no comments at all, because they mislead the reader and can cause false assumptions.

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In general, you should strive to write code that is so clear that it doesn't need comments. This isn't always practical, though...

Appendix:
More if/else examples & practice

More practice

What will this code print?

```
yourAge = 50
catsYouOwn = 5
if (catsYouOwn > (yourAge / 10)):
    print "You are officially a cat lady!"
elif (catsYouOwn == (yourAge / 10)):
    print "Careful! You are close to becoming a cat lady"
else:
    print "Congrats, you are not a cat lady"
```

More practice

What will this code print?

```
yourAge = 50
catsYouOwn = 5
if (catsYouOwn > (yourAge / 10)):
    print "You are officially a cat lady!"
elif (catsYouOwn == (yourAge / 10)):
    print "Careful! You are close to becoming a cat lady"
else:
    print "Congrats, you are not a cat lady"
```

Result

```
Careful! You are close to becoming a cat lady
```

More practice

What will this code print?

```
alive = True
breathing = False

if alive and breathing:
    print "Everything is ok!"
elif alive and not breathing:
    print "You! Go get help!"
elif not alive and breathing:
    print "Zombie attack?"
elif not alive and not breathing:
    print ":("
```

More practice

What will this code print?

```
alive = True
breathing = False

if alive and breathing:
    print "Everything is ok!"
elif alive and not breathing:
    print "You! Go get help!"
elif not alive and breathing:
    print "Zombie attack?"
elif not alive and not breathing:
    print ":("
```

Result

```
You! Go get help!
```

More practice

What will this code print?

```
alive = True
breathing = False

if alive and breathing:
    print "Everything is ok!"
if alive and not breathing:
    print "You! Go get help!"
if not alive and breathing:
    print "Zombie attack?"
if not alive and not breathing:
    print ":("
```

More practice

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Result

```
You! Go get help!
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More practice

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alive = True
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if not alive and not breathing:
    print ":("
```

Result

```
You! Go get help!
```

What's the difference?

Here we used only `if` statements instead of `elif`.

This example gives the same result as the previous example, but notice how that might not always be the case!

The setup shown here allows for the possibility that more than one of these statements can be executed, while the previous setup does not.

This could be good, or not, depending on what you want to do. Always think carefully about which approach makes more sense for what you want to accomplish.

More practice

What will this code print?

```
codon = "ATG"
if (len(codon) != 3):
    print "Error, codons must be 3 characters"
else:
    if (codon == "ATG"):
            print "This is a start codon"
    elif (codon == "TAG") or (codon == "TGA") or (codon == "TAA"):
            print "This is a stop codon"
    else:
            print "This is not a start or stop codon"
print "Goodbye!"
```

More practice

What will this code print?

```
codon = "ATG"
if (len(codon) != 3):
    print "Error, codons must be 3 characters"
else:
    if (codon == "ATG"):
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    elif (codon == "TAG") or (codon == "TGA") or (codon == "TAA"):
            print "This is a stop codon"
    else:
            print "This is not a start or stop codon"
print "Goodbye!"
```

Result

```
This is a start codon
Goodbye!
```