



Just Enough Python: Instructor Guide

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Version	Release Date	Description
201511a	02/02/2016	Corrected name of exercise on slide 06-32 and in course timings of instructor guide.
201511	01/29/2016	Initial Release

NOTE: The Exercise Instructions follow the course slides.

Suggested Course Timings

Day 1	[Total classroom time: 8 hours, 15 minutes]
Arrivals and registration	[15 minutes total]
1. Introduction <ul style="list-style-type: none">• 20 minutes lecture	[20 minutes total]
2. Introduction to Python <ul style="list-style-type: none">• 25 minutes lecture• 20 minutes exercise: Using IPython• 15 minutes exercise: Loudacre Mobile	[1 hour total]
3. Variables <ul style="list-style-type: none">• 40 minutes lecture• 30 minutes exercise: Variables	[1 hour, 10 minutes total]
4. Collections <ul style="list-style-type: none">• 55 minutes lecture• 30 minutes exercise: Collections	[1 hour, 25 minutes total]
5. Flow Control <ul style="list-style-type: none">• 45 minutes lecture• 30 minutes exercise: Flow Control	[1 hour, 15 minutes total]
6. Program Structure <ul style="list-style-type: none">• 45 minutes lecture• 40 minutes exercise: Program Structure	[1 hour, 25 minutes total]
7. Libraries <ul style="list-style-type: none">• 35 minutes lecture• 45 minutes exercise: Libraries	[1 hour, 20 minutes total]
8. Conclusion <ul style="list-style-type: none">• 5 minutes lecture	[5 minutes total]

Issues Fixed in this Release

This is the first release of this course

Troubleshooting Advice

This section explains advice for identifying and resolving known issues.

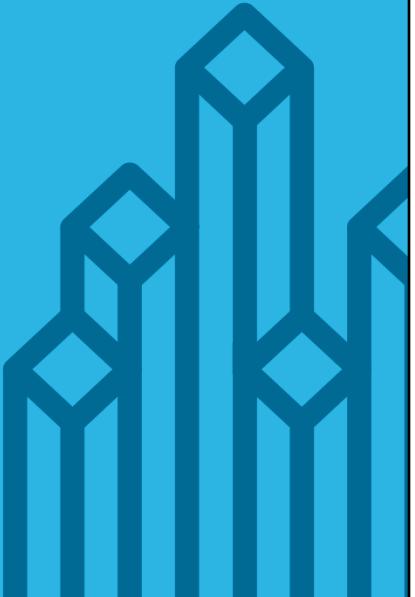
The Just Enough VM for JEP 201511 does not contain any Cloudera software. The class offers Python using IPython.

The class has not yet been delivered. When it has, check back here for issues and advice.



Just Enough Python

201511



Welcome to "Just Enough Python"

This is a crash course in Python that is intended to teach you "just enough" to be well prepared for Cloudera Developer courses that use Python.



Introduction

Chapter 1



Goal: This chapter is intended to inform students what to expect from the course and for the instructor to learn about the students' level of expertise as well as how they plan to apply what they'll learn.

Course Chapters

■ Introduction

- Introduction to Python
- Variables
- Collections
- Flow Control
- Program Structure
- Working with Libraries
- Conclusion



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There are eight chapters in the course. We'll look at them in detail in the Introduction to Python (Chapter 2).

Chapter Topics

Introduction

▪ About this Course

- About Cloudera
- Course Logistics
- Introductions



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This slide shows the main topics covered in the current chapter. The upcoming topic is highlighted to illustrate what is about to be covered.

Course Objectives

During this course, you will learn

- “Just Enough” Python Programming
 - “Just Enough” means to enable a solid foundation for Hands-On Exercises in Cloudera Developer classes
 - Not “proficient as a Python programmer” (Pythonista, Pythoneer)



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This class very specifically prepares you for Cloudera classes as rapidly and directly as possible. The class is not trying to cram everything into a crash course, and it is not a goal for you to become some kind of expert Python Programmer. The goal is to learn “Just Enough” Python so that learning the language is not a distraction from learning to develop with Hadoop or Spark in later classes.

Audience Background

- **Students should possess the following prerequisites for this course**
 - Interest in one of Cloudera's developer-oriented courses
 - *Some* programming experience
 - No specific language or level of experience
 - Familiarity with object-oriented programming concepts
 - Basic skills and vocabulary
- **The following are *not* required (and are not covered in this course)**
 - Experience with Cloudera products
 - Experience with Hadoop or Spark
 - Experience with data analytics



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You are assumed to have programmed in some language before – that 'print' and 'variable' will not be new concepts. Also, you are expected to know Object Oriented programming and what a 'class', 'object', 'instance', and 'method' are. The class does not assume any specific language. The class assumes that Big Data and Hadoop classes are ahead for you and that you will not know about Big Data technologies.

The class does not cover any Big Data concepts or techniques and does not cover any Cloudera software.

Note:

In general, people with a strong Java background will prefer the Just Enough Scala (JES) class to this class. Scala is a superset of Java. People with any other programming background will likely prefer this Just Enough Python (JEP) class because Python is a more automated and forgiving language and much easier to learn than Scala.

Chapter Topics

Introduction

- About this Course
- About Cloudera**
- Course Logistics
- Introductions

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About Cloudera (1)



- The leader in Apache Hadoop-based software and services
- Founded by Hadoop experts from Facebook, Yahoo, Google, and Oracle
- Provides support, consulting, training, and certification for Hadoop users
- Staff includes committers to virtually all Hadoop projects
- Many authors of industry standard books on Apache Hadoop projects

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Cloudera was founded in 2008. Our staff also includes the ASF chairperson and creator of Hadoop, Doug Cutting, as well as many involved in the project management committee (PMC) of various Hadoop-related projects. The person who literally wrote the book on Hadoop, Tom White, works for Cloudera.

There are many Cloudera employees who have written or co-authored books on Hadoop-related topics, and you can find an up-to-date list here [<http://www.cloudera.com/content/cloudera/en/developers/home/hadoop-ecosystem-books.html>]. Instructors are encouraged to point out that many of these books are available at a substantial discount to students in our classes [<http://shop.oreilly.com/category/deals/cloudera.do>].

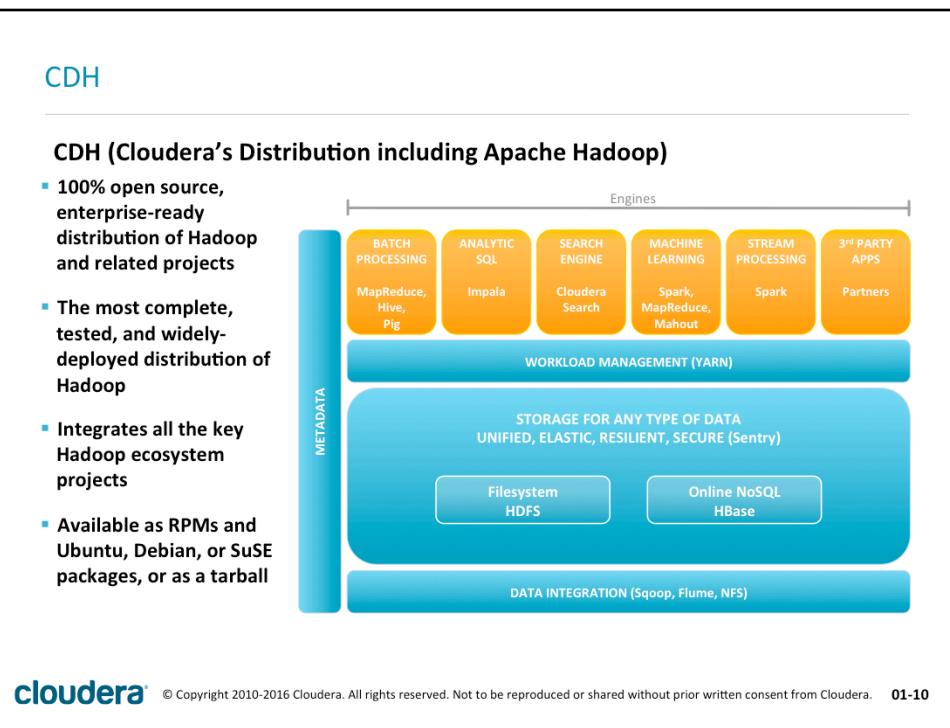
About Cloudera (2)

- Our customers include many key users of Hadoop
- We offer several public training courses, such as
 - Cloudera Developer Training for Apache Spark and Hadoop
 - Cloudera Administrator Training for Apache Hadoop
 - Cloudera Data Analyst Training: Using Pig, Hive, and Impala with Hadoop
 - Designing and Building Big Data Applications
 - Data Science at Scale Using Spark and Hadoop
 - Cloudera Training for Apache HBase
- On-site and customized training is also available



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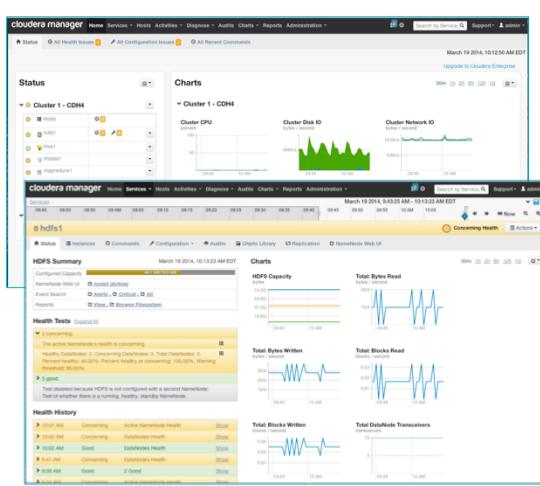
You can see a list of customers that we can reference on our Web site [<http://cloudera.com/content/cloudera/en/our-customers.html>]. Note that Cloudera also has many customers who do not wish to be referenced, and it is essential that we honor this. The only exception to this important rule is that you may reference something that was intentionally made available to the public in which Cloudera or that customer has disclosed that they are a Cloudera customer. For example, it is permissible to mention an article in a reputable trade publication in which Cloudera's CEO mentions a specific customer or the keynote address that the customer's CTO gave at the Strata conference talking about the benefits they've experienced as a Cloudera customer.



You can think of CDH as analogous to what RedHat does with Linux: although you could download the “vanilla” kernel from kernel.org, in practice, nobody really does this. If you’re in this class, it is probably because you’re thinking about using Hadoop in production and for that you’ll want something that’s undergone greater testing and is known to work at scale in real production systems. That’s what CDH is: a distribution which includes Apache Hadoop and all the complementary tools you’ll be learning about in the next few days, all tested to ensure the different products work well together and with patches that help make it even more useful and reliable. And all of this is completely open source, available under the Apache license from our Web site.

Cloudera Express

- **Cloudera Express**
 - Completely free to download and use
- **The best way to get started with Hadoop**
- **Includes CDH**
- **Includes Cloudera Manager**
 - End-to-end administration for Hadoop
 - Deploy, manage, and monitor your cluster



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Main point: Cloudera Express is free, and adds Cloudera-specific features on top of CDH, in particular Cloudera Manager (CM).

Note in case anyone asks: the free version of Cloudera Manager (i.e., the product now known as Cloudera Express) once had a 50-node limit, but no longer does.

Cloudera Enterprise

- **Cloudera Enterprise**

- Subscription product including CDH and Cloudera Manager

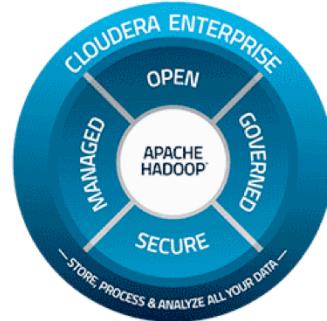
- **Includes support**

- **Includes extra Cloudera Manager features**

- Configuration history and rollbacks
 - Rolling updates
 - LDAP integration
 - SNMP support
 - Automated disaster recovery

- **Extend capabilities with Cloudera Navigator subscription**

- Event auditing, metadata tagging capabilities, lineage exploration
 - Available in both the Cloudera Enterprise Flex and Data Hub editions



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LDAP = Lightweight Directory Access Protocol

SNMP = Simple Network Management Protocol

Chapter Topics

Introduction

- About this Course
- About Cloudera
- **Course Logistics**
- Introductions



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Logistics

- Class start and finish times
- Lunch
- Breaks
- Restrooms
- Wi-Fi access
- Virtual machines

Your instructor will give you details on how to access the course materials and exercise instructions for the class



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This is a good time to start the VM, if they're not already running.

The registration process for students is:

1. Visit [<http://training.cloudera.com/>]
2. Register as a new user (ensure that you give an e-mail address which you can check from here, since the system will send a confirmation e-mail to you)
3. Confirm registration by clicking on the link in the e-mail
4. Log in (if the system has not already logged you in)
5. Enter the course ID and enrollment key (which the instructor will have been sent the week before the class starts)
6. Once this is done, the student will be taken to the course page, from which they can download the slides and exercise instructions. Emphasize that they must, at the very least, download the exercise instructions. Unless this is an onsite course they should not download the VM – it is already on the classroom machines, and downloading it here will consume too much bandwidth.

Note: The VM for this course provides the standard hands-on training environment and experience, but does not contain CDH (nor any Cloudera software, for that matter). Also, note that the VM currently provides Python 2.6.6, which works with CDH.

Chapter Topics

Introduction

- About this Course
- About Cloudera
- Course Logistics
- **Introductions**



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Introductions

- **About your instructor**

- **About you**

- Where do you work? What do you do there?
- Do you have experience with UNIX or Linux?
- What programming languages have you used?
- How much programming experience do you have?
- What do you expect to gain from this course?



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Establish your credibility and enthusiasm here. You'll likely want to mention your experience as an instructor, plus any relevant experience as a developer, system administrator, DBA or business analyst. If you can relate this to the audience (because you're from the area or have worked in the same industry), all the better.

This is also an opportunity to get to know the students, so you can tailor your explanations and analogies to the experience that they already have. It is a good idea to draw out a grid corresponding to the seat layout and write students' names down as they introduce themselves, allowing you to remember someone's name a few days later based on where they're sitting.

The outline for all our courses are available online [<http://cloudera.com/content/cloudera/en/training/courses.html>], so you should be familiar with them and will know whether a student's expectations from the course are reasonable.



Introduction to Python

Chapter 2

We have a number of general items to cover before starting the technical content and learning to program in Python.

Course Chapters

- Introduction
- **Introduction to Python**
- Variables
- Collections
- Flow Control
- Program Structure
- Working with Libraries
- Conclusion



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There are eight chapters in the course.

Introduction to Python

In this chapter you will learn

- The history of Python and what makes Python special among languages
- The purpose and scope of the class, and what parts of Python will be discussed and what topics are beyond the aims of this class
- Explanation of how Python syntax is represented in the class slides
- Introduction to the Hands-On Exercise environment including IPython

Chapter Topics

Introduction to Python

▪ Python Background Information

- Scope
- Exercises
- Essential Points
- Hands-On Exercise: Using IPython
- Hands-On Exercise: Loudacre Mobile



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Let's discuss a little about Python, and why it has become a popular language in the Big Data era.

Python

- **General purpose high-level programming language**
 - Multi-paradigm (functional, object-oriented, procedural, logical)
- **Started by Guido van Rossum in 1989**
 - Version 1.0 released in 1994
 - Transferred to the Python Software Foundation in 2001
- **Design philosophy**
 - Readability
 - Explicit is better than implicit
 - Simple is better than complex, complex better than complicated
 - Fewer lines of code, easier coding
 - Dynamic typing
 - Automatic memory management
 - Comprehensive library



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Python was created in 1989 by Guido van Rossum in the Netherlands. He named it after "Monty Python's Flying Circus". It was intended to be a language that was more readable and less laborious to code than other languages of the time. Version 0.9.0 was first made public in 2/1991. Version 1.0 was published in 1994. Guido passed control to the Python Software Foundation in 2001 and continues to steer development of the language. His PSF title is "BDFL" – Benevolent Dictator For Life.

One of the key design ideas that's embodied in Python (if you read between the lines here...) is "Let the Computer Do The Work". There are a lot of things the computer can figure out for you. And when the computer does that, you don't have to. So a lot of the coding that is performed by ritual in other languages like Java and C++ is just absent in Python, making it much easier to get results quickly. Python has become a very popular language because the TCO (total cost of ownership – cost to develop and maintain Python code) is overall lower than the TCO for other languages such as Java, Ruby, and so forth.

Chapter Topics

Introduction to Python

- Python Background Information
- **Scope**
- Exercises
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Python programming can be a semester-long course – or two of them. It is powerful, but deep. So... we had to be very selective about what we chose to be part of this course and what we left out. Let's explore the reasoning behind those choices.

In Scope

- **Python 2.6 / 2.7 (not 3.x)**
- **Variables**
 - `integer, float, boolean, string`
- **Collections**
 - `list[], tuple(), set{}, frozenset, dictionary`
- **Flow Control**
 - Code blocks, `if, if else, if elif, else`
 - `while, for in range, for in list, try`
- **Program Structure**
 - Functions, anonymous functions, generators
- **Working with Libraries**
 - `import, from import, sys, math`



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Subjects covered in this course.

Notice that we've come up with this sorting for you. By narrowing the scope, we can spend a decent amount of time and focus on each core subject so that you'll have a solid foundation in the basics of Python as used in our classes. In some cases we cover slightly more Python than is used in our classes to make sure your base of skills is solid and complete.

About 130+ concepts covered in the course. The training method we use is to introduce the concepts in the course and then jump into hands on exercises to anchor the concepts as practical skills.

Out of Scope

- Random numbers
- Statistical or date/time functions
- Advanced string manipulation
- Serialization, JSON, or XML
- Time functions or timers
- GUIs or Web applications
- Database I/O or network I/O
- Python concurrency and process management
- Code debugging or prototyping facilities
- Application packaging and deployment



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Subjects that are specifically NOT covered in this course. And this might serve as a follow-on checklist of items to learn if you DID want to become a Pythonista later.

Chapter Topics

Introduction to Python

- Python Background Information
- Scope
- **Exercises**
 - Essential Points
 - Hands-On Exercise: Using IPython
 - Hands-On Exercise: Loudacre Mobile



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Python Shell – REPL

- **The Python shell is entered by typing `python`**

- The default shell
- Does not interface with the host file system, no path completion
- Does not provide command completion
- Is REPL: Read – Evaluate – Print – Loop
 - When you enter an expression, Python immediately evaluates it, assigns the value to an implicit variable, and prints it to the console
 - REPL is excellent for interactive code exploration

```
$ python  
  
->>> a = 123  
->>> 123  
->>> type(a)  
->>> type <'int'>
```



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More info on REPLs can be found on Wikipedia: [http://en.wikipedia.org/wiki/Read%E2%80%93eval%E2%80%93print_loop].

IPython Shell

- The IPython shell is entered by typing `ipython`

- IPython is a separate project from Python
- Provides programming features over the default shell
- File system interaction, `ls`, pathname completion (*tab*)
- Command completion and suggestions (*tab-tab*)
- Integrated Python help / documentation with `help()`
- Run files from within the shell with `run filename`
- Interrogate objects with `?object`
- Edit files with `%ed`
- After editing the program, if you exit using `[Esc]wq`, the program will be run

This is the shell we will use in class

```
$ ipython
In [1]: a = 123
In [2]: print a
123
In [3]: type(a)
Out[3]: int
```

Example of the look of the IPython shell

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02-11

Note:

Some people report that exiting the editor using shift-z-z (ZZ), the program **may** not run.

The course author tested it on the 201511 Just Enough VM and found that it ran every time.

Some people prefer :wq

The program is run consistently when exiting using :wq

Formatting Conventions of Documentation

- **Keywords and syntax in bold**
- **Developer-supplied names and variables in italics**
- **Developer-provided code in gray**
- **Call-outs in italic blue text**

```
def name(parameters) :  
    code-block  
    return variable
```

Optional return variable

Formatting Conventions of Code Examples

- Code examples are shown on a pale blue background
- The code you enter is displayed without any prompt in black type
- The system response is shown with a > prompt and in blue type

```
s = "Titanic 4000"  
print s  
  
> Titanic 4000
```

Line continuation

```
months={1:'JAN',2:'FEB',3:'MAR',4:'APR',5:'MAY',  
       6:'JUN',7:'JUL',8:'AUG',9:'SEP',10:'OCT',  
      11:'NOV',12:'DEC'}
```

Python has a 79-character line limit.
Continue lines explicitly with a single backslash.



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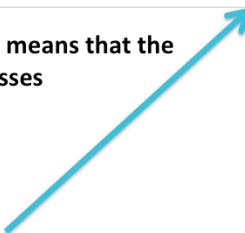
Python Line Limit is 79 characters as of release PEP-8 (2008).

The preferred way of wrapping long lines is by using Python's **implicit** line continuation inside parentheses, brackets and braces. If necessary, you can add an extra pair of parentheses around an expression, but sometimes using Python's **explicit** continuation, which is a single backslash.

Make sure to indent the continued line appropriately. The preferred place to break around a binary operator is after the operator, not before it.

Used In Other Cloudera Training

- This symbol, in the upper right corner of the slide, means that the technique is frequently used in other Cloudera classes



Loudacre Mobile

- **Loudacre is a mobile phone carrier**

- They have provided us with realistic device log data from their mobile phones which we will be using in our exercises
 - Loudacre is a fictional company

- **About the log data**

- Every time a phone has a catastrophic error requiring a soft or warm restart, the phone reports device status information and sends it to the central system where it is collected for later analysis



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Note: Review the next several slides on basic programming before going to the first preparatory exercise.

Basic File I/O

- **Use the built-in file object and its methods**

- Methods: `open()`, `read()`, `readline()`, and `close()`
- File modes: `r`=read, `w`=write, `a`=append
- File format: `b`=binary, `t`=text (default)

```
line = ''  
file = open('loudacre.log', 'rt')  
while True:  
    line = file.readline()  
    if not line:  
        break  
    print line  
file.close()
```



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`readline()` reads to the EOL character at the end of the line.

Note: This code is a direct example of what is needed in the exercise. Please review this code with the class carefully.

Some of the Flow Control elements are covered in detail in a later chapter. However, if you cover some of them here it is sufficient for the exercise at the end of this chapter.

Basic Printing and Keyboard Input

- Use the built-in `print()` function

- Basic printing of variables: `print var1, var2, var3`
 - Print formatted string:

- `print formatstring %(var1, var2, var3)`
 - Formatting: %d=integer, %r=real (float), %s=string

```
s = "Sorrento F41L"
print s

formatstring = "Device temperature %d to %r celsius"
print formatstring %(24, 31.24)

> Sorrento F41L
> Device temperature 24 to 31.24 Celsius
```



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Basic Keyboard Input

- Use the `raw_input()` function

```
s = raw_input("Enter: ")  
print s  
  
> Enter:  
> Enter: Titanic 4000  
> Titanic 4000
```

Chapter Topics

Introduction to Python

- Python Background Information
- Scope
- Exercises
- **Essential Points**
- Hands-On Exercise: Using IPython
- Hands-On Exercise: Loudacre Mobile



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Essential Points

- **Background information about Python**
- **Scope and version coverage**
- **Symbolism and syntax used in slides**
- **Introduction to exercises, IPython shell, and Loudacre**



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Chapter Topics

Introduction to Python

- Python Background Information
- Scope
- Exercises
- Essential Points
- **Hands-On Exercise: Using IPython**
- Hands-On Exercise: Loudacre Mobile



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Hands-On Exercise: Using IPython

▪ Start using IPython shell

- Use the shell interactively (REPL)
- Try some simple Python
- Use the IPython shell to execute OS commands, **pwd** and **ls**
- Try the integrated **help()** system
- Edit and run a program using **%ed**

Chapter Topics

Introduction to Python

- Python Background Information
- Scope
- Exercises
- Essential Points
- Hands-On Exercise: Using IPython
- **Hands-On Exercise: Loudacre Mobile**



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Hands-On Exercise: Loudacre Mobile

■ Introduction to the `loudacre.log` data

- Edit and run a file I/O program
- Read each line of `loudacre.log` and print it



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Variables

Chapter 3



In this chapter we will explore basic variables.

The data structures supported in a language have a profound influence on the general approach to problem-solving and the way in which programs are written.

Note: important points are identified with '[*]'

Course Chapters

- Introduction
- Introduction to Python
- **Variables**
- Collections
- Flow Control
- Program Structure
- Working with Libraries
- Conclusion

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There are eight Chapters in the course. We'll look at them in detail in just a moment.

Variables

In this chapter you will learn

- How to create new variables without explicitly declaring them, using Python's dynamic typing
- How to distinguish between Mutable and Immutable properties of variables
- What is the basic usage and manipulation of numerical variables, booleans, and strings?
- How to build sophisticated string transformations using chaining, slices, and concatenation techniques



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Chapter Topics

Variables

▪ Python Variables

- Numerical
- Boolean
- String
- Essential Points
- Hands-On Exercise: Variables



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Variables

▪ Basic I/O

- `raw_input()`
- `print()`

```
yourVar = raw_input('yourPromptHere')
print(yourVar)
```

Optional prompt

▪ Variable Names

- Initial letter, letters and numbers, case sensitive, underscore but no other special characters
- Reserved words of the language, keywords, prohibited
- `__` (double underscore) reserved for some built-in object methods
- Convention:
 - Initial caps for classes, initial lowercase for instances



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Basic I/O – Python supports Web I/O and GUI I/O through optional modules, but this course will only use console I/O (keyboard and display). We don't need "fancy" formatted I/O, since we are mainly just using the `print()` function to explore the results of applying methods to variables. Variable names are just as you'd expect.

Familiarity with OO is a pre-requisite for this course, however, because these items were not previously defined, they are defined here:

- **Built-in Object Methods** – Methods of objects that are defined in the base language (not in an optional or external library) and do not need to be imported are prefixed with a double underscore. One example is `__init__`. You don't have to define it, Python will add it automatically.
- **Classes** – From Wikipedia Programming Glossary: "An object-oriented programming , a class is a template definition of the method s and variable s in a particular kind of object . Thus, an object is a specific instance of a class; it contains real values instead of variables."
- **Instances** – From Wikipedia: "In object-oriented programming (OOP), an instance is a specific realization of any object. Formally, "instance" is synonymous with "object" as they are each a particular value (realization), and these may be called an instance object; "instance" emphasizes the distinct identity of the object. The creation of an instance is called instantiation."
- **Object** – From Wikipedia: "In computer science, an object is a location in memory having a value and possibly referenced by an identifier. An object can be a variable, a data structure, or a function. In the class-based object-oriented programming paradigm, "object" refers to a particular instance of a class where the object can be a combination of variables, functions, and data structures."

Preview of Variables

▪ Basic Variables

- Integers
- Floats
- Strings
- Booleans

▪ Compound Variables

- Lists
- Tuples
- Sets
- Frozensets
- Dictionaries

```
type(yourVar)
```

Almost everything in Python is some kind of object or variable.

There are a few additional types available in Python such as a “bytearray” that are outside the scope of this course.



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These are the variables we will be discussing in the remainder of the class.

[*] If you are ever confused by the Dynamic Typing in Python, you can always use the type() function to find out the current type of a variable.

Properties of Python Variables

▪ Dynamically Typed

- In other languages you need to declare variable type
- In Python type is established on first use

▪ Mutable versus Immutable

- Immutable – value cannot be changed after initial assignment
- Only two collections (Tuple and Frozenset) are immutable

▪ Re-assignable

- Python re-evaluates type with every assignment
 - In some other languages attempts to use the same variable name with a different type will cause an error

```
abc = 10  
abc = 'hello'
```

Now abc is an integer

Now abc is a string

Python doesn't care!

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03-7

We've covered Dynamically Typed. However, there are a few other properties that apply to variables and will help the students relate Python to whatever language they already know. These are 'mutable' versus immutable.

[*] Mutable. All of the Basic variables in Python are mutable. And most of the Compound variables in Python are mutable. Only a couple of compound variables (collections) are immutable. The number one cause of bugs in multi-threaded code are data items that can change value while being used concurrently. This creates bugs that are really hard to track down and maybe be subject to race conditions. Using immutable data means that the value of data can't be changed after it is initialized. So, basically, if a concurrent thread needs to change a value, it has to make its own copy of the variable rather than potentially changing a variable that other code depends on.

[*] Re-assignable. Another challenge for people coming from strongly typed languages is that a variable can be reassigned to a different type within a single program. "With great power comes great responsibility" (Spider Man, the Movie). Programmers who rely on the compiler to tell them to error when re-using a variable name as a different type need to be more careful. On the other hand, they no longer need to declare the type of a variable before it is used – so a lot of typing is saved and the code is a lot easier to read.

Dynamic Typing in Python

- Type is established by the initial value assigned to a variable name
 - The type is inferred by context clues
 - You must give a variable an initial value or Python will not recognize the variable
 - No explicit type declaration
 - Type can be changed whenever an assignment is made

```
abc = 10  
abc = 1.57
```

Now abc is an integer

Now abc is a float

- Python supports multiple assignment syntax

transitive

```
ab = bc = 7
```

ab and bc are both assigned 7

distributive

```
ab, bc, cd = 8, 10, 43
```

ab is 8, bc is 10, and cd is 43

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[*] Dynamic typing. Python provides Dynamic Typing. Part of the philosophy of Python is that human beings shouldn't have to do work that computers can do. And this applies to determining the type of variable that should be used. Python can determine the type using inference from the context. For example, if the right side of an assignment has all numerals and a decimal, then the variable should be of the 'float' type.

Type of a variable can change. One thing that can be confusing for people coming from a 'strongly typed' language is that a variable can change type while it is being used. Every time an assignment is made to a variable, Python re-evaluates the type and updates it. That can be confusing because 'abc' might be an integer in one part of the code, and then change type to a float or a string in another part of the code.

[*] Multiple assignments. Python enables multiple assignments on a single line, either through transitive (all variables are given the same initial value) or distributive (each variable on the left side of the equals sign is associated with the value in the same position on the right side).

Automated Memory Management

- **Python provides automated memory management**

- You don't have to "allocate" and remember to "free" memory to prevent a memory leak

- **Garbage Collection**

- When a variable is no longer needed, the memory is released
 - Scope and reference counters determine whether a variable is needed



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[*] Built-in memory management. Another difference between Python and other languages (especially lower-level languages like C) that do not provide memory management. You have to 'free' any memory that has been allocated. One feature that low-level coders often have to implement is a memory management system to guard against consuming memory. They need to free memory when it is not being used. When this doesn't work it can cause a 'memory leak' which is another painful bug to troubleshoot.

[*] Memory management is based on scope and reference count. Python tracks variable use by scope, and when execution passes out of the scope for a variable, its reference count is decremented. When the reference count reaches zero, the variable is placed on a queue for recycling at a convenient time.

Instructor value-add. Additional detail if needed.

- When a variable is initiated, Python creates a Reference Counter for it
- When a variable is used, the Reference Counter is incremented
- When the variable is no longer being used (falls out of scope) the Reference Counter is decremented
- When it reaches zero, the variable becomes eligible for recycling
- The space is not immediately recovered, but is placed in queue and Python recycles the space on its own schedule

General Points about Python Variables

- Basic I/O is simple, in Python you don't need a lot of boilerplate code
- There are basic variables and collections built from the basic variables
- Understanding the variable types (especially collections) makes Python make sense and is crucial to writing "Pythonic" code
- You don't declare a variable, you initialize it
 - Python infers type by context
- Python re-evaluates and potentially changes the variable type on each assignment.
 - `type(var)` tells you a variable's current type vs. `print(var)` which tells you its value
- Python automatically recycles memory when it is no longer being used
 - You don't have to `free()` variables

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Note: Just reviewing key points of the overview before diving into the details with each variable type.

Chapter Topics

Variables

- Python Variables
- **Numerical**
- Boolean
- String
- Essential Points
- Hands-On Exercise: Variables

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03-11

First are numbers... integers and floats.

Numerical Variables and Arithmetic

▪ Precedence and Operations

- Follows mathematical operations

```
ab = 1 + 2 * 3  
print(ab)  
> 7
```

- Uses `**` instead of `^` for exponentiation

- Supports reflexive operators

```
ab += bc → ab = ab + bc
```

- Does not support increment/decrement (`ab++`, `ab--`)

- Provides floor division, a companion to the modulus operator

*floor division
operator*

`7 // 5 = 1`

The number of whole times 5 will “go into” 7

modulus

`7 % 5 = 2`

The partial remainder (i.e. 2/7ths remains)

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Pretty much as you'd expect...

There are a few differences from other languages.

[*] Python uses `**` instead of `^` for exponentiation. The `^` is a logical operator between Set objects.

[*] Also, for programmers accustomed to increment and decrement (`x++` and `x--`), Python doesn't support this. Instead, use the reflexive `x += 1`

[*] Python provides a floor division operator that is the companion of modulus. Details about floor division on the next slide.

Division Operations

- **How should division be implemented in a dynamic typing language?**
 - Two integer operands *could* return a floating point result (unlike in C)
- **True Division (The way division is handled in mathematics)**
 - Example: $3/2 = 1.5$ and $1/4 = 0.25$
- **Classical Division (The way C language implements division)**
 - If both operands are integers: $3/2 = 1$ and $1/4 = 0$ (truncation)
 - Floating example: $3.0/2.0 = 1.5$ and $1/4 = 0.25$
- **Python 2.2 → Classical Division**
 - If both operands are integers, results are truncated
 - Floor Division Operator '//' – Example: $3.0//2.0 = 1$ and $1//4 = 0$

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Yes, the floor division operator looks like a C-style comment

The issue is that in a dynamic typing language like Python, the results of two integer operands can be a float rather than an integer. By breaking with classical division (as implemented in 'C') which preserves the integrity of the type in the result, Python breaks code-level compatibility with legacy code in favor of being more "math-like". The change is introduced in phases. 2.2 introduced the "Floor Division" operator and warned developers who expected the integer/truncation behavior to start migrating their code to use '//' . In 3.0 the transition was completed by changing the default behavior of division, so that if both operands are integers, and the result is not whole, the result will be passed back as a floating point variable rather than truncating it to fit in an integer format.

This debate has led to much consternation. However, as we know from Scala's design and uses with Big Data, fidelity to math will win out.

Numerical Interactions between Int and Float

▪ Numbers

- Implicit transformation: **int to float** and **float to int**
- Python handles mixing of int and float variables ... as expected

```
int  
mixed int and float  
?  
Dev_temp_celsius = 45  
Fahrenheit = 9.0/5.0 * Dev_temp_celsius + 32  
type(Fahrenheit)  
> type <'float'>
```

- Explicit transformation (casting):

```
int(float_var), float(int_var)
```

```
Dev_temp = 37  
fTemp = float(Dev_temp)  
print fTemp  
> 37.0
```

```
Latitude = 33.19135811  
iLat = int(Latitude)  
print iLat  
> 33
```



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[*] Dynamic typing – context interpretation.

Basically, Python figures out if there is a float involved and makes the resulting variable assignment into a float.

Dev_temp_celsius → the mobile device temperature in the Loudacre data.

Overheating may be one reason that certain models restart.

If the GPS is enabled, the device reports Latitude and Longitude.

Numerical Interactions with Strings

▪ Strings

- There is **no bin, oct, or hex** type in Python
- **hex (num), oct (num), bin (num)** all return type **str** strings

```
Unique_Device_ID="ff375011-34f0-4758-bade-e68cea787115"
```

```
print(hex(13552))  
> "0x34f0"
```

- Strings are **not** implicitly converted to numeric variables
- Explicit transformation functions provided

- **str(), hex(), oct(), bin()**
- **int(), float()** ← works appropriately for string type

```
ab = "123.45"  
bc = float(ab)  
print bc  
> 123.45
```

```
ab = "123.45"  
bc = int(ab)  
> <Error>
```

The string must be in the proper format



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[*] There are no low-level binary, octal, or hexadecimal variable types. These functions convert decimal to their representation as strings. So it is basically for formatting output. You CAN specify hex and binary values as input such as using 0x... and Python will parse this input and convert it to a decimal and store it as an integer.

The Unique_Device_ID is a string composed of hexadecimal sequences in the Loudacre data.

[*] Also, a string containing an integer or floating point number can be converted into an integer or float variable. The casting functions int() and float() use polymorphism to properly process strings.

Note that in the code that generates an error in the slide, int(ab) could optionally be casted to a float first, and then there would be no problem.

This is a good point to discuss "Duck Typing" as an instructor value-add. We don't specifically describe Duck Typing in the slides. But you can explain that Python knows whether it is looking at a string or an integer, and calls the appropriate version of the function to cast the source.

This concept is covered in the final chapter on object oriented programming as polymorphism.

Numbers to String Transformation Examples

```
a = bin(13552)
type(a)
> <type 'str'>
print a
> '0b11010011110000'

a = oct(13552)
type(a)
> <type 'str'>
print a
> '032360'

a = hex(13552)
type(a)
> <type 'str'>
print a
> '0x34f0'
```

```
print(0x79 + 1)
> 122
```

Python recognizes the notation and converts it to a decimal integer before performing the math operations



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[*] The assumption in Python is that decimals are your 'calculating' system, and that binary, octal, and hexadecimal are primarily methods to display the results of calculations.

Math Library

▪ Floating Point Math Accuracy

- Accuracy is adaptive to the platform on which Python is running
- Warning! Don't code with reliance on floating point accuracy

▪ *If you need better controls, take a look at the math module*

▪ The Math Library

- The math library is not built-in as it is in other languages, it must be loaded
- Calling semantics

Usually returns
a floating point

```
import math  
yourVar = math.function(yourParameters)
```

Function of your choice



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[*] Math functions that are commonly 'built in' to other languages are a separate module in Python. You have to 'import math' to enable those functions. We are not going into detail here, but making the learner aware, as they are likely going to need math for Data Analytics.

Note: One reason we are mentioning this at all is that math functions are native in many other programming languages, and we don't want students 'hitting the wall' if they expect sin() or sqrt() to 'just work'.

There is more about math and importing of modules later in the class.

Chapter Topics

Variables

- Python Variables
- Numerical
- **Boolean**
- String
- Essential Points
- Hands-On Exercise: Variables



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Booleans

- **bool variables are used to control program flow**
 - branching, conditional execution, looping
 - ... *more in the chapter on flow control...*
- **bool variables are created by assigning a True or False value**
 - **True** and **False** are *case sensitive* and *are not delimited*

`GPS_status = True`

Creates a bool with the value **True**

`GPS_status = 'True'`

Creates a string of characters T-r-u-e

`GPS_status = true`
<Error>

Causes an error because variable named **true** has not been initialized
Same for **TRUE**



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[*] Main point here are that Boolean values in Python are **True** and **False** (with initial caps) and that '**true**' and '**TRUE**' are not boolean values, but undefined variable names in Python.

GPS_status is a boolean value set in the Loudacre data, indicating whether GPS is enabled (**True**) or disabled (**False**) on the mobile device.

Note: Students coming from other languages may be habituated to pre-processor directives in which textual variations have been set to expand to the logical value – meaning that even if the language is case sensitive, the programmer may be habituated that it doesn't make a difference.

Booleans are used for Flow Control in Python. We have a whole chapter on that later in the class. So we are just mentioning it here for foreshadowing.

Comparatives

▪ Inequalities

- <, >, <=, >=
- In Python, => and =< are syntax errors

▪ Equalities

- ==, !=
- Both <> and != are valid
- You can mix types, so 1 == 1.0 results in True

▪ Logic

- and, or, not

▪ Identities

- Compares the identity `id(var)` to see if symbolic names refer to the same exact object in memory
- is, is not

```
a = b =7  
  
print id(a)  
> 4298189096  
  
print id(b)  
> 4298189096  
  
print a is b  
> True
```

a and b are two different names for the same object in memory



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The Comparatives are pretty much as you'd expect.

A few peculiarities...

[*] Python allows '<>' instead of '!=', and also the English phrase 'is not'.

Note: You should mention that the syntax shown is all that's supported. Students with other language experience might expect to see text alternatives such as _IS_EQUAL_TO_, or .GT. or 'greater_than' that are used in some contexts to make code more readable.

These operators are overloaded to support Duck Typing for compound variables and mixed type operations. For example, you can test if int < string (Integers, no matter how large a number, are always less than any string).

Chapter Topics

Variables

- Python Variables
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Strings

▪ Delimiters

- Single-quote or double-quote
- The start and end delimiter must be the same character
- Curly quotes and slanted quotes are not valid delimiters

▪ Composition

- Use the escape sequence (backslash) for literal characters
- \t = tab, \n = newline, \b=backspace, \r = carriage return

`ab = "Python\ttext" → Python ext`

\t became a tab

- Use the r (raw) prefix for a literal string

`ab = r'Python\ttext' → Python\ttext`

- Use double-escape to indicate a single backslash

`ab = 'Python\\text' → Python\text`

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[*] You can use single quotes or double quotes to denote a string.

Python doesn't have a char type, so there is no need to distinguish between a character literal '' and a string literal " ".

[*] Escape sequences in strings.

The escape sequence (\...) within a string is – as you'd expect. it is the usual standard escape sequences from formatted strings.

You can disable a single escape sequence with another slash, so '\\ → \\'

[*] One peculiarity of Python is that embedded single or double quotes must be escaped.

Example: "He said \'stop\'!" → He said 'stop'!

Note: Students might be familiar with triple delimiter such as "He said ""stop""! which won't work in Python.

Another Python feature, is you can disable escape sequence processing by prefixing the string with the letter 'r'. (raw) This is a lot easier than trying to maintain double-escapes when generating HTML or other scripts where the backslash is a native character.

String Manipulation: Concatenation

▪ Concatenation

- Use the + plus operator
- `join(sequence)`

```
Style, Model = 'Sorrento', 'F10L'
Device_Name_and_Number = Style + " " + Model
print Device_Name_and_Number
> Sorrento F10L

StyMod = Style.join(Model)
print StyMod
> FSorrento1Sorrento0SorrentoL
```



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The '+' is used for both arithmetic and for string concatenation.

Device Make and Model number is a single field in the Loudacre data. We've identified the separate parts here to illustrate concatenation.

Join performs an interleaving or repetitive concatenation.

String Manipulation: Slices

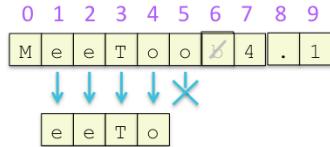
▪ Slice

- A substring consisting of an individual character is called a “slice”
- `string[offset]`
- The offset is zero-based, so the first character is `str[0]`

▪ Slice Range

- A substring consisting of multiple characters
- `string[start:end]`
- *Warning! upper bound is non-inclusive*
 - The “end” character is not included in the substring

```
device = 'MeToo 4.1'  
print device[1:5]  
> eeTo
```



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[*] In Python the syntax `name[x]` is called a 'slice' and `name[x:y]` a 'slice range'. In other languages this is called an array or a subscripted element or just a range.

[*] The lower bound is inclusive in the substring, but the upper bound is not. The lack of symmetry can be confusing to those who have used other languages where the upper bound is inclusive.

The reason for non-inclusion of the upper bound makes more sense if you consider it as a mathematical expression. For an entity i ; if you were to start numbering it as parts with '1', you'd mathematically describe the set of parts of i as $1 \leq i < N+1$. A natural consequence of simplifying this expression to start with zero would be: $0 \leq i < N$. And that means the ' n th' element is 'greater than' i and not included in the parts of i .

[*] One key awareness is that Python elevates the 'slice' syntax to the level of an operator. It can be used on any collection. We introduce it here in the context of a String. But it applies to all collection sequences such as lists and tuples. You're going to see 'slice' return later in this chapter, so make sure you introduce and enforce proper Python terminology to set the students up for understanding later.

String Transformation

Case Manipulation

```
string.title()  
string.capitalize()  
string.lower()  
string.upper()  
string.swapcase()
```

Justification

```
string.ljust(width,fillchar)  
string.rjust(width,fillchar)  
string.center(width,fillchar)
```

Space Manipulation

```
string.strip(chars)  
string.rstrip(chars)  
string.lstrip(chars)  
string.expandtabs(tabsize)
```

Editing

```
string.split('delimiter')  
string.partition('char')  
string.rpartition('char')  
string.splitlines(integer)  
string.replace(str1,str2)
```



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This is just a light overview of the kinds of string methods that are supported in Python.

You don't need to cover them in detail here.

[*] We are going to use split() in the hands on exercises in this course. Split is used to convert delimited strings to lists. And this method is used frequently in our developer courses.

Note:

We need collections (lists) to demonstrate how 'split' parses a delimited string into separate elements. So we will cover this in detail in the next chapter, not here.

Chaining Example

- Methods are called from the object using the dot operator, as in most object oriented programming languages
- You can *chain* methods in Python. In the example shown, the results of the `title()` method are passed to the `swapcase()` method

```
device = "titanic 2300"
> titanic 2300
device.title()
> 'Titanic 2300'
device.swapcase()
> 'TITANIC 2300'
device.swapcase().title()
> 'Titanic 2300'
```



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[*] You can endlessly chain methods in Python. The methods are processed from right to left and the results of each method become the source for the subsequent method.

String Interrogation

Format

```
string.isalpha()  
string.isdigit()  
string.islower()  
string.isspace()  
string.istitle()  
string.isupper()
```

Constitution

```
string1.startswith(string2)  
string1.endswith(string2)  
string1.count(string2)  
string1.find(string2)  
len(string)
```



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Ways to find information about strings and the contents of strings.

Chapter Topics

Variables

- Python Variables
- Numerical
- Boolean
- String
- **Essential Points**
- Hands-On Exercise: Variables



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Essential Points

- **Python does a lot of things automatically for you with variables**
 - That makes the code cleaner and easier to read
 - But you need to *know what it is doing for you*, or it is easy to get confused – *one reason we are spending so much time on variables*
 - The basic types are integer, float, boolean, and string
- **Int and Float behave as you'd expect**
 - math is an “add in,” so math functions don't work by default
- **Boolean**
 - **True** and **False**
- **String**
 - Slice `str[x]`, `str[start:end]` ← “end” is not inclusive



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Just reviewing key points.

Chapter Topics

Variables

- Python Variables
- Numerical
- Boolean
- String
- Essential Points
- **Hands-On Exercise: Variables**



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Hands-On Exercise: Variables

■ Interactive Exploration

- Explore Numerical variables
- Operators, Operators, Casting, Math Functions, Booleans

■ Program

- Write a program to extract fields from a single data record



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Interactive Exploration

Numerical variables

Operators and reflexive operators

Casting

 Integer and Float

 Binary, Octal, and Hexadecimal

Advanced math functions

Booleans and comparators

Program

Write a program to extract fields from a single data record

Sample record string is in `sample_one_record.txt`

String methods, `find()`, `upper()`, Slices

Boolean



Collections

Chapter 4



In this chapter we will explore compound Data Structures called 'Collections'.

The data structures supported in a language have a profound influence on the general approach to problem-solving and the way in which programs are written.

Course Chapters

- Introduction
- Introduction to Python
- Variables
- Collections**
- Flow Control
- Program Structure
- Working with Libraries
- Conclusion



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Collections

In this chapter you will learn

- Essential information about Python's powerful collection types
- What are the different properties of each collection type, and suggestions about when to use one type or another
- How to create, manage, interrogate, and update collections

Chapter Topics

Collections

- Lists
 - Tuples
 - Sets
 - Dictionaries
 - Essential Points
 - Hands-On Exercise: Collections



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Collections

- Collection types are powerful and can influence program design.

Type	Description	Mutable	Ordered	Unique	Paired
List	A serial collection of objects.	X			
	<code>list.sort()</code> → ordered collection	X	X		
Tuple	An immutable collection of objects				
Set	An unordered collection of unique objects	X		X	
	<code>sorted(set)</code> → ordered and unique	X	X	X	
Frozenset	An immutable ordered collection of unique objects		X		
Dictionary	An ordered collection of unique key-value object pairs	X		X	X

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Different sources use the terms "Collections", "Sequences" and "Sequence Variables" interchangeably. Sometimes they are referred to as "Lists" after the first and most common collection type.

A lot of the power of Python is due to these extremely flexible and powerful collections.

A useful way to categorize variables is by (1) Mutable or Immutable, (2) Ordered or 'as is', (3) Unique or Repeatable elements, and (4) single values or pairs of values (key-value pairs).

[*] A list is in natural 'as is' order, but can be sorted to create order within it. A list can also be ordered without being unique, by using the `list.sort()` method.

[*] A Tuple is basically an immutable list.

[*] A Set is a list that is unique. It can be ordered (ascending order) with the `sort` method.

[*] A Frozenset is basically an immutable Set.

[*] And a Dictionary is a Set with Key Value pairs rather than individual values.

Collections Syntax

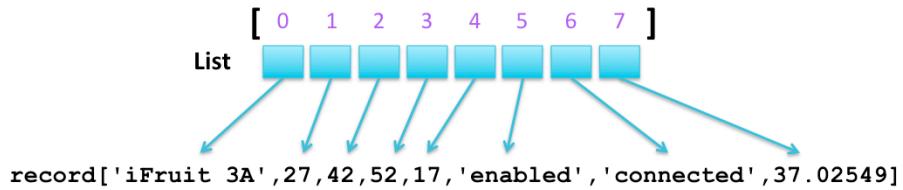
Collections

```
list[element1, element2, element3]  
tuple(element1, element2, element3)  
set(element1, element2, element3)  
dictionary{key1:value1, key2:value2}
```

The colon between key and value literals differentiates the initialization of a dictionary from initialization of a set.

Lists

- A list is a serial collection of elements
 - Elements do not have to be of the same type
 - Elements can be other collections (nested)
 - Default qualities – lists are unordered and non-unique
 - A list can be created by initializing a variable with comma separated elements surrounded by square brackets []



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[*] A list is a sequence of values separated by commas and surrounded by square brackets.

[*] elements in lists don't have to be of the same type. But it is more common to see lists of a single type and Tuples of multiple types.

Note:

The illustrations only show a list as being composed of basic variables, because this is all we've covered so far in the course. In Python, the collections are collections of objects. So you can actually use a list as an element of a list (nested structure) as well as other collections and even other types of objects, such as functions.

List Operations

- **element in list**
 - Returns **True** if the element is in the list
- **element not in list**
 - Returns **True** if the element is not in the list
- **n * list**
 - Copies the list *n* times and concatenates the copies

```
devices = ['iFruit', 'Sorrento']
devices = 2 * devices
print devices
> ['iFruit', 'Sorrento', 'iFruit', 'Sorrento']
```



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04-8

[*] Operators are overloaded and do what you'd expect.

Comparators (equalities and inequalities) are overloaded for lists. They will compare each element in the two lists, left-to-right, to evaluate.

Whiteboard:

```
list1 = [1,1,1]
list2 = [1,1,2]
list1 < list2 → True
```

List Modification

- **list.append(element)**
 - Appends an element after the final element in a list

- **list.insert(offset, element)**
 - Inserts an element into a list after the offset

- **list.remove(element)**
 - Removes the first occurrence of element from the list

```
models = ['Sorrento','iFruit','Titanic']
models.remove('iFruit')
print models
> ['Sorrento', 'Titanic']
```

- **list.pop()**
 - Returns the last element in the list and removes it



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[*] list.append(element) vs. list.extend(list2)

list.append(element) adds one element to the end of the list.

Working with Multiple Lists

- `list3 = list1 + list2`
 - Returns a new list containing the elements from `list1` and `list2`
 - Does not change the original lists
- `list1.extend(list2)`
- `list1 += list2`
- `list1 = list1 + list2`
 - Concatenates the elements from `list2` onto `list1`
 - Copies all elements in `list2` to the end of `list1`
 - Overwrites the contents of `list1`



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[*] `list.append(element)` vs. `list.extend(list2)`

`list.append(element)` adds one element to the end of the list.

`list.extend (list2)` adds ALL of the elements in `list2` to the end of `list1`. Note that it does this by copying. So if you later change the value of an element in `list2`, `list1`'s copy is not affected.

append() Versus extend() for Collections

```
mods1 = ['Sorrento','iFruit','Titanic']
mods2 = ['Ronin','MeToo']

mods1.append(mods2)
print mods1
> ['Sorrento','iFruit','Titanic',['Ronin','MeToo']]
```

The last item is a list.
This is a common
mistake!

```
mods1 = ['Sorrento','iFruit','Titanic']
mods2 = ['Ronin','MeToo']

mods1.extend(mods2)
print mods1
> ['Sorrento','iFruit','Titanic','Ronin','MeToo']
```



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Slices of a List

- The slice notation works the same with collections as it did with strings
- Notice that the first element is 0, so $q[0] \rightarrow 1$, and $q[5] \rightarrow 6$
- Slice range
 - The lower bound is included in the slice, but the upper bound is not.
- Range increment
 - Selects a subset of elements in a list, skipping some
- Slices applies to all collection types

```
q = [1,2,3,4,5,6,7,8,9]
q[5]
> 6
```

```
q = [1,2,3,4,5,6,7,8,9]
q[2:5]
> [3, 4, 5]
```

```
q = [1,2,3,4,5,6,7,8,9]
q[1:9:3]
> [2, 5, 8]
```



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[*] Slices work the same way in lists as we discussed in strings, effecting each element rather than each character.

[*] Slices can have a third element. This is the 'iterator'.

Note:

The iterator will be important later because it is often used with a collection to process only certain elements in a collection. In other languages you would use a variation of the "for" loop to iterate in this way. In Python it is more common and elegant to use "slices" to imply iteration instead of explicit loops.

Python `del` keyword

- **`del list`**
 - Deletes the entire list
- **`del list[offset]`**
 - Deletes the element at the given offset
- **`del list[start:end]`**
 - Deletes the range of elements from start to end-1
 - end is not included in the elements deleted
- **`del list[start:end:increment]`**
 - Deletes the elements within the range

```
q = [1,2,3,4,5,6,7,8,9]
del q
print q
> < Error>
```

```
q = [1,2,3,4,5,6,7,8,9]
del q[3]
> q = [1,2,3,5,6,7,8,9]
```

0 1 2 3 4 5 6 7 8

```
q = [1,2,3,4,5,6,7,8,9]
del q[2:6]
> q = [1,2,7,8,9]
```

```
q = [1,2,3,4,5,6,7,8,9]
del q[1:9:2]
> q = [1,3,4,7,9]
```

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[*] Note that 'del' is a Python keyword, not a method of the object or a function.

When you delete the entire list, it *undefines* the variable.

Note:

The `del` keyword queues an object to memory management for recycling. Some functions such as `list.remove(element)` are the same as `del list.element`

List Interrogation

- **len(list)**
 - The number of elements in the list
- **list.count(element)**
 - Counts the number of identical elements in a list
- **list.min()**
 - Returns the minimum value element in the list
- **list.max()**
 - Returns the maximum value element in the list
- **list.index(element)**
 - Returns the offset of the first occurrence of element in the list

```
q= ['a', 'b', 'c', 'b', 'c', 'c']
q.count('c')
> 3

print len(q)
> 6
```

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[*] `len(list)` versus `list.count(element)`

`len()` *length* returns the number of elements in the list.

`list.count(element)` searches the list for identical instances of 'element' and returns a count of the number of them in the list.

List Transformation

- **list.sort()**
 - Sorts the list of elements in ascending order in place
 - Changes the order of the list itself
 - *The original order is lost*
- **sorted(list)**
 - Returns a sorted copy
- **list.reverse()**
 - Reverses the current order of elements in the list in place
 - Changes the order of the list itself
 - *The prior order is lost*

```
q = [4,5,3,2,1,7,9,8]
q.sort()
print q
> [1,2,3,4,5,7,8,9]
```

Common error!

```
a = list.sort()
will set a to an empty list
```

```
q = [4,5,3,2,1,7,9,8]
q.reverse()
print q
> [8,9,7,1,2,3,5,4]
```



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04-15

[*] list.sort() vs. list.reverse()

list.sort orders the list in ascending order. This is one of the few functions in Python that is destructive, in that the original order of the list is lost. It does not create a new list that is ordered and return that, it actually changes the order of the list in place.

list.reverse() changes the order of elements in the list, first to last. Note that it does not sort the list. So if you called reverse on the original order it will reverse the original order.

If you want to sort in descending order, you'd call list.sort() then list.reverse() or...
list.reverse().sort()



Conversion between Strings and Lists

- **list = string.split(delimiter)**
 - Create a list from a delimited string
 - The **split()** method is used frequently in Cloudera classes

- **mystring = delimiter.join(list)**
 - Method for converting a list to a string
 - Note that this is a method of the delimiter... *looks awkward*
 - works with any delimiter string, including the empty string ("")

```
ab = '1,2,3,4,5'
print ab
> 1,2,3,4,5

mylist = ab.split(',')
print mylist
> ['1','2','3','4','5']

cd = "-".join(mylist)
print cd
> 1-2-3-4-5
```



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[*] split

Shown – comma delimited. You can use anything in the parameter string as delimiter.

Note: Split is very common in our Developer classes because it is used to process delimited data and pass it to an RDD (Resilient Distributed Dataset).

[*] .join

The .join method is very awkward, because you actually have to call the delimiter as an object and then .join as the method. The intuitive structure seems like it should be...

list.join("delimiter") ← but this won't work
instead you need
"delimiter".join(list)

List File I/O

- **Use the `readlines()` method**

- Reads all the lines in the file to end-of-file (EOF)
- Returns each line as a separate element in a list

```
lines = [ ]  
  
file = open('example.txt','r')  
lines = file.readlines()  
file.close()  
print lines
```



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`readline()` reads to the EOL character at the end of the line.

`readlines()` –with and 's'– reads the entire file until EOF and places each line into an element in a list.

Example Code

- This code reads the entire `loudacre.log` file
- Each line is stored in one element of a list

```
devlog = []
file = open('loudacre.log', 'r')
devlog = file.readlines()
file.close()
print devlog[75]

> '2014-03-15:10:10:21, Titanic 1000,
f1c9e8fe-6235-4fd9-afd2-057922d50f58, 81, 63, 26, 40,
12, 0, TRUE, enabled, enabled, 35.45767939,
-117.5590077'
```



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Creating a List by Splitting a String

- This code uses `split()` to store each field as a string into an element of a list

```
onerecord = devlog[75].split(',')
print onerecord
> ['2014-03-15:10:10:21',
> 'Titanic 1000',
> 'f1c9e8fe-6235-4fd9-afd2-057922d50f58',
> '81',
> '63',
> '26',
> '40',
> '12',
> '0',
> 'TRUE',
> 'enabled',
> 'enabled',
> '35.45767939',
> '-117.5590077\r\n']
```



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This example uses a record (at element index 75) read from the code on the previous slide, and calls the `split` method on that string to split it using a comma as a delimiter. This has the effect of producing a new list, where each field in that record is an element.

Chapter Topics

Collections

- Lists
- Tuples**
- Sets
- Dictionaries
- Essential Points
- Hands-On Exercise: Collections



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Tuples

- Originated from the abstraction of the common counting sequence... triple, quadruple, pentuple, septuple, octuple, ... n -tuple → tuple
- The mathematical concept of a Tuple is “a sequence of elements”
 - In math (1,2,3,4,5) is a pentuple – five elements
- In Python, a tuple is an immutable collection. It has all the same operation and interrogation methods as a list, but none of the manipulation or transformation methods
- The values are assigned when the tuple is created and cannot be changed other than through re-assignment
- Trying to call a method that changes the constitution of a tuple will result in an error
- Create a tuple with the parenthesis () notation.

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Tuple

[*] A tuple in Python is an immutable list. This is accomplished by not defining any methods for tuples that would change or add information. The tuple is basically fixed after it is initialized.

[*] You create a tuple the same as you would a list, but use parenthesis instead of square brackets. Initialization is the only time you can assign a value to a tuple. All of the methods that change, add to, remove from, or order a list are missing for the tuple.

Note:

The concept of a tuple is one specific thing in mathematics, but it has been interpreted and implemented differently in programming languages and systems. People may have different expectations of the tuple depending on where they learned the concept. For some students, a tuple is a pair of values, and when you give the first value in the pair, the second one is returned. This key-value pair in Python is called a Dictionary. So if they ask about that functionality, tell them it is covered a bit later. For other students, a tuple is not a key-value, but still a pair of values. This is easily implemented in Python as the even and odd elements in the tuple. So tuple[0] and tuple[1] would be the first pair, and tuple[2] and tuple[3] would be the second pair. Then you iterate over first and second elements with a slice using an increment value such as tuple[0:n:2] or tuple[1:n:2].

Python Mutable Versus Immutable – Lists

▪ Mutable

- Performing a function on an object may change the content of the object
- The identity of the object is unchanged

▪ Immutable

- Performing a function cannot change the content of the object
- If change does occur, the resulting object has a new identity

```
wifiA = ['25','34','enabled']
id(wifiA)
> 4347030920
wifiB = ['connected']
id(wifiB)
> 4347029048
wifiA += wifiB
print wifiA
> ['25','34','enabled','connected']
```

```
id(wifiA)
> 4347030920

a = 25
id(a)
> 4298188664
a += 1
id(a)
> 4298188640
```

Python lists are considered mutable – the object ID remains the same Python integers are considered immutable – the object id changes for the variable named a

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04-22

Python has a peculiar notion and implementation of mutable versus immutable.

In the above examples, a list is concatenated using the reflexive "+=" operator, and an integer it incremented using the same operator.

Using the Python id() function to display the object id reveals what's going on under the covers. In the case of the list, the change happens in place and the original object is changed.

By displaying the id before and after, we can see that it is still the same object, ending in '20'. Changing an object in place means that it is 'mutable' according to Python.

In the second example, a very similar operation is performed on an integer.

However, the original object (id ending in '64') is lost and a new object ending in id '40' is created.

For this reason, Python considers the integer to be immutable, even though many other interpretations and implementation in other languages would consider it mutable since the result is that variable 'a' has a new value.

Note: the Python id() function prints out the memory address associated with a symbol. In the example in the second block, the id(a) reveals that the a += 1 resulted in allocation of a new variable named 'a' at a different location in memory.

Immutable Tuple – No Change Methods

- You can't modify the order or membership of a tuple once it is assigned

```
t = (1,2,3,4)
type(t)
> <type 'tuple'>

t.append(5)
> AttributeError: 'tuple' object has no attribute 'append'
t.extend(t)
> AttributeError: 'tuple' object has no attribute 'extend'
t.sort()
> AttributeError: 'tuple' object has no attribute 'sort'
del t[2]
> TypeError: 'tuple' object doesn't support element deletion
```



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[*] Tuples are immutable after initialization.

Note:

The error message is shown above as it appears in the Python shell. Note that it says 'attribute' is not defined. It is quite clear from the calling semantics with the parenthesis for passing parameters, that these are not attributes, but methods. The error is in error.

Immutable Tuple

- You can re-assign the value of an entire tuple, but it creates a new object

Tuple

```
t = (1,2,3,4)
print t
> (1,2,3,4)
print id(t)
> 4300627208

t = t + t

print t
> (1,2,3,4,1,2,3,4)
print id(t)
> 4297732776
```

List

```
mylist = [1,2,3,4]
print mylist
> [1,2,3,4]
print id(mylist)
> 4300881792

mylist.extend(mylist)

print mylist
> [1,2,3,4,1,2,3,4]
print id(mylist)
> 4300881792
```



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Casting Between Tuples and Lists

- Lists commonly contain elements of the same type, although this is not a rule
- Tuples commonly contain elements of different types, to represent a record
- A tuple can be reassigned. Casting a tuple into a list, modifying it, and then Casting it back into a tuple is called *unfreezing* and *freezing*

```
t = (39,18,29,1)
type(t)
> <type 'tuple'>
print t
> (39,18,29,1)

mylist = list(t)
print mylist
> [39,18,29,1]

list.append(5)

t = tuple(mylist)
print t
> (39,18,29,1,5)
```



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04-25

[*] You can 'cast' a tuple to a list and a list to a tuple to 'unfreeze' and 'refreeze'.

Note:

Note that when you cast the list back to the tuple, it is actually a new location in memory. So in the example above, the first 't' is a tuple. Then it is converted to list lst, then converted to another 't' tuple. The new tuple replaces the old one, and the old one is queued for memory recycling.

Chapter Topics

Collections

- Lists
- Tuples
- Sets**
- Dictionaries
- Essential Points
- Hands-On Exercise: Collections



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Sets

- Sets are unordered and unique

```
ifruit = set(['1','5','5','3A','3','4','2','3A','4A','5'])
print ifruit
> set(['1', '3', '2', '5', '4', '3A', '4A'])
```

- A set is represented by comma separated elements
 - In 2.6, required syntax is `set([...])`
 - In 2.7, a set can be specified using curly braces `{ }`
- You can create a new sorted set with the `sorted()` function

```
ifruit = sorted(ifruit)
print ifruit
> set(['1', '2', '3', '3A', '4', '4A', '5'])
```



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Sets

ifruit models of mobile phone.

[*] A set is defined by a comma delimited series of elements bounded by curly braces.

[*] The main properties of a set are that it is unordered and unique. You can see in the example that sorting of the long series of values result in the very orderly series from lowest to highest, and with no repeated elements.

Note: Actually, it IS ordered – it is in order of entry.

Casting Sets

- You can create a set from a tuple or a list using `set()`
- Casting with sets works the same as between lists and tuples

```
mylist = [5,3,4,1,2,5,3,5]
s1 = set(mylist)
print s1
> set([1,2,3,4,5])
```

```
mytuple = (5,3,4,1,2,5,3,5)
s2 = set(mytuple)
print s2
> set([1,2,3,4,5])
```



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04-28

Sets

[*] A set is defined by a comma delimited series of elements bounded by curly braces.

[*] The main properties of a set is that it is ordered and unique. You can see in the example, that initialization of the long series of values result in the very orderly series from lowest to highest, and with no repeated elements.

Set Theory Methods and Operators

- **set1.union(set2)**
 - All the elements in both sets
 - Symbolic notation also works: **set1 | set2**
- **set1.intersection(set2)**
 - Only elements that are in both sets, and not in only one
 - Symbolic notation also works: **set1 & set2**

```
s1 = {1,2,3,4,5}  
s2 = {3,4,5,6,7}  
  
s1.union(s2)  
> set([1, 2, 3, 4, 5, 6, 7])  
s1.intersection(s2)  
> set([3, 4, 5])  
print s1 & s2  
> set([3, 4, 5])
```



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[*] The methods on sets provide 'set theory' operators, such as union, intersection (difference, and symmetric difference are on the next slide).

Set Theory Methods and Operators

- **`set1.difference(set2)`**

- Provides the difference between the sets
- The elements that are in either one or the other set, but are not in the intersection
- Symbolic notation: `set1 - set2`

- **`set1.symmetric_difference(set2)`**

- Symbolic notation: `set1 ^ set2`
- Returns the set of all elements that are not in the intersection

```
s1 = {1,2,3,4,5}
s2 = {3,4,5,6,7}

s1.difference(s2)
> set([1, 2])

s2.difference(s1)
> set([6, 7])

s1 ^ s2
> set([1, 2, 6, 7])
```



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Set Interrogation Methods

- **`set1.isdisjoint(set2)`**
 - Returns **True** if both sets share no elements
- **`set1.issubset(set2)`**
 - Returns **True** if every element in `set1` is in `set2`
 - Symbolic notation: `set1 <= set2`
- **`set1.issuperset(set2)`**
 - Returns **True** if every element in `set2` is in `set1`
 - Symbolic notation: `set1 >= set2`
- **`set2 > set1`**
 - Proper subset
 - Returns **True** if `set2` contains all elements of `set1`, and one or more additional elements



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[*] The sets can be compared and interrogated about their relationship.

Set Manipulation Methods

- Sets have their own manipulation methods
- `set.add()`
 - Adds an element to the set
- `set.update()`
- `set.copy()`
- `set.pop()`
- `set.discard()`



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04-32

[*] In a list, you would append elements, but in a set, you add them. This makes sense because when an element is added to a list it will not necessarily appear at the end, but will appear in order. And if the element is redundant with the same element already in the set, it will result in no change to the set.

Example: .pop takes no arguments in sets. It destructively removes the first element from the set.

.pop in the list collection takes an argument. This is an offset into the list and that element is destructively removed from the lists.

```
mySet = set([1,2,3,4])
set.pop()
> 1
mySet
set([2,3,4])
```

```
myList = [1,2,3,4]
myList.pop(2)
myList
List[1,2,4]
```

frozenset

- You can create a frozenset from a set using `frozenset()`
- A frozenset is immutable
 - Tuple is to list as frozenset is to set

```
s1 = {1, 2, 3, 4, 5}
f1 = frozenset(s1)
type(f1)
> < type 'frozenset' >

print(f1)
> frozenset([1,2,3,4,5])

f1.add(6)
> AttributeError: 'frozenset' object has no attribute 'add'
```



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04-33

[*] Frozenset is to set as tuple is to list

A frozenset is an immutable set.

Chapter Topics

Collections

- Lists
- Tuples
- Sets
- **Dictionaries**
- Essential Points
- Hands-On Exercise: Collections



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Dictionaries

- A dictionary is a set composed of key-value pairs
- Define using set notation – curly braces with pairs separated by commas
- Pairs are defined using a colon – **key: value**
 - Keys and values can be of any basic type

```
modelnumbers = {'F40L':'Sorrento', 'F41L':'Sorrento',
                '2500':'Titanic', '3000':'Titanic', '3A':'iFruit',
                '4':'iFruit'}
type(modelnumbers)
> < type 'dict' >

print modelnumbers['3A']
> 'iFruit'

print modelnumbers['2500']
> 'Titanic'
```



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- [*] A Dictionary is a Set made up of Key-Value pairs.
- [*] You create a Dictionary by defining the elements in the set with the ':' between the Key and Value and each key:value pair is separated by commas.
- [*] Dictionary[key] returns the corresponding value.
- [*] The keys in Python are objects and do not have to be numerical.
- [*] Keys and values can be of ANY type

```
modelnumbers =
{ 'F40L':'Sorrento', 'F41L':'Sorrento', '2500':'Titanic',
  '3000':'Titanic', '3A':'iFruit', '4':'iFruit'}
```

Dictionaries and Lists

- When you explicitly cast a dictionary to any other collection, you get the keys, not the values
- Use the `values()` method to get the values

```
modellist = list(modelnumbers)
print modellist
> ['F41L', 'F40L', '4', '3A', '2500', '3000']

print modelnumbers.values()
> ['Sorrento', 'Sorrento', 'iFruit', 'iFruit',
   'Titanic', 'Titanic']
```



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04-36

[*] Casting a Dictionary to another collection results in the list of keys, not the values.

Instructor value-add

This is probably too detailed for the scope of this course. But the information is listed here in case it is useful.

A Tuple or Frozenset can be a key in a key:value pair, but a list and a set cannot be a key because they are mutable, meaning that the id of the objects could change.

Dictionary Methods

- **`dict[key]`**
 - Returns the value associated with the key
- **`dict[key] = newvalue`**
 - Overwrites the old value with the new value for that key
- **`dict1.update(dict2)`**
 - Adds or updates key-value pairs in `dict1` using contents of `dict2`
- **`len(dict)`**
 - Provides the number of key-value pairs in the dictionary
- **`del dict[key]`**
 - Removes the entry identified by the specified key from the dictionary
- **`dict.pop(key)`**
 - Returns the value and removes the key-value pair from the dictionary

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04-37

[*] You can update the key in a key:value pair.

`dict[key] = newkey`
updates one key

`dict1.update(dict2)`

Uses the elements in `dict2` to update/change the elements in `dict1`

Key:Value pairs are updated or added if necessary

Chapter Topics

Collections

- Lists
- Tuples
- Sets
- Dictionaries
- **Essential Points**
- Hands-On Exercise: Collections



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Part 1: What's your Prediction ?

```
a = [1, 3, 5, 4, 7, 4]
b = ('jan','feb','mar','apr','may')
c = {3, 5, 7, 5, 7, 24, 3, 'big'}
d = {1:'iFruit', 2:'Ronin', 3:'Sorrento', 'T':'Titanic'}
e = [a, b, c, d]
f = (a, b, c, d)

print e
print f

type(e)
type(f)
```

What type of collection will **e** and **f** be ?



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04-39

Let's have a little interactive quiz and see how everyone does.

What will be printed for **e** and for **f** and what type are they?

Note: answers on next slide

e is a list (square brackets), and **f** is a tuple(parenthesis)

Part 1: Results

```
print e
> [[1, 3, 5, 4, 7, 4],
   ('jan', 'feb', 'mar', 'apr', 'may'),
   set([24, 'big', 3, 5, 7]),
   {1: 'iFruit', 2: 'Ronin', 3: 'Sorrento', 'T': 'Titanic'}]

print f
> ([1, 3, 5, 4, 7, 4],
   ('jan', 'feb', 'mar', 'apr', 'may'),
   set([24, 'big', 3, 5, 7]),
   {1: 'iFruit', 2: 'Ronin', 3: 'Sorrento', 'T': 'Titanic'})

type(e)
> <type 'list'>

type(f)
> <type 'tuple'>
```

Part 2: What's your Prediction ?

```
# Old values
#
a = [1, 3, 5, 4, 7, 4]
b = ('jan','feb','mar','apr','may')

# New values
#
a = {5, 4, 3, 2, 1}
b = ('jun','jul','aug','sep','oct')

print e
print f
```

Will the new values or the old values be displayed when **e** and **f** are printed?



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04-41

Now for the tricky part...

Originally, 'b' was 'jan','feb','mar'...

Now we are updating it to 'jun', 'jul', 'aug'.

Q: How will this affect 'e' and 'f'.

Remember, 'e' and 'f' were made from 'b'. Both of them included 'b'. Now that we've changed the definition of 'b' will 'e' and 'f' contain the old months ('jan') or the new months ('jun')?

The student's intuition should lead them to guess that when list 'e' and tuple 'f' were created, that the then current value of 'b' was copied into the new data structures, not imported by reference.

Part 2: Results

```
print e
> [[1, 3, 5, 4, 7, 4],
   ('jan', 'feb', 'mar', 'apr', 'may'),
   set([24, 'big', 3, 5, 7]),
   {1: 'iFruit', 2: 'Ronin', 3: 'Sorrento', 'T': 'Titanic'}]

print f
> ([1, 3, 5, 4, 7, 4],
   ('jan', 'feb', 'mar', 'apr', 'may'),
   set([24, 'big', 3, 5, 7]),
   {1: 'iFruit', 2: 'Ronin', 3: 'Sorrento', 'T': 'Titanic'})
```

The list `e` and the tuple `f` still contain the original versions of `a` and `b`.

Take-away: Collections are constructed by duplication, not by reference.

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The original relationship between 'e' and 'f' and 'b' was not preserved.

[*] Collections are assigned and constructed by copying data elements, not by reference. So the logical association is lost after the assignment has been executed.

Part 3: What's your Prediction ?

```
a = [1, 2, 3, 4, 5]
b = [a, a, a, a, a]
c = [b, b, b, b, b]
d = [c, c, c, c, c]

print d[3][3][3][3]
```

This illustrates how complex collections can be built up.

Part 3: Results

```
a = [1, 2, 3, 4, 5]
b = [a, a, a, a, a]
c = [b, b, b, b, b]
d = [c, c, c, c, c]

print d[3][3][3][3]
> 4
```

Part of the Python philosophy is “complex” without being “complicated”

Take-away: You can create very complex nested objects to organize data.



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[*] Collections can be nested.

Essential Points

- **Collections**

- May consist of elements of different types
 - Can contain other collections as elements (nested)

- **Lists** []

- **Tuples** ()

- **Sets** {}

- **Frozensets** – immutable sets

- **Dictionaries** {key:value}



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Chapter Topics

Collections

- Lists
- Tuples
- Sets
- Dictionaries
- Essential Points
- **Hands-On Exercise: Collections**



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Hands-On Exercises: Collections

■ Part 1

- Process a file line-by-line into a nested list

■ Part 2

- Read an entire file into a list



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Note – they don't know flow control yet, so the more sophisticated exercise comes next.

This exercise is mainly for familiarity with the collections and their methods.

This exercise is just for familiarity with collections and file I/O. Iterators and conditionals (for and if) are needed to address individual elements within a collection. More sophisticated exercises with lists, sets, and tuples are in the next chapter.



Flow Control

Chapter 5



Course Chapters

- Introduction
- Introduction to Python
- Variables
- Collections
- **Flow Control**
- Program Structure
- Working with Libraries
- Conclusion



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Flow control – how control is passed from one section of code to another.

Flow Control

In this chapter you will learn

- How to loop and perform repetitive operations
- How to iterate over individual items in a Collection
- How to make a block of code conditionally execute
- How to identify and handle exceptions

Chapter Topics

Flow Control

■ Code Blocks

- Repetitive Execution
- Iterative Execution
- Conditional Execution
- Tentative Execution (Exception Handling)
- Essential Points
- Hands-On Exercise: Flow Control

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05-4

[*] First – how we create sections of code, called 'code blocks'

[*] Next – how to change flow of control. Python uses keywords that operate on code blocks to change the execution of the code.

Code Blocks

- Code blocks in Python are represented by indentation
 - Not curly braces
 - End of line sequence (EOLS), not semicolon
- Statements in a block must be indented identically
 - If your indentation is off – even by a space – then it is an error

```
a,b = 7, 12
if 1 < 9 :
    print a
else :
    print b:
> 7
```

```
a,b = 7, 12
if 1 < 9 :
    print a
else :
    print b:
> IndentationError: expected an indented block
```



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05-5

[*] Code blocks in Python are indicated by indentation.

[*] No alternatives – such as curly braces

[*] You have to indent a code block by at least one space. You can indent by more than one space. However, once the initial indent is started, all other lines in the block must be indented the same number of spaces. If you indent more, then it is a new code block – and potentially a syntax error.

Code Block Mistakes

- In the example on the right, `else :` is no longer associated with a corresponding `if` because the line `print 'hi'` ended the scope of the `if` statement.
- Below, one space too much is also an error.

```
a,b = 7, 12
if 1 < 9 :
    print a
    print 'hi'
```

```
a,b = 7, 12
if 1 < 9 :
    print a
    print 'hi' ←
else :
    print b

> Error line 5
> else :
>     |
> SyntaxError: invalid syntax
```

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[*] It is easy to create code block error. Just indent for readability or forget a space and you've got a syntax error.

The indentation keeps Python code easily readable, but can be very annoying to those who have not had to be concerned with consistent indentation before.

Chapter Topics

Flow Control

- Code Blocks
- **Repetitive Execution**
- Iterative Execution
- Conditional Execution
- Tentative Execution (Exception Handling)
- Essential Points
- Hands-On Exercise: Flow Control

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05-7

Repetitive execution is also called "looping".

Conditional Looping

- **while test:**
- Identifies a code block to be executed repeatedly while **test** is **True**
- if **test** is never **False**, it is an *infinite loop*
 - If you accidentally enter an infinite loop in the Python shell, break with CTRL-D or CTRL-C

Note: variable used in test must be initialized before use

**while test:
code-block**

When test is False ...continue

Code to execute repeatedly while test is **True**

```
a = 1  
while a < 10:  
    print a  
    a = a + 1  
print("complete")
```



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05-8

[*] While executes a code block repeatedly if test is **True**.

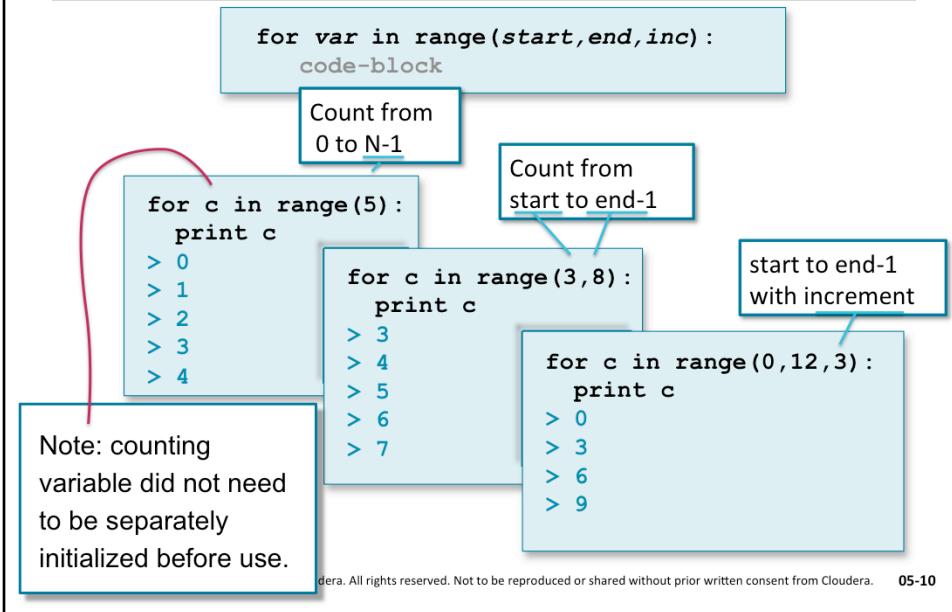
[*] You must modify some variable involved in the test within the code block or it will continue to loop until interrupted by a 'break' or program interrupt sequence. Such behavior is called an *infinite loop*.

Example Code

- This code prints each record of mobile phone data

```
count = 0
while count < len(devlog):
    print count, len(devlog[count])
    print devlog[count]
    count += 1
```

Countable Looping



Countable looping is implemented with a "for" construct, and is handy when you need an integer that increments in a specific pattern. In other languages, countable loops are critical because they are used to index collections. Python provides iterative looping for collections, so countable looping is less significant.

- [*] Upper end of range is not inclusive.
- [*] Bottom end of range IS inclusive.
- [*] Increment is optional. If omitted, '1' is used.

Note:

`for...in...range()` is really a subset of `for....in...collection`. However, we are introducing it first because students can find it confusing to discuss iteration first if they are more familiar with a countable looping language. Presenting the topics in this order ensures that the counting questions are already answered before you discuss iteration.

Note: 'c' in the for loop is initialized automatically by the interpretation of the for statement, which is why it did not need to be initialized in a separate statement.

Modifying Loop Operations

▪ **break**

- Ends a loop

```
for i in range(100):
    if(i > 4):
        break
    print i
> 0
> 1
> 2
> 3
> 4
```

▪ **continue**

- Skips one iteration of a loop

```
for i in range(10):
    if(i==5):
        continue
    print(i)
> 0
> 1
> 2
> 3
> 4
> 6
> 7
> 8
> 9
```



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05-11

[*] **break** unconditionally ends the loop, forcing execution to resume at the code following the looping code block.

[*] **continue** forces execution to resume at the top of the loop, skipping the remainder of the code in the current code block. In the example above, when the looping counter, i, is equal to 5, the print line is skipped.

Chapter Topics

Flow Control

- Code Blocks
- Repetitive Execution
- **Iterative Execution**
- Conditional Execution
- Tentative Execution (Exception Handling)
- Essential Points
- Hands-On Exercise: Flow Control



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Iteration of collections is separate from countable looping in Python.

Iteration

- **for each_element in list:**
 - Execute a block of code for each element in a **list**, **tuple**, **set**, **frozenset**, or **dictionary**
- Returns variable of type of the element

```
for each_element in collection :  
    code-block
```

Code to execute for each element in collection

```
mylist = [1,2,3,4,5,6]  
for each in mylist:  
    print each  
> 1  
> 2  
> 3  
> 4  
> 5  
> 6  
  
type(each)  
> <type 'int'>
```



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05-13

[*] Executes a code block for each individual element in a collection (list, tuple, set, frozenset, or dictionary). The element is returned to the variable (`each_element` in the example in the slide).

Note that because `collection` can consist of many types of elements, the variable type for '`each_element`' could change as each element is fetched.

Key and Value Iteration

- Example of iterating over keys and values simultaneously in a Dictionary

```
modelnumbers = {'F40L':'Sorrento', 'F41L':'Sorrento',
                '2500':'Titanic', '3000':'Titanic', '3A':'iFruit',
                '4':'iFruit'}

for key,value in modelnumbers.items():
    print key,value
> F41L Sorrento
> F40L Sorrento
> 4 iFruit
> 3A iFruit
> 2500 Titanic
> 3000 Titanic
```



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List Comprehension

- Python provides a technique to create a new list from an existing collection by placing an iterator within brackets
 - Each element is processed to create the new list

```
newlist = [code for each_element in collection]
```

```
devicetemp=[30,33,54,34,29,49]
Ftemp = [elem*9/5+32 for elem in devicetemp]
print Ftemp

> [86, 91, 129, 93, 84, 120]
```



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05-15

Iteration with Enumeration

- **for each_element in enumerate(list):**
 - Returns a two-value tuple where the element at index 0 is the enumeration, and the element at position 1 is the item content

```
mylist = ['Ronin', 'MeToo', 'iFruit']
for each in enumerate(mylist):
    print each
> (0, 'Ronin')
> (1, 'MeToo')
> (2, 'iFruit')

type(each)
> <type 'tuple'>

len(each)
> 2
```



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[*] enumerate passes back an enumeration (counting) of the ordinal number of the element in the collection (0, 1, 2, ...) paired with the element itself. The variable returned is a two-element tuple with the number in the zero position followed by the element itself in the one position.

Corresponding Iteration with Zip

- **for each_element in zip(list1,list2):**
 - Returns a two-value tuple where the 0 element comes from the first list, and the 1 element is the corresponding element from the second list

```
mylist1 =['Ronin','MeToo','iFruit','Sorrento']
mylist2 =[ 's1','4.0','3A','F41L']
for each in zip(mylist1, mylist2):
    print each
> ('Ronin','s1')
> ('MeToo','4.0')
> ('iFruit','3A')
> ('Sorrento','F41L')

type(each)
> <type 'tuple'>

len(each)
> 2
```



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05-17

[*] zip ordinal matches and pairs corresponding elements in two collections. The first element in list1 is paired with the first element in list2, and a two-element tuple is returned with the pair.

Many students may think of file compression when they hear “zip” in a computer class. We recommend explaining that this method is unrelated to compression, but instead the name should convey that it works like a zipper (items from the two independent sides come together piece by piece).

Multiple List Iteration with `zip()` and List Comprehension

```
x = ['x1', 'x2', 'x3']
y = ['y1', 'y2']
for a,b in zip(x,y):
    print a,b
> x1 y2
> x2 y2
```

```
x = ['x1', 'x2', 'x3']
y = ['y1', 'y2']
for a,b in[(a,b) for a in x for b in y]:
    print a,b
> x1 y1
> x1 y2
> x2 y1
> x2 y2
> x3 y1
> x3 y2
```

Multiple list iteration
without the need for
explicit nested for
loops or counters



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05-18

Note: The :for comprehension" isn't just a "for statement" as exist in other languages. This isn't just an alternative syntax to create nested for loops. There is no need to define a counting variable (as would appear in the for construct in other languages) just to serially access items in a group. And Python knows that the for comprehensions are defined together, so it has the discretion to implement the generation. For example, it can construct a single loop with multiple pointers to address contents in x and in y, looping for x*y. It is not forced to implement two concentric loops.

Note: map() example below can be used in context with zip() to illustrate the flexibility of the :for comprehension. map() is covered elsewhere in the course in more detail.

```
x = ['x1', 'x2', 'x3']
y = ['y1', 'y2']
for a,b in map(None,x,y):
    print a,b
> x1 y1
> x2 y2
> x3 None
```

Chapter Topics

Flow Control

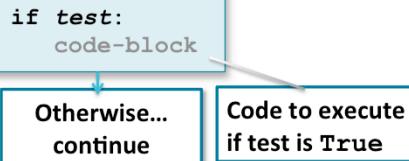
- Code Blocks
- Repetitive Execution
- Iterative Execution
- **Conditional Execution**
- Tentative Execution (Exception Handling)
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Conditional Testing with **If**

- **if test:**
- **Make a block of code conditional**
 - If False, continue on next line of code following the block
- **test**
 - Boolean
 - **True or False**
 - Comparator
 - Operators discussed in chapter on variables
 - **==, !=, <, >**
 - **<=, >=**
 - **is, is not**
 - Ends with a colon



```
# Device not to exceed 120 F
#   120 F = 48.889 C
#
devicetemp=[30,33,54,34,29,49]
maxtemp = 48.8889

for eachtemp in devicetemp:
    if eachtemp > maxtemp:
        print eachtemp
> 54
> 49
```

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05-20

[*] Use If (test): to cause code to be executed only if 'test' is **true**.

[*] test is any of the operators or comparators resulting in a boolean.

Alternative Conditions with **Else**

- Adds an alternate block of code to execute if test is False
- **else:** identifies alternate block of code
 - **else:** keyword is aligned with **if**
 - requires indented block beneath
- Either code block 1 or 2 will be executed, then processing will continue

```
if test:  
    code-block-1  
else:  
    code-block-2
```

Code to execute if test is **True**

Code to execute if test is **False**

```
device = "Titanic 2000"  
if device[8:13] == "2000":  
    print "Model recognized"  
else :  
    print "Model unknown"  
> Model recognized
```



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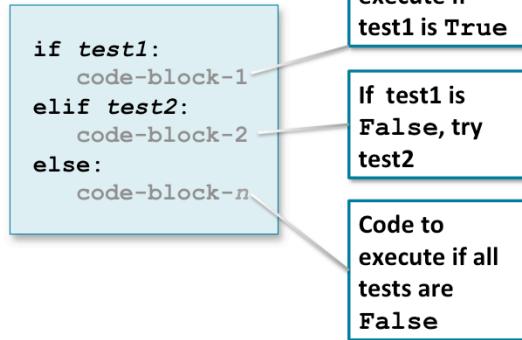
05-21

[*] Else

Adds a code block to be executed when test is false.

Elif

- Creates alternate tests
- elif test2:** identifies an alternate test to perform if **test1** is False
 - If **True** executes following code block



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05-22

[*] Elif adds an additional test and code block to be executed if this alternative test is **true**.

[*] Python evaluates test1. If it is **true**, then its associated code block is executed. If not, then test2 is evaluated. If test 2 is **true**, then its associated code block is executed. This continues through test N. If none of the tests was **true**, then Python executes the code block identified by "Else".

Stacking Elif's

- Python does not have a switch() case construct
- Use multiple elif's
 - Else...If...
- If test1 is False, try test2, if test2 is False, try test3, if test3 is False try test4...
.. <else:>.. if all the previous tests were False... then *do this*

```
if test1:  
    code-block-1  
elif test2:  
    code-block-2  
elif test3:  
    code-block-3  
elif test4:  
    code-block-4  
elif test5:  
    code-block-5  
elif test6:  
    code-block-6  
elif test7:  
    code-block-7  
else:  
    code-block-n
```

Code to execute if test1 is True

Code to execute if all tests are False



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05-23

[*] You can stack up "Elif's" to simulate a "switch() and case:" statement which is a common construct in many languages, but not available in Python.

Example of `Elifs`

- Titanic phones are advertised by brand name rather than model number
- Advertising names are based on types of sailing ships
- Example shows use of `if...elif` to recognize model number and print corresponding market name

```
# Get make and model from keyboard
device = raw_input('Make Model :')

# Recognize model number
if device[8:13] == "1000":
    mod = 'Clipper'
elif device[8:13]== "1100":
    mod = 'Schooner'
elif device[8:13]== "2000":
    mod = 'Sloop'
elif device[8:13]== "2100":
    mod = 'Caravel'
elif device[8:13]== "2200":
    mod = 'Cutter'
else :
    mod = device[8:13]
# Prepare output string
mod = device[0:8]+mod
print mod
```



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05-24

Single-line If

- Python supports a single-line conditional statement
 - also called an “*inline function*”

```
return-true if(test) else return-false
```

Python does not support the ternary operator (the conditional operator) that is common in many other languages

```
a = 5  
'low' if a <= 5 else 'high'  
> 'low'
```

Example of a Ternary Operator

```
# test ? return-true : return-false  
a = 5  
a <= 5 ? 'low' : 'high'  
> Syntax Error
```

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05-25

Instructor value add:

Python does not support unconditional branching, such as GOTO or JUMP to Label, that would continue execution at a labeled location in code.

Chapter Topics

Flow Control

- Code Blocks
- Repetitive Execution
- Iterative Execution
- Conditional Execution
- **Tentative Execution (Exception Handling)**
- Essential Points
- Hands-On Exercise: Flow Control

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05-26

Tentative execution is also called error handling or exception handling.

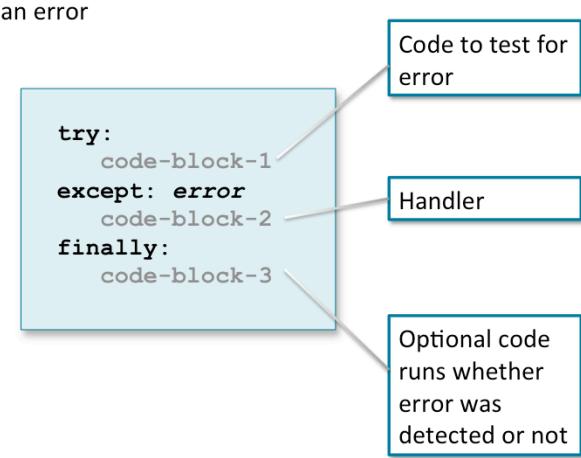
Tentative Execution

■ Exception Handling

- The opportunity to execute code in the event of an error rather than quitting

■ Errors

- **NameError**
- **ValueError**
- **IndexError**
- **SyntaxError**



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[*] When an error is detected by Python, the default behavior is to halt execution and terminate the program. Instead, you can provide a code block to be executed if the error occurs.

This can be handy if you expect an error to occur.

[*] Use **try** to identify the code block for which an exception handler is to be defined. Then use **except** to define the type of error that causes the associated code block to be executed. A code block tagged with **finally** will run following the try: code block whether or not an error was detected.

Error Handling

```
mylist =['Ronin','MeToo','iFruit','Sorrento']
print len(mylist)
toofar = len(mylist)+1 ← Index out of bounds
index = 0
for index in range(0,toofar):
    print mylist[index]

> Ronin
> MeToo
> iFruit
> Sorrento
> IndexError : List out of range
```

How can we *trap* the IndexError so that the program doesn't quit?

Error Handling

```
mylist =['Ronin','MeToo','iFruit','Sorrento']
print len(mylist)
toofar = len(mylist)+1
index = 0
try:
    for index in range(0,toofar):
        print mylist[index]
except IndexError:
    print ">> tragedy averted"
finally:
    print ">> continuing"

> Ronin
> MeToo
> iFruit
> Sorrento
> >> tragedy averted
> >> continuing
```

Code block must
be indented



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Chapter Topics

Flow Control

- Code Blocks
- Repetitive Execution
- Iterative Execution
- Conditional Execution
- Tentative Execution (Exception Handling)
- **Essential Points**
- Hands-On Exercise: Flow Control



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Essential Points

- **Code blocks**
 - Code flow in Python is dependent on indented code blocks
- **Conditional (True/False) execution using if, elif, and else**
 - Stack **elif**'s to simulate **switch() ...case:**
- **while is used in conditional (True/False) looping**
- **for is used for repetition**
 - **for in range()**
 - **for element in collection**
 - **for element in enumerate(collection)**
 - **for element in zip(collection1, collection2)**
- **try is used for exception handing**



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Chapter Topics

Flow Control

- Code Blocks
- Repetitive Execution
- Iterative Execution
- Conditional Execution
- Tentative Execution (Exception Handling)
- Essential Points
- **Hands-On Exercise: Flow Control**

Hands-On Exercise: Flow Control

■ Part 1

- Prepare a brand index and a model index using sets

■ Part 2

- Prepare an information base from data read from the Loudacre log file



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05-33

Part 1

Prepare a brand index and a model index using sets

Part 2

Prepare an information base from data read from the loudacre log file

Use `split()`, `sorted()`, and arithmetic, casting, and conditional flow to prepare and process the data

Cast the final information base to a tuple



Program Structure

Chapter 6



Course Chapters

- Introduction
- Introduction to Python
- Variables
- Collections
- Flow Control
- **Program Structure**
- Working with Libraries
- Conclusion



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Program Structure

In this chapter you will learn

- How to create and work with named functions including a basic understanding of function context and scoping
- How to create and work with anonymous functions (also known as Lambda functions)
 - Note: Lambda functions are used extensively to interface with Big Data services and software
- How to pass one function to another function by reference
- The purpose and general use of Python generators

Chapter Topics

Program Structure

▪ Named Functions

- Anonymous Functions (Lambda)
- Generator Functions
- Essential Points
- Hands-On Exercise: Program Structure



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Named Functions

- Defines a function and associates it with a name

- **return** must be indented so it is 'within' the function
- **return** is optional

```
def name(parameters):  
    code-block  
    return variable
```

Function gets a local copy of the passed parameters

```
return(1, 2, "data")
```

Optional return variable

Q: Will this work?
If so, what type of variable will it return?

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06-5

[01] You create a function in Python using the keyword **def**. Parameters are passed to the function by copying, so if you modify the value of a parameter, only the local copy is altered, not the source in the calling code.

[02] The function is delimited by the indented code block. You do not need a **return**, and it does not terminate the function.

[03] A single optional variable can be returned.

Note: *if not specified, functions return <type 'NoneType'>*

[04] Will it work? Yes. That is correct syntax, even without a space between 'return' and the variable. But how does this work if only a single variable is returned?

The answer is that the parenthesis define a tuple. So the syntax shown will return a Tuple with elements 1,2, and "data".

So although Python only returns one variable, that can be a collection, so you can pass back multiple results.

Note:

Most languages treat return values as a stack and pass back a single value.

Students familiar with other languages might expect to pass back a memory address (pointer) to a base location in memory (a structure) containing multiple variables.

Example of Named Functions

```
# Define function to return month from date time stamp
#
def getmonth(dts):
    months={1:'JAN',2:'FEB',3:'MAR',4:'APR',5:'MAY',
            6:'JUN',7:'JUL',8:'AUG',9:'SEP',10:'OCT',
            11:'NOV',12:'DEC'}
    month = dts[5:7]
    nummonth = int(month)
    return months[nummonth]

dts="2014-03-15:10:10:20"
print getmonth(dts)
```

> MAR

Continuation marks used for formatting of slide.
The marked lines can be entered as a single line of code or use continuation marks for readability.



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Variable Scope

- Variables may be defined within the function (i.e., local scope)
- Local variables defined in the code that calls a function are not visible to the function that is being called
- Parameters are passed into functions by copying, not by reference
- Modifying the value of a parameter only modifies the local copy
- When a function returns, the local variables defined within the function are lost
- It is possible to define global variables by prefixing their definition with the **global** keyword, but this should be avoided whenever possible



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06-7

[05] All variables within the function are local and do not change anything outside of the function.

[06] The variables defined within the function are called the 'function context'. A new function context is created every time a function is called. By default, this 'function context' is queued for recycling when a function completes execution.

[07] You can override the default behavior of an individual variable using the **global** keyword. This will cause Python to use the variable from the calling context. And changes to the value of that variable will survive the end of the function execution and the recycling of the function context. The use of **global** is generally regarded as poor coding practice among Python developers.

Note:

The following two slides are a code walk-through showing execution of code and the resulting scoping behavior. We have included this code walk-through because scoping can be confusing to students who have not encountered it before.

Scope

▪ Definitions

- **a** is a passed parameter
- **b** is a global variable
- **c** is a local variable

▪ Changes

- In the call to **fun1()** all three variables are incremented

▪ Results

- What will happen in the main program after the call to **fun1()**
- *What will the result of the print statements be?*

```
# -- function definition
def fun1(a):
    global b
    c = 1
    # -- change of values
    a += 1    # passed parameter
    b += 1    # global variable
    c += 1    # local variable
    return a

# -- main
a = 7
b = 3
d = fun1(a)

print a  # What will this do?
print b  # What will this do?
print c  # What will this do?
```

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06-8

Answer to “a”

```
# -- function definition
def fun1(a):
    global b
    c = 1
    # -- change of values
    a += 1    # passed parameter
    b += 1    # global variable
    c += 1    # local variable

# -- main
a = 7
b = 3
fun1(a)

print a
print b
print c
```

- a is 7
- When a is passed into fun1 (), fun1 gets a local copy of a
- Local-a has the same value as the a in main, 7
- Local-a is incremented to 8
- When fun1 () ends, and control returns to main, local-a is deleted
- The print a statement prints the value of global-a, 7, and not local-a, which no longer exists



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Answer to “b”

```
# -- function definition
def fun1(a):
    global b
    c = 1
    # -- change of values
    a += 1    # passed parameter
    b += 1    # global variable
    c += 1    # local variable

# -- main
a = 7
b = 3
fun1(a)

print a
print b
print c
```

- b is 3
- The statement `global b` in `fun1()` makes global-b accessible from within the function
- When b is incremented in `fun1()`, it is global-b
- The `print b` statement prints the value of global-b which is now 4



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Answer to “c”

```
# -- function definition
def fun1(a):
    global b
    c = 1
    # -- change of values
    a += 1    # passed parameter
    b += 1    # global variable
    c += 1    # local variable

# -- main
a = 7
b = 3
fun1(a)

print a
print b
print c
```

- c does not exist in main
- In fun1 (), a local variable c is created and given a value of 1
- Local-c is incremented to 2
- When fun1 () ends, and control returns to main, local-c is deleted
- The print c statement causes an <Error>, because in the global context c never existed



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Single-Line Notation Functions

```
def name(parameters): return code-line
```

- Occurs on a single line
- **return** keyword precedes single line of code

No code-block here

```
def CtoF(tempC): return (tempC*9/5) + 32  
print CtoF(25)
```

```
> 77
```



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06-12

[08] The single line notation for a function places the main code inside the domain of the **return** keyword (instead of preceding it).

These two definitions result in identical functions:

```
def myfun1 (ab):  
    temp = ab** .5  
    return temp
```

```
def myfun1 (ab) : return ab** .5
```

Pass by Reference

- When a function name appears in parentheses, meaning it is passed as a parameter, Python executes it
- When a function name appears without parentheses, Python treats it as an object and passes it by reference (*called first class functions*)

Parentheses:
execute

```
def square(number):
    return number*number

def halve(number):
    return number/2

def doit(somefunction,input):
    return somefunction(input)

doit(halve,7)
> 3
doit(square,7)
> 49
```

No parentheses,
pass by
reference

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06-13

Note: In version 2.6.6 I will return '3', but in version 2.7.x it will return 3.5

Chapter Topics

Program Structure

- Named Functions
- **Anonymous Functions (Lambda)**
- Generator Functions
- Essential Points
- Hands-On Exercise: Program Structure



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06-14

Note:

Lambda functions, that are covered next, are critical to our Spark Developer class. In Spark you create lambda functions and assign them to the spark context (sc), which is how the functions are exported to be executed on the servers in the cluster.



Anonymous Functions

```
lambda parameters: code-line
```

- Enables a function to be defined inline without a symbolic name
 - Defined within the call to another function
 - Useful for one-time functions where reuse is not an objective
 - Limited to a single line – tiny functions
 - Code must implicitly return a value

filter()

- Iterates over each element in the collection and returns only those elements that match the criteria determined by the function
 - The code below simulates **filter**'s basic operation
 - An example using **filter** is on the next slide

```
filter(test_function, collection)
```

```
def myfilter(function, collection):  
    newlist=[]  
    for each in collection[1:]:  
        if function(each):  
            newlist.append(each)  
    return newlist
```



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06-16

Example `filter()`

- Anonymous function in call to `filter()`

```
# -- display only names fewer than 6 characters
#
devices = ['iFruit', 'Sorrento', 'Titanic', 'Ronin', 'MeToo']

filtered_devices = filter(lambda x: len(x)<6, devices)
print filtered_devices

> ['Ronin', 'MeToo']
```



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map()

- Iterates over each element in the collection and returns 1-for-1 elements that are transformed by the function

- The code below simulates map's basic operation
- An example using map is on the next slide

```
map(transform_function, collection)
```

```
def mymap(function, collection):  
    newlist=[]  
    for each in collection[1:]:  
        newlist.append(function(each))  
    return newlist
```



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06-18

Example `map()`

- Anonymous function in call to `map()`

```
# -- CPU utilization for devices was read as strings
#   Convert to numeric, and turn them into percentages
#
cpu_util= ['32','46','18','76','23','49','91','87']

cpu_percent = map(lambda c: float(c)/100.0, cpu_util)
print cpu_percent

> [0.32, 0.46, 0.18, 0.76, 0.23, 0.49, 0.91, 0.87]
```



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Note: The above output is from Python 2.6.6 loaded on our VM.

The above output in Python 2.7 would look like this:

> [0.32, 0.46, 0.18, 0.76, 0.23, 0.49, 0.91, 0.87]

Second Example of `map()`

- You can pass `map()` multiple collections of the same size

```
# -- Find the absolute difference between ambient
#     temperature and device temperature
#
ambient = [21,26,54,87,69,77,61,47,81,49,37]
device  = [86,97,53,98,31,61,71,70,92,98,58]

variation = map(lambda x,y: abs(x-y), ambient,device)
print variation

> [65, 71, 1, 11, 38, 16, 10, 23, 11, 49, 21]
```



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reduce()

- Iterates over a sequence of elements in the collection and performs a function on the sequence

- The code below simulates **reduce**'s basic operation
- An example using **reduce** is on the next slide

```
reduce(reduce_function, collection)
```

```
def myreduce(function, collection):  
    tally = collection[0]  
    for next in collection[1:]:  
        tally = function(tally, next)  
    return tally
```

Example `reduce()`

▪ Anonymous function in call to `reduce()`

```
# -- restarts is a dictionary the contains number of
#   reported device restarts by brand name
#   This code uses reduce() to calculate the total
#   number of restarts on all devices
#
restarts = {'MeToo':7,'Ronin':7,'Sorrento':15,      \
'Titanic':11, 'iFruit':7}
total = reduce(lambda x,y: x+y, restarts.values())
print total
> 47
```



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Chapter Topics

Program Structure

- Named Functions
- Anonymous Functions (Lambda)
- **Generator Functions**
- Essential Points
- Hands-On Exercise: Program Structure



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Problem #1



- Loudacre marketing wants to send an advertising text message to every telephone in the 555 area code.
- First challenge is to write a program to generate all the phone numbers
 - 555-eee-ssss = 3 + 1 + 3 + 1 + 4 = Each phone is a 12 character string
 - Skip zeroes in the exchange field
 - $aaa-123-4567 = 10,000,000 =$ about 10 million numbers
 - $12 \times 10m = 120$ MB of data

Messages

872-0117
Cut your monthly payment in half with
Loudacre mobile service!

phonegen()

- Generates the phone numbers in the 555 area code in sequence skipping leading zeroes in the exchange digits
- Returns a list of the numbers generated
- This code takes about 30 seconds to run on the target platform

```
def phonegen():  
    d1=d2=d3=d4=d5=d6=d7 = 0  
    phonelist = []  
    for d1 in range(1,10):  
        for d2 in range(1,10):  
            for d3 in range(1,10):  
                for d4 in range(0,10):  
                    for d5 in range(0,10):  
                        for d6 in range(0,10):  
                            for d7 in range(0,10):  
                                phone = '555'+'-'+str(d1)+ \  
str(d2)+str(d3)  
                                phone = phone+'-'+str(d4)+ \  
str(d5)+str(d6)+str(d7)  
                                phonelist.append(phone)  
    return phonelist  
  
# -- test program  
list_of_phones = phonegen()  
for each_phone in list_of_phones:  
    # send_message(each_phone)  
    print each_phone
```

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06-25

Problem #2

- The advertising program was a success! Marketing wants to expand to cover 250 area codes in the United States.
- Concerns
 - 250 area codes x 120 MB each = 30 GB of data
 - *My computer only has 16 GB of RAM!*
 - The previous program took about 30 seconds to generate the list
 - *The new program will take about two hours to generate the list!*
- What's needed is a way to iterate over each phone number in sequence
- But how do you iterate with a function?
 - Local variables are lost when the function returns
 - How would you preserve the current state so you could continue at the next number in sequence each time you call `phonegen()`?



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Generators

- A Python generator is an iterable function
 - Also known as a *cofunction* in computer science
- **yield**
 - Preserves the functional context (local variables and state)
 - Returns control to the caller
 - Passes an iterator object back



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`next(functional_context)`

Resumes processing the function at the point where it was suspended

Note:

Note that the `yield` in Python works differently than in Scala. In Python, “`yield`” returns a generator (similar to Scala’s iterator). In Scala, it returns a materialized collection (which could be used to create an iterator, as covered in the JES class.)

Area Codes for `phonegen()`

- Yield will pass back functional context. So a new way to pass the phone number back to the calling code is needed

```
#-- Global phone number
phonenum = "-"

# --- Generate all phone numbers in the target area codes
def phonegen():
    target_area_codes = [555, 205, 251, 256, 334, 907, 480, 520, \\
623, 928, 501, 870, 209, 213, 310, 323, 408, 415, 510, 530, 559, \\
562, 619, 626, 650, 661, 707, 714, 760, 805, 818, 831, 858, 909, \\
916, 925, 949, 303, 719, 720, 970, 203, 860, 302, 305, 321, 352, \\
386, 407, 561, 727, 754, 772, ... , ... , 704, \\
828, 910, 919, 980, 701, 216, 234, 330, 419, 440, 513, 614, 740, \\
717, 724, 814, 878, 401, 803, 843, 864, 210, 214, 254, 281, 361, \\
409, 469, 512, 682, 713, 806, 817, 830, 832, 903, 915, 936, 940, \\
956, 972, 979, 435, 801, 802, 276, 434, 540, 571, 703, 757, 804, \\
206, 253, 360, 425, 509, 715, 920, 307]
```

phonegen()

- Python Generator expression
- Returns an iterator

```
def phonegen():
    global phonenum
    d1=d2=d3=d4=d5=d6=d7 = 0
    for d1 in range(1,10):
        for d2 in range(1,10):
            for d3 in range(1,10):
                for d4 in range(0,10):
                    for d5 in range(0,10):
                        for d6 in range(0,10):
                            for d7 in range(0,10):
                                phone = '555'+'-'+str(d1)+ \
                                        str(d2)+str(d3)
                                phone = phone+'-'+str(d4)+ \
                                        str(d5)+str(d6)+str(d7)
                                phonenum = phone
                                yield phonenum

    it = 0
    for phonenum in phonegen():
        if it > 50:
            break
        print phonenum
        it += 1
```



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06-29

Python Generator passes back the function as an iterator.

Note: This covers the common use of a Python Generator and is considered 'Pythonic' code.

Chapter Topics

Program Structure

- Named Functions
- Anonymous Functions (Lambda)
- Generator Functions
- **Essential Points**
- Hands-On Exercise: Program Structure



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Essential Points

- **Named functions**
 - Call by reference
- **Variable scoping and the function context**
 - Global
- **Anonymous (lambda) functions**
 - Commonly used in: `filter()`, `map()`, `reduce()`
- **Generator functions**
 - `yield`



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Chapter Topics

Program Structure

- Named Functions
 - Anonymous Functions (Lambda)
 - Generator Functions
 - Essential Points
- **Hands-On Exercise: Program Structure**



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Hands-On Exercise: Program Structure

■ Named Functions

- Write a function that controls how `filter()` works
- Pass by reference to a named function

■ Anonymous Functions

- Convert `filter()` program to use anonymous function

■ Generator Functions

- Write a number series generator using a standard function



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Named Functions

Write a function that controls how `filter()` works

Pass by Reference to a named function

Anonymous Functions

Convert `filter()` program to use anonymous function

Use Python `map()` to prepare temperature data (`string` to `float`, degrees Celsius to degrees Fahrenheit)

Use Python `reduce()` to find the hottest device

Generator Functions

Write a number series generator using a standard function

Convert the series generator for scalability using `yield` and `next()`



Working with Libraries

Chapter 7



Course Chapters

- Introduction
- Introduction to Python
- Variables
- Collections
- Flow Control
- Program Structure
- Working with Libraries**
- Conclusion



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Working with Libraries

In this chapter you will learn

- How to organize code into separate modules
- How to gain and control access to modular code
- What is offered in common standard libraries



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Chapter Topics

Working with Libraries

▪ Storing and Retrieving Functions

- Module Control
- Common Standard Libraries
- Essential Points
- Hands-On Exercise: Libraries



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Python Modules

- Also called a “library”
- The program that is loaded into Python from the command line is the main program
 - `$ python program.py`
- Load code from other *.py files into the main program
 - `import libraryname`
 - Searches the path for `libraryname.py`
 - Loads the library as an object, and all functions as methods
 - To access `fun1()` in `libraryname`, use
`libraryname.fun1()`
 - `from libraryname import fun1, fun2, fun3`
 - Loads the functions directly into the main program
 - To access `fun1()`, use `fun1()`



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Example Library

File: library.py

```
def loadfile(filename):
    lines=[ ]

    file = open(filename,'rt')
    lines = file.readlines();
    file.close()
    return lines

def userinput(prompt):
    keybuffer = raw_input(prompt)
    return keybuffer
```



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07-6

Examples of Accessing the Library

- The `import` syntax loads the functions as methods of the library object
- The `from` syntax loads the functions directly into the main program symbol table

```
import library

mylist = library.loadfile('loudacre.log')
print mylist
print "\n\n"

myline = library.userinput('Greetings: ')
print myline
```

```
from library import loadfile, userinput

mylist = loadfile('loudacre.log')
print mylist
print "\n\n"

myline = userinput('Greetings: ')
print myline
```



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The "import" syntax is considered easier to debug and maintain, but it loads everything. If you only need a few functions and don't want to load a large library of code that won't be run, use the "from" syntax.

Note:

```
from library import *
```

This works but is considered bad practice.

Chapter Topics

Working with Libraries

- Storing and Retrieving Functions
- **Module Control**
- Common Standard Libraries
- Essential Points
- Hands-On Exercise: Libraries



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How Does Python Find Libraries?

- **At Python startup**

- Current directory where the program is located
- **PYTHONPATH**
 - OS-dependent path
 - A list of directory names with the same syntax as **PATH** in the OS
 - Path to default libraries such as **prefix/lib/pythonversion**

- **After program is running**

- The path is available and can be changed by a running program
- It is located in **sys.path**
- Add to path with **sys.path.append(newpath)**

Example of Adding to the Path

▪ Adding a user-defined directory of libraries

```
import sys
print sys.path

> [
    '/Library/Frameworks/Python.framework/Versions/2.7/bin',
    '/Library/Python/2.7/site-packages/bigquery-2.0.17-py2.7.egg',
    '/Library/Python/2.7/site-packages/httplib2-0.8-py2.7.egg',
    '/Library/Python/2.7/site-packages/oauth2client-1.2-py2.7.egg',
    ...and so forth ...

sys.path.append('/home/user/python-libs')
```



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Site-Specific Paths

- Provides a single location for maintenance of site-specific paths
- On import, `site` extends `sys.path` with `sys.prefix` and `sys.exec_prefix`
 - The exact files/paths are OS-dependent
 - Example Unix: `lib/python$version/site-packages` and `lib/site-python`
 - You can globally set/change site-specific paths

```
import sys
print sys.path
print sys.prefix
print sys.exec_prefix

import site
print site.PREFIXES
print site.USER_BASE
print site.USER_SITE
```

Where Do Libraries Come From?

- **Standard (ships with Python)**

- Not loaded by default, must be imported
 - Examples: `sys, math, re`

- **Separately installed**

- `*.egg` files
 - A Python “egg” (`*.egg`) is a distribution of a Python project that may contain code, metadata, and resources
 - Separately installed using `pip` or `easy_install`

```
/Library/Python/2.7/site-packages  
  
bigquery-2.0.17-py2.7.egg  
oauth2client-1.2-py2.7.egg  
pip-1.5.2-py2.7.egg  
google_api_python_client-1.2-py2.7.egg  
python_gflags-2.0-py2.7.egg
```



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`sys` is operating system

`math` is advanced math

`re` is RegEx – regular expressions

`*.egg` files are used to distribute program, similar to `.jar` files in Java

For example, a developer might create `*.egg` files to distribute programs to a cluster of machines.

Creating `*.egg` files is beyond the scope of this course.

What's in a Library?

```
▪ import libraryname  
▪ dir(libraryname)
```

```
import math  
dir(math)  
> ['__doc__', '__file__', '__name__', '__package__',  
'acos', 'acosh', 'asin', 'asinh', 'atan', 'atan2',  
'atanh', 'ceil', 'copysign', 'cos', 'cosh', 'degrees',  
'e', 'erf', 'erfc', 'exp', 'expm1', 'fabs', 'factorial',  
'floor', 'fmod', 'frexp', 'fsum', 'gamma', 'hypot',  
'isinf', 'isnan', 'ldexp', 'lgamma', 'log', 'log10',  
'log1p', 'modf', 'pi', 'pow', 'radians', 'sin', 'sinh',  
'sqrt', 'tan', 'tanh', 'trunc']
```



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Special Strings

- **`__doc__`** Contains a documentation string
- **`__name__`**
 - Contains a string with the context in which the code is running, name of the library if imported, or `__main__`
- **`__file__`** Contains the path from which the library originated

```
print math.__doc__
> 'This module is always available. It provides access
to the\nmathematical functions defined by the C
standard.'
print math.__name__
> 'math'
print math.__file__
> '/Library/Frameworks/Python.framework/Versions/2.7/lib/
python2.7/lib-dynload/math.so'
```



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Example of `__name__`

- A program can test `__name__` to determine if it is running after import in a main program or if it is running standalone

- One use is to test code that only runs if the library is executed standalone

```
if __name__ == '__main__':
    # only prints if in main program
    print "running library test"

def loadfile(filename):
    lines=[ ]

    file = open(filename,'rt')
    lines = file.readlines();
    file.close()
    return lines
```

```
$ python library.py
> running library test
```



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`__name__` can be used to determine whether code is being executed as a separate program or if it has been imported (as a library) into another program.

Sometimes programs are written to be used both as independent 'standalone' programs and also to be imported as libraries. One common method is to use a condition as shown in this example around library code. When the code is run standalone, it executes a test program that verifies that the library is working properly and drives its critical functions with sample or testing values. When the code is imported, the condition bypasses the test.

Passing Command Line Arguments

- **Arguments are passed from the command line using the sys module**

- **sys** is a built-in; not enabled by default, you have to import it
 - **import sys**

- **Arguments on the command line are passed as space-delimited string**

```
$ python args.py 1 2 3  
→ sys.argv[0]='1', sys.argv[1]='2', sys.argv[2]='3'  
  
$ python args.py 1,2,3  
→ sys.argv[0] = '1,2,3'
```

```
import sys  
  
arguments = len(sys.argv)  
for i in range(0,arguments):  
    print "argv[",i,"] ", sys.argv[i]
```



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Chapter Topics

Working with Libraries

- Storing and Retrieving Functions
- Module Control
- **Common Standard Libraries**
- Essential Points
- Hands-On Exercise: Libraries



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Built-in `sys`

- **import sys**
 - Imports system environment object
 - **help(sys)** → details on available values and methods
 - **sys.version**
 - Gives the version of Python
 - '2.7.6 (v2.7.6:3a1db0d2747e, Nov 10
2013, 00:42:54) \n[GCC 4.2.1 (Apple Inc.
build 5666) (dot 3)]'
 - **sys.executable**
 - Gives the path to the Python executable
 - **sys.getrefcount(var)**
 - Gives the refcount of a variable



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Built-in `math`

- `import math`
 - Imports the math module
- `math.ceil()`
 - rounds up to a whole number, returns a `float`
- `math.floor()`
 - rounds down to whole number, returns a `float`
- `math.sqrt()`
 - square root
- `math.pi()`
 - constant
- `math.e()`
 - constant

More information:

<https://docs.python.org/2/library/math.html>



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This is a very high level overview of some functions and constants.

Note:

This is to serve as general awareness concerning math... 'more to learn here'. Refer interested students to the link at the bottom of the page.

Demonstration:

```
sqrt(16)      → Error
math.sqrt(16) → Error
import math
math.sqrt(16) → 4.0
```

Built-in `re`

- `import re`
 - Imports regular expression module for sophisticated pattern matching
 - `re.compile(pattern)`
 - Creates the `pattern` object
 - Loads and parses the regular expression search string
 - `pattern.match(content)`
 - creates the `Match` object
 - Executes the regular expression code and stores the results
 - You can then call methods on the pattern object to investigate
 - `pattern.start(), pattern.end()`
 - `pattern.group(), pattern.span()`

Overview of Regular Expressions

- **RegEx re-defines elements within the pattern string that already have a different meaning to Python outside of the search string**
 - [] = delimits a group of characters, any of which are a match
 - [0-9] = matches characters between zero and nine
 - [^0-9] = matches any characters *except* zero through nine
 - [0-9]* = matches number of times (zero or more repetitions)
 - . = matches any character *except* a newline
 - \w = matches any whitespace character
- **Python wrinkle... if you wanted to match '['**
 - you'd have to escape it like this in the search string: \[
 - but... Python will process the escape sequence in the string...
 - so... you'd need to escape the escape and the bracket: \\\[
 - or... use Python raw: r"\["
 - or... triple quotes: """match[this] string exactly"""



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In Python, because strings have to be escaped with a backslash, and the same trick is used within Regular Expression strings, the result can be cumbersome multi-escape sequences. You can bypass Python's escape sequence processing using the `r"..."` (raw) modifier immediately before a string.

RegEx Example

```
import re

regobj = re.compile("[a-z]*")
print(type(regobj))
mat = regobj.match("abcdefghijklm")

print(mat)
print(type(mat))
print
print(mat.start(), mat.end(), mat.group(), mat.span())

> <type '_sre.SRE_Pattern'>
> <_sre.SRE_Match object at 0x1006ae030>
> <type '_sre.SRE_Match'>

> (0, 11, 'abcdefghijklm', (0, 11))
```



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Chapter Topics

Working with Libraries

- Storing and Retrieving Functions
- Module Control
- Common Standard Libraries
- Essential Points**
- Hands-On Exercise: Libraries

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Essential Points

- **Creating and Using Libraries**
 - Method-calling semantics
 - `import library`
 - Function-calling semantics
 - `from library import functions`
- **Control**
 - Paths
 - Special strings
 - Pip and `*.egg`
- **Standard Libraries**
 - `sys, math, site, re`



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Note: library 're' is Regular Expressions

Chapter Topics

Working with Libraries

- Storing and Retrieving Functions
 - Module Control
 - Common Standard Libraries
 - Essential Points
- **Hands-On Exercise: Libraries**

Hands-On Exercise: Libraries

- **Demonstrate basic skills with Python Modules**

- Create a library file and call it from a main program
- Move the library to a different location
- Use a common standard library to interface with the OS
- Use the RegEx library to perform a sophisticated search



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Demonstrate basic skills with Python Modules

Create a library file and call it from a main program

`import` semantics
`from` semantics

Move the library to a different location

Update the Python search path so the library can be found

Use a common standard library to interface with the OS

Identify the number of arguments passed to the command line
Read and display each argument

Use the RegEx library to perform a sophisticated search



Conclusion

Chapter 8



Course Chapters

- Introduction
- Introduction to Python
- Variables
- Collections
- Flow Control
- Program Structure
- Working with Libraries
- Conclusion



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Course Objectives

During this course, you will learn

- “Just Enough” Python Programming
 - “Just Enough” means to enable a solid foundation for Hands-On Exercises in Cloudera training classes
 - Not “proficient as a Python programmer” (Pythonista, Pythoneer)



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This class very specifically prepares you for Cloudera classes as rapidly and directly as possible. The class is not trying to cram everything into a crash course, and it is not a goal for you to become some kind of expert Python Programmer. The goal is to learn “Just Enough” Python so that learning the language is not a distraction from learning to develop with Hadoop or Spark in later classes.

Which Course to Take Next?

Cloudera offers a range of training courses for you and your team

- **For developers**

- *Cloudera Developer Training for Apache Spark and Hadoop*
 - *Designing and Building Big Data Applications*

- **For system administrators**

- *Cloudera Administrator Training for Apache Hadoop*

- **For data analysts and data scientists**

- *Cloudera Data Analyst Training: Using Pig, Hive, and Impala with Hadoop*
 - *Data Science at Scale using Spark and Hadoop*

- **For architects, managers, CIOs, and CTOs**

- *Cloudera Essentials for Apache Hadoop*



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Just Enough Python: Hands-On Exercises

Instructor Guide

Please see the Hands-On Exercise Manual for exercise instructions. There are currently no additional instructor notes for the exercises in this course.



Just Enough Python: Hands-On Exercises

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General Notes

Notational Convention

In some command-line steps in the exercises, you will see lines like this:

```
$ hdfs dfs -put shakespeare \
/user/training/shakespeare
```

The dollar sign (\$) at the beginning of each line indicates the Linux shell prompt. The actual prompt will include additional information (e.g., [training@localhost training_materials]\$) but this is omitted from these instructions for brevity.

The backslash (\) at the end of the first line signifies that the command is not completed, and continues on the next line. You can enter the code exactly as shown (on two lines), or you can enter it on a single line. If you do the latter, you should *not* type in the backslash.

Copying and Pasting from the Hands-On Exercises Manual

For code exercises that rely on complex text strings a separate *.txt file has been provided so that you can copy and paste the code without formatting concerns.

If you wish, you can usually copy code and strings from this Hands-On Exercises manual and paste them into your terminal sessions. However, please note two important exceptions:

Straight single and double quotation marks in this document are automatically replaced with curly quotes for style, which will result in a syntax error when cut-and-pasted into the Python shell or a program.

If you copy and paste table entries that exceed a single line, a space will be inserted at the end of each line.

Please use caution when copying and pasting from table entries when performing the exercises.

Writing Python Programs

1. Files with the suffix `.py` are Python program files. We are going to be working with more complex programs during the remainder of the course. So we will need to edit `*.py` files and run them.
2. We have installed a graphical editor (`gedit`) on the class exercise machine, or you can use a variation of `vi` if you prefer.
3. To run a program, from the command line, type `python filename.py`
4. **Python** is the default shell that ships with the deployment. We will be using a separate interactive shell called **IPython** in this class. It provides additional features and better integration with the underlying platform than the default Python shell.
5. You can edit a file without leaving IPython using the command `%ed`. The default behavior is to launch the `vi` editor. When you save and exit the editor (`<ESC>:wq`) the IPython shell will automatically load the file that was edited and run the program.
6. You can load and run a program without leaving IPython by typing
`run filename.py`

Hands-On Exercise: Using IPython

Files and Data Used in this Exercise

Exercise directory: /home/training/training_materials/jep

In this exercise you will start the IPython shell and use it interactively.

The Default Python Shell

We will not be using the default Python shell in this class. If you want to try the default Python shell, just open a terminal and type **python**

```
$ python
>>>
# You can enter python code directly in the shell and
it executes it immediately. To quit from the python
shell, you need to call the quit function.

>>> quit()
$
```

The interactive Python shell comes with the Python installation. It's great for testing out code snippets and learning how the Python language works. However, it is not a coding tool, in that you can't load and save program files. Also, it has limited interaction with the host environment, so it does not provide path and filename completion or command completion. It does not provide access to Python documentation. And it does not have any features to help interrogate objects.

IPython Shell

In this class we will be using the IPython shell. This is an REPL (Read-Evaluate-Print-Loop) shell. It provides a method for having interactive sessions with Python. We will use this to explore some of the basic principles of the Python language.

The IPython shell is an advanced shell that provides additional programming features over the default shell. IPython is a separate project and must be downloaded and installed separately from Python itself. There are three variations of IPython, **console**, **qt** (which provides inline graphics), and **web-notebook**. The **console** version is used in this class.

IPython also provides *magic* commands. A magic command is a command preceded by the percent sign (%), which passes a command to the host Linux system. For example, `%ed` is an IPython magic command to edit a program file. IPython also has native commands that do not require a percent sign. For example, `run filename.py` will load and run a Python program file in IPython.

1. Open a terminal and change to the directory containing the exercise files.

```
$ cd ~/training_materials/jep/
```

Use the `ls` command to examine the contents of this directory and its subdirectories. All of the files you need for the exercises are here. Also, there are solutions to all of the exercises that you can view if you need help.

2. In this exercise you will use the IPython shell in interactive (REPL) mode. To start the IPython shell, open a terminal and type `ipython`. You may then enter Python statements, such as those shown below:
 - a. Enter `ab = 25`.
 - b. Then enter `ab`.
 - c. Observe that IPython prints 25.

```
$ ipython
In [1]:
In [2]: ab = 25
In [3]: ab
Out[3]: 25
In [4]:
```

3. The IPython shell has integrated help that will give you information about the Python language. You start it by entering `help()`. Type the following:

```
In [5]: help()
help >
```

4. Enter a search term. For example, enter `int` to view the Python documentation on the `int()` function. When viewing the documentation, you can press the `f` key to move one page forward and the `b` key to move one page backward.

```
help > int

Help on class int in module __builtin__:

class int(object)
| int(x[, base]) -> integer
|
| Convert a string or number to an integer, if
possible. A floating point
| argument will be truncated towards zero (this does
not include a string
| representation of a floating point number!) When
converting a string, use
```

5. Enter `q` to stop viewing the documentation. Enter `q` again (or press enter) to exit the help utility.

```
q
help > q
```

6. Exit the IPython shell using the quit command.

```
In [2]: quit
$
```

7. From within IPython, running `pwd` will identify the current directory, while running `ls` will list the files in the current directory. Type the following:

```
$ ipython
In [1]: pwd
Out[1]: u'/home/training/training_materials/jep'

In [2]: ls
data/ manifest.txt*  solutions/

In [3]: ls data
loudacre.log*  sample_one_record.txt*

In [4]: ls solutions
(many items are listed)
```

8. You can use an editor directly from IPython by typing `%ed`. Type `i` to put the editor into input mode. Enter the following lines:

```
In [5]: %ed hellopython.py
mystring = raw_input('Greeting: ')
print mystring
```

- Type [Esc] :wq to save the code, quit the editor and run the program.

```
In [6]: %ed hellopython.py
Editing... done. Executing edited code...
Greeting: myname
myname
In [7]:
```

- Now, enter mystring?. The question mark tells IPython that you want to interrogate the object from the program that just ran.

```
In [8]: mystring?
Type: str
String form: myname
Length: 6
Docstring:
str(object) -> string

Return a nice string representation of the object.
If the argument is a string, the return value is the
same object.
```

In case you want to review the completed program, you will find a copy in the **solutions/Hello-solved.py** file.

This is the end of the Exercise

Hands-On Exercise: Loudacre Mobile

Files and Data Used in this Exercise

Exercise directory: `~/training_materials/jep`

Data file: `~/training_materials/jep/data/loudacre.log`

In this exercise, you will write a program and use it to explore the sample data.

Introducing Loudacre

Loudacre is a mobile phone carrier. They have provided us with a log file, `loudacre.log` in the `data` subdirectory, which contains error information from mobile phones. Whenever the phone restarts following an error, it gathers diagnostic information and sends it back to Loudacre's central facility where the data is collected for analysis. Let's take a look at the fields in the log file.

File I/O

1. Enter the following program using `%ed` from IPython, command line `vi`, or a graphical editor, and run it using the `run` command. Note that Python is very specific about indentation. It uses indentation to define code blocks. Python requires each level of indentation to be one column, and all other lines in the same code block to be indented identically.

```

line=' '
file =\
open('/home/training/training_materials/jep/data/\
loudacre.log','rt')
while True:
    line = file.readline()
    if not line:
        break
    print line

```

The data/loudacre.log file is in comma-delimited format. The last line should look like this:

2014-03-15:10:10:31,Titanic 4000,1882b564-c7e0-4315-aa24-
228c0155ee1b,58,36,39,31,15,0,TRUE,enabled,enabled,40.69206648
,-119.4216429

The fields in each line represent device data interpreted as follows:

Field	Data Example
Date Time:	2014-03-15:10:10:31
Model name and number:	Titanic 4000
Unique device ID:	1882b564-c7e0-4315-aa24-228c0155ee1b
Device temperature (Celsius):	58
Ambient temperature (Celsius):	36
Battery available (percent):	39
Signal strength (percent):	31
CPU utilization (percent):	15
RAM memory usage (percent):	0
GPS status (enabled=TRUE, disabled=FALSE):	TRUE
Bluetooth status (enabled, disabled, or connected):	enabled
WiFi status (enabled, disabled, or connected):	enabled
Latitude:	40.69206648
Longitude:	-119.4216429

The completed program is in `solutions/Readlog-solved.py`. The solution file differs slightly from what is shown above in that it does not use backslashes to continue the `open` statement across multiple lines.

This is the end of the Exercise

Hands-On Exercise: Variables

Files and Data Used in this Exercise

Exercise directory: /home/training/training_materials/jep

Numerical Variables

1. The Loudacre log contains device temperature information. Try the following explorations using the IPython interactive shell to learn how Python works with integer and floating-point variables.

```
# Numerical variable basics  
  
# tempC = temp Celsius  
# tempF = temp Fahrenheit  
# C_to_F = 9/5  
  
tempC = 27  
C_to_F = 1.8  
tempF = tempC * C_to_F +32  
  
# type() tells you the type of object  
print type(tempC), type(tempF)  
print tempC, tempF
```

2. Continue exploring Python's dynamic typing and variables:

```
# multiple assignment and dynamic typing
ambientTemp, deviceTemp = 19, 47.0
print type(ambientTemp), type(deviceTemp)
print ambientTemp, deviceTemp

ambientTemp = 27.0
deviceTemp = 58
print type(ambientTemp), type(deviceTemp)
# note: the types have changed dynamically
```

Python dynamically determines the type of a variable every time an assignment is made. In other languages, attempting to assign a value to a variable of a different type will result in an error. The type of the variable can be changed in Python. In the example, the type of `ambientTemp` and `deviceTemp` switch from `int` to `float` and `float` to `int`.

By figuring out what the type of a variable should be based on context, Python reduces the amount of typing required to program.

The exploration is recorded as a program in **solutions/Numerical-solved.py**.

Operators and Reflexive Operators

3. Loudacre reports CPU utilization in percentages. Use IPython interactively to explore operators and reflexive operators.

```
# operators and reflexive operators  
#  
#   cpuT1 = sample CPU utilization at time 1  
#   cpuT2 = sample CPU utilization at time 2  
  
cpuT1 = 17  
cpuT2 = 38  
averageCPU = (cpuT1 + cpuT2) / 2.0  
print "Average CPU: ", averageCPU  
  
# New software could reduce cpu utilization by 12%  
reduction = 12.0/100  
print "Expected CPU: ", cpuT2-(cpuT2*reduction)  
  
# Increment cpu utilization at time 1 by 1%  
cpuT1 += 1  
print cpuT1
```

Code continues on next page

```
# Find total of time 1 and time 2 cpu samples
#
cpuT1 += cpuT2
print cpuT1

# Increment cpuT2
# cpuT2++    <-- results in an error
#
cpuT2 = cpuT2 + 1
print cpuT2

# Python provides 'floor division' and modulus
print 37.0 / 5.0
print 37.0 // 5.0 # Gives the whole divisor
print 37.0 % 5.0 # Gives the remainder

# Explicit casting between integer and float
cpuT1, cpuT2 = 50, 30.1
print cpuT1, cpuT2
cpuT1 = float(cpuT1)
cpuT2 = int(cpuT2)
print cpuT1, cpuT2
```

The exploration is recorded as a program in **solutions/Operators-solved.py**.

Binary, Octal, and Hexadecimal

4. Each Loudacre device has a unique device ID in hexadecimal. To make sure you can work with the ID in binary, octal, and hexadecimal in Python, try entering and casting ID values.

Create the following program using %ed or a graphical editor and then run it.

```
# -- Unique ID --
#     PartC = 0x13f4
PartC = 0x13f4
print "ID      :", PartC
#
# Even though you entered PartC as a hex value,
# Python converted it to decimal

# Now try casting as you did with int() and float()
hexID = hex(PartC)
binID = bin(PartC)
octID = oct(PartC)

print "hex ID: ", hexID, type(hexID)
print "bin ID: ", binID, type(binID)
print "oct ID: ", octID, type(octID)
```

Python has no binary, octal, or hexadecimal variable types. You can enter these values as literals, and Python will convert them to decimal. Prefixes are `0x` for hex, leading zero for octal, and `0b` for binary. Attempting to cast decimal values to binary, octal, and hexadecimal generates formatted strings ready for output.

The completed program is in `solutions/BinOctHEX-solved.py`.

Advanced Mathematical Functions

5. Use IPython interactively to explore the built-in math functions.

Math functions that are integrated in other languages are separate built-in libraries in Python. The library must be imported prior to use.

The completed program is in **solutions/AdvMath-solved.py**

```
sqrt(192)
# produces an error

from math import sqrt
print sqrt(192)
```

There will be more on the math library later in the course in the chapter on Python libraries.

Strings

Use the following string to represent one record in the `loudacre.log` file. This string can also be copied from the `data/sample_one_record.txt` file.

```
record = "2014-03-15:10:10:31,Titanic 4000, \
1882b564-c7e0-4315-aa24-228c0155ee1b, \
58,36,39,31,15,0, \
TRUE(enabled,enabled, \
40.69206648,-119.4216429"
```

6. Print out the record and the length of the record. The length should be 132 characters.

7. Use the `find()` string method to locate the start of the model name (`Titanic`). Then use slice ranges to extract the model name and model number into separate variables. Remember that the model number comes immediately after the model name in the data.
8. Use the `upper()` string method to turn the name into uppercase and store it in a new string
9. Use a reflexive operator to concatenate the model number onto the new string.

The completed program is in **solutions/Strings-solved.py**.

Boolean

10. Extract the Bluetooth and WiFi fields from the record string.

Each field can contain three values: enabled, disabled, and connected

11. Use `==` to determine if Bluetooth and WiFi are ON and print the results.
12. Use `==` to determine if WiFi is connected to an access point.

Hint: use `string.find()` in REPL mode to locate the start value of a slice.

13. Bonus exercise: Print out the device temperature field for records greater than 50 degrees.

The completed program is in the **solutions/Boolean-solved.py** file.

This is the end of the Exercise

Hands-on Exercise: Collections

Files and Data Used in this Exercise

Exercise directory: `~/training_materials/jep`

Data file: `~/training_materials/jep/data/loudacre.log`

Reading the Data

Use the line at a time `readline()` technique to read the `loudacre.log` file. Each record is read as a string. In this exercise you will process each string and break out the fields into a separate list. Finally, you will store the list of fields into a list of records to create an information base. You will use a simple `while()` loop. Please refer to the completed program as necessary.

Each string returned from `readline()` is a record composed of comma-delimited fields. Use the `split()` method to separate each record into a list of fields. Store the list of fields into a list of records using the `list.append()` method.

1. Print out the number of records in the list.
2. Print out the number of fields in each record.

Note: This is a *nested* list. The first list contains elements that are lists.

3. Print out field 2 (the unique ID field) for records 375, 410, and 435.
4. Did you get the following?

`8d431088-c262-4f26-8d2f-9fb558cc6242`

`99a93ac5-19a6-4123-91f6-08c695d7b6e0`

`077ea017-3de3-4f14-8964-56ab9c987bb5`

The completed program is in the `solutions/Split-solved.py` file.

Part 2

In this exercise you will read the `loudacre.log` file into memory twice using two different file-reading techniques. Then you will compare the buffers to see if the two methods produce the same results.

5. Create an empty list, `loglist1`.
6. Read the `loudacre.log` file using the line-at-a-time technique using the `readline()` method. Append each line to the list `loglist1`.
7. Close the file with `file.close()`
8. Create an empty list, `loglist2`.
9. Read the `loudacre.log` file using the list-at-a-time technique with `readlines()` – note the “s” in the method name – which returns an entire list object instead of individual lines.
10. Close the file with `file.close()`
11. Print out the length of `loglist1` and `loglist2`. Are they the same length?
12. Compare `loglist1` and `loglist2`. Do they have the same value? Hint: you can compare them with `==`. Python knows they are lists and will compare all elements in each list in sequence to determine if they are identical.
13. Append one more of the last line read from `loglist1` onto to `loglist2`.
Compare the lists again. Do they have the same value?
14. Concatenate `loglist2` onto `loglist1`. Hint: use the reflexive operator. How many records does `loglist1` have now?

Note: The process of reading all of the lines of a file into a list is fast and efficient. However, the activity is atomic. That means you can't process each line using `split()` as in the last exercise. To process the lines you will need to iterate over the elements in the list, which will be covered in the next chapter.

The completed program is in the `solutions/`**List-solved.py** file.

This is the end of the Exercise

Hands-On Exercise: Flow Control

Files and Data Used in this Exercise

Exercise directory: ~/training_materials/jep

Data file: ~/training_materials/jep/data/loudacre.log

Part 1

In this exercise you will be preparing a brand index and a model index using sets. The final sets are to be ordered and unique, displaying the brands and the models mentioned in the loudacre.log.

The completed program is in the **solutions/Index-solved.py** file.

1. Read the loudacre.log file into memory using `readlines()`
2. Separate each record into a list using `split()`
3. Locate the model name and number field (Example: "Titanic 4000"). Collect the model field into a `set()`.

Note that there is no literal for the empty set. If you initialize a variable like `allmodels = {}`, you will get a "dict" type instead of a "set" type. So you must initialize like so: `allmodels = set()`

4. Use `split()` to separate the brand name (Example: "Titanic") from the model number. Hint: The brand name is separated from the model number by a space.
5. Collect the brand names into a `set()`.
6. Sort both indexes. There is no `sort()` method for sets. Use `sorted()`
7. Print the brand list and the total number.
8. Print the model list and the total number.

How many brands are mentioned in the `loudacre.log` file?

How many unique models of device are there?

Part 2

In this exercise you will be processing and preparing an information base from the device log file. The fields in the log file are stored as strings. You will be converting these to `int`, `float`, and `bool` types to make it easier to use the data later. Also, the final information base may be used by concurrent programs, so it needs to be made immutable by making it into a tuple. Because the tuple cannot be changed after it is initialized, you will have to construct the information base in a list first, and then cast it to a tuple.

The completed program is in the `solutions/Devicebase-solved.py` file.

- 9.** Read the `loudacre.log` file into memory using `readlines()`
- 10.** Separate each record into fields using `split()`
- 11.** Convert the following fields from strings to integer values: Device Temperature, Ambient Temperature, Battery Available, Signal Strength, CPU Utilization, and RAM usage. Hint: the fields are in sequence.
- 12.** Convert the Device Temperature and Ambient Temperature from Celsius to Fahrenheit. Hint: $\text{Fahrenheit} = 9/5 * \text{Celsius} + 32$
- 13.** Convert the GPS status to a `bool` Boolean value. Hint: the `TRUE` or `FALSE` in the file is a string.
- 14.** Convert the latitude and longitude from strings to floating point values.
- 15.** Isolate the brand name from the model name and number field, and insert this after the date and time stamp field using the `insert()` method. Hint: use `split()`. The brand name and model number are separated by a space.
- 16.** Append the fully processed record to a temporary device base list.
- 17.** After the temporary base is constructed, cast it to a tuple to “freeze” it. Print out the number of records in the tuple and the type to verify it's a tuple.

- 18.** You should now be able to write code that uses the tuple to answer the following questions: How many Sorrento brand devices are found in the `loudacre.log` file, and how many of them had GPS turned on?

This is the end of the Exercise

Hands-On Exercise: Program Structure

Files and Data Used in this Exercise

Exercise directory: ~/training_materials/jep

Data file: ~/training_materials/jep/data/loudacre.log

Pass by Reference

In this exercise you will be creating a filtered version of the information base from the last exercise using the built-in `filter()` function, and passing by reference a function that will perform the filtering.

The field we want to use in the filter is nested in `element[1]` – the brand name of the device that you inserted in step 6 of the previous exercise. You will create a function that returns `True` if the length of this field is greater than 7.

You will first create the function as a standard named function. Next, you will comment that out and recreate the function as a single-line named function. In the next exercise, you will convert the function to an inline anonymous function using the `lambda` keyword.

The completed program is in the `solutions/Functions-solved.py` file.

1. Copy the program from the last exercise, or copy the `solutions/Devicebase-solved.py` file to use as a starting point.
2. Write a function `biggerthan` that returns `True` if the length of the `field[1]` of the object that is passed to it is greater than 7.
3. Pass `biggerthan` and `devicebase` to filter and store the results. How many records are there in the results?

4. Now comment out the first version of `biggerthan` (place `#` in the first column), and recreate `biggerthan` in a single-line function definition. Are the results the same? Demonstrate that the results are the same by printing the length (number of elements) in the result.

Lambda Functions

In this exercise you will replace the named functions from the previous exercise with an anonymous function.

The completed program is in the `solutions/Lambda-solved.py` file.

5. Comment out the second version of `biggerthan` and the call to `filter()` that uses a named function.
6. Rewrite the call to `filter()` using an inline anonymous (`lambda`) function. Demonstrate that the results are the same by printing the length (number of elements) in the result.

Python Map and Reduce

In this exercise, you will prepare a list of data using Python's `map()` function and then find the largest result with Python's `reduce()` function.

7. Extract all the device temperature data into a tuple.
8. Convert the temperatures to Fahrenheit using the Python `map()` function with an anonymous function to perform the conversion.
9. Use `reduce()` to find the average device temperature, with an anonymous function to perform the comparison. You will need to use `reduce` to generate the sum of the values, and then divide that by the total number of values.
10. What is the hottest device temperature?

The completed program is in `solutions/MapReduce-solved.py`.

Generator Part 1

Security has decided to use a little-known mathematical series to generate part of the unique device IDs. The Stern series is defined as the ratio of the whole number to the sum of its digits.

Here is an example:

Whole number in sequence: 951

Sum of the digits: $9 + 5 + 1 = 15$

Ratio of the whole to the sum of the digits: $951/15 = 63.4$

- 11.** Define a function that generates all the numbers in the series up to `maxnum`. The numbers should be stored as pairs of tuples with the first element in the tuple being the whole number (`int`) and the second number being the ratio (`float`). Store each tuple in a list. Then have the function return the list to the calling program.
- 12.** The calling program should iterate over the entire list, printing out each pair of tuples in the series.
- 13.** Generate the first 500 numbers in the series.

What is the ratio for number 481?

The completed program is in `solutions/Series-solved.py`.

Generator Part 2

Security needs the first 32 billion numbers in the series. The problem is, there is not enough memory on the platform to hold the list of values. Turn the previous program into a Python Generator using `yield`.

- 14.** You will need to remove the “return” from the function and add `yield`. The `yield` must be inside the loop.
- 15.** The `yield` will return the iterator.

16. Because you can no longer return the pair of the whole number and the ratio, you will need a global tuple to make sure the calling program receives both results.

17. Generate the first 500 numbers this way.

The completed program is in the **solutions/Generator-solved.py** file.

This is the end of the Exercise

Hands-On Exercise: Libraries

Files and Data Used in this Exercise

Exercise directory: `~/training_materials/jep`

Data file: `~/training_materials/jep/data/loudacre.log`

Using an Import Statement

In this exercise, you will create a simple library and use it in a main program.

1. Create a library with two functions, `loadfile()` and `userinput()`.
2. Use `readlines()` in `loadfile` to read a log file and return a list containing the contents of the file.
3. The `userinput()` function should read text from the console using `raw_input()` and print it.
4. Finally, write a main program that loads the library and calls the two functions.

The completed main program is in `solutions/Import-solved.py`, while the completed library program is in `solutions/Library06AB.py`.

Using a “from” Import Statement

In this exercise, you will adapt the previous program to use the "from" import method and its calling semantics.

5. Copy the main program and adapt it to use `from libraryname import functions` instead of `import libraryname`

The completed program is in `solutions/From-solved.py`.

Path

In this exercise, you will use one method to expand the locations where libraries can be staged.

6. Relocate the library you created in the previous steps to a subdirectory and give it a new name. (In the example, the `Library06AB.py` module was copied into a subdirectory under `/solutions` called `/library` and renamed to `pathlibdemo.py`).
7. Use `sys.path.append()` within the main program to update the search path so that Python can find the library file again.

The completed program is in the **solutions/Path-solved.py** file, while the library program is in **solutions/library/pathlibdemo.py**.

Arguments

In this exercise, you will process arguments from the command line. For example, you might enter:

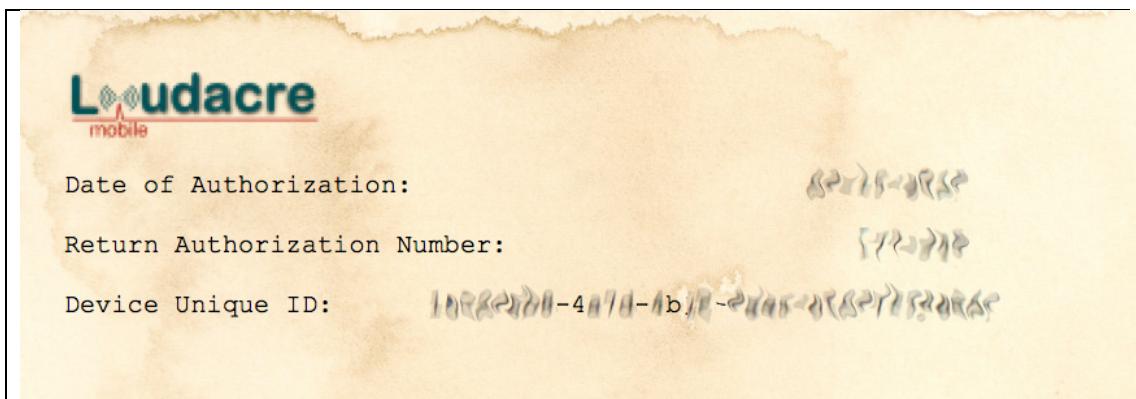
```
$ python myprogram.py Titanic 4400 connected
```

8. Load any libraries you need to access the system environment.
9. Discover how many command line arguments were passed in.
10. Iterate over the arguments and print them.

The completed program is in the **solutions/Args-solved.py** file.

RegEx

Below is a Return Authorization form that arrived water-damaged. As you can see, the only bits of information that are still readable are the "4" and the "b" in the Device Unique ID. We know that the device has been having issues and likely logged a restart record in the `data/loudacre.log` file. Your challenge is to locate any records based on only these two pieces of information, and hopefully recover the unique Device ID so that the RA record can be found. To accomplish this, you will use the Python `re` (Regular Expression) library. Refer to the completed program as necessary for help with using Regular Expressions in Python.



11. The program will read the `loudacre.log` file, then use a regular expression to search the list of Unique IDs for a match.
12. The phone we are looking for has a “4” in the first column of the second part of the unique ID, and a “b” in the second column of the third part of the unique ID.
`xxxxxxxxx-4xxx-xbxx-xxxx-xxxxxxxxxxxx`
13. Read `loudacre.log` and separate out the Unique Device ID field.
14. Import the `re` library, and craft a regular expression to find records matching the criteria.
15. Iterate over the records. Print the entire record that matches.

The completed program is in `solutions/RegEx-solved.py`.

This is the end of the Exercise