Flow Control

1. Introduction

2. Elements of Flow Control

3. Importing Modules

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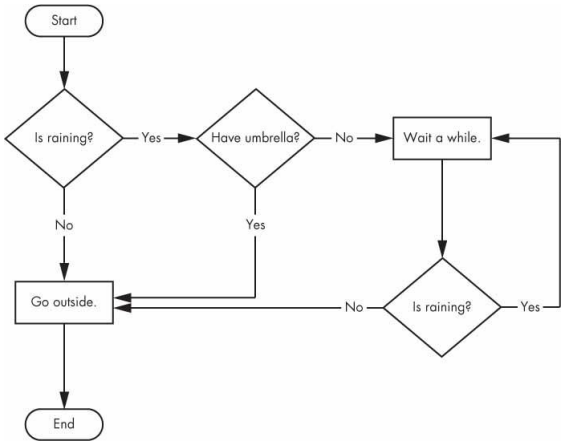
These flow control statements directly correspond to the symbols in a flowchart!



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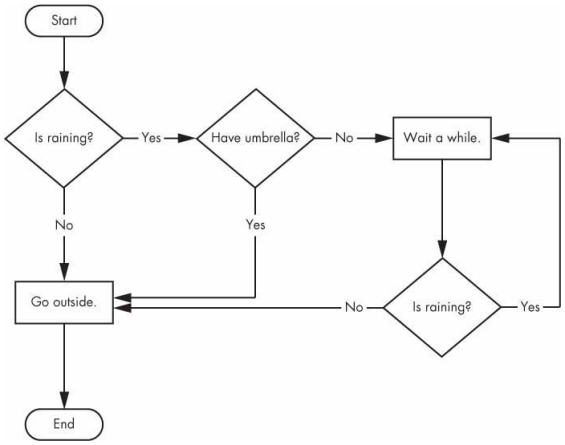

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But before you learn about flow control statements, you first need to learn how to represent those **yes** and **no** options and understand how to write those branching points as Python code. To that end, let's explore Boolean values, comparison operators, and Boolean operators.

Boolean expressions

A ***boolean expression*** is an expression that is either True or False. The following examples use the operator `==`, which compares two operands and produces `True` if they are equal and `False` otherwise:

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In [2]:
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print(5 == 5)
print(5 == 6)
```

```
True
False
```

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```

```
True
False
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```

```
True
False
```

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In [3]:
```
type(True), type(False)
```

Out[3]:
```
(bool, bool)
```

The `==` operator is one of the ***comparison operators*** or relational operators; the others are:

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	Meaning
x != y	x is not equal to y
x > y	x is greater than y
x < y	x is less than y
x >= y	x is greater than or equal to y
x <= y	x is less than or equal to y
x is y	x is the same as y
x is not y	x is not the same as y

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In [4]:
```
print(42==42)
print(42==42.0)          # It will compare its value!
print(42=='42')          # int/float are always different from string
print(2!=3)
print('hello'=='Hello') # Python is case sensitive
print(42 < 100)
print(42 >= 100)
```

```
True
True
False
True
False
True
False
```

In [5]:
```
display_quiz(path+"bool.json", max_width=800)
```

Which of the following is a Boolean expression? Select all that apply.

3 + 4	3 + 4 == 7	3 == 4	True	"False"

Boolean (Logical) Operators

The three ***Boolean operators*** (`and`, `or`, and `not`) are used to operate on Boolean values. Like comparison operators, they evaluate these expressions down to a Boolean value. Let's explore these operators in detail.

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Expression	Evaluates to . . .
True and True	True
True and False	False
False and True	False
False and False	False

Expression	Evaluates to . . .
True or True	True
True or False	True
False or True	True
False or False	False

Expression	Evaluates to . . .
True or True	True
True or False	True
False or True	True
False or False	False

Expression	Evaluates to . . .
not True	False
not False	True

In [6]:
```
print((4 < 5) and (5 < 6))
print((6 < 5) or (9 < 6))
print((1 == 2) or (2 == 2))
print(not (1==3) and (3==4))
```

```
True
False
True
False
```

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```
print((4 < 5) and (5 < 6))
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print((1 == 2) or (2 == 2))
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The computer will evaluate the left expression first, and then it will evaluate the right expression.

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```

```
True
False
True
False
```

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The Boolean operators have an order of operations just like the math operators do. After any math and comparison operators evaluate, Python evaluates the `not` operators first, then the `and` operators, and then the `or` operators.

Arithmetic operators take precedence over logical operators. Python will always evaluate the arithmetic operators first. Next comes the relational operators. Finally, the logical operators are done last.

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Level	Category	Operators
7 (high)	exponent	**
6	multiplication	*, /, //, %
5	addition	+, -
4	relational	==, !=, <=, >=, >, <
3	logical	not
2	logical	and
1 (low)	logical	or

In [7]:
```
display_quiz(path+"logical.json", max_width=800)
```

What is the correct Python expression for checking to see if a number stored in a variable x is between 0 and 5.

0 < x < 5	x > 0 and < 5	x > 0 or x < 5	x > 0 and x < 5

Elements of Flow Control

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Flow control statements often start with a part called the ***condition*** and are always followed by a block of code called the ***clause*** or body.

The Boolean expressions you've seen so far could all be considered conditions, which are the same thing as expressions; the condition is just a more specific name in the context of flow control statements!

Blocks of Code

Lines of Python code can be grouped together in ***blocks***. You can tell when a block begins and ends from the ***indentation*** of the lines of code. There are three rules for blocks.

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1. Blocks begin when the indentation increases.

2. Blocks can contain other blocks.
3. Blocks end when the indentation decreases to zero or to a containing block's indentation.

Blocks are easier to understand by looking at some indented code, so let's find the blocks in part of a small game program, shown here:

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In [8]:
```
name = 'Mary'
password = 'swordfish'
if name == 'Mary':
    print('Hello, Mary')
    if password == 'swordfish':
        print('Access granted.')
    else:
        print('Wrong password.')
```

```
Hello, Mary
Access granted.
```

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```

```
Hello, Mary
Access granted.
```

You can view the execution of this program at https://autbor.com/blocks/. The first block of code starts at the line `print('Hello, Mary')` and contains all the lines after it. Inside this block is another block, which has only a single line in it: `print('Access Granted.')`. The third block is also one line long: `print('Wrong password.')`.

An `IndentationError` occurs if you have more than one statement in a block and those statements do not have the same indentation:

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if name == 'Mary':
  print('Hello, Mary')
    if password == 'swordfish':
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    else:
        print('Wrong password.')
```

```
  File "C:\Users\adm\AppData\Local\Temp\ipykernel_35736\140440185.py",
line 5
    if password == 'swordfish':
    ^
IndentationError: unexpected indent
```

In [10]:
```
display_quiz(path+"block.json", max_width=800)
```

How many lines of code (statement) can appear in the indented code block below the if and else lines?

- Zero or more.
- One or more, and each must contain the same number.
- One or more.
- Just one.

Conditional execution

The control statement affords us a mechanism for jumping from one part of a program to another. This enables what is called ***control structures***.

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In Python, an `if` statement consists of the following:

- The `if` keyword
- A condition (that is, an expression that evaluates to `True` or `False`)
- A colon
- Starting on the next line, an indented block of code (called the `if` body)

The boolean expression after the `if` statement is called the condition. We end the `if` statement with a colon character (`:`) and the line(s) after the `if` statement are indented. If the logical condition is true, then the indented statement gets executed. If the logical condition is false, the indented statement is skipped.

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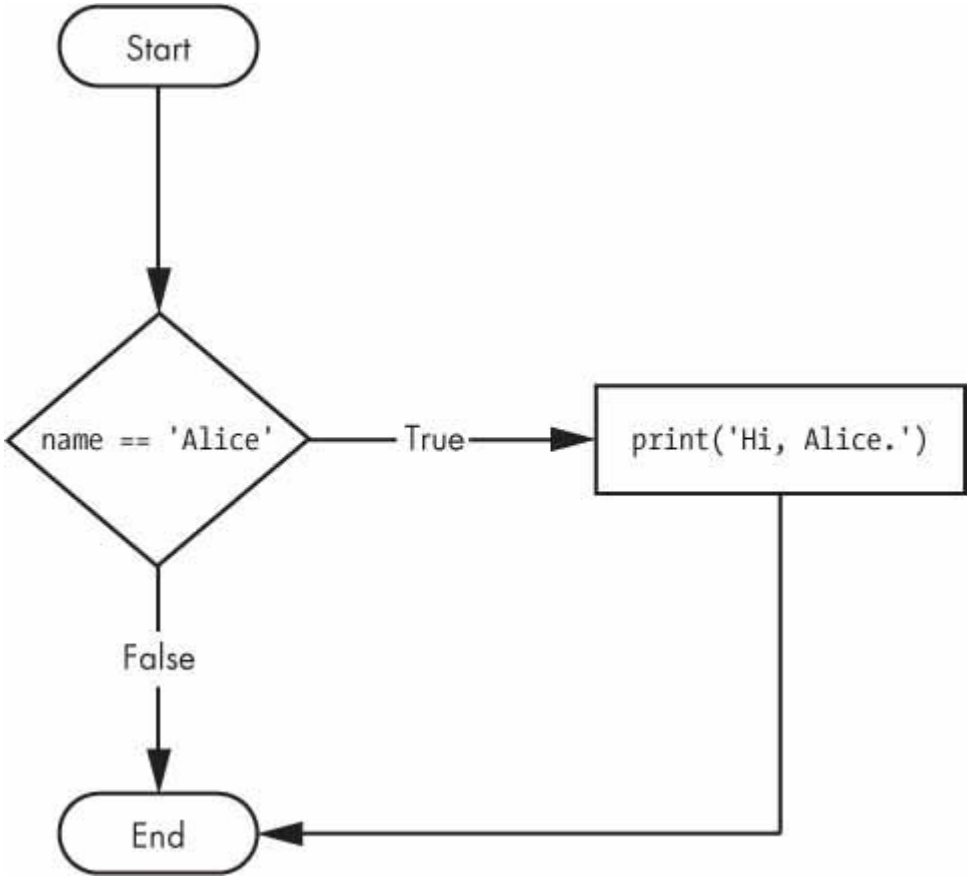
In [ ]:
```
name = 'Mary'
if name == 'Alice':
    print('Hi, Alice.')
```



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In [11]:
```
if name == 'Alice':
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else:
    print('Hello, stranger.')
```

```
Hello, stranger.
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You can also write the above code in one line using the ***ternary conditional operator***:

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```

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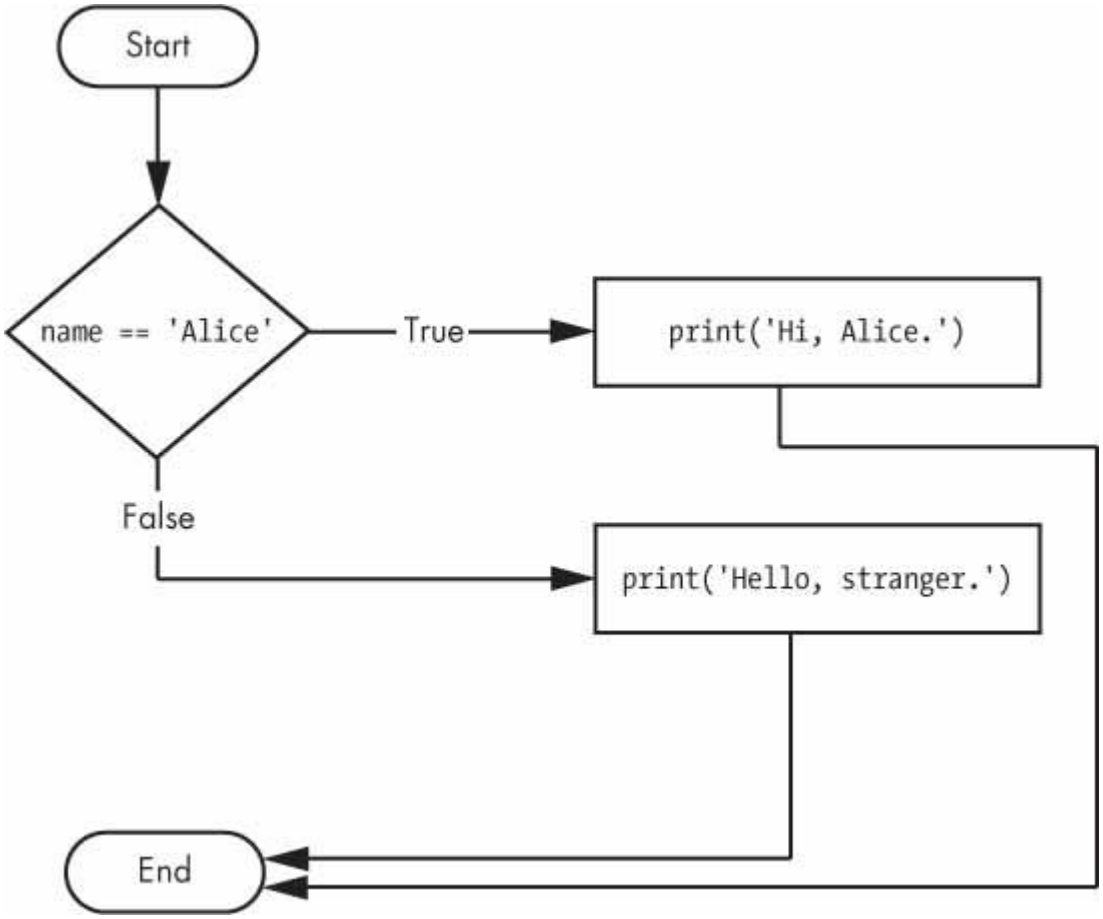
Hello, stranger.
```

You can also write the above code in one line using the ***ternary conditional operator***:

In [12]:
```
print('Hi, Alice.') if name == 'Alice' else print('Hello, stranger.') # Note
```

```
Hello, stranger.
```



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In [13]:
```
name = 'Carol'
age = 3000
if name == 'Alice':
    print('Hi, Alice.')
elif age < 12:
    print('You are not Alice, kidd.')
else:
    print('You are neither Alice nor a little kid.')
```

```
You are neither Alice nor a little kid.
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```

```
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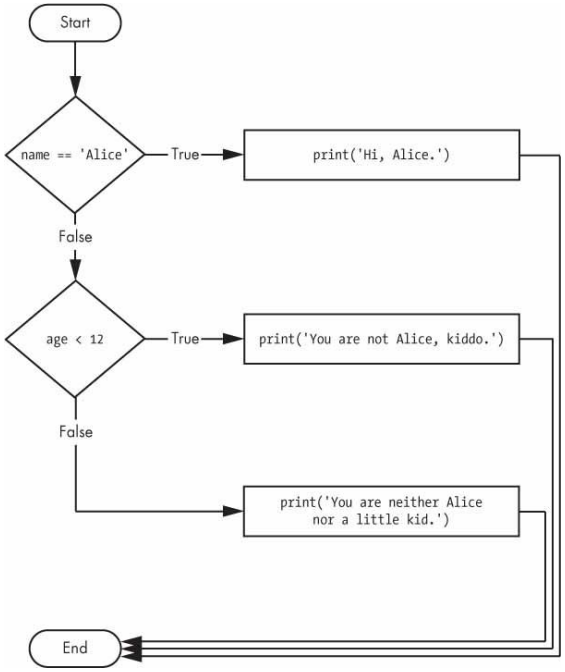
```

You can view the execution of this program at https://autbor.com/littlekid/. In plain English, this type of flow control structure would be “If the first condition is true, do this. Else, if the second condition is true, do that.



source: https://automatetheboringstuff.com/2e/chapter2/

In [14]:
```
display_quiz(path+"conditions.json", max_width=800)
```

What will the following code print if x = 3, y = 5, and z = 2?

```
if x < y and x < z:
    print("a")
elif y < x and y < z:
    print("b")
else:
    print("c")
```

b

a

c

Exercise 1: Write a program that prompts the user to enter a `row` and `column` (each between 0 and 7) corresponding to an chessboard square, then prints ”black” or ”white” depending on the square’s color; if either input is outside the 0–7 range, it prints ”out of board.”

> Exercise 1: Write a program that prompts the user to enter a `row` and `column` (each between 0 and 7) corresponding to an chessboard square, then prints "black" or "white" depending on the square's color; if either input is outside the 0–7 range, it prints "out of board."

source: https://inventwithpython.com/pythongently/images/image011.png

In [ ]:

```
row = int(input("Enter row :"))
column = int(input("Enter column :"))
# If the column and row is out of bounds, print out of board:
if column ____ or column ___ or row ___ or row ____:
    print('out of board')
# If the even/oddness of the column and row match, print 'white':
____ column % _ == row % _:
    print('white')
# If they don't match, then print 'black':
____:
    print('black')
```

Loops and Iterations

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In [15]:
```
spam = 0
while spam < 5:
    print('Hello, world.')
    spam += 1 # equivalent to spam = spam + 1
```

```
Hello, world.
Hello, world.
Hello, world.
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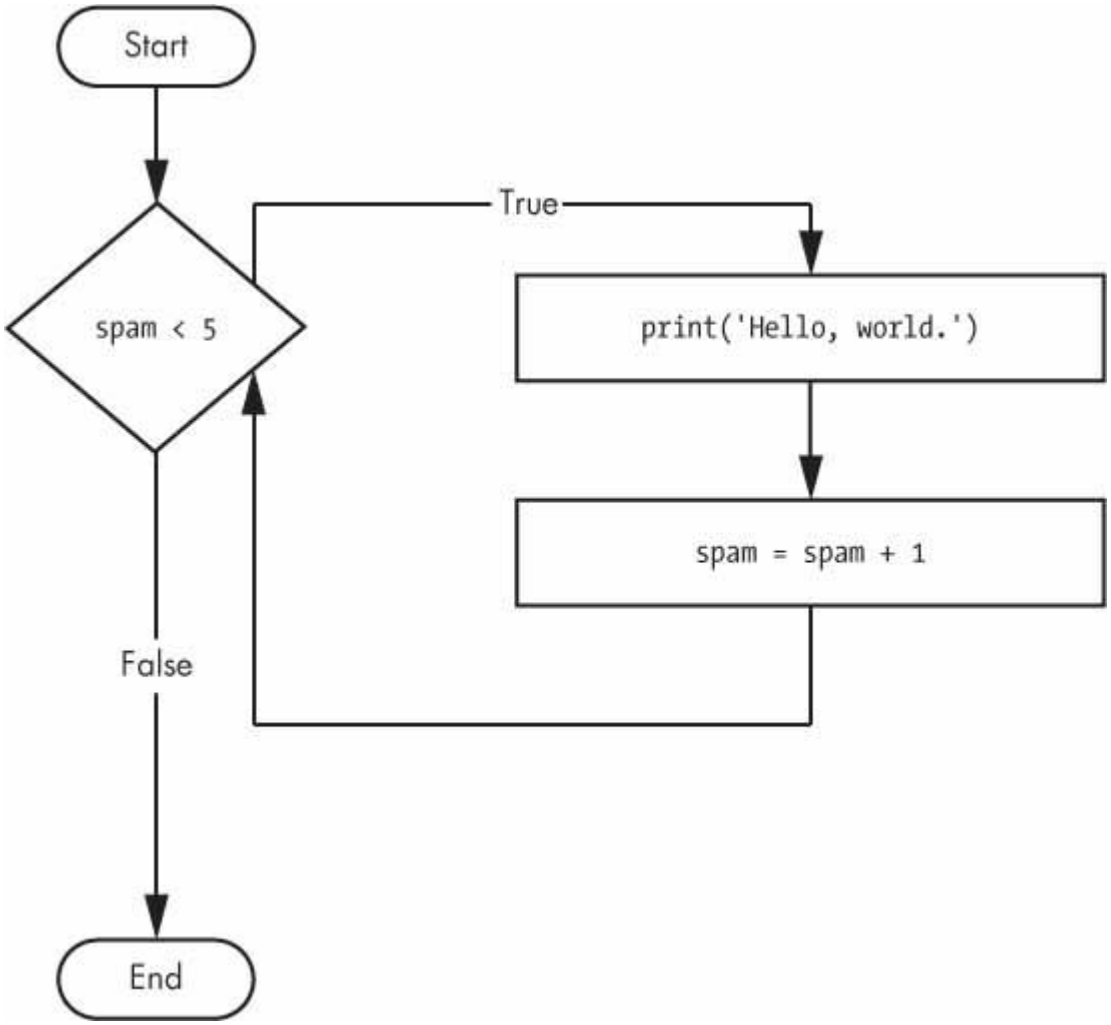
```

Augmented assignments abbreviate assignment expressions in which the same variable name appears on the left and right of the assignment's `=` as above



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More formally, here is the flow of execution for a `while` statement:

1. Evaluate the condition, yielding `True` or `False`.
2. If the condition is false, exit the `while` statement and continue execution at the next statement.
3. If the condition is true, execute the body and then go back to step 1.

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2. If the condition is false, exit the `while` statement and continue execution at the next statement.
3. If the condition is true, execute the body and then go back to step 1.

In the `while` ***loop***, the condition is always checked at the start of each ***iteration*** (that is, each time the loop is executed). If the condition is `True`, then the body is executed, and afterward, the condition is checked again. The first time the condition is found to be `False`, the while body is skipped.

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In [16]:
```
prompt = "\nTell me something, and I will repeat it back to you:"
prompt += "\nEnter 'quit' to end the program. "
message = ""
while message != 'quit':
    message = input(prompt)
    print(message)
```

```
Tell me something, and I will repeat it back to you:
Enter 'quit' to end the program. hi
hi

Tell me something, and I will repeat it back to you:
Enter 'quit' to end the program. quit
quit
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quit
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We first set up a variable `message` to keep track of whatever value the user enters. We define `message` as an empty string, `""`, so Python has something to check at the first time.

Note that Python considers `0`, `None`, empty string, and empty container as `False` and all other things are `True`!

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In [17]:
```
bool(""), bool(0), bool(None), bool(prompt), bool(12)
```

Out[17]:
```
(False, False, False, True, True)
```

Using `break` to Exit a Loop

The above program works well, except that it prints the word 'quit' as if it were an actual message. In fact, there is a shortcut to getting the program execution to break out of a `while` loop's body early. If the execution reaches a ***`break` statement***, it immediately exits the while loop's body！

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In [19]:
```
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message = ""
while True:
    message = input(prompt)
    if message == 'quit':
        break
    else:
        print(message)
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Enter 'quit' to end the program. hi
hi

Tell me something, and I will repeat it back to you:
Enter 'quit' to end the program. quit
```

The fourth line creates an ***infinite loop***; it is a `while` loop whose condition is always `True`. After the program execution enters this loop, it will exit the loop only when a `break` statement is executed.

`continue` Statemet

Rather than breaking out of a loop entirely without executing the rest of its code, you can use the ***`continue` statement*** to return to the beginning of the loop based on the result of a conditional test. For example, consider a loop that counts from 1 to 10 but prints only the odd numbers in that range:

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In [20]:
```
current_number = 0
while current_number < 10:
    current_number += 1
    if current_number % 2 == 0:
        continue
    else:
        print(current_number, end=' ')
```

```
1 3 5 7 9
```

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    else:
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```

```
1 3 5 7 9
```

Note that the built-in function `print()` displays its argument(s), then moves the cursor to the next line. You can change this behavior with the argument `end`. We used one space (' '), so each call to print displays the character's value followed by one space!

In [21]:
```
display_quiz(path+"while.json", max_width=800)
```

The following code contains an infinite loop. Which is the best explanation for why the loop does not terminate?

- You cannot compare n to 0 in while loop. You must compare it to another variable.
- In the while loop body, we must set n to False, and this code does not do that.
- answer starts at 1 and is incremented by n each time, so it will always be positive
- n starts at 10 and is incremented by 1 each time through the loop, so it will always be positive

"TRUTHY" and "FALSY" Values

Let us delve into the following program:

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In [22]:
```
name = ''
while not name:
    print('Enter your name:')
    name = input()

print('How many guests will you have?')
numOfGuests = int(input())

if numOfGuests:
    print('Be sure to have enough room for all your guests.')
print('Done')
```

```
Enter your name:
phonchi
How many guests will you have?
3
Be sure to have enough room for all your guests.
Done
```

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while not name:
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print('Done')
```

```
Enter your name:
phonchi
How many guests will you have?
3
Be sure to have enough room for all your guests.
Done
```

You can view the execution of this program at https://autbor.com/howmanyguests/.

`for` Loops and the `range()` Function

The `while` loop keeps looping `while` when its condition is `True`, but what if you want to execute a block of code **only a certain number of times**? You can do this with a ***`for` loop statement*** and the `range()` function.

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A `for` statement looks something like `for i in range(5)`: and includes the following:

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- The `for` keyword
- A variable name
- The ***`in` keyword***

- A call to the `range()` funtion with up to three integers passed to it (The `for` statement can iterate over a ***sequence*** item by item!)
- A colon
- Starting on the next line, an indented block of code (called the for body)

Let’s create a new program to help you see a `for` loop in action.

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In [23]:
```
print('My name is')
for i in range(5):
    print('Jimmy Five Times (' + str(i) + ')')
```

```
My name is
Jimmy Five Times (0)
Jimmy Five Times (1)
Jimmy Five Times (2)
Jimmy Five Times (3)
Jimmy Five Times (4)
```

Let's create a new program to help you see a `for` loop in action.

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My name is
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Jimmy Five Times (1)
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Jimmy Five Times (3)
Jimmy Five Times (4)
```

You can view the execution of this program at https://autbor.com/fivetimesfor/.

You can actually use a `while` loop to do the same thing as a `for` loop; `for` loops are just more concise.

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In [24]:
```
print('My name is')
i = 0
while i < 5:
    print('Jimmy Five Times (' + str(i) + ')')
    i = i + 1
```

```
My name is
Jimmy Five Times (0)
Jimmy Five Times (1)
Jimmy Five Times (2)
Jimmy Five Times (3)
Jimmy Five Times (4)
```

The Starting, Stopping, and Stepping Arguments to `range()`

Some functions can be called with multiple arguments separated by a comma, and `range()` is one of them. This lets you change the integer passed to `range()` to follow any sequence of integers, including starting at a number other than zero.

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In [25]:
```
for i in range(12, 16):
    print(i)
```

```
12
13
14
15
```

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    print(i)
```

```
12
13
14
15
```

The `range()` function can also be called with three arguments. The first two arguments will be the start and stop values, and the third will be the step argument.

In [26]:
```
for i in range(0, 10, 2):
    print(i)
```

```
0
2
4
6
8
```

In [26]:
```
for i in range(0, 10, 2):
    print(i)
```

```
0
2
4
6
8
```

You can even use a **negative number** for the step argument to make the `for` loop count down instead of up.

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for i in range(0, 10, 2):
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```

```
0
2
4
6
8
```

You can even use a **negative number** for the step argument to make the `for` loop count down instead of up.

In [27]:
```
for i in range(5, -1, -1):
    print(i)
```

```
5
4
3
2
1
0
```

In [28]:
```
display_quiz(path+"for.json", max_width=800)
```

How many times is the word HELLO printed by the following statements?

```
s = "python rocks"
for ch in s:
    print("HELLO")
```

12	Error, the for statement needs to use the range() function.
10	11

> Exercise 2: Write a script that displays the following triangle patterns. Use `for` loops to generate the patterns.

```
*
**
***
****
*****
******
*******
********
*********
**********
```

Hint: Try to use nested loops and use the outer loop to display each row while the inner loop to display each column

In [ ]:

```
for row in range(__,__):
    for column in range(__,__):
        print('*', end='')
    print()
```

Importing Modules

All Python programs can call a basic set of functions called **built-in functions**, including the `print()`, `input()`, `len()` and `range()` functions you've seen before.

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Python also comes with a set of modules called the ***standard library***. Each module is a Python program that contains a related group of functions that can be embedded in your programs.

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For example, the `math` module has mathematics-related functions. The `random` module has random number-related functions, and so on.

Before you can use the functions in a module, you must ***import*** the module with an `import` statement. In code, an `import` statement consists of the following:

- The `import` keyword

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- The `import` keyword
- The name of the module
- Optionally, more module names, as long as they are separated by commas

Once you import a module, you can use all the cool functions of that module. Let's give it a try with the `random` module, which will give us access to the `random.randint()` function.

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In [29]:
```
import random
for i in range(5):
    print(random.randint(1, 10))
```

```
3
8
2
1
7
```

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```

You can view the execution of this program at https://autbor.com/printrandom/. The `random.randint()` function call evaluates to a random integer value between the two integers that you pass it.

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```
3
8
2
1
7
```

You can view the execution of this program at https://autbor.com/printrandom/. The `random.randint()` function call evaluates to a random integer value between the two integers that you pass it.

Since `randint()` is in the `random` module, you must first type `random.` in front of the function name to tell Python to look for this function inside the `random` module.

Ending a Program Early with the `sys.exit()` Function

The last flow control concept to cover is how to terminate the program. Programs always terminate if the program execution reaches the bottom of the instructions.

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However, you can cause the program to terminate before the last instruction by calling the `sys.exit()`. Since this function is in the `sys` module, you have to `import sys` before your program can use it.

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However, you can cause the program to terminate before the last instruction by calling the `sys.exit()`. Since this function is in the `sys` module, you have to `import sys` before your program can use it.

In [30]:
```
%%writefile exit.py

import sys

while True:
    print('Type exit to exit.')
    response = input()
    if response == 'exit':
        sys.exit()
    print('You typed ' + response + '.')
print('This line will not be printed')
```

```
Overwriting exit.py
```

In [31]:
```
%run exit.py
```

```
Type exit to exit.
hi
You typed hi.
Type exit to exit.
exit
```

In [31]:
```
%run exit.py
```

```
Type exit to exit.
hi
You typed hi.
Type exit to exit.
exit
```

By using expressions that evaluate to `True` or `False` (also called conditions), you can write programs that make decisions on what code to execute and what code to skip. You can also execute code over and over again in a loop while a certain condition evaluates to `True`.

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%run exit.py
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You typed hi.
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These flow control statements will let you write more intelligent programs. You can also use another type of flow control by **writing your own functions**, which is the topic of the next chapter.

In [32]:
```
from jupytercards import display_flashcards
fpath= "https://raw.githubusercontent.com/phonchi/nsysu-math106A/refs/heads/m
display_flashcards(fpath + 'ch2.json')
```

Flow control statements

Next

>